# CITY OF ENGLEWOOD MAJOR DRAINAGEWAY PLAN

# BASELINE HYDROLOGY - FINAL REPORT

**SEPTEMBER 2022**

PROJECT SPONSORS

MHFD MILE HIGH FLOOD DISTRICT

Englewood COLORADO

PREPARED BY

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**Dewberry**®

September 2022

Mr. Jon Villines
Program Manager, Watershed Services
Mile High Flood District
2480 West 26th Avenue, Suite 156-B
Denver, Colorado 80211

Re: City of Englewood Major Drainageway Plan
MHFD Agreement No. 20-07.23

Dewberry Engineers is pleased to submit the City of Englewood Major Drainageway Plan.

The Dewberry project team thanks the Mile High Flood District and the City of Englewood for their assistance in the preparation of this study. We appreciate the opportunity to work with you on this project and look forward to working with you in the future.

Sincerely,

E. Danny Elsner, P.E., CFM
Water Resources Department Manager

Haley Jo Heinemann, P.E., CFM
Project Engineer

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# 1.0 INTRODUCTION

## 1.1 Authorization

Dewberry Engineers was retained to complete a Major Drainageway Plan (MDP) for watersheds draining to the City of Englewood, Colorado, co-sponsored by the Mile High Flood District (MHFD) and the City of Englewood (Englewood). The *Agreement Regarding Major Drainageway Plan for City of Englewood* (Agreement No. 20-07.23) was executed on July 27, 2020.

## 1.2 Purpose and Scope

The purpose of this study was to create a comprehensive city-wide MDP for the City of Englewood that would update hydrology, evaluate the existing drainage system, and prioritize improvement projects to alleviate drainage and flooding problems.

This MDP re-studied 15 stormwater drainage basins (Table 2-1) across the city and references the conceptual design recommendations from separate Master Plans that were previously completed for 4 of the main drainageways flowing through Englewood, namely: Big Dry Creek, Little Dry Creek, Dry Gulch, and West Harvard Gulch. Those master plans are:

- RESPEC. *Big Dry Creek Downstream of County Line Road Flood Hazard Area Delineation Report*. Sponsored by City of Englewood, Mile High Flood District, et. al. February 2018.
- WRC Engineering. *Little Dry Creek (ARAPCO) Watershed Downstream Portions Major Drainageway Planning Phase – B Preliminary Design Report*. Sponsored by Urban Drainage and Flood Control District, et. al. August 2004. *Downstream limit at Clarkson Street
- Matrix Design Group. *Harvard Gulch and Dry Gulch Major Drainageway Plan Report*. Sponsored by City of Englewood, Urban Drainage and Flood Control District, et. al. December 2016.
- Denver Public Works. *City and County of Denver Storm Drainage Master Plan*. September 2014.

The following tasks were completed for the 15 stormwater drainage basins (Study Area):

- Acquired input from project sponsors.
- Collected existing information, including previous MDP and drainage studies.
- Obtained base mapping and GIS information from MHFD and Englewood.
- Obtained 2018 planimetric data from the Denver Regional Council of Governments (DRCOG) and alley paving plans from Englewood.
- Delineated basin boundaries and parameters based on underground and above ground drainage paths.
- Developed existing and future conditions baseline hydrology using the Colorado Urban Hydrograph Procedure (CUHP) 2005, version 2.0.1 and the Environmental Protection Agency Storm Water Management Model (EPA SWMM), version 5.1.015.
- Informed the baseline hydrology SWMM model overland flow paths and splits with 2D modeling.
- Compared the baseline hydrology results with previous studies.

## 1.3 Planning Process

Portions of the Study Area have been analyzed in previous stormwater Master Plans and studies. The original, contemporary city-wide Master Plan is the 1998-1999 *City of Englewood Outfall Systems Plan* by Turner Collie & Braden, which was updated by Calibre Engineering in the 2018-2019 *City of Englewood Flood Proofing Study & Outfall Systems Plan Update.* The 1998-1999 Outfall Systems Plan (OSP) provided storm sewer alternatives for a 2- to 5-year system, while the OSP Updates are based on conveyance of the 25-year event. Most recently, a Master Plan was published by Hazen and Sawyer in 2020 that focused on areas outside of the Calibre study where flood related problems have been identified. The 2020 Hazen and Sawyer study did not perform any hydrology. For a summary of the key previous studies, see Section 3.0.

Several meetings were held with the MHFD and Englewood to discuss the goals, status, hydrologic analysis, areas of concern, potential alternatives, and comments. Meeting minutes and comment responses are included in Appendix A.

- August 19, 2021 – MHFD and Englewood returned comments on the draft Baseline Hydrology Report.

## 1.4 Mapping and Surveys

One-foot contours and a digital elevation model (DEM) created from 2013 DRCOG LiDAR were provided by MHFD. Other information such as GIS files of jurisdictional boundaries, existing stormwater infrastructure, and roadways were obtained from Englewood, MHFD, Denver, Littleton, and Arapahoe County. All data is spatially referenced using the NAD 1983 Colorado State Plane, Central Zone projected coordinate system. Vertical elevations are referenced using the NAVD 1988 vertical datum. Two existing City detention ponds were surveyed by Wilson & Company in May 2021, and portions of the existing storm sewer were surveyed by Wilson & Company in May 2022.

## 1.5 Data Collection

Drainage studies and as-built drawings were collected from MHFD and Englewood. Additional datasets such as topography, planimetric shapefiles and soil data was collected from various sources. The main items that were used for the preparation of this study are listed in reverse chronological order in Table 1-1.

## 1.6 Acknowledgments

Project sponsors include:

- Mile High Flood District
- City of Englewood

The individuals who assisted in the preparation of this MDP include:

| | |
|---|---|
| Jonathan Villines, PE, CFM | MHFD – Watershed Services Project Manager |
| Charlie Pajares, PE, CFM | MHFD – Project Engineer |
| Jeff Battiste, EI | MHFD – Staff Engineer |
| Brik Zivkovich, CFM | MHFD – Staff Engineer |
| Tim Hoos, PE, CFM | Englewood – Capital Projects and Engineering Manager |
| Maria D'Andrea, PE | Englewood – Director of Public Works |
| Carrie Evenson, PhD, PE, CFM | Englewood – Stormwater Program Manager |
| Ken Cecil, PE, CFM | Dewberry – Principal Engineer |
| Danny Elsner, PE, CFM | Dewberry – Project Manager |
| Haley Heinemann, PE, CFM | Dewberry – Project Engineer |
| Katie Kerstiens, EI, CFM | Dewberry – Staff Engineer |


Please note that this report includes information from multiple previous studies; therefore, several figures, photos, and blocks of text have been borrowed from the studies listed below. Direct citations are limited for purposes of readability.

- Hazen and Sawyer. *City of Englewood Stormwater System Master Plan*. 2020.
- Calibre Engineering. *City of Englewood Floodproofing Study & Outfall Systems Plan Update*. 2018-2019.
- Moser & Associates Engineering. *Analysis and Alternatives Evaluation of the Acoma Street Drainage Problem*. 2002.
- Muller Engineering. *Stormwater Sewer Report.* 1999.
- Turner Collie & Braden. *City of Englewood Outfall Systems Alternatives Evaluation Report*. 1999.
- Turner Collie & Braden. *City of Englewood Probable Areas Affected by Flooding from the 100-year Storm*. 1998.
- Sellards & Grigg Consulting Engineers. *Englewood Storm Drainage Plan.* 1971.
- Ripple and Howe. Consulting Engineers. *Proposed Drainage Plan for Englewood, Colorado Engineer's Preliminary Report.* 1955.

**Table 1-1** Data Collected

| Title/Dataset | Date of Receipt or Publication | Source |
|---|---|---|
| GIS geodatabase of existing storm sewer infrastructure | September 15, 2021 | City of Englewood |
| New survey of Rotolo Park and Bates-Logan detention facilities | May 21, 2021 | MHFD |
| Storm sewer as-built drawings | May 3, 2021 | City of Englewood |
| Figure of planned alley paving | April 2, 2021 | City of Englewood |
| Web Soil Survey GIS shapefiles and report | January 6, 2021 | NRCS |
| GIS shapefiles of planimetric dataset for: roofprints, edge of pavement, parking lots, sidewalks, and driveways. | 2018 | DRCOG |
| DRCOG elevation data including DEM, 1-ft contours, and LiDAR LAS files | 2013 | MHFD |

### Missing Data

The following data was unavailable at the time of this study:

- GIS shapefiles of existing Cherry Hills Village storm sewer infrastructure
- Planimetric GIS shapefiles of pervious surfaces

# 2.0 STUDY AREA DESCRIPTION

## 2.1 Project Area

### City of Englewood

The City of Englewood, Colorado is a community of approximately 30,000 residents located south of Denver. The City is bordered by a number of other communities, including Sheridan to the west, Littleton to the south, and Cherry Hills Village to the East (Figure 2-1). The City spans just under 7 square miles.

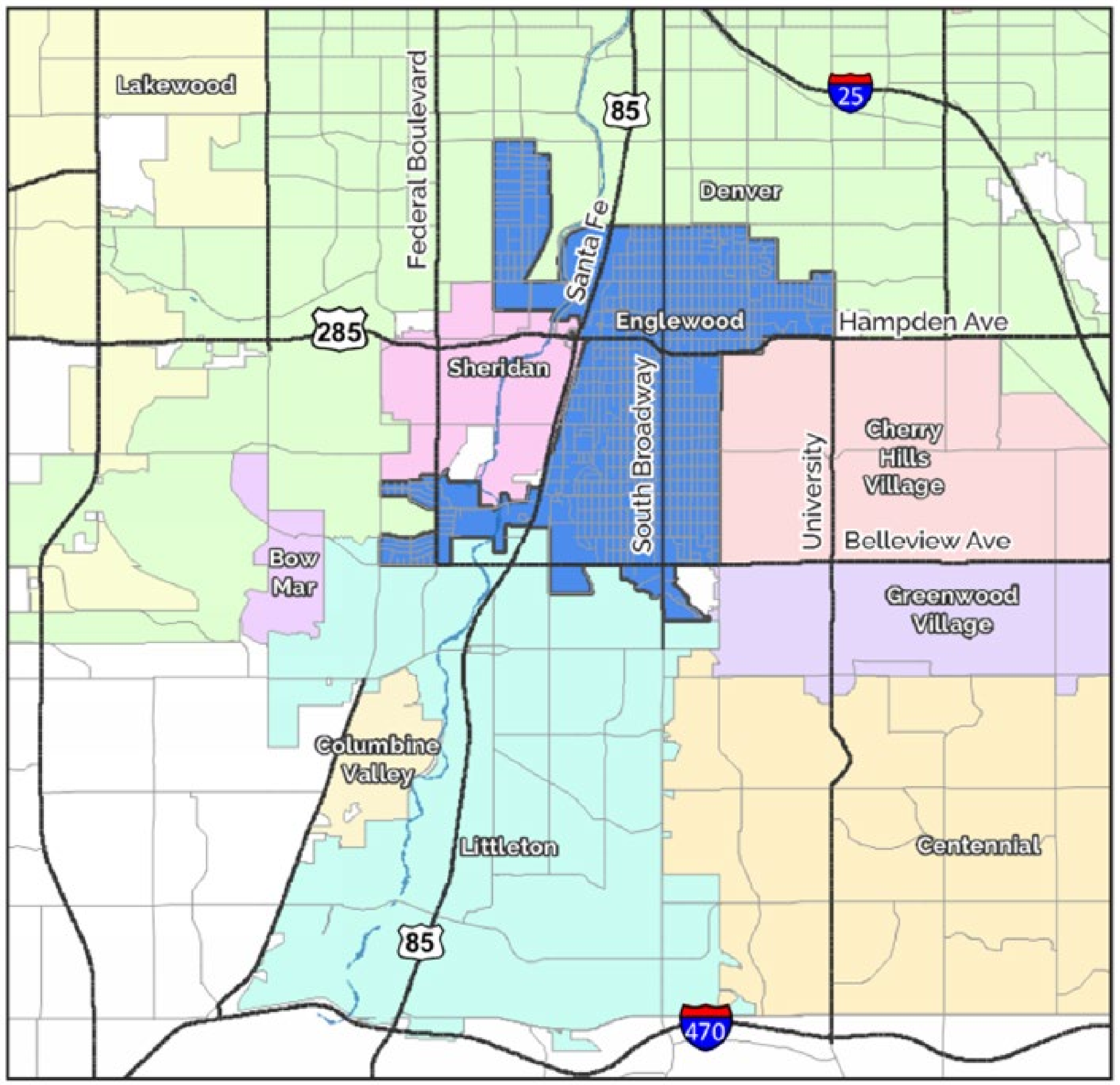


**Figure 2-1 Project Area**

*Source: Englewood Forward: Comprehensive Plan. December 2016.*

### Drainage Basin Description

There are 19 stormwater drainage basins that flow through the City, each ranging in size and geographical traits (Figure 2-2). Each of these basins contains stormwater infrastructure that collects runoff and transports it to a storm sewer trunkline or one of the 4 main open channel drainageways studied by other MHFD Major Drainageway Plans (MDPs) and Flood Hazard Area Delineations (FHADs): Big Dry Creek, Little Dry Creek, Dry Gulch, and West Harvard Gulch. All stormwater from the City ultimately discharges to the South Platte River, either via open channels or directly from storm sewer outfalls.

As previously stated, the 4 main open channel drainageways have been studied in separate Master Plans; therefore, their drainage basins (or watersheds) are **not** re-studied by this MDP. Instead, the conceptual design recommendations published in the previously developed studies (listed below) are referenced:

- RESPEC. Big Dry Creek Downstream of County Line Road Flood Hazard Area Delineation Report. Sponsored by City of Englewood, Mile High Flood District, et. al. February 2018.
- WRC Engineering. Little Dry Creek (ARAPCO) Watershed Downstream Portions Major Drainageway Planning Phase – B Preliminary Design Report. Sponsored by Urban Drainage and Flood Control District, et. al. August 2004. (Downstream limit at Clarkson Street)
- Matrix Design Group. Harvard Gulch and Dry Gulch Major Drainageway Plan Report. Sponsored by City of Englewood, Urban Drainage and Flood Control District, et. al. December 2016.
- Denver Public Works. City and County of Denver Storm Drainage Master Plan. September 2014.

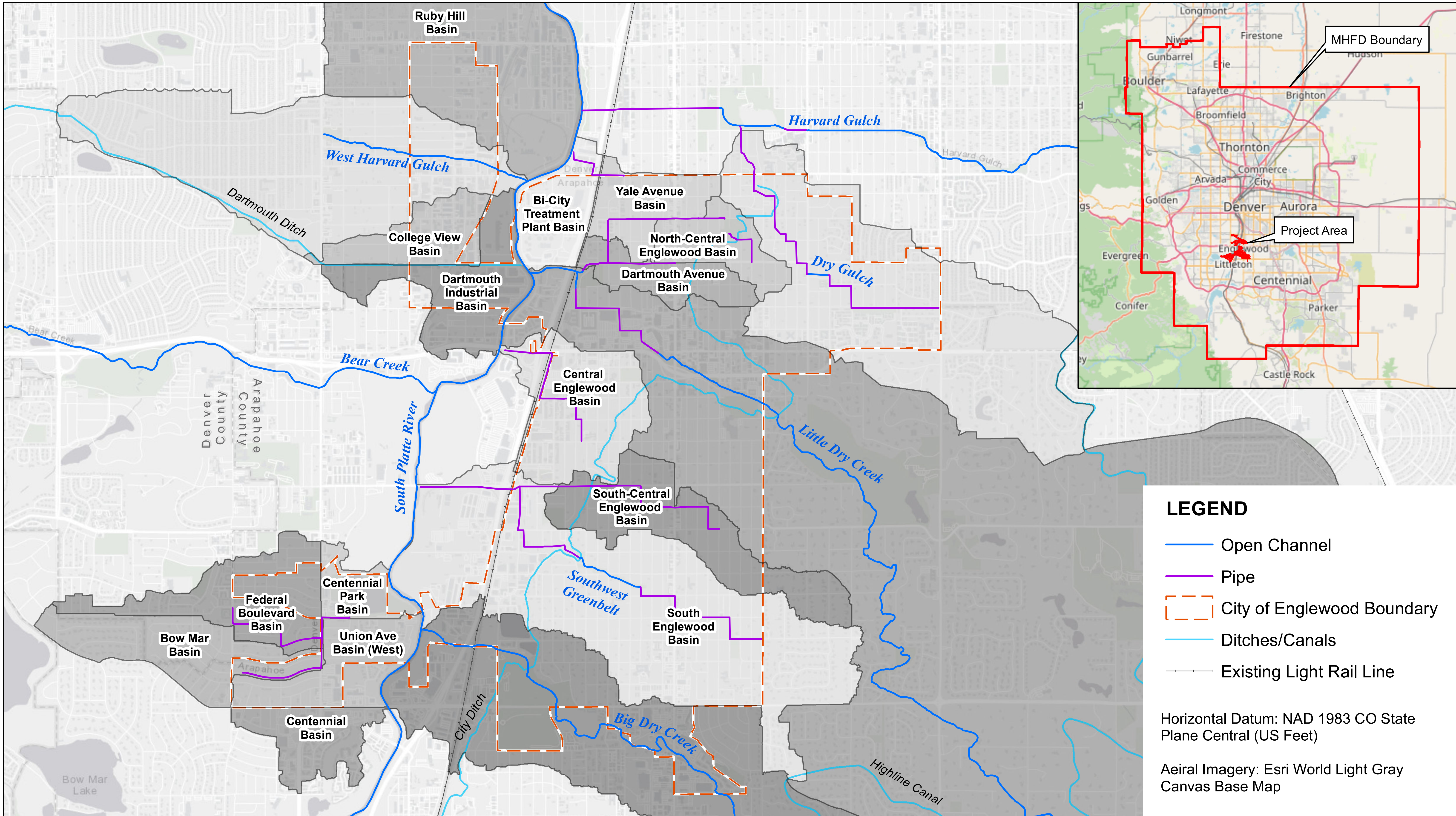


FIGURE 2-2
CITY DRAINAGE BASINS

N

0 0.25 0.5
Miles
1 inch = 0.5 miles

MHFD MILE HIGH FLOOD DISTRICT

Englewood COLORADO

CITY OF ENGLEWOOD
MAJOR DRAINAGEWAY PLAN

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Previous Englewood studies have named several subbasins within the Big Dry Creek and Little Dry Creek watersheds. The subbasins generally represent the area contributing to each of the major storm sewer trunk lines. The subbasins are listed below by watershed for reference. Additionally, previous studies commonly referred to the Dry Gulch watershed as the Northeast Englewood Basin, and the West Harvard Gulch watershed as the Northwest Englewood Basin. Finally, the 2020 Hazen report divided the North Englewood Basin into the North-Central Englewood and Dartmouth Avenue basins. That division was maintained in this report because the 2 basins drain in different directions.

- **Big Dry Creek Watershed**

  Union Avenue Basin (North)

  Big Dry Confluence Basin

  Filtration Plant Basin

  Big Dry Creek Basin

  Brookridge Basin

- **Little Dry Creek Watershed**

  Platte River Drive Basin

  City Center Basin

  East Hampden Avenue Basin

  Jefferson Avenue Basin

  Bannock Basin

  Broadway Basin

  High School Basin

## Study Area Description

The remaining 15 drainage basins have been reanalyzed in this study and are herein referred to as the Study Area. The 15 basins, listed in Table 2-1 and displayed in Figure 2-3, mostly rely on street/gutter and storm sewer infrastructure for stormwater conveyance, rather than open channels.

The Study Area is generally bordered by Evans Avenue on the north, S. Franklin Street on the east, Belleview Avenue on the south, and S. Sheridan Boulevard on the west. It comprises approximately 7 square miles total. Approximately 3.9 square miles are located inside the City's jurisdiction, and 2.7 square miles contribute to the City from surrounding cities and towns, including: Denver, Bow Mar, Sheridan, Littleton, Cherry Hills Village, and Greenwood Village. Like the City of Englewood, the drainage basins are bisected by the South Platte River, with approximately 3.8 square miles of right bank tributary area and 2.8 square miles of left bank tributary area. Several of the subbasins are Direct Flow Areas (DFA's) to the South Platte River and several of the basins originate outside of the city limits.

## Existing Regional Detention

Two regional detention basins – Bates-Logan and Rotolo Park – were included in this study's baseline hydrology. Bates-Logan and Rotolo Park detention basins are located in the North-Central Englewood and South Englewood basins, respectively. The Bates-Logan detention basin was built in 1978/1979 as part of the *North Central Englewood Basin, Phase III* storm sewer project designed by Sellards & Grigg Consulting Engineers. The Rotolo Park detention basin was built in 1974/1975 as part of the *South Englewood Storm Drainage Project* designed by Sellards & Grigg Consulting Engineers. Hydrologic information is included in Section 3.4.

**Table 2-1** Study Area Basins

| Basin | Area | |
|---|---|---|
| | (acres) | (square miles) |
| Bi-City Treatment Plant | 157 | 0.25 |
| Bow Mar | 272 | 0.42 |
| Centennial | 155 | 0.24 |
| Centennial Park | 95 | 0.15 |
| Central Englewood | 323 | 0.50 |
| College View | 155 | 0.24 |
| Dartmouth Avenue | 133 | 0.21 |
| Dartmouth Industrial | 261 | 0.41 |
| Evans Avenue | 347 | 0.54 |
| Federal Boulevard | 274 | 0.43 |
| North-Central Englewood | 140 | 0.22 |
| South-Central Englewood | 341 | 0.53 |
| South Englewood | 1,221 | 1.91 |
| Union Avenue (West) | 205 | 0.32 |
| Yale Avenue | 156 | 0.24 |
| **Total** | **4,232** | **6.62** |

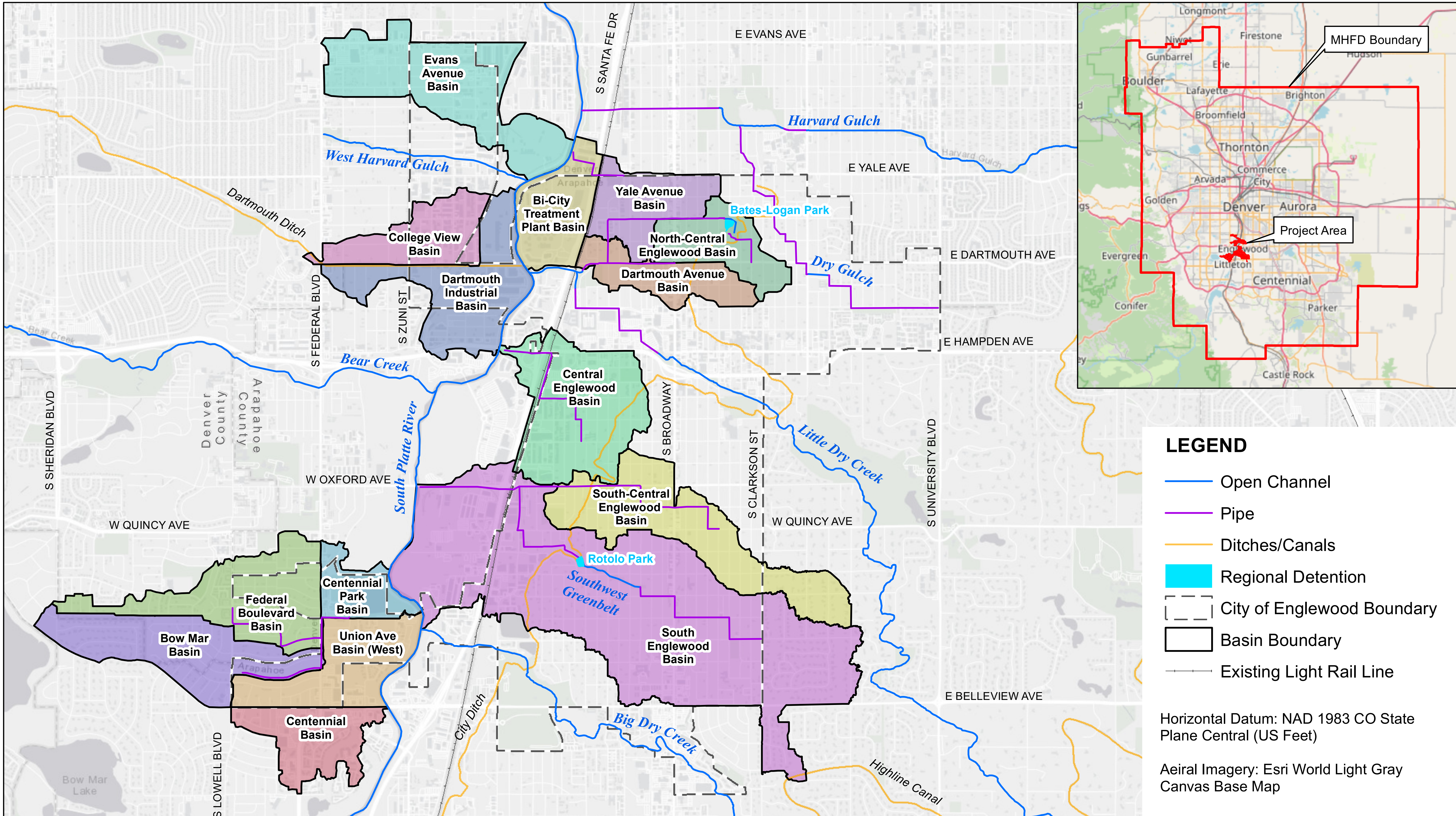


FIGURE 2-3 STUDY AREA DRAINAGE BASINS

N

0 0.25 0.5

Miles

1 inch = 0.5 miles

CITY OF ENGLEWOOD MAJOR DRAINAGEWAY PLAN

### Irrigation Ditches

City Ditch, originally designed as an irrigation ditch in the 1800s, bisects the City of Englewood. City Ditch originates at Chatfield Reservoir south of Littleton, carrying water northeast to serve as part of the drinking water supply for Englewood. The remaining flow continues north and discharges at Harvard Gulch where Denver Water uses it for irrigation. The ditch consists of open channel, elevated flumes, and underground pipelines.

In 1999, the City inventoried 21 locations where stormwater enters the City Ditch. Most of these locations are direct runoff from streets, alleys, and nearby communities (Figure 2-4). In an effort to minimize stormwater runoff and reduce pollutant loads, the City has piped large portions of the ditch.

The scope of this study did not include detailed hydrologic or hydraulic analysis of the City Ditch. Conceptual project selection considers impacts to the City Ditch, including possible reduction in the number of stormwater entry points or reduction of discharge into City Ditch at existing stormwater entry points.

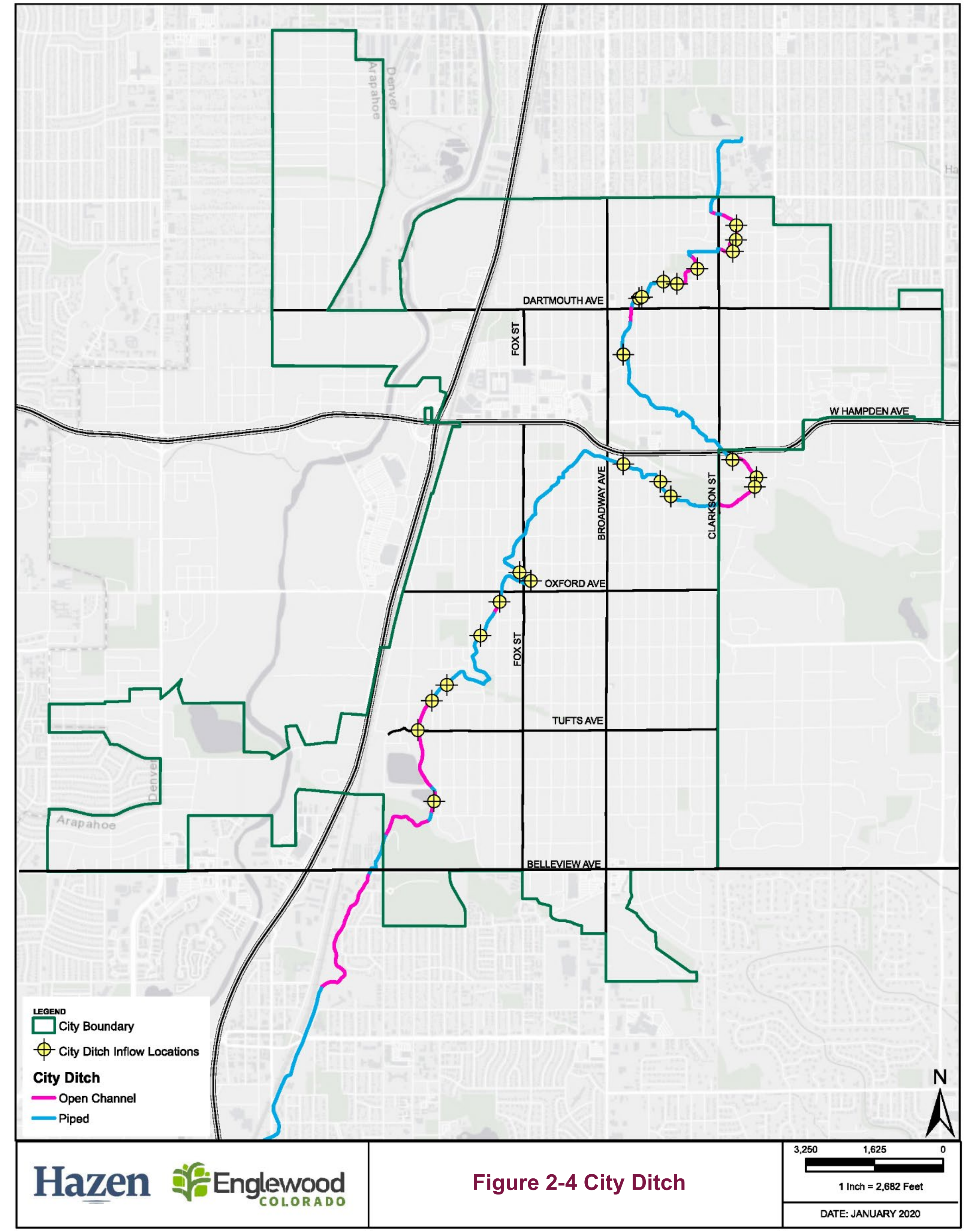

Figure 2-4 City Ditch

*Source: Hazen and Sawyer, 2020*

### Planned Construction

Two stormwater improvement projects were under design at the time of this study. Due to the timing of this MDP, neither of these projects were included in the baseline hydrology but are included in the Alternatives Analysis. The two stormwater improvement projects and their statuses at initiation of this project are summarized below:

1. Preliminary analysis was underway for the *South Englewood Flood Reduction Project*, with construction expected to begin sometime in 2022. The project will address localized flooding during major rain events in the South Englewood Basin caused by bottlenecks in the existing storm sewer system near Rotolo Park and E. Oxford Avenue. The project is being designed to manage flows from a storm event that has a 4% probability of occurring in any given year, also called a 25-year storm. The planned system enhancements are to:

    a. Address a system bottleneck at Rotolo Park with larger outlet piping, allowing more runoff to drain from Rotolo Park and the upper South Englewood Basin areas.

    b. Construct a new stormwater detention pond downstream of Rotolo Park, allowing more runoff to drain from the South Englewood Basin and be temporarily stored without building a larger, costly outfall pipe to the South Platte River.

2. The *Acoma Street Area Drainage Study* was completed by Ulteig in the Fall of 2020, which recommended several storm sewer and inlet improvements for immediate modification within the South Englewood basin from approximately E. Chenango Avenue to E. Stanford Avenue on both sides of S. Broadway. Bids were received on May 18, 2021 to construct the improvements in Priority areas 1, 2 and 3 as outlined in the Ulteig report.

### Soils

Soil data was collected from the Natural Resources Conservation Service (NRCS) Web Soil Survey. The soils east of the South Platte River primarily consist of hydrologic soil groups (HSG) B and C, which are generally characterized as having moderate to low infiltration rates. Areas west of the South Platte River consist of mainly HSG C and D soils, which have low infiltration rates. Some small pockets of HSG A and B are also found in the western watersheds. A soils map is included in Figure B-1 in Appendix B.

## 2.2 Land Use

The watersheds are fully developed with only a few areas that remain undeveloped. Existing development mostly consists of single-family residential and commercial areas along with multiple open space recreational areas and a small amount of industrial land use. Land use is not expected to significantly change in the future. The only large-scale change known at the time of this study is Englewood's plan to pave all existing gravel alleys sometime in the near future. However, paving alleyways will not cause a significant increase in watershed imperviousness. Additional discussion of land use and corresponding percent impervious values is included in Section 3.3.

## 2.3 Basin Description

Within the 15 study area basins, drainage is primarily conveyed through existing storm sewers or as surface flow by streets/gutters. Once the capacity of the streets/gutters is reached, overflow is conveyed through residential buildings following the contours along the east/west historic drainage path. There is very little existing open channel in the study area basins; therefore, a general description of each watershed and its major storm sewer lines is provided in lieu of a typical open channel reach description.

For the purposes of this Master Plan, storm sewers are considered major for pipe sizes greater than 36”. Smaller lateral lines are not discussed below nor included in the baseline hydrology. An exception was made in the North-Central Basin to include pipes as small as 30” in order to capture existing conditions upstream of the Bates-Logan detention pond.

### Bi-City Treatment Plant Basin

The Bi-City Treatment Plant Basin is 157 acres of land at the Englewood-Littleton Wastewater Treatment Plant located just north of the Little Dry Creek confluence with the South Platte River. The basin is a DFA to the South Platte River.

### Bow Mar & Federal Boulevard Basins

The Bow Mar and Federal Boulevard Basins convey runoff from the southwest portion of the City to the Centennial Park Lake/Pond, which discharges to the South Platte River. The upper reaches of the drainage basins are bounded on the west by Marston Reservoir, to the east by S. Federal Boulevard, to the north by W. Quincy Avenue, and the south by W. Belleview Avenue. The Bow Mar basin is 272 acres and the Federal Boulevard basin is 274 acres.

The major Bow Mar storm sewer line begins at S. Lowell Boulevard and W. Grand Avenue as a 36” pipe. From there, runoff is conveyed east along W. Grand Avenue into a 48” pipe starting at S. Irving Street. The 48” pipe continues east to S. Federal Boulevard. At S. Federal Boulevard, the storm sewer increases to 66” and goes north to W. Layton Avenue where it intersects the Federal Boulevard basin line. The combined flows of the Bow Mar Basin and the Federal Boulevard Basin are then conveyed north to Union Avenue and then east along W. Union Avenue in a 66” pipe before discharging to the Centennial Park Lake/Pond and on to the South Platte River. The Centennial Park Lake/Pond is a former gravel pit, now state-stocked for fishing. It is not a stormwater detention facility.

The major Federal Boulevard storm sewer line begins at W. Union Avenue and S. Lowell Boulevard as a 36” line that increases to a 42” storm sewer and then merges with the Bow Mar Basin in the 66” pipe at W. Layton Avenue and S. Federal Boulevard. For a short distance at W. Wagon Trail Drive and S. Lowell Boulevard, the 36” pipe converts to a 29”x45” box culvert.

A major flow split occurs in the Bow Mar Basin at W. Grand Avenue and S. Federal Boulevard where overland flow turns south and transfers into the Centennial Basin at W. Belleview Avenue. Overland flow at W. Belleview Avenue either enters the dual barrel 5’x7’ box culverts or continues above ground along

W. Belleview Avenue, through Centennial Square along S. Prince Street, and into the South Platte River.

### Centennial and Union Avenue (West) Basins

The Centennial Basin is 155 acres located inside the City of Littleton that conveys runoff from the southwest to the South Platte River at W. Belleview Avenue. This basin is served by dual barrel 5’x7’ box culverts along W. Belleview Avenue and accepts flow from the Bow Mar Basin split at W. Belleview Avenue and S. Federal Boulevard, as well as flow from the Union Avenue (West) Basin. The Union Avenue (West) Basin drains 205 acres between the Bow Mar and Centennial basins.

### Centennial Park Basin

Centennial Park Basin is 95 acres located in southwest Englewood on the west side of the South Platte River. This basin accepts flow from the Bow Mar and Federal Boulevard basins via a 66” pipe that outflows to the Centennial Park Lake/Pond. The pond is a former gravel pit, now state-stocked for fishing. It is not a stormwater detention facility and it discharges into the South Platte River.

### Central Englewood Basin

The Central Basin drains north to W. Hampden Avenue and then west along the Hampden corridor to the South Platte River. The drainage basin is 323 acres bounded on the east by S. Bannock Street, on the north by Hampden Avenue, on the south by Oxford Avenue, and on the west by S. Santa Fe Drive and the South Platte River. The major storm sewer system begins on S. Huron Street at E. Mansfield Avenue as a 36” pipe, which proceeds north on S. Huron Street and jogs west to follow S. Inca Street north to E. Kenyon Avenue. At E. Kenyon Avenue, the 36” pipe continues west to the corner of S. Windermere Street where the pipe turns north and increase to 48”. The 48” pipe continues to W. Hampden Avenue. The Hampden system then conveys flow west to the South Platte River, increasing in size to 72” and then 84”.

The Central Basin receives basin transfer at several locations from the northern edge of the South-Central Basin along E. Oxford Avenue. Basin transfers from South-Central Basin to Central Basin are as follows:

- South-Central stormwater exceeding the capacity of the 48” pipe at E. Oxford Avenue and S. Elati Street splits northwest into the residential area in Central subbasin 625.
- South-Central stormwater exceeding the capacity of the 60” pipe at E. Oxford Avenue splits north following S. Jason Street and S. Inca Street into Central subbasin 625.
- South-Central stormwater exceeding the capacity of the 72” and 78” pipes at E. Oxford Avenue splits north into Central subbasin 630 west of S. Jason Street.

### College View and Dartmouth Industrial Basins

The College View and Dartmouth Industrial basins convey runoff from the northwest portion of the City to the east and northeast into the South Platte River. The basins are bounded on the west by S. Federal Boulevard, on the east by S. Platte River Drive, on the south by W. Hampden Avenue, and on the north by W. Bates Avenue. Runoff originates in the City and County of Denver west of S. Zuni Street. The College View Basin is 155 acres and the Dartmouth Industrial Basin is 261 acres. The tributary drainage area from Denver is about 97 acres.

The major storm sewer begins as a 40” line at W. Dartmouth Avenue and S Zuni Street. The line flows east along W. Dartmouth Avenue, increasing to 48” at the BNSF railroad, and a 4.5’x6’ box culvert before discharging to the South Platte River.

### Dartmouth Avenue Basin

The Dartmouth Avenue Basin drains 133 acres of area along Dartmouth Avenue in a westerly direction until it discharges into Little Dry Creek. The basin is approximately bounded by S. Washington Street to the east, W. Cornell Avenue on the north, E. Floyd Avenue on the south and S. Santa Fe Drive to the west. The major storm line begins as a 48” pipe at W. Dartmouth Avenue and S. Broadway. The 48” pipe increases to 72” at S. Acoma Street that continues until approximately S. Inca Way, where it discharges into Little Dry Cree in an 8’x5’ concrete box culvert (CBC). Discharges to Little Dry Creek also include flow from the North-Central and Yale Avenue basins’ 72” line that combines with the 72” Dartmouth Avenue line at S. Fox Street. North-Central Basin and Yale Avenue Basin runoff not captured by the 72” line flows overland to the north away from the Dartmouth Avenue Basin.

### Evans Avenue Basin

The Evans Avenue Basin is 347 acres of a larger Denver watershed (Ruby Hill/Basin 0065-01) that flows east into the South Platte River. All of the Ruby Hill Basin was studied in the 2019 Storm Drainage Master Plan (SDMP). The 347 acre area analyzed as part of this Master Plan are either located within the City and County of Denver or are draining to Denver. The southern basin boundary follows W. Iliff Avenue, from which runoff flows overland northeast towards W. Evans Avenue and then to storm inlets at S. Raritan Street, S. Tejon Street, S. Vallejo Street, and S. Zuni Street. Storm sewer owned by Denver Public Works is located here along W. Evans Avenue. The additional area tributary to the intersection of W. Evans Avenue and S. Pecos Street (the rest of Ruby Hill/Basin 0065-01) is not captured in this study because the primary system has been studied in the current Denver SDMP.

### North-Central Englewood and Yale Avenue Basins

The North-Central Englewood Basin drains 140 acres in a northwest direction toward S. Broadway. The Yale Avenue Basin drains in a northern direction toward E. Yale Avenue. The basins are approximately bounded by S. Ogden Street on the east, E. Yale Avenue on the north, E. Floyd Avenue on the south and S. Santa Fe Drive to the west.

The major trunk line begins as a 30” pipe at E. Cornell Avenue and S. Washington Street where it receives flow from about 35 acres of drainage area. The 30” pipe increases to 36” and then 42” as it routes flow around the eastern edge of Bates Logan Park, before combining with the Bates-Logan detention facility outlet pipe. Runoff that exceeds the storm sewer capacity or that is directly tributary to the Park is detained in the 2.6 acre-ft Bates-Logan detention facility. The Bates-Logan detention facility is accounted for in this study's baseline hydrology.

From the detention facility outlet, the storm sewer continues west along E. Bates Avenue in a 15" pipe that increases to 24" at S. Logan Street and then to 36" at the alley between S. Lincoln Street and S. Sherman Street. A major split occurs at E Bates Avenue and S Broadway, as overland flow turns north along S. Broadway and underground flow continues in a 36" pipe west along W. Bates Avenue. The overland flow continues north to Yale Avenue where it enters the City of Denver's jurisdiction and the Harvard Gulch watershed.

The storm sewer continues west in a 72" pipe from S. Acoma Street to W. Fox Street. At W. Fox Street, the 72" pipe turns south, carrying flow in the opposite direction of the overland flow draining north. It continues south until W. Dartmouth Avenue, where it intersects the 72" Dartmouth Basin trunk line and eventually outfalls to the Little Dry Creek along W. Dartmouth Avenue east of S. Santa Fe Drive.

Stormwater that is not captured in the 72" line between S. Acoma and S. Fox Streets drains north toward the RTD Light Rail Maintenance Facility. Some of that stormwater is intercepted by a 36" line at W. Yale Avenue at Fox Street. This 36" line flows west under S. Santa Fe Drive and to the South Platte River along S. Platte River Drive. The stormwater not intercepted at S. Fox Street flow north beyond W. Yale Avenue and into the Harvard Gulch watershed.

#### South and South-Central Englewood Basins

The South and South-Central basins drain north and northwest and are served by two separate storm sewer trunk lines which combine at S. Huron Street and W. Oxford Avenue and then drain west to the South Platte River. The upper reaches of the South Basin originate in Greenwood Village where runoff is conveyed through Cherry Hills Village and into Englewood. The South and South-Central basins are approximately bounded by E. Franklin Street on the east, the South Platte River on the west, Belleview Avenue to the south, and Oxford Avenue to the north.

The South-Central Basin is about 341 acres. The major South-Central basin storm sewer begins as a 36" pipe at E. Quincy Avenue and S. Logan Street. It increases to 42" at E. Quincy Avenue and S. Grant Street, where it turns north until E. Princeton Avenue. The line turns west again at E. Princeton Avenue, transitioning to a 68"x38" elliptical pipe between S. Sherman Street and S. Acoma Street. The line returns to 42" at S. Acoma Street and continues west to S. Cherokee Street, where it turns north. About halfway to E. Oxford Avenue, the line increases to 48" and then flows west along E. Oxford Avenue. It increases to 54" at S. Elati Street, 60" at S. Galapago Street, 76" at S. Kalamath Street, and 78" at S. Lipan Street.

The South Basin is about 1,221 acres. The South Basin's major storm sewer system begins at E. Layton Avenue and S. Clarkson Street in a 40" pipe where it receives runoff generated from approximately 210 acres outside of the City limits. The storm sewer increases to 48" for most of the L-shaped section between S. Washington Street and E. Union Avenue, with about 320 feet of smaller, 36" pipe between S. Pearl Street and S. Pennsylvania Street near Duncan Park. At E. Union Avenue and S. Pennsylvania Street, the pipe increases to 54", then decreases again to 48" for about 300 feet between S. Grant Street and S. Sherman Street. The pipe returns to 54" at S. Sherman Street until turning north onto S. Broadway Avenue and increasing to 60". The 60" line then turns west on W. Tufts Avenue, increases to 76" at S. Acoma Street, and then decreases to 60" again for about 185 feet. The pipe then returns to 76" and turns north onto S. Cherokee Street, where it discharges into an open channel called the Southwest Greenbelt (Greenbelt). According to a 2018 article by the Englewood Historic Preservation Society, the Greenbelt was constructed in 1973 as recommended by the 1998-1999 Turner Collie & Braden OSP report. At that time, about 3 dozen homes were removed to provide space for the Greenbelt.

The Greenbelt flows northwest to W. Stanford Avenue and S. Huron Street, where it is routed through the 6 ac-ft Rotolo Park detention basin. The Rotolo Park detention facility is accounted for in the baseline hydrology of this Master Plan. The detention basin empties into a 48"x78" HECMP near City Ditch at S. Jason Street. The storm sewer continues to the northwest and increases to 60" near W. Radcliff Avenue, and 84" near S. Kalamath Street. The South Englewood line intersects the South Central line at the intersection of W. Oxford Avenue and S. Navajo Street. The combined flow continues west on W. Oxford Avenue until discharging into the South Platte River through a 93" pipe.

## 2.4 Environmental Assessment

### 2.4.1 Wetlands and Riparian Zones

A desktop review of wetland and riparian areas was completed using the National Wetland Inventory (NWI) data. The wetland types found in the City of Englewood include: lake, freshwater pond, freshwater emergent wetland, freshwater forested/shrub wetland, and riverine. The lake wetland type is found at the Centennial Park Lake and a small section of Little Dry Creek northwest of E. Hampden Avenue and S. Broadway Avenue. Riverine wetlands are located along the South Platte River, West Harvard Gulch, Little Dry Creek, Big Dry Creek, and sections of the City Ditch. There are small sections across Englewood that include freshwater pond wetlands and freshwater forested/shrub wetlands. Freshwater emergent wetlands are sparsely located along the South Platte River. Riparian zones within Englewood consist only of riparian forested/shrub which are mainly located along the South Platte River with some areas located along Big Dry Creek at Belleview Park and Oxbow Park. This habitat is dominated by woody vegetation that lies adjacent to streams. Figure 2-5 delineates wetland and riparian areas based on NWI data.

### 2.4.2 Threatened and Endangered Species

The U.S. Fish and Wildlife Service (USFWS) (https://ecos.fws.gov/ecp/) currently lists the following threatened species for Arapahoe County: Preble's meadow jumping mouse, Western prairie fringed orchid, and Ute ladies'-tresses. There are currently no endangered species listed in Arapahoe County.

The City of Englewood is within the Denver metropolitan Block Clearance Zone (BCZ) for the Ute ladies'-tresses, Western prairie fringed orchid, and the Preble's meadow jumping mouse. The BCZ is an area that the USFWS has determined that the species in question is not likely to currently exist. However, the BCZ does not remove the protections for these species that may occur within in it. As such, these species are not anticipated to be a concern for projects within the City of Englewood jurisdiction.

### 2.4.3 Landfills and Contamination

There are several known historical landfill areas within the City of Englewood. This data is from the Tri County Health Department. The landfills are generally located on the west side of S. Santa Fe Drive between Hampden Avenue and W. Belleview Avenue. There are also a couple of small historical landfill areas along Big Dry Creek near Cornerstone Park. The historic landfills are shown in Figure 2-6.

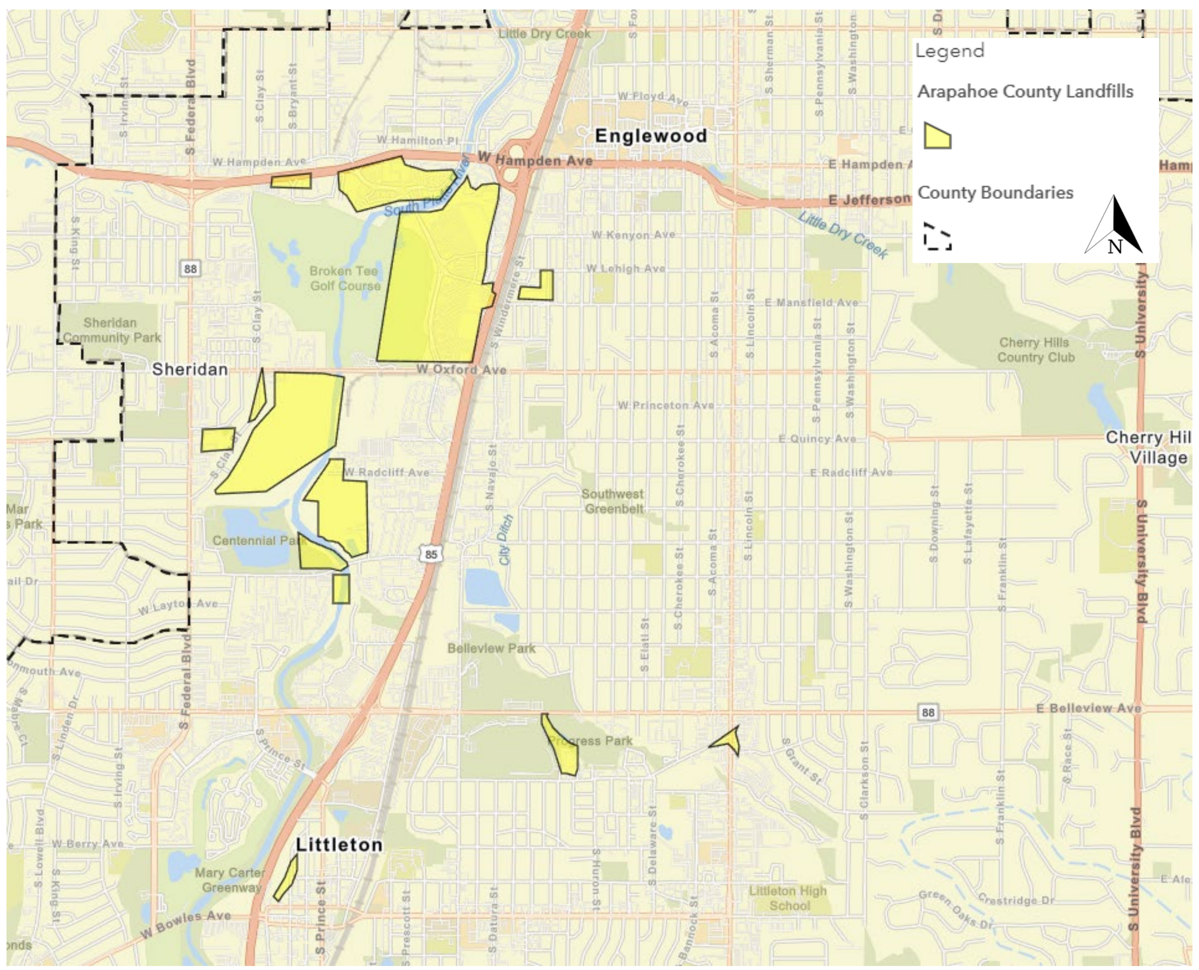

Figure 2-6 Historic Landfills in Arapahoe County

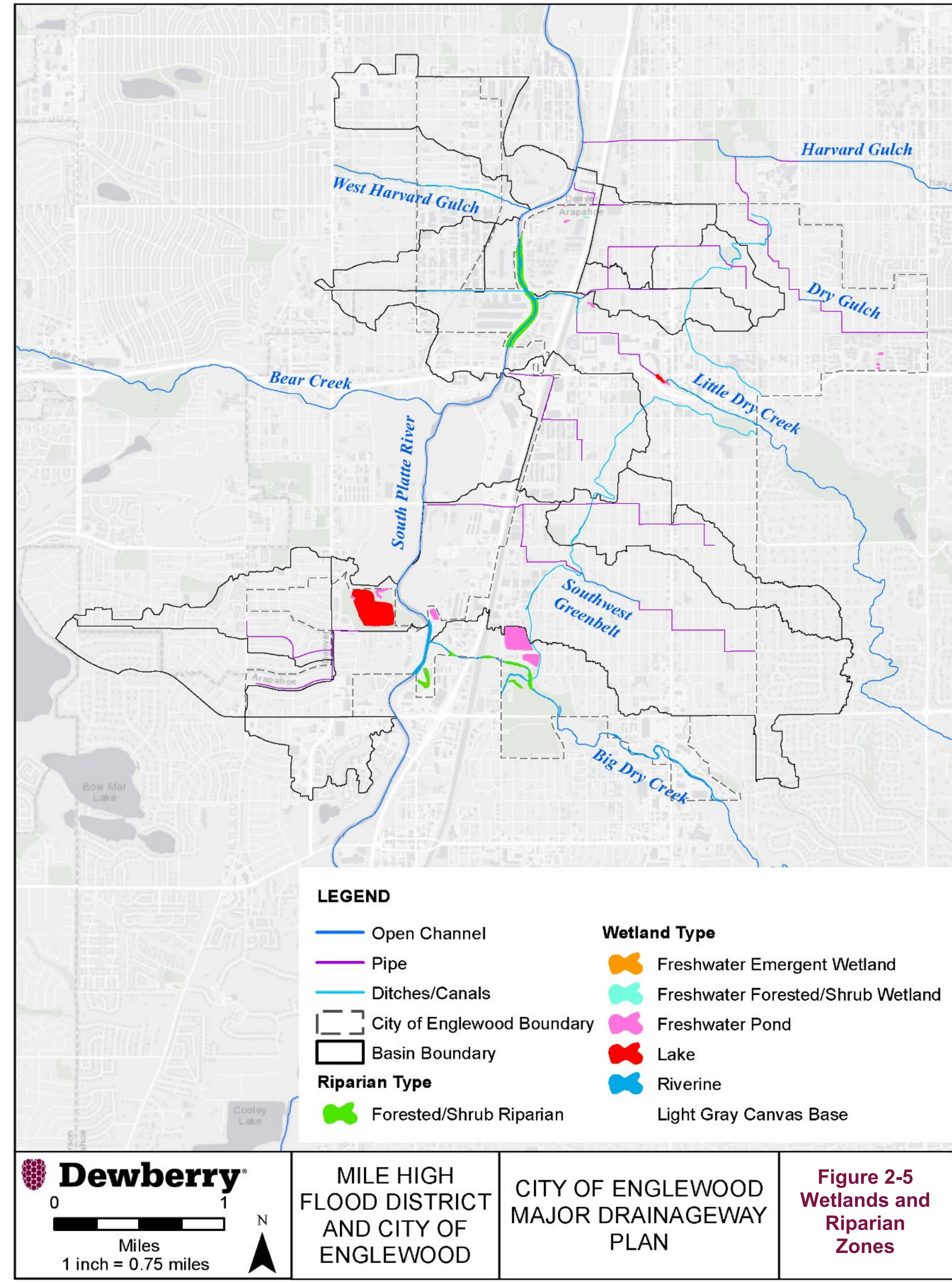

Figure 2-5 Wetlands and Riparian Zones

# 3.0 PREVIOUS STUDIES

Over the last 6 decades, several stormwater studies have been completed for the City. Each study varied in scope, ranging from hydrology and hydraulics to condition assessment. Dewberry reviewed the studies as listed in Table 3-1. Each study is summarized below.

The 4 watersheds with their own Master Plans– Big Dry Creek, Little Dry Creek, Dry Gulch, and West Harvard Gulch – are not described within this section. The latest study for each is as defined in Section 1.2.

**Table 3-1** Summary of Previous Studies

| Study Name | Year | Firm |
|---|---|---|
| City of Englewood Stormwater System Master Plan | 2020 | Hazen and Sawyer |
| City of Englewood Floodproofing Study & Outfall Systems Plan Update | 2018-2019 | Calibre Engineering |
| Analysis and Alternatives Evaluation of the Acoma Street Drainage Problem | 2002 | Moser & Associates Engineering |
| Stormwater Sewer Report | 1999 | Muller Engineering |
| City of Englewood Outfall Systems Alternatives Evaluation Report | 1999 | Turner Collie & Braden |
| City of Englewood Probable Areas Affected by Flooding from the 100-year Storm | 1998 | Turner Collie & Braden |
| Englewood Storm Drainage Plan | 1971 | Sellards & Grigg Consulting Engineers |
| Proposed Drainage Plan for Englewood, Colorado Engineer's Preliminary Report | 1955 | Ripple and Howe Consulting Engineers |

## 3.1 City of Englewood Stormwater System Master Plan (Hazen and Sawyer, 2020)

The most recent stormwater study was the Stormwater System Master Plan prepared by Hazen and Sawyer. The purpose of the study was to establish an initial Master Plan for the City's stormwater system that would provide an understanding of existing and future needs over the next 15 years. The following tasks were completed as part of the Master Plan:

- Review known problematic flood areas outside of the 2018-2019 Calibre study area
- Review 36-inch and larger diameter stormwater mains located outside of other study areas

During Hazen's initial review of the City's GIS data, limited information was available for 36-inch and larger diameter storm piping outside of the Calibre study area. Therefore, it was concluded that Hazen would focus primarily on the other key tasks, including the following:

- Identify key stormwater programs and projects to address capital and operation and maintenance (O&M) needs
- Prioritize recommended projects and programs
- Develop a Class 5 cost estimate for prioritized projects and programs
- Establish a 15-year capital improvement plan (CIP)

## 3.2 City of Englewood Floodproofing Study & Outfall Systems Plan Update (Calibre Engineering, 2018-2019)

The 1998-1999 OSP was updated by Calibre Engineering in the 2018-2019 *City of Englewood Flood Proofing Study & Outfall Systems Plan Update.* The focus of the Calibre study was on the South Englewood Basin, South-Central Englewood Basin, Central Englewood Basin, Yale Avenue Basin, and North Englewood Basin. As previously stated, the North Englewood Basin was divided into the North-Central Englewood and Dartmouth Avenue basins in the 2020 Hazen report. The division was maintained in this report because the 2 basins ultimately drain to different locations.

The purpose of the 2018-2019 OSP Update was to more accurately estimate the location and intensity of flooding and propose new projects to mitigate it. The study updated the hydrology by using CUHP Version 2.0.0 and EPA SWMM version 5.1.013, while adopting the original 1998-1999 OSP point rainfall depths, watershed delineations, percent imperviousness', lengths, slopes, and Horton's infiltration parameters. The study also performed a survey of local citizens to help identify problem areas. The 5 basins west of the South Platte River were not included in the study.

The goal of the study was to answer the following questions:

- What can be done immediately to flood-proof homes in the affected areas?
- What long-term regional storm drainage improvements can be implemented to eliminate or greatly reduce flooding?
- What is the status of the Oxford Avenue stormwater outfall, and what can the City do to prevent future failures and/or sinkholes?

The study also performed hydrologic and hydraulic modeling and condition assessment of the Oxford Pipeline system. Multiple projects were identified with an approximate total cost of $58M (Hazen and Sawyer, 2020). Three of these projects have been recently re-evaluated in an effort to reduce costs, including:

- S1 – South Platte River to Navajo Street
- S2 – Oxford Street to Rotolo Park
- S3 – Cherokee Street to Clarkson Street

### 3.3 Analysis and Alternatives Evaluation of the Acoma Street Drainage Problem (Moser & Associates Engineer, 2002).

The Acoma Street Drainage Improvements study area was located between S. Cherokee Street and S. Broadway. The report found that inadequate pipe capacity was the issue for flooding and made project specific recommendations for additional stormwater infrastructure including detention facilities. The estimated cost in 2002 was approximately $150,000-$175,000 (Hazen and Sawyer, 2020). Based on discussion with the City, none of these alternatives have been constructed as of the date of this MDP (Hazen and Sawyer, 2020).

### 3.4 Stormwater Sewer Report (Muller Engineering)

In 1999, the City contracted with Muller Engineering (Muller) to perform a Citywide inventory of the stormwater system. Muller estimated that there was approximately 17,000 linear feet (LF) of corrugated steel pipe (CSP) with approximately 6,000 LF that would require rehabilitation by 2003. At that time, the estimated construction cost was approximately $2M. Based on discussion with City staff, none of these costs were found in the past invoices and therefore assumed not implemented (Hazen and Sawyer, 2020).

### 3.5 City of Englewood Outfall Systems Alternatives Evaluation Report (Turner Collie & Braden, 1998-1999)

In 1999, the city and MHFD worked with the engineering firm Turner Collie & Braden to prepare an Outfall Systems Planning Study for the entire city. This study identified & analyzed various alternatives and made recommendations to alleviate drainage & flooding problems for a typical 2- to 5-year rainfall event. This study did not include a hydraulic analysis or related cost projections for improvements to City Ditch but did locate where stormwater flow enters City Ditch. Recommendations from this study included the construction of additional stormwater infrastructure, upsizing existing pipes and the incorporation of additional detention facilities, with projected costs of $12.7M (Hazen and Sawyer, 2020). Localized flooding improvements totaled approximately $500,000 and the expansion of the storm sewer system in the Central, South and College View basins was estimated at approximately $1.8M (Hazen and Sawyer, 2020). From a GIS desktop review, it appears some inlets and piping were added but, overall, most of the recommended improvement projects have not been implemented (Hazen and Sawyer, 2020).

### 3.6 City of Englewood Probable Areas Affected by Flooding from the 100-year Storm (Turner Collie & Braden, 1998)

In March 1998, Turner, Collie, & Braden, Inc. defined approximate 100-year floodplain boundaries for the smaller outfall areas within the City. The major drainageways of Little Dry Creek, Big Dry Creek, West Harvard Gulch, and the South Platter River were excluded from the study. The study used simplified methods, not to be mistaken for the level of floodplain analysis detail normally completed as part of a FHAD or FEMA flood insurance study. The study identified that the floodplains in both the Northern and Southern portions of Englewood had the potential to impact many properties.

### 3.7 Englewood Storm Drainage Plan (Sellards & Grigg Consulting Engineers, 1971)

The 1971 Storm Drainage Plan determined that the city was greatly deficient in protection from storm water runoff and, as a result, many of the Plan’s recommended capital improvements were implemented including construction of 2 stormwater detention facilities.

### 3.8 Proposed Drainage Plan for Englewood, Colorado Engineer’s Preliminary Report (Ripple and Howe Consulting Engineers, 1955)

The 1955 report is the first known comprehensive stormwater study for Englewood and believed to be the impetus for much of the City’s storm drain system built in the 50s, 60s, and 70s. According to the report, the proposed systems were designed to handle a 2- to 5-year rainfall event.

## 4.0 FLOOD HISTORY

The City of Englewood has experienced flooding throughout the years in various locations. The City experiences two types of flooding: localized and riverine. Localized flooding (often referred to as urban flooding) occurs in streets and low-lying areas such as yards and first-floors or basements as a result of high-intensity rainfall and lack of drainage in an urban area. Riverine flooding is associated with drainageways when rainfall causes water to overflow the channel’s banks and inundate its floodplain. Below is a summary of the most well-known events and should not be taken as an exhaustive history.

### 4.1 Summary of Urban Flooding

#### July 2018 Storm

The most recent major urban flooding occurred in July 2018 in the South Englewood Basin. On July 23 and 24, Englewood experienced extreme rainfall. According to the MHFD, the July 23 and 24 storms had high rainfall rates categorized as having a 1-2% Annual Exceedance Probability (AEP). The flood event resulted in a tragic death at 4650 South Acoma Street, caused wide-spread damage, was front-page-news, resulted in a sinkhole in a major roadway, and created a sense of urgency for stormwater planning throughout the community. The City of Englewood Public Works Department immediately set about the task of prioritizing stormwater improvements through revitalized stormwater master planning.

The sinkhole resulting from the 2018 storm developed at S. Santa Fe Drive and W Oxford Avenue, just outside Englewood city limits. This location is known for flooding after heavy rain and as a “bottleneck” in the existing storm sewer system. At least 3 sinkholes had occurred in the same stretch of W. Oxford Avenue in previous years.

Street flooding at South Broadway and East Union Avenue.
Source: 9news.com, July 24, 2018


Flooding of the railroad underpass at West Oxford Avenue and South Santa Fe Drive
Source: 9news.com, July 25, 2018


Street Flooding at unknown location
Source: 9news.com, July 25, 2018

### Other Urban Flooding

According to the 2017 FHAD created by Matrix Design group, another major flood occurred on July 8, 2001. No major damage was reported, but the storm system in the Harvard Gulch and Dry Gulch watersheds was at full capacity and caused damage and flooding to detention areas. In the same report, Matrix notes that other major flood events that exceeded storm infrastructure capacity and caused damage occurred on the following dates: July 19, 2011, June 6, 2012, August 8, 2013, June 11, 2015, and June 24, 2015. During these events, water left the storm sewer system via surcharging at manholes and inlets, creating sinkholes and caused major street and residential flooding.

According to the 1971 report, *Englewood Storm Drainage Plan* by Sellards & Grigg Consulting Engineers, several areas of ponding and localized flooding occurred in 1971. The study attributed the primary cause as urban encroachment into historic drainage paths, which disconnected drainage areas from a sufficient outfall and caused ponding and frequent localized flooding. Problem locations associated with this event were identified and republished in the 1998-1999 OSP by Turner Collie & Braden, which can be found in

Drawing 2 of their report. As part of the 2018-2019 Calibre OSP, Calibre visited many homes in the City and noted efforts by individual homeowners to floodproof their homes. According to Calibre, this indicates that the 2018 flood was not the first to result in damage to homes. For example, many eyewitnesses relayed past flooding of garages, basements, and main floor levels. Calibre provided additional one-on-one and public meetings to learn more about the flooding and to educate the public on residential flood proofing. An interactive Google Map of reported locations of flooding can be found at Calibre's virtual report here: [https://www.calibre-engineering.com/survey-results](https://www.calibre-engineering.com/survey-results). Specific areas of flooding catalogued in Calibre's virtual report are listed below.

- S. Washington Street between E. Yale Avenue and E. Amherst Avenue
- 4100 block of S. Broadway
- Alley between 4100 and 4200 S. Broadway
- Alleys at S. Ogden Street going north from E. Cornell Avenue (2900-3000)
- 2980 S. Ogden Street (illegal wall)
- Infrastructure under S. Ogden Street
- Rotolo Park
- E. Radcliff Avenue from Rotolo Park to cul-de-sac
- 4400 Block of S. Huron Street
- W. Oxford Avenue and S. Santa Fe Drive
- W. Dartmouth Avenue and S. Santa Fe Drive
- Barde Park/Charles Hay School
- Alley south of E. Tufts Avenue between S. Lincoln Street and S. Broadway
- Corners at W. Mansfield Avenue and S. Inca Street
- S. Clarkson Street and S. Clarkson Circle at E. Amherst Avenue
- S. Lipan Street
- Along W. Quincy Avenue and S. Navajo Street
- Along the Southwest Greenbelt
- Gutters at the corner of W. Stanford Avenue and S Delaware Street
- Downstream of All Souls Catholic Church
- Drains at S. Corona Street downstream of E. Dartmouth Avenue
- Drains at S. Corona Street and E. Cornell Avenue
- S. Downing Street
- S. Broadway and E. Floyd Avenue
- W. Hampden Avenue at Big O Tires
- W. Radcliff Avenue at 1200 Block
- S. Windermere Street between W. Lehigh Avenue and W Oxford Avenue
- 4000 block of S. Jason Street
- Alley behind 4100 S. Lincoln Street
- W Quincy Avenue at S. Jason Street
- S. Sherman Street
- Areas next to newly developed lots
- Alleys along S. Acoma Street (specifically at 4600 block)
- Corner of S. Lincoln Street and E. Amherst Avenue
- North on S. Sherman Street from E. Dartmouth Avenue past E. Cornell Avenue
- Street at 4600 S. Grant Street
- Temporary manmade culvert at 4660 S. Bannock Street
- Paved yard two houses downstream of 4660 S. Bannock Street
- Former City Ditch
- W. Radcliff Avenue and S. Lipan Street
- South side of Stanford Avenue from east to west
- Alleys on W. Stanford Avenue between S. Cherokee and S. Bannock Streets

A 2002 study by Moser & Associates Engineering entitled *Acoma Street Drainage Problems* was completed to better understand drainage system problem spots along S. Acoma Street in the South Englewood Basin. No further information was available as to the history or frequency of issues at that location.


*The 1913 flood at 3476 South Broadway*
*Source: Englewood Public Library, Englewood Colorado Photo Gallery*

*Flood of 1963 street flooding at Gilpin Street and unknown cross-street*
*Source: Englewood Public Library, Englewood Colorado Photo Gallery*

### 4.2 Summary of Riverine Flooding

Other than the South Platte River, the main open channels in the City are Big Dry Creek, Little Dry Creek, West Harvard Gulch, and the Southwest Greenbelt. The first three of these drainageways have been studied in separate Master Plans (see Section 1.2), which can be referenced for more in-depth flooding histories. Below is a brief summary of some of the most well-known riverine flood events.

**Big Dry Creek:** Much of the Big Dry Creek channel is located in parks and open space that generally have adequate flood capacity. There are no records of major flooding events on Big Dry Creek (RESPEC 2018).

**Little Dry Creek:** Little Dry Creek drains into the City at S. Clarkson Street as an open channel and quickly flows into a series of underground pipes, staying there for the majority of its length within city limits. One location of flooding was noted in the 1927 flood at S. Broadway, causing debris collection and bridge failure. FEMA's publication of the regulatory Flood Insurance Rate Map (FIRM) depicts Little Dry Creek's flood hazard zones within city limits are on Panel No. 08005C0163K.

**West Harvard Gulch:** The main channel is deeply incised and generally contains the 100-year floodplain. Few structures are located within the regulatory floodplain (Denver SDMP 2019).

*Street cave-in over Little Dry Creek at South Broadway, 1927*
*Source: Denver Public Library Digital Collections*

# 5.0 HYDROLOGIC ANALYSIS

### 5.1 Overview

Hydrology was developed for the baseline condition using existing infrastructure for both existing and future land use conditions. Peak discharges were analyzed for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year return periods. The Colorado Urban Hydrograph Procedure (CUHP) 2005 version 2.0.1 was used to generate hydrographs for each subwatershed. Hydrographs were routed using the EPA Storm Water Management Model (EPA SWMM) version 5.1.015 to establish peak flow rates at design points.

A summary of the CUHP model parameters and the EPA SWMM input/output can be found in Appendix B.

### 5.2 Design Rainfall

One-hour and 6-hour rainfall depths were obtained from the *City of Englewood Storm Drainage Criteria Manual* (February 2020) and supplemented with the National Oceanic and Atmospheric Administration

(NOAA) Atlas 14 where City published rainfall depths were unavailable. The water quality (WQ) event is pre-defined, according to the CUHP manual, to be a 0.6-inch rainfall event for the 1-hour duration. None of the project basins exceed 5 square miles and therefore no area adjustments to rainfall were required. Table 5-1 lists the point rainfall depths. The unadjusted rainfall distributions are provided in Table B-1.

**Table 5-1** Point Rainfall

| Recurrence Interval (year) | Rainfall Depth (in) 1-Hour | 6-Hour |
|---|---|---|
| WQ | 0.60 | N/A |
| 2 | 0.82 | 1.27 |
| 5 | 1.08 | 1.65 |
| 10 | 1.31 | 1.99 |
| 25 | 1.66 | 2.51 |
| 50 | 1.95 | 2.94 |
| 100 | 2.25 | 3.41 |
| 500 | 3.04 | 4.63 |

## 5.3 Subbasin Characteristics

### Subbasin Delineation

The 15 basin boundaries and their subbasins were delineated using the 2013 DRCOG LiDAR provided by MHFD, previous drainage studies, and site visits. The basins were divided into 82 subbasins consistent with runoff conditions during major storm events. Where available, subbasin areas from previous studies were used as a starting point for basin delineation. The subwatersheds range in size from 17 to 114 acres, with an average size of 52 acres. The subbasins are shown on Figure B-4 in Appendix B.

### Length, Centroid Length & Slope

Existing utility information and the 2013 DRCOG LiDAR provided by MHFD were used to identify subwatershed flow path lengths, distance to centroid lengths, and average basin slopes. These parameters were determined based on the direction of overland flow, which was not always coincident with storm sewer alignments. Private detention ponds and the City Ditch were not included in the modeling.

### Basin Imperviousness

The DRCOG 2018 planimetric dataset and the National Land Cover Database (NLCD) 2019 Urban Imperviousness layer were used to calculate the existing condition percent imperviousness for each watershed, rather than the standard municipal land use categories. The planimetric dataset was acquired by DRCOG as part of the Regional Planimetric Data Project, which uses high-resolution imagery from the Denver Regional Aerial Photography Project (DRAPP) as a reference to digitize features of the built environment. The following features were used: building roof prints, edge of pavement, parking lots, sidewalks, and driveways. The 2018 planimetric dataset covered the majority of impervious area in the City and the remaining "undefined" areas were assigned to NLCD 2019.

The future conditions land use was created by supplementing the existing condition land use with the locations of gravel alleys slated for paving by Englewood in the near future. This is the study's only difference between existing and future condition land use. Approximately 37.4 miles of dirt and gravel alleys will be paved.

The planimetric categories and their designated percent impervious values are shown in Table 5-2. Impervious values were assigned based on USDCM Volume 1 Table 6-3 and NLCD land use classification. The weighted percent imperviousness over all 15 basins is estimated to be 67.7% for the existing condition and 68.2% for the future condition. Because the existing and future condition percent imperviousness is so similar, the difference between the hydrologic output is considered negligible. As a result, **only the future condition hydrology will be used for the remaining phases of this project**. The existing condition peak flows and volumes are included in Appendix B for reference only.

**Table 5-2** Planimetric Categories and Assigned Impervious Values

| Category | Percent Impervious |
|---|---|
| Unpaved Parking | 10% |
| Landscaped Islands (Planimetric data names: Pervious Parking & Mixed Parking) | 5% |
| Unpaved Corridor | 10% |
| Unpaved Median | 5% |
| Driveways | 90% |
| Roof prints | 90% |
| Impervious Parking | 90% |
| Paved Corridor | 90% |
| Mixed Median | 15% |
| Sidewalks | 90% |

### Depression Losses

Depression losses were defined using Table 6-6 in the MHFD Urban Storm Drainage Criteria Manual (USDCM). Each DRCOG 2018 planimetric category was assigned a pervious or impervious depression loss between 0.05 and 0.4 to calculate a weighted average of each subbasin. Pervious areas such as mixed/unpaved medians, lawns, and open space were assigned a value of 0.35, representative of lawn grass. Large paved areas such as roads, sidewalks, and parking lots were assigned a value of 0.1. A value of 0.05, which represents sloped roofs, was assigned to residential homes. A value of 0.1 was assigned to commercial and industrial buildings to represent depression losses for flat roofs.

### Infiltration

Infiltration rates and Horton's decay coefficients were assigned using Table 6-7 in the USDCM and NRCS soil classifications. A weighted average of values per HSG was calculated for each subwatershed. Hydrologic soil groups are shown on Figure B-1 in Appendix B.

## 5.4 Existing Detention

Two publicly-owned, regional detention facilities are included in the baseline hydrology and listed below. Private detention, reservoirs/lakes, and inadvertent detention were not modeled.

- Bates-Logan detention (North-Central Englewood Basin)
- Rotolo Park detention (South Englewood Basin)

These facilities were also included in the 1998-1999 OSP hydrology, but stage-storage-discharge information was updated for this MDP. Both facilities were surveyed by Wilson & Company in May 2021 to calculate the new stage-storage-discharge curves. The stage-storage curves include data points above the surveyed spillway and embankment elevations for continuity of flow in the EPA SWMM model.

The Bates-Logan detention facility is a 2.6 acre-ft pond built in 1978/1979 as part of the *North Central Englewood Basin, Phase III* storm sewer project, designed by Sellards & Grigg Consulting Engineers. The facility was also included in the 1998-1999 OSP baseline hydrology. The pond has experienced natural sedimentation over time, reducing the 1998-1999 OSP 6 acre-ft capacity by 3.4 acre-ft. This reduction in capacity is reflected in the updated hydrology.

The Rotolo Park detention facility is a 6 acre-ft pond built in 1974/1975 as part of the *South Englewood Storm Drainage Project,* designed by Sellards & Grigg Consulting Engineers. The facility was included in the 1998-1999 OSP baseline hydrology as a 7 acre-ft detention basin.

The stage-storage-discharge information for both facilities can be found in Table B-3 in Appendix B.

## 5.5 Hydrograph Routing

Hydrographs were routed using the EPA Storm Water Management Model (EPA SWMM) version 5.1.015 and the kinematic wave method. The SWMM model parameters were determined using the 2013 DRCOG LiDAR provided by MHFD, as-built drawings, utility GIS shapefiles, and 2022 utility survey. Outside of the Big Dry Creek, Little Dry Creek, Dry Gulch, West Harvard Gulch, and Southwest Greenbelt open channels, Englewood's stormwater is conveyed by storm sewer and roadways; therefore, the majority of the SWMM conveyance elements are representative of pipes and street flow rather than open channels. The street sections were modeled according to the average width of the road and typical sections for residential, collector, and arterial classifications like those outlined in the *City of Englewood 2020 Design and Construction Standards and Specifications*. Larger roads with more-complex cross sections (like S. Broadway and Hampden Avenue) were modeled using typical trapezoidal sections.

Because this is a Master Plan level analysis, only the larger portions of the existing storm sewer are modeled – generally defined as lines 36" or greater. Limited storm sewer data was available; therefore, portions of the sewer lines were surveyed by Wilson & Co in May 2022. Assumptions were made where required, as listed below.

- It was assumed that the 36" storm drain line surveyed at W. Quincy Avenue and S. Navajo Street connects the downstream 72" pipe to the upstream 84" pipe.
- It was assumed that the 72" pipe picked up at W. Hampden Avenue and the S. Santa Fe Drive off-ramp extends upstream to the east side of the railroad.

For segments of the storm sewer with unknown slopes, a minimum slope of 0.5% was assumed. Per standard practice, the model disregards potential inlet capacity limitations. The Manning's n values for channels, pipe, and street elements were increased 25% per guidance published in the USDCM. Manning's n values were set to 0.012 for streets, 0.035 for off-street/lawns, and 0.02 for storm sewer pipes. Conveyance element lengths were estimated using ArcGIS in *NAD 83 Colorado State Plane, Central Zone*. Some subwatersheds are direct flow areas (DFA's) to the South Platte River and, as such, did not need to be routed in SWMM.

See Appendix B for the EPA SWMM input parameters and 100-year future conditions output. A schematic of the model is included in Figure B-5.

### Flow Splits

At multiple locations in the City, the alignment of existing storm mains deviates from the direction of above ground runoff during high intensity events. In some cases, the two paths rejoin a short distance downstream, while in others the overland flow transfers to another basin. The splits occur at locations where overland runoff is intercepted by a major road, such as S. Broadway, or where overtopped gutters follow the low ground between residential and commercial buildings instead of along streets and gutters. These splits were not accounted for by previous Master Plan studies, but are accounted for in the Baseline Hydrology of this study. The most significant flow splits are listed below.

- South & South-Central Englewood Basins:

  1. Runoff splits near E. Layton Avenue & S. Pennsylvania Street and flows northwest to E. Union Avenue, where it re-joins the existing 54" pipe near S. Grant Street. Runoff not captured by the sewer splits again, flowing northwest to E. Tufts Avenue and S. Lincoln Street, where it follows grade back to the south and crosses S. Broadway just north of E. Union Avenue. Runoff continues to drain northwest where it is either intercepted

by smaller lateral pipes along S. Acoma Street or by S. Bannock Street. All flow ultimately discharges to the Southwest Greenbelt north of W. Tufts Ave on S. Cherokee Street.

2. Runoff not captured by the storm sewer on W. Oxford Avenue between S. Jason and S. Kalamath streets either flows west along W. Oxford toward S. Santa Fe Drive or continues flowing north, transferring into the Central Englewood Basin.

- Dartmouth Avenue Basin:

3. Runoff not captured by storm sewer on E. Dartmouth Avenue is intercepted by S. Broadway and flows north, transferring into the North-Central Englewood Basin.

- North-Central Englewood Basin:

4. Runoff not captured by storm sewer on E. Bates Avenue is intercepted by S. Broadway and flows north, transferring into the Yale Avenue Basin.

- Bow Mar Basin:

5. Runoff not captured by north-running storm sewer at W. Grand Avenue and S. Federal Boulevard is intercepted by Federal and flows south and southwest, transferring into the Union Avenue (West) and Centennial basins.

## 5.6 Previous Study Hydrology

Two previous Master Plans have been completed for the 15 baseline hydrology basins: the 1998-1999 Turner Collie & Braden OSP and the 2018-2019 Calibre Engineering OSP Update.

The 2018-2019 OSP Update built on the 1998-1999 OSP hydrology by updating to CUHP Version 2.0.0 and EPA SWMM version 5.1.013. The OSP Update adopted the 1998-1999 OSP point rainfall depths, watershed delineation, percent imperviousness, length, slope, and Horton's infiltration parameters. Differences between the 1998-1999 OSP and OSP Update baseline flows and volumes can be attributed to the changes in software parameters and calculations that have occurred since the 1990's and the identification of split flows in this study. The basins west of the South Platte River were not included in the OSP Update.

A comparison of the 100-year peak flows between this study and the 2 previous OSP's is shown in Table 5-4. In general, average unit discharges have decreased with each subsequent study, primarily from updates to the CUHP calibration. The notes column calls out significant differences from the previous studies resulting from significant flow transfers that were not previously accounted for. Because of this and the age of the data from the 1998-1999 OSP and OSP Update, a point-by-point reconciliation of values is unwarranted. However, general comparisons between hydrologic methodologies are noted below.

- Point rainfall depths used in the 1998-1999 OSP were larger than the City of Englewood and NOAA Atlas 14 values used in this study. See Table 5-3 for a comparison.

- The 1998-1999 OSP calculated peak flows using the Rational Method, resulting in higher peak flows. The 2019 OSP Update used CUHP version 2.0.0 and this study uses CUHP version 2.0.1, resulting in lower peak flows.

- The 1998-1999 OSP used land use categories to determine percent imperviousness, while this study used planimetric and NLCD data. The average 1998-1999 OSP and OSP Update imperviousness for the eastern basins was 48.9% (existing = future conditions) versus 68.2% (existing = future conditions) for this study. Some basins' percent impervious cover, such as Dartmouth Industrial Basin, differ more significantly from that published in the old studies because the planimetric data reflects actual conditions rather than idealized land use categories.

- Flow was routed using UDSWMM in the 1998-1999 OSP in contrast to EPA SWMM 5.1.013 in the 2019 OSP Update and EPA SWMM 5.1.015 in this study. This study also accounts for several locations of basin transfer and split flow between residential buildings, which was not previously accounted for. See the "Notes" column in Table B-4.

- Subbasin areas were redefined by this study but approximate sizes remained similar to the old studies. The 1998-1999 OSP subbasins ranged in size from 14.7 to 128 acres, with an average of 44.7 acres. Basins for this study range from 17 to 114 acres, with an average size of 52 acres.

- This study updated the stage-storage-discharge curves for the Bates-Logan and Rotolo Park detention facilities using 2021 survey information which showed a decrease in capacity of 3.4 acre-ft at the Bates-Logan detention pond since the 1990's.

**Table 5-3** Previous Study Point Rainfall Reconciliation Table

| | 1-Hour Point Rainfall Depth (in) | |
|---|---|---|
| Recurrence Interval | 1998-1999 OSP & 2018-2019 OSP Update | Dewberry MDP |
| 2-year | 0.95 | 0.82 |
| 5-year | 1.35 | 1.08 |
| 10-year | 1.55 | 1.31 |
| 50-year | 2.25 | 1.95 |
| 100-year | 2.60 | 2.25 |

**Table 5-4** Previous Study Hydrology Reconciliation Table

| Location | Design Point | | 100-YR Storm Event Peak Flows (cfs) | | | Tributary Area (ac) | | Unit Discharge (cfs/ac) | | | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1998/1999 OSP and 2020 OSP Update | Dewberry MDP | 98/99 OSP | 2020 OSP Update | Dewberry MDP | 1998/1999 OSP and 2020 OSP Update | Dewberry MDP | 1998/1999 OSP | 2020 OSP Update | Dewberry MDP | |
| W Grand Ave and S Federal Blvd | 554 | JUNCT_1525 | 1156 | - | 517 | 211 | 272 | 5.48 | - | 1.90 | |
| W Hampden Ave and S Windermere St | 610 | JUNCT_1605 | 835 | 638 | 1104 | 253 | 291 | 3.30 | 2.52 | 3.79 | Dewberry MDP accounts for additional flow from South Englewood Basin |
| SPR Outfall near W Hampden Ave | 611 | OTF_1598 | 900 | 706 | 1097 | 282 | 323 | 3.19 | 2.50 | 3.40 | Dewberry MDP accounts for additional flow from South Englewood Basin |
| Dartmouth Ave and S Cherokee St | 644 | JUNCT_1708 | 328 | 221 | 141 | 99 | 73 | 3.31 | 2.23 | 1.93 | Dewberry MDP accounts for small flow loss to North-Central Englewood Basin |
| Little Dry Creek Outfall near Dartmouth Ave | 645 | OTF_1698 | 555 | 428 | 357 | 353 | 308 | 1.57 | 1.21 | 1.16 | Dewberry MDP accounts for small flow loss to North-Central Englewood Basin |
| SPR Outfall near W Dartmouth Ave | 645 | OTF_1148 | 636 | - | 988 | 333 | 377 | 1.91 | - | 2.62 | |
| W Union Ave and S Federal Blvd | 552 | JUNCT_1505 | 1615 | - | 782 | 666 | 546 | 2.42 | - | 1.43 | Dewberry MDP accounts for large flow loss to Centennial Basin |
| Upstream of Bates-Logan Detention Facility | 654 | POND_1435 | 307 | 237 | 126 | 100 | 68 | 3.07 | 2.37 | 1.85 | |
| Downstream of Bates-Logan Detention Facility | 658 | JUNCT_1434 | 263 | 187 | 92 | 100 | 68 | 2.63 | 1.87 | 1.35 | |
| E Layton Ave and S Clarkson St | 588 | JUNCT_1900 | 823 | 591 | 300 | 315 | 209 | 2.61 | 1.88 | 1.44 | |
| E Union Ave and S Broadway | 601 | JUNCT_1870 | 1406 | 964 | 849 | 508 | 518 | 2.77 | 1.90 | 1.64 | |
| Upstream of Rotolo Park Detention Facility | 593 | POND_1835 | 2157 | 1549 | 1221 | 795 | 762 | 2.71 | 1.95 | 1.60 | |
| Downstream of Rotolo Park Detention Facility | 566 | JUNCT_1834 | 2239 | 1633 | 1219 | 839 | 762 | 2.67 | 1.95 | 1.60 | |
| W Quincy Ave and S Navajo St | 563 | JUNCT_1825 | 2502 | 1826 | 1271 | 941 | 805 | 2.66 | 1.94 | 1.58 | |
| W Oxford Ave and S Navajo St | 561 | JUNCT_1818 | 3355 | 2493 | 1324 | 1268 | 1305 | 2.65 | 1.97 | 1.01 | Dewberry MDP accounts for large flow loss to Central Englewood Basin |
| SPR Outfall near W Oxford Ave | 560 | OTF_1800 | 3300 | 2477 | 1487 | 1268 | 1415 | 2.60 | 1.95 | 1.05 | Dewberry MDP accounts for large flow loss to Central Englewood Basin |
| W Princeton Ave and S Broadway | 577 | JUNCT_1949 | 417 | 274 | 252 | 182 | 176 | 2.29 | 1.51 | 1.43 | |

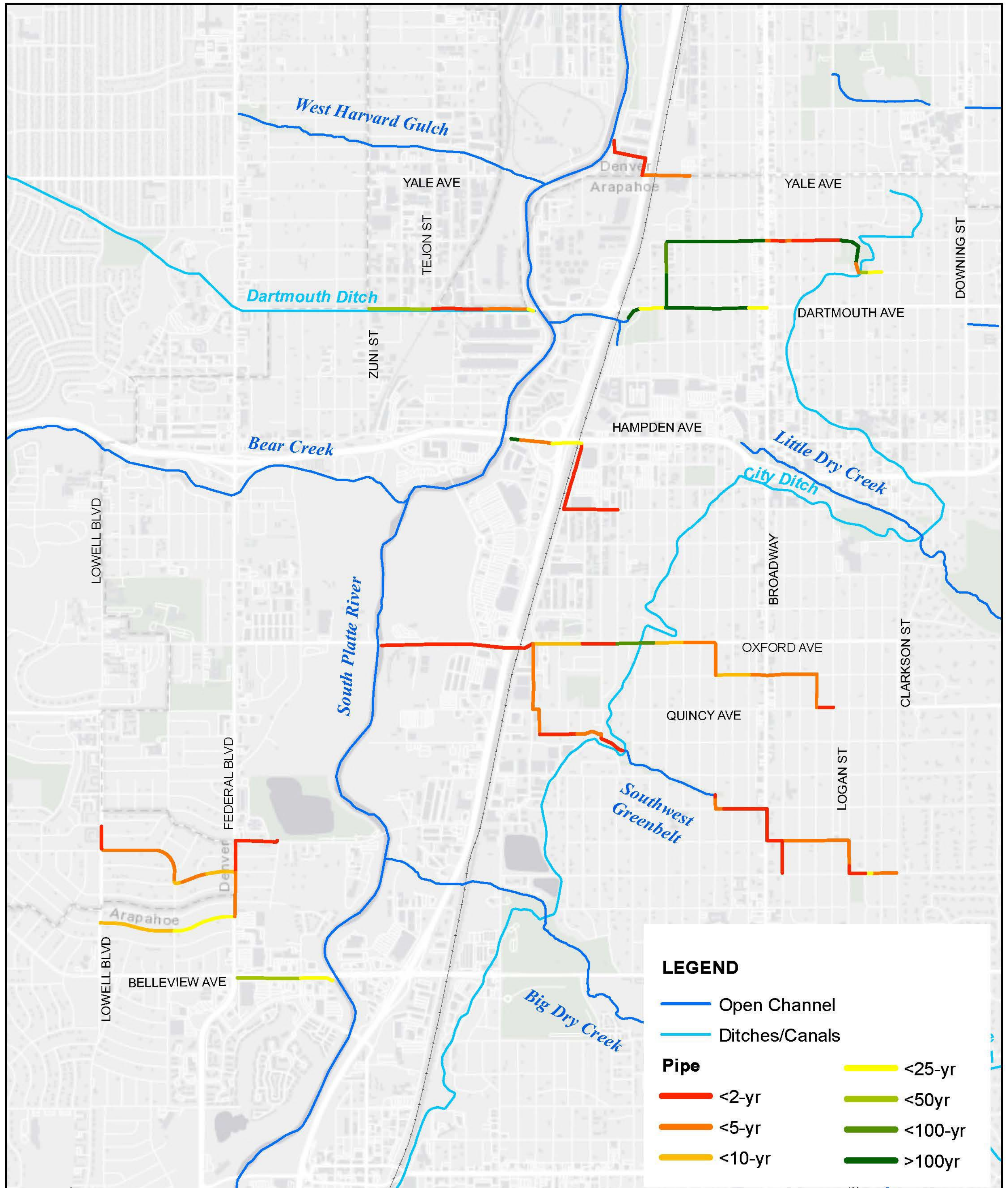

Figure 5-1 Existing Storm Sewer Capacity

## 5.7 Results of Analysis

The baseline unit flows and volumes generally decreased from the 1998/1999 OSP, as shown in Section 3.6. The baseline peak flows and volumes for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year storm events for all SWMM nodes can be found in Tables B-4 and B-5 in Appendix B. Baseline hydrographs and peak flow profiles are shown in Figure B-6 and B-7, respectively. Approximate capacities for existing storm sewer greater than 36” are shown in Figure 5-1.

**Table 5-5** Baseline Peak Flows at Select Design Points

| Basin | Location | Design Point | Future (cfs) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | $Q_2$ | $Q_5$ | $Q_{10}$ | $Q_{25}$ | $Q_{50}$ | $Q_{100}$ | $Q_{500}$ |
| Bow Mar | W Grand Ave and S Federal Blvd | JUNCT_1525 | 104 | 153 | 198 | 327 | 406 | 517 | 769 |
| Central | SPR Outfall near W Hampden Ave | OTF_1598 | 164 | 252 | 321 | 515 | 742 | 1097 | 1891 |
| Central | Near W Hampden Ave and S Jason St | JUNCT_1605 | 150 | 222 | 291 | 531 | 739 | 1104 | 1891 |
| Central | W Kenyon Ave and S Windermere St | JUNCT_1615 | 111 | 160 | 207 | 412 | 656 | 984 | 1700 |
| Dartmouth Industrial | SPR Outfall near W Dartmouth Ave | OTF_1148 | 261 | 366 | 449 | 665 | 840 | 988 | 1401 |
| Federal Boulevard | Outfall to Centennial Park Pond | OTF_1504 | 236 | 331 | 392 | 536 | 648 | 780 | 1085 |
| Federal Boulevard | W Union Ave and S Federal Blvd | JUNCT_1505 | 238 | 336 | 393 | 537 | 649 | 782 | 1087 |
| Federal Boulevard | W Layton Ave and S Federal Blvd | JUNCT_1515 | 179 | 248 | 271 | 354 | 414 | 485 | 650 |
| Dartmouth Avenue | Outfall to Little Dry Creek | OTF_1698 | 113 | 159 | 198 | 288 | 323 | 357 | 411 |
| Dartmouth Avenue | W Dartmouth Ave and S Fox St | JUNCT_1700 | 98 | 137 | 170 | 245 | 268 | 290 | 315 |
| North-Central | Downstream of Bates-Logan Detention Facility | JUNCT_1434 | 33 | 47 | 55 | 66 | 70 | 92 | 156 |
| North-Central | Upstream of Bates-Logan Detention Facility | POND_1435 | 15 | 22 | 37 | 74 | 98 | 126 | 193 |
| South | SPR Outfall near W Oxford Ave | OTF_1800 | 406 | 587 | 776 | 1100 | 1269 | 1487 | 1965 |
| South | W Oxford Ave and S Navajo St | JUNCT_1818 | 363 | 567 | 726 | 1013 | 1153 | 1324 | 1735 |
| South | Downstream of Rotolo Park Detention Facility | JUNCT_1834 | 212 | 354 | 451 | 776 | 948 | 1219 | 1825 |
| South | Upstream of Rotolo Park Detention Facility | POND_1835 | 286 | 408 | 531 | 797 | 954 | 1221 | 1830 |
| South | E Union Ave and S Broadway | JUNCT_1870 | 191 | 272 | 335 | 527 | 667 | 849 | 1262 |
| South-Central | W Oxford Ave and S Jason St | JUNCT_1935 | 141 | 198 | 249 | 365 | 440 | 529 | 786 |
| South-Central | W Princeton Ave and S Broadway | JUNCT_1949 | 53 | 77 | 89 | 154 | 197 | 252 | 375 |
| South-Central | E Quincy Ave and S Logan St | JUNCT_1955 | 32 | 46 | 65 | 116 | 148 | 188 | 278 |

# 6.0 REFERENCES


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Englewood Historic Preservation Society. Newsletter Vol. 7 No 1. The History of Flooding in Englewood. Doug Cohn. September 2018.

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WRC Engineering. Little Dry Creek (ARAPCO) Watershed Downstream Portions Major Drainageway Planning Phase – B Preliminary Design Report. Sponsored by Urban Drainage and Flood Control District, et. al. August 2004.

# Appendix A

# Project Correspondence

Dewberry

# ENGLEWOOD MDP KICKOFF MEETING MINUTES

**Date:** August 11, 2020
**Time/Location:** 2:00 – 3:00 pm / Teams Meeting
**Attendees:** Tim Hoos/Englewood, Shea Thomas/MHFD, Jon Villines/MHFD, Ken Cecil/Dewberry, Haley Heinemann/Dewberry, Allie Beikmann/Dewberry, Dana Morris/Dewberry, Danny Elsner/Dewberry

## Meeting Minutes

Red items are action items for Englewood and/or MHFD

### Summary of Scoping Meeting

- The goal of this MDP will be to utilize the information provided by previous studies (focus on 3 overall studies), to update and build upon their recommendations, and to prioritize proposed improvements and provide guidance for Englewood to begin implementation and construction.

### Current Phase – Data Collection

- Update on collecting/reviewing studies
  - **2019 Englewood OSP (Calibre)**
    - Englewood to get the hard data (CUHP and SWMM model)
  - **1999 Englewood OSP (Turner Collie & Braden)**
    - Need to review this study to understand the updates that are needed.
  - 2017 Harvard Gulch/ Dry Gulch FHAD (Matrix)
    - supplemental
  - 2004 Little Dry Creek MDP (WRC)
    - Supplemental
    - Study coming soon through MHFD
    - Area will be excluded from H&H
    - Perhaps focus on overland flow and localized flooding
  - 2018 Big Dry Creek FHAD (Respec)
    - Supplemental
    - Area will be excluded from H&H
    - Perhaps focus on overland flow and localized flooding
    - Refer to study for prioritization of recommended improvements (alternatives)
  - **2020 City of Englewood Master Plans (Hazen & Sawyer)**
    - Englewood will send the stormwater master plan
  - West Harvard Gulch is on the 5-year list
- Missing information needed
- Deliverable is a summary of studies and a modified MDP scope incorporating studies
  - Date and source of hydrology and hydraulics
  - Map of each study (overlapped?)

### Schedule

- Finish Review – Late August
- Scope Submittal – Early September
  - Scope to be reviewed by MHFD and Englewood to ensure the hydrology scope matches the overall Final Deliverable

### Miscellaneous Items

- Oxford Outfall – try to push this area first – design could be on the shelf till this study is done
- FHAD discussion – Englewood to talk internally
- Final Deliverable will need to be discussed as we continue along the project

Dewberry

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Greenwood Village, Colorado 80111
Phone: 303.368.5601
Fax: 303.368.5603

# MEETING AGENDA

**Date/Time:** **November 23, 2020 @ 3:30 p.m.**
**Location:** **Microsoft Teams Meeting**
**Project:** **Englewood MDP Re-Kickoff Meeting**

**Attendees:**

| Dewberry | Mile High Flood District | City of Englewood |
|---|---|---|
| Ken Cecil | Jon Villines | Tim Hoos |
| Danny Elsner | Brik Zivkovich | Maria D'Andrea |
| Haley Heinemann | Melanie Poole | |
| Katie Kerstiens | | |

**Discussion Items:**

1. **Introductions**

2. **Project Goal**

   a. The goal of this stage is to get up-to-date hydrology across Englewood while utilizing completed work from previous studies. Dewberry will update and build upon the recommendations from these previous studies and ultimately prioritize proposed improvements. This will provide guidance for Englewood as they plan for future implementation and construction.

3. **MDP Scope – Attached is the map and table from the scope**

   a. 2019 Calibre OSP studied five major basins. Dewberry will use the 2013 LiDAR data to update basin information. The latest NOAA rainfall will be used to run the latest version of CUHP and the SWMM model will be run in the latest version.

   b. 1999 Turner Collie & Braden OSP studied six major basins. Dewberry will recreate the basin delineation, update the basin parameters, update to the latest NOAA rainfall data, and run the model in the latest version of CUHP. A new SWMM model will be created and will be run in the latest version.





   c. The five Direct Flow Areas will have a full study done since there are no current studies for these areas.

   d. The three major basins (Big Dry Creek, Northeast Englewood, and Little Dry Creek) have been studied more recently so there will be no update to their hydrology.

4. **Pluvial Study Scope**

   a. Dewberry has an additional contract with MHFD to do a Pluvial Study. A Rain-on-Grid model will be created for all basins within the Englewood area. The results from this study will help inform the recommendations within the Englewood MDP.

   b. Obtaining the City of Englewood's portal information for flooding points may be helpful in completed this study.

5. **Rough Schedule**

   a. Late December – Complete basin updates and CUHP parameters, begin producing excess rainfall from CUHP and start Rain-on-Grid modeling

   b. Late January – Complete Rain-on-Grid modeling

   c. Late February – Submit Hydrology Report

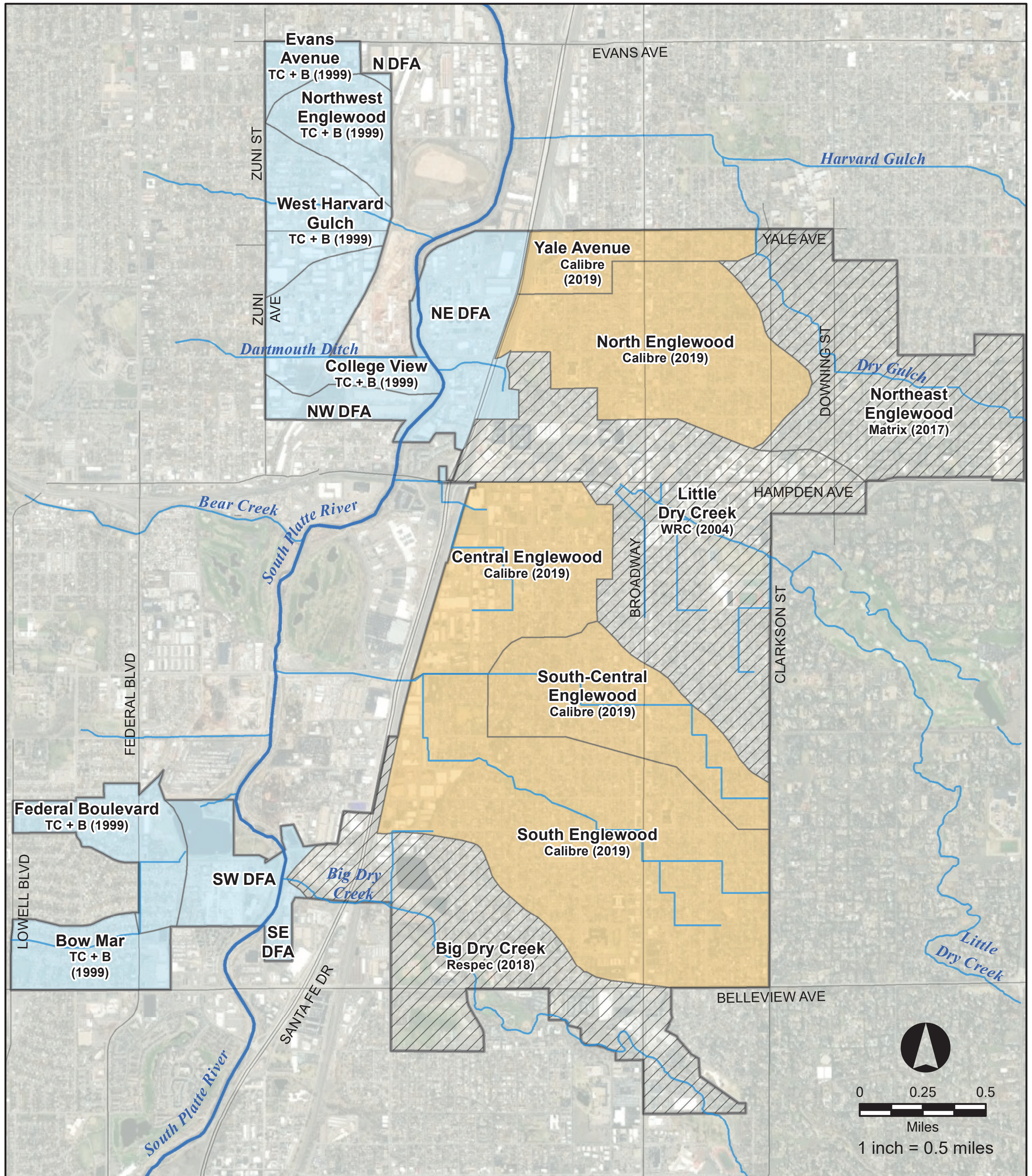


FIGURE 1
RECOMMENDED LIMITS OF STUDY FOR HYDROLOGY

**Recommendations**
- Update study
- Full study
- No action

Project: Englewood MDP
Task: Data Collection
Map Date: 9/23/2020

MHFD MILE HIGH FLOOD DISTRICT

Dewberry

Englewood COLORADO

Client: City of Englewood
Project: Englewood MDP
Task: Data Collection

Recommendations for Englewood MDP Hydrology
Reference Summary - Task 2

9/24/2020

| Basin | Currently Adopted Study | Used for Currently Adopted Study | | | |
|---|---|---|---|---|---|
| | | Hydrology Parameters | | | |
| | | CUHP Topography | CUHP Land Use | CUHP Version | SWMM Version |
| *Dewberry 2020 MDP* | - | *2013 LIDAR* | *Zoning data, current* | *2.0.1 (2019)* | *Version 5.1.015 (2020)* |
| North Englewood | Calibre (OSP, 2019) | City of Englewood (1990s) | 1997 Englewood zoning data | 2016, version 2.0.0 | Version 5.1.013 |
| Central Englewood | Calibre (OSP, 2019) | City of Englewood (1990s) | 1997 Englewood zoning data | 2016, version 2.0.0 | Version 5.1.013 |
| South-Central Englewood | Calibre (OSP, 2019) | City of Englewood (1990s) | 1997 Englewood zoning data | 2016, version 2.0.0 | Version 5.1.013 |
| South Englewood | Calibre (OSP, 2019) | City of Englewood (1990s) | 1997 Englewood zoning data | 2016, version 2.0.0 | Version 5.1.013 |
| Yale Avenue | Calibre (OSP, 2019) | City of Englewood (1990s) | 1997 Englewood zoning data | 2016, version 2.0.0 | Version 5.1.013 |
| Big Dry Creek | RESPEC (MDP & FHAD, 2018) | 2012 Ayres survey | Englewood zoning data | 2005, version 1.4.2 | Version 5.0.022. |
| Northeast Englewood | Matrix (MDP & FHAD, 2017) | 2013 LiDAR Data | 2014 Englewood zoning data | 2005, version 1.4.4 | Version 5.0.022. |
| Little Dry Creek | WRC (MDP & FHAD, 2004) | 2001 G-Squared, LLC survey | Unspecified | 2000, Version 1.1 | UDSWM-2000, Version 1.4.1. |
| Bow Mar | TC & B (OSP, 1999) | City of Englewood (1990s) | 1997 Englewood zoning data | 1997 (CUHPFPC2) | UDSWM386 |
| Federal Boulevard | TC & B (OSP, 1999) | City of Englewood (1990s) | 1997 Englewood zoning data | 1997 (CUHPFPC2) | UDSWM386 |
| Evans Avenue | TC & B (OSP, 1999) | City of Englewood (1990s) | 1997 Englewood zoning data | 1997 (CUHPFPC2) | UDSWM386 |
| Northwest Englewood | TC & B (OSP, 1999) | City of Englewood (1990s) | 1997 Englewood zoning data | 1997 (CUHPFPC2) | UDSWM386 |
| West Harvard Gulch | TC & B (OSP, 1999) | City of Englewood (1990s) | 1997 Englewood zoning data | 1997 (CUHPFPC2) | UDSWM386 |
| College View | TC & B (OSP, 1999) | City of Englewood (1990s) | 1997 Englewood zoning data | 1997 (CUHPFPC2) | UDSWM386 |
| SW DFA | None | UNSTUDIED | | | |
| SE DFA | None | UNSTUDIED | | | |
| NW DFA | None | UNSTUDIED | | | |
| NE DFA | None | UNSTUDIED | | | |
| N DFA | None | UNSTUDIED | | | |

| | |
|---|---|
| Red | = Updated Recommended |
| Yellow | = Possible Update Recommended |
| Green | = No Update Recommended |

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Q:\50127646\Project Info\Reports by Others\Englewood MDP References Summary

Client: City of Englewood
Project: Englewood MDP
Task: Data Collection

Recommendations for Englewood Pluvial Flood Study
in Support of Englewood MDP
Reference Summary - MHFD

9/24/2020

| Basin | Currently Adopted Study | Used for Currently Adopted Study | | | |
|---|---|---|---|---|---|
| | | Hydrology Parameters | | | |
| | | CUHP Topography | CUHP Land Use | CUHP Version | SWMM Version |
| *Dewberry 2020 MDP* | - | *2013 LIDAR* | *Zoning data, current* | *2.0.1 (2019)* | *Version 5.1.015 (2020)* |
| North Englewood | Calibre (OSP, 2019) | City of Englewood (1990s) | 1997 Englewood zoning data | 2016, version 2.0.0 | Version 5.1.013 |
| Central Englewood | Calibre (OSP, 2019) | City of Englewood (1990s) | 1997 Englewood zoning data | 2016, version 2.0.0 | Version 5.1.013 |
| South-Central Englewood | Calibre (OSP, 2019) | City of Englewood (1990s) | 1997 Englewood zoning data | 2016, version 2.0.0 | Version 5.1.013 |
| South Englewood | Calibre (OSP, 2019) | City of Englewood (1990s) | 1997 Englewood zoning data | 2016, version 2.0.0 | Version 5.1.013 |
| Yale Avenue | Calibre (OSP, 2019) | City of Englewood (1990s) | 1997 Englewood zoning data | 2016, version 2.0.0 | Version 5.1.013 |
| Big Dry Creek | RESPEC (MDP & FHAD, 2018) | 2012 Ayres survey | Englewood zoning data | 2005, version 1.4.2 | Version 5.0.022. |
| Northeast Englewood | Matrix (MDP & FHAD, 2017) | 2013 LiDAR Data | 2014 Englewood zoning data | 2005, version 1.4.4 | Version 5.0.022. |
| Little Dry Creek | WRC (MDP & FHAD, 2004) | 2001 G-Squared, LLC survey | Unspecified | 2000, Version 1.1 | UDSWM-2000, Version 1.4.1. |
| Bow Mar | TC & B (OSP, 1999) | City of Englewood (1990s) | 1997 Englewood zoning data | 1997 (CUHPFPC2) | UDSWM386 |
| Federal Boulevard | TC & B (OSP, 1999) | City of Englewood (1990s) | 1997 Englewood zoning data | 1997 (CUHPFPC2) | UDSWM386 |
| Evans Avenue | TC & B (OSP, 1999) | City of Englewood (1990s) | 1997 Englewood zoning data | 1997 (CUHPFPC2) | UDSWM386 |
| Northwest Englewood | TC & B (OSP, 1999) | City of Englewood (1990s) | 1997 Englewood zoning data | 1997 (CUHPFPC2) | UDSWM386 |
| West Harvard Gulch | TC & B (OSP, 1999) | City of Englewood (1990s) | 1997 Englewood zoning data | 1997 (CUHPFPC2) | UDSWM386 |
| College View | TC & B (OSP, 1999) | City of Englewood (1990s) | 1997 Englewood zoning data | 1997 (CUHPFPC2) | UDSWM386 |
| SW DFA | None | UNSTUDIED | | | |
| SE DFA | None | UNSTUDIED | | | |
| NW DFA | None | UNSTUDIED | | | |
| NE DFA | None | UNSTUDIED | | | |
| N DFA | None | UNSTUDIED | | | |

| | |
|---|---|
| Red | = Updated Recommended |
| Yellow | = Possible Update Recommended |
| Green | = No Update Recommended |

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Q:\50127646\Project Info\Reports by Others\Englewood MDP References Summary

Dewberry

# MEETING MINUTES

**DATE:** August 20, 2021

**TIME:** 10:00 a.m.

**LOCATION:** Microsoft Teams

**PROJECT:** Englewood MDP

**PURPOSE:** Baseline Hydrology Report Review

**ATTENDEES:**

| Dewberry | Mile High Flood District | City of Englewood |
|---|---|---|
| Danny Elsner<br>Haley Heinemann<br>Katie Kerstiens | Jon Villines<br>Charlie Pajares | Tim Hoos |

## Discussion Items:

1) Meeting goals
   a. Discuss how to wrap up Baseline Hydrology report and BLE Pluvial Flood Hazard Memorandum
   b. Discuss next phase of Alternatives
2) Summary of Hydrology and Pluvial Flood Hazard
   a. MDP + Pluvial vs. Calibre study
      i. Level of detail – Compared to the Calibre/TCB hydrology, the MDP baseline hydrology was completed at a larger scale by using subbasin delineations of a larger average size more in line with the CUHP methodology.
      ii. Rain-on-grid vs. point flow – Calibre's 2D point flow results are similar to the rain-on-grid results in terms of flow path and approximate limits of 100-year inundation. This is indicative of the existing storm sewer system's inability to capture a volume of storm water large enough to greatly impact the ultimate 100-year flowpath, as is expected for the existing storm sewer system design capacity.
         1. Discuss: "The Calibre study identified existing piping that is sized to handle 100 year flows and could be the focus of areas of interest. It would be good to pursue this to adjust results that may show larger than expected ponding depths and account for the existing storm sewer's contribution." (Tim Hoos). Dewberry will provide some additional explanation in the memorandum regarding the 100-yr capacity pipes outlined by the Calibre report and their context within the system as a whole. There are some



segments with higher capacities; however, several of these are limited by bottlenecks downstream with much lower capacities.

3) Draft Baseline Hydrology report
   a. Comments were provided by MHFD on 8/19/2021 and the City on 8/20/2021. Dewberry will review and schedule a meeting with MHFD for further discussion.
      i. Items to be discussed further:
         1. MHFD noted that the Baseline Hydrology is currently assuming that the underground flow path and above ground flow path match, as is generally typical of an MDP. Is this a realistic assumption to be made for this situation? Special consideration may be warranted for where the main flow path is overland flow separate from the storm sewer.
         2. Are the assumed storm sewer slopes okay or should survey be considered at some locations where GIS data was particularly limited?
         3. Consider use of FLO-2D
         4. Discuss together the boundaries of other recent studies to make sure we aren't missing any large areas of land. (Harvard Gulch, Big Dry Creek, West Harvard Gulch/ Denver SDMP).
         5. Time noted that the Ulteig Acoma Street Area Drainage Study has been especially helpful for the City by looking at the upper end of the system, optimizing the existing system, and ensuring storm water makes it to the major system. Due to Englewood's unique storm water system, the team determined the Englewood MDP should achieve a higher level of detail than a typical MDP or OSP. While the funding is not available to complete a master plan at an "inlet-level" scale, it was agreed that the Englewood MDP could cover major trunklines and major laterals, along with some suggestions of future locations for detailed studies. As a result, a "traditional" hydrology is needed for conventional planning and FHAD acceptance; however, some additional hydrology will likely be needed at a finer scale to supplement Alternative Analysis for secondary trunklines and laterals. The following plan is suggested:
            a. Dewberry will make a plan for how to complete the "traditional" baseline hydrology and when/how to supplement the baseline hydrology with smaller-scale hydrology for secondary trunklines and laterals.
            b. Following acceptance of the baseline hydrology, Dewberry

Dewberry

will scope Alternative Analysis to include the supplemental work. The scope will also include time for additional team meetings and coordination since this is an atypical study.

6. Discuss possibility of comparing results to Ulteig's recommended improvement areas to verify consistency and adequate design coverage. Phases already under contract will be considered "completed", while others may be verified against the new baseline hydrology.

7. The Alternatives will look into the feasibility of a storm sewer level of service for the 25-year or 100-year.

4) The benefits of including a FHAD was discussed. The delay in project time is not considered an issue, as any capital improvements will first require time to collect project funding.

   a. Tim noted that the resulting flood maps of an Englewood FHAD would be especially helpful for documentation and explanation of current flood risk and why mitigation projects are warranted.

   b. Jon will discuss the concept with Brooke and Stacey to determine the current best practices for 2D-backed floodplain mapping and any other special considerations we should be aware of for an Englewood FHAD.

      i. The BLE Pluvial analysis should be helpful supplemental information to an Englewood FHAD.

5) Draft Englewood BLE Pluvial Flood Hazard Memorandum

   a. Dewberry will wrap up and submit the final memorandum. The memo figures will consist of the raw KMZ files and one static map depicting 100-year flood-prone areas in relation to existing storm sewer infrastructure. More detailed language will be added to explain why the sewer segments with 100-year capacity were not considered in the BLE models.

**Action Items:**

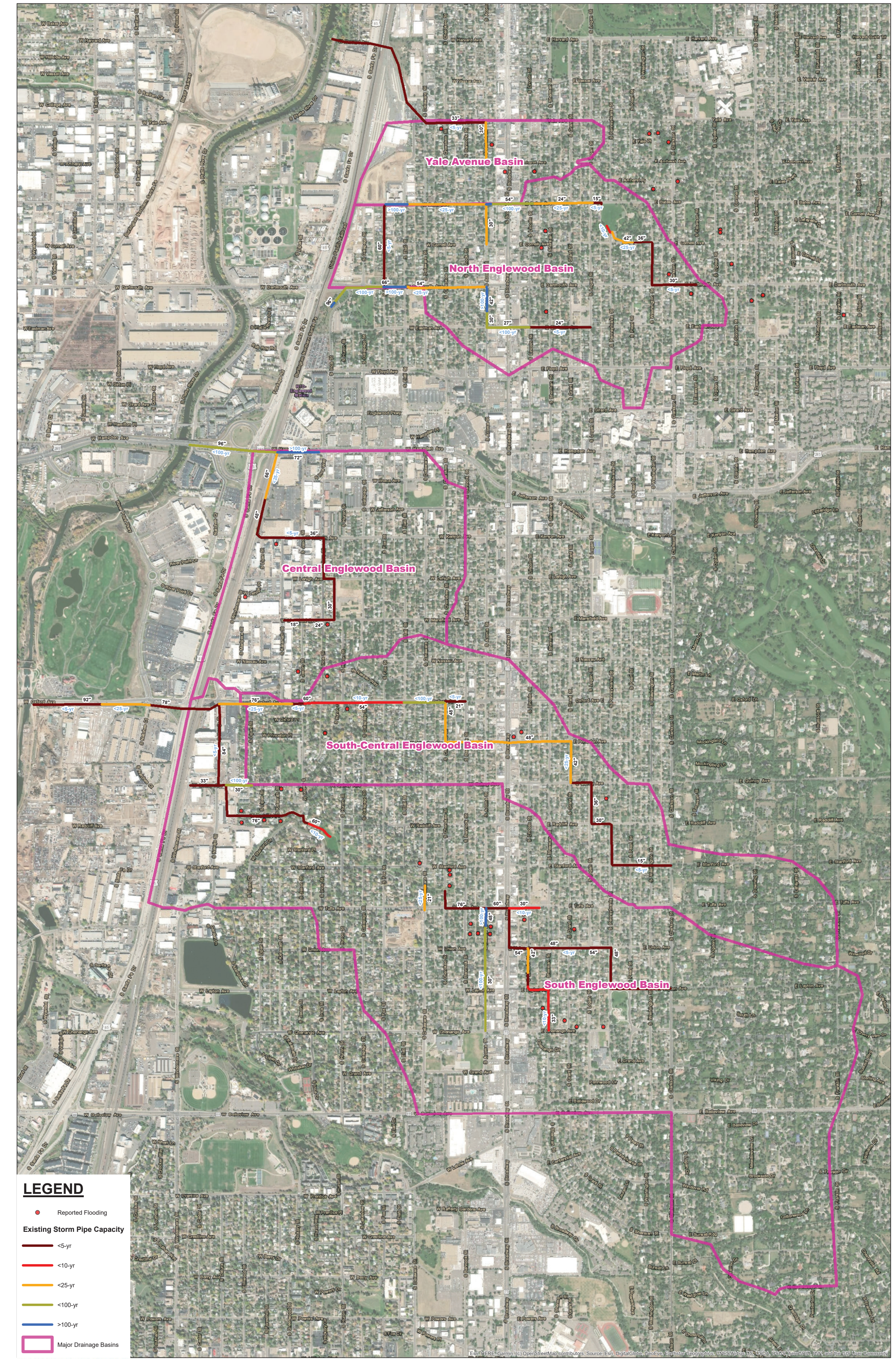
1) Dewberry – Submit final BLE Pluvial Memo

2) Dewberry – Review Baseline Hydrology comments and schedule meeting with MHFD to review changes and confirm we are on the right track for FHAD and Alternative Analysis.

3) MHFD – Jon will discuss the Englewood FHAD concept with Brooke and Stacey to determine the current best practices for 2D-backed floodplain mapping and any other special considerations we should be aware of for an Englewood FHAD.

Dewberry



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# MEETING MINUTES

**DATE:** September 7, 2021

**TIME:** 2:00 p.m.

**LOCATION:** Microsoft Teams

**PROJECT:** Englewood MDP

**PURPOSE:** Baseline Hydrology Report Review (No. 2)

**ATTENDEES:**

| Dewberry | Mile High Flood District | City of Englewood |
|---|---|---|
| Danny Elsner<br>Haley Heinemann<br>Katie Kerstiens | Jon Villines<br>Charlie Pajares<br>Jeff Battiste | Tim Hoos |

**Discussion Items:**

1) Baseline Hydrology enhancements

   a. Discussed recommended improvements to baseline hydrology. Improvements would include using the pluvial flood hazard assessment to inform the complicated overland flow paths and the level of connectivity detail in SWMM, use preliminary results to select more strategic design points and subbasins, and improve basin transfer estimation.

   b. It's recommended that the baseline hydrology enhancements include an increase in resolution necessary to include Tier 2 recommendations in the Alternatives Analysis. As such, alternatives for Tier 2 lines would be considered by doing smaller-scale rational hydrology in the Alternatives Analysis phase. Based on pluvial results, some Tier 3 projects may also be identified for future study but no conceptual design in the MDP.

      i. Tier 1 = MDP-level major trunk line

      ii. Tier 2 = Secondary trunk lines, major laterals, upper-basin trunk lines (we are here)

      iii. Tier 3 = Site-civil analysis (not included)

   c. Dewberry conducted a comprehensive review of the City's GIS and as-built data available for existing storm sewer infrastructure. The recommendation was made to survey locations without reliable City data or unclear connectivity. The team agreed that a comprehensive and workable model of Englewood hydrology is the overall goal and that an important step will be to gather missing information.

      i. Tim mentioned that in some cases manholes have been paved over, making it difficult to survey system connectivity in the past.



      ii. Englewood may have collected some additional storm sewer information since sharing their GIS database in 2020. Tim will review and share with Dewberry.

      iii. Tim believes that there may have been some storm sewer survey collected for the Ulteig Acoma Street study. Tim will review and share with Dewberry.

      iv. Tim will confirm what survey is planned or has been completed by HDR in the South Englewood basin and share with Dewberry.

      v. Tim will see if the City has a copy of the "Storm Sewer Inventory Report. City of Englewood. Muller Engineering Company, Inc. March 1999."

      vi. Dewberry will update the recommended survey locations based on the additional survey data that Tim is able to provide.

      vii. MHFD and Englewood will price out survey costs.

2) Earmarked comments on the draft Baseline Hydrology report were reviewed. Resolutions not listed below will be included in the comment response with the final Baseline Hydrology Report.

   a. Storm water inflow locations along the City Ditch will be added to the report, including the figure from the 2020 Hazen master plan. Opportunities to reduce storm water inflow volume or locations will be considered during the Alternatives phase.

   b. Tim will look for documentation regarding whether the City has any responsibility for the railroad ditch between West Harvard Gulch and Evans Avenue west of the South Platte River. Routing of the Northwest Englewood and Evans Avenue basins will be confirmed based on the information received.

   c. Big Dry Creek subbasin 30 sends overland flow north to the South Englewood basin, while storm sewer infrastructure is routed to Big Dry Creek to the south. Following the topography, the tributary area will be accounted for in the South Englewood hydrology and a note will be added to the report that this area should be considered in future Big Dry Creek studies as well. Deviations from other surrounding master plan delineations will be confirmed and annotated in the report.

   d. The typical MHFD report template will not be as closely followed for this project and Dewberry is free to reference other recent studies as much as needed to provide a comprehensive account of the City's major drainage. The group agreed that the typical interactive figures wont be needed.

   e. During the Alternatives phase, Dewberry will review areas of existing inadvertent detention and explore opportunities to formalize into maintenance eligible detention. Dewberry will also add the proposed improvements designed by Ulteig and HDR to the alternatives models to confirm their impact on the baseline hydrology.

f. The formal environmental assessment will be deferred to the Alternatives phase of the project. In the meantime, Dewberry will review NWI data and include a figure of any existing wetlands.

g. Dewberry will monitor the time step used for the SWMM model and update as necessary.

3) Next Steps

a. Finalize baseline hydrology amendment

b. Address comments and submit final Baseline Hydrology Report

c. Submit final BLE Pluvial Flood Hazard Memorandum

d. Share final report and memo with HDR

**Action Items:**

- Tim will share the available storm sewer inventory information listed under 1) c. above with Dewberry.
- Tim will look for documentation regarding whether the City has any responsibility for the railroad ditch between West Harvard Gulch and Evans Avenue.
- Dewberry will update the storm sewer survey exhibit with the inventory information shared by Tim.
- Dewberry will schedule a meeting with Brooke, Stacey and the project team for early October to discuss Englewood FHAD options.
- MHFD will review the proposed scope & fee for hydrology enhancements.

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| No. | Page | Section | Reviewer | Comment | Response |
|---|---|---|---|---|---|
| 1 | 4 | 1.2 | THoos | List these in order stated above | Revised. |
| 2 | 4 | 1.5 | THoos | Any missing information to note? | Missing items added. |
| 3 | 4 | 1.2 | cpajares | Please updated to Mile High Flood District | Updated |
| 4 | 4 | 1.3 | cpajares | Update during Final vers. | Updated. |
| 5 | 5 | 1.6 | THoos | PE, CFM | Added. |
| 6 | 5 | 1.6 | cpajares | Add Charlie Pajares, PE, CFM (MHFD Project Engineer) | Added. |
| 7 | 6 | 2.1 | THoos | List these in order stated above | Revised. |
| 8 | 6 | 2.1 | THoos | Will a map be included of where the ditch is open and accepts stormwater? | The 2020 Hazen map has been added, along with some further description. |
| 9 | 6 | 2.1 | cpajares | Does the size of these basins mean they are ineligible for FEMA mapping? Isn't there a 1 sq mi threshold, or am I imagining that? | FEMA SID 110 states: "Flooding sources with contributing drainage area less than 1-square mile and/or with an average flood depth of less than one foot shall not be included in the Flood Risk Project scope of work, unless they have been analyzed on the effective FIRM or a justified need is identified during Discovery." This is generally not used as a hard-and-fast rule and is more often used to reduce study scopes. If the District decides to move forward with a FHAD and eventual FIRM/PMR, there should be no issue based on the smaller drainage areas. |
| 10 | 6 | 2.1 | cpajares | needs to be clearly shown on the mapping | City Ditch & Highline Canal CL's added to figures. |
| 11 | 6 | 2.1 | cpajares | let's say "rather than conveyance by an open channel," it's still technically a major drainageway. | Section revised to clarify. |
| 12 | 7 | 2.1 | THoos | upstream of | Section revised to clarify project location. |
| 13 | 7 | 2.1 | THoos | located | Section revised to clarify project location. |
| 14 | 7 | 2.1 | THoos | basin | Section revised to clarify project location. |
| 15 | 7 | 2.1 | THoos | How would these projects be expected to impact the baseline hydrology? | Discussed during review meeting that the effects of these projects will be considered during the Alternatives phase and will not effect the baseline hydrology. |
| 16 | 7 | 2.3 | THoos | should this read "mostly"? | Revised to "mostly" |
| 17 | 7 | 2.3 | THoos | where does this eventually outfall into? | Added outfall description for Bow Mar basin. |
| 18 | 7 | 2.3 | THoos | Are there 27" pipes downstream from the 66" pipe? | There are no known 27" pipes downstream of the larger pipes. Added text to clarify layout. |
| 19 | 7 | 2.1 | THoos | the South | Fixed. |
| 20 | 7 | 2.3 | THoos | How/where does this eventually outfall? | Added outfall description for College View basin. |
| 21 | 7 | 2.3 | THoos | How/where does this eventually outfall? | Added outfall description for Evans Avenue basin. |
| 22 | 7 | 2.1 | cpajares | Request feedback from local gvmt. Are there any additional improvement projects in the area (construction, planned or in design?) | Discussed during review meeting. No other current projects are underway. |
| 23 | 7 | 2.3 | cpajares | What about the basins between Santa Fe and SPR? Do they get picked up by the 96" RCP? Why are we not accounting for those in the system? | Previously unclear if there was any inflow west of Santa Fe or a separate CDOT system. Utility survey clarified the systems combine and a basin between Santa Fe and SPR has been added to the routing to account for the total area. |

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| No. | Page | Section | Reviewer | Comment | Response |
|---|---|---|---|---|---|
| 24 | 7 | 2.3 | cpajares | Basin requires outer boundary refinement to tie-in to the Denver SDMP | Reviewed delineation against neighboring studies. For Denver SDMP, edges generally match, with some small differences made based on design point and missing tributary area. All edges are coincident with the BDC 2015 MDP subbasins. Edges generally match the Harvard Gulch 2017 MDP, with some small changes based on our topo. |
| 25 | 7 | 2.3 | cpajares | Not in SWMM model, not outfalling to SPR? Do we know the condition of the system downstream or how our updates impact it? Basins require refinement to tie-in to Denver SDMP | Evans avenue basin is served by CCD storm sewer which was included in the 2019 SDMP. Two basins are included in the baseline hydrology to provide reference information for the southern side of Evans Avenue in Englewood to compare against previous reports, if needed. Further exploration is not considered warranted. Per meeting discussion, basin delineation was reviewed for general agreement with SDMP. |
| 26 | 7 | 2.3 | cpajares | Model shows a box culvert. Please add description | Added description. |
| 27 | 7 | 2.3 | cpajares | How about the 42" pipe? Please add description | Added description. |
| 28 | 7 | 2.3 | cpajares | Where do these come from? Upper and Lower trunk lines? please use consistent naming through the basin description sections. | Upper and lower came from previous master plan reports. Updated to clarify. |
| 29 | 7 | 2.3 | cpajares | Where did we get this info from? have we confirmed with City? | Englewood Herald. Confirmed with Tim. |
| 30 | 7 | 2.3 | cpajares | Pipe is 60" at Acoma Street. Please verify | Verified and updated description. |
| 31 | 7 | 2.3 | cpajares | I only see 48" and higher in the model. Please confirm | Verified and updated description. |
| 32 | 7 | 2.3 | cpajares | Basin delineation requires refinement to tie-in to Denver SDMP and 2017 Harvard Gulch MDP | Reviewed delineation against neighboring studies. For Denver SDMP, edges generally match, with some small differences made based on design point and missing tributary area. All edges are coincident with the BDC 2015 MDP subbasins. Edges generally match the Harvard Gulch 2017 MDP, with some small changes based on our topo. |
| 33 | 7 | 2.3 | cpajares | Not in SWMM model, not outfalling to SPR? Do we know the condition of the system downstream or how our updates impact it? Basins require refinement to tie-in to Denver SDMP | Survey confirmed this area discharges to a 72" RCP under the RR and out of the City to a concrete lined channel. No need to route in SWMM. |
| 34 | 7 | 2.3 | cpajares | Please be consistent with street naming. Add "Street""Avenue", etc. Typ. whole document. | Updated for consistency. Please note that when an east-west road is mentioned in reference to both sides of Broadway, there is no "E" or "W" prefix included. |
| 35 | 7 | 2.1 | cpajares | Need to mention the Oxford Ave outfall project. | Clarification added to project description. Now referenced as South Englewood Flood Reduction Project to match City website name. |
| 36 | 7 | 2.3 | cpajares | Please include the storm sewers on the map (for all basins). | Created a pipe representation shapefile to supplement open channel CL's from MHFD. |
| 37 | 7 | 2.3 | cpajares | Please review subwatershed basins included in the attached GDB. We would like you to review the outer boundaries and confirm we don't want to change our approach. There are a few areas that were not captured by our study or the older MDPs so we'll have to confirm those don't need to be included here. Please note that Denver SDMP basins were delineated using contours and then refined based on existing storm sewer so it would be good to take a hard look at those. | Reviewed delineation against neighboring studies. For Denver SDMP, edges generally match, with some small differences made based on design point and missing tributary area. All edges are coincident with the BDC 2015 MDP subbasins. Edges generally match the Harvard Gulch 2017 MDP, with some small changes based on our topo. |

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|---|---|---|---|---|---|
| 38 | 8 | 2.4 | THoos | List the four here again for clarification | Section revised to clarify. |
| 39 | 8 | 2.3 | THoos | and outfalls to the South Platte River from the same 93" pipe as the South Englewood Basin. | Added clarification to text. |
| 40 | 8 | 2.3 | cpajares | Model shows a 42" | Verified and updated description. |
| 41 | 8 | 2.3 | cpajares | How about the 36" line modeled for conduit 313-2/3. Please verify and restate, seems like the pipe size fluctuates up and down instead of increasing. | Verified and updated description. |
| 42 | 8 | 2.3 | cpajares | Seems like we're missing quite a bit of system description similar to other watersehds. Please update. | Added additional detail |
| 43 | 8 | 2.4 | cpajares | Consider photographic evidence for the area since significant flooding has been observed. - Consider documenting major street crossings (if impacted) and/or other structures. | Added list of major street crossings impacted by flooding from the Calibre OSP update report and included several photographs. |
| 44 | 8 | 2.4 | cpajares | Really need to expand on this. | Expanded on flood history. |
| 45 | 8 | 2.4 | cpajares | The flood history section (although it's good that you link to the Calibre study), is insufficient. It needs to detail the history of recent events including the death at 4650 S Acoma St in 2018, the multiple sinkholes on Oxford Ave at Santa Fe, any other known flooding, include photos, etc. | Added a lot more flooding history including those mentioned along with several photos. |
| 46 | 8 | 2.5 | cpajares | Need to include the baseline environmental assessment of potential waters of the US, known wetlands, etc. | Discussed during the meeting. Included wetlands and riparian zones, T&ES, and landfills/contamination sections. Remaining environmental assessment will be completed following Baseline Hydrology when contract for subcontractor can be made. |
| 47 | 9 | Figure 2-1 | THoos | Can the different City shading colors be made a bit more contrasting on this map. | We've added a municipality figure into Section 2 so could fix competing shading and could remove the City shading from this map. |
| 48 | 9 | Figure 2-1 | cpajares | Please differentiate between streams and ditches. | Ditches/Canals differentiated on figures. |
| 49 | 9 | Figure 2-1 | cpajares | Should we scale this in miles? | Changed scale to miles. |
| 50 | 10 | 3.3 | THoos | Does this need to be addressed? | Please disregard. Areas have been picked up. |
| 51 | 10 | 3.3 | THoos | Do we know if any private ponds exist? | Per discussion with MHFD, no private ponds can be accounted for in the Baseline Hydrology however, areas of existing inadvertant ponding or detention will be considered for proposed detention facilities. |
| 52 | 10 | 3.3 | THoos | planimetric | Fixed. |
| 53 | 10 | Table 3-1 | cpajares | 1.95 per Table 3-3. Please update for consistency. | Updated for consistency. |
| 54 | 10 | 3.3 | cpajares | Is this correct? From contours or from DEM? Please specify. | Changed references to LiDAR and added description to Section 1.4 that the 1-foot contours and the DEM are from the 2013 DRCOG LiDAR. |
| 55 | 10 | 3.3 | cpajares | Are these correct? it seems like basins 116 and 119 are within the BowMar and Federal Basins? | Please disregard. |
| 56 | 10 | 3.3 | cpajares | confirm. | Changed references to LiDAR and added description to Section 1.4 that the 1-foot contours and the DEM are from the 2013 DRCOG LiDAR. |

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| No. | Page | Section | Reviewer | Comment | Response |
|---|---|---|---|---|---|
| 57 | 10 | 3.3 | cpajares | Please supplement your delineation with Denver's SDMP | Reviewed delineation against neighboring studies. For Denver SDMP, edges generally match, with some small differences made based on design point and missing tributary area. All edges are coincident with the BDC 2015 MDP subbasins. Edges generally match the Harvard Gulch 2017 MDP, with some small changes based on our topo. |
| 58 | 10 | 3.2 | cpajares | Is 10 sq mi the threshold? I feel like we have applied DARF for smaller basins than that but I could be mistaken. | Typo, should be 5 square miles. Fixed in text and we are still below the threshold for area correction. |
| 59 | 10 | 3.4 | cpajares | Results of the pluvial study should be able to inform the primary flow path, where it differs from the underground path, right? | Yes. Results of pluvial study have been used to inform the primary flow path for delineation and routing. |
| 60 | 11 | 3.4 | THoos | Is this reduction accounted for in the updated hydrology? | Yes, the reduction in Bates-Logan detention capacity is accounted for in the updated hydrology. Added a note to text to clarify. |
| 61 | 11 | Table 3.2 | cpajares | Please cite source for %Impervious Values. | Added source (USDCM table). |
| 62 | 11 | 3.5 | cpajares | Does this warrant completing an early infrastructure survey since it heavily dictates the Hydrology? | We agree it is warranted, especially given the age of the system and the missing updates to hydrology in recent studies. Survey was completed in 2022. |
| 63 | 11 | 3.5 | cpajares | Is this appropriate? Most of these streets are probably 60 years old. | Confirmed the use of typical road sections from criteria manual based on the following. Sections were applied based on the average road width, rather than level of service. Trapzoidal sections were used to approximate the more complex road sections like Broadway and Hampden. |
| 64 | 11 | 3.5 | cpajares | Do we know of any known flood-prone areas? or areas with decaying infrastructure that might not be conducive of this assumption? | The note about inlets capacity was meant to explain how an MDP does not address individual inlet capacity or location issues. Removed from text to avoid confusion. The model does account for locations where the direction of overland flow is not the same as the underground system. |
| 65 | 11 | 3.5 | cpajares | Let's confirm all of these areas during our call | Confirmed during call. |
| 66 | 11 | 3.5 | cpajares | Is this a standard approach? | Can disregard. More detail was added to model to ensure the direction of overland flow is captured when not following the direction of the underground system. |
| 67 | 11 | 3.5 | cpajares | Is this a standard approach for SPR? | Yes, it is a standard approach to have Direction Flow Areas along the SPR where no routing is required. |
| 68 | 11 | 3.5 | cpajares | is this the 2013 DRCOG LiDAR? haven't seen it referred to as USGS LIDAR (or 2014) before. also, was a DEM or contour version used? | Yes. Updated to 2013 DRCOG LiDAR and clarified in Section 1.4 that the 1-foot contours and the DEM are both from the LiDAR. We did use both the DEM and contours for our work; for simplification in these later references I'll just reference the DEM/LiDAR. |
| 69 | 11 | 3.5 | cpajares | Is this an appropriate assumption for hydrologic phase? There may be areas where primary routing in the 100-year is on the surface? | I think this was stated confusingly. Updated to note that the hydrology doesn't account for inlet capacity issues (standard hydro sasumption). Primary routing is very often on the surface and that is captured in the modeling. |
| 70 | 12 | Table 3-3 | cpajares | Update for consistency. 1.94 or 1.95? | Updated. 1.95 per Englewood Drainage Criteria Manual. |
| 71 | 13 | Table 3-4 | THoos | Are there any significant differences in this table that should be highlighted/pointed out? | Discussion added to text. |
| 72 | 22 | Figure B-1 | cpajares | This not built-out yet? | Discussed during meeting. The hydrology maps will be made separately rather than into an interactive map. |
| 73 | 23 | Figure B-1 | cpajares | Please match colors on Map. Probably a transparency issue. | Colors fixed on map. |

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| No. | Page | Section | Reviewer | Comment | Response |
|---|---|---|---|---|---|
| 74 | 24 | Figure B-1 | cpajares | Is this showing that all that purple area is "undefined" in the planimetrics? Is there no category for grass or lawns? That's what most of it appears to be, right? This was all assigned 10% imp? | Yes, there was not a category for the "undefined" area in the planimetrics. Discussed during meeting & decided to supplement planimetrics with NLCD to replace "undefined" area. This increased the imperviousness into the 70's, but that appears to be more consistent with the "built-out" nature of the city. Updated impervoius values were also compared against the Harvard Gulch and Dry Gulch MDP. Both our study and theirs puts the Dry Gulch area in the 50%. |
| 75 | 25 | Figure B-1 | cpajares | is there a difference between page 24 and 25? please remove duplicate. | Duplicate removed. |
| 76 | 27 | Figure B-1 | cpajares | Pond? | Made ponds more visible in SWMM schematic. |
| 77 | 27 | Figure B-1 | cpajares | missing a few. ok if size is restrictive. | Noted. |
| 78 | - | CUHP | cpajares | Nodes 301 and 302 are included in the CUHP run, however they are not included in the SWMM model routing. Do these basins drain directly to SPR and thus are not accounted for? Or should they be routed to a divider between 661 and 660? | The following subbasins are not routed in SWMM because they flow directly to SPR or out of Englewood: 40, 41, 50, 54, 55, 100, 105, 110, 115, 175, 500, 805, 810. Subbasins 301 and 302 (now 40/41 and 405) flow directly to the SPR and north out of Englewood. |
| 79 | - | CUHP | cpajares | Please consider revising subcatchments 42, 43, **82**, 94, 96 and 302 which show questionable length to width ratios. | Subbasins were reviewed and revised to improve l/w ratios. All ratios are now =<7 except for subbasin 521. This subbasin was divided to improve the ratio to 8, but the nature of the area is long and narrow. |
| 80 | - | CUHP | cpajares | Nodes 21, 22, 33, 110, 120, 121, 303, 501 and 502 are included in the CUHP runs, however they are not included in the SWMM model routing. Do these basins drain directly to SPR and thus are not accounted for? Please confirm approach. | The following subbasins are not routed in SWMM because they flow directly to SPR or out of Englewood: 40, 41, 50, 54, 55, 100, 105, 110, 115, 175, 500, 805, 810. Subbasins 301 and 302 (now 40/41 and 405) flow directly to the SPR and north out of Englewood. |
| 81 | - | CUHP | cpajares | Subcatchments 21, 22, 120 and 121 are included in the CUHP run but not on the watershed subcatchment map. Please confirm where these are at. Updated map or CUHP as needed. | These subcatchments from the rain-on-grid analysis were removed from the MDP CUHP runs. |
| 82 | - | CUHP | cpajares | Several of the subcatchment show questionable length to width ratios (>7). These subcatchments include 21, 22, 31, 113-116, 120, 303, 501 and 502. Can we justify revising these subcatchments to reach a ratio closer to 4. | Subbasins were reviewed and revised to improve l/w ratios. All ratios are now =<7 except for subbasin 521. This subbasin was divided to improve the ratio to 8, but the nature of the area is long and narrow. |
| 83 | - | CUHP | cpajares | Future imperviousness for some basins show a decrease even though most include newly paved driveways. Please verify that the future percent imperviousness are accounted for properly. | Verified future percent imperviousness is accounted for. All values show no change or an increase. |
| 84 | - | SWMM | cpajares | Please confirm that 5hr run is sufficient to determine the peak flows for the system routing. | Confirmed. |
| 85 | - | SWMM | cpajares | Time step is unusually high. What is the reason for using 5mins instead of 30-60 secs which is more commonly used. Please help us understand the reason behind it. | Discussed during comment review meeting. Time step was set high to smooth curve oscillation resulting from the large change in flow area between the gutter and full street section of overflow transects. In order to reduce the time step, the transect cross sections for roads were updated to remove the gutter low flow line. The time step is now 60 seconds. |

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| No. | Page | Section | Reviewer | Comment | Response |
|---|---|---|---|---|---|
| 86 | - | SWMM | cpajares | Given that the system is primarily routed through the storm sewers. Do we believe we have enough data to properly model the East and West storm sewer systems? Should we consider surveying the infrastructure inverts and confirming pipe sizes to accurately depict the resulting peak flows? Are there any areas in particular where the GIS data provided was not sufficient? | Discussed during comment review meeting. Survey was collected by Wilson in 2022 for lines greater than 36" where no data was available or existing data was unclear. Surveyors were unable to pick up all inverts due to paved-over manholes and unknown connectivity but enough data was captured for the purposes of MDP-level study. Some assumptions have been listed in the report. |
| 87 | - | SWMM | cpajares | For Storge curves. Please be consistent with rounding approach on Area. | Updated. |
| 88 | - | SWMM | cpajares | Max depths at node dividers reported in the node summary are unusually high, about twice as much as the max depth set in the divider geometry table. This happens throughout both models (East and West). Can you please clarify why this is? Is this a bug from EPA SWMM or a result of the overflow link offset? Will this impact the resulting peak flows? | Discussed during meeting. This is an automatic depth calculated by EPA SWMM as a result of the overflow link offset. Offsets were used in this model to allow for accounting of both road slope and pipe slope. Per the SWMM model, bigger manhole depths and associated storage area in dual-drainage models like this one have minimal impact to peak flows. |

*Note: After the baseline hydrology comments were made by MHFD, it was decided that rain-on-grid analysis should be used to revise delineation and routing. Several subbasins were added and the numbering/naming convention was updated to prevent duplicates and maintain consistency. Additionally, the east and west SWMM models were combined for simplification purposes. Therefore, specific subbasin numbers referenced in the comments no longer apply. However,*

# Appendix B

# Hydrologic Analysis

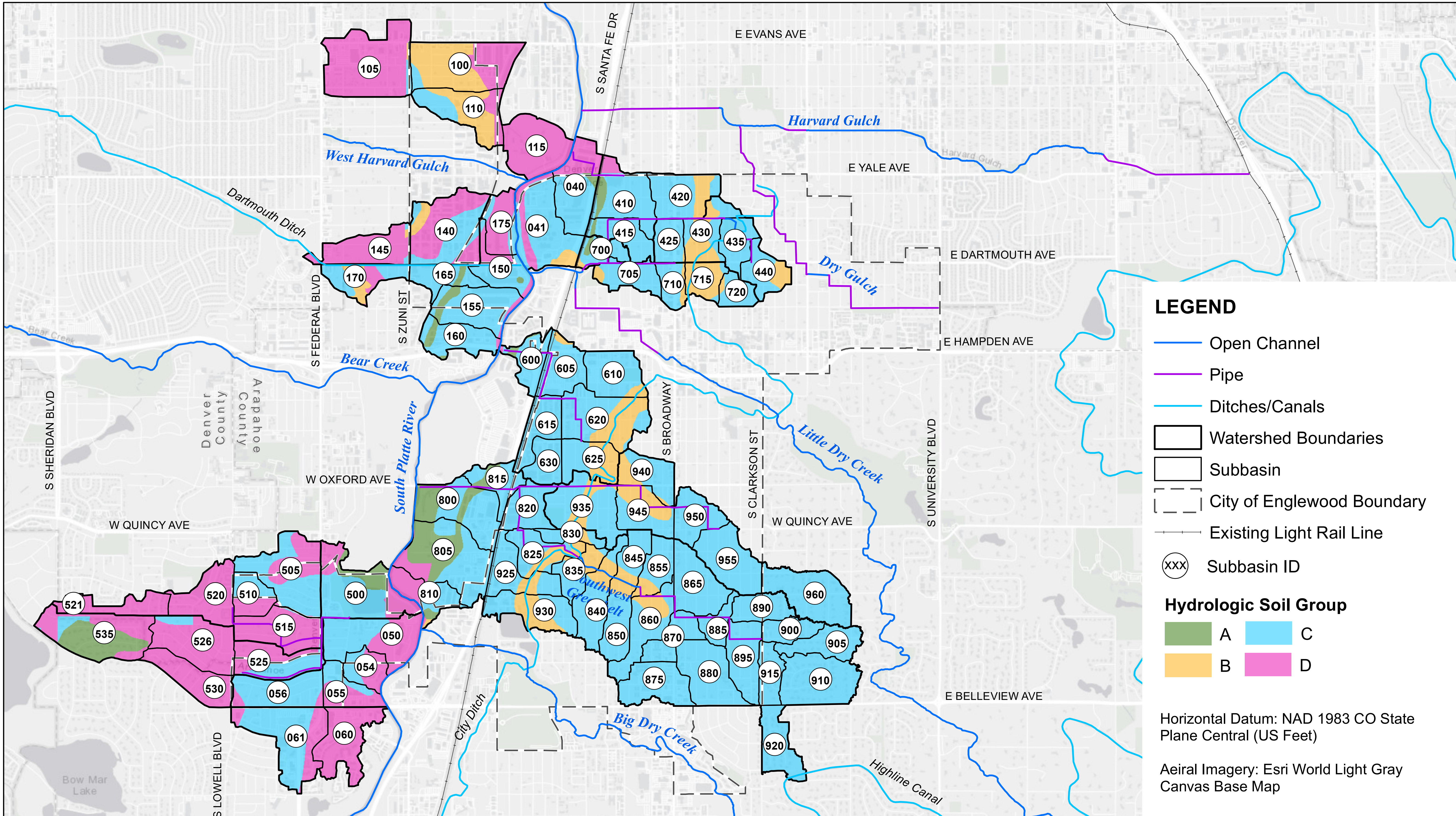


FIGURE B-1 SOILS MAP

N

0 0.25 0.5
Miles
1 inch = 0.5 miles

MHFD MILE HIGH FLOOD DISTRICT

Englewood COLORADO

CITY OF ENGLEWOOD
MAJOR DRAINAGEWAY PLAN

Dewberry

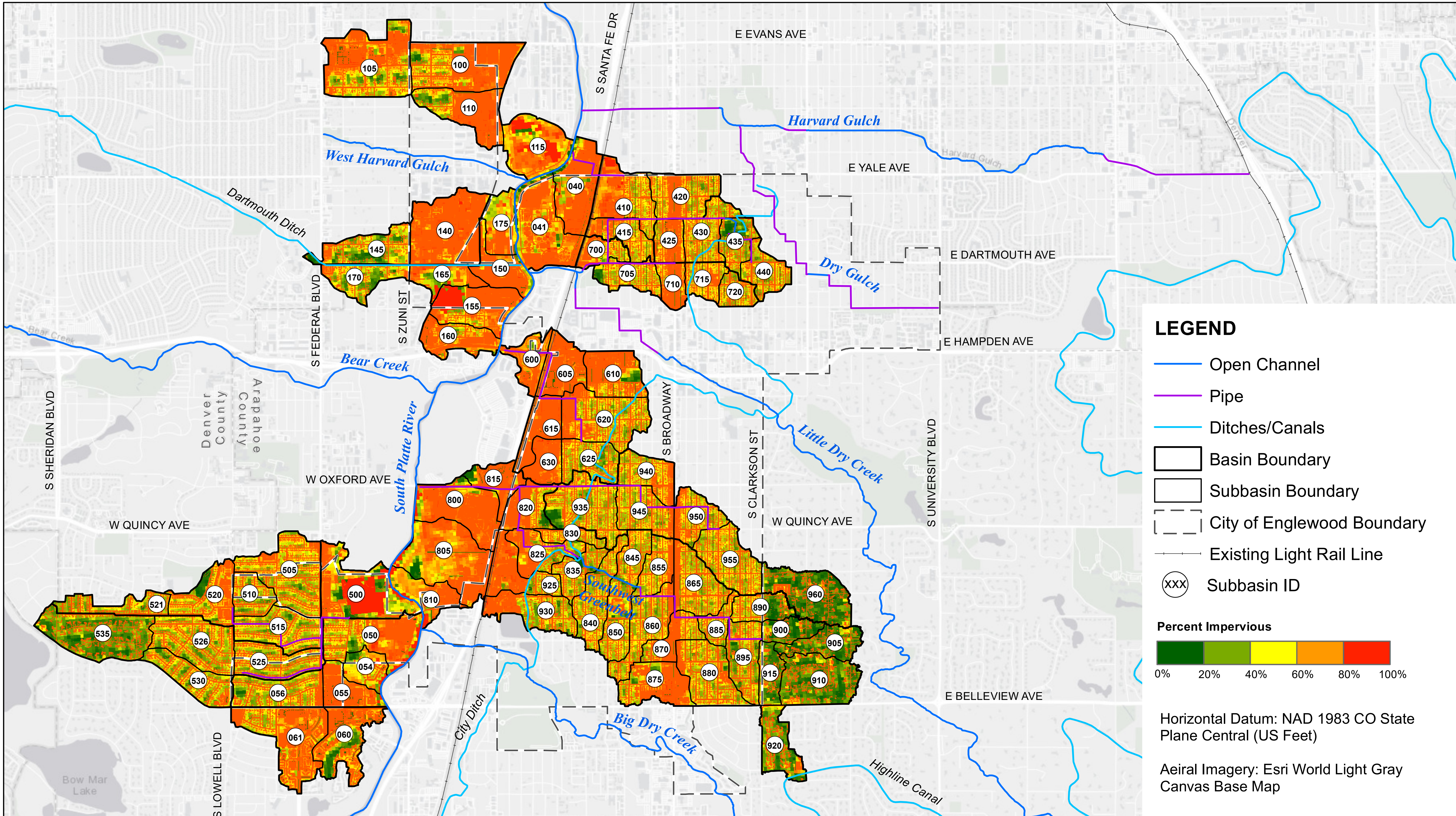


FIGURE B-2 EXISTING CONDITIONS LAND USE

N

0 0.25 0.5

Miles

1 inch = 0.5 miles

MHFD MILE HIGH FLOOD DISTRICT

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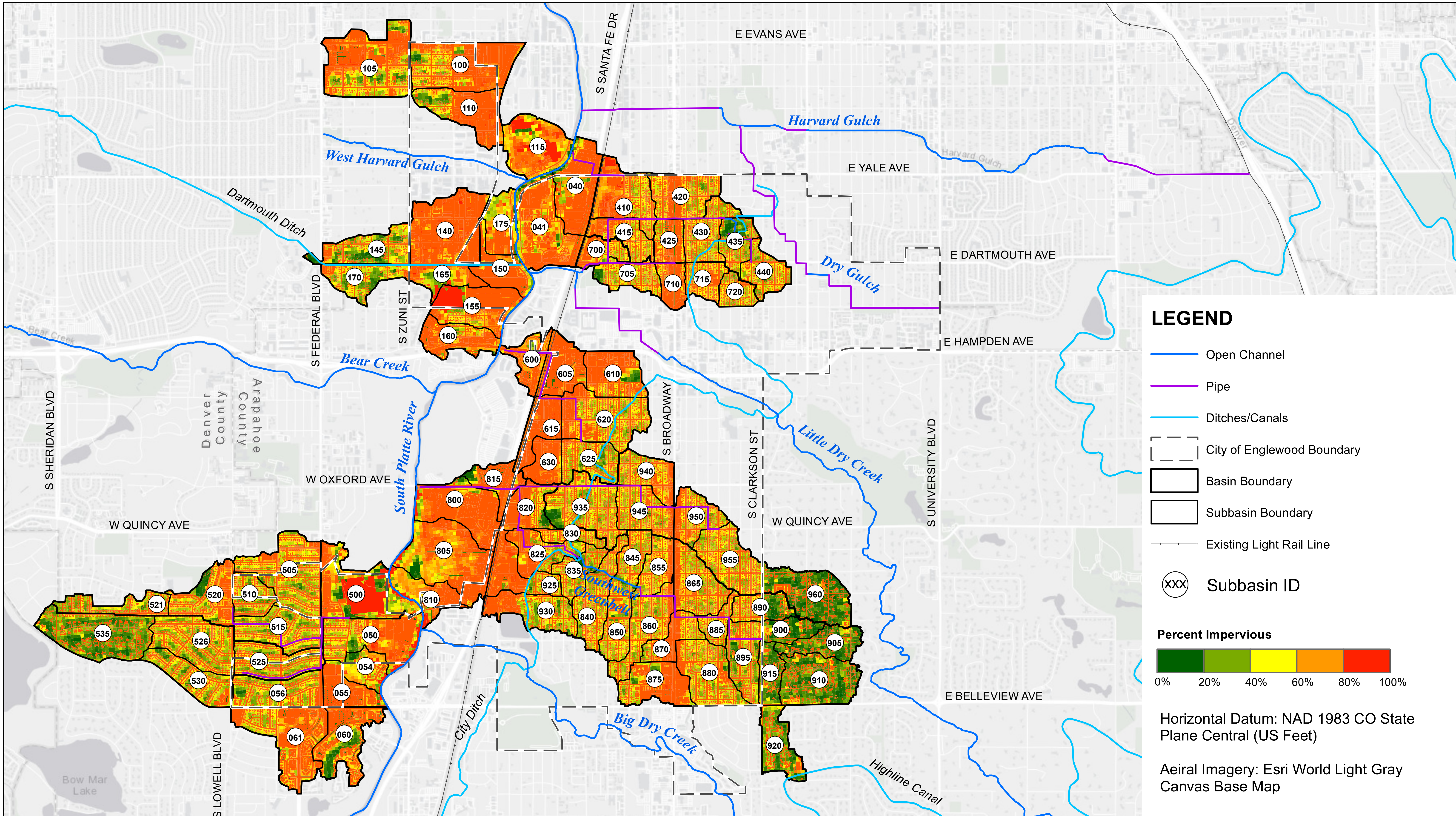


FIGURE B-3 FUTURE CONDITIONS LAND USE

N

0 0.25 0.5
Miles
1 inch = 0.5 miles

MHFD MILE HIGH FLOOD DISTRICT

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