City & County of Denver
Storm Drainage Master Plan

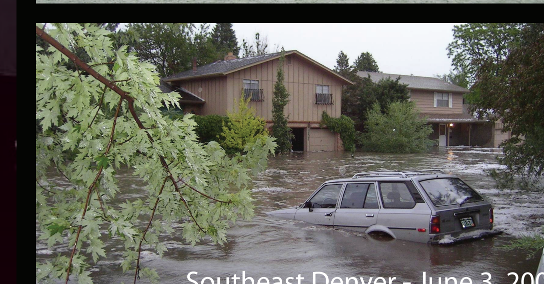
June 2009

Matrix Design Group Inc.
Integrated Design Solutions

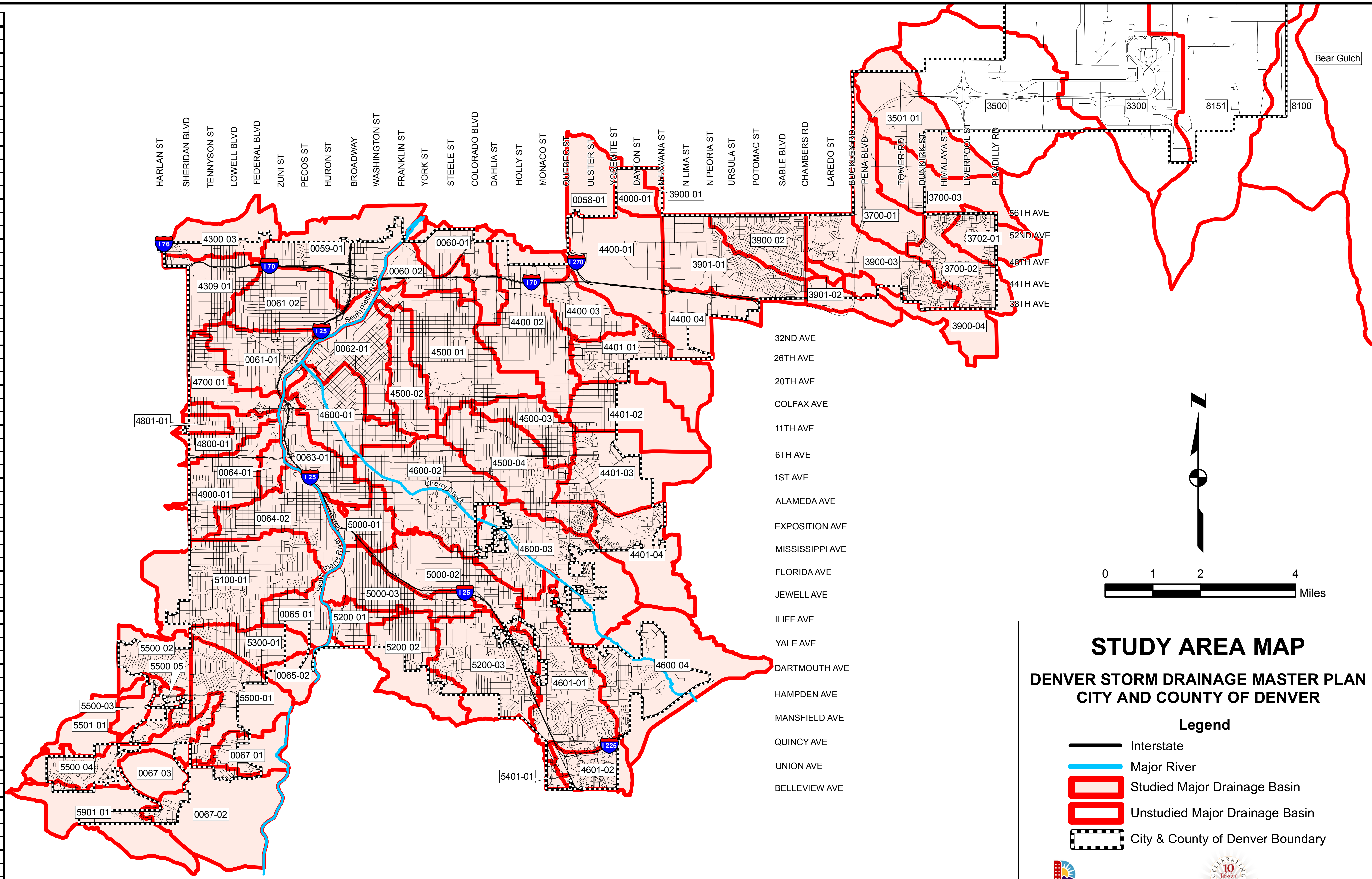
South Broadway - July 1998

Downtown Denver - 2002

North Central Denver - August 18, 2004



Southeast Denver - June 3, 2005



STUDY AREA MAP

DENVER STORM DRAINAGE MASTER PLAN
CITY AND COUNTY OF DENVER

Legend

- Interstate
- Major River
- Studied Major Drainage Basin
- Unstudied Major Drainage Basin
- City & County of Denver Boundary

DENVER THE MILE HIGH CITY

Matrix Design Group, Inc. An Employee Owned Company

DENVER STORM DRAINAGE MASTER PLAN

PROJECT CE21032

Adopted
City & County of Denver
Resolution No. 110, Series of 2009, October 5, 2009
City Clerk's Filing Number 09-964, October 1, 2009

Prepared for:
The City and County of Denver
Department of Public Works

DENVER
THE MILE HIGH CITY

Errata June 2010

Page	Basin	Comment
1		Table of Contents
6		Section 1.3.2: Additional studies
36-37	0060-01	Flow rates, potential ponding
38-39	0060-02	Flow rates, potential ponding
49	0062-01 / 4500-02	Potential ponding
96-97	4400-02	Flow rates, potential ponding
111-112	4500-01	Flow rates, potential ponding
117	4500-02 / 0062-01	Potential ponding
123	4600-02	Potential ponding

~~June 2009~~
Revised June 2010

Prepared by:
Matrix Design Group, Inc.
Integrated Design Solutions
1601 Blake Street, Suite 200
Denver, Colorado 80202
(303) 572-0200
(303) 572-0202 fax

This page left intentionally blank.

Table of Contents

ACKNOWLEDGMENT

The project team wishes to acknowledge the various individuals who assisted in the preparation of this 2009 update to the Storm Drainage Master Plan study for the City & County of Denver. A Technical Advisory Committee (TAC) made up of the project sponsors provided guidance during the study process. The TAC met regularly for the 2005 Master Plan and the 2009 updated version to provide valuable insight and direction to the study. The members of the TAC are:

Michael Anderson, Denver
Terry Baus, Denver
Peter Baertlein, Denver
Tom Blackman, Denver
Stephen Choi, Denver
Ted Christianson, Denver
Saeed Farahmandi, Denver
Mike Flick, Denver
Walt Hime, Denver
Frank Kemme, Denver
Dennis Ohlrogge, Denver
David Ridenour, Denver
Rick Stretz, Denver
Brian Schat, Denver
Randy Schnicker, Denver
Paul Tessar, Denver
Lesley Thomas, Denver
Kimberly Watanabe, Denver
Kevin Stewart, Urban Drainage & Flood Control District
Ken MacKenzie, Urban Drainage & Flood Control District

Cover Photo Credits:
Large photo: Flickr user dagpeak
(Creative commons license - http://creativecommons.org/licenses/by-nd/2.0/)
Historic: date and source unknown
Fire Trucks: date and source unknown
July 1998: Julie Federico
2002: source unknown
August 18, 2004: source unknown
June 3, 2005: Anna-Maria Sepulveda

The following members of the consultant project team contributed significant time and effort to the preparation of this updated master plan report:

Matrix Design Group, Inc. Team:
Stu Williams, Principal-In-Charge
Robert Krehbiel, Project Manager
Tim Fairbank
Wilson Wheeler
Ron Ramold
HungTeng Ho
Bryan Troester
Eduardo San
Jennifer Newby
Chris Martin
Jeff Clonts

1.0 BACKGROUND

1.1 Introduction

This publication is formulated in compliance with Denver Revised Municipal Code, Division 4, Storm Drainage, Section 56-110 Master Drainage Plan, dated August 1, 1982. Additionally, the document incorporates the practices and principles of Volumes I and II of the Urban Drainage and Flood Control District (UDFCD) ***Drainage Criteria Manual*** and City & County of Denver ***Storm Drainage Design and Technical Manual.***

This Storm Master Plan updates the 2005 publication with new Geographic Information Systems (GIS) data, including:

- 2006 Aerial Topography
- 2007 Imperviousness Surface Areas
- 2020 Land Use Classifications from Blueprint Denver
- Additional As-Built Storm Drain Infrastructure Data

This update process includes all of the City & County of Denver, except DIA, and provides a detailed evaluation of hydrologic conditions and conceptual-level design of drainage improvements within the following basins:

ID	OUTFALL	NAME/LOCATION	AREA (mi²)	FUTURE LAND USE COMPOSITE IMPERVIOUSNESS
0058-01	South Platte River	Prairie Gateway	1.58	40.65%
0059-01	South Platte River	Globeville - Utah Junction	3.66	64.50%
0060-01	South Platte River	I-70 & Colorado Boulevard	2.00	64.42%
0060-02	South Platte River	I-70 & York	1.40	64.53%
0061-01	South Platte River	27th & Federal	2.23	56.44%
0061-02	South Platte River	Highland	2.98	57.87%
0062-01	South Platte River	Lower Platte Valley	2.29	74.04%
0063-01	South Platte River	Central Platte Valley	2.03	73.75%
0064-01	South Platte River	1st & Federal	0.49	64.60%
0064-02	South Platte River	Valverde	2.65	61.14%
0065-01	South Platte River	Ruby Hill	1.25	55.45%
0065-02	South Platte River	Dartmouth	0.76	86.86%
0067-01	South Platte River	College View	1.29	55.17%
0067-02	South Platte River	West Belleview	0.88	49.65%
0067-03	No Outfall	Marston Lake	1.06	93.76%
3501-01	Second Creek	West Fork Second Creek	3.45	41.05%
3700-01	First Creek	Peña Corridor	2.23	52.09%
3700-02	First Creek	Green Valley Ranch	2.12	48.92%
3700-03	First Creek	Dogwood & Blue Grama Tribs.	2.61	61.13%
3702-01	First Creek	Tributary "T"	1.48	68.56%
3900-01	Irondale Gulch	Stapleton East Section 10	0.22	48.00%
3900-02	Irondale Gulch	East Montbello	1.91	47.55%
3900-03	Irondale Gulch	Parkfield	2.96	61.83%
3900-04	Irondale Gulch	Majestic Commerce Center	1.81	76.52%
3901-01	Irondale Gulch	West Montbello	3.27	66.50%
3901-02	Irondale Gulch	Gateway	0.97	60.25%
4000-01	Rocky Mountain Arsenal	Stapleton West Section 10	0.74	34.02%
4300-03	Clear Creek	North of I-70	1.81	50.39%
4309-01	Clear Creek	Berkeley Lake	1.83	46.59%
4400-01	Sand Creek	North Stapleton	3.86	62.74%
4400-02	Sand Creek	Quebec Corridor	4.41	62.55%
4400-03	Sand Creek	Stapleton	1.51	66.79%
4400-04	Sand Creek	East Stapleton	1.90	66.10%
4401-01	Westerly Creek	South Stapleton	3.01	49.09%
4401-02	Westerly Creek	11th Avenue to Montview	2.83	59.36%
4401-03	Westerly Creek	Lowry	3.52	41.74%
4401-04	Westerly Creek	South of Alameda	2.85	65.09%
4500-01	Montclair	City Park	4.28	46.52%
4500-02	South Platte	36th & Downing	1.74	56.39%
4500-03	Montclair	Park Hill - Colfax Avenue	1.49	52.20%
4500-04	Montclair	Park Hill - 6th Avenue	3.68	45.44%
4600-01	Cherry Creek	Central Business District	2.67	72.56%
4600-02	Cherry Creek	Cherry Creek Mall	4.57	52.40%
4600-03	Cherry Creek	Upper Cherry Creek	5.57	65.27%
4600-04	Cherry Creek	Cherry Creek Reservoir	5.74	49.99%
4601-01	Goldsmith Gulch	Lower Goldsmith Gulch	4.04	51.13%
4601-02	Goldsmith Gulch	Middle Goldsmith Gulch	1.34	64.43%
4700-01	Sloan's Lake	West Colfax Avenue	1.58	57.88%
4800-01	Lakewood Gulch	12th & Federal	1.18	51.58%
4801-01	Dry Gulch	12th & Sheridan	0.39	62.00%
4900-01	Weir Gulch	West 6th Avenue	2.33	50.12%
5000-01	I-25 & South Platte	West Washington Park	1.23	63.66%
5000-02	I-25	University & Mexico North	2.84	54.35%
5000-03	Florida	University & Mexico South	2.29	51.24%
5100-01	Sanderson Gulch	West Florida Avenue	5.56	49.45%
5200-01	Harvard Gulch	Harvard Gulch Lower Basin	0.85	54.72%
5200-02	Harvard Gulch	Harvard Gulch Middle Basin	2.75	47.38%
5200-03	Harvard Gulch	Harvard Gulch Upper Basin	3.84	51.11%
5300-01	West Harvard Gulch	West Yale Avenue	1.44	52.34%
5401-01	Greenwood Gulch	South Monaco Parkway	0.17	73.66%
5500-01	Bear Creek	Fort Logan	3.12	53.57%
5500-02	Bear Creek	Upper Bear Creek	1.86	44.34%
5500-03	Bear Creek	Academy Park Tributary	0.60	62.66%
5500-04	Bear Creek	Marston Lake North	2.24	42.93%
5500-05	Bear Creek	Pinehurst Tributary	0.70	42.08%
5501-01	Bear Creek	Henry's Lake	1.35	35.03%
5901-01	Dutch Creek	Coon Creek	3.09	53.67%
	TOTAL		152.38	
	AVERAGE			56.86%

1.2 Executive Summary

At the direction of Denver Revised Municipal Code, Division 4, Section 110, Denver's Storm Drainage Master Plan will be updated every 5 years to enable a 5-year planning cycle to be maintained. Consequently, the plan will be subject to regular modifications and holders of the plan are therefore encouraged to contact the City & County of Denver Department of Public Works Engineering Division, Capital Projects Management Group for the most currently available information.

Drainage basins at Denver International Airport (DIA) have been excluded from this 2009 update in accordance with DIA's independent implementation of its own storm drainage and water quality infrastructure.

Urban stormwater management within the City & County of Denver has increasingly become a critical infrastructure element as major improvement programs and asset re-development efforts are implemented across the city. The following Master Plan updates and refines the 2005 ***Storm Drainage Master Plan*** to reflect changes in land use densities and stormwater infrastructure. Existing conditions were modeled using the Colorado Urban Hydrograph Procedure (CUHP 2000) and Urban Drainage Stormwater Management Model (UD-SWMM) software developed by UDFCD. The Denver Land Use and Transportation (LUT) study produced ***Blueprint Denver: An Integrated Land Use and Transportation Plan*** (herein referred to as "Blueprint Denver"), which ostensibly prepares the City for continued urbanization and redevelopment. Also, the City has implemented a myriad of stormwater management programs to comply with the Municipal NPDES permit, including inventorying the stormwater systems and construction of local and regional Best Management Practices (BMP's). One of the major goals of this updated plan is the integration of these documents and programs into a comprehensive Public Works management program.

Adaptive Urban Stormwater Management

Traditionally drainage in the Denver Metropolitan Area has been managed with a combination of underground storm drains, overland flow conveyance elements (e.g. roads and channels) and regional detention facilities. Currently, it is Denver's policy to require drainage systems design to conform with the "Level of Service" goal of fully conveying, ***at a minimum,*** the minor or initial storm event within pipes or channels. "Minor" or "initial" storm is defined by the Denver Drainage Criteria as a 2-year storm event for residential properties and the 5-year storm event for commercial and industrial districts. Runoff from storm events exceeding the minor storm up to the 100-year storm is conveyed in streets up to 1 foot deep in the gutter or in surface drainageways. Open channels, gulches, streams, rivers and creeks are designed to convey the 100-year storm event. As the City & County of Denver continues to densify, land values have increased resulting in higher easement and right-of-way costs for open channels. Also, parks and other open space areas continue to be improved to provide a more active and urban setting that limits the availability of storage for stormwater detention. The City will continue to evaluate redevelopment areas for land acquisition for regional detention facilities to reduce peak flows. The conveyance system must accommodate and improve the "Level of Service" provided by City drainage infrastructure.

Current System Deficiencies

The study determined the capacity of the existing storm sewer drainage system within a majority of the older sections of the City & County of Denver correlates to between a 1 and 5 year system. Runoff generated from larger storm events is temporarily stored in streets and ultimately conveyed to gulches and streams via the combination of roads and storm sewers when capacity becomes available. Complaints records maintained by the City since 1990 indicate that annually there are a number of storms that result in limited flooding and property damage. The records do not show serious chronic flood hazards, but instead reveal a more regular pattern of problems related to maintenance and nuisance flows.

Initial hydrologic models show that the storage which exists within the City street provides important flood flow attenuation and, as a result, it will be important to phase improvements from downstream to upstream to avoid eliminating storage that would increase peak discharges upon existing systems below. The models also show that two distinct drainage basins exist: 1) basins delineated by storm sewer catchments for minor storm conveyance designs, and 2) overland flow basins that relate to larger storm events where mapping of potential inundation areas is appropriate to measure the risk of flooding posed by flooding streets or shallow non-regulatory floodplains. Because the minor storm system in many areas diverts flow from natural drainageways or contravenes topography, "split flow conditions" exist, whereby flow in pipes does not follow surface flow patterns.

Existing storm drainage infrastructure was considered deficient if the minor event flow was greater than 100% capacity of the infrastructure. Proposed infrastructure was designed to be 80% full when conveying the minor event flow.

Approaches to Providing an Upgraded Drainage System

The following criteria are used to evaluate storm drainage improvements:

- Maximize level of public safety and property protection
- Ensure compatibility with ***Blueprint Denver***
- Ensure compatibility with projected year 2020 land uses and needs
- Minimize negative environmental impacts such as 404 Permitting, NPDES Permitting, and other Clean Water Acts implications
- Maximize opportunities for water quality enhancement
- Minimize life cycle costs
- Support and be compatible with current capital improvement program for drainage and other Public Works programs
- Encourage and enable development participation
- Provide flexibility in phasing
- Minimize drainage impacts to transportation facilities, especially intersections, and high capacity roadway systems
- Minimize construction impacts to already developed properties
- Provide multi-means and multi-use facilities to the maximum extent possible, and
- Provide a document that is rational and likely to foster public and political support for drainage improvements.

Cost effective implementation of a city-wide 100-year drainage system is not practical because of the significant capital cost of retrofit construction and limited annualized flood hazard reduction. Consequently, a phased program is recommended that prioritizes improvements to address current hazards while improving the minor storm system.

This Storm Drainage Master Plan identifies capital improvements based upon the hydrologic modeling and the "Level of Service" goal. In many cases, meeting this goal requires upsizing an existing pipe by one or two pipe sizes. This master plan shows the capital improvement as a basis for evaluating, prioritizing and designing capital improvements. It is not intended in all cases to recommend removing the existing pipe and replacement with a larger pipe. ***Value engineering*** (beyond the scope of this master plan) will evaluate the condition of the existing pipe, potentially propose a parallel pipe, determine whether additional flow can be carried in the street, identify a new outfall and/or accept existing conditions where the cost/benefit ratio is less than one.

The proposed capital improvements, in general, are shown as complete replacement with a round pipe with conveyance capacity for the appropriate level of service based upon existing land use. Conflicting utilities and other constraints will necessitate drainage infrastructure equivalents such as box culverts, elliptical pipe or open channels. The assumed slope of the proposed pipe is either the same as an existing pipe, street grade or at 0.50%. Proposed pipe 48" or greater has been profiled as part of this Master Plan update and are included in the Technical Appendices. Slopes are chosen to avoid utility conflicts. Shallower slopes, determined during preliminary design, may necessitate larger pipes/box culverts.

Denver's drainage criteria require all storm pipes to be reinforced concrete pipe (RCP). Many of the older existing drain pipes were constructed with brick or other materials such as vitrified clay pipe (VCP). Evaluating the material or age of existing pipes is beyond the scope of this project, and replacement is based upon capacity rather than condition. Denver maintenance forces will need to compile a separate inventory of capital improvements based upon pipe degradation.

All existing collector storm pipes must be 18-inch diameter or larger according to Denver Drainage Criteria. (15-inch pipe is allowed only if no more than one inlet is connected to the pipe.) Therefore, all storm pipes less than 18-inch diameter and longer than 100-feet (assumed to represent collector pipes rather than laterals) have been queried in the GIS and shown in this capital improvement program as replacement with new 18-inch RCP.

1.3 Goals of the Storm Drainage Master Plan

1.3.1 Management Interviews

To provide direction to the planning process and capitalize on the extensive experience and knowledge of staff, selected members of the City Public Works and Planning Departments were interviewed in 2002 and 2003. The following questions were posed to these stakeholders:

<u>What are the Primary Drainage Issues confronting the City?</u>

- In many areas, the existing City drainage system does not meet current drainage criteria, whereby the initial storm (2-year recurrence for residential areas and 5-year recurrence for commercial/industrial areas) cannot be fully conveyed within pipes or dedicated drainage channels. In other words, the current drainage system is generally undersized except for the major drainageways, which have been improved over the years (e.g. South Platte River, Goldsmith Gulch, Harvard Gulch),
- It is impractical and prohibitively expensive to upsize the storm drain system on a City-wide basis to provide for a 100-year storm,
- The Master Plan needs to understand the implications of redevelopment. Major projects such as Stapleton or Lowry benefited from scale economies and private-sector developer investments to construct new improvements to outfall to major drainageways. Smaller redevelopment projects such as those within North Cherry Creek basin or lower downtown lack the financing and cohesion to build regional drainage systems, and
- Because the existing drainage system consisting of a combination of storm drains and surface street flow does not strictly satisfy 100-year standards, City staff must review waiver requests on a regular basis and need a decision-making tool for evaluating the reasonableness of proposals.

<u>What Are the Goals for the Master Plan Update Process?</u>

- Create optimal value with the master plan to capitalize on available revenues from the drainage enterprise fund while providing the greatest reduction in flood hazards,
- Ensure that facilities are designed to be maintainable, and that a commensurate budget for on-going maintenance is anticipated and provided for,
- Encourage the use of multi-purpose facilities such as incorporating linear parks within riparian corridors and co-locating detention facilities within other municipally owned properties or parks,
- Provide a framework document that informs developers of potential drainage deficiencies within project areas so that property values reflect the risk of flooding or level of capital investment required to address stormwater management issues,
- Provide a "toolbox" for reviewing development proposals (including waiver requests when appropriate), including access to background information used in the plan and hydrologic models that may be modified by staff as more specific development proposals are made within each, and
- Provide a framework for continued urbanization of the City & County of Denver and implementation of the concepts and tenets of ***Blueprint Denver: An Integrated Land Use and Transportation Plan***.

<u>What Threats or Obstacles Would Prevent Denver From Obtaining This Goal?</u>

- The relatively short timeframe and broad expanse of the study area poses a major challenge to evaluation of the basins in a street-by-street detail. Hydrologic modeling should be developed in sufficient detail to support the conceptual design and sizing of infrastructure. There should not be an effort to develop new technology or precisely define urban floodplains.
- Because the City has limited enterprise funds for construction of new facilities, a 100-year storm drain system will likely be unachievable in most drainage basins. The plan needs to establish a rationale for appropriation of funds based upon current level of service drainage criteria.

<u>What is an Appropriate Measure for Success of the Update Process?</u>

- Completion of the Master Plan with enough detail to validate or justify modification of the City's current CIP,
- Establishment of a framework for screening options and supporting a preferred plan for implementation, and
- Creation of a document that is usable and provides for continued update by the City's GIS and annual storm drainage master plan update process.

1.3.2 Additional Studies

In accordance with Denver Revised Municipal Code (DRMC) Section 56-110(c), the City and County of Denver as a matter of course conducts additional studies as may be necessary to determine the most cost-effective approach and the estimated costs of constructing the drainage facilities shown on the master plan which do not presently exist.

1.4 Objectives of the Storm Drainage Master Plan

1.4.1 Criteria for Screening Evaluation

In order to identify potential solutions and to screen alternatives for selection of a preferred approach, technical working groups were challenged with establishing specific goals and objectives against which alternatives could be measured for achievement. The proposed alternative matrix showing the achievement (high, moderate, and low) is shown in the table on the following page.

CITY AND COUNTY OF DENVER STORM DRAINAGE MASTER PLAN UPDATE

Alternatives Ranking Matrix

	OBJECTIVES												
	Safety	*Land Use*			*Environmental*	*Capital Budgeting*				*Infrastructure*		*Economic*	*Political*
ALTERNATIVE	Maximizes Level of Property Protection or Public Safety	Compatibility with BluePrint Denver	Compatibility with Current Land Uses	Reduces Permit Requirements	Minimizes Negative Environmental Impacts	Minimizes Construction Costs	Supports Current Capital Improvement Program	Enables Developer Participation	Provides Flexibility in Phasing	Minimizes Drainage Impacts on Transportation	Provides Multi-Purpose Benefits	High Benefit Cost Ratio	Galvanizes Public Support
1. No Action: Maintain Existing Condition	Low	Low	Moderate	High	High	High	Low	Low	High	Low	Low	Moderate	Moderate
2. Enlarged/Stabilized Open Channels	High	Moderate	Moderate	Low	Low	Moderate	Moderate	Moderate	Moderate	High	Moderate	Moderate	Moderate
3. Replace/Enlarge Ex. Storm Sewers	High	High	Moderate	Moderate	High	Low	High	Moderate	Moderate	High	Low	Low	Moderate
4. Construct New Storm Sewers	High	High	Moderate	Moderate	Moderate	Low	Moderate	High	Moderate	High	Low	Low	Moderate
5. Enlarge Existing Regional Detention	High	Moderate	Low	Moderate	Moderate	Moderate	Low	Moderate	High	Moderate	High	High	Moderate
6. Construct New Regional Detention	High	Moderate	Low	Moderate	Low	Moderate	Low	Low	High	Moderate	High	High	Low
7. Enlarged Bridges or Culverts	High	High	Moderate	Moderate	Moderate	Low	Moderate	Moderate	Moderate	High	Low	Moderate	Moderate
8. Improve Intersections	Moderate	High	High	High	High	Moderate	High	Low	Moderate	High	Low	Moderate	Moderate
9. On-Site/Rooftop/Underground Detention	Low	Moderate	Moderate	High	Moderate	Moderate	Low	High	High	Low	Low	High	Moderate
10. Acquire/Control Flood Prone Property	High	Low	Low	High	Moderate	High	Low	Low	High	Low	Moderate	High	Low
11. Floodproofing	Moderate	Low	High	Moderate	High	High	Low	High	High	Low	Low	High	Moderate
12. Obtain Flood Insurance	Moderate	Moderate	High	Moderate	High	High	Low	High	High	Low	Low	High	Low

Key: High Achievement
Moderate Achievement
Low Achievement

1.5 Plan Formulation

1.5.1 Geology

The City of Denver is built across the deepest part of the asymmetrical Denver basin, which was formed and filled during late Cretaceous and early Tertiary periods. Deep wells have not been drilled into the pre-Cambrian metamorphic rocks in this part of the basin, but seismic data reveals that this formation lies about 13,000 feet beneath the surface. The sandstone, shale, limestone, and other sedimentary rocks that occur between the basement formations and the surface, range in age from Pennsylvanian to Paleocene. Many small faults probably are present in these sediments, although very little is known about the formations below the Denver area. Most outcrops of bedrock in Denver consist of the Denver formation of Paleocene Age, although the Arapahoe Formation of Cretaceous Age outcrops in the low areas near the South Platte River. These two formations are similar in lithology and were deposited as a result of alluvial action, torrential floods, and dilation in quiet lakes. Overlying the bedrock surface at most places is a relatively thin covering of unconsolidated surficial materials composed of boulders, cobbles, gravel, sand, silt and clay. The surficial alluvial material making up the floodplain and terraces of the South Platte River is predominantly sand and gravel with some silt and clay beds. Figure 1 illustrates the bedrock topography for the downtown area of the South Platte River, Cherry Creek, and Sand Creek. This map identifies a paleo-channel alignment of Cherry Creek primarily through what now has been defined as Basin 4400-02.

1.5.2 Climate

The Lower South Platte drainage area experiences a climate commonly known as a semiarid continental type. The area is characterized as a zone of transition from a plains to a foothills climate. The area has cold, dry winters and cool, relatively dry summers. Typically, there are low precipitation rates and humidity, pronounced variations in diurnal and seasonal temperatures, and periods of high winds.

Average annual temperature is around 49° with a recorded high in 1939 of 104° and a low of –30° recorded in 1936. Diurnal fluctuations usually range from 26° to 29° for most months; however, around July daily fluctuations can be as much as 31°. A wide average range in daily temperatures is typical of the high plains. Extremely hot weather in summer or extremely cold weather in winter generally does not last long and is followed by more moderate temperatures.

Annual precipitation averages about 14.2 inches. More than two-thirds of the precipitation falls from April to September, which is the average annual growing season. On average, Denver experiences about 75 storm events annually. Of these 75 events, about 46 on an average annual basis produce less than 0.1 inch of precipitation. About 22 of the remaining 29 runoff-producing average annual events total between 0.1 inches and 0.5 inches of precipitation. Typically, Denver experiences only 7 large storm events (greater than 0.5 inches) annually. These significant storm events are characterized by short duration, high-intensity rain showers that overwhelm the existing drainage system for several hours.

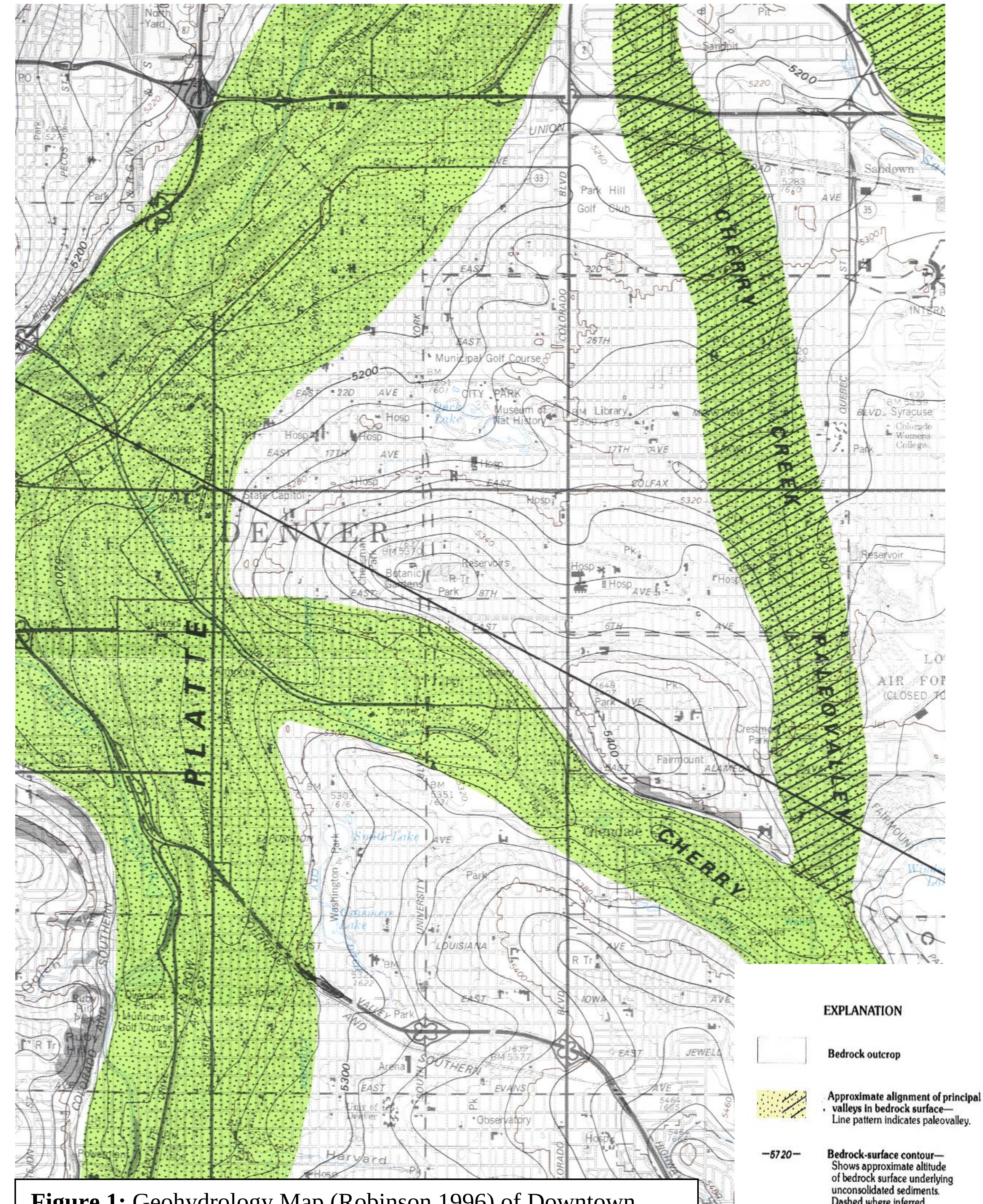


Figure 1: Geohydrology Map (Robinson 1996) of Downtown Denver showing bedrock contours and evidence of historic channel alignments. The map shows Cherry Creek once flowed through Basin 4400-02 between Quebec and Colorado Boulevard.

The driest months are December through January. Average annual snowfall at Denver is about 59 inches. Humidity averages about 39% during the day and 62% during the night. Humidity is slightly higher in winter than in summer. The sun shines approximately 69% of the possible sunlight hours annually.

Wind speed averages about 5.9 mph, and upslope winds predominate from the south and west. An average wind speed is not adequate to describe conditions in the area. Low wind conditions have been experienced and often contribute to air pollution problems. High velocity winds often destroy trees, crops, and structures, and winds in excess of 90 mph have been recorded.

1.5.3 Topography

The South Platte River Drainage Basin can be divided into a plains region and a mountain region. The plains exhibit a trellis drainage pattern; streams flowing in alluvial channels. The mountain regions are characterized by a dendritic drainage pattern.

The Lower South Platte drainage area topography represents flat to gentle undulating plains with elevations ranging from 5,650 feet in the southeast to 4,950 feet in the floodplain of the South Platte River. Drainage from the west flows easterly from the foothills into tributaries of the South Platte River. On the east side of the South Platte River in the Denver area, major drainage flows lead from southeast to northwest by way of Cherry Creek, Sand Creek and Harvard Gulch.

1.5.4 Flood History

The City & County of Denver and surrounding metropolitan areas lie within the watershed of the South Platte River. The drainage area above Denver comprises approximately 3,800 square miles. Existing development within the floodplain is essentially industrial and has taken place in areas previously devoted to gardening and farming. Residential areas within the historic floodplain include Globeville, Valverde and scattered smaller developmental areas.

Numerous flood control and mitigation measures have been implemented throughout the years to reduce the flood hazards. In 1901 Mayor Speer suggested constructing walls along Cherry Creek, the first ordinance was passed in 1908, and construction was completed in November 1915. A Cherry Creek Flood Commission was appointed in 1912 and recommended a dam with reservoir capacity of 12,000 acre-feet. However, the Castlewood Dam built on Cherry Creek in 1890 failed in August 1933. After the 1933 flood, City officials decided to build a flood control dam at Kenwood. Also during this time, Works Progress Administration (WPA) workers straightened and riprapped the Cherry Creek banks. In 1950, the U.S. Army Corps of Engineers completed Cherry Creek Dam 1,000 feet upstream from Kenwood Dam.

June 1965, the South Platte River severely flooded Denver. Following the flood, several steps were taken to mitigate the effects of flooding from such an event. Congressional support was sought to build Chatfield Dam as a flood control structure. The Mayor of Denver constituted a South Platte River Development study group to develop a plan for the Platte River Valley that would incorporate various flood control measures. Several private groups in the community organized themselves to provide support for the planning effort. The preliminary report for Chatfield Dam was issued in December of 1965 and construction was completed in 1973.

The following is a summary of the major storm and flood events in the Denver metro area:

May-June 1844 – The earliest flood for which circumstantial evidence is available occurred in 1844. The bottomlands in the vicinity of Denver were covered in water “extending from the bluff on Cherry Creek to the extreme bluff on the South Platte River” according to Major James Bridger in a June 22, 1864 article in the Denver Commonwealth.

May 19-20, 1864 - Heavy rain over the upper basin of Cherry Creek caused 19 deaths along Cherry Creek and the South Platte River in Denver. The flood from May 18 combined with this flood and covered the lower sections of the city with 1 to 5 feet of water. The flood washed out several bridges and swept large buildings off their foundations. Property damage from the flood was estimated at approximately one million dollars.

July 14, 1912 – A thunderstorm with heavy rain in the late afternoon combined with a similar storm south of the city to produce widespread flooding on Cherry Creek in downtown Denver and resulted in two deaths. The flooding in Denver was the worst since 1864 and covered approximately 3 square miles of lower downtown. Bridges along Cherry Creek were washed out and water lapped at the floor of the Broadway Bridge over the South Platte. The floodwater caused great damage to the sewerage system, parkways, bridges and to residences and commercial warehouses near Cherry Creek. Flood damage was estimated at several million dollars.

May 21, 1914 – A severe thunderstorm produced heavy rainfall of 0.83 inches in 15 minutes. Flooding caused considerable damage to bottomlands in eastern and southern parts of Denver.

June 2-7, 1921 – During April the snowfall had been unusually heavy, approximately three times its normal depth for that month. Rainfall measurements in the foothills ranged from 3 to 5.5 inches from June 2 through 7. The South Platte River in the canyon reached a stage of 9 feet and washed out the tracks of the Colorado and Southern Railroad. The bottomlands in the valley below Denver were flooded, with the overflow being as much as 4 miles wide near Sterling. The overflow reportedly stretched the 43 miles from the mouth of the canyon to Denver.

August 2-3, 1933 – 3 to 9 inches of rain in 9 hours caused Castlewood Dam on Cherry Creek to fail. Seven people died in Denver. Damage was estimated at 1 million dollars.

September 10, 1933 – A cloudburst occurred over the South Platte River between Denver and the foothills, with the center over Plum Creek, Little Dry and Big Dry Creek basins. Although information on tributary flows is limited, it was estimated that the Plum Creek discharge downstream from the confluence of the East and West branches was about 30,000 cubic feet per second attenuating to about 5,500 cubic feet per second at the mouth. On Cherry Creek a peak value of about 15,000 cubic feet per second was estimated to have occurred near the mouth while upstream near the site of the Cherry Creek Dam, a peak of 34,000 cubic feet per second was estimated. The peak values on Cherry Creek were partially the result of failure of a small dam located in the upper reaches of the basin. On the South Platte at the U.S.G.S. stream gaging station at Denver, the peak discharge was 22,000 cubic feet per second, which was the largest flood on record prior to the 1965 event (gaging station established in 1895).

May 1942 – Heavy rains caused extensive damages along the South Platte River. The high water destroyed five bridges including those at West Evans and West Mississippi.

August 2-3, 1951 – Almost 3½ inches of rain fell on the Denver Metro area.

July 9, 1953 – Heavy rains caused an estimated 2 million dollars damage from flooded stores and basements across metro Denver. The floodwaters reached a depth of 3 feet on streets in some sections of the city, damaging streets and automobiles. The heavy rainfall at Lowry Air Force Base totaled 3.9 inches.

July 30-August 3, 1956 – Up to 12 inches of rain fell in five days in the Denver area and on the western slope, causing $5 million in damage.

June 16, 1965 -- Black Wednesday, the day Denver was hit by the worst natural disaster in the city's history. After a cloudburst that dumped 15 inches of water on mountain slopes southwest of Denver, a devastating flood struck 20 counties, including Denver along the South Platte River. Twenty-five people were killed, and property damage was estimated at more than $500 million. Since that time, Chatfield and Bear Creek Dams have been constructed greatly reducing the flood threat to Denver from precipitation over major sub-drainage basins.

July 23, 1965 – Heavy rains in Aurora washed out earthen bridges over Sand Creek. Several highways were washed out to the east and southeast of Denver.

July 24, 1965 – Heavy rain fell over all of the Denver and Aurora areas, causing some flooding of roads, streets, and bridges.

July 7, 1967 – A storm caused flood damage in southwest and south Denver. Unofficial reports indicated rainfall of 2 inches in 30 minutes and more than 3 inches total from the storm. Streets and buildings were flooded by the heavy runoff. Hail in some areas contributed to flooding by blocking storm drains. Water reached a depth of 5 feet in the street. Police rescued numerous stranded motorists. In southwest metro Denver, 100 to 150 homes were flooded, and there was one fatality.

May 4-12, 1969 – Heavy rains caused flooding on the South Platte River in Denver.

June 8, 1969 – Heavy rain flooded streets and underpasses throughout metro Denver. The heaviest amounts of rain fell in south Denver and Englewood, where unofficial totals of 5 to 6 inches were reported. Mud, debris, and hail carried by the heavy runoff clogged drains and increased the amount of flooding. Approximately 40 cars and a large truck were inundated at an underpass on I-25, and several more were inundated or buried in mud in other areas. A large number of basements were flooded and streets and highways were heavily damaged in some areas.

June 11, 1970 – Over 3 inches of heavy rain flooded streets and underpasses throughout metro Denver.

May 5-18, 1973 - Prolonged rains of up to 6 inches on May 5th and 6th in the South Platte Basin, along with melting of a large snow pack, produced major flooding during the next two weeks along Clear Creek, Sand Creek, and the South Platte River in the Denver metro area. One person died and damages were estimated at around 120 million dollars.

July 20, 1975 – Heavy rains caused flash flooding across metro Denver, resulting in the closing of several streets and damage to numerous homes and businesses.

June 13, 1984 – One of the worst hailstorms ever experienced in metro Denver occurred. Torrential rains with as much as 4.75 inches in Lakewood clogged drains and caused widespread damage from flooding. There was one fatality.

May 16-17, 1995 – Significant moisture and upslope flow caused flooding across metro Denver. Moderate to heavy rains which began on the evening of the 16th developed in the foothills and spread eastward over metro Denver throughout the night. After the spring floodwaters receded, the Colorado Water Conservation Board (CWCB) and the Colorado Office of Emergency Management reported 15 flood-related deaths statewide and damage estimates approached $20 million.

June 4, 1995 - The heaviest measured rainfall was from a gauge operated by the Pinehurst Golf and Country Club located in southwest Denver where a reported 3.2 inches fell in less than one hour. Residential flooding and storm drainage problems were reported along a small south-bank tributary to Bear Creek. The June 4th storm also caused flood problems in other parts of Denver, Englewood and Sheridan. This single thunderstorm produced the highest peak flows for the year along lower Bear Creek and the South Platte River through Denver.

July 19, 1997 - At approximately 4:00 p.m., a severe thunderstorm in NE Denver and NW Aurora produced 3.83 inches of rain in less than an hour, exceeding the official Denver one-hour record of 2.2 inches set on August 13, 1921. This storm was accompanied by copious amounts of hail with stone diameters reaching 1.25 inches. Westerly Creek, a tributary to Sand Creek that enters the old Stapleton International Airport property from the south, flowed out of its banks and nearly overtopped Montview Boulevard. The Montview culverts are designed to safely pass a 10-year flood, a project completed by Denver, Aurora and UDFCD in 1980.

July 27, 1997 - Between 3:00 and 4:00 p.m., Goldsmith Gulch in Denver was hit by heavy rains with 1.66 inches falling at the Denver Tech Center (DTC). Downstream floodwaters approached 10-year levels causing the recently completed side-channel detention facility near Iliff Avenue to function. This flood control facility, constructed by Denver and UDFCD in 1996 was credited with preventing damages downstream. Local residents were pleased with its performance. A minor glitch did occur, however, when the pump that drains the facility failed to start. Denver Wastewater Management Division officials corrected the problem the next day.

The Eastman Avenue ALERT gage peaked at 4 p.m. at a depth of 7.4 feet with an estimated discharge of 1670 cfs, exceeding its prior record of 1470 cfs (8/2/91). The Temple Pond gage at the DTC had a maximum water depth of 8.2 feet and a peak outflow of 470 cfs.

Iliff Stormwater Detention Basin on Goldsmith Gulch

July 28, 1997 - Some significant flooding occurred in Denver with Goldsmith Gulch being hit hard for the second consecutive day, exceeding the prior day's peak at Eastman Avenue by one foot and setting a new record of 2040 cfs at 6:30 p.m. Upstream at Temple Pond, Goldsmith floodwaters pooled to a depth of 9.5 feet releasing 500 cfs. Downstream of Eastman at Yale Avenue the peak flow was estimated at 1850 cfs and classified as a 10-year event. According to the Goldsmith Gulch design hydrology model, the discharge at Eastman approached the 50-year mark. As with the previous day's storm, the Iliff detention facility and improved channel reaches performed as designed, preventing significant damages. By 9:00 p.m., Goldsmith Gulch floodwaters had combined with Cherry Creek flows causing the Market Street gage in lower downtown Denver to measure its new record peak of 3200 cfs. The Cherry Creek gage at Steele Street also set a new record at 2350 cfs. Heavy rains in other parts of Denver and Aurora caused localized flooding of many roads, parking lots and basements.

Goldsmith Gulch downstream of Yale Avenue on July 28, 1997.

July 29, 1997 - Late evening rainfall on July 28 caused the Sand Creek ALERT gage to measure a new record flow of 4200 cfs at 2:47 a.m. (see July 19 discussion). At Sand Creek Park near its crossing with I-225, the pedestrian trail crossing was overtopped by 4.4 feet, and the discharge was estimated at 3480 cfs, another ALERT gage record. A parking lot flooded at Quebec Street and Leetsdale Drive in Denver to the point that a car was found floating in it.

August 11, 1997 - Hail depths of up to 2 feet, driving rains and high winds caused an estimated $150-million in damage in Lakewood and Denver. A rainfall amount of 1 inch in 10-minutes was measured by the Cherry Creek gage in downtown Denver, and after the hail melted, the total measured precipitation exceeded 2 inches. Cherry Creek flowed wall-to-wall at a depth of approximately 5 feet with a peak discharge of 2640 cfs. This was the second highest measurement for Cherry Creek for the year, exceeded only by the July 28 event.

September 4, 1997 - Cherry Creek flowed wall-to-wall. Five rain gages had alarmed (1 inch in less than 1-hour) by 9:45 p.m. The locations and amounts were accurately reported to the public at the start of the 10 p.m. broadcast.

July 24, 1998 - Heavy rains that occurred during the evening caused problems in Denver with flooded basements, stranded drivers and downed power lines. A forecaster for the NWS measured 3 inches in 30 minutes at his home near W. 38th Avenue and Federal Boulevard. The railroad viaduct near 38th and Fox (Basin 0061-01) trapped motorists in water 4 to 5 feet deep. This notorious flood area has been less of a problem in recent years due to drainage improvements completed by Denver and UDFCD, but this storm clearly exceeded the design rainfall amounts.

July 30, 1998 - Denver streets flooded, zodiac boats were needed for rescues at "Lake Logan" (Logan Street underpass of I-25) and a kayaker was rescued from the South Platte at Santa Fe.

July 31, 1998 - A flash flood watch was issued by the NWS shortly after 2 p.m. for the entire Front Range from Colorado Springs to Fort Collins. In Denver, street flooding damaged private property in the vicinity of Evans Avenue and Lipan Street.

April 29-May 1, 1999 - On April 30 and May 1, the NWS issued flood watches for the South Platte River and other large Denver area streams. Gradual rises in river stage were observed due to relatively high rainfall accumulations over the prior week. Englewood Dam recorded a record high water depth of 16.2 feet on April 30. Spillway flows begin at a depth of 40 feet. Flood control improvements to this District-owned, normally dry detention dam were completed in 1976.

July 31, 1999 - Martin Luther King Boulevard in the Park Hill area of Denver was barricaded due to flooding between Colorado Boulevard and Quebec Street. However, this measure did not stop six motorists from driving into the flooded area and stalling. Sand Creek recorded its annual peak while the Havana Park detention facility in the Westerly Creek basin overflowed into neighborhood streets. Thunderstorm rain in Denver and Aurora exceeded one inch at 8 gaging stations with 1.69 inches occurring at Horseshoe Park in Aurora.

August 10, 1999 - In the Denver area, more than 3 inches were reported to have fallen in less than an hour. The highest ALERT rain measurement was 2.52 inches, near I-225 and Sand Creek in Aurora. In addition to the wind and rain, hail and lightning caused problems for many areas including DIA.

August 17, 2000 - Denver Fire Fighter, Bob Crump, died in the line of duty after rescuing a woman from floodwaters in the vicinity of E. 49th Avenue and Colorado Boulevard (Basin 0060-01). Mr. Crump lost his life after being pulled into a submerged open 36 inches storm sewer. The storm at this location was estimated to be a 75-year event. The flooding that was realized this day was somewhat unexpected. Morning analysis indicated minimum flood potential, but weather conditions changed substantially by mid-afternoon. Within 10 to 15 minutes, heavy rainfall was occurring over northern Douglas County and the Littleton area. By 4 p.m., the NWS had issued an urban and small stream flood advisory for this storm and at 4:37 p.m. the advisory was upgraded to a flash flood warning for a large portion of the Denver metropolitan area.

May 3-5, 2001 - Three days of steady upslope rain saturated soils along the Front Range. Rainfall amounts totaled 2 to 3 inches over much of Denver causing some minor street flooding while larger streams like Cherry Creek and the South Platte River rose above normal. Two reservoirs monitored by the ALERT system recorded their annual peaks on May 5.

June 20, 2001 - At 7:20 p.m., heavy rain and damaging hail struck DIA causing major damage. Between 40 and 50 mobile homes were also damaged in the Watkins area.

July 8, 2001 - Serious street and stream flooding hit Denver between 4 and 6 p.m. The storms were accompanied by high winds and small hail. Flash flooding was observed on Harvard Gulch, Goldsmith Gulch, Cherry Creek, the South Platte River, and along I-25 where the infamous "Lake Logan" (Logan St./I-25 underpass) once again stopped traffic. The Harvard Gulch at Jackson Street rain gage measured the heaviest rainfall of 0.67 inches in 5 minutes and 2.48 inches in an hour.

Goldsmith Gulch upstream of Mexico Avenue on July 8, 2001.

July 23, 2001 - A highly localized storm impacted rush hour traffic around the Denver Tech Center. Hail, wind and rainfall amounts exceeding 1.2 inches in 30 minutes slowed travel on I-25 and I-225. Funnel clouds were also reported. The South Platte River gage at Union Avenue recorded its record flow for the year.

August 5, 2002 - A heavy thunderstorm near DIA set a record high water level for the 2-year-old ALERT stream gage on Third Creek. The rain gage at that station measured 2.36 inches and prompted the NWS to issue a flash flood warning. Most of the metro area received less than an inch of rain while two gages in the Bear Creek basin measured over an inch.

September 13, 2002 - Once again the I-25/Logan Street underpass was inundated by stormwater - this time disrupting traffic for over 3 hours during evening rush hour. A number of motorists were rescued from their vehicles. Rainfall totals 1.06 inches to 1.18 inches were measured near the I-25 corridor between the Denver Tech Center and Broadway. The Transportation Expansion Project (T-REX) construction vastly improved this historic drainage problem.

August 18, 2004 – It was a deluge that produced standing water across the entire region and an average of 1.62 inches of precipitation fell on Denver. The South Platte River swelled to 10,000 cfs from 300 cfs earlier in the day. The Denver Fire Department responded to nearly 180 calls between 4:30 and 6:30 pm, 10 times the normal volume. Many of those calls requested water rescues. City and State crews used snowplows to clear water from clogged drains in Denver. About 5 inches fell on the Denver Zoo. A car was swept over a 6-foot embankment about 1:00 am. Two lanes of northbound I-25 at West Alameda Avenue were closed under 8 inches of standing water. The worst flooding spots were: I-25 at Alameda and I-70 in the area of Vasquez, Steele and York streets, Manna Pro grain elevators at 44th and Madison, and the Union Pacific Railroad bed was washed out at the BNSF crossing between Madison and Monroe Streets leaving 100’ of track hanging in mid air.

June 3, 2005

A heavy thunderstorm swept through southeast Denver flooding 9 homes in the Hamden Heights neighborhood to varying degrees as well as flooding East Girard west of Havana, damaging numerous parked cars. This storm was estimated to be between a 50 and 100-year rainfall event. Surcharging on storm drain manholes in Five Points was recorded.

Flooding on E Eastman Avenue on June 3, 2005.

July 4, 2006
Independence Day was a weather-producer in 2006 with nature contributing its own fire works. Denver and Arvada were the primary targets for heavy rainfall with many gages reporting more than an inch of rain. The Cherry Creek gage at Steele Street measured the greatest amount of 1.73 inches. The rainfall did not, however, prevent the anticipated celebrations from taking place. Five stream gages recorded annual peaks.

August 13, 2006
Multiple storms occurred during the evening hours causing the ALERT system to generate 11 rainfall alarms from 7 stations in Denver, Aurora and Golden between 8:15 and 10:40 pm. Annual peaks occurred at 8 stream gages on Harvard Gulch, Goldsmith Gulch, Westerly Creek and the South Platte River. This was a busy day for the ALERT system, but fortunately, no major damages were reported—just some nuisance flooding during the late evening. Consequently, this event attracted little media attention.

August 14, 2006
Heavy rainfall was recorded in the Capitol Hill area, causing flooding on East Colfax at Clarkson, Williams and Colorado Boulevard. Businesses and subterranean condominiums along 17th Avenue from Lafayette to Humboldt were also flooded.

August 19, 2006
Northwest Denver experienced an intense localized storm cell resulting in flooding at the W. 38th Avenue underpass of the railroad tracks between Inca and Fox.

May 14, 2007 - A thunderstorm developed rapidly due to multiple thunderstorm outflow boundaries that were initiated by weak and moderate thunderstorms across western Jefferson and western Boulder Counties. The thunderstorm produced heavy rainfall of 0.75” to 1.50” in 10-30 minutes across eastern Jefferson, Denver, western Arapahoe and southwest Adams Counties. Short lead Red Flood Alerts were issued for these 4 counties. Two-year-old Jose Matthew Jauregui Jr. was swept away by rapidly rising water along a bike path in Lakewood Gulch at Decatur Street. His body was later recovered downstream in the South Platte River.

Flooding in southern Denver on July 27, 2007.
(Photo Courtesy Denver Post)

July 27, 2007 - A Flash Flood Watch was issued for the entire Denver area due to the threat of very heavy rainfall that could initiate flash flooding and urban flooding. Strong thunderstorms developed late in the afternoon across the southern portion of Denver. The storms moved very slowly to north producing heavy rainfall of 1.50” to 2.50” in 30-60 minutes prompting a Flash Flood Warning for Denver, Arapahoe and Adams Counties.

August 8, 2008- A severe thunderstorm cell moved through central, east central and southeast Denver causing flooding in the Country Club neighborhood, Cherry Creek North, Hale Parkway, Severn Place between Jersey and Jasmine, S. Holly and Pacific Place and E. Mississippi and Leetsdale/Parker Road. In some areas 2” to 2.5” of rain was recorded in a 1 hour period equivalent to a 100-year storm. Several homes, business and apartments were flooded in each of these areas.

1.5.5 Existing Conditions

The Technical Appendix notebooks are organized by basin and include all Hydrologic Models. Existing drainage conditions have been evaluated through field reconnaissance, research of complaint records, and detailed hydrologic modeling using the Colorado Urban Hydrograph Procedure (CUHP 2000) and Urban Drainage Stormwater Management Model (UD-SWMM) software developed by UDFCD. Modeling of the fully urbanized basins within the City & County of Denver poses a significant challenge because of the high degree of impervious area and complex basin routing inherent in the system. To ensure that a reasonable model was developed to simulate these conditions, there has been extensive coordination among the consultant team, City & County of Denver staff, and UDFCD. The participation of this team of experts has resulted in the development of sophisticated models which are linked with GIS-based capital budgeting tools. This approach will enable the models to be incorporated in subsequent versions of CUHP and UDSWM, including the incorporation of future GIS advancements and graphical user interfaces (GUI).

Parameters for Stormwater Runoff
Volume 1 of the UDFCD Storm Drainage Criteria Manual provides the basis for input data for CUHP. In order to more accurately simulate the potential for runoff under future conditions, the Denver GIS database has been used to evaluate existing land uses and densities within commercial and residential areas. These have been compared with the permitted densities (and corresponding imperviousness) for current zoning and have been overlain with ***Blueprint Denver*** to ensure that a reasonable upper limit is used. Generally, the imperviousness for residential areas was set at 52%, commercial/retail from 80 to 90% and industrial 90 to 95%.

One-hour rainfall depths for the CUHP model have been obtained from Volume 1 for the following current periods:
- 2-year = 0.95 inches
- 5-year = 1.34 inches
- 100-year = 2.57 inches

Evaluation of Split Flow Conditions
Hydrologic modeling of drainage conditions within Denver is further complicated by split flow conditions whereby the direction of storm sewers contravenes the surface gradient. The storm sewer system generally has 1-year capacity under current conditions and 2 to 5-year capacity with proposed improvement conditions. Delineation of the basins is important to ensure proper sizing of proposed improvements and also to evaluate overland flood flow conditions. As a result, two models have been developed: 1) a low flow model for the minor storm event and 2) a split flow model which extracts the low flow and accounts for transbasin diversions of flow to enable mapping of potential hazard areas under 100-year storm event conditions. Potential ponding areas are shown as shaded zones on the full-size work maps (see Technical Appendices or GIS database) to facilitate planning staff review of development applications and to advise potential landowners or developers of inherent localized flood hazards. These are areas where ponding or flow depths could exceed 18"; however, they have not been mapped using regulatory criteria or modeling techniques and are therefore considered only a rough guide of potential ponding.

1.5.6 Future Development

The Denver Storm Drainage Master Plan is one of several documents that will feed information into the City's Comprehensive Plan. ***Blueprint Denver*** is another essential framework document that both identifies major transportation network improvements and establishes the basis for future land use planning. To assist with future planning, "Areas of Change" and "Areas of Stability" have been delineated in ***Blueprint Denver***. The Areas of Change map is included for reference to show the potential for changing hydrology and highlight the areas where capital investment in infrastructure is expected.

2.0 MAJOR DRAINAGEWAYS

The following is a description of each of the major drainageways within the City & County of Denver, beginning furthest downstream and continuing upstream.

2.1 South Platte River (Basin 0000)

The South Platte River is the largest receiving waterway in the Denver Metropolitan area and flows from south to north along the I-25 corridor through the City & County of Denver. Within the city limits of Denver, the South Platte River meanders along a path some 11.7 miles in length from Dartmouth Avenue to Franklin Street. The drainage basin covers approximately 4,850 square miles extending from the Continental Divide in the Rocky Mountain Front Range to the high plains and foothills of eastern Colorado. The mountainous portion of this basin is generally unsuited for dense development, while the foothills and high plains areas are actively being developed. The intense urbanization in the metropolitan area consists primarily of residential and commercial areas and some industrial regions along the river valley.

The South Platte River flood potential is mitigated by Chatfield Reservoir (constructed in 1973) located on the South Platte River, along with Cherry Creek Reservoir (constructed 1950) and Bear Creek Reservoir (constructed 1977) located on major tributaries. Short duration flooding will continue to occur from extremely heavy precipitation in those areas below the dam-sites. Peak 100-year flows of the South Platte vary from 5,000 cfs near Chatfield to 38,000 cfs at the confluence with Sand Creek. Normal discharges in the South Platte River are generally about 100 cfs, but approach about 1,000 cfs during the spring runoff period. Average daily flows are highly affected by treated effluent discharges from the Metro Wastewater Reclamation District treatment plant.

2.2 Second Creek (Basin 3500)

Second Creek drains about 27 square miles of area to the South Platte River. The basin is about 15 miles long and 3.4 miles wide at its widest point. The drainage basin ranges in elevation from 4, 990 at the South Platte River to 5,650 feet at the basin divide. Second Creek has a natural irregular channel section in the upper reaches above the O'Brian Canal. The Second Creek Basin is crossed by US Hwy 85, U-76, the Union Pacific and Burlington Northern Railroads, the O'Brian Canal, Fulton Ditch and the Burlington Ditch. Second Creek has a natural irregular channel section above the O'Brian Canal and a small, poorly defined channel section between the O'Brian Canal and the South Platte River. Existing development within the Second Creek basin is mainly agricultural, with irrigated farmland located in the South Platte River Valley and dryland farming and pasture in the upstream areas.

The southern land area of the Second Creek drainage basin within the Denver city limits drains via a tributary known as the *West Fork of Second Creek*. This tributary drains about 3 square miles of area to Second Creek. The Highline Canal terminates at the West Fork. The sustained unused flow in the Highline Canal has been wasted to the West Fork downstream of 64th Avenue, and the flows have eroded the channel on the West Fork. At Tower Road, the West Fork channel is about 15 feet deep with vertical and very steep, unstable banks. The confluence of Second Creek and the West Fork of Second Creek is a wide, relatively flat area supporting a stand of cottonwood trees. Some wetland areas are present in the upper reaches of the West Fork, but, as the channel has eroded, the channel banks have become incised and support only a narrow band of wetland or riparian vegetation. The floodplain is contained within the channel except at road crossings, where overtopping may occur. The banks are unstable and some lateral channel migration may occur during large flows.

2.3 First Creek (Basin 3700)

The First Creek basin drains an area of 47.2 square miles. The headwaters of First Creek are located in Arapahoe County, south of I-70 and east of E-470. Runoff from the basin flows in a northwesterly direction. First Creek crosses Peña Boulevard just north of 56th Avenue and flows through the northeastern portion of the Rocky Mountain Arsenal. First Creek is an east bank tributary to the South Platte River, and outfalls at approximately 128th Avenue. The basin shape is long and narrow, approximately 26 miles long and 2 to 4 miles wide. The average stream slope above Rocky Mountain Arsenal is about 31 feet per mile, and flattens to about 23 feet per mile below Rocky Mountain Arsenal

The upper reaches of First Creek are primarily undeveloped irrigated cropland with wide swales and channels for drainageways. Toward the center of the basin, First Creek bisects Green Valley Ranch, which consists of medium density, single-family residences. First Creek then enters Rocky Mountain Arsenal with a more incised, low flow channel and wider floodplain areas.

The lower First Creek basin is located downstream from 56th Avenue and Peña Boulevard and continues to the South Platte River. The lower First Creek basin consists of irrigated farmland with pockets of light industrial and residential properties. Conveyance within the lower First Creek drainage consists of broad undefined channels with little or no defined thalweg. Between US-85 and Brighton Boulevard, the channel is incised with a well-defined thalweg. The O'Brian Canal and the Burlington Ditch which intercept runoff in First Creek cross the reach of First Creek below Rocky Mountain Arsenal.

2.4 Irondale Gulch (Basin 3900)

Irondale Gulch, which contains approximately 26.7 square miles, lies immediately southwest of First Creek and drains the general area near the intersection of I-70 and Picadilly Road and the Adams County line, through the Montbello area, the Arsenal and Commerce City with an eventual outfall to the South Platte River at approximately East 96th Avenue. The southwest boundary of the basin is primarily the north side of I-70 until reaching the former Stapleton International Airport, where the basin boundary lies just west of Havana Street. This basin is long and narrow, with a total length of 28 miles to the South Platte River and 1½ to 2 miles wide. The average slope of the basin is about 26 feet per mile, which remains fairly constant throughout the drainageway. The drainageways through the Arsenal contain several lakes and detention areas. The drainage below the Arsenal is primarily storm sewer or roadside ditches, with capacity for only minor floods.

2.5 Clear Creek (Basin 4300)

Clear Creek is a west bank tributary to the South Platte River, and has its source in the Rocky Mountains west of Denver. Flowing in a generally easterly direction from the Continental Divide, Clear Creek enters the high plains in Golden. Within this lower reach, Clear Creek passes through unincorporated areas of Adams and Jefferson Counties, and the cities of Golden, Wheatridge, Arvada and Denver. Clear Creek crosses the northwest corner of Denver for a distance of 0.2 miles in the vicinity of 52nd Avenue and Gray Street.

The drainage area at the mouth is 575 square miles, of which 400 square miles are in the mountain region above Golden. There are 11 major reservoirs in the lower Clear Creek basin, three of which are on-stream and provide some residual flood control effects downstream from each site. Ralston Reservoir was built in 1938 by Denver and receives water from Ralston and South Boulder Creeks. Although Ralston Reservoir is not operated for flood control purposes, there are approximately 2,400 acre-feet of storage available. Maple Grove Reservoir is located on Lena Gulch at West 27th Avenue and has approximately 452 acre-feet of available storage. Leyden Lake is an irrigation water storage reservoir on Leyden Creek upstream from Indiana Street, and has approximately 550 acre-feet of uncontrolled storage.

2.6 Sand Creek (Basin 4400)

Sand Creek is an east bank plains tributary of the South Platte River. The Sand Creek basin lies in north-central Colorado, to the east and northeast of Denver's Central Business District. The Sand Creek basin encompasses an area of 189 square miles. The basin is long and narrow, with a length of 32 miles and an average width of 6 miles. Portions of Elbert, Douglas, Arapahoe, Denver and Adams Counties are included in the drainage area. Sand Creek originates at the confluence of Coal Creek and Murphy Creek. Sand Creek joins the South Platte River in the vicinity of I-270 in Commerce City, north of Denver city limits. The reach of Sand Creek within Denver is located along I-70 near the Stapleton Redevelopment area. Principle tributaries of Sand Creek are Toll Gate Creek and Westerly Creek.

2.7 Westerly Creek (Basin 4401)

The Westerly Creek tributary area consists of approximately 18 square miles of highly developed area from the low rolling divide between Cherry Creek and West Toll Gate Creek to the confluence with Sand Creek. The basin is about 8.5 miles long, 3 miles wide at its widest point. The crescent shaped area drains in a northwest-to-north direction with an average slope of 0.9 percent.

Development in the Westerly Creek drainage basin is at a state of full development consisting of townhouses, condominiums, apartments, single family homes, motels, large shopping complexes, streets, parking areas and highways. This development and the basin slope contribute to the rapid response time for storm runoff and increased stormwater runoff.

The upper reaches of Westerly Creek begin in the City of Aurora. Runoff of peak events is captured in Westerly Creek Dam, built in 1989 on the former Lowry Air Force Base at Alameda and Havana. Westerly Creek fully contains the 500-year flood event and outlets via a 48" pipe. Flows from the Lowry Redevelopment area enter Westerly Creek and then are detained in Kelly Road Dam at 11th Avenue. The channel and culverts from Kelly Road Dam to Montview at the Stapleton Redevelopment area have been improved to the 10-year storm design. The Westerly Creek channel through the Stapleton site has been improved to 100-year capacity. All storm outfalls to Westerly Creek within the Stapleton site have regional water quality treatment at the end of pipe.

2.8 Cherry Creek (Basin 4600)

The Cherry Creek tributary area consists of 410 square miles of which 385 square miles drain into Cherry Creek Reservoir. The dam is designed to release a maximum of 300 cfs during the 100-year event and 5,000 cfs in the Probable Maximum Reservoir Release (PMF) to the lower Cherry Creek channel, which has a current capacity of between 4,000 and 11,000 cfs.

The lower Cherry Creek basin covers 25.2 square miles, with Goldsmith Gulch contributing 7.7 square miles of the total area. The lower channel of Cherry Creek flows 11.5 miles from the reservoir to the South Platte River confluence in the vicinity of Speer Boulevard.

The lower channel has been improved to contain the 100-year storm from 1st Avenue to the confluence. These improvements generally consist of cleaning, shaping, and landscaping the channel bottom.

2.9 Goldsmith Gulch (Basin 4601)

The Goldsmith Gulch basin encompasses an area of 7.8 square miles from Arapahoe Road northwest to the confluence with Cherry Creek. Through Denver, the tributary area is primarily urbanized or in the process of development from a mix of commercial and residential construction. Many channel improvements have been completed along Goldsmith Gulch to reduce the potential of flood damage. The channel has been stabilized and regional parks have been constructed in the floodplain. Detention facilities have also been constructed along the channel at Bible Park, Wallace Park, Rosamond Park and at Iliff and Monaco. Channel slopes are generally mild with several newer drop structures along the reach.

The Highline Canal bisects Goldsmith Gulch at East Cornell Avenue. Goldsmith Gulch passes underneath the Highline Canal and East Cornell Avenue through a concrete box culvert.

The upper portion of Goldsmith Gulch includes the recent I-25 TREX construction site. New storm sewer and detention facilities drain the I-225 and I-25 interchange to Goldsmith Gulch.

2.10 Sloan's Lake (Basin 4700)

The Sloan's Lake drainage basin flows eastward from a high point near 26th Avenue and Garrison Street in Lakewood and outfalls into the South Platte River near Colfax Avenue and Invesco Field. The drainage basin lies within Denver's jurisdiction east of Sheridan Boulevard and is bounded by West 32nd Avenue on the north, Colfax Avenue on the south, Garrison Street on the west, and the South Platte River on the east. The basin totals almost 5.5 square miles within Denver, Lakewood, Edgewater, and Wheatridge. Since the basin is fully developed and heavily urbanized, the major drainageways are not clearly identifiable. Most of the historic drainage channels have either been filled in or built over to the point of obliteration.

The most prominent geographic feature within the basin is Sloan's Lake. The lake, which occupies 176.5 acres of a 290-acre Denver park, has been and continues to be a valuable recreational resource for the metropolitan area. In addition to its scenic and recreational significance, the lake provides the important function of regulating and controlling downstream flows that otherwise would be allowed to run uninhibited through West Denver. The lake reduces peak flow rates from about 2,904 cfs to 166 cfs during the 100-year event.

2.11 Lakewood Gulch (Basin 4800)

Lakewood Gulch is a major drainageway that originates in Lakewood and flows easterly toward the South Platte River between 6th Avenue and Colfax Avenue. The Lakewood Gulch basin consists of approximately 16 square miles beginning in the foothills and extending easterly 10 miles to the South Platte River in the vicinity of Colfax Avenue. The tributary area is essentially fully developed in Denver and in the eastern portion of Lakewood. The basin is also developed in the western portion of Lakewood and Jefferson County.

2.12 Dry Gulch (Basin 4801)

The Dry Gulch basin consists of approximately 3.7 square miles lying predominantly in Lakewood. Dry Gulch is tributary to Lakewood Gulch in the vicinity of 10th Avenue and Perry Street in Denver, and extends westward a length of 5.7 miles along the general alignment of Colfax Avenue to Simms Street. The basin is essentially fully developed, with commercial establishments along Colfax Avenue and residential development comprising the remainder of the basin.

2.13 Weir Gulch (Basin 4900)

Weir Gulch meanders eastward from Green Mountain for approximately 8.3 miles to the confluence with the South Platte River in the vicinity of West 9th Avenue. The 7.2 square mile drainage basin is fully urbanized in Denver and mostly developed west of Sheridan Boulevard in Lakewood. Much of Weir Gulch is lacking natural stream character and riparian vegetation. Many sections of the gulch are underground in a concrete box culvert or open on the top in a 3-sided concrete box.

There are two defined major drainageways tributary to Weir Gulch within the City of Denver. The 1st Avenue Tributary to Weir Gulch is located just north of 1st Avenue and flows in an easterly direction. The drainage basin is bounded by 6th Avenue on the north, West Alameda Avenue on the south, Raleigh Street on the east, and Wadsworth Boulevard on the west. This tributary of the Weir Gulch system is approximately 2 miles long and about 0.8 mile wide, with an average slope of 1.5 percent.

The Dakota Avenue Tributary to Weir Gulch lies within Denver's jurisdiction east of Sheridan Boulevard and is located just south of Dakota Avenue flowing in an easterly direction. It is bounded by West Alameda Avenue on the north, West Alaska Avenue on the south, Sheridan Boulevard on the west, and Xavier Street on the east. This tributary is about ¼-miles wide and has an average slope of 1½ percent.

Strip parks have been developed by the Denver Parks and Recreation Department from 1st Avenue to Alameda Avenue along the gulch. This development consists mainly of grassed channels and the installation of asphalt bike paths. Barnum Park is located on both sides of 6th Avenue on the west side of Federal Boulevard. Barnum Lake, located south of 6th Avenue has been improved to contain the 100-year storm within the Weir Gulch channel. The open park area north of 6th Avenue, known as the Federal Boulevard Detention Reservoir, is designed to reduce the 25-year flow to a 10-year flow or less. The lower Weir Gulch channel from Federal to the South Platte River outfall has capacity for the 10-year storm.

2.14 Sanderson Gulch (Basin 5100)

Sanderson Gulch flows 8.63 miles in an easterly direction from South Union Boulevard above Smith Reservoir to the South Platte River in the vicinity of West Florida Avenue. This drainage basin, which encompasses approximately 9 square miles, is fully developed in Denver and is being rapidly urbanized west of Sheridan Boulevard. The entire basin's drainage area extends west to the top of Green Mountain, and channel slopes are generally mild.

Green belts and parks have been located along the Sanderson Gulch floodplain. Drainageway improvements have been constructed to contain the 100-year event within open channels; however, roadway culverts were designed for the 10-year frequency discharge.

2.15 Harvard Gulch (Basin 5200)

Harvard Gulch flows west through the southern part of Denver for a length of 5.6 miles to its confluence with the South Platte River at Wesley Avenue. The total drainage basin area is approximately 7.4 square miles. The Highline Canal meanders through the southeast portion of the basin and does intercept storm flow. Single-family residences primarily urbanize the basin. Commercial development is generally located along Colorado Boulevard, Broadway and Santa Fe Drive. The residential portion of the basin is very dense with small lots having an estimated 52 percent average imperviousness.

The Harvard Gulch Flood Control project, completed in 1966, contains the 10-year flood underground in a box culvert from Logan Street to the South Platte River. A grass-lined open channel was designed though Harvard Gulch Park, with an off-line detention pond in the park.

Highway I-25 and the TREX construction project bisect the upper portion of Harvard Gulch. Drainage improvements for TREX through the Holly Hills area include several detention/water quality basins as well as a new storm sewer system. The TREX storm sewer is connected to Denver's existing storm sewer system at two locations along the west side of I-25: 1) the TREX storm sewer system to the south outfalls to the Highline Canal, and 2) the storm sewer system to the north outfalls to the existing 36-inch storm sewer within Yale Avenue.

2.16 West Harvard Gulch (Basin 5300)

West Harvard Gulch flows east 2.8 miles through Denver to its confluence with the South Platte River in the vicinity of Yale Avenue. The total area of the drainage basin is approximately 1.4 square miles. The average width of the basin is 0.66 mile, and the channel slopes range from 1.3 to 2.4 percent. The basin elevations range from approximately 5,525 feet to 5,250 feet.

The West Harvard Gulch Basin is primarily in residential development. Commercial areas are situated along Federal Boulevard, and a light industrial park is located in the Basin's lower reaches. Loretto Heights College sits on the ridge that forms the southern boundary of the basin.

In the West Harvard Gulch Basin, the main drainageway was piped in an underground conduit that extended from just above the Colorado and Southern Railroad to Zuni Street. This reach has been restored and an improved grass lined and concrete trickle channel carries the flood events. Channel slopes within this reach are stabilized with grouted sloping boulder drops.

During the 100-year flood event, most of the flood flow will be contained in the channel. At the confluence of the South Platte River, the main channel flows through an 84" diameter concrete pipe. This pipe has inadequate capacity to carry the 100-year flow resulting in shallow flooding around the Arapahoe Power Plant. Some ponding and overtopping will occur at Zuni, Clay and Decatur Street crossings during the 100-year flood event.

2.17 Bear Creek (Basin 5500)

Bear Creek generally flows eastward from its headwaters at Mount Evans through the towns of Evergreen and Morrison until it reaches the metropolitan area of Denver where it is tributary to the South Platte. The basin drainage basin is approximately 36 miles long and has an average width of about 9 miles. This encompasses approximately 261 square miles of drainage area. Elevations in the basin range from approximately 14,260 feet at Mount Evans to 5,260 feet at the mouth. Turkey Creek, a major tributary, drains about 52 square miles and enters into Bear Creek approximately 2 miles downstream of Morrison. A majority of the basin is in the mountains, with the remainder draining the foothills and high plains region. The drainage basin area inside the Denver's city limits is about 12 square miles in size.

The completion of Bear Creek Dam in 1977 just downstream of Morrison has a great effect on the peak discharges of the 8.2-mile Bear Creek reach below the Dam. The Dam acts as a flood control reservoir that intercepts flows from areas in the upper and middle parts of the basin. At the Bear Creek Dam, peak flows from the 100-year event have been reduced from 30,000 cubic feet per second (cfs) to approximately 1,000 cfs through storage in the reservoir.

2.18 Marston Lake North (Basin 5501)

The Marston Lake drainage basin consists of approximately 2.1 square miles of limited developed area, in the southwest corner of Denver. Various areas within the basin are subject to flooding which could increase in severity and frequency with continued urbanization of the basin without drainageway improvements. The basin originates approximately ½ mile west of Kipling Street between Belleview and Quincy Avenues, and extends approximately 4.4 miles in a northeasterly direction to its confluence with Bear Creek. Continued development in these areas, planned for mostly residential with some light commercial business, is expected to increase runoff rates.

Marston Lake is owned and operated by the Denver Water Board and serves as a major link in the water supply system for Denver and much of the metropolitan area. The Lake acts as a sump and is isolated from receiving or discharging stormwater.

The drainage basin traverses various jurisdictions and ownerships including Jefferson County, Denver, Denver Water Board, Marston Water Treatment Plant grounds, Pinehurst Country Club Golf Course, and United Sates Government properties to the south of Fort Logan National Cemetery.

Improvements to the drainageway have been accomplished by the Denver Water and by the Urban Drainage and Flood Control District. The north side of the Marston Lake Dam was reconstructed to allow room for an open channel, which, along with an improvement completed by the Urban Drainage and Flood Control District provides improved 100-year capacity channel from Old Wadsworth Boulevard to West Quincy Avenue.

3.0 CAPITAL IMPROVEMENTS PROGRAM

3.1 Cost Modeling

Development of cost estimates is an important component of the master planning process. Costs have been compiled to assist in the evaluation of drainage alternatives and to provide for systematic capital budgeting for future improvement programs. Bid data has been obtained from the City & County of Denver for the period 1999 to 2008 and statistically analyzed to derive regression equations that reflect typical construction practices within the City & County of Denver. A detailed tabulation of all unit costs and a listing by project is shown in the **GIS Appendix** and linked to the GIS database for project cost analysis. General unit costs (in 2008 dollars) are summarized below:

- Storm Sewer (66 in. and smaller): $ 3.42 per inch diameter per lineal foot
- Storm Sewer (72 in. – 96 in.): $ 4.96 per inch diameter per lineal foot
- Storm Sewer (> 96 in – 120 in.): $ 6.27 to $7.41 per inch per lineal foot
- Elliptical Storm Sewer 1½ times the equivalent round pipe
- Jack and Bore Pipe: $ 22.80 per inch diameter foot
- Box Culverts: $ 684 per cy concrete, plus $0.80 per lb. steel
- Headwalls: $ 684 per cy concrete
- Manholes: $ 2,650.50 - $10,944 each Type A, C, B and P
- Manhole Cone floe Box Culverts $1,500 each
- Inlets: $ 2,850 for typical 6-foot Type 14 curb opening
  Assumed four inlets constructed per manhole
- Inlet laterals: Assumed 20 feet of 18” RCP per inlet
- Stormwater Detention: $ 45,600 per acre-foot
- Asphalt Patch (assumed 8-ft wider than the pipe diameter): $ 8.00 per sy-in ($145.46/ton) for assumed 9-inch full depth section
- Dry Utility Administration Cost: 5% of sub-total construction costs
- Wet Utility Relocation Cost: $2,280 per crossing for sanitary sewer avoidance
  $1,140 to $22,800 for relocation of water, depending upon size

Indirect costs and contingency have been expressed as a percentage of direct construction costs. These include the following:

• Traffic control:	3%
• Mobilization/Demobilization:	10%
• Design and Engineering:	15%
• Materials Management (limited environmental remediation and disposal):	7%
• Contract Administration/Construction Management:	10%
• Contingency:	25%
INDIRECT COST TOTAL	70%

Note: Property acquisition is specific to final design and not included in the project costs.

3.2 Summary of Capital Costs

Cost by Project
A summary of costs for all basins and all projects within those basins is presented on the following pages, sorted first by basin, and then sorted by project. Costs are tabulated through automated GIS electronic master planning routines and are based upon unit prices developed in 2008. In some cases the automated costing may not match exactly hand calculated project costs shown in the individual Appendix Project Notebooks. However, great care has been taken to ensure these differences are within 5% or less.

In some cases, multiple alternatives are proposed which have been designated in the Basin ID. There is not sufficient information at this time to select a preferred alternative, so all alternatives have been shown for comparison.

This Drainage Master Plan does not distinguish between *Developer* cost and *City* cost. In particular, capital improvements have been shown for new developing areas (i.e., Stapleton), although their funding will certainly be borne by different entities and budgets than for retro-fit improvements of existing development.

Cost by Basin
For purposes of developing an overall construction cost by basin, costs are summarized below by simply selecting the least cost alternative. The total project cost to upgrade the City’s storm drainage infrastructure to meet minimum current drainage criteria for the entire City is estimated to be about $1,143 M in 2008 dollars.

SUMMARY OF PROJECT COSTS BY BASIN

ID	OUTFALL	NAME/LOCATION	CIP COST (2008 Dollars)
0058-01	South Platte River	Prairie Gateway	$0
0059-01	South Platte River	Globeville - Utah Junction	$1,427,210
0060-01	South Platte River	I-70 & Colorado Boulevard	$12,390,370
0060-02	South Platte River	I-70 & York	$32,050,563
0061-01	South Platte River	27th & Federal	$47,419,099
0061-02	South Platte River	Highland	$70,494,650
0062-01	South Platte River	Lower Platte Valley	$15,898,566
0063-01	South Platte River	Central Platte Valley	$38,579,961
0064-01	South Platte River	1st & Federal	$11,690,880
0064-02	South Platte River	Valverde	$24,071,892
0065-01	South Platte River	Ruby Hill	$12,103,934
0065-02	South Platte River	Dartmouth	$342,252
0067-01	South Platte River	College View	$2,357,628
0067-02	South Platte River	West Belleview	$1,601,693
0067-03	No Outfall	Marston Lake	$0
3501-01	Second Creek	West Fork Second Creek	$13,505,964
3700-01	First Creek	Pena Corridor	$25,060,487
3700-02	First Creek	Green Valley Ranch	$0
3700-03	First Creek	Dogwood & Blue Gamma Tribs.	$14,122,366
3702-01	First Creek	Tributary "T"	$0
3900-01	Irondale Gulch	Stapleton East Section 10	$759,696
3900-02	Irondale Gulch	East Montbello	$1,871,731
3900-03	Irondale Gulch	Parkfield	$0
3900-04	Irondale Gulch	Majestic Commerce Center	$7,467,232
3901-01	Irondale Gulch	West Montbello	$34,867,193
3901-02	Irondale Gulch	Gateway	$0
4000-01	Rocky Mountain Arsenal	Stapleton West Section 10	$3,953,520
4300-03	Clear Creek	North of I-70	$5,811,792
4309-01	Clear Creek	Berkeley Lake	$0
4400-01	Sand Creek	North Stapleton	$32,876,518
4400-02	Sand Creek	Quebec Corridor	$35,013,969
4400-03	Sand Creek	Stapleton	$5,552,365
4400-04	Sand Creek	East Stapleton	$30,603,047
4401-01	Westerly Creek	South Stapleton	$1,276,563

ID	OUTFALL	NAME/LOCATION	CIP COST (2008 Dollars)
4401-02	Westerly Creek	11th Avenue to Montview	$3,357,705
4401-03	Westerly Creek	Lowry	$0
4401-04	Westerly Creek	South of Alameda	$10,364,679
4500-01	Montclair	City Park	$81,471,542
4500-02	South Platte	36th & Downing	$49,962,688
4500-03	Montclair	Park Hill - Colfax Avenue	$30,965,027
4500-04	Montclair	Park Hill - 6th Avenue	$72,352,426
4600-01	Cherry Creek	Central Business District	$47,675,277
4600-01 0062-01	Cherry Creek & South Platte River	Central Business District	$1,624,497
4600-02	Cherry Creek	Cherry Creek Mall	$45,369,769
4600-03	Cherry Creek	Upper Cherry Creek	$40,304,600
4600-04	Cherry Creek	Cherry Creek Reservoir	$3,449,682
4601-01	Goldsmith Gulch	Lower Goldsmith Gulch	$8,809,753
4601-02	Goldsmith Gulch	Middle Goldsmith Gulch	$0
4700-01	Sloan Lake	West Colfax Avenue	$10,751,930
4800-01	Lakewood Gulch	12th & Federal	$4,931,314
4801-01	Dry Gulch	12th & Sheridan	$1,117,228
4900-01	Weir Gulch	West 6th Avenue	$3,734,357
5000-01	I-25 & South Platte	West Washington Park	$19,370,018
5000-02	I-25	University & Mexico North	$8,167,310
5000-03	I-25	University & Mexico South	$9,603,021
5100-01	Sanderson Gulch	West Florida Avenue	$43,070,711
5200-01	Harvard Gulch	Harvard Gulch Lower Basin	$36,836,026
5200-02	Harvard Gulch	Harvard Gulch Middle Basin	$48,612,557
5200-03	Harvard Gulch	Harvard Gulch Upper Basin	$48,327,788
5300-01	West Harvard Gulch	West Yale Avenue	$5,913,058
5401-01	Greenwood Gulch	South Monaco Parkway	$0
5500-01	Bear Creek	Fort Logan	$8,030,368
5500-02	Bear Creek	Upper Bear Creek	$10,600,148
5500-03	Bear Creek	Academy Park Tributary	$0
5500-04	Bear Creek	Marston Lake North	$3,688,295
5500-05	Bear Creek	Pinehurst Tributary	$1,398,964
5501-01	Bear Creek	Henry's Lake	$0
5901-01	Dutch Creek	Coon Creek	$0
	TOTAL		$1,143,031,879

STATEMENT OF PROBABLE COSTS IN 2008 DOLLARS

PROJECT			HARD COSTS								INDIRECT COSTS						TOTALS	
BASIN	ID	PROJECT	PIPE	MANHOLE	INLETS	ASPHALT PATCH	DRY UTILITY RELOCATE	WET UTILITY RELOCATE	DETENTION	TOTAL CONSTRUCTION COSTS	TRAFFIC CONTROL (3%)	MOBILIZATION (10%)	DESIGN & ENGINEERING (15%)	MATERIALS MANAGEMENT (7%)	ADMIN-ISTRATIVE (10%)	CONTINGENCY (25%)	TOTAL	TOTAL BY BASIN
0059-01	E	W 52ND AVE, W 51ST AVE, AND RAILROAD YARD	$483,139	$60,534	$64,800	$188,804	$39,978	$2,280		$839,535	$25,186	$83,954	$125,930	$58,767	$83,954	$209,884	$1,427,210	$1,427,210
0060-01	F1	LOWER PARK HILL OUTFALL	$1,625,729	$92,169	$178,200	$468,240	$121,580	$67,260		$2,553,178	$76,595	$255,318	$382,977	$178,722	$255,318	$638,294	$4,340,402	
	G	50TH AVE INTERCEPTOR	$490,627	$102,486	$129,600	$209,884	$47,371	$14,820		$994,788	$29,844	$99,479	$149,218	$69,635	$99,479	$248,697	$1,691,140	
	H	COLUMBINE AND YORK UPGRADES	$594,034	$152,703	$243,000	$405,844	$74,054	$85,500		$1,555,135	$46,654	$155,514	$233,270	$108,859	$155,514	$388,784	$2,643,730	
	I	RIVERSIDE OUTFALL	$751,321	$52,839	$97,200	$225,272	$56,446	$2,280		$1,185,358	$35,561	$118,536	$177,804	$82,975	$118,536	$296,340	$2,015,110	
	L	N COLORADO BLVD IMPROVEMENTS	$166,951	$53,010	$324,000	$206,112	$37,903	$7,980		$795,956	$23,879	$79,596	$119,393	$55,717	$79,596	$198,989	$1,353,126	
	M	MILWAUKEE ST IMPROVEMENTS	$69,768	$7,952	$48,600	$68,000	$9,716			$204,036	$6,121	$20,404	$30,605	$14,283	$20,404	$51,009	$346,862	$12,390,370
0060-02	A	E 45TH AVE	$2,761,377	$285,941	$745,200	$1,476,872	$270,537	$141,360		$5,681,287	$170,439	$568,129	$852,193	$397,690	$568,129	$1,420,322	$9,658,189	
	B	N BRIGHTON BLVD OUTFALL	$4,342,350	$246,892	$421,200	$808,968	$294,903	$78,660		$6,192,973	$185,789	$619,297	$928,946	$433,508	$619,297	$1,548,243	$10,528,053	
	C	N RACE ST OUTFALL	$2,197,754	$291,698	$615,600	$1,073,404	$215,079	$123,120		$4,516,655	$135,500	$451,666	$677,498	$316,166	$451,666	$1,129,164	$7,678,315	
	D	NATIONAL WESTERN IMPROVEMENTS	$1,209,154	$141,327	$469,800	$476,940	$117,255	$47,880		$2,462,356	$73,871	$246,236	$369,353	$172,365	$246,236	$615,589	$4,186,006	$32,050,563
0061-01	A	19TH AND 23RD AVENUE OUTFALLS	$797,941	$55,473	$145,800	$200,888	$60,803	$15,960		$1,276,865	$38,306	$127,686	$191,530	$89,381	$127,686	$319,216	$2,170,670	
	B	20TH AVENUE COLLECTION SYSTEM	$817,845	$124,431	$518,400	$670,976	$111,314	$94,620		$2,337,586	$70,128	$233,759	$350,638	$163,631	$233,759	$584,396	$3,973,897	
	C	20TH AVENUE OUTFALL	$2,005,947	$167,421	$405,000	$752,504	$170,249	$74,100		$3,575,221	$107,257	$357,522	$536,283	$250,265	$357,522	$893,805	$6,077,875	
	D	24TH AVENUE COLLECTION SYSTEM	$1,451,851	$237,605	$858,600	$1,286,468	$205,292	$271,320		$4,311,136	$129,334	$431,114	$646,670	$301,780	$431,114	$1,077,784	$7,328,932	
	E	29TH AVENUE COLLECTION SYSTEM	$2,366,471	$366,225	$745,200	$1,374,708	$251,351	$174,420		$5,278,375	$158,351	$527,838	$791,756	$369,486	$527,838	$1,319,594	$8,973,238	
	F	7TH STREET OUTFALL	$2,697,936	$194,157	$405,000	$770,448	$208,222	$96,900		$4,372,663	$131,180	$437,266	$655,899	$306,086	$437,266	$1,093,166	$7,433,526	
	G	CENTRAL STREET COLLECTION AND OUTFALL SYSTEM	$1,345,332	$217,028	$518,400	$662,792	$145,386	$164,160		$3,053,098	$91,593	$305,310	$457,965	$213,717	$305,310	$763,274	$5,190,267	
	H	UPPER 29TH AVENUE AND UPPER ZUNI COLLECTION SYSTEM	$1,434,717	$201,409	$680,400	$1,038,008	$175,650	$158,460		$3,688,644	$110,659	$368,864	$553,297	$258,205	$368,864	$922,161	$6,270,694	$47,419,099
0061-02	A	W 34TH/35TH AVENUE COLLECTION SYSTEM	$1,416,516	$238,705	$615,600	$1,005,116	$174,855	$221,160		$3,671,952	$110,159	$367,195	$550,793	$257,037	$367,195	$917,988	$6,242,319	
	B	W 34TH AVE AND LIPAN ST OUTFALL	$2,756,646	$102,056	$178,200	$350,844	$171,667	$45,600		$3,605,013	$108,150	$360,501	$540,752	$252,351	$360,501	$901,253	$6,128,521	
	C	40TH AVENUE AND FEDERAL COLLECTION SYSTEM	$2,301,010	$326,040	$874,800	$1,521,436	$260,341	$183,540		$5,467,167	$164,015	$546,717	$820,075	$382,702	$546,717	$1,366,792	$9,294,185	
	D	42ND AVENUE AND FEDERAL COLLECTION SYSTEM	$909,877	$107,245	$518,400	$766,388	$118,573	$69,540		$2,490,023	$74,701	$249,002	$373,503	$174,302	$249,002	$622,506	$4,233,039	
	E	W 46TH AVENUE COLLECTION SYSTEM	$1,247,717	$173,850	$680,400	$1,022,228	$161,625	$108,300		$3,394,120	$101,824	$339,412	$509,118	$237,588	$339,412	$848,530	$5,770,004	
	F	W 47TH AVENUE COLLECTION SYSTEM	$1,436,026	$284,857	$599,400	$842,268	$162,346	$84,360		$3,409,257	$102,278	$340,926	$511,389	$238,648	$340,926	$852,314	$5,795,738	
	G	CHAFFEE PARK INTERCEPTOR	$1,574,527	$448,618	$810,000	$1,098,968	$203,047	$128,820		$4,263,980	$127,919	$426,398	$639,597	$298,479	$426,398	$1,065,995	$7,248,766	
	H	FOX STREET OUTFALL	$2,086,506	$104,425	$178,200	$383,147	$138,640	$20,520		$2,911,438	$87,343	$291,144	$436,716	$203,801	$291,144	$727,860	$4,949,446	
	I	LOWER W 38TH AVENUE COLLECTION SYSTEM	$2,651,779	$133,722	$502,200	$1,014,716	$221,334	$124,260		$4,648,011	$139,440	$464,801	$697,202	$325,361	$464,801	$1,162,003	$7,901,619	
	J	LOWER INCA STREET COLLECTION SYSTEM UPGRADES	$1,866,180	$170,744	$453,600	$850,176	$172,678	$112,860		$3,626,238	$108,787	$362,624	$543,936	$253,837	$362,624	$906,560	$6,164,606	
	K	UPPER W 38TH AVENUE COLLECTION SYSTEM	$1,543,043	$332,025	$729,000	$1,061,236	$189,535	$125,400		$3,980,239	$119,407	$398,024	$597,036	$278,617	$398,024	$995,060	$6,766,407	$70,494,650
0062-01	B	27TH ST IMPROVEMENTS	$5,594,376	$335,727	$858,600	$1,955,036	$445,338	$163,020		$9,352,097	$280,563	$935,210	$1,402,815	$654,647	$935,210	$2,338,024	$15,898,566	$15,898,566
0063-01	A	W 13TH AVE OUTFALL	$998,155	$142,701	$340,200	$632,204	$111,192	$110,580		$2,335,032	$70,051	$233,503	$350,255	$163,452	$233,503	$583,758	$3,969,554	
	B	W 7TH AVE OUTFALL	$2,842,630	$164,041	$340,200	$652,552	$201,339	$27,360		$4,228,122	$126,844	$422,812	$634,218	$295,969	$422,812	$1,057,030	$7,187,807	
	C	W BAYAUD AVE OUTFALL	$3,707,821	$446,723	$1,490,400	$2,008,420	$394,695	$240,540		$8,288,599	$248,658	$828,860	$1,243,290	$580,202	$828,860	$2,072,150	$14,090,619	
	D	W ELLSWORTH AVE OUTFALL	$350,522	$32,341	$48,600	$51,800	$24,676	$10,260		$518,199	$15,546	$51,820	$77,730	$36,274	$51,820	$129,550	$880,939	
	E	W MULBERRY PL OUTFALL	$1,778,530	$77,846	$324,000	$438,576	$134,368	$68,400		$2,821,720	$84,652	$282,172	$423,258	$197,520	$282,172	$705,430	$4,796,924	
	F	W 3RD AVE OUTFALL	$1,710,468	$168,293	$356,400	$425,668	$135,436	$47,880		$2,844,145	$85,324	$284,414	$426,622	$199,090	$284,414	$711,036	$4,835,045	
	G	W COLFAX AVE IMPROVEMENTS	$708,638	$96,926	$388,800	$349,608	$78,966	$35,340		$1,658,278	$49,748	$165,828	$248,742	$116,079	$165,828	$414,570	$2,819,073	$38,579,961
0064-01	A	W 3RD AVE OUTFALL	$55,466	$10,602	$64,800	$68,476	$10,309	$6,840		$216,493	$6,495	$21,649	$32,474	$15,155	$21,649	$54,123	$368,038	
	B	W 8TH AVE OUTFALL	$729,811	$20,389	$97,200	$199,084	$52,666	$6,840		$1,105,990	$33,180	$110,599	$165,898	$77,419	$110,599	$276,498	$1,880,183	
	C	W 5TH AVE OUTFALL	$2,957,933	$108,921	$372,600	$620,304	$207,149	$83,220		$4,350,127	$130,504	$435,013	$652,519	$304,509	$435,013	$1,087,532	$7,395,217	
	D	FEDERAL BLVD IMPROVEMENTS	$443,170	$122,009	$243,000	$294,388	$57,351	$44,460		$1,204,378	$36,131	$120,438	$180,657	$84,306	$120,438	$301,094	$2,047,442	$11,690,880
0064-02	A	18" UPGRADES	$96,526	$23,854	$145,800	$119,168	$19,381	$2,280		$407,009	$12,210	$40,701	$61,051	$28,491	$40,701	$101,752	$691,915	
	B	S HURON ST OUTFALL	$127,922	$29,911	$48,600	$105,704	$16,519	$18,240		$346,896	$10,407	$34,690	$52,034	$24,283	$34,690	$86,724	$589,724	
	C	W ALAMEDA AVE OUTFALL	$7,678,868	$241,227	$696,600	$1,320,056	$507,269	$208,620		$10,652,640	$319,579	$1,065,264	$1,597,896	$745,685	$1,065,264	$2,663,160	$18,109,488	
	D	W ARIZONA AVE OUTFALL	$746,308	$34,276	$97,200	$174,000	$53,672	$21,660		$1,127,116	$33,813	$112,712	$169,067	$78,898	$112,712	$281,779	$1,916,097	
	E	W TENNESSEE AVE OUTFALL	$1,025,209	$83,452	$129,600	$292,332	$77,442	$18,240		$1,626,275	$48,788	$162,628	$243,941	$113,839	$162,628	$406,569	$2,764,668	$24,071,892
0065-01	A	18" UPGRADES	$21,054	$5,301	$32,400	$25,992	$4,237			$88,984	$2,670	$8,898	$13,348	$6,229	$8,898	$22,246	$151,273	
	B	S LIPAN ST OUTFALL	$2,314,345	$12,579	$81,000	$255,840	$134,100	$18,240		$2,816,104	$84,483	$281,610	$422,416	$197,127	$281,610	$704,026	$4,787,376	
	C	S PECOS ST AND W ILIFF IMPROVEMENTS	$528,841	$148,389	$259,200	$308,208	$62,973	$14,820		$1,322,431	$39,673	$132,243	$198,365	$92,570	$132,243	$330,608	$2,248,133	
	D1	W EVANS AVE IMPROVEMENTS	$571,448	$100,464	$129,600	$270,540	$54,572	$19,380		$1,146,004	$34,380	$114,600	$171,901	$80,220	$114,600	$286,501	$1,948,206	
	D2	W EVANS AVE EXTENSION	$828,120	$160,030	$210,600	$413,224	$83,164	$51,300		$1,746,438	$52,393	$174,644	$261,966	$122,251	$174,644	$436,610	$2,968,946	$12,103,934
0065-02	A	S BRYANT ST IMPROVEMENTS	$67,306	$7,952	$48,600	$65,600	$9,587	$2,280		$201,325	$6,040	$20,132	$30,199	$14,093	$20,132	$50,331	$342,252	$342,252
0067-01	A	S QUITMAN ST IMPROVEMENTS	$203,681	$23,854	$145,800	$207,896	$30,145	$21,660		$633,036	$18,991	$63,304	$94,955	$44,313	$63,304	$158,259	$1,076,162	
	B	W UNION AVE IMPROVEMENTS	$254,858	$63,583	$178,200	$197,328	$35,895	$23,940		$753,804	$22,614	$75,380	$113,071	$52,766	$75,380	$188,451	$1,281,466	$2,357,628
0067-02	A	W GRAND AVE IMPROVEMENTS	$353,724	$85,244	$162,000	$265,560	$44,865	$30,780		$942,173	$28,265	$94,217	$141,326	$65,952	$94,217	$235,543	$1,601,693	$1,601,693
3501-01	A	HIGH POINTE DETENTION #102	$659,148	$10,692			$33,492			$703,332	$21,100	$70,333	$105,500	$49,233	$70,333	$175,833	$1,195,664	
	C	SECOND CREEK GRADE CONTROL	$6,300,015	$495,232		$78,480	$344,826	$22,800		$7,241,353	$217,241	$724,135	$1,086,203	$506,895	$724,135	$1,810,338	$12,310,300	$13,505,964
3700-01	A	BLUE GAMMA DETENTION	$1,127,670	$3,000	$32,400	$19,584	$59,133		$12,275,520	$13,517,307	$405,519	$1,351,731	$2,027,596	$946,211	$1,351,731	$3,379,327	$22,979,422	
	B	DOGWOOD GULCH DETENTION	$397,176				$19,859		$807,120	$1,224,155	$36,725	$122,416	$183,623	$85,691	$122,416	$306,039	$2,081,065	$25,060,487
3700-03	A	IRONDALE GULCH DETENTION - 01							$597,360	$597,360	$17,921	$59,736	$89,604	$41,815	$59,736	$149,340	$1,015,512	
	B	POND 815 DETENTION	$886,920				$44,346		$1,782,960	$2,714,226	$81,427	$271,423	$407,134	$189,996	$271,423	$678,556	$4,614,185	
	E	POND 802 DETENTION	$570,812	$12,074	$16,200	$19,968	$30,953		$1,472,880	$2,122,887	$63,687	$212,289	$318,433	$148,602	$212,289	$530,722	$3,608,909	
	G	IRONDALE GULCH DETENTION - 06							$2,352,960	$2,352,960	$70,589	$235,296	$352,944	$164,707	$235,296	$588,240	$4,000,032	
	H	IRONDALE GULCH DETENTION - 07							$501,600	$501,600	$15,048	$50,160	$75,240	$35,112	$50,160	$125,400	$852,720	
	I	IRONDALE GULCH DETENTION - 03							$18,240	$18,240	$547	$1,824	$2,736	$1,277	$1,824	$4,560	$31,008	$14,122,366

STATEMENT OF PROBABLE COSTS IN 2008 DOLLARS

PROJECT			HARD COSTS								INDIRECT COSTS						TOTALS	
BASIN	ID	PROJECT	PIPE	MANHOLE	INLETS	ASPHALT PATCH	DRY UTILITY RELOCATE	WET UTILITY RELOCATE	DETENTION	TOTAL CONSTRUCTION COSTS	TRAFFIC CONTROL (3%)	MOBILIZATION (10%)	DESIGN & ENGINEERING (15%)	MATERIALS MANAGEMENT (7%)	ADMIN-ISTRATIVE (10%)	CONTINGENCY (25%)	TOTAL	TOTAL BY BASIN
3900-01	A	STAPLETON - 10							$446,880	$446,880	$13,406	$44,688	$67,032	$31,282	$44,688	$111,720	$759,696	$759,696
3900-02	A	E 53RD AVE IMPROVEMENTS	$228,695	$23,735	$97,200	$158,676	$26,270	$17,100		$551,676	$16,550	$55,168	$82,751	$38,617	$55,168	$137,919	$937,849	
	B	E MAXWELL PL IMPROVEMENTS	$219,393	$25,091	$113,400	$151,620	$26,159	$13,680		$549,343	$16,480	$54,934	$82,401	$38,454	$54,934	$137,336	$933,882	$1,871,731
3900-04	B	E BOLLING DR IMPROVEMENTS	$890,112				$44,506		$3,055,200	$3,989,818	$119,695	$398,982	$598,473	$279,287	$398,982	$997,454	$6,782,691	
	C	HIMALAYA RD OUTFALL	$383,496				$19,175			$402,671	$12,080	$40,267	$60,401	$28,187	$40,267	$100,668	$684,541	$7,467,232
3901-01	A	18" UPGRADES	$135,206	$23,854	$145,800	$141,588	$22,607	$5,700		$474,755	$14,243	$47,476	$71,213	$33,233	$47,476	$118,689	$807,085	
	B	E 45TH AVE IMPROVEMENTS	$7,411,807	$304,161	$518,400	$1,167,468	$475,222	$102,600		$9,979,658	$299,390	$997,966	$1,496,949	$698,576	$997,966	$2,494,914	$16,965,419	
	C	E 47TH AVE IMPROVEMENTS	$3,193,115	$113,916	$437,400	$1,023,108	$243,222	$96,900		$5,107,661	$153,230	$510,766	$766,149	$357,536	$510,766	$1,276,915	$8,683,023	
	D	E 53RD AVE IMPROVEMENTS	$2,184,073	$131,580	$226,800	$483,920	$152,003	$13,680		$3,192,056	$95,762	$319,206	$478,808	$223,444	$319,206	$798,014	$5,426,496	
	E	E ALBROOK DR IMPROVEMENTS	$545,380	$110,523	$226,800	$323,080	$62,227	$38,760		$1,306,770	$39,203	$130,677	$196,016	$91,474	$130,677	$326,692	$2,221,509	
	F	E ANDREWS DR IMPROVEMENTS	$173,093	$18,793	$97,200	$131,896	$21,391	$6,840		$449,213	$13,476	$44,921	$67,382	$31,445	$44,921	$112,303	$763,661	$34,867,193
4000-01	A	STAPLETON - 10							$1,326,960	$1,326,960	$39,809	$132,696	$199,044	$92,887	$132,696	$331,740	$2,255,832	
	B	STAPLETON - 11							$998,640	$998,640	$29,959	$99,864	$149,796	$69,905	$99,864	$249,660	$1,697,688	$3,953,520
4300-03	A	N FEDERAL BLVD OUTFALL	$853,119	$122,379	$307,800	$578,780	$94,586	$29,640		$1,986,304	$59,589	$198,630	$297,946	$139,041	$198,630	$496,576	$3,376,716	
	B	CLEAR CREEK OUTFALL	$954,106	$52,002	$81,000	$274,800	$68,209	$2,280		$1,432,397	$42,972	$143,240	$214,860	$100,268	$143,240	$358,099	$2,435,076	$5,811,792
4400-01	A	E 56TH AVE IMPROVEMENTS	$1,405,210	$82,291	$178,200	$412,544	$104,026	$2,280	$720,480	$2,905,031	$87,151	$290,503	$435,755	$203,352	$290,503	$726,258	$4,938,553	
	B	E 51ST AVE OUTFALL	$4,444,844	$82,797	$162,000	$770,900	$273,996	$19,380	$2,795,280	$8,549,197	$256,476	$854,920	$1,282,380	$598,444	$854,920	$2,137,299	$14,533,636	
	C	STAPLETON - 03	$2,447,629	$193,077	$275,400	$898,688	$190,968	$4,560	$54,720	$4,065,042	$121,951	$406,504	$609,756	$284,553	$406,504	$1,016,260	$6,910,570	
	D	INTERNAL NORTH STAPLETON IMPROVEMENTS	$1,567,995	$361,665	$599,400	$943,220	$174,298	$13,680	$159,600	$3,819,858	$114,596	$381,986	$572,979	$267,390	$381,986	$954,964	$6,493,759	$32,876,518
4400-02	A	36TH AVENUE IMPROVEMENTS	$517,967	$90,716	$226,800	$372,136	$62,718	$46,740		$1,317,077	$39,512	$131,708	$197,562	$92,195	$131,708	$329,269	$2,239,031	
	B1	38TH AVENUE & HOLLY STREET COLLECTOR	$2,505,444	$243,789	$356,400	$762,928	$195,594	$43,320		$4,107,475	$123,224	$410,748	$616,121	$287,523	$410,748	$1,026,869	$6,982,708	
	B2	38TH AVENUE & HOLLY STREET COLLECTOR EXTENSION	$2,603,421	$362,548	$745,200	$1,412,392	$271,283	$302,100		$5,696,944	$170,908	$569,694	$854,542	$398,786	$569,694	$1,424,236	$9,684,804	
	C	LEYDEN STREET IMPROVEMENTS	$262,636	$47,196	$113,400	$177,148	$30,589	$11,400		$642,369	$19,271	$64,237	$96,355	$44,966	$64,237	$160,592	$1,092,027	
	D	38TH AVENUE INTERCEPTOR	$1,111,505	$80,541	$129,600	$321,940	$85,257	$61,560		$1,790,403	$53,712	$179,040	$268,560	$125,328	$179,040	$447,601	$3,043,684	
	E	MONACO STREET PARKWAY IMPROVEMENTS	$1,328,507	$232,218	$388,800	$784,408	$140,801	$82,080		$2,956,814	$88,704	$295,681	$443,522	$206,977	$295,681	$739,204	$5,026,583	
	F2	UPPER PARK HILL OUTFALL	$1,300,392	$224,609	$518,400	$895,728	$153,682	$134,520		$3,227,331	$96,820	$322,733	$484,100	$225,913	$322,733	$806,833	$5,486,463	
	F3	MLK BOULEVARD AND FOREST STREET EXTENSION	$309,319	$29,127	$162,000	$291,656	$40,859	$25,080		$858,041	$25,741	$85,804	$128,706	$60,063	$85,804	$214,510	$1,458,669	$35,013,969
4400-03	A	STAPLETON - 04	$143,640	$25,137	$48,600	$92,000	$15,469			$324,846	$9,745	$32,485	$48,727	$22,739	$32,485	$81,212	$552,239	
	C	QUEBEC ST OUTFALL	$1,749,030	$173,412	$324,000	$511,428	$140,060	$43,320		$2,941,250	$88,238	$294,125	$441,188	$205,888	$294,125	$735,312	$5,000,126	$5,552,365
4400-04	A	STAPLETON - 06	$3,072,340	$20,400	$97,200	$445,472	$182,569	$15,960		$3,833,941	$115,018	$383,394	$575,091	$268,376	$383,394	$958,485	$6,517,699	
	B	STAPLETON - 07	$2,308,481	$423,020	$1,522,800	$787,924	$252,111			$5,294,336	$158,830	$529,434	$794,150	$370,604	$529,434	$1,323,584	$9,000,372	
	C	STAPLETON - 08	$6,018,883	$232,412	$664,200	$1,447,692	$422,548	$87,780		$8,873,515	$266,205	$887,352	$1,331,027	$621,146	$887,352	$2,218,379	$15,084,976	$30,603,047
4401-01	A	STAPLETON - 09	$167,300	$60,049	$324,000	$163,812	$35,758			$750,919	$22,528	$75,092	$112,638	$52,564	$75,092	$187,730	$1,276,563	$1,276,563
4401-02	A	E COLFAX AVE OUTFALL	$141,650	$25,436	$64,800	$111,132	$17,949	$15,960		$376,927	$11,308	$37,693	$56,539	$26,385	$37,693	$94,232	$640,777	
	B	E 17TH AVE OUTFALL	$617,201	$88,429	$162,000	$334,200	$61,744	$33,060		$1,296,634	$38,899	$129,663	$194,495	$90,764	$129,663	$324,158	$2,204,276	
	C	E RICHTHOFEN PL OUTFALL	$109,372	$13,224	$64,800	$89,544	$14,360	$10,260		$301,560	$9,047	$30,156	$45,234	$21,109	$30,156	$75,390	$512,652	$3,357,705
4401-04	A	S ALTON ST IMPROVEMENTS	$116,246	$16,758	$32,400	$55,620	$11,450	$7,980		$240,454	$7,214	$24,045	$36,068	$16,832	$24,045	$60,114	$408,772	
	B	E MISSISSIPPI AVE DETENTION							$592,800	$592,800	$17,784	$59,280	$88,920	$41,496	$59,280	$148,200	$1,007,760	
	C	S HAVANA ST OUTFALL	$3,455,678	$209,086	$372,600	$945,964	$250,648	$29,640		$5,263,616	$157,908	$526,362	$789,542	$368,453	$526,362	$1,315,904	$8,948,147	$10,364,679
4500-01	A	E 33RD AVENUE SYSTEM	$4,625,796	$401,344	$1,036,800	$1,768,504	$400,229	$172,140		$8,404,813	$252,144	$840,481	$1,260,722	$588,337	$840,481	$2,101,203	$14,288,181	
	B	38TH STREET SYSTEM	$349,189	$73,894	$178,200	$256,868	$44,162	$25,080		$927,393	$27,822	$92,739	$139,109	$64,918	$92,739	$231,848	$1,576,568	
	C	40TH AVENUE SYSTEM	$4,973,623	$631,618	$1,215,000	$1,878,028	$452,128	$344,280		$9,494,677	$284,840	$949,468	$1,424,202	$664,627	$949,468	$2,373,669	$16,140,951	
	D	CITY PARK SYSTEM	$1,154,414	$280,611	$534,600	$763,848	$141,804	$102,600	$866,400	$3,844,277	$115,328	$384,428	$576,642	$269,099	$384,428	$961,069	$6,535,271	
	E	HIGH STREET SYSTEM	$15,788,807	$283,472	$891,000	$1,664,776	$938,642	$144,780		$19,711,477	$591,344	$1,971,148	$2,956,722	$1,379,803	$1,971,148	$4,927,869	$33,509,511	
	F	JACKSON STREET SYSTEM	$1,421,321	$95,550	$145,800	$279,224	$99,204	$42,180		$2,083,279	$62,498	$208,328	$312,492	$145,830	$208,328	$520,820	$3,541,575	
	G	26TH AVENUE SYSTEM	$522,439	$85,158	$275,400	$425,040	$69,164	$75,240		$1,452,441	$43,573	$145,244	$217,866	$101,671	$145,244	$363,110	$2,469,149	
	H	E 19TH AVENUE SYSTEM	$785,150	$204,630	$356,400	$494,832	$95,528	$69,540		$2,006,080	$60,182	$200,608	$300,912	$140,426	$200,608	$501,520	$3,410,336	$81,471,542
4500-01-100YR	A	40TH & 40TH 100-YEAR IMPROVEMENTS	$20,544,392	$121,806	$275,400	$846,400	$1,094,017	$92,340		$22,974,355	$689,231	$2,297,436	$3,446,153	$1,608,205	$2,297,436	$5,743,589	$39,056,405	$39,056,405
4500-02	A	31ST ST OUTFALL	$10,802,381	$1,000,055	$2,365,200	$3,391,100	$896,975	$380,760		$18,836,471	$565,094	$1,883,647	$2,825,471	$1,318,553	$1,883,647	$4,709,118	$32,022,001	
	C	36TH ST OUTFALL	$2,623,800	$59,418	$113,400	$246,372	$153,004	$17,100		$3,213,094	$96,393	$321,309	$481,964	$224,917	$321,309	$803,274	$5,462,260	
	D	E 33RD AVE SYSTEM	$1,343,041	$230,793	$874,800	$994,164	$182,514	$207,480		$3,832,792	$114,984	$383,279	$574,919	$268,295	$383,279	$958,198	$6,515,746	
	E	N MARION ST SYSTEM	$739,650	$126,255	$405,000	$563,360	$96,216	$90,060		$2,020,541	$60,616	$202,054	$303,081	$141,438	$202,054	$505,135	$3,434,919	
	H	E 12TH AVE IMPROVEMENTS	$336,692	$71,564	$437,400	$390,336	$70,806	$180,120		$1,486,918	$44,608	$148,692	$223,038	$104,084	$148,692	$371,730	$2,527,762	$49,962,688
4500-03	A	16TH AVENUE SYSTEM	$5,198,780	$133,743	$453,600	$844,576	$335,240	$74,100		$7,040,039	$211,201	$704,004	$1,056,006	$492,803	$704,004	$1,760,010	$11,968,067	
	B	GLENCOE STREET SYSTEM	$4,478,059	$280,659	$567,000	$1,138,164	$330,091	$137,940		$6,931,913	$207,957	$693,191	$1,039,787	$485,234	$693,191	$1,732,978	$11,784,251	
	C	MONACO STREET SYSTEM	$1,815,385	$380,988	$680,400	$1,003,220	$202,037	$160,740		$4,242,770	$127,283	$424,277	$636,416	$296,994	$424,277	$1,060,692	$7,212,709	$30,965,027
4500-04	A	JACKSON STREET SYSTEM	$5,894,705	$29,379	$243,000	$483,784	$334,253	$34,200		$7,019,321	$210,580	$701,932	$1,052,898	$491,352	$701,932	$1,754,830	$11,932,845	
	B	HALE PARKWAY SYSTEM	$5,856,651	$235,968	$664,200	$1,252,492	$408,446	$159,600		$8,577,357	$257,321	$857,736	$1,286,604	$600,415	$857,736	$2,144,339	$14,581,508	
	C	8TH AVENUE SYSTEM	$3,088,739	$470,763	$729,000	$1,073,108	$273,895	$116,280		$5,751,785	$172,554	$575,178	$862,768	$402,625	$575,178	$1,437,946	$9,778,034	
	D	KRAMERIA STREET SYSTEM	$2,848,681	$447,507	$874,800	$1,365,764	$283,906	$141,360		$5,962,018	$178,861	$596,202	$894,303	$417,341	$596,202	$1,490,504	$10,135,431	
	E	GRAPE STREET SYSTEM	$2,855,952	$441,892	$810,000	$1,432,926	$287,641	$212,040		$6,040,451	$181,214	$604,045	$906,068	$422,832	$604,045	$1,510,113	$10,268,768	
	F	JACKSON STREET SYSTEM LATERALS	$1,559,746	$352,353	$599,400	$1,023,916	$184,580	$156,180		$3,876,175	$116,285	$387,618	$581,426	$271,332	$387,618	$969,044	$6,589,498	
	G	COLORADO BOULEVARD SYSTEM	$2,465,205	$395,751	$777,600	$1,293,568	$253,959	$147,060		$5,333,143	$159,994	$533,314	$799,971	$373,320	$533,314	$1,333,286	$9,066,342	$72,352,426

STATEMENT OF PROBABLE COSTS IN 2008 DOLLARS

PROJECT			HARD COSTS								INDIRECT COSTS						TOTALS	
BASIN	ID	PROJECT	PIPE	MANHOLE	INLETS	ASPHALT PATCH	DRY UTILITY RELOCATE	WET UTILITY RELOCATE	DETENTION	TOTAL CONSTRUCTION COSTS	TRAFFIC CONTROL (3%)	MOBILIZATION (10%)	DESIGN & ENGINEERING (15%)	MATERIALS MANAGEMENT (7%)	ADMIN-ISTRATIVE (10%)	CONTINGENCY (25%)	TOTAL	TOTAL BY BASIN
4600-01	A	STOUT ST OUTFALL EAST	$2,354,033	$213,383	$1,101,600	$1,058,948	$242,155	$115,140		$5,085,259	$152,558	$508,526	$762,789	$355,968	$508,526	$1,271,315	$8,644,941	
	B	CHERRY CREEK OUTFALLS	$2,148,838	$307,660	$745,200	$1,340,082	$239,971	$257,640		$5,039,391	$151,182	$503,939	$755,909	$352,757	$503,939	$1,259,848	$8,566,965	
	C	W 14TH AVE EXTENSION	$258,921	$55,718	$145,800	$219,048	$35,228	$25,080		$739,795	$22,194	$73,980	$110,969	$51,786	$73,980	$184,949	$1,257,653	
	D	W 8TH AVE OUTFALL	$295,776	$45,829	$145,800	$235,896	$37,191	$20,520		$781,012	$23,430	$78,101	$117,152	$54,671	$78,101	$195,253	$1,327,720	
	E	W 9TH AVE OUTFALL	$819,760	$84,628	$259,200	$298,192	$74,514	$28,500		$1,564,794	$46,944	$156,479	$234,719	$109,536	$156,479	$391,198	$2,660,149	
	F	WEST COLFAX AVE OUTFALL	$1,860,730	$227,135	$648,000	$1,111,552	$198,071	$114,000		$4,159,488	$124,785	$415,949	$623,923	$291,164	$415,949	$1,039,872	$7,071,130	
	G	CURTIS ST OUTFALL	$1,962,602	$293,804	$1,166,400	$1,291,103	$245,157	$189,240		$5,148,306	$154,449	$514,831	$772,246	$360,381	$514,831	$1,287,076	$8,752,120	
	H	N BANNOCK ST IMPROVEMENTS	$324,914	$68,201	$307,800	$330,280	$53,384	$36,480		$1,121,059	$33,632	$112,106	$168,159	$78,474	$112,106	$280,265	$1,905,801	
	I	N SPEER BLVD IMPROVEMENTS	$72,518	$19,561	$113,400	$89,528	$16,118	$27,360		$338,485	$10,155	$33,848	$50,773	$23,694	$33,848	$84,621	$575,424	
	J	W 13TH AVE EXTENSION	$118,483	$24,710	$81,000	$95,928	$17,488	$29,640		$367,249	$11,017	$36,725	$55,087	$25,707	$36,725	$91,812	$624,322	
	K	GRANT ST STORM DRAIN	$1,408,168	$137,826	$324,000	$593,912	$128,325	$102,600		$2,694,831	$80,845	$269,483	$404,225	$188,638	$269,483	$673,708	$4,581,213	
	L	W 11TH AVE IMPROVEMENTS	$385,489	$69,323	$178,200	$266,760	$47,839	$57,000		$1,004,611	$30,138	$100,461	$150,692	$70,323	$100,461	$251,153	$1,707,839	$47,675,277
4600-01/0062-01	A	MARKET STREET ALIGNMENT STORM DRAIN	$406,768	$83,106	$145,800	$211,708	$45,504	$62,700		$955,586	$28,668	$95,559	$143,338	$66,891	$95,559	$238,896	$1,624,497	$1,624,497
4600-02	A	DOWNING ST OUTFALL	$1,326,105	$188,173	$729,000	$1,087,940	$175,966	$188,100		$3,695,284	$110,859	$369,528	$554,293	$258,670	$369,528	$923,821	$6,281,983	
	B	LAFAYETTE ST OUTFALL	$243,859	$34,456	$210,600	$222,648	$37,516	$38,760		$787,839	$23,635	$78,784	$118,176	$55,149	$78,784	$196,960	$1,339,327	
	C	E 5TH AVE OUTFALL	$1,825,884	$303,869	$972,000	$1,136,072	$217,648	$115,140		$4,570,613	$137,118	$457,061	$685,592	$319,943	$457,061	$1,142,653	$7,770,041	
	D	E 6TH AVE OUTFALL	$42,140	$7,826		$13,216	$3,159			$66,341	$1,990	$6,634	$9,951	$4,644	$6,634	$16,585	$112,779	
	E	E CEDAR AVE	$183,100	$31,806	$194,400	$212,140	$32,668	$31,920		$686,034	$20,581	$68,603	$102,905	$48,022	$68,603	$171,508	$1,166,256	
	G	E EXPOSITION IMPROVEMENTS	$1,086,902	$208,335	$567,000	$798,048	$140,139	$142,500		$2,942,924	$88,288	$294,292	$441,439	$206,005	$294,292	$735,731	$5,002,971	
	H	COLORADO BLVD	$1,069,842	$82,010	$307,800	$506,400	$100,982	$53,580		$2,120,614	$63,618	$212,061	$318,092	$148,443	$212,061	$530,154	$3,605,043	
	I	N UNIVERSITY BLVD OUTFALL	$1,320,770	$211,356	$550,800	$775,780	$148,977	$120,840		$3,128,523	$93,856	$312,852	$469,278	$218,997	$312,852	$782,131	$5,318,489	
	J	5TH AVE IMPROVEMENTS	$301,994	$72,760	$194,400	$210,212	$39,937	$19,380		$838,683	$25,160	$83,868	$125,802	$58,708	$83,868	$209,671	$1,425,760	
	K	BAYAUD OUTFALL	$2,656,206	$283,385	$972,000	$1,519,172	$283,394	$237,120		$5,951,277	$178,538	$595,128	$892,692	$416,589	$595,128	$1,487,819	$10,117,171	
	L	18" UPGRADES	$480,312	$100,719	$615,600	$506,844	$90,475	$106,020		$1,899,970	$56,999	$189,997	$284,996	$132,998	$189,997	$474,992	$3,229,949	$45,369,769
4600-03	A	E EXPOSITION AVE OUTFALL	$4,090,580	$488,822	$1,344,600	$2,231,076	$423,087	$306,660		$8,884,825	$266,545	$888,482	$1,332,724	$621,938	$888,482	$2,221,206	$15,104,202	
	B	S FOREST ST OUTFALL	$976,074	$77,909	$194,400	$254,204	$76,041	$18,240		$1,596,868	$47,906	$159,687	$239,530	$111,781	$159,687	$399,217	$2,714,676	
	C	S HOLLY ST OUTFALL	$299,571	$46,128	$210,600	$306,076	$44,259	$22,800		$929,434	$27,883	$92,943	$139,415	$65,060	$92,943	$232,358	$1,580,036	
	D	S HONEY WAY OUTFALL	$63,899	$18,554	$113,400	$78,888	$13,737			$288,478	$8,654	$28,848	$43,272	$20,193	$28,848	$72,120	$490,413	
	E	E FLORIDA AVE OUTFALL	$3,370,515	$100,957	$307,800	$792,440	$232,063	$69,540		$4,873,315	$146,199	$487,332	$730,997	$341,132	$487,332	$1,218,329	$8,284,636	
	F	S ONEIDA ST OUTFALL	$45,708	$9,716	$48,600	$40,590	$7,402	$3,420		$155,436	$4,663	$15,544	$23,315	$10,881	$15,544	$38,859	$264,242	
	G	S VALE DR OUTFALL	$126,773	$17,482	$97,200	$137,864	$19,650	$13,680		$412,649	$12,379	$41,265	$61,897	$28,885	$41,265	$103,162	$701,502	
	H	JEWELL AVE OUTFALL	$273,053	$25,137	$129,600	$155,568	$29,453	$5,700		$618,511	$18,555	$61,851	$92,777	$43,296	$61,851	$154,628	$1,051,469	
	I	S NIAGARA ST OUTFALL	$4,046,425	$165,484	$405,000	$989,596	$283,289	$59,280		$5,949,074	$178,472	$594,907	$892,361	$416,435	$594,907	$1,487,268	$10,113,424	$40,304,600
4600-04	A	18" UPGRADES	$171,321	$53,010	$324,000	$211,508	$38,733	$14,820		$813,392	$24,402	$81,339	$122,009	$56,937	$81,339	$203,348	$1,382,766	
	E	DARTMOUTH AVENUE OUTFALL	$610,817	$110,808	$162,000	$267,472	$57,897	$6,840		$1,215,834	$36,475	$121,583	$182,375	$85,108	$121,583	$303,958	$2,066,916	$3,449,682
4601-01	A	18" UPGRADES	$481,317	$73,578	$437,400	$482,752	$78,027	$85,500		$1,638,574	$49,157	$163,857	$245,786	$114,700	$163,857	$409,644	$2,785,575	
	B	E ILIFF AVE IMPROVEMENTS	$665,177	$131,693	$226,800	$452,800	$74,564	$14,820		$1,565,854	$46,976	$156,585	$234,878	$109,610	$156,585	$391,464	$2,661,952	
	C	S MONACO PKWY IMPROVEMENTS	$327,828	$63,121	$145,800	$228,192	$38,760	$10,260		$813,961	$24,419	$81,396	$122,094	$56,977	$81,396	$203,490	$1,383,733	
	D	S TAMARAC DR IMPROVEMENTS	$451,303	$89,036	$210,600	$297,040	$55,420	$60,420		$1,163,819	$34,915	$116,382	$174,573	$81,467	$116,382	$290,955	$1,978,493	$8,809,753
4700-01	A	N STUART ST OUTFALL	$43,831	$5,301	$32,400	$26,752	$5,585	$3,420		$117,289	$3,519	$11,729	$17,593	$8,210	$11,729	$29,322	$199,391	
	B	N WOLFE ST OUTFALL	$48,325	$5,301	$32,400	$32,300	$6,087	$3,420		$127,833	$3,835	$12,783	$19,175	$8,948	$12,783	$31,958	$217,315	
	C1	W 16TH AVE IMPROVEMENTS	$1,167,747	$45,267	$194,400	$371,164	$92,121	$63,840		$1,934,539	$58,036	$193,454	$290,181	$135,418	$193,454	$483,635	$3,288,717	
	C2	W 17TH & 18TH AVE IMPROVEMENTS	$107,422	$21,204	$129,600	$132,620	$20,796	$25,080		$436,722	$13,102	$43,672	$65,508	$30,571	$43,672	$109,180	$742,427	
	D	W COLFAX AVE IMPROVEMENTS	$1,776,167	$74,946	$226,800	$533,248	$132,382	$36,480		$2,780,023	$83,401	$278,002	$417,003	$194,602	$278,002	$695,006	$4,726,039	
	E	W LAKESHORE DR IMPROVEMENTS	$246,076	$31,806	$194,400	$257,440	$37,455	$19,380		$786,557	$23,597	$78,656	$117,984	$55,059	$78,656	$196,639	$1,337,148	
	F	W 26TH AVE IMPROVEMENTS	$48,673	$5,301	$32,400	$47,440	$6,748	$1,140		$141,702	$4,251	$14,170	$21,255	$9,919	$14,170	$35,426	$240,893	$10,751,930
4700-01-100YR	A	SLOAN'S LAKE 100-YR OUTFALL	$6,445,352	$76,406	$324,000	$844,880	$388,408	$77,520		$8,156,566	$244,697	$815,657	$1,223,485	$570,960	$815,657	$2,039,142	$13,866,164	$13,866,164
4800-01	A	N STUART ST IMPROVEMENTS	$67,654	$24,861	$145,800	$83,524	$16,491	$7,980		$346,310	$10,389	$34,631	$51,946	$24,242	$34,631	$86,578	$588,727	
	B	N KNOX CT IMPROVEMENTS	$83,557	$6,880	$32,400	$81,440	$11,639	$28,500		$244,416	$7,332	$24,442	$36,662	$17,109	$24,442	$61,104	$415,507	
	C	N IRVING ST IMPROVEMENTS	$251,267	$61,969	$372,600	$259,540	$54,280	$140,220		$1,139,876	$34,196	$113,988	$170,981	$79,791	$113,988	$284,969	$1,937,789	
	D	N WOLFF ST IMPROVEMENTS	$507,672	$81,825	$178,200	$304,572	$55,722	$42,180		$1,170,171	$35,105	$117,017	$175,526	$81,912	$117,017	$292,543	$1,989,291	$4,931,314
4801-01	A	N STUART ST IMPROVEMENTS	$296,801	$46,029	$81,000	$173,568	$31,295	$28,500		$657,193	$19,716	$65,719	$98,579	$46,004	$65,719	$164,298	$1,117,228	$1,117,228
4900-01	A	N YATES ST IMPROVEMENTS	$130,897	$15,903	$97,200	$132,908	$19,358	$10,260		$406,526	$12,196	$40,653	$60,979	$28,457	$40,653	$101,632	$691,096	
	B	S JULIAN ST OUTFALL	$433,834	$156,205	$243,000	$248,760	$55,743	$33,060		$1,170,602	$35,118	$117,060	$175,590	$81,942	$117,060	$292,650	$1,990,022	
	E	W EXPOSITION AVE IMPROVEMENTS	$75,370	$9,531	$48,600	$82,660	$11,150	$6,840		$234,151	$7,025	$23,415	$35,123	$16,391	$23,415	$58,538	$398,058	
	F	W 1ST AVE OUTFALL	$142,430	$13,207	$64,800	$128,372	$18,352	$18,240		$385,401	$11,562	$38,540	$57,810	$26,978	$38,540	$96,350	$655,181	$3,734,357
5000-01	A	18" UPGRADES	$321,548	$68,913	$421,200	$371,640	$60,476	$26,220		$1,269,997	$38,100	$127,000	$190,500	$88,900	$127,000	$317,499	$2,158,996	
	B	CENTER AVE OUTFALL	$4,325,416	$71,256	$469,800	$582,144	$273,742	$26,220		$5,748,578	$172,457	$574,858	$862,287	$402,400	$574,858	$1,437,144	$9,772,582	
	C	E DAKOTA AVE IMPROVEMENTS	$397,473	$72,571	$437,400	$443,080	$70,148	$52,440		$1,473,112	$44,193	$147,311	$220,967	$103,118	$147,311	$368,278	$2,504,290	
	D	ALAMEDA AND SANTA FE OUTFALL	$528,513	$52,632	$243,000	$165,472	$50,393	$18,240		$1,058,250	$31,748	$105,825	$158,738	$74,078	$105,825	$264,562	$1,799,026	
	E	S GRANT ST COLLECTION AND 18" UPGRADES	$444,257	$92,839	$518,400	$408,200	$74,667	$29,640		$1,568,003	$47,040	$156,800	$235,200	$109,760	$156,800	$392,001	$2,665,604	
	F	SOUTH BROADWAY IMPROVEMENTS	$90,740	$41,296	$64,800	$66,200	$13,152			$276,188	$8,286	$27,619	$41,428	$19,333	$27,619	$69,047	$469,520	$19,370,018
5000-01-100YR	A	CENTER AVE 100-YEAR OUTFALL	$17,458,098	$109,638	$356,400	$1,561,456	$976,674	$47,880		$20,510,146	$615,304	$2,051,015	$3,076,522	$1,435,710	$2,051,015	$5,127,536	$34,867,248	$34,867,248
5000-02	A	DAHLIA ST. AND ASBURY AVENUE	$456,119	$125,001	$259,200	$389,328	$62,850	$27,360		$1,319,858	$39,596	$131,986	$197,979	$92,390	$131,986	$329,964	$2,243,759	
	B	MEXICO AVENUE	$143,537	$26,505	$162,000	$150,284	$25,085	$19,380		$526,791	$15,804	$52,679	$79,019	$36,875	$52,679	$131,698	$895,545	
	C	SOUTH HIGH SCHOOL DETENTION	$837,185	$114,515	$194,400	$286,668	$73,234	$31,920	$684,000	$2,221,922	$66,658	$222,192	$333,288	$155,535	$222,192	$555,480	$3,777,267	
	D	18" UPGRADES	$161,287	$37,107	$226,800	$199,120	$35,035	$76,380		$735,729	$22,072	$73,573	$110,359	$51,501	$73,573	$183,932	$1,250,739	$8,167,310

STATEMENT OF PROBABLE COSTS IN 2008 DOLLARS

PROJECT			HARD COSTS								INDIRECT COSTS						TOTALS	
BASIN	ID	PROJECT	PIPE	MANHOLE	INLETS	ASPHALT PATCH	DRY UTILITY RELOCATE	WET UTILITY RELOCATE	DETENTION	TOTAL CONSTRUCTION COSTS	TRAFFIC CONTROL (3%)	MOBILIZATION (10%)	DESIGN & ENGINEERING (15%)	MATERIALS MANAGEMENT (7%)	ADMIN-ISTRATIVE (10%)	CONTINGENCY (25%)	TOTAL	TOTAL BY BASIN
5000-03	A	S BROADWAY EXTENSION	$202,820	$55,404	$81,000	$123,952	$23,387	$4,560		$491,123	$14,734	$49,112	$73,668	$34,379	$49,112	$122,781	$834,909	
	B	E IOWA AVE EXTENSION	$872,902	$153,815	$307,800	$572,588	$97,578	$44,460		$2,049,143	$61,474	$204,914	$307,371	$143,440	$204,914	$512,286	$3,483,542	
	C	S WASHINGTON ST DRAIN	$1,082,471	$186,219	$307,800	$569,344	$108,318	$20,520		$2,274,672	$68,240	$227,467	$341,201	$159,227	$227,467	$568,668	$3,866,942	
	D	18" UPGRADES	$97,942	$31,806	$194,400	$120,916	$24,134	$37,620		$506,818	$15,205	$50,682	$76,023	$35,477	$50,682	$126,704	$861,591	
	E	SUB-BASIN 600 IMPROVEMENTS	$120,658	$8,091			$6,437			$135,186	$4,056	$13,519	$20,278	$9,463	$13,519	$33,796	$229,817	
	F	BROADWAY IMPROVEMENTS NORTH OF MISSISSIPPI	$99,809	$8,379	$16,200	$58,368	$9,138			$191,894	$5,757	$19,189	$28,784	$13,433	$19,189	$47,974	$326,220	$9,603,021
5100-01	A	18" UPGRADES	$399,401	$119,272	$729,000	$493,088	$88,235	$23,940		$1,852,936	$55,588	$185,294	$277,940	$129,706	$185,294	$463,234	$3,149,992	
	B	S CARLAN ST OUTFALL	$728,514	$86,471	$210,600	$310,224	$68,557	$35,340		$1,439,706	$43,191	$143,971	$215,956	$100,779	$143,971	$359,926	$2,447,500	
	C	S DECATUR ST OUTFALL	$438,430	$93,865	$194,400	$341,464	$55,118	$34,200		$1,157,477	$34,724	$115,748	$173,622	$81,023	$115,748	$289,369	$1,967,711	
	D	S FEDERAL BLVD OUTFALL	$581,085	$115,020	$194,400	$369,784	$66,206	$63,840		$1,390,335	$41,710	$139,034	$208,550	$97,323	$139,034	$347,584	$2,363,570	
	E	S NAVAJO ST OUTFALL	$3,409,643	$340,632	$615,600	$1,347,636	$293,599	$158,460		$6,165,570	$184,967	$616,557	$924,836	$431,590	$616,557	$1,541,392	$10,481,469	
	F	S QUITMAN ST IMPROVEMENTS	$82,737	$18,554	$113,400	$80,640	$15,508	$14,820		$325,659	$9,770	$32,566	$48,849	$22,796	$32,566	$81,415	$553,621	
	G	S TEJON ST OUTFALL	$200,686	$42,780	$48,600	$125,904	$21,240	$6,840		$446,050	$13,382	$44,605	$66,908	$31,224	$44,605	$111,512	$758,286	
	H	S TENNYSON ST IMPROVEMENTS	$3,222,039	$133,813	$664,200	$1,090,896	$261,304	$115,140		$5,487,392	$164,622	$548,739	$823,109	$384,117	$548,739	$1,371,848	$9,328,566	
	I	S UTICA OUTFALL	$799,580	$36,658	$145,800	$342,320	$68,099	$37,620		$1,430,077	$42,902	$143,008	$214,512	$100,105	$143,008	$357,519	$2,431,131	
	J	S VRAIN ST OUTFALL	$412,329	$72,244	$340,200	$446,712	$65,227	$33,060		$1,369,772	$41,093	$136,977	$205,466	$95,884	$136,977	$342,443	$2,328,612	
	K	S XAVIER ST OUTFALL	$164,509	$19,163	$97,200	$173,188	$23,558	$17,100		$494,718	$14,842	$49,472	$74,208	$34,630	$49,472	$123,680	$841,022	
	L	W JEWELL AVE IMPROVEMENTS	$648,678	$117,222	$162,000	$315,056	$64,029	$37,620		$1,344,605	$40,338	$134,460	$201,691	$94,122	$134,460	$336,151	$2,285,827	
	M	W KENTUCKY AVE IMPROVEMENTS	$873,721	$175,275	$307,800	$541,484	$97,023	$42,180		$2,037,483	$61,124	$203,748	$305,622	$142,624	$203,748	$509,371	$3,463,720	
	N	HARVEY PARK LAKE OUTFALL	$222,197			$142,716	$18,759	$10,260		$393,932	$11,818	$39,393	$59,090	$27,575	$39,393	$98,483	$669,684	$43,070,711
5100-01-100YR	A	100 YEAR SYSTEM	$860,075	$210,672	$324,000	$543,784	$101,259	$86,640		$2,126,430	$63,793	$212,643	$318,964	$148,850	$212,643	$531,608	$3,614,931	
	B	S NAVAJO ST OUTFALL	$4,191,507	$225,554	$291,600	$1,158,076	$299,778	$128,820		$6,295,335	$188,860	$629,534	$944,300	$440,673	$629,534	$1,573,834	$10,702,070	
	C	W ARIZONA AVE OUTFALL	$2,269,693	$62,722	$97,200	$292,992	$137,384	$25,080		$2,885,071	$86,552	$288,507	$432,761	$201,955	$288,507	$721,268	$4,904,621	$19,221,622
5200-01-ALT 1	A	ASBURY OUTFALL	$1,850,178	$143,168	$243,000	$433,200	$135,244	$35,340		$2,840,130	$85,204	$284,013	$426,020	$198,809	$284,013	$710,032	$4,828,221	
	B	BROADWAY TRIBUTARY (SOUTH OF EVANS)	$407,056	$63,726	$194,400	$278,708	$48,847	$33,060		$1,025,797	$30,774	$102,580	$153,870	$71,806	$102,580	$256,449	$1,743,856	
	C	BROADWAY TRIBUTARY (SOUTH OF HARVARD)	$546,589	$27,336	$178,200	$159,340	$45,972	$7,980		$965,417	$28,963	$96,542	$144,813	$67,579	$96,542	$241,354	$1,641,210	
	E	BROADWAY TRIBUTARY (SOUTH OF WESLEY)	$90,678	$25,137	$48,600	$38,827	$10,276	$2,280		$215,798	$6,474	$21,580	$32,370	$15,106	$21,580	$53,950	$366,858	
	F	DELAWARE TRIBUTARY (SOUTH OF EVANS)	$143,496	$44,602	$81,000	$109,572	$20,074	$22,800		$421,544	$12,646	$42,154	$63,232	$29,508	$42,154	$105,386	$716,624	
	G	DELAWARE TRIBUTARY (SOUTH OF HARVARD)	$133,298	$56,904	$97,200	$88,320	$19,071	$5,700		$400,493	$12,015	$40,049	$60,074	$28,035	$40,049	$100,123	$680,838	
	I	EVANS OUTFALL	$438,799	$80,050	$145,800	$207,672	$45,212	$31,920		$949,453	$28,484	$94,945	$142,418	$66,462	$94,945	$237,363	$1,614,070	
	J	EVANS TRIBUTARY (EAST OF BROADWAY)	$591,858	$93,234	$226,800	$433,324	$71,251	$79,800		$1,496,267	$44,888	$149,627	$224,440	$104,739	$149,627	$374,067	$2,543,655	
	K	GALAPAGO TRIBUTARY (SOUTH OF EVANS)	$114,967	$9,262	$48,600	$80,800	$13,308	$12,540		$279,477	$8,384	$27,948	$41,922	$19,563	$27,948	$69,869	$475,111	
	L	GALAPAGO TRIBUTARY (SOUTH OF HARVARD)	$72,394	$2,650	$16,200	$19,360	$5,530			$116,134	$3,484	$11,613	$17,420	$8,129	$11,613	$29,034	$197,427	
	M	GALAPAGO TRIBUTARY (SOUTH OF WESLEY)	$36,033	$7,952	$48,600	$35,120	$6,385			$134,090	$4,023	$13,409	$20,114	$9,386	$13,409	$33,522	$227,953	
	N	SUPPLEMENTAL MAJOR CONDUIT IN HARVARD	$7,346,296	$27,870	$129,600	$648,320	$409,143	$30,780		$8,592,009	$257,760	$859,201	$1,288,801	$601,441	$859,201	$2,148,002	$14,606,415	
	O	SUPPLEMENTAL MAJOR CONDUIT IN ILIFF	$7,361,482	$33,870	$194,400	$704,000	$416,398	$34,200		$8,744,350	$262,330	$874,435	$1,311,652	$612,105	$874,435	$2,186,088	$14,865,395	$44,507,633
5200-01-ALT 2	A	ASBURY OUTFALL	$2,145,396	$124,529	$259,200	$442,208	$150,334	$35,340		$3,157,007	$94,710	$315,701	$473,551	$220,990	$315,701	$789,252	$5,366,912	
	B	BROADWAY TRIBUTARY (SOUTH OF EVANS)	$479,245	$69,804	$210,600	$328,556	$56,291	$37,620		$1,182,116	$35,463	$118,212	$177,317	$82,748	$118,212	$295,529	$2,009,597	
	C	BROADWAY TRIBUTARY (SOUTH OF HARVARD)	$546,589	$28,836	$194,400	$159,340	$46,857	$7,980		$984,002	$29,520	$98,400	$147,600	$68,880	$98,400	$246,000	$1,672,802	
	E	BROADWAY TRIBUTARY (SOUTH OF WESLEY)	$90,678	$25,137	$48,600	$38,827	$10,276	$2,280		$215,798	$6,474	$21,580	$32,370	$15,106	$21,580	$53,950	$366,858	
	F	DELAWARE TRIBUTARY (SOUTH OF EVANS)	$320,256	$47,278	$162,000	$229,212	$39,818	$37,620		$836,184	$25,086	$83,618	$125,428	$58,533	$83,618	$209,046	$1,421,513	
	G	DELAWARE TRIBUTARY (SOUTH OF HARVARD)	$133,298	$43,395	$97,200	$88,320	$18,396	$5,700		$386,309	$11,589	$38,631	$57,946	$27,042	$38,631	$96,577	$656,725	
	I	EVANS OUTFALL	$528,824	$64,474	$113,400	$209,693	$47,416	$31,920		$995,727	$29,872	$99,573	$149,359	$69,701	$99,573	$248,932	$1,692,737	
	J	EVANS TRIBUTARY (EAST OF BROADWAY)	$591,858	$93,234	$226,800	$433,324	$71,251	$79,800		$1,496,267	$44,888	$149,627	$224,440	$104,739	$149,627	$374,067	$2,543,655	
	K	GALAPAGO TRIBUTARY (SOUTH OF EVANS)	$135,083	$24,870	$81,000	$109,852	$18,281	$14,820		$383,906	$11,517	$38,391	$57,586	$26,873	$38,391	$95,976	$652,640	
	L	GALAPAGO TRIBUTARY (SOUTH OF HARVARD)	$72,394	$2,650	$16,200	$19,360	$5,530			$116,134	$3,484	$11,613	$17,420	$8,129	$11,613	$29,034	$197,427	
	M	GALAPAGO TRIBUTARY (SOUTH OF WESLEY)	$36,033	$7,952	$48,600	$35,120	$6,385			$134,090	$4,023	$13,409	$20,114	$9,386	$13,409	$33,522	$227,953	
	N	SUPPLEMENTAL MAJOR CONDUIT IN HARVARD	$7,174,280	$28,006	$129,600	$472,896	$391,778	$30,780		$8,227,340	$246,820	$822,734	$1,234,101	$575,914	$822,734	$2,056,835	$13,986,478	
	P	ROSEDALE PARK DETENTION	$98,551	$10,524	$16,200	$18,512	$7,303	$2,280	$3,400,000	$3,553,370	$106,601	$355,337	$533,006	$248,736	$355,337	$888,342	$6,040,729	$36,836,026
5200-02	A	COLUMBINE OUTFALL	$14,405	$3,657	$16,200	$17,784	$2,716	$2,280		$57,042	$1,711	$5,704	$8,556	$3,993	$5,704	$14,260	$96,970	
	B	CORNELL TRIBUTARY (FLOWS TO ENGLEWOOD)	$60,616	$10,602	$64,800	$67,688	$10,527	$6,840		$221,073	$6,632	$22,107	$33,161	$15,475	$22,107	$55,268	$375,823	
	C	DARTMOUTH TRIBUTARY (FLOWS TO ENGLEWOOD)	$36,998	$7,952	$48,600	$40,172	$7,826	$22,800		$164,348	$4,930	$16,435	$24,652	$11,504	$16,435	$41,087	$279,391	
	D	DRY GULCH MAJOR CONDUIT	$4,542,077	$35,292	$113,400	$287,056	$250,074	$21,660		$5,251,559	$157,547	$525,156	$787,734	$367,609	$525,156	$1,312,890	$8,927,651	
	E	FLORA TRIBUTARY (FLOWS TO ENGLEWOOD)	$228,059	$35,084	$194,400	$214,248	$35,528	$38,760		$746,079	$22,382	$74,608	$111,912	$52,226	$74,608	$186,520	$1,268,335	
	G	GAYLORD OUTFALL (NORTH OF HARVARD GULCH)	$35,705	$6,880	$32,400	$34,800	$5,660	$3,420		$118,865	$3,566	$11,886	$17,830	$8,321	$11,886	$29,716	$202,070	
	H	GAYLORD OUTFALL (SOUTH OF HARVARD GULCH)	$30,411	$6,308	$32,400	$37,544	$5,447	$2,280		$114,390	$3,432	$11,439	$17,158	$8,007	$11,439	$28,598	$194,463	
	I	HARVARD GULCH PARK TO RACE	$14,961,913	$78,017	$324,000	$1,260,720	$835,906	$93,480		$17,554,036	$526,621	$1,755,404	$2,633,105	$1,228,783	$1,755,404	$4,388,509	$29,841,862	
	J	ILIFF TRIBUTARY (EAST OF CORONA)	$20,069	$6,308	$32,400	$24,776	$5,318	$22,800		$111,671	$3,350	$11,167	$16,751	$7,817	$11,167	$27,918	$189,841	
	K	JOSEPHINE OUTFALL	$11,204	$3,657	$16,200	$13,832	$2,359	$2,280		$49,532	$1,486	$4,953	$7,430	$3,467	$4,953	$12,383	$84,204	
	L	LAFAYETTE OUTFALL (NORTH OF HARVARD)	$540,701	$154,374	$307,800	$316,280	$68,580	$52,440		$1,440,175	$43,205	$144,018	$216,026	$100,812	$144,018	$360,044	$2,448,298	
	M	LAFAYETTE OUTFALL (SOUTH OF HARVARD)	$39,706	$9,452	$64,800	$49,020	$8,206	$1,140		$172,324	$5,170	$17,232	$25,849	$12,063	$17,232	$43,081	$292,951	
	N	PENNSYLVANIA OUTFALL	$15,924	$3,158		$15,520	$1,901	$3,420		$39,923	$1,198	$3,992	$5,988	$2,795	$3,992	$9,981	$67,869	
	O	RACE OUTFALL	$48,837	$9,452	$64,800	$52,464	$9,006	$4,560		$189,119	$5,674	$18,912	$28,368	$13,238	$18,912	$47,280	$321,503	
	P	UNIVERSITY OUTFALL (NORTH OF HARVARD GULCH)	$279,984	$54,720	$194,400	$199,048	$37,377	$19,380		$784,909	$23,547	$78,491	$117,736	$54,944	$78,491	$196,227	$1,334,345	
	Q	UNIVERSITY OUTFALL (SOUTH OF HARVARD GULCH)	$239,858	$38,343	$194,400	$222,500	$36,807	$41,040		$772,948	$23,188	$77,295	$115,942	$54,106	$77,295	$193,237	$1,314,011	
	R	WESLEY TRIBUTARY (EAST OF CORONA)	$27,004	$7,250	$32,400	$26,320	$5,903	$25,080		$123,957	$3,719	$12,396	$18,594	$8,677	$12,396	$30,989	$210,728	
	S	WILLIAMS OUTFALL	$40,630	$10,602	$64,800	$50,160	$8,595	$5,700		$180,487	$5,415	$18,049	$27,073	$12,634	$18,049	$45,122	$306,829	
	T	YORK OUTFALL	$99,358	$16,513	$81,000	$95,656	$14,854	$4,560		$311,941	$9,358	$31,194	$46,791	$21,836	$31,194	$77,985	$530,299	
	U	CORONA OUTFALL	$76,498	$1,007		$79,552	$9,107	$25,080		$191,244	$5,737	$19,124	$28,687	$13,387	$19,124	$47,811	$325,114	$48,612,557

STATEMENT OF PROBABLE COSTS IN 2008 DOLLARS

PROJECT			HARD COSTS								INDIRECT COSTS						TOTALS	
BASIN	ID	PROJECT	PIPE	MANHOLE	INLETS	ASPHALT PATCH	DRY UTILITY RELOCATE	WET UTILITY RELOCATE	DETENTION	TOTAL CONSTRUCTION COSTS	TRAFFIC CONTROL (3%)	MOBILIZATION (10%)	DESIGN & ENGINEERING (15%)	MATERIALS MANAGEMENT (7%)	ADMIN-ISTRATIVE (10%)	CONTINGENCY (25%)	TOTAL	TOTAL BY BASIN
5200-03	A	AMHERST OUTFALL	$118,606	$16,530	$81,000	$97,104	$16,175	$10,260		$339,675	$10,190	$33,968	$50,951	$23,777	$33,968	$84,919	$577,448	
	AA	STEELE OUTFALL	$110,705	$20,474	$97,200	$94,860	$16,675	$10,260		$350,174	$10,505	$35,017	$52,526	$24,512	$35,017	$87,544	$595,295	
	B	BIRCH OUTFALL	$301,070	$90,601	$194,400	$216,192	$41,367	$25,080		$868,710	$26,061	$86,871	$130,306	$60,810	$86,871	$217,178	$1,476,807	
	BB	YALE OUTFALL (COLORADO TO BIRCH)	$1,279,902	$7,500	$81,000	$137,344	$76,541	$25,080		$1,607,367	$48,221	$160,737	$241,105	$112,516	$160,737	$401,842	$2,732,525	
	C	CLAYTON OUTFALL (SOUTH OF HARVARD GULCH)	$553,897	$132,129	$275,400	$329,348	$68,187	$72,960		$1,431,921	$42,958	$143,192	$214,788	$100,234	$143,192	$357,980	$2,434,265	
	CC	YALE OUTFALL (BIRCH TO CLERMONT)	$275,060	$1,500	$16,200	$31,872	$16,403	$3,420		$344,455	$10,334	$34,446	$51,668	$24,112	$34,446	$86,114	$585,575	
	D	CLAYTON TRIBUTARY (SOUTH OF AMHERST)	$259,824	$93,708	$194,400	$195,928	$38,618	$28,500		$810,978	$24,329	$81,098	$121,647	$56,768	$81,098	$202,744	$1,378,662	
	DD	YALE OUTFALL (CLERMONT TO BROOK)	$435,236			$50,432	$24,283			$509,951	$15,299	$50,995	$76,493	$35,697	$50,995	$127,488	$866,918	
	E	CLERMONT OUTFALL	$813,858	$147,658	$453,600	$533,068	$99,917	$50,160		$2,098,261	$62,948	$209,826	$314,739	$146,878	$209,826	$524,565	$3,567,043	
	EE	YALE OUTFALL (BROOK TO DENNISON)	$419,771	$3,000	$32,400	$48,640	$25,533	$6,840		$536,184	$16,086	$53,618	$80,428	$37,533	$53,618	$134,046	$911,513	
	F	COLORADO OUTFALL (NORTH OF HARVARD GULCH)	$1,627,617	$261,345	$518,400	$775,068	$164,822	$114,000		$3,461,252	$103,838	$346,125	$519,188	$242,288	$346,125	$865,313	$5,884,129	
	FF	YALE OUTFALL (DENNISON TO DAHLIA)	$523,201	$3,000	$32,400	$70,448	$31,680	$4,560		$665,289	$19,959	$66,529	$99,793	$46,570	$66,529	$166,322	$1,130,991	
	G	COLORADO OUTFALL (SOUTH OF HARVARD GULCH)	$453,965	$89,309	$307,800	$402,028	$65,562	$58,140		$1,376,804	$41,304	$137,680	$206,521	$96,376	$137,680	$344,201	$2,340,566	
	GG	YALE OUTFALL (DAHLIA TO EUDORA)	$214,246	$9,879	$32,400	$44,220	$15,208	$3,420		$319,373	$9,581	$31,937	$47,906	$22,356	$31,937	$79,843	$542,933	
	H	COOK OUTFALL	$389,634	$86,519	$129,600	$183,112	$41,837	$47,880		$878,582	$26,357	$87,858	$131,787	$61,501	$87,858	$219,646	$1,493,589	
	HH	YALE OUTFALL (EUDORA TO GLENCO)	$362,179	$33,516	$64,800	$105,768	$28,826	$10,260		$605,349	$18,160	$60,535	$90,802	$42,374	$60,535	$151,337	$1,029,092	
	I	DAHLIA OUTFALL	$183,695	$38,361	$113,400	$141,472	$24,359	$10,260		$511,547	$15,346	$51,155	$76,732	$35,808	$51,155	$127,887	$869,630	
	II	YALE OUTFALL (GLENCO TO HUDSON)	$286,448	$36,822	$81,000	$124,468	$26,779	$6,840		$562,357	$16,871	$56,236	$84,354	$39,365	$56,236	$140,589	$956,008	
	J	DARTMOUTH TRIBUTARY	$454,005	$116,765	$405,000	$400,628	$71,157	$46,740		$1,494,295	$44,829	$149,430	$224,144	$104,601	$149,430	$373,574	$2,540,303	
	K	ADAMS WAY IMPROVEMENTS	$72,743	$13,224	$64,800	$59,556	$10,573	$1,140		$222,036	$6,661	$22,204	$33,305	$15,543	$22,204	$55,509	$377,462	
	L	DENNISON OUTFALL	$92,730	$15,219	$81,000	$82,204	$13,786	$4,560		$289,499	$8,685	$28,950	$43,425	$20,265	$28,950	$72,375	$492,149	
	M	EASTMAN TRIBUTARY (EAST OF FOREST)	$902,249	$213,493	$469,800	$514,130	$108,404	$68,400		$2,276,476	$68,294	$227,648	$341,471	$159,353	$227,648	$569,119	$3,870,009	
	N	EUDORA OUTFALL	$1,543,308	$185,849	$324,000	$577,344	$133,805	$45,600		$2,809,906	$84,297	$280,991	$421,486	$196,693	$280,991	$702,476	$4,776,840	
	O	FILLMORE OUTFALL	$42,271	$6,880	$32,400	$41,200	$6,195	$1,140		$130,086	$3,903	$13,009	$19,513	$9,106	$13,009	$32,522	$221,148	
	P	GLENCOE OUTFALL (SOUTH OF YALE)	$258,018	$71,877	$178,200	$194,168	$36,196	$21,660		$760,119	$22,804	$76,012	$114,018	$53,208	$76,012	$190,030	$1,292,203	
	Q	GLENCOE TRIBUTARY (SOUTH OF HIGHLINE CANAL)	$609,259	$137,655	$291,600	$405,484	$75,221	$60,420		$1,579,639	$47,389	$157,964	$236,946	$110,575	$157,964	$394,910	$2,685,387	
	S	HARVARD TRIBUTARY (EAST OF CLAYTON)	$165,822	$65,322	$129,600	$125,508	$24,712	$7,980		$518,944	$15,568	$51,894	$77,842	$36,326	$51,894	$129,736	$882,204	
	U	JACKSON OUTFALL (NORTH OF HARVARD GULCH)	$77,401	$12,181	$64,800	$75,440	$11,662	$3,420		$244,904	$7,347	$24,490	$36,736	$17,143	$24,490	$61,226	$416,336	
	V	JACKSON OUTFALL (SOUTH OF HARVARD GULCH)	$49,166	$6,880	$32,400	$47,920	$7,046	$4,560		$147,972	$4,439	$14,797	$22,196	$10,358	$14,797	$36,993	$251,552	
	W	MANSFIELD TRIB. (FLOWS TO CHERRY HILLS VILLAGE)	$117,170	$27,132	$145,800	$103,864	$20,667	$19,380		$434,013	$13,020	$43,401	$65,102	$30,381	$43,401	$108,503	$737,821	
	X	MONROE OUTFALL	$76,294	$13,862	$64,800	$66,392	$11,523	$9,120		$241,991	$7,260	$24,199	$36,299	$16,939	$24,199	$60,498	$411,385	$48,327,788
5300-01	A	18" UPGRADES	$16,129	$5,301	$32,400	$19,912	$3,687			$77,429	$2,323	$7,743	$11,614	$5,420	$7,743	$19,357	$131,629	
	B	S FEDERAL BLVD IMPROVEMENTS	$432,623	$84,445	$243,000	$321,452	$55,729	$33,060		$1,170,309	$35,109	$117,031	$175,546	$81,922	$117,031	$292,577	$1,989,525	
	C	S ZUNI ST OUTFALL	$852,236	$180,684	$405,000	$651,056	$106,216	$35,340		$2,230,532	$66,916	$223,053	$334,580	$156,137	$223,053	$557,633	$3,791,904	$5,913,058
5500-01	A	18" UPGRADES	$149,468	$29,156	$178,200	$184,528	$27,695	$12,540		$581,587	$17,448	$58,159	$87,238	$40,711	$58,159	$145,397	$988,699	
	B	S LOWELL BLVD OUTFALL	$643,625	$126,329	$162,000	$246,208	$59,706	$15,960		$1,253,828	$37,615	$125,383	$188,074	$87,768	$125,383	$313,457	$2,131,508	
	C	S UTICA ST IMPROVEMENTS	$473,781	$47,140	$48,600	$104,556	$34,673	$19,380		$728,130	$21,844	$72,813	$109,220	$50,969	$72,813	$182,032	$1,237,821	
	D	W AMHERST AVE IMPROVEMENTS	$289,948	$47,709	$291,600	$357,960	$52,097	$54,720		$1,094,034	$32,821	$109,403	$164,105	$76,582	$109,403	$273,508	$1,859,856	
	E	FT LOGAN CEMETERY IMPROVEMENTS							$515,280	$515,280	$15,458	$51,528	$77,292	$36,070	$51,528	$128,820	$875,976	
	F	VRAIN ST IMPROVEMENTS	$187,737	$77,292	$97,200	$120,244	$26,233	$42,180		$550,886	$16,527	$55,089	$82,633	$38,562	$55,089	$137,722	$936,508	$8,030,368
5500-02	A	18" UPGRADES	$69,809	$23,854	$145,800	$86,184	$16,396	$2,280		$344,323	$10,330	$34,432	$51,648	$24,103	$34,432	$86,081	$585,349	
	B	S NEWLAND ST OUTFALL	$397,041	$55,789	$210,600	$295,348	$49,535	$31,920		$1,040,233	$31,207	$104,023	$156,035	$72,816	$104,023	$260,058	$1,768,395	
	C	S SHERIDAN BLVD OUTFALL	$804,343	$139,045	$388,800	$609,848	$100,522	$68,400		$2,110,958	$63,329	$211,096	$316,644	$147,767	$211,096	$527,740	$3,588,630	
	D	S WEBSTER ST OUTFALL	$1,334,502	$84,724	$210,600	$321,888	$99,695	$42,180		$2,093,589	$62,808	$209,359	$314,038	$146,551	$209,359	$523,397	$3,559,101	
	E	W BATES AVE IMPROVEMENTS	$102,262	$21,204	$129,600	$108,190	$18,462	$7,980		$387,698	$11,631	$38,770	$58,155	$27,139	$38,770	$96,924	$659,087	
	F	W DARTMOUTH AVE IMPROVEMENTS	$83,065	$10,602	$64,800	$80,960	$12,313	$6,840		$258,580	$7,757	$25,858	$38,787	$18,101	$25,858	$64,645	$439,586	$10,600,148
5500-04	A	S WADSWORTH WAY IMPROVEMENTS	349866	55404	97200	177320	35244	25080		740114	22203	74011	111017	51808	74011	185028	$1,258,192	
	B	W UNION AVE IMPROVEMENTS	$516,344	$77,955	$210,600	$264,012	$55,042	$31,920	$273,600	$1,429,473	$42,884	$142,947	$214,421	$100,063	$142,947	$357,368	$2,430,103	$3,688,295
5500-05	A	FOOTHILLS GC IMPROVEMENTS	$213,494	$13,252	$81,000	$83,990	$19,644	$1,140		$412,520	$12,376	$41,252	$61,878	$28,876	$41,252	$103,130	$701,284	
	B	FOOTHILLS GC IMPROVEMENTS - 01							$27,360	$27,360	$821	$2,736	$4,104	$1,915	$2,736	$6,840	$46,512	
	C	FOOTHILLS GC IMPROVEMENTS - 02							$54,720	$54,720	$1,642	$5,472	$8,208	$3,830	$5,472	$13,680	$93,024	
	D	S HARLAN ST DETENTION - 01							$18,240	$18,240	$547	$1,824	$2,736	$1,277	$1,824	$4,560	$31,008	
	E	S HARLAN ST DETENTION - 02							$27,360	$27,360	$821	$2,736	$4,104	$1,915	$2,736	$6,840	$46,512	
	F	S HARLAN ST DETENTION - 03							$91,200	$91,200	$2,736	$9,120	$13,680	$6,384	$9,120	$22,800	$155,040	
	G	S PIERCE WAY DETENTION							$191,520	$191,520	$5,746	$19,152	$28,728	$13,406	$19,152	$47,880	$325,584	$1,398,964

4.0 REFERENCES

ASCG Incorporated, *Montclair Basin, Denver Storm Drainage Master Plan*, September 7, 2004.

Boyle Engineering Corporation, *Results from First Creek Future Conditions Model*, Update, July 31, 2003

Boyle Engineering Corporation, *2003 Irondale Gulch Watershed Master Plan Implementation Hydrology Model Update*, July 9, 2003.

BRW, Inc., *Lowry Master Drainage Plan, Addendum No. 2*, December 1998.

BRW, Inc. and Matrix Design Group, Inc. Final Stapleton Infrastructure Master Plan. December, 2000.

Camp Dresser & McKee, Inc. *Flood Hazard Area Delineation Marston Lake North*. February 1979.

Camp Dresser & McKee, Inc. *Flood Hazard Area Delineation Westerly Creek*. January 1977.

Camp Dresser & McKee, Inc. *Major Drainageway Planning - Marston Lake North Phase B Development of Preliminary Plan*. October 1979.

Camp Dresser & McKee, Inc. *Major Drainageway Planning – Westerly Creek Volume II*. February 1977.

Centennial Engineering, Inc., *Flood Hazard Area Delineation, Weir Gulch Tributaries, 1st Avenue - Dakota Avenue*, July 1977.

Centennial Engineering, Inc., *Major Drainageway Planning – Weir Gulch Tributaries – 1st Avenue, Dakota Avenue Depew Street Basin*, July 1978.

Centennial Engineering, Inc., *Major Drainageway Planning, Weir Gulch Tributaries, 1st Avenue and Dakota Avenue, Phase A Report*, October 1977.

Centennial Engineering, Inc. *Final Master Drainage Study (Lower Downtown) 20th Street Viaduct Replacement South Platte River to Lower Downtown*. August 1992.

Centennial Engineering, Inc. *North I-25 Bus/HOV Project Drainage Maps with SWMM Elements*. April 1992.

Centennial Engineering, Inc. *North I-25 Bus/HOV Project Master Plan Sub-Basins*. January 1993.

CDM, *Harvard Gulch/University Hills/Yale-Glencoe System Master Plan and Preliminary Design,* April 2005.

Chow, Ven Te, Ph.D. *Open-Channel Hydraulics*. 1959.

City and County of Denver Department of Public Works Wastewater Management Division. *Denver Storm Drainage Master Plan*. July, 1989.

City and County of Denver Department of Public Works Wastewater Management Division. *Storm Drainage Master Plane, April 2005*.

City and County of Denver Department of Public Works Wastewater Management Division. *Storm Drainage Design and Technical Criteria*. January 2006.

City and County of Denver. Assessment Data Collection Manual.

City and County of Denver Department of Parks and Recreation, *Lake Management and Protection Plan*, April 2004.

Colorado Department of Transportation, *Valley Highway-Logan to 6th Avenue Record of Decision*, June 2007.

Denver County Assessors Office. *2003 Property Value Database*.

ERO Resources Corporation, *Draft Environmental Assessment, Irondale Gulch Preliminary Drainage Study*, July 16, 2003.

Federal Emergency Management Agency Mitigation Directorate. *Engineering Principles and Practices for Retrofitting Flood Prone Residential Buildings*. January 1995.

Forest City Stapleton, *East-West Linear Park Detention Facility Stapleton – Final Drainage Report*, November 1, 2002.

Forest City Stapleton, *Infrastructure Master Plan – Section 5: Stormwater Management System*, March 2001.

Forest City Stapleton, *North Stapleton Infrastructure Master Plan*, May 2004.

Forest City Stapleton, *North Stapleton Infrastructure Master Amendment No. 1*, December 2006.

Forest City Stapleton, *Stapleton Filing No. 2 – Final Drainage Report*, December 2000.

Forest City Stapleton, *Stapleton Planning Area 4 Schematic Phase Report*, May 2004.

Forest City Stapleton, *Stapleton Filing No. 7 – Final Drainage Report*, September 2006.

Forest City Stapleton, *Stapleton Filing No. 18 – Final Drainage Report,* April 2006.

Forest City Stapleton, *Stapleton Filing No. 19 – Final Drainage Report*, November 2006.

Frasier & Gingery, Inc., *Major Drainageway Planning – Sanderson Gulch/Weir Gulch, Volume I Report*, August 1972.

Frasier & Gingery, Inc., *Major Drainageway Planning – Sanderson Gulch/Weir Gulch, Volume II Drawings*, August 1972.

Gingery Associates, Inc. *Flood Hazard Area Delineation Bear Creek*. December 1979.

Gingery Associates, Inc. *Flood Hazard Area Delineation Goldsmith Gulch and Tributaries*. June 1976.

Gingery Associates, Inc. *Flood Hazard Area Delineation Harvard Gulch, West Harvard Gulch & Dry Gulch*. December 1979.

Gingery Associates, Inc. *Flood Hazard Area Delineation Sanderson Gulch & North Sanderson Gulch*. August 1979.

Gingery Associates, Inc. *Goldsmith Gulch Major Drainageway Planning*. November 1977.

HDR. *Rocky Mountain Ditch, Outfall Systems Planning Study, Preliminary Design Report*. August 2003.

Henkels & McCoy, Inc., *Denver International Business Center Master Drainage Plan*, January 6, 2000.

Henkels & McCoy, Inc., *Final Drainage Report and Stormwater Quality Control Plan, Denver International Business Center Filing No. 8*, August 1999, Revised January 7, 2000.

Hydrosystems Engineering Consulting Service, *Hydrology Study for the Goldsmith Gulch Drainage Basin*, October 5, 1989.

Hydrosystems Engineering Consulting Service, *Appendix to Hydrology Study for the Goldsmith Gulch Drainage Basin*, March 23, 1994.

Icon Engineering, Inc., *Sanderson Gulch Drop Structure Inventory and Bank Stabilization, South Platte River Confluence to Sheridan Boulevard, Engineering Assessment and Maintenance Master Plan*, January 2002.

J.F. Sato and Associates. *Coors Field Phase 2, Offsite Drainage Basins Plan Sheet*. March 1994.

Jacobs Carter Burgess. *South Broadway from Arizona Avenue to Kentucky Avenue Preliminary Drainage Report*, May 2008.

Kiowa Engineering Corporation, *Academy Park Tributary to Bear Creek – Outfall Systems Planning Study*, December 1997.

Kiowa Engineering Corporation, *Academy Park Tributary to Bear Creek – Outfall Systems Planning Study – Preliminary Design Report*, July 1999.

Kiowa Engineering Corporation, *Upper Weir Gulch Major Drainageway Planning Study – Alternative Development and Evaluation*, October 1992.

Kiowa Engineering Corporation. *Second Creek and Direct Flow Area 0053 Outfall Planning Study, Preliminary Design*. May 1990.

Kiowa Engineering Corporation, *Pinehurst Tributary to Bear Creek Outfall Systems Planning Study, Preliminary Design Report*, December 1999.

Kiowa Engineering Corporation. *Globeville-Utah Junction Watershed Outfall Systems Planning Study Preliminary Design Report*. February, 2000.

Kiowa Engineering Corporation, *Westerly Creek (Lower) Drainageway Update, Hydrology Report*, December 2008.

Kiowa Engineering Corporation, *Westerly Creek (Lower) Drainageway Update, Major Drainageway Planning, Phase A Report*, June 2009.

Kirkham, Michael and Associates, *Master Storm Drainage Study, Fairlake Development*, Revised March 1994.

Kirkham, Michael and Associates, *Quincy Lake Phase III Drainage Report*, June 2003.

Landmark Engineering, Ltd., *Final Drainage Report on Stormwater Quality Control Plan, Gravesite Development and Cemetery Improvements, Fort Logan National Cemetery*, December 2003.

Love & Associates, Inc., *Prairie Gateway Outfall Systems Planning Alternative Evaluation Report*, August 2002.

Love & Associates, Inc., *Prairie Gateway Outfall Systems Planning Preliminary Design Report*, April 25, 2003.

Martin/Martin, Inc. *Revision to the First Creek and DFA 0055 Outfall Systems Master Plan (Picadilly Road to Buckley Road)*. November 18, 1998.

Martin/Martin Consulting Engineers, *Denver International Airport Drainage Master Plan – Part Three Analysis of Full Development Plan, Final Report*, June 2004.

Martin/Martin Consulting Engineers, *Union Pacific Realty Company Property, Phase IV and V, Irondale Gulch Basin Drainage Plan*, January 6, 1994.

Martin/Martin Consulting Engineers, *Gateway Park Parcel IV West Irondale Gulch Basin Drainage Plan*, October 8, 1996.

Matrix Design Group, Inc., *40^{th}/40^{th} Storm Drain Outfall Report*, January 2008.

Matrix Design Group, Inc., *Federal Boulevard Storm Sewer Improvements Preliminary Drainage Report*, October 2008.

Matrix Design Group, Inc., *North Stapleton Infrastructure Master Plan*, Approved December 2006.

MB Consulting, Inc., *Single Tree at DIA Filing #2 Master Drainage Plan*, December 18, 1998.

McLaughlin Water Engineers, Ltd., *Stormwater Outfall Systems Plan Stapleton Area*, July 1995.

McLaughlin Water Engineers, Ltd. *South Platte River Central Platte Valley: Alternative Evaluation and Preliminary Design Report*. December 1989.

Merrick and Company, *Flood Hazard Area Delineation Westerly Creek*, March 1983.

Merrick and Company, *Outfall Systems Planning, Westerly Creek East of Havana*, October 1996.

Merrick and Company. *Urban Drainage & Flood Control District Denver, Glendale, Arapahoe County: Flood Hazard Delineation Cherry Creek*. July 1976.

Merrick and Company, Harmon, and O'Donnell & Henninger Associates, Inc. *Major Drainageway Planning Cherry Creek*. May 1977.

Merrick and Company, Harmon, O'Donnell & Henninger Associates, Inc., and Alan M. Voorhees & Associates, Inc. *Master Plan for Cherry Creek the Phase "A" Study Report*. July 30, 1976.

Mosier, *Upper First Creek Baseline Hydrology Report*, May 2009.

Muller Engineering Company, Inc. *First Creek Master Plan Adjustments*, September 30, 2004.

Nelson-Haley-Patterson & Quirk. Montbello Storm Drainage, Preliminary Design. Vol. II – Drawings. May 1975.

Pardue, Cornwell & Associates, Inc., *Majestic Commerce Center, Irondale Gulch Basin Master Drainage Plan*, April 8, 1998.

PB Americas Inc., *Hydrologic and Hydraulic Draft Report for Denver Union Station.* October 17, 2008.

PBS&J, *27th & Federal Stormwater Master Plan (Basin 0061-01, 0061-02).* April 2005.

PBS&J, *Cherry Creek Neighborhood Drainage Study Final Report*, May 2009

PBS&J, *Hampden Heights Area Flood Investigation and Improvement Plan*, June 2002.

PBS&J, *RTD FasTracks East Corridor Draft Drainage Master Plan*, October 2008.

Roberts Consultants, Inc., *Green Valley Ranch, First Creek Basin, Outfall Study for Future Development Parcels*, May 10, 2000.

Robson, S.G. *Geohydrology of the Shallow Aquifers in the Denver Metropolitan Area*, Colorado. 1996.

Rocky Mountain Consultants, Inc., *Lakeshore Village Final Drainage Report and Stormwater Management Plan*, Revised January 2000.

S.A. Miro, Inc., ODP/FDP *Master Drainage Report for Highpointe*, Revised December 3, 2004.

S.A. Miro, Inc., *Master Utilities Report for Highpointe at DIA FDP/GDP*, Revised July 23, 2004.

S.A. Miro, Inc., C.P. Bedrock, Inc., Denver Connection Master Drainage Plan, February 28, 2003.

Sellards & Grigg, Inc., *Flood Hazard Area Delineation, Dry Gulch and Tributaries*, November 1977.

Sellards & Grigg, Inc., *Evaluation of Debris and Flood Control On Goldsmith Gulch, I-225 To Iliff Avenue*, December 2004.

Sellards & Grigg, Inc., *Flood Hazard Area Delineation Lakewood Gulch*, February 1979.

Sellards & Grigg, Inc., *University and Mexico Basin Hydrology and Hydraulics Master Plan*, April 2005.

Simons, Li & Associates, Inc. *Storm Drainage Planning Upper Westerly Creek Outfall System*, March 1982.

Southeast Corridor Constructors, *Drainage Report, Area 2.2, 100% Final, I-25/LRT Southeast Corridor*. April 21, 2003.

Stewart, Kevin G., P.E. *Flood Warning and Preparedness*. March 3, 2003.

Stormwater & Environmental Consultants, Inc., A Subdivision of Olsson Associates, *Alternatives Evaluation Report, Planning of Holly Hills Area Tributary to Harvard Gulch Outfall Systems.* April 2000.

Stormwater & Environmental Consultants, Inc., A Subdivision of Olsson Associates, *Preliminary Design Report, Planning of Holly Hills Tributary to Harvard Gulch Outfall Systems.* October 2001.

Turner Collie & Braden, Inc. *Lower First Creek and DFA 0055 Outfall Systems Planning Hydrology Report*. August 2000.

Turner Collie & Braden, Inc., *City of Englewood Outfall Systems Planning, Preliminary Design Report*, September 1999.

Turner Collie & Braden, Inc., *Amended Final Drainage Report for Hampden Town Center, Revised* November 13, 2000.

Turner Collie & Braden, Inc., *Stapleton Sitewide Infrastructure Master Plan*, 1996.

Turner Collie & Braden, Inc., *Amended Master Drainage Report for Hampden Town Center*, Revised August 13, 2002.

Urban Drainage and Flood Control District *Urban Drainage Stormwater Management Model - PC Version*. February 2001.

Urban Drainage and Flood Control District. *Colorado Urban Hydrograph Procedure Computer Program*, February 2001(May 2003 Correction).

Urban Drainage and Flood Control District. *Urban Storm Drainage Criteria Manual*, Volumes I & II. June 2001.

Urban Drainage and Flood Control District. *Urban Storm Drainage Criteria Manual*, Volume III. September 1999.

Urban Drainage and Flood Control District. *Colorado Urban Hydrograph Procedure Computer Program,* February 2001(May 2003 Correction).

Urban Drainage and Flood Control District. *South Platte River: A Plan for the Future - Chatfield to Brighton*. December 1985.

URS Company, *Flood Hazard Area – Dutch Creek, Lilley Gulch, Coon Creek & Three Lakes Tributary*, May 1978.

URS Company, *Flood Hazard Area – Sloan's Lake Basin*, October 1977.

URS Company, *Major Drainageway Planning – Dutch Creek, Lilley Gulch, Coon Creek Drainage Basin Area, Phase B Preliminary Design*, August 1979.

URS Company, *Major Drainageway Planning – Sloan's Lake Basin, Interim Report, Phase A*, March 1977.

URS Company, *Major Drainageway Planning – Sloan's Lake Basin, Phase B*, December 1977.

U.S. Army Corps of Engineers, Westerly Creek Dam and Kelly Road Dam – Water Control Manual

USACE, *Westerly Creek Dam and Kelly Road Dam-Water Control Manual,* April 1991.

Vestal Engineering, Inc., *Green Valley Ranch Final Drainage Plan*, March 22, 2004.

Vestal Engineering, Inc., *Green Valley Ranch First Creek Himalaya to Tower Subbasin, Basin Boundaries*, January, 2004.

Vestal Engineering, Inc., *Green Valley Ranch Master Drainage Map, Developed Basin Map*, August 11, 2003.

Washington Group International, *Globeville Utah Junction Watershed Outfall System Planning Re-Study*, October 2004.

WRC Engineering, Inc., *Henry's Lake Basin – Phase B Technical Addendum*, January 1984.

WRC Engineering, Inc., *Henry's Lake Drainageway – Phase B Report*, December 1983.

WRC Engineering, Inc., *Major Drainageway Planning - Hydrological Report Henry's Lake Basin Phase A Report*, December 1982.

WRC Engineering, Inc., *Major Drainageway Planning of Denver High Line Canal and Little Dry Creek Watershed (ARAPCO), Phase A Alternatives Evaluation Report*, May 2003.

WRC Engineering, Inc., *Major Drainageway Planning of Denver High Line Canal (Dad Clark Gulch to Mississippi Avenue) Phase B Preliminary Design*, June 2004.

WRC. *Four Square Mile Area - Storm Drainage Outfall Alternatives*. August 1985.

WRC. *Outfall System Planning – Four Square Mile Area*. August 1985.

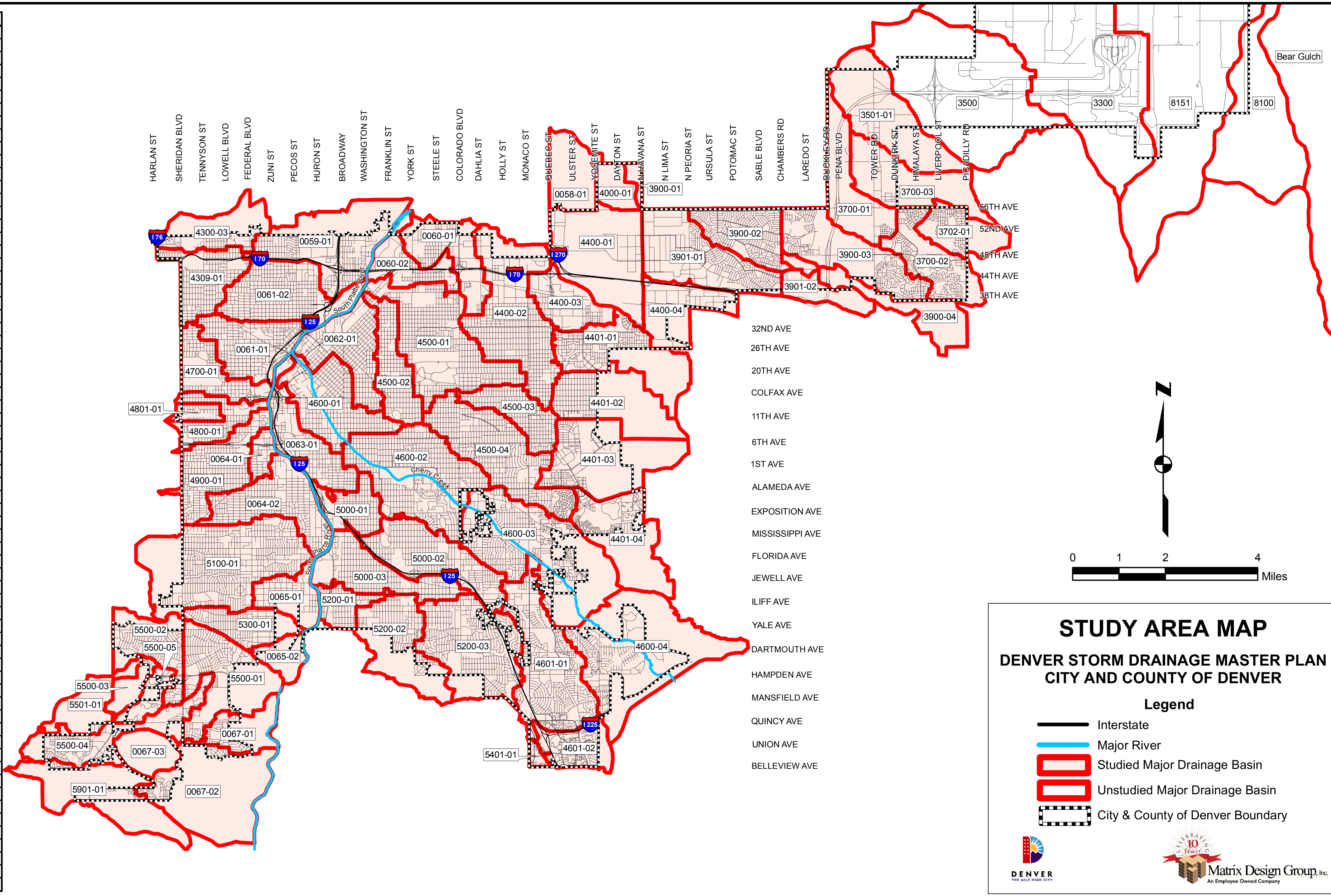
Wright Water Engineers, Inc. *First Creek and DFA 0055 Outfall Systems Master Plan, Preliminary Design Report*. February 9, 1990.

Wright Water Engineers, Inc. *Irondale Gulch and DFA 0055 Stormwater Outfall Systems Plan, Preliminary Design Report*. May 1990.

Wright Water Engineers, Inc. *Flood Hazard Area Delineation South Platte River: Denver Metropolitan Area Sand Creek to Oxford Avenue* September 1985.

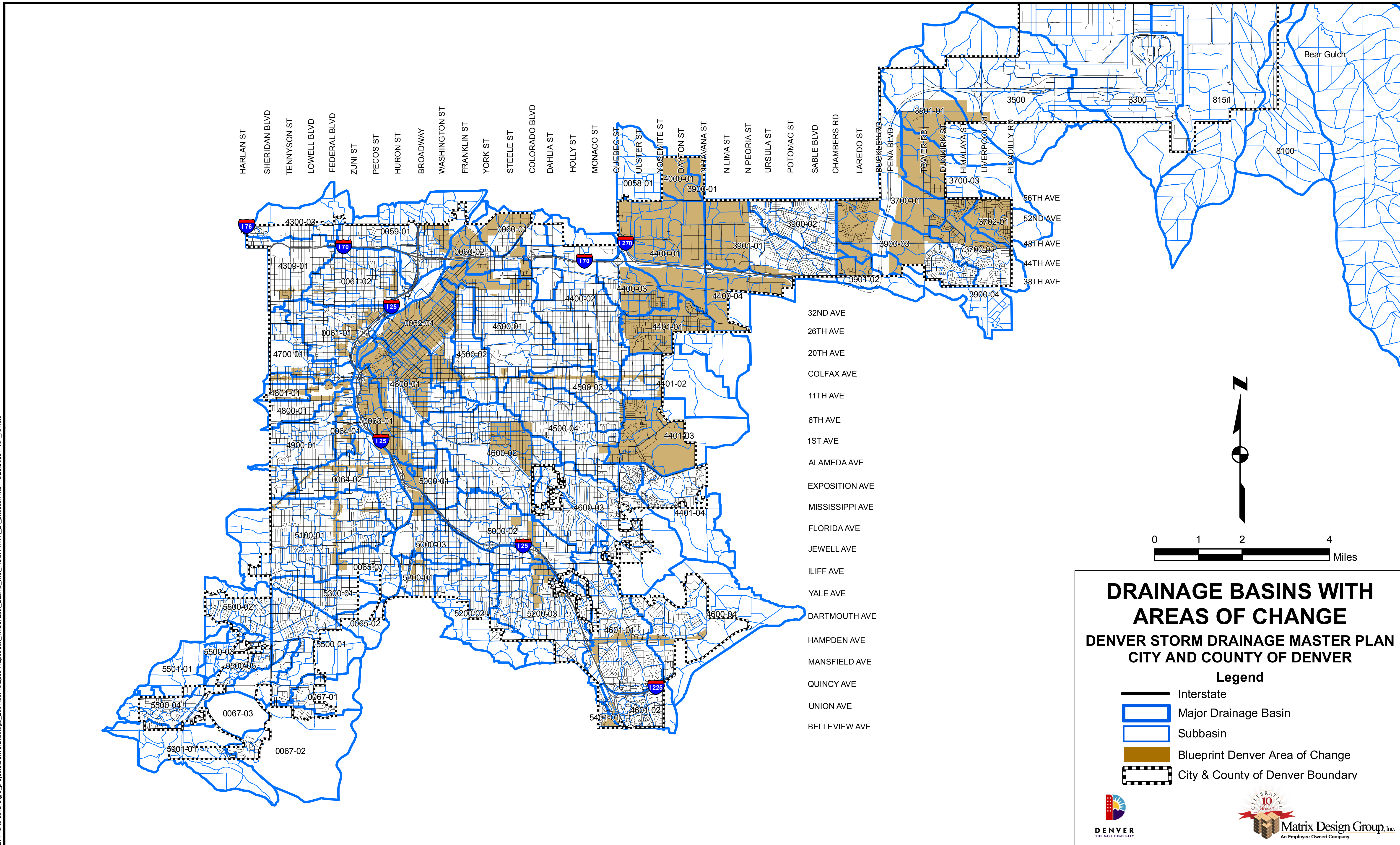
Wright Water Engineers, Inc. *Major Drainageway Planning South Platte River Chatfield Dam to Baseline Road, Phase B,* 2 Volumes. November 1985.

Major Basin	Page
0058-01	33
0059-01	35
0060-01	37
0060-02	39
0061-01	41
0061-02	45
0062-01	49
0063-01	51
0064-01	53
0064-02	55
0065-01	57
0065-02	59
0067-01	61
0067-02	63
0067-03	65
3501-01	67
3700-01	69
3700-02	71
3700-03	73
3702-01	75
3900-01	77
3900-02	79
3900-03	81
3900-04	83
3901-01	85
3901-02	87
4000-01	89
4300-03	91
4309-01	93
4400-01	95
4400-02	97
4400-03	99
4400-04	101
4401-01	103
4401-02	105
4401-03	107
4401-04	109
4500-01	111
4500-02	117
4500-03	113
4500-04	115
4600-01	119
4600-02	123
4600-03	125
4600-04	127
4601-01	129
4601-02	131
4700-01	133
4800-01	137
4801-01	137
4900-01	139
5000-01	141
5000-02	145
5000-03	147
5100-01	149
5200-01	153
5200-02	157
5200-03	159
5300-01	161
5401-01	163
5500-01	165
5500-02	167
5500-03	169
5500-04	171
5500-05	173
5501-01	175
5901-01	177



FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activeapps\mapbook_mxd\Study_Area_all_phases.mxd, 6/25/2009, ron_arnold

This sheet left intentionally blank



FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activeApps\mapbook_mxd\Matrix_Basins_with_AOC(11X17)_all_phases.mxd, 6/25/2009, ron_rarnold

Basin: 0058-01 (Prairie Gateway)

Existing Basin Description:
This basin is a tributary to the South Platte River and is located in Denver and Adams Counties north of Stapleton. The basin consists of about 1,011 acres, the northern portion which consists of the Rocky Mountain Arsenal.

The basin was loosely defined in Denver's 1989 Master Plan and included a portion of north Stapleton (south of 56th), as well as the Postal Facility and Adams County (north of 56th). Basin 4400-01 includes all area south of 56th Avenue in accordance with the approved Drainage Master Plan for the Stapleton Redevelopment site, dated March 2001. Therefore, the resulting basin lies north of 56th Avenue.

Although most of the land in this basin is within Adams County, it is included in this Denver study for the approximately 70-acre Denver Water Pump Station and Postal Facility. The surrounding area was previously part of the Rocky Mountain Arsenal, but has been cleaned and transferred to the U.S. Fish and Wildlife Service, which in-turn has transferred the land to Commerce City. This land is known as the "Prairie Gateway," which includes Dick's Sporting Goods Soccer Stadium.

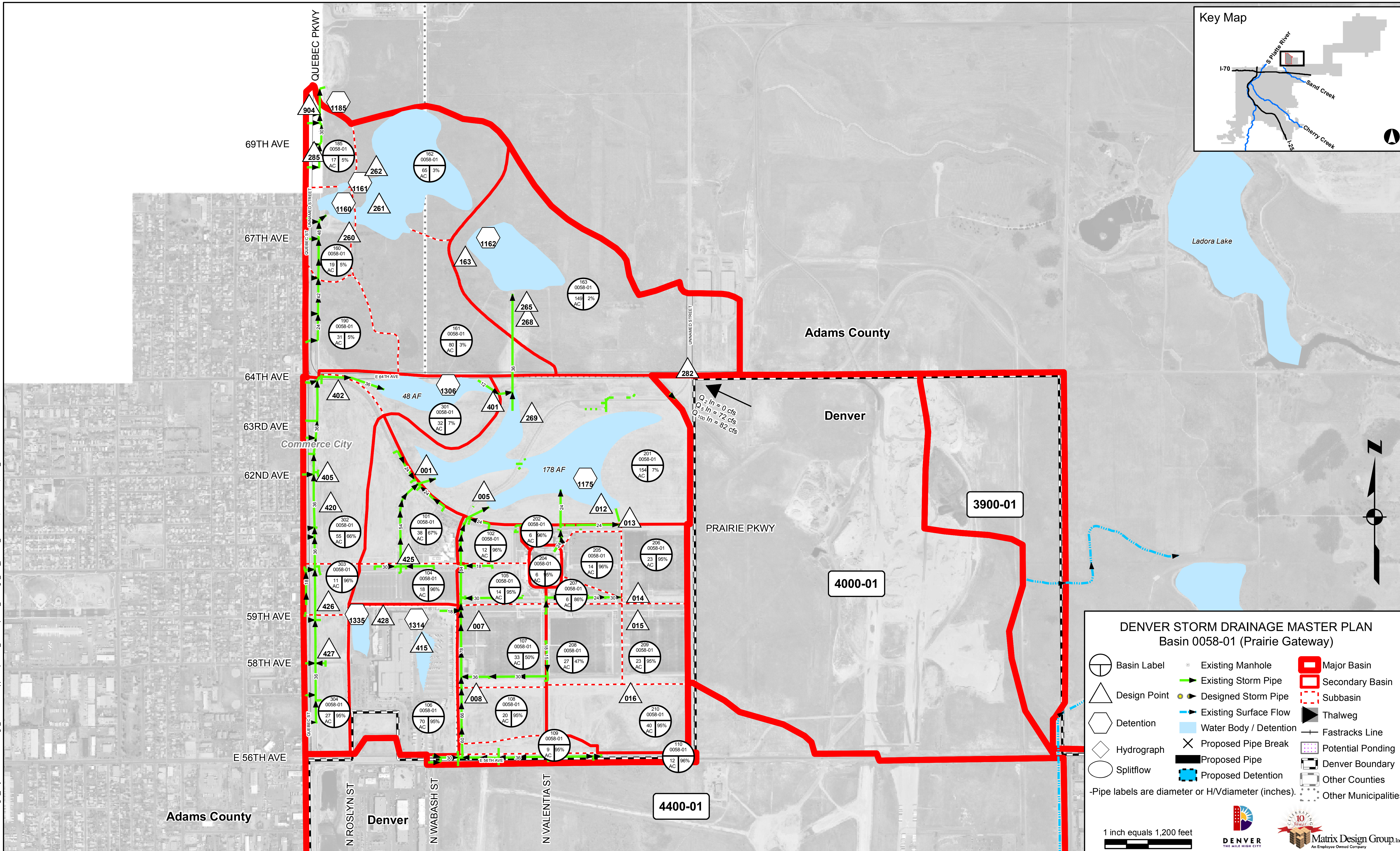
The site was studied in detail by the Urban Drainage & Flood Control District, Adams County and Commerce City in a report titled, "***Prairie Gateway Outfall Systems Planning Alternative Evaluation Report***," dated August 2002. The report concluded that the 100-year storm could be retained on the site rather than upsizing the storm sewer outfalls through Commerce City to the South Platte River. There are many existing natural depressions on the site that can contain the 100-year rainfall event. In addition, the US Postal Facility existing retention ponds contain the 100-year storm. The Prairie Gateway report identifies the maximum available storage for the Postal Facility as 10.7 acre-feet for the 30-acre parking lot, and 29.6 acre-feet for the 31.7-acre Bulk Mail Facility.

With the redevelopment of the Prairie Gateway site for the Dick's Sports Soccer Stadium, drainage east of Quebec Street and north of 56th Avenue has been directed into two major regional retention ponds with approximately 225 acre-feet of retention storage for the 100-year, 24 hour storm event. By agreement, these retention ponds discharge into the Rocky Mountain Arsenal between storms by controlled releases.

Developed Conditions Hydrology:

BASIN 0058-01

Design Point	Tributary Area	Peak Discharge		
		2-Year	5-Year	100-Year
	(acres)	*(cfs)*	*(cfs)*	*(cfs)*
1	126	164	241	431
5	100	128	193	420
6	88	107	164	362
7	73	84	131	295
8	41	59	85	172
13	139	200	294	617
14	119	168	248	523
15	90	123	182	390
16	40	67	95	191
101	38	44	71	168
102	12	20	29	58
104	19	31	44	87
105	14	23	33	67
106	70	101	144	293
107	33	25	46	123
108	20	34	48	97
109	9	13	19	38
110	12	14	20	42
160	19	0	9	39
162	65	2	36	159
163	149	2	32	162
185	17	0	8	35
190	31	0	7	47
201	154	9	64	273
202	6	10	14	29
204	6	9	14	28
205	14	23	33	66
206	23	37	53	107
207	6	8	12	26
208	27	17	32	87
209	23	39	55	112
210	40	67	95	191
262	214	4	60	289
269	651	564	874	1952
285	361	7	119	567
301	32	2	17	71
302	55	49	80	192
303	11	19	27	54
304	28	46	66	132
313	94	101	128	273
420	94	107	162	325
425	88	126	179	286
426	39	65	93	186
904	361	7	119	567
1160	130	3	53	247
1161	344	7	111	533
1162	149	2	32	162
1175	525	460	736	1680
1185	361	7	119	567
1306	126	104	143	334
1314	70	103	147	299
1335	70	101	144	230



FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activemaps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/24/2009, ron_ramold

Basin 0059-01 (Globeville -Utah Junction)

Existing System Description:
This basin consists of 2345 acres (3.66 square miles) and is mostly built-out. I-25 traverses the middle of the basin and I-70 traverses the southern portion of the basin. The I-25/I-70 interchange is within this basin. ***Blueprint Denver*** shows much of the industrial area northeast of the I-25/I-70 interchange as "Areas of Change." The northern approximately one-third of the basin is within Adams County.

Basin drainage is predominately west to east, with eight major outfalls to the South Platte River. A ninth outfall exists at 58th Avenue, in Adams County. Rennick railroad yard, west of I-25, intercepts a significant amount of the basin drainage from the west and diverts the discharge to the south. I-25 also is a barrier to the runoff due to the limited crossing capacity and elevated design. The outfall systems south of approximately I-70 have capacity for the major storm (not including the railroad yard diversion). The capacities of the outfall systems north of approximately 47th Avenue vary from less than the 5-year flood event to approximately a 25-year event.

Constraints to drainage infrastructure in this basin include:
- Crossing the railroad yards west of I-25
- Crossing I-25
- Multiple large Metro sewers just west of the South Platte River
- The South Platte River west bank levee

Drainage Deficiencies:
The existing drainage system has limited capacity at the Rennick railroad yard where the existing 54"x28" elliptical corrugated metal pipe at the west next to railroad and a 48" corrugated metal pipe crosses underneath the railroad with less than 5-year capacity.

Potential Ponding Areas:
In a major flood, I-25 creates a potential ponding area at West 52nd Avenue and Bannock Street and a potential ponding area at West 43rd Avenue and Cahita Ct. Potential ponding is also possible around the CDOT pond at the east of I-25 and the north of the 51st Avenue and the area located at the north of 51st Avenue and west of Washington Street because of topographic constraints. There's also a potential ponding area at I-70 and North Pecos Street. Potential ponding is also possible in a major storm event north and east of the Argo Park detention pond located near E 49th Avenue and N. Pearl Street.

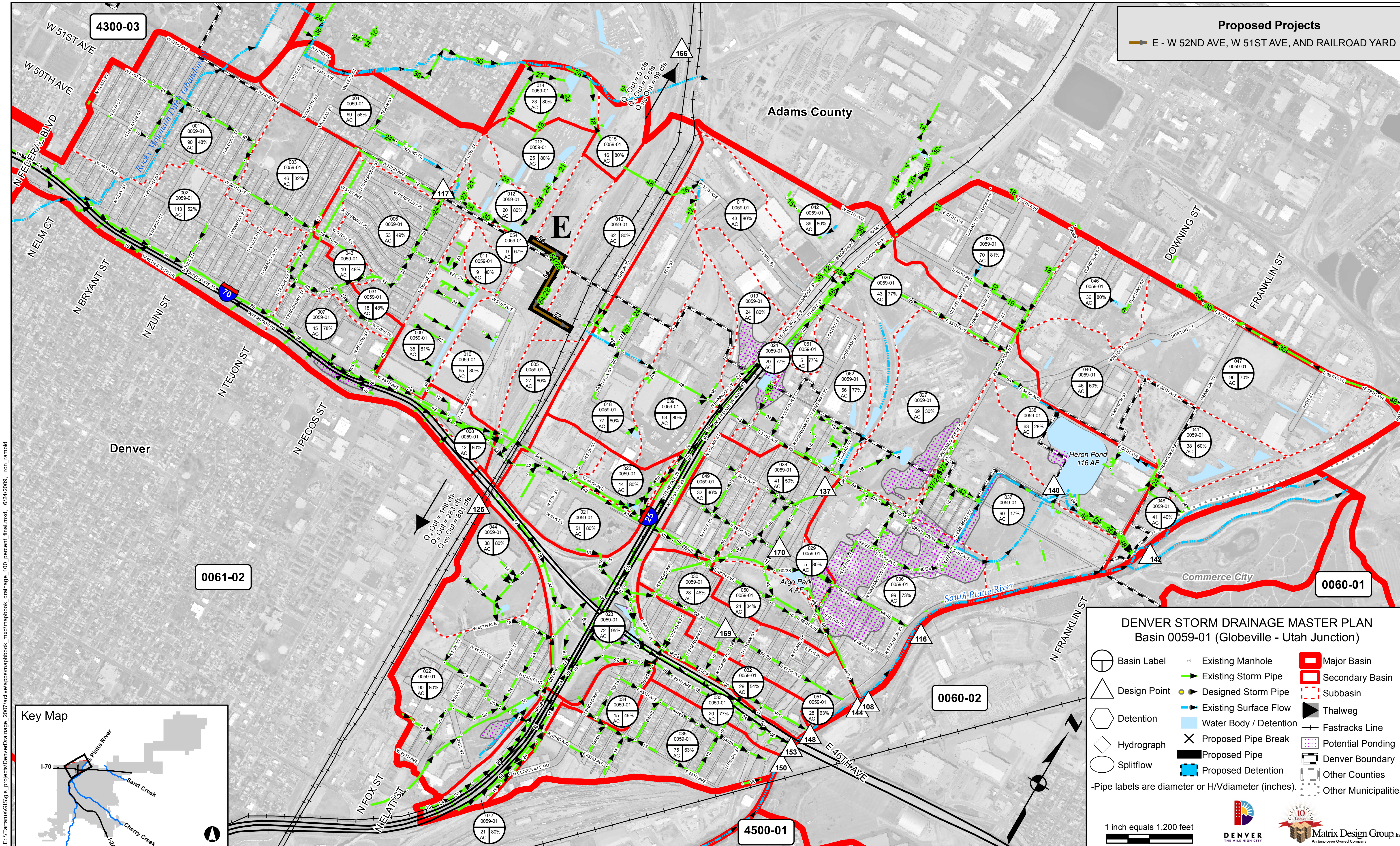
Proposed Capital Improvements:
The following drainage improvements have been proposed to increase the level of service to a minimum of 5-year capacity.

<u>Project E: West 52nd Avenue, West 51st Avenue and Railroad Yard</u> includes upsizing the existing 60-inch storm sewer that goes east underneath the railroad track to a 72-inch equivalent storm sewer and upsizing the existing 54'x28" elliptical corrugated metal pipe to a 54-inch equivalent from approximately the intersection of Kalamath Street and E. 51st Avenue to the intersection of Kalamath Street and E. 52nd Avenue to convey the 5-year discharge.

Hydrology:
The following table summarizes existing conditions hydrology:

BASIN 0059-01

Design Point	Contributing Basins	Tributary Area (acres)	Peak Discharge 2-Year (cfs)	Peak Discharge 5-Year (cfs)	Peak Discharge 100-Year (cfs)
108	1, 2, 3, 7, 8, 20, 21, 28, 31, 49, 50	313.3	129	161	172
116	1, 2, 3, 7, 8, 20, 21, 28, 29, 31, 49	177.2	71	72	78
117	4	69.1	23	61	214
125	1, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 16, 31, 43, 54	383.8	168	283	801
137	14, 15, 17, 18, 19, 24, 26, 39, 42, 53	281.1	139	189	197
140	14, 15, 17, 18, 19, 24, 26, 27, 36, 37, 38, 39, 42, 53	727	265	404	949
142	14, 15, 17, 18, 19, 24, 26, 27, 36, 37, 38, 39, 42, 53	727	0	0	267
144	30, 51	56	36	63	131
148	32, 34, 72	65.2	30	47	115
150	22, 35, 44	203.1	58	96	236
153	23, 33	92.2	88	109	161
169	30	28.4	18	33	91
170	1, 2, 3, 7, 8, 20, 21, 28, 31, 49	40.9	26	49	303


DENVER STORM DRAINAGE MASTER PLAN
Basin 0059-01 (Globeville - Utah Junction)
Proposed Projects
E - W 52ND AVE, W 51ST AVE, AND RAILROAD YARD
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.
Key Map
Adams County
Denver
Commerce City
South Platte River
Heron Pond
116 AF
Argo Park
4 AF
4300-03
0061-02
0060-01
0060-02
4500-01
Q 2 Out = 0 cfs
Q 5 Out = 0 cfs
Q 100 Out = 89 cfs
Q 2 Out = 188 cfs
Q 5 Out = 283 cfs
Q 100 Out = 801 cfs
W 51ST AVE
W 50TH AVE
N FEDERAL BLVD
N ELM CT
N BRYANT ST
N ZUNI ST
N TEJON ST
N PECOS ST
N FOX ST
N ELATI ST
N FRANKLIN ST
DOWNING ST
FRANKLIN ST
E 46TH AVE
FILE: \\Tartarus\GIS\gis_projects\Denver\Drainage_2007\activelapps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/24/2009, ron_ramold

Basin 0060-01 (I-70 & Colorado Boulevard)

Existing System Description:
This basin includes a mix of industrial and residential land uses, and consists of 1,279 acres (1.99 square miles). It is fully built-out with older neighborhood residential in the upper reaches and commercial in the lower reaches. ***Blueprint Denver*** shows the region downstream (northwest) of Vasquez Boulevard as an "Area of Change". The upper reaches of Basin 0060-01 are shown as "Areas of Stability". All drainage from this basin outfalls to the South Platte River.

Drainage Deficiencies:
The existing drainage system has capacity to convey less than the 1-year storm event to the outfall. Rainfall runoff in excess of the storm drain capacity has a history of ponding in the sump and flat areas. Major drainage problems have been experienced along the Smith Road corridor and along Vasquez Boulevard near Sand Creek. Specific drainage deficiencies include:

- The existing Union Pacific Railroad (UPPR) right-of-way creates a major barrier for surface flow and causes broad flooding of the Swansea Park area.
- Improved conveyance (storm sewer) is needed in York Street above Brighton Boulevard and in the industrial zones above Vasquez Boulevard.

Potential Ponding Areas:
An extensive area of potential ponding has been identified within Basins 0060-01 and 4400-02, related primarily to ponding behind railroad tracks, I-70, and other sumps in the lower portions of each basin. A total of 716 structures with a structure value (excluding land value) of $120.6M (per 2003 Denver Assessors' records) lie within the 501-acre zone most severely impacted by the flooding.

Proposed Capital Improvements:
Drainage improvements in these basins should be viewed primarily to achieve the minimum performance objectives for residential and commercial areas (2- and 5-year system capacities) established for the Denver stormwater program, primarily due to the high cost of retrofitting new storm sewer in existing streets. Proposed capital improvements include:

Project F1: Lower Park Hill Outfall A new 5-year storm drain system is needed in Dahlia Street. This proposed project will connect downstream to the planned 84" at Dahlia St and Smith Road (currently in design) and project 4400-02 F2 upstream.

Project G: 50th Avenue Interceptor A new storm drain system is needed in 50th Avenue. This proposed project will connect to the existing storm drain system at 50th Avenue and Colorado Blvd.

Project H: Columbine and York Upgrades A 5-year storm drain system is needed in Brighton Boulevard from York Street, extending south in Brighton Boulevard, York Street and Columbine Street.

Project I: Riverside Outfall A 5-year 78-inch outfall storm sewer is proposed within York Street from Brighton Boulevard to outfall to the South Platte River. This proposed project would provide an outfall system for 0060-01-H upstream.

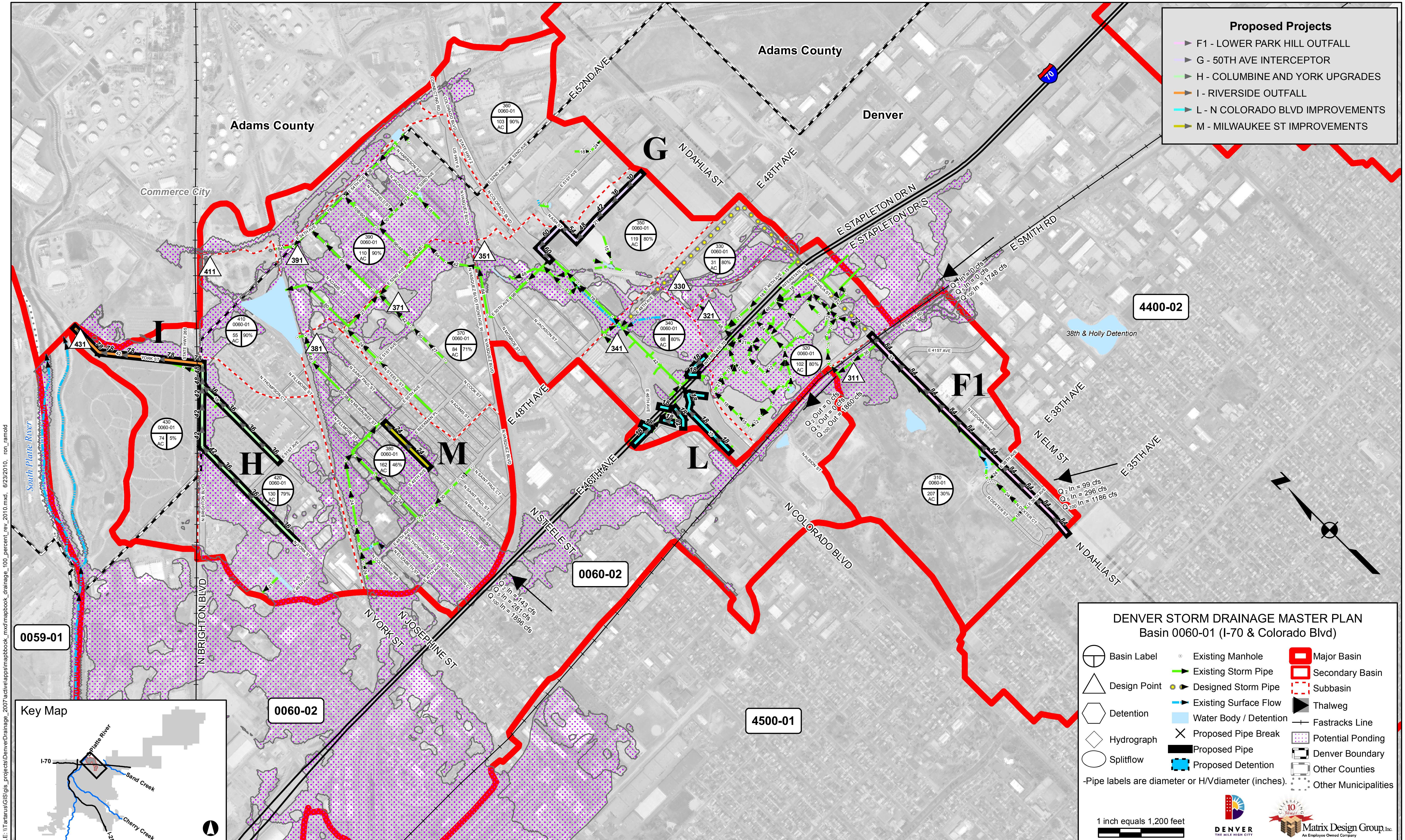
Project L: N Colorado Blvd Improvements This project includes the addition of storm sewers in local roads to improve the interception of the minor storm events.

Project M: Milwaukee St Improvements A new 24-inch storm drain is needed in Milwaukee St from 50th Avenue to 49th Avenue.

Existing Hydrology:

Design Point / Flow Element	Contributing Basins and Split Flow Routing Elements	Basin Parameters	Discharge		
		Area	Q2-yr	Q5-yr	Q100-yr
		(acres)	(cfs)	(cfs)	(cfs)
310	310	207	59	140	450
311	310, 1615*, 1627*	207	98	308	2581
320	320	102	149	224	490
321	320, 1635*	102	149	224	490
330	330	31	38	57	125
331	330	31	38	57	125
340	340	68	80	120	266
341	340, 1330*, 1331*	408	275	466	1182
350	350	120	169	253	554
351	350, 1340*	527	329	515	1174
360	360	103	170	248	509
370	370	84	89	142	328
371	370	84	89	142	328
380	380	162	80	153	427
381	380, 1651*	246	145	304	1861
390	390	110	173	252	519
391	390, 1350*	883	430	620	1416
410	410	55	79	115	238
411	1390	938	714	1170	3298
420	420	130	168	254	559
421	420	130	168	254	559
430	430	74	4	41	173
431	420,430	204	110	210	609
441	500, 510	split	93	176	445

*See map in Technical Appendix for locations of all split flow routing elements.


Proposed Projects
F1 - LOWER PARK HILL OUTFALL
G - 50TH AVE INTERCEPTOR
H - COLUMBINE AND YORK UPGRADES
I - RIVERSIDE OUTFALL
L - N COLORADO BLVD IMPROVEMENTS
M - MILWAUKEE ST IMPROVEMENTS
Adams County
Denver
Commerce City
South Platte River
E 52ND AVE
E 48TH AVE
E 46TH AVE
E 38TH AVE
E 35TH AVE
E SMITH RD
E STAPLETON DR N
E STAPLETON DR S
N DAHLIA ST
N ELM ST
N COLORADO BLVD
N STEELE ST
N YORK ST
N JOSEPHINE ST
N BRIGHTON BLVD
38th & Holly Detention
4400-02
0060-02
0059-01
4500-01
G
I
H
M
L
F1
DENVER STORM DRAINAGE MASTER PLAN
Basin 0060-01 (I-70 & Colorado Blvd)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.
Key Map
Platte River
I-70
Sand Creek
Cherry Creek
I-25

Basin 0060-02 (I-70 & York)

Existing System Description:
This basin consists of 934 acres (1.46 square miles) and is fully built-out with older neighborhood residential in the upper reaches and industrial in the lower reaches. The National Western Stock Show grounds are located within this drainage basin. ***Blueprint Denver*** shows the industrial portions of the basin as "Areas of Change". Only the residential neighborhoods are shown as "Areas of Stability". All drainage from this basin outfalls to the South Platte River.

A total of three trans-basin overland flows are observed in this basin, especially in the major event. Two of them are inflows from basin 4400-02 and 4500-01 at the upstream portion of this basin. The one from basin 4400-02 flows west along Smith Road and enters this basin at the Colorado Boulevard crossing. The other one from basin 4500-01 enters this basin at the intersection of the 39th & Madison. The third trans-basin overland flow is across 46th Avenue between N. Clayton Street and N. Steele Street that diverts excess runoff into basin 0060-01.

Intercepted stormwater is discharged to the South Platte River via at least 12 storm drainage outfalls. However, the only major (larger than 48inch) outfall exists at Race Court just upstream of the Burlington Ditch headgate. This outfall (Design Point 1541) drains 597 acres tributary areas discharging via a 78-inch pipe and parallel 42-inch pipe which have a total capacity of about 410 cfs. Following the criteria of an 80% full flow pipe, the existing system has less than a 2-year level of service, whereas current criteria requires a 5-year level of service for commercial/industrial areas.

Constraints to drainage infrastructure in this basin include:
- Crossing a major rail switching yard west of Blake Street
- Crossing I-70
- Crossing a railroad next to Brighton Boulevard
- An elevated section of the Metro Sewer creating a wall barrier for drainage

Drainage Deficiencies:
The existing drainage system will pond water beyond a 2-year storm event, and certainly more ponding will occur in a 100-year event.

Proposed Capital Improvements:
The trans-basin overland flows were not taken into consideration when sizing the proposed projects. Once the upstream proposed projects are constructed the trans-basin flows will be intercepted by the proposed systems in each basin and there will be no more trans-basin flow.

Four major storm drain projects have been proposed in this basin to increase the level of service from a 2-year capacity to a 5-year capacity.

<u>Project A: East 45th Avenue</u> includes an extension of the lateral network south of I-70. Currently, stormwater is collected in 45th Avenue. These improvements extend the storm drains into 44th and 43rd Avenues, and upsize the crossing under I-70 from an existing 66-inch to a 96-inch pipe.

<u>Project B: North Brighton Boulevard Outfall</u> involves construction of a new outfall at a new location. There is no easy or obvious new outfall route to the South Platte River; access is either restricted by I-70 or the Stock Show complex. To maximize the use of the existing pipe network, a new 96-inch outfall has been proposed through the National Western Stock Show grounds to the South Platte River. Negotiations are needed to obtain an easement for a new drainage outfall in this area, if the existing outfall is to remain without replacement. Other minor outfall pipes also need to be upsized to improve the level of service in the area.

<u>Project C: North Race Street Outfall</u> involves upsizing existing storm pipe north of I-70. The railroad is a major barrier for constructing new pipe in this area. There are few roadway crossings of the railroad in the area. The 91-acre area (sub-basin 020) northeast of Vasquez Boulevard and I-70 is currently drained by an 18-inch pipe under I-70. The proposed pipe follows a new alignment in 48th Avenue to avoid construction in the I-70 corridor.

<u>Project D: National Western Improvements</u> involves enlarging existing storm drain outfalls near I-70. Specifically, a 30-inch outfall south of I-70 (Design Point 110) is upsized to a 48-inch pipe. A 24-inch outfall north of I-70 (Design Point 100) is upsized to a 48-inch pipe. A 30-inch outfall north of I-70 (Design Point 90) is upsized to a 54-inch pipe. Preliminary design may consider parallel pipes for this project rather than complete replacement.

Potential Ponding:
The study shows areas around the National Western Stock Show complex as subject to potential ponding during major storm events. These areas are located along the South Platte River Valley and at localized areas and sumps. Redevelopment of the site would warrant drainage improvements in this area.

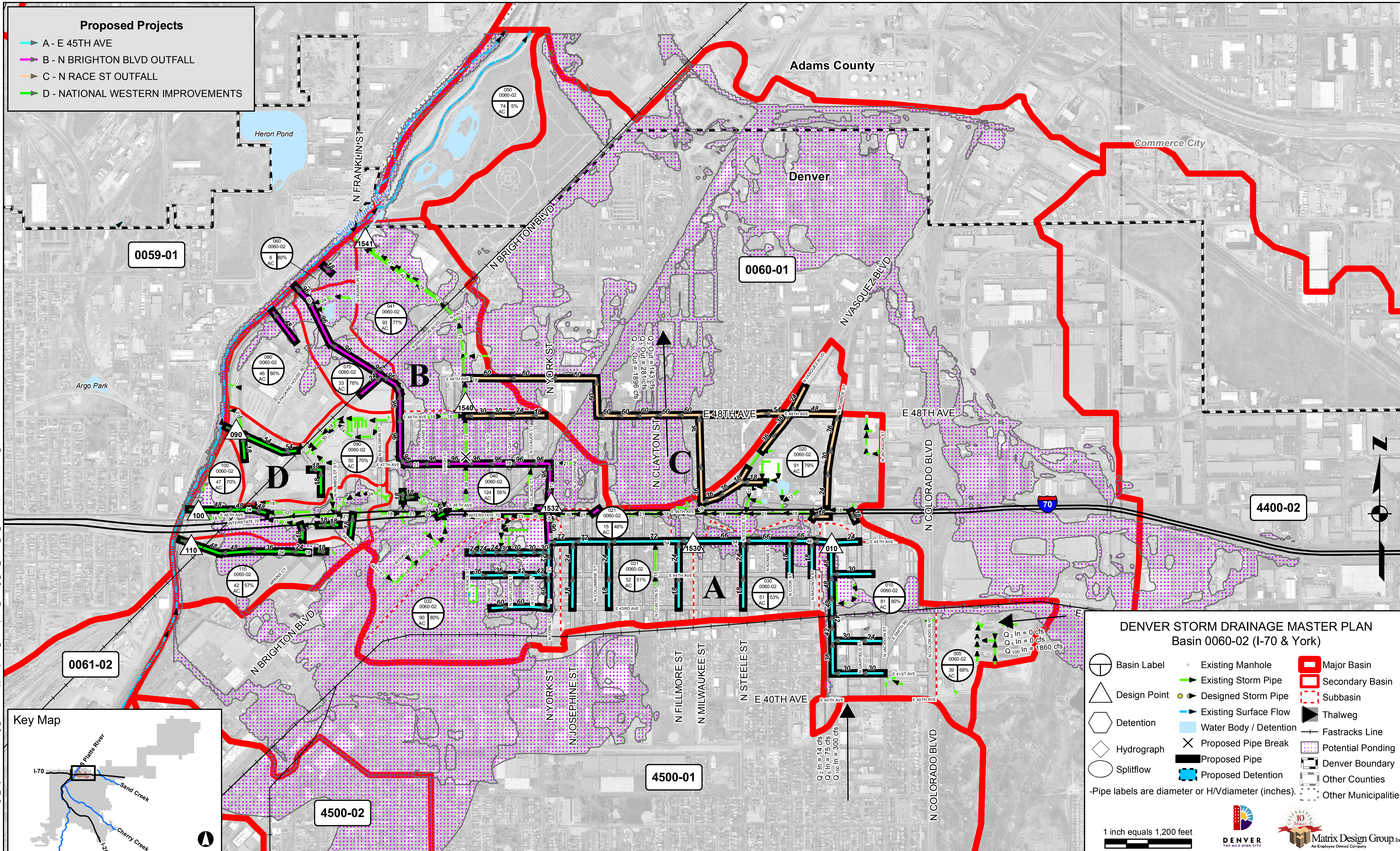
A second area of potential ponding in this basin is the result of overflow from Basins 4400-02 and 0060-01. Runoff from these basins enters Basin 0060-02 along Smith Road and crosses 46th Avenue between N. Clayton Street and N. Steel Street, and flows overland back into Basin 0060-01. Alternative drainage improvements in these basins may reduce the threat of potential ponding in this area.

Another area of potential ponding (not shown on the map) is the result of overland flow from the Montclair Basins (4500). Runoff in excess of the pipe capacity may enter this basin south of I-70 near 40th Avenue. Further detailed study of the Montclair Basin may add areas of potential ponding in the southeastern reaches of Basin 0060-02.

Existing Hydrology:
The following table summarizes existing conditions hydrology:

<u>BASIN 0060-02</u>

Design Point	Contributing Basins	Tributary Area (acres)	Peak Discharge 2-Year (cfs)	Peak Discharge 5-Year (cfs)	Peak Discharge 100-Year (cfs)
10	10	81	95	144	318
90	90	50	57	92	214
100	100	47	45	73	170
110	110	42	41	72	179
1530	10, 30, split flow 631 from 4400-02 & 641 from 4500-01	170	129	216	1949
1532	10,20,21,30-32, split flow 631, 641 minus 651	418	243	349	713
1540	10,20,21,30-32, 40, split flow 631, 641 minus 651	542	312	442	1025
1541	10,20,21,30-32, 40, 41, split flow 631, 641 minus 651	635	324	428	1095


Proposed Projects
A - E 45TH AVE
B - N BRIGHTON BLVD OUTFALL
C - N RACE ST OUTFALL
D - NATIONAL WESTERN IMPROVEMENTS
DENVER STORM DRAINAGE MASTER PLAN
Basin 0060-02 (I-70 & York)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.
Key Map
I-70
S Platte River
Sand Creek
Cherry Creek
I-25
Adams County
Commerce City
Denver
Heron Pond
Argo Park
South Platte River
0059-01
0060-01
0061-02
4400-02
4500-01
4500-02
N FRANKLIN ST
N BRIGHTON BLVD
N YORK ST
N JOSEPHINE ST
N CLAYTON ST
N FILLMORE ST
N MILWAUKEE ST
N STEELE ST
N VASQUEZ BLVD
N COLORADO BLVD
E 48TH AVE
E 40TH AVE
Q_2 Out = 143 cfs
Q_5 Out = 281 cfs
Q_{100} Out = 1896 cfs
Q_2 In = 0 cfs
Q_5 In = 0 cfs
Q_{100} In = 1860 cfs
Q_2 In = 14 cfs
Q_5 In = 75 cfs
Q_{100} In = 300 cfs
A
B
C
D
70

Basin 0061-01 (27th and Federal Basin)

Existing System Description:
The 27th and Federal basin is located in northwest Denver. The approximate boundaries of the basin are W. 19th Avenue on the south (Invesco Field at Mile High Stadium), W. 34th Avenue on the north, the South Platte River to the east and a varying edge on the west primarily extending to N. Newton Street, with some portions extending as far west as N. Wolff Street. The basin is comprised of approximately 1428 acres (2.23 sq mi) of fully developed area. The basin generally drains from west to east and has multiple outfalls into the South Platte River.

The basin is composed of a variety of land uses including residential, parks, commercial and industrial land uses. Much of the basin is residential with commercial areas primarily located along Federal Boulevard and the I-25 corridor.

Blueprint Denver shows the area within ½ mile of I-25, bounded on the east by I-25, W. 20th Avenue on the south, and W. 33rd Avenue on the North as an area subject to change. The remainder (over three-quarters of the basin) is shown as being an "Area of Stability".

All drainage from this basin outfalls to the South Platte River. Intercepted stormwater is discharged in over 9 separate storm drainage outfalls which cross under I-25, ultimately discharging into the South Platte. Some of the more major outfalls include:

- 50-inch pipe at W. 20th Avenue and N. Bryant Street
- 48-inch x 72-inch pipe at W. 25th Avenue and W. Byron Place
- 5ft x 8ft box culvert at Central Street and 19th Street

Drainage Deficiencies:
In general, much of the existing system is undersized and does not adequately convey the 2-year or 5-year design flows. Storm drain infrastructure in this basin has undersized outfalls, incomplete networks of storm drain laterals and is primarily composed of brick and clay pipe systems which do not meet Denver Public Works' current drainage criteria for size and/or material. Much of the system was previously a part of a combined sewer system which has since been separated from the sanitary component.

The 27th and Federal basin lies on a relatively steep area on the side of the South Platte River Valley. As a result, water tends to move quickly through the basin and generally does not produce areas of severe ponding. However, there are two major flow paths within the overall basin that do see shallow overland flooding. This shallow flooding is primarily contained in the streets when a storm event exceeds the storm drain capacity. The two major flow paths are generally described as follows:

- Beginning near the intersection of N. King Street and W. 27th Avenue, traveling south along N. King Street traveling east down W. 24th Avenue and W. 23rd Avenue to Federal Boulevard, south in Federal Boulevard to W. 20th Avenue and then east toward Mile High Stadium.
- Beginning near Irving Street and Speer Boulevard, traveling southeast along Speer Boulevard to I-25.

Proposed Capital Improvements:
Drainage improvements in this basin are primarily recommended to achieve the minimum performance objectives as described in Denver's Drainage Criteria; 2-year and 5-year systems for residential and commercial areas respectively. To meet these requirements, most of the existing storm drain network will need to be replaced. These improvements can be phased in smaller projects following the completion of the major project components. Proposed capital improvements include:

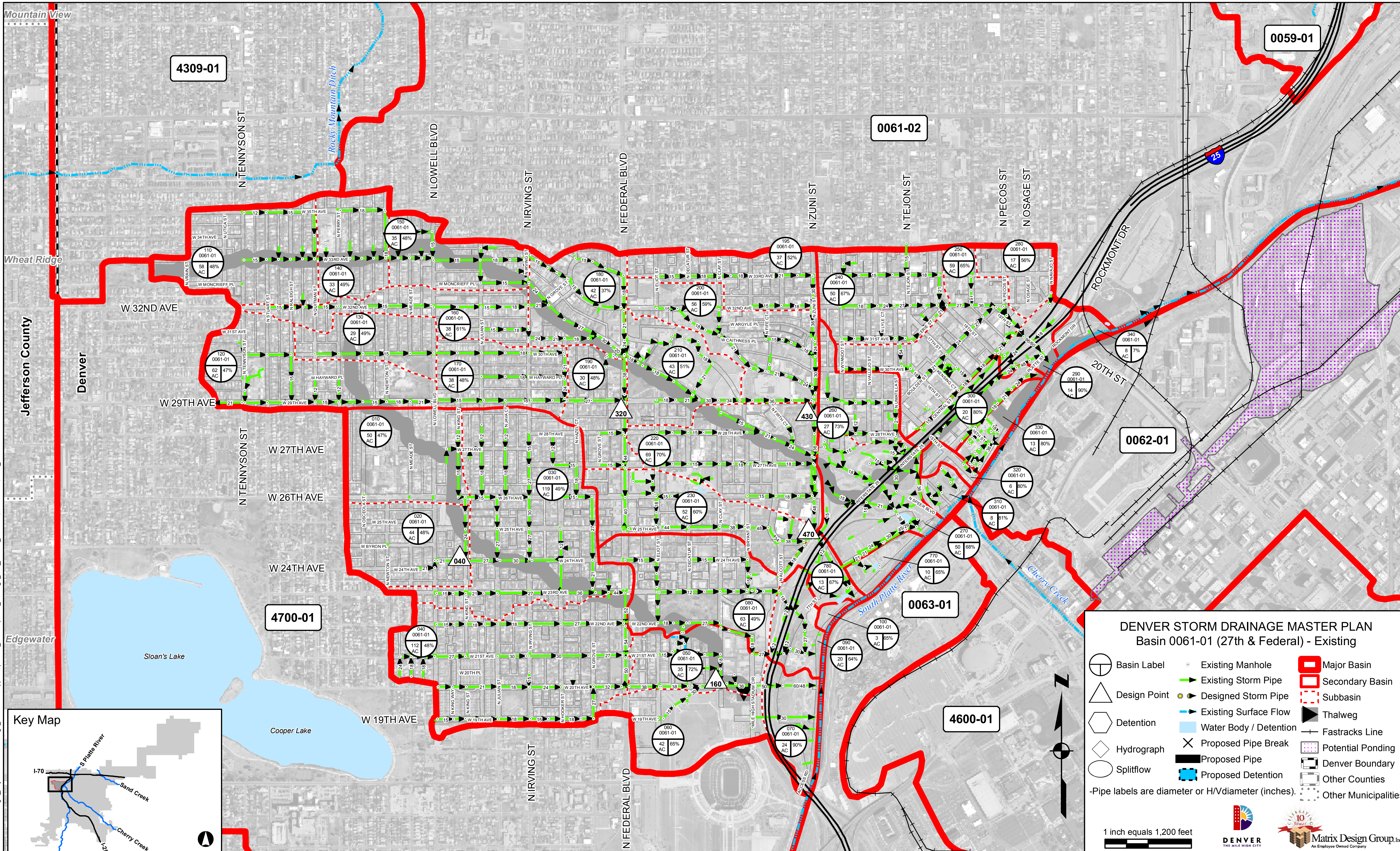
- Construction of storm drains in local roads shown to improve interception of minor storm event runoff and conveyance within neighborhoods.
- Installation of four new outfalls under I-25 at N. Bryant Street and 19th Avenue; at N. Bryant Street and W. 20th Avenue; at W. 23rd Avenue and N. Alcott Street; and at N. Zuni Street and W. Byron Place;
- Installation of major storm drain interceptors connecting to the I-25 outfalls.

Basin 0061-01 EXISTING CONDITIONS

Design Point Minor Event Model	**Contributing Basins** Minor Event Model	**Tributary Area** Minor Event *(acres)*	**Peak Discharge** **2-Year** *(cfs)*	**5-Year** *(cfs)*	**100-Year** *(cfs)*
50	50, split flow from 10 - 40	359	194	224	322
185	110, 130, 140, 150, 160, 170, 180, split flow from 120	336	142	270	816
200	200, 210, split flow from 195	136	95	169	368
230	110, 130-190, 220, 230, split flow from 120, 195, 200, 210	623	303	499	1307

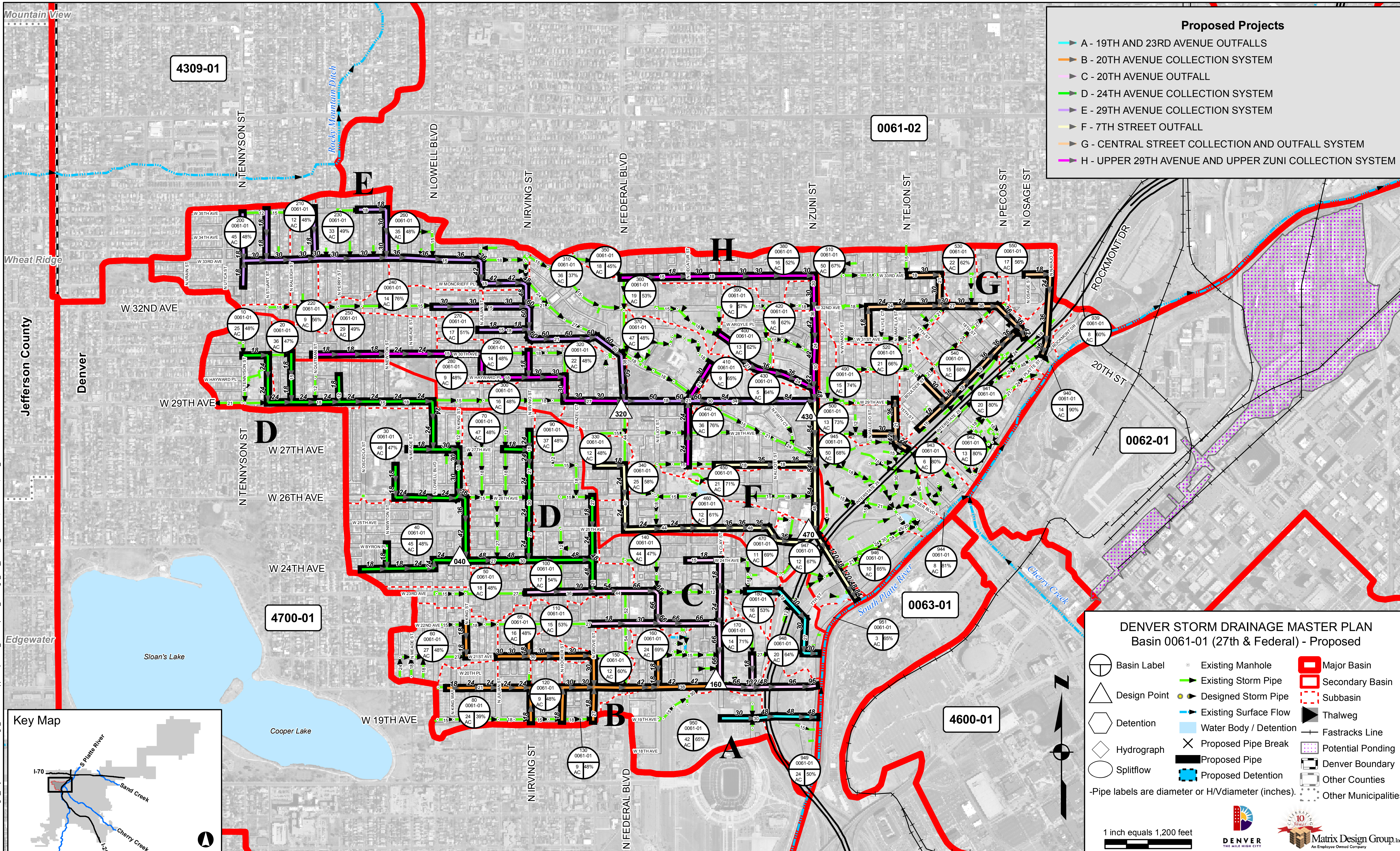
Basin 0061-01 PROPOSED CONDITIONS

Design Point Minor Event Model	**Contributing Basins** Minor Event Model	**Tributary Area** Minor Event *(acres)*	**Peak Discharge** **2-Year** *(cfs)*	**5-Year** *(cfs)*
40	10, 20, 30, 40	155	82	144
160	10-50, 60, 65, 70-160	454	258	436
320	200-260, 280-320	291	174	303
430	200-260, 280-320, 350-430	445	269	483
470	200-260, 280-340, 350-470	562	357	638



FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activelapps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/24/2009, ron_ramold

This sheet left intentionally blank



Proposed Projects
A - 19TH AND 23RD AVENUE OUTFALLS
B - 20TH AVENUE COLLECTION SYSTEM
C - 20TH AVENUE OUTFALL
D - 24TH AVENUE COLLECTION SYSTEM
E - 29TH AVENUE COLLECTION SYSTEM
F - 7TH STREET OUTFALL
G - CENTRAL STREET COLLECTION AND OUTFALL SYSTEM
H - UPPER 29TH AVENUE AND UPPER ZUNI COLLECTION SYSTEM
DENVER STORM DRAINAGE MASTER PLAN
Basin 0061-01 (27th & Federal) - Proposed
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.
Key Map
4309-01
0061-02
0062-01
0063-01
4600-01
4700-01
Mountain View
Wheat Ridge
Edgewater
Jefferson County
Denver
W 32ND AVE
W 29TH AVE
W 27TH AVE
W 26TH AVE
W 24TH AVE
W 19TH AVE
N TENNYSON ST
N LOWELL BLVD
N IRVING ST
N FEDERAL BLVD
N ZUNI ST
N TEJON ST
N PECOS ST
N OSAGE ST
ROCKMONT DR
20TH ST
Sloan's Lake
Cooper Lake
Rocky Mountain Ditch
South Platte River
Cherry Creek

Basin 0061-02 (Highland Basin)

Existing System Description:
The Highland basin is located in northwest Denver. The approximate boundaries of the basin are W. 34th Avenue to the south, I-70 on the north, the South Platte River to the east and a varying edge on the west extending as far west as N. Berry Street. The basin is comprised of approximately 1909 acres (2.98 square miles) of fully developed area. The basin generally drains from west to east and has multiple outfalls into the South Platte River.

The basin is composed of a variety of land uses including residential, parks, commercial and industrial land uses. Much of the basin is residential with commercial areas primarily located along Federal Boulevard, W. 38th Avenue, and the I-25 corridor. Many areas have mixed commercial/retail space on street corners with gas stations, convenience stores and other neighborhood retail outlets. The northeast corner of the basin is composed of industrial and warehouse uses. This area is generally bounded by I-70 (north) and W. 44th Ave (south) and N. Pecos Street (west) and the Rennick Railyard (east).

Blueprint Denver shows areas subject to change in the vicinity of W. 38th Avenue, just west of Federal Boulevard, N. Inca Street, north of W. 38th Avenue, and W. 44th Avenue, just east of Federal Boulevard. The remainder of the basin is shown as being an "Area of Stability".

All drainage from this basin outfalls to the South Platte River. Intercepted stormwater is discharged in over 5 separate storm drainage outfalls which cross under I-25, ultimately discharging into the South Platte. Some of the more major outfalls include:

- 8 x 8 box culvert and 4 x 7 box culvert at W. 34th Avenue and N Lipan Street
- 60-inch x 84-inch pipe at W 38th Avenue and I-25
- 24-inch storm pipe crossing under I-25 at Inca Street draining a small local basin just west of I-25
- A 36-inch and a 30-inch storm drain crossing under I-25 just north of the Park Avenue overpass, draining a small local basin on the west side of I-25

Drainage Deficiencies:
Storm drain infrastructure in this basin has undersized outfalls, incomplete networks of storm drain laterals and is primarily composed of brick and clay pipe systems which do not meet Denver's drainage criteria for size and/or material. Much of the system was previously a part of a combined sewer system which has since been separated from the sanitary component.

The Highland Basin lies on a relatively steep area on the side of the South Platte River Valley. As a result, water tends to move quickly through the basin and generally does not produce areas of severe ponding. However, there are three major flow paths within the overall basin that do see shallow overland flooding. This shallow flooding is primarily contained in the streets when a storm event exceeds the storm drain capacity. The three major flow paths are generally described as follows:

- Beginning at the intersection of N. Meade Street and W. 38th Avenue, traveling east along W. 37th Ave, across Federal Boulevard. Continuing east on W. 36th Ave., W. 37th Avenue and W. 38th Avenue and finally south down N. Lipan Street to I-25.
- Beginning at the intersection of N. King Street and W. 41st Avenue, traveling southeast, ultimately reaching 38th Avenue and the low point under the Rennick Railyard.
- Beginning at the intersection of N. Federal Boulevard and W. 45th Avenue, traveling southeast to W. 44th Avenue and Vallejo Street, then northeast to W. 46th Avenue and Lipan Street continuing east to the Rennick Railyard.

In general, much of the existing system is undersized and does not adequately convey the 2-year or 5-year design flows. The recently installed system along N. Inca Street was designed for the 2-3/4 year event and was constructed of concrete pipe, however, the design frequency identified in this study indicates the need for a 5-year system, therefore this system is undersized as well.

Proposed Capital Improvements:
Drainage improvements in this basin are primarily recommended to achieve the minimum performance objectives as described in Denver's Drainage Criteria Manual; 2-year and 5-year systems for residential and commercial areas, respectively. To meet these requirements, most of the existing storm drain network will need to be replaced. These improvements can be phased in smaller projects following the completion of the major outfall project components. Proposed capital improvements include:

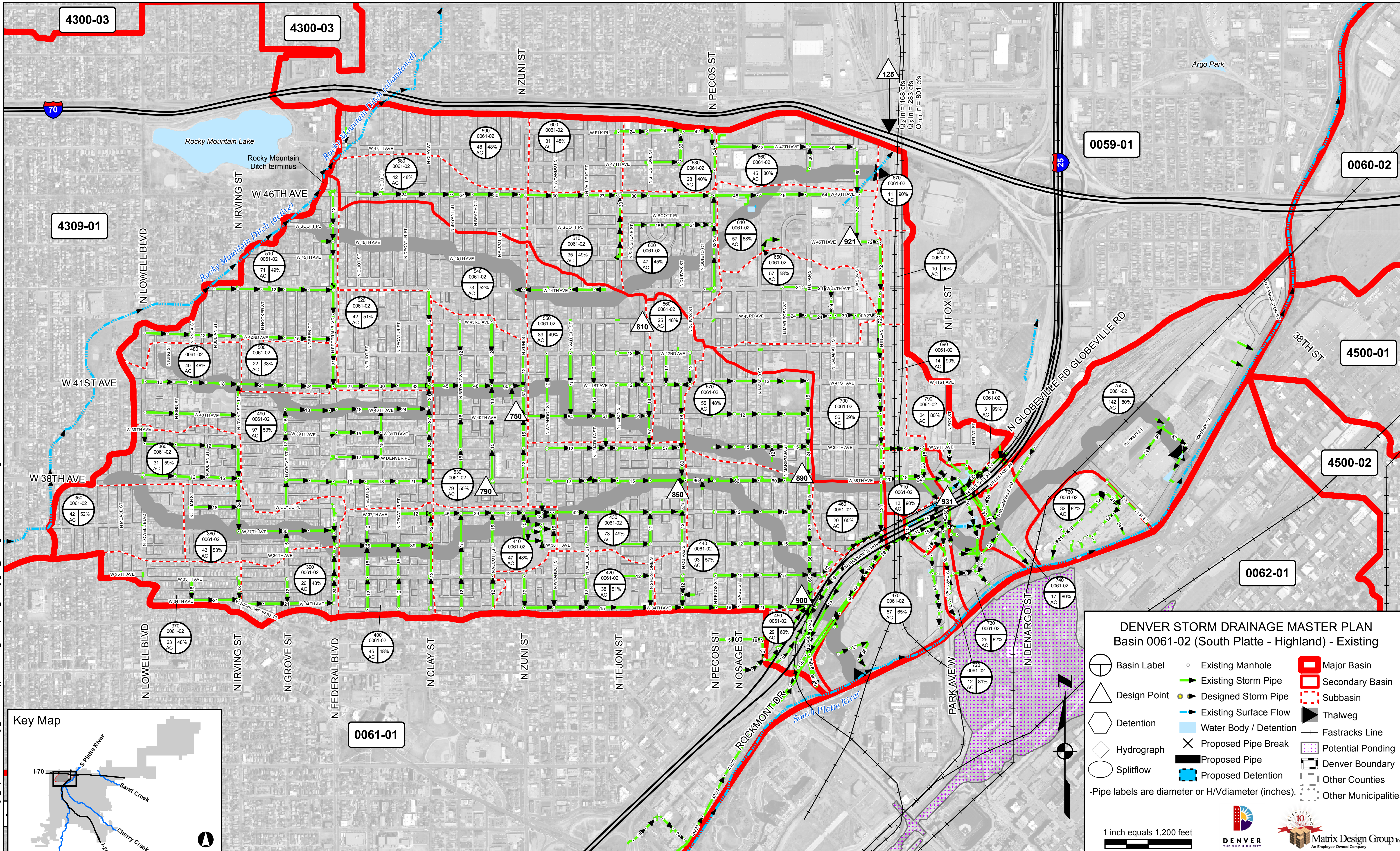
- Installation of new outfalls under I-25 at W. 34th Avenue and Lipan Street; and Park Avenue and I-25.
- Installation of major storm drain interceptors connecting to the I-25 outfalls.
- Construction of storm drains in local roads shown to improve interception of minor storm event runoff and conveyance within neighborhoods.

Basin 0061-02 EXISTING CONDITIONS

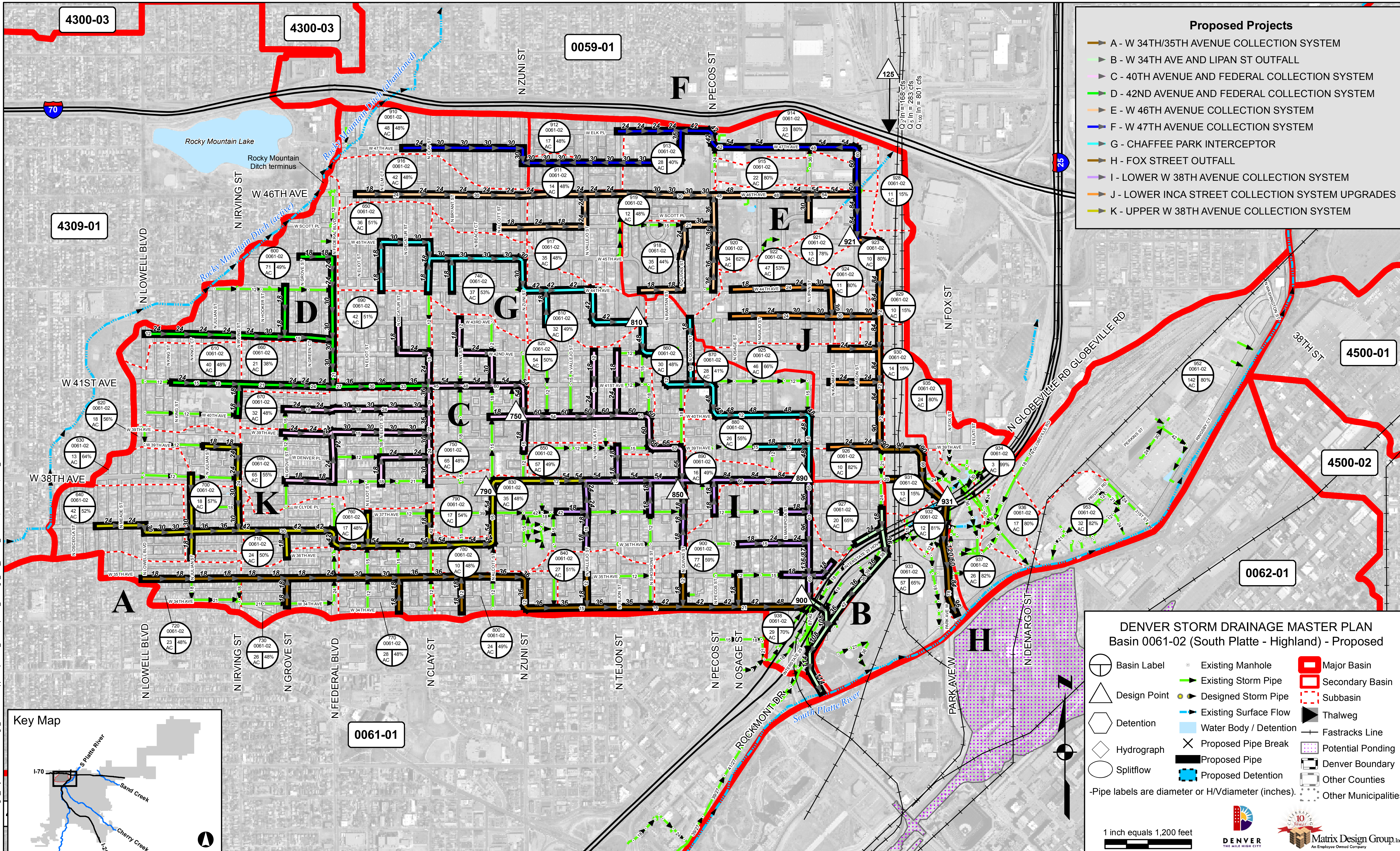
Design Point Minor Event Model	**Contributing Basins** Minor Event Model	**Tributary Area** Minor Event *(acres)*	**Peak Discharge** 2-Year *(cfs)*	5-Year *(cfs)*	100-Year *(cfs)*
400	350-400	209	112	210	626
430	350-410, 430, 480-560	867	426	794	2434
440	420, 440, split flow from 350-410, 430, 480-570	1052	450	550	857
530	480, 490, 500, 510, 520, 530	350	204	384	1101
650	580, 590, 600, 610, 620, 630, 640, 650, 660	390	230	380	952
710	580-660, 700, 710, split flow from 350-410, 430, 480-570	460	319	864	3257
1575	split flow from 350-410, 430, 480-570	921	367	367	367

Basin 0061-02 PROPOSED CONDITIONS

Design Point Minor Event Model	**Contributing Basins** Minor Event Model	**Tributary Area** Minor Event Model *(acres)*	**Peak Discharge** 2-Year *(cfs)*	5-Year *(cfs)*
750	600, 610, 660-690, 750	337	202	364
790	620, 630, 640, 700, 710, 760, 780, 790	159	106	193
810	650, 740, 810	106	66	123
850	600-640, 660-710, 750, 760, 780, 790, 820, 830, 850	641	366	681
890	600-640,660-710,750,760,780,790,820,830,850,880,890	848	477	881
900	600-640, 660-730, 750-800, 820-850,880,890, 900	1052	580	1082
921	911-921	323	213	362
931	911-926, 931	460	309	523


DENVER STORM DRAINAGE MASTER PLAN
Basin 0061-02 (South Platte - Highland) - Existing
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.
Key Map
S Platte River
Sand Creek
Cherry Creek
I-70
I-25
4300-03
4309-01
0059-01
0060-02
4500-01
4500-02
0062-01
0061-01
Rocky Mountain Lake
Rocky Mountain Ditch terminus
Rocky Mountain Ditch (abandoned)
Rocky Mountain Ditch (active)
Argo Park
South Platte River
W 46TH AVE
W 41ST AVE
W 38TH AVE
N LOWELL BLVD
N IRVING ST
N GROVE ST
N FEDERAL BLVD
N CLAY ST
N ZUNI ST
N TEJON ST
N PECOS ST
N OSAGE ST
N FOX ST
N GLOBEVILLE RD
GLOBEVILLE RD
38TH ST
ROCKMONT DR
PARK AVE W
N DENARGO ST
Q_2 In = 168 cfs
Q_5 In = 283 cfs
Q_{100} In = 801 cfs
125
750
790
810
850
890
900
921
931

This sheet left intentionally blank


Proposed Projects
A - W 34TH/35TH AVENUE COLLECTION SYSTEM
B - W 34TH AVE AND LIPAN ST OUTFALL
C - 40TH AVENUE AND FEDERAL COLLECTION SYSTEM
D - 42ND AVENUE AND FEDERAL COLLECTION SYSTEM
E - W 46TH AVENUE COLLECTION SYSTEM
F - W 47TH AVENUE COLLECTION SYSTEM
G - CHAFFEE PARK INTERCEPTOR
H - FOX STREET OUTFALL
I - LOWER W 38TH AVENUE COLLECTION SYSTEM
J - LOWER INCA STREET COLLECTION SYSTEM UPGRADES
K - UPPER W 38TH AVENUE COLLECTION SYSTEM
DENVER STORM DRAINAGE MASTER PLAN
Basin 0061-02 (South Platte - Highland) - Proposed
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER THE MILE HIGH CITY
Matrix Design Group, Inc.
Key Map
4300-03
0059-01
4309-01
4500-01
4500-02
0062-01
0061-01
Rocky Mountain Lake
Rocky Mountain Ditch terminus
South Platte River
W 46TH AVE
W 41ST AVE
W 38TH AVE
N LOWELL BLVD
N IRVING ST
N GROVE ST
N FEDERAL BLVD
N CLAY ST
N ZUNI ST
N TEJON ST
N PECOS ST
N OSAGE ST
N FOX ST
PARK AVE W
N DENARGO ST
ROCKMONT DR
N GLOBEVILLE RD
38TH ST

Basin 0062-01/4500-02 (Lower Platte Valley)

Existing System Description:
This basin includes a mix of industrial, commercial and residential land uses, and includes 2,574 tributary acres (4.02 square miles). The basin is fully built-out with older neighborhood residential in the upper reaches and commercial in the lower reaches. This basin includes Lower Downtown, Coors Field, rail yards, and a number of existing residential neighborhoods. It is characterized by terrace topography in the upper portions of the basin and very flat outfalls near the South Platte River. This condition results in inadvertent detention near the basin headwaters and surcharge of storm sewers in lower reaches.

Currently, most of the drainage (nearly 75% of the basin) outfalls through one 81-inch storm pipe at 36th Street. Design Point 1560 shows that 1,936 acres are tributary to this one outfall. This pipe has approximately 476 cfs capacity, but the hydrology indicates the flow will be 1,024 cfs in a 2-year event, and 1,727 cfs in a 5-year event (design flow). There are opportunities for regional water quality treatment off the existing 81-inch pipe near the South Platte outfall since it currently can convey a ½-inch rainfall (WQCV) over such a large developed basin area.

Drainage Deficiencies:
The existing drainage system has less than a 1-year capacity. Rainfall runoff in excess of the storm drain capacity has a history of ponding in the sump and flat areas. Many of the existing storm drains surcharge out the manholes during large storm events. Major drainage problems have been experienced in this basin, particularly north of Coors Field.

During a major storm event, split flow conditions exist in the basin, whereby storm runoff is exported and imported out and into this basin. For split flow condition, see the Hydrologic and Hydraulic Draft Report for Denver Union Station – 100-year Flood Protection by PB Americas, Inc., October 17, 2008 and the East Corridor Master Plan by PBS&J attached in the Technical Appendices.

Proposed Capital Improvements:
This basin requires improvements primarily to the outfall since the lateral network is currently extensive in this basin. The outfall should have 5-year capacity, whereas the lateral network through the residential areas should have a 2-year capacity.

The existing 81-inch outfall is undersized, and additional outfalls are needed to relieve the burden on the existing pipe. Constructing two new outfalls in this basin will reduce the tributary area of the existing outfall. Five major drainage projects are proposed for this basin as described below:

Project A: 31st Street Outfall includes a completely new 114-inch outfall in 31st Street. This proposed storm drain will continue up the basin in Downing Street and branch into new laterals around Children's Hospital. The existing pipe will be cut and plugged to provide additional capacity in the downstream system where the new pipe crosses the existing storm pipe. Work on this project should begin at the outfall and extend upward to improve the level of drainage service in the basin.

Project B: 27th Street Improvements includes maximizing the use of the newly constructed 108-inch pipe in 29th Street for the Coors Field Parking Lot. Currently, the tributary area to the pipe is only 88 acres. The outfall will extend up 27th Street and then Washington Street and Clarkson Street with a 96-inch pipe transitioning down to smaller pipe up into the basin. This project also includes a new upsized pipe network in Market Street south of 27th Street and a new box and pipe network in Champa St south of 27th Street.

Project C: 36th Street Outfall includes replacing the existing outfall from an 78-inch pipe to a 102-inch pipe. Efforts were made to preserve this pipe by sending more stormwater to new outfalls, however, this became impractical, and the existing outfall must be replaced or a parallel pipe constructed.

Project D: East 33rd Avenue system includes balancing out the remainder of the basin tributary to the existing outfall. A new 42-inch pipe at 33rd and Downing Street will disconnect the existing pipe and convey runoff to the large 81-inch pipe in Downing. In addition, existing small storm drains are proposed to be replaced with 18-inch pipes to meet current drainage criteria and reduce maintenance.

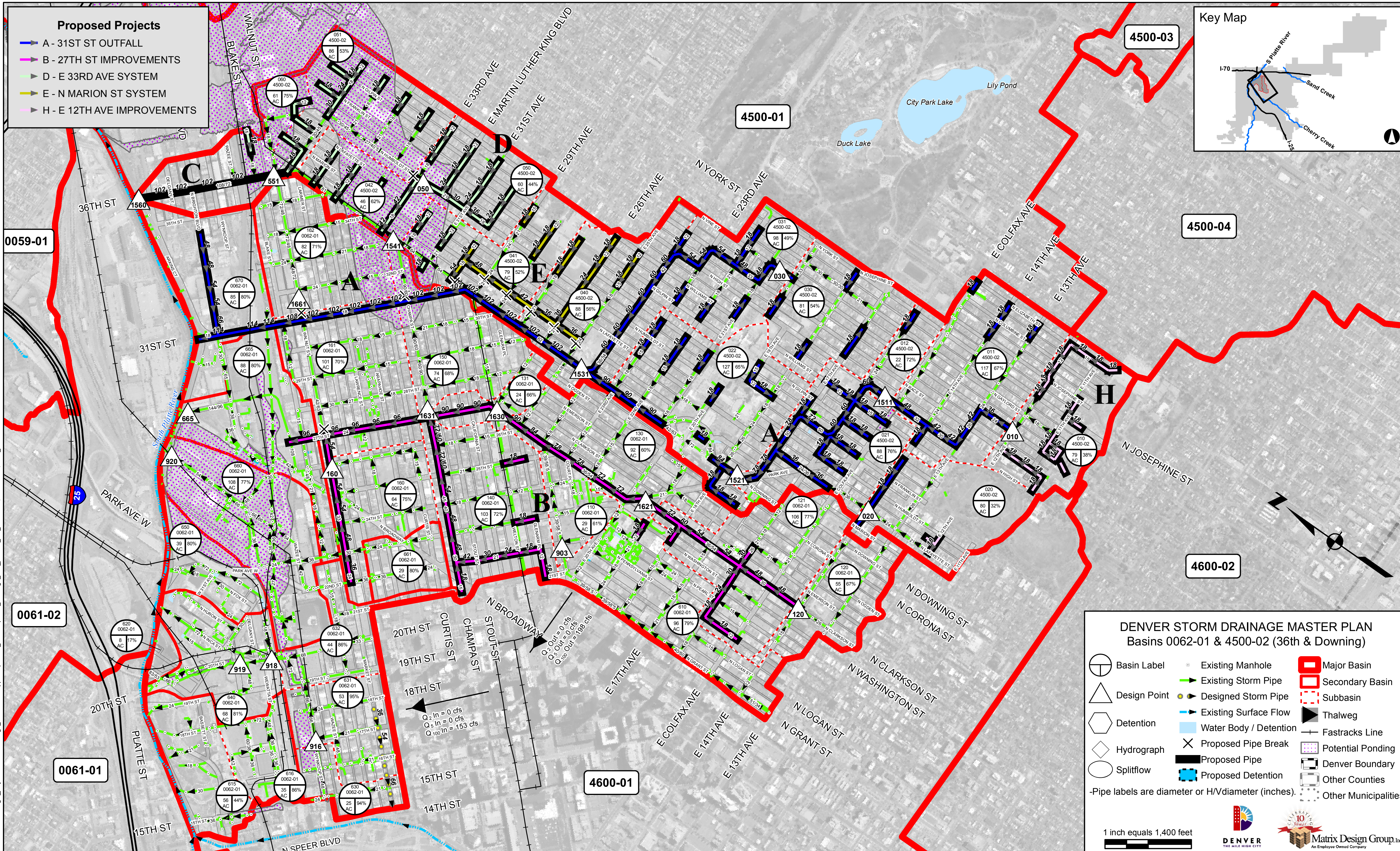
Project E: North Marion Street system includes balancing out the remainder of the basin tributary to the existing 36th Street outfall. A new pipe in Marion between 25th and 30th Avenues that varies from 48-inch to 36-inch will collect six laterals and convey runoff to the existing 64-inch pipe in Downing. Marion was selected as an appropriate alignment due to the apparent absence of existing utilities in the street corridor. In addition, existing small storm drains are proposed to be replaced with 18-inch pipes to meet current drainage criteria and reduce maintenance.

Project H: E. 12th Ave Improvements include replacing existing small pipes with 18-inch diameter pipes to meet current drainage criteria, improve collection/conveyance and reduce maintenance problems.

BASIN 0062-01, 4500-02 Existing Hydrology:

Design Point Minor Event Model	Design Point Overland Flow Model (PBS&J)	Contributing Basins Minor Event Model	Tributary Area Minor Event Model *(acres)*	Peak Discharge* 2-Year *(cfs)*	5-Year *(cfs)*	100-Year *(cfs)*
10	NA	10	79	48	102	NA
20	NA	20	80	38	88	NA
30	NA	30	81	72	128	NA
50	NA	50	60	38	75	NA
120	NA	120	55	64	104	NA
160	NA	160	64	70	108	NA
551	36	10-51,110-162,610	1875	1021	1717	**2702**
610	NA	610	96	135	205	NA
615	NA	615	56	33	65	NA
616	NA	616	35	52	76	NA
665	NA	665	88	94	142	NA
903	1120	610	96	135	205	**370**
920	NA	630, 631, 632, 640	190	224	327	NA
1320	NA	10-20	298	176	343	NA
1510	1660	110, 120, 121, 610	286	279	430	**1245**
1511	10	10,11	196	167	283	**542**
1521	NA	10-21	386	260	467	NA
1531	1530	10-31	692	421	641	**1716**
1541	NA	10-41,110-150,610	1436	847	1378	NA
1560	NA	10-60,110-162,610	1936	1024	1727	NA
1630	NA	110-130,610	378	354	560	NA
1631	1640	110-140,610	504	426	680	**1612**
1661	NA	160,161	165	163	260	NA

* 100-year discharge in **bold** represents analysis based on "overland" drainage paths determined from topography (see East Corridor Master Plan by PBS&J). Other events (2-year, 5-year, and remaining 100-year) are analyzed based on existing pipe network flow paths.


Proposed Projects
A - 31ST ST OUTFALL
B - 27TH ST IMPROVEMENTS
D - E 33RD AVE SYSTEM
E - N MARION ST SYSTEM
H - E 12TH AVE IMPROVEMENTS
Key Map
I-70
S Platte River
Sand Creek
Cherry Creek
I-25
City Park Lake
Duck Lake
Lily Pond
4500-01
4500-03
4500-04
4600-01
4600-02
0059-01
0061-01
0061-02
DENVER STORM DRAINAGE MASTER PLAN
Basins 0062-01 & 4500-02 (36th & Downing)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,400 feet
DENVER THE MILE HIGH CITY
Matrix Design Group, Inc. An Employee Owned Company
Q_2 In = 0 cfs
Q_5 In = 0 cfs
Q_{100} In = 153 cfs
Q_2 Out = 0 cfs
Q_5 Out = 0 cfs
Q_{100} Out = 198 cfs
FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activeapps\mapbook_mxd\mapbook_drainage_100_percent_rev_2010.mxd, 6/23/2010, ron_ramold

Basin 0063-01 (Central Platte Valley)

Existing System Description:
This basin consists of a majority of the Central Platte Valley area of downtown Denver. This basin consists of 1,297 acres (2.03 square miles) and includes older neighborhood residential in the upper reaches east of the railroad tracks and Sante Fe, and commercial in the lower reaches. All drainage from this basin will outfall into the South Platte River. Intercepted stormwater is discharged via at least 32 storm drainage outfalls, which are comprised mainly of local storm drains from I-25 and adjacent properties. Some of the existing larger outfalls include:

- Bayaud Avenue outfall is 36-inch (54-inch upstream) with 344 tributary acres
- 3rd Avenue outfall is 54-inch with 214 tributary acres
- 6th Avenue outfall is 72-inch with 256 tributary acres
- 13th Avenue outfall is 42-inch with 119 tributary acres
- Colfax Avenue outfall is 36-inch with 39 tributary acres
- Elitch outfall is 48-inch with 44 tributary acres

The storm drain infrastructure consists of a random network of drains and laterals. Drainage from the basin is constrained by the elevation of the South Platte River and I-25, which generally reduces capacity and creates sump or surcharge conditions during major storm events. The reach adjacent to the South Platte River between 6th Avenue and Cherry Creek is in the 100-year floodplain, but the South Platte channel improvements scheduled for 2009 through 2012 may remove these properties from riverine flooding.

Drainage Deficiencies:
The existing drainage systems have capacities varying from a 1-year to a 5-year storm event. Rainfall runoff in excess of the storm drain capacity has a history of ponding within the commercial and industrial areas against the railroad and I-25. Drainage problems have been experienced at Bayaud and Galapago where the railroad creates a sump and localized ponding (see “Potential Ponding” delineation). Flooding has occurred within Broadway, exacerbated by the roadway cross-section, which has steep side slopes and reduced conveyance capacity due to construction over an old trolley bed. Localized ponding occurs frequently at W. Wellsworth and Lipan Street due to topographic constraints imposed by the existing railroad and I-25.

The basin delineation is based upon the storm drain network. The only split flow situation in this basin where the pipe flow contravenes the site topography is at the Elitches site. Runoff in excess of the 16’x4’ box culvert capacity at the Pepsi Center will flow from the Auraria Campus and the Pepsi Center area northwest into Six Flags Elitch Gardens.

Proposed Capital Improvements:
Blueprint Denver shows the majority of the basin (commercial areas) subject to change. Only the residential neighborhood east of the railroad tracks between Alameda and 8th Avenue is shown as an “Areas of Stability”, a relatively small area of the overall basin. Difficulties in constructing additional or replacement storm drains are the crossing of the railroad and I-25. It was mentioned in CDOT’s Valley Highway – Logan to 6th Avenue Record of Decision (ROD) dated June 2007, Section 4.9.1.4 Stormwater Drainage, that Denver’s master plan and subsequent drainage improvements should be considered with each phase of final design for the Valley Highway Project.

<u>Project A: West 13th Avenue Outfall</u> includes replacing the existing 42-inch outfall with a new 66-inch pipe to provide a 5-year level of service. The enlargement of the existing system is carried up the storm drains along 13th Avenue. The 13th Avenue outfall is shown with a lateral extension of a 54-inch storm drain further into the sub-basin for connection by future redevelopment.

<u>Project B: West 7th Avenue Outfall</u> The existing 72-inch storm drain in 7th Avenue must be upsized to an 90-inch pipe to provide a minimum 5-year level of service. An existing constriction occurs where a 60-inch pipe with 0.61% slope connects downstream to a 42-inch and 48-inch pipe at 0.61%. This intermediate reach of pipe between Quivas and Tejon should be replaced with a larger pipe (78-inch) for 5-year capacity.

<u>Project C: West Bayaud Avenue</u> The existing system has less than a 1-year event capacity (Design Point 1516 with 344 tributary acres). The Bayaud Avenue outfall consisting of a 54-inch pipe is proposed for replacement with an 84-inch pipe for a 5-year system. (Alternatively, a 100-year system to serve the sump at Galapago & Bayaud would require a 120-inch pipe outfall.) At Galapago, the proposed pipe jogs over to Ellsworth Avenue to preserve the existing trunk system upstream. Since flooding is known to occur in Broadway, the proposed storm system extends to Logan and has a lateral extending south in N. Lincoln Street to provide additional storm conveyance in this area.

<u>Project D: West Ellsworth Avenue</u> A short 24-inch storm drain outfall in Ellsworth under I-25 should be replaced with a 54-inch pipe to provide 5-year capacity, and eliminate frequent ponding at Ellsworth and Lipan caused by blockage of the runoff by the railroad at I-25.

<u>Project E: West Mulberry Place</u> A new 48”x72” box culvert outfall is proposed in Mulberry Place. This 60 acre area is currently served by 15 and 18-inch outfalls. Redevelopment of the area will prompt the construction of a new outfall.

<u>Project F: West 3rd Avenue Outfall</u> A new 78-inch outfall will replace the existing 60-inch outfall in 3rd Avenue to achieve a 5-year level of service.

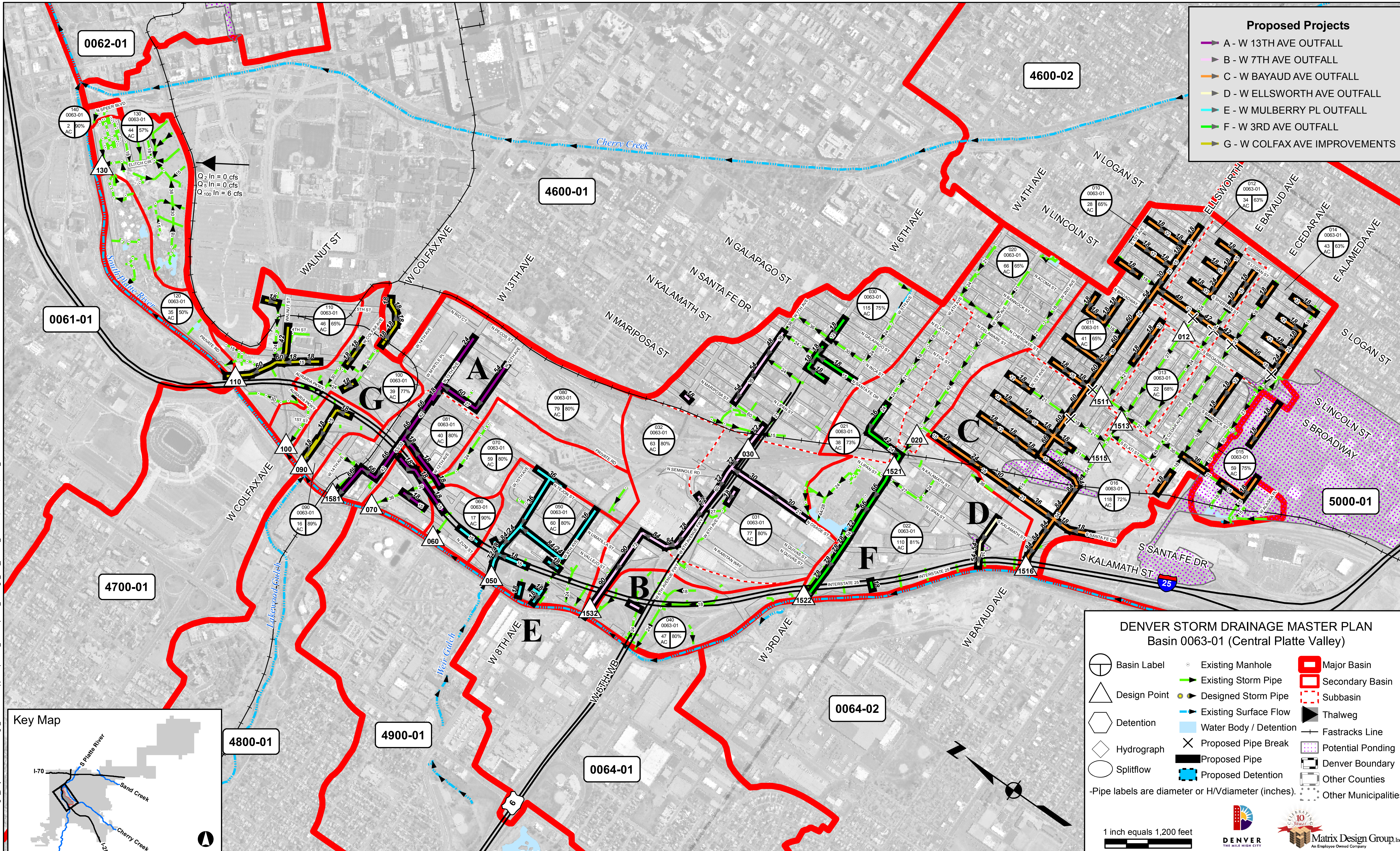
<u>Project G: West Colfax Avenue Improvements</u> 18-inch upgrades and replacement of an existing 36-inch pipe with a new 60-inch pipe is proposed in this general area.

Existing Hydrology:

BASIN 0063-01

Design Point Minor Event Model	Design Point Overland Flow Model	Contributing Basins Minor Event Model	Tributary Area Minor Event Model (acres)	Peak Discharge* 2-Year (cfs)	5-Year (cfs)	100-Year (cfs)
12		12	34	31	51	120
20		30	115	153	239	537
50		50	60	86	129	283
60		60	17	27	39	81
70		70	59	64	97	216
90		90	16	24	35	74
100		100	39	43	65	147
110		110	46	44	73	175
130	1530	130	44	39	68	**173**
1511		10,11	69	65	107	267
1513		10-13	124	112	187	473
1515		10-15	226	198	323	809
1516		10-16	344	258	413	1090
1521		20,21	104	88	142	338
1522		20-22	214	196	290	644
1532		30-32	256	248	344	842
1581		80,81	119	105	160	390

* 100-year discharge in **bold** represents analysis based on "overland" drainage paths determined from topography. Other events (2-year, 5-year, and remaining 100-year) are analyzed based on existing pipe network flow paths.



DENVER STORM DRAINAGE MASTER PLAN
Basin 0063-01 (Central Platte Valley)
Proposed Projects
A - W 13TH AVE OUTFALL
B - W 7TH AVE OUTFALL
C - W BAYAUD AVE OUTFALL
D - W ELLSWORTH AVE OUTFALL
E - W MULBERRY PL OUTFALL
F - W 3RD AVE OUTFALL
G - W COLFAX AVE IMPROVEMENTS
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.
Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
0062-01
0061-01
4600-01
4600-02
4700-01
4800-01
4900-01
0064-01
0064-02
5000-01
Cherry Creek
South Platte River
Lakewood Gulch
Weir Gulch
Barnum Park Lake
W COLFAX AVE
W 13TH AVE
WALNUT ST
N MARIPOSA ST
N KALAMATH ST
N SANTA FE DR
N GALAPAGO ST
W 6TH AVE
W 4TH AVE
N LINCOLN ST
N LOGAN ST
E BAYAUD AVE
E CEDAR AVE
E ALAMEDA AVE
S LOGAN ST
S LINCOLN ST
S BROADWAY
S SANTA FE DR
S KALAMATH ST
W BAYAUD AVE
W 3RD AVE
W 8TH AVE
W 6TH AVE WB
Q_2 In = 0 cfs
Q_5 In = 0 cfs
Q_{100} In = 6 cfs

Basin 0064-01 (1^{st} & Federal)

Existing System Description:
This basin is tributary to Weir Gulch and the South Platte River by topography and pipe network. In general, this basin is located south of Weir Gulch. This basin consists of 312 acres (0.49 square miles) and includes residential in the upper reaches, and industrial/commercial in the lower reaches. Much of the industrial land is within the current South Platte River floodplain.

Intercepted stormwater is discharged via 6 storm drainage outfalls into the South Platte River. The outfalls include:

South Platte River
- Yuma Street outfall is 21-inch for local drainage
- 5th Avenue outfall is 42-inch with 172 tributary acres
- 6th Avenue 42-inch outfall for 74 tributary acres
- 6th Avenue 15-inch outfall for local drainage
- 7th Avenue 36-inch outfall
- 8th Avenue 24-inch outfall

The storm drain infrastructure consists of a random network of drains and laterals in the low reaches and collectors in the residential reaches. The condition and capacity of the existing inlets is unknown at this time.

Blueprint Denver shows the Federal Boulevard subject to change along with some of the commercial and industrial area adjacent to the South Platte River. The residential neighborhoods are shown as "Areas of Stability" in ***Blueprint Denver***.

Drainage Deficiencies:
Significant portions of Basin 0064-01 are within the South Platte River regulatory floodplain, including sub-basins 10, 20, and 32.

The areas in the South Platte River floodplain have capacity for the 2-year storm event, although this area should have a 5-year level of service by land use criteria.

Proposed Capital Improvements:
Proposed South Platte River channel improvements from W. 14th Avenue to W. 8th Avenue will remove much of the development in this basin from the regulatory floodplain. The lower reaches of Weir Gulch have been improved to convey drainage during the 100-year event.

No major drainage complaints have been reported in these basins outside the regulatory floodplains due to the relatively steep gradient toward the receiving drainageways and lack of sumps or flat areas. This basin generally meets Denver drainage criteria. The roads and drainage pipe convey the 2-year storm event in residential areas and 5-year storm event in the commercial/industrial areas.

Most of the capital improvements proposed in Denver's 1989 Master Plan have been constructed. This area has been improved by construction of diversion facilities to Weir Gulch implemented since the 1989 plan.

A difficulty in constructing additional or replacement storm drain outfalls is the presence of the Metro Sanitary Sewer along the west bank of the South Platte River. Otherwise, railroad tracks and the interstate are located on the opposite bank of the South Platte, and there are relatively few obstructions for new storm pipe in this basin. Proposed projects include:

Project A: West 3rd Avenue Outfall Storm drain laterals are extended further into the basin to reduce street flooding. Storm pipes smaller than 18" have been upgraded to 18" per current criteria.

Project B: West 8th Avenue Outfall A new 3'x6' box culvert outfall is proposed in 8th Avenue.

Project C: West 5th Avenue Outfall A new 4'x10' box culvert outfall is proposed in 5th Avenue to better serve properties in the current South Platte River floodplain. All 12-inch and 15-inch collector storm drains do not meet current drainage criteria and have been proposed for replacement with 18-inch pipes

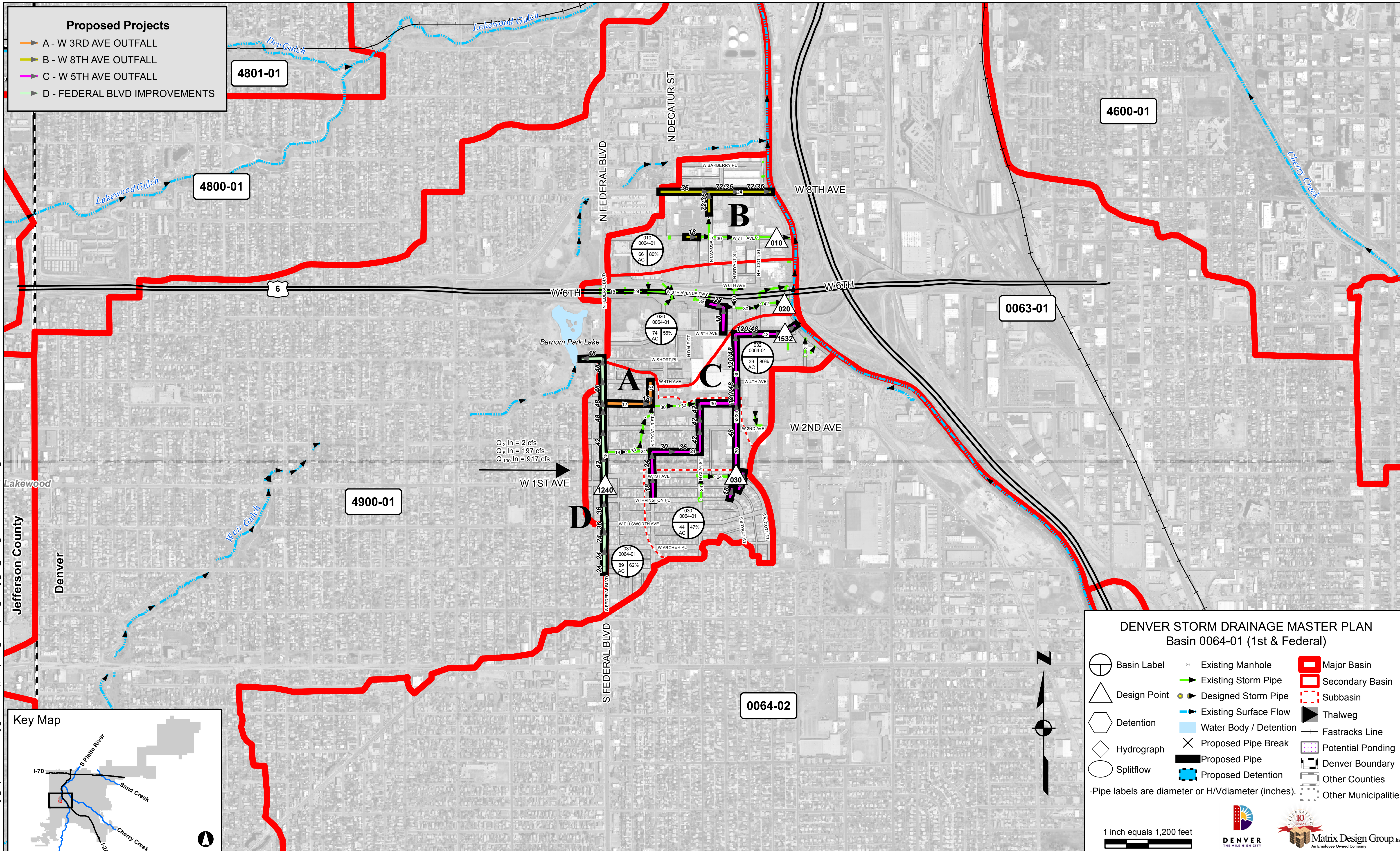
Project D: Federal Blvd. Improvements This storm drain was analyzed in *Federal Boulevard Storm Sewer Improvements Preliminary Drainage Report* by Matrix Design Group Inc. in October 2008. Historically, stormwater from Federal Boulevard between Alameda and 6th Avenue drains to the east and discharges directly to the South Platte River at 5th Avenue. The existing system does not have adequate capacity and needs to be upsized. Two potential outfall locations were studied; the South Platte River and Barnum Lake on Weir Gulch. The recommended alignment consists of proposed pipe in Federal Boulevard starting at Bayaud Avenue and extending north to Short Place then west to Barnum Lake.

Existing Hydrology:

BASIN 0064-01

Design Point	Contributing Basins	Tributary Area	Peak Discharge		
		(acres)	2-Year (cfs)	5-Year (cfs)	100-Year (cfs)
10	10	66	78	118	260
20	20	74	57	100	253
30	30	44	34	66	176
50	50	214	166	306	838
1240*	40,50	296	2	197	917
1532	30,31,32,40,50	467	126	297	1288

*Sub-basins 40 and 50 are a part of Major Basin 4900-01. Only a portion of runoff from these two sub-basins enters Basin 0064-01.


Proposed Projects
A - W 3RD AVE OUTFALL
B - W 8TH AVE OUTFALL
C - W 5TH AVE OUTFALL
D - FEDERAL BLVD IMPROVEMENTS
4801-01
4800-01
4600-01
0063-01
4900-01
0064-02
Lakewood Gulch
Dry Gulch
Weir Gulch
Cherry Creek
Barnum Park Lake
N FEDERAL BLVD
S FEDERAL BLVD
N DECATUR ST
W 8TH AVE
W 6TH
W 2ND AVE
W 1ST AVE
Lakewood
Jefferson County
Denver
Q2 In = 2 cfs
Q5 In = 197 cfs
Q100 In = 917 cfs
A
B
C
D
DENVER STORM DRAINAGE MASTER PLAN
Basin 0064-01 (1st & Federal)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
Key Map
S Platte River
Sand Creek
Cherry Creek
I-70
I-25
Matrix Design Group, Inc.

Basin 0064-02 (Valverde)

Existing System Description:
This basin drains to the South Platte River between 4th Avenue on the north and Sanderson Gulch on the south. The western boundary of the basin is Morrison Road. This basin consists of 1694 acres (2.65 square miles). Much of the upper basin is comprised of residential neighborhoods, while the lower portion is mostly commercial/industrial along the South Platte River. An existing detention basin is located in West-Bar-Val-Wood-Park. Improvements have been constructed along Mississippi Avenue, which convey 310 cfs to Sanderson Gulch. The improvements effectively remove almost all the Huston Lake area from this basin when considering the minor storm events. In the major storm, a 100-year runoff 1,267 cfs is imported into this basin via Mississippi Gulch located east of S. Pecos and W. Mosier Place. An outfall system plan study is underway by Matrix Design Group to evaluate alternative conveyance systems to address this issue.

The storm drain infrastructure consists of a network of trunk lines and laterals including fifteen outfalls. Drainage from the basin is constrained by the South Platte River floodplain, which parallels the west side of the river throughout the basin and has minimal topographic relief.

BluePrint Denver shows Federal Boulevard, Alameda Avenue, and Morrison Road subject to change, along with some of the commercial/industrial areas adjacent to the South Platte River.

Currently, a significant portion of the drainage basin (55% of the tributary area) outfalls through a 9’ x 4½’ box culvert at W. 4th Avenue and Vallejo Street. Design point 1150 shows that 931 acres are tributary to this one outfall.

Drainage Deficiencies:
The existing pipe system that outfalls into the South Platte along Vallejo Street is undersized. Generally, the lower portion of the system is located in the South Platte floodplain, which is relatively flat for drainage purposes. The 9’ x 4½’ box culvert is deficient due to the minimal 0.19% slope. The system can convey the 2-year event in some areas but not in others. A 5-year design criteria should be set for this industrial area.

The storm sewers around West-Bar-Val-Wood-Park along Bayaud Avenue, Yuma Street, Cedar Avenue, and Alcott Street are undersized.

The system in Dakota Avenue below Federal Boulevard will convey less than a one-year event. Storm drains below the commercial areas of Federal Boulevard should be sized for a 5-year event according to Denver’s storm drainage criteria. Storm sewers are almost non-existent along Federal Boulevard, which is a major transportation arterial along west Denver.

Localized drainage problems occur in the industrial areas along the river mostly due to relatively flat grades. The areas north and south of Vanderbilt Park have been identified with drainage problems as well as properties along S. Jason Street.

Proposed Capital Improvements:
This basin requires improvements primarily to the outfall since the lateral network is currently extensive in this basin. The outfall should have 5-year capacity, whereas the lateral network through the residential areas should have a 2-year capacity.

<u>Project A: 18-Inch Upgrades</u> Upsizing various pipes to the City’s 18-inch minimum diameter pipe.

<u>Project B: S. Huron St. Outfall</u> A 42-inch outfall is proposed along Huron Street to serve commercial properties along the South Platte River in the southern portion of the basin.

<u>Project C: W. Alameda Ave. Outfall</u> A new 84-inch outfall is proposed along Alameda Avenue to relieve the existing Vallejo Street system. The new pipe will receive a portion of the flow from the Alameda/Alcott intersection, while the remainder of the flow will be conveyed by the existing Vallejo Street outfall. Improvements are proposed in Alcott Street between Alameda and Virginia Avenues. The existing 66-inch pipe between Alameda and Dakota Avenues can be upsized to an 84-inch pipe to convey the 5-year event. A new 60-inch pipe is proposed between Dakota and Virginia Avenues to connect the proposed Virginia Avenue line to the main system. The proposed 60-inch pipe along Virginia Avenue will relieve the existing system in Dakota Avenue by providing additional conveyance to serve sub-basins 50, 60, 70, and 90. The improvements extend west of Federal Boulevard and then along Federal Boulevard (or the alley west of Federal) to provide stormwater interception for Federal Boulevard.

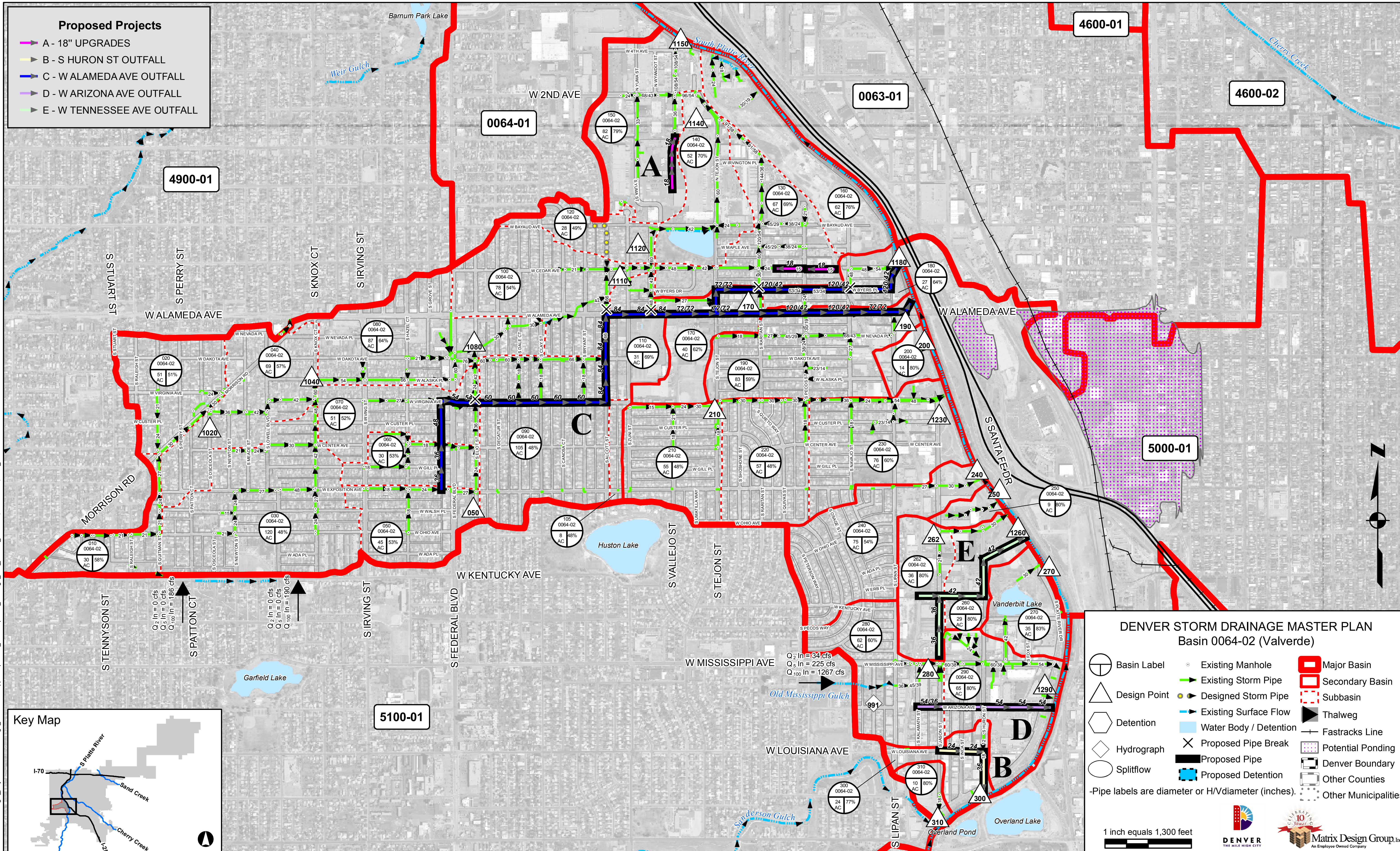
<u>Project D: W. Arizona Ave. Outfall</u> A 54-inch outfall is proposed along Huron Street to serve commercial properties along the South Platte River in the southern portion of the basin.

<u>Project E: W. Tennessee Ave. Outfall</u> A 42-inch outfall is proposed along Huron Street near Vanderbilt Park to reduce flooding along Jason Street.

Existing Hydrology:

<u>BASIN 0064-02</u>

Design Point	Contributing Basins	Tributary Area (acres)	Peak Discharge 2-Year (cfs)	Peak Discharge 5-Year (cfs)
50	50	45	21	38
160	160	62	84	129
170	170	40	31	52
190	190	83	57	98
200	200	14	19	29
210	210	55	34	64
240	240	75	46	82
250	250	9	12	19
262	262	36	44	66
270	270	35	50	75
280	280	62	72	300
300	300	24	29	44
310	310	10	14	21
1020	10,20	81	55	98
1040	10,20,30,40	271	168	290
1080	10-80	484	291	457
1090	10-90	589	339	529
1110	10-120	729	383	634
1120	10-120	729	379	634
1124	10-120	729	89	563
1140	10-140	848	189	527
1150	10-150	931	267	561
1180	170,180	68	39	66
1230	210,220,230	188	99	157
1260	260,262	65	69	108
1290	280,290	127	123	317



FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activelaps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/24/2009, ron_ramold

Basin: 0065-01 (Ruby Hill)

Existing System Description:
The Ruby Hill basin is bounded between Federal Boulevard and the South Platte River, and generally between Colorado Avenue and Iliff Avenue. Ruby Hill Park is located along the South Platte River in the northern portion of this basin, north of Jewell Avenue. A Power Plant is located in the southern portion of the basin along the South Platte River. Approximately 20% of the basin is located within the boundaries of Englewood (south of Evans, between Zuni and Pecos), and the remainder is in Denver.

The Ruby Hill drainage basin is approximately 1.25 square miles in size and is fully developed with residential and industrial properties in the upper reaches, and industrial properties in the lower reaches along the banks of the South Platte River. The basin is relatively steep with Evans Avenue generally being the low point (thalweg) of the drainage basin.

The Evans system outfalls via a 72" pipe to the South Platte River. Other outfalls in the basin include a 36" pipe in Warren, a 48"x72" RCBC in Iliff and other small local outfalls.

Drainage Deficiencies:
The existing drainage system has capacity to convey less than the 5-year storm event within Evans Avenue and Jewell Avenue. A small strip of Potential Ponding areas occur within basins 300, 310 and 320, in a commercial area, where the railroad embankment blocks the flow path to the South Platte River. The Potential Ponding area is immediately adjacent to the railroad tracks and is too thin to show on the adjoining map at this scale. The flat topography along the South Platte River makes it difficult to adequately drain the lower portion of this basin. Other problem areas include:

- Basins 220, 230, 240, 250 and 260, which drain an industrial/residential area, should be sized for the 5-year event. The 5-year flow rate is 399 cfs. The existing 36-inch storm sewer capacity cannot handle even the 2-year event of 221 cfs.

Proposed Capital Improvements:
Drainage improvements in this basin should be viewed primarily to achieve the minimum objectives for residential and commercial areas (2-and 5-year system capacities) established for the City and County of Denver. Although this basin has not been identified by ***Blueprint Denver*** as a significant area of change, re-development of this area could provide an opportunity to construct the proposed facilities. Two existing detention ponds are located within the upper portion of the basin. The detention ponds are located north of W. Evans Ave, between S Vallejo Street and S. Tejon Street. The two existing detention basins are small and are not modeled in the hydrologic analysis. No improvements to these facilities are proposed.

The proposed storm sewer improvements are summarized below:

<u>Project A: 18-inch Upgrades</u> Includes upsizing an existing 15-inch storm sewer lateral located within the alley between Kalamath and Jason Street to an 18-inch storm sewer.

<u>Project B: S. Lipan St. Outfall</u> Construct a new outfall to the South Platte River in S. Lipan Street This new system will be between Jewell Avenue and Evans Avenue and extend west in Evans Avenue to Navajo Street. This new outfall will convey the 5-year storm event from Proposed Projects C, D1 and D2 to the South Platte River.

<u>Project C: S. Pecos and W. Iliff Improvements</u> Construct a new 5-year storm sewer to collect and convey storm flows along the west side of the Burlington Northern and Santa Fe Railroad and around the commercial site along South Pecos Street to Proposed Project B in Evans Avenue.

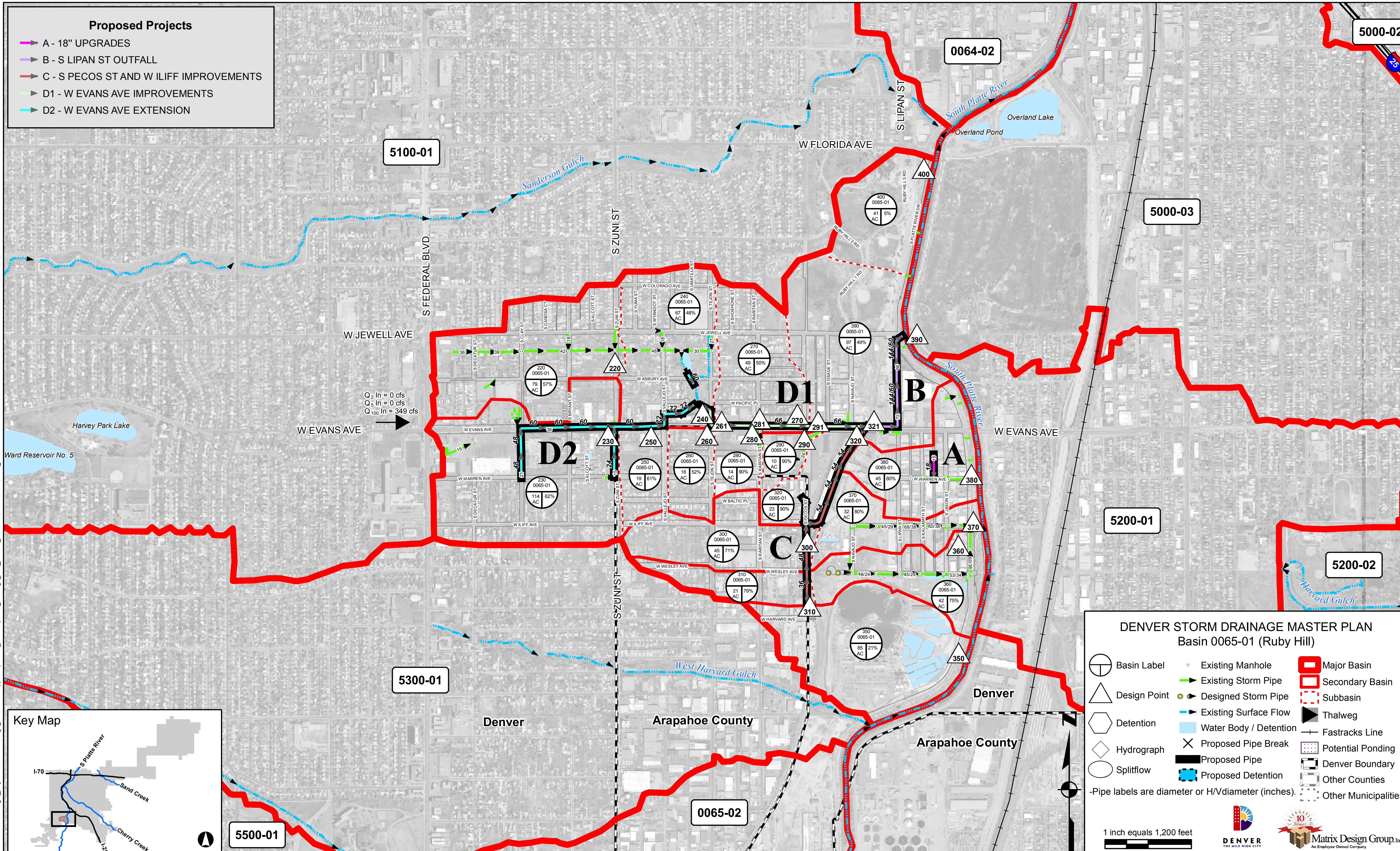
<u>Project D1: W. Evans Avenue Improvements</u> Upsize the existing storm sewer in Evans Avenue between S. Navajo Street and S. Tejon Street to convey the flows from Proposed Project D2 to Proposed Project B.

<u>Project D-2: W. Evans Ave. Extension</u> Upsize the existing storm sewer facility to a 5-year capacity within Evans Avenue from the existing detention pond at W. Pacific Place to S. Clay Street Upsize laterals in S. Clay Street and S. Zuni Street between W. Evans Avenue and W. Warren Avenue. Upsize the culvert under W. Asbury Ave between the two small detention ponds.

Existing Hydrology:

<u>BASINS 0065-01</u>

Design Point	Contributing Basins	Tributary Area (acres)	Peak Discharge 2-Year (cfs)	Peak Discharge 5-Year (cfs)
220	220	79	59	102
230	230	115	126	212
240	240	67	37	71
250	230,250	134	135	228
260	260	18	14	25
261	220,230,240,250,260	298	221	399
270	270	49	30	57
280	280	14	22	31
281	261,280	312	237	411
290	290	10	16	23
291	270,281,290	371	279	482
300	300	45	51	81
310	310	21	28	42
320	320	23	37	54
321	291,320	395	303	527
350	350	85	22	65
360	360	62	62	97
370	300,310,360,370	140	143	227
380	380	45	49	74
390	321,390	492	328	521
400	400	41	2	22


Proposed Projects
A - 18" UPGRADES
B - S LIPAN ST OUTFALL
C - S PECOS ST AND W ILIFF IMPROVEMENTS
D1 - W EVANS AVE IMPROVEMENTS
D2 - W EVANS AVE EXTENSION
DENVER STORM DRAINAGE MASTER PLAN
Basin 0065-01 (Ruby Hill)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
Key Map
0064-02
5000-02
5100-01
5000-03
5200-01
5200-02
5300-01
5500-01
0065-02
W FLORIDA AVE
W JEWELL AVE
W EVANS AVE
S FEDERAL BLVD
S ZUNI ST
S LIPAN ST
Sanderson Gulch
South Platte River
West Harvard Gulch
Harvard Gulch
Harvey Park Lake
Ward Reservoir No. 5
Overland Lake
Overland Pond
Denver
Arapahoe County
A
B
C
D1
D2

Basin: 0065-02 (Dartmouth)

Existing System Description:
The Dartmouth Basin borders West Harvard Gulch Basin directly to the south. The Dartmouth basin is bounded between Federal Boulevard and the South Platte River, and generally between Amherst and Hampden Avenues. Most of the basin is located within the boundaries of Englewood, and only approximately 30% of the basin is in Denver. Denver's portion includes the upper steep reaches north of W. Dartmouth Avenue between Federal Boulevard and Zuni Street, and an industrial complex located along the banks of the South Platte River north of Dartmouth Avenue.

Dartmouth Basin is approximately 0.76 square miles in size and is fully developed with residential properties in the upper reaches, and industrial properties in the lower reaches along the banks of the South Platte River. Land use mix in the basin is about 1/3 residential and 2/3 commercial and industrial. The basin is relatively steep with Dartmouth Avenue generally being the low point (thalweg) of the drainage basin.

No outfall pipes in this basin are shown in the Denver GIS database since the outfall for this Basin is in Englewood.

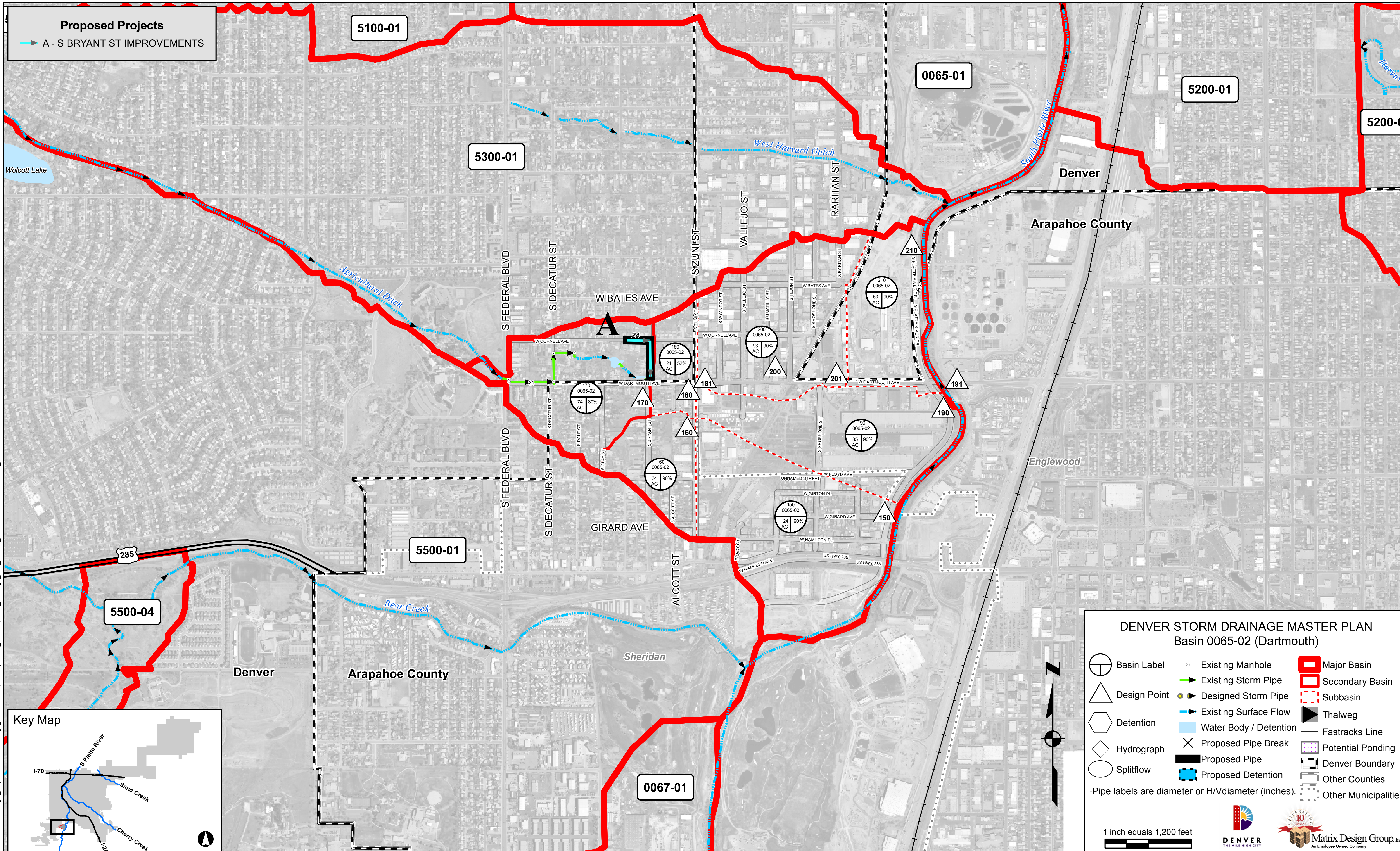
Drainage Deficiencies:
Currently this basin drains east to Englewood's storm sewer system which drains into the South Platte River. The 5-year flow rate is 424 cfs. The existing Englewood system ranges in size from a 42-inch pipe to 73"x55" elliptical pipe. There is not sufficient data to determine if the existing Englewood pipe is sufficient to convey the 5-year storm event. No future improvements will be proposed outside of the City and County of Denver.

Proposed Capital Improvements:
Project A: S. Bryant Street Improvement Only a small improvement is recommended along South Bryant Street from Dartmouth Avenue to and west in Cornell Avenue. A 24-inch, 2-year capacity storm sewer is proposed.

Existing Hydrology:

BASINS 0065-02

Design Point	Contributing Basins	Tributary Area	Peak Discharge	
			2-Year	5-Year
		(acres)	*(cfs)*	*(cfs)*
150	150	124	206	296
160	160	34	54	79
170	170	74	107	160
180	180	21	17	32
181	160,170,180	129	178	256
190	190	85	105	153
191	160,170,180,190,200	307	403	549
200	200	93	153	221
201	160,170,180,190,200	222	317	424
210	210	53	65	95


Proposed Projects
A - S BRYANT ST IMPROVEMENTS
5100-01
0065-01
5200-01
5200-02
5300-01
5500-01
5500-04
0067-01
Wolcott Lake
West Harvard Gulch
South Platte River
Agricultural Ditch
Bear Creek
Denver
Arapahoe County
Englewood
Sheridan
S FEDERAL BLVD
S DECATUR ST
S ZUNI ST
VALLEJO ST
RARITAN ST
W BATES AVE
GIRARD AVE
ALCOTT ST
285
A
Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
DENVER STORM DRAINAGE MASTER PLAN
Basin 0065-02 (Dartmouth)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.

Basin: 0067-01 (College View)

Existing System Description:
The College View basin has a total drainage area of approximately 1.3 square miles. This basin flows east through Denver and Littleton to its confluence with the South Platte River. The lower portion is outside the City and County of Denver and was not studied. The basin is currently fully developed with the exception of a few scattered vacant lots including residential, commercial and industrial areas.

Drainage Deficiencies:
The entire storm sewer within the College View basin is adequately sized for the 2-year storm event. However, the storm sewer system should have 5-year capacity due to the commercial areas through the neighborhood. Much of the residential area along West Quincy Avenue does not have any storm sewer system and would benefit from a new lateral.

Proposed Capital Improvements:
Two major storm drain projects have been proposed in this basin to increase the level of service from a 2-year capacity to a 5-year capacity.

<u>Project A: S. Quitman Street Improvements</u> A new 18-inch to 24-inch storm sewer from W. Quinn Place to W. Stanford Avenue and S. Quitman Street is proposed.

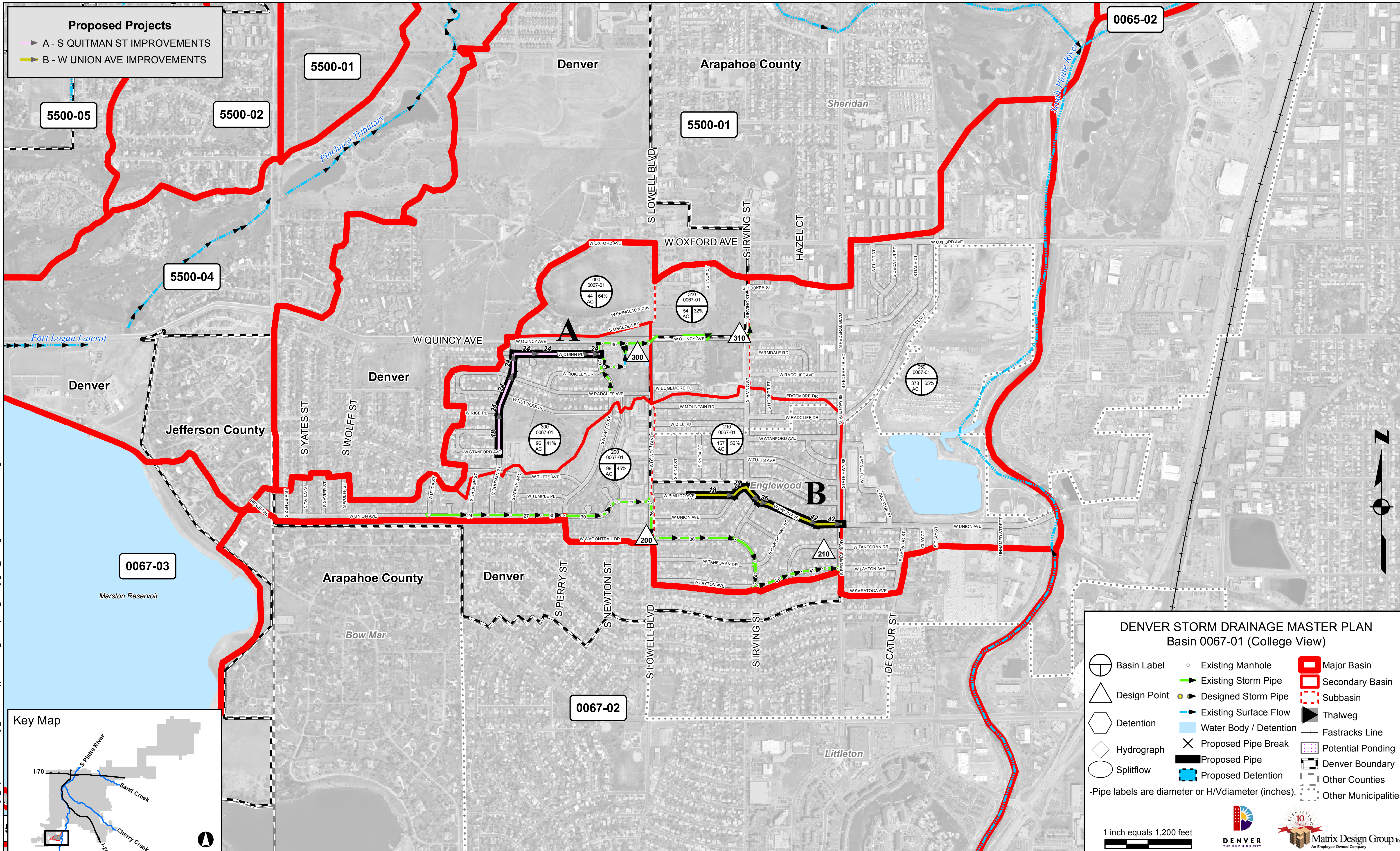
<u>Project B: West Union Avenue Improvements</u> The existing storm sewer system along West Union Avenue does not meet the minimum required performance objectives for a 5-year storm sewer. Upsizing the existing storm sewer system to a 42" pipe will satisfy this requirement.

Difficulties in constructing a new outfall system for this basin would include coordination with downstream municipalities at the two outfall locations, Lowell Boulevard and Federal Boulevard. Agreements should be in place before any designs are considered.

Existing Hydrology:

BASIN 0067-01, 0067-02

- Design Point	- Contributing Basins	- Tributary Area	- Peak Discharge		
			2-Year	5-Year	100-Year
		(acres)	(cfs)	(cfs)	(cfs)
20	20	71	12	46	171
30	30	23	14	28	79
40	30,40	51	29	56	155
50	50	121	114	189	452
60	60	44	38	63	153
70	70	82	76	137	351
80	70,80	209	156	291	775
90	70,80,90	319	214	407	1139
200	200	99	43	84	238
210	200, 210	256	156	291	772
300	300	96	44	89	255
310	300, 310	150	63	134	403


Proposed Projects
A - S QUITMAN ST IMPROVEMENTS
B - W UNION AVE IMPROVEMENTS
5500-01
5500-05
5500-02
5500-04
0065-02
0067-03
0067-02
Denver
Arapahoe County
Jefferson County
Sheridan
Englewood
Littleton
Bow Mar
Marston Reservoir
Fort Logan Lateral
Pinehurst Tributary
South Platte River
W OXFORD AVE
W QUINCY AVE
S LOWELL BLVD
S IRVING ST
HAZEL CT
S YATES ST
S WOLFF ST
S PERRY ST
S NEWTON ST
DECATUR ST
A
B
300
310
200
210
DENVER STORM DRAINAGE MASTER PLAN
Basin 0067-01 (College View)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
Matrix Design Group, Inc.
An Employee Owned Company

Basin: 0067-02 (West Belleview)

Existing System Description:
The West Belleview basin has a total drainage area of approximately 4.2 square miles. This basin flows east through Denver and Littleton to its confluence with the South Platte River. The lower portion of this basin is outside the City and County of Denver and was not studied. The upper portion of the Fort Logan basin includes Marston Reservoir. The basin is currently fully developed with the exception of a few scattered vacant lots including residential, commercial and industrial areas.

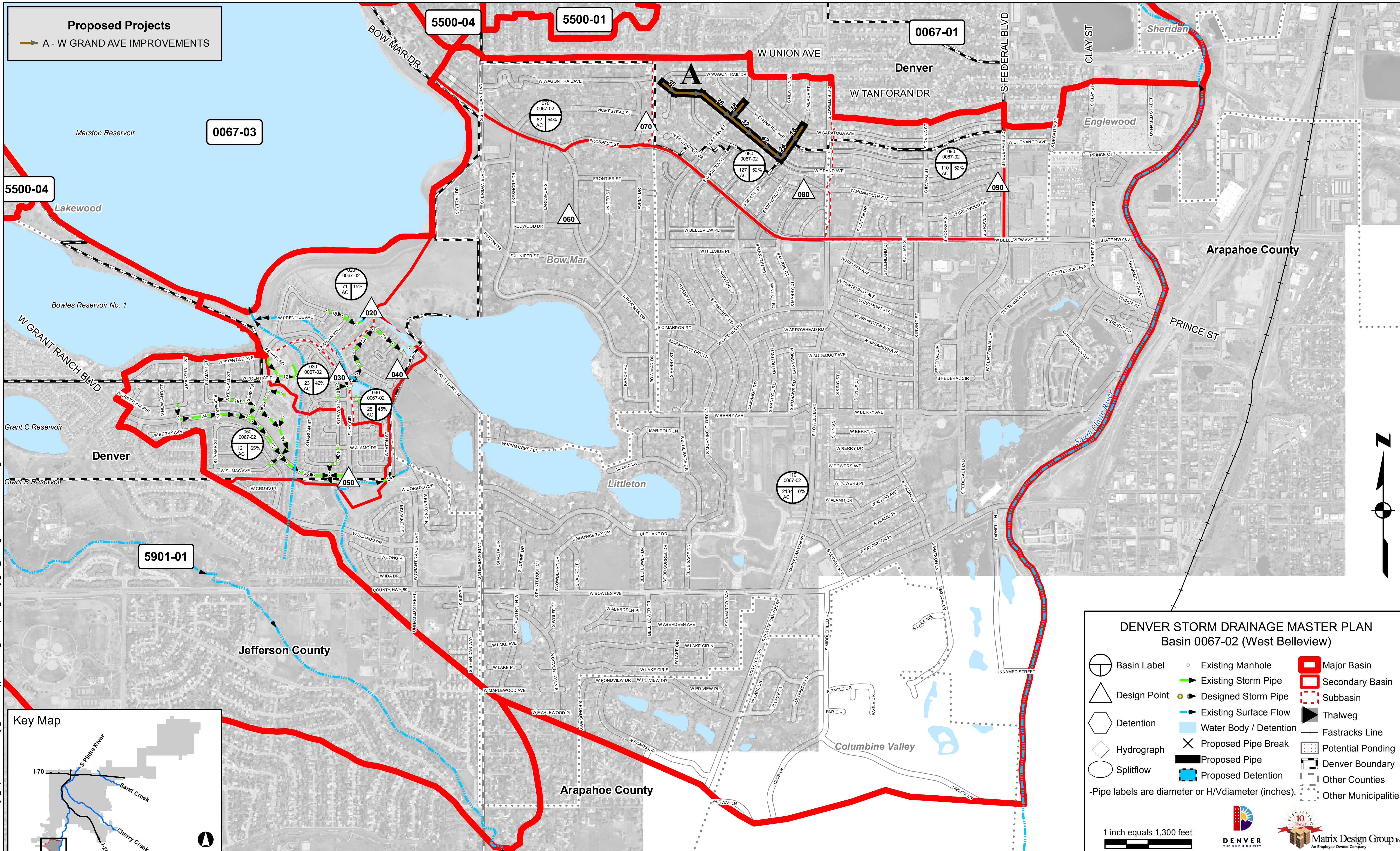
Drainage Deficiencies:
The existing development in these basins is relatively new. Grant Ranch within basin 0067-02 has been fully developed and the storm sewer appears to be adequate in this area. The drainage basins to the north along W. Belleview Avenue and within basin 0067-02 have no existing storm sewer in Denver's GIS database.

Proposed Capital Improvements:
Project A: W. Grand Avenue Improvements The existing residential neighborhood along W. Grand Avenue currently does not have any storm sewer. A 2-year capacity storm sewer system is proposed along W. Grand Avenue and will connect to Englewood's storm sewer system at W. Grand Avenue and S. Meade Street

Existing Hydrology:

BASIN 0067-01, 0067-02

- Design Point	- Contributing Basins	- Tributary Area (acres)	- Peak Discharge 2-Year (cfs)	5-Year (cfs)	100-Year (cfs)
20	20	71	12	46	171
30	30	23	14	28	79
40	30,40	51	29	56	155
50	50	121	114	189	452
60	60	44	38	63	153
70	70	82	76	137	351
80	70,80	209	156	291	775
90	70,80,90	319	214	407	1139
200	200	99	43	84	238
210	200210	256	156	291	772
300	300	96	44	89	255
310	300, 310	150	63	134	403

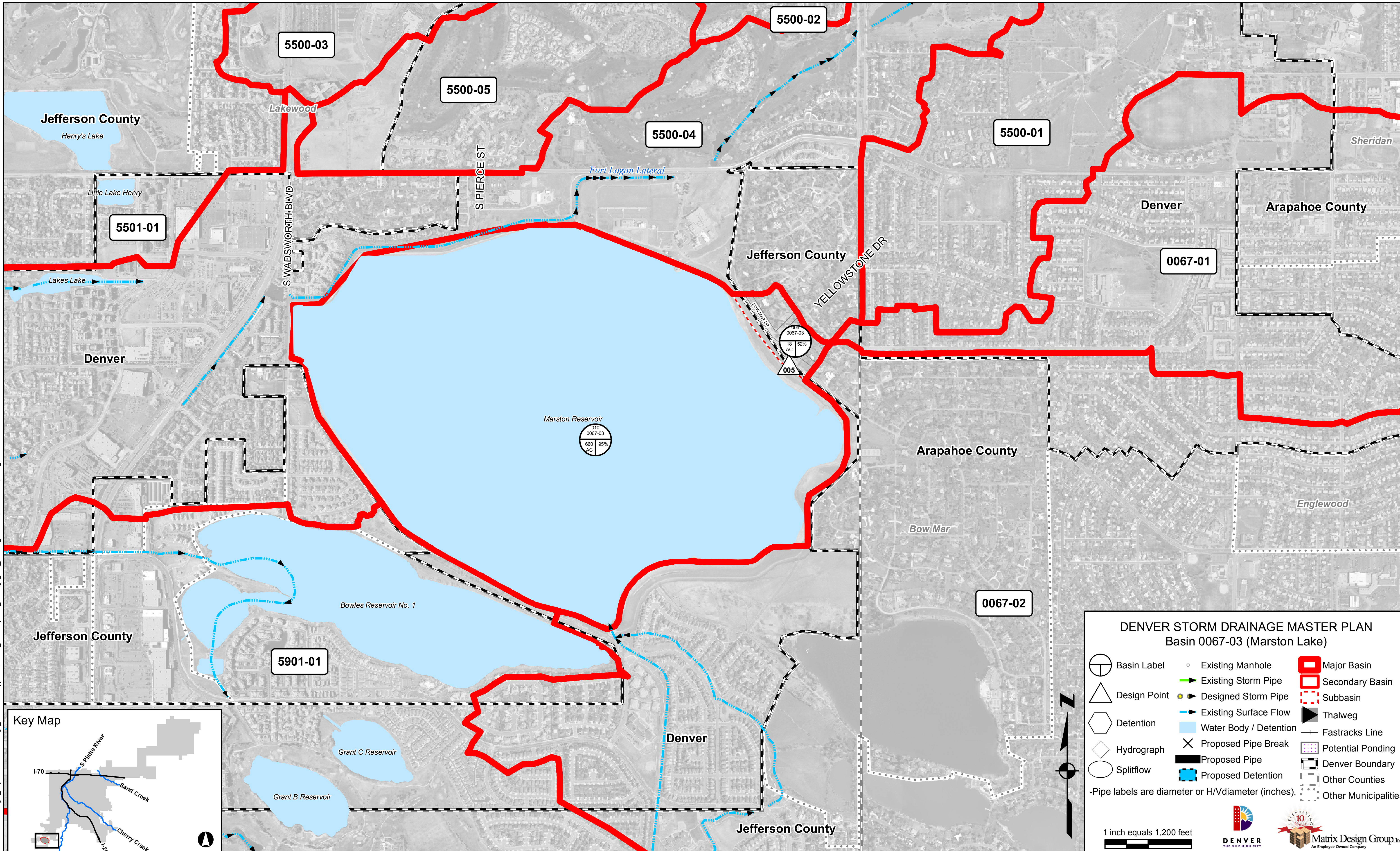

Proposed Projects
A - W GRAND AVE IMPROVEMENTS
5500-04
5500-01
0067-01
0067-03
5901-01
W UNION AVE
Denver
W TANFORAN DR
S FEDERAL BLVD
CLAY ST
Sheridan
Englewood
Marston Reservoir
Lakewood
Bowles Reservoir No. 1
W GRANT RANCH BLVD
Grant C Reservoir
Grant B Reservoir
Bow Mar
BOW MAR DR
Littleton
Arapahoe County
PRINCE ST
South Platte River
Jefferson County
Columbine Valley
Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
DENVER STORM DRAINAGE MASTER PLAN
Basin 0067-02 (West Belleview)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,300 feet
DENVER THE MILE HIGH CITY
Matrix Design Group, Inc. An Employee Owned Company

Basin: 0067-03 (Marston Lake)

Existing System Description:
The Marston Lake basin has a total drainage area of approximately 1.1 square miles. This basin is within Denver and has no outlet. A 12-foot high berm surrounds the reservoir and keeps stormwater from entering or leaving. A small portion of Marston Reservoir does include a small residential area with no outlet.

Drainage Deficiencies:
No drainage deficiencies are identified at this time.

Proposed Capital Improvements:
No improvements are proposed.


5500-03
5500-02
5500-05
5500-04
5500-01
Jefferson County
Henry's Lake
Lakewood
Little Lake Henry
5501-01
S WADSWORTH BLVD
S PIERCE ST
Fort Logan Lateral
Sheridan
Denver
Arapahoe County
0067-01
Jefferson County
YELLOWSTONE DR
Lakes Lake
Denver
005
Marston Reservoir
Arapahoe County
Englewood
Bow Mar
Bowles Reservoir No. 1
0067-02
Jefferson County
5901-01
Grant C Reservoir
Grant B Reservoir
Denver
Jefferson County
Key Map
I-70
S Platte River
Sand Creek
Cherry Creek
I-25
DENVER STORM DRAINAGE MASTER PLAN
Basin 0067-03 (Marston Lake)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.

Basin 3501-01 (West Fork Second Creek)

Existing System Description:
The West Fork of Second Creek is located along the southern boundary of DIA within the City and County of Denver and drains about 3 square miles of area to the main branch of Second Creek. West Fork Second Creek flows across Peña Boulevard at the 90° bend and continues in a northwesterly direction, eventually outfalling to the South Platte River. There is limited existing development within the West Fork Second Creek basin. The land is mainly agricultural, with dryland farming and pasture in the upper reaches.

The Highline Canal terminates at the West Fork. The sustained unused flow in the Highline Canal has historically been wasted to the West Fork downstream of 64th Avenue, and the flows have eroded the channel on the West Fork. At Tower Road the West Fork channel is about 15 feet deep with vertical and very steep, unstable banks. The confluence of Second Creek and the West Fork of Second Creek is a wide, relatively flat area supporting a stand of cottonwood trees. Some wetland areas are present in the upper reaches of the West Fork, but, as the channel has eroded, the channel banks have become incised and support only a narrow band of wetland or riparian vegetation. The floodplain is contained within the channel except at road crossings, where overtopping may occur. The banks are unstable and some lateral channel migration may occur during large flows.

Identified Drainage Problems/Deficiencies:
West Fork Second Creek is largely undeveloped, and drainage is primarily via open channels and swales. There are few storm drain pipe systems within the basin. Since there is little development, the system currently functions without ponding or drainage problems, except for channel erosion which will be exacerbated by further development.

Proposed Capital Improvements:
The drainage basin is currently mostly undeveloped with a low imperviousness. The ***Second Creek and Direct Flow Area 0053 Outfall Planning Study, Preliminary Design*** completed by Kiowa Engineering for the Urban Drainage & Flood Control District in May 1990, assumes the upper reaches of the basin will be developed with an average 70% imperviousness. The OSP calls for channel stabilization measures by constructing a series of drop structures along the channel. These improvements will be constructed commensurate with development.

The Peña Boulevard Transportation Corridor includes land extending 250 feet from centerline for a future light rail/ commuter rail line. Therefore, existing and proposed detention ponds are not immediately adjacent to Peña Boulevard.

Two regional detention facilities are currently proposed in the basin, along with multiple, smaller detention facilities serving future developments.

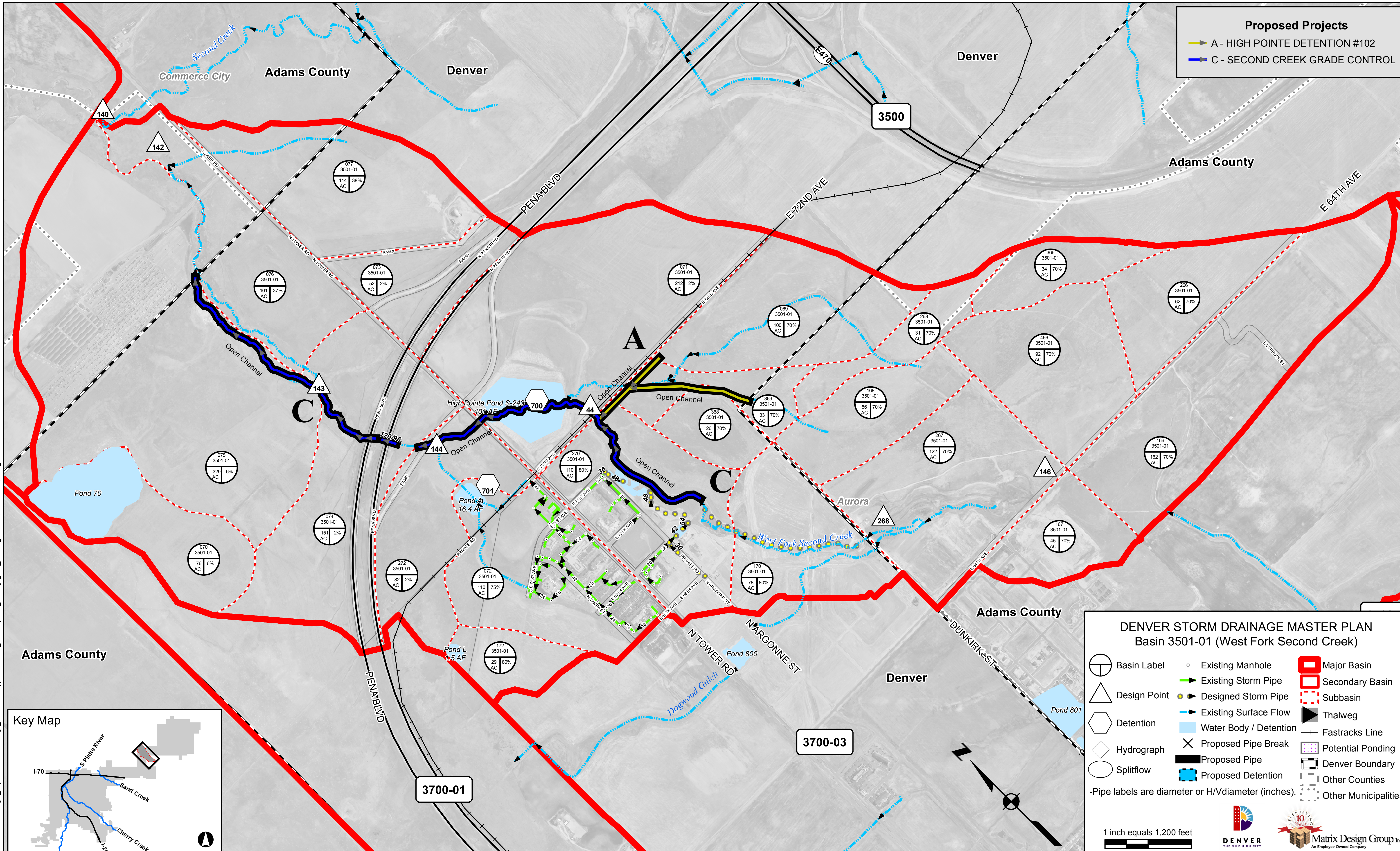
Project A: High Pointe Pond #102
The 95 acre-foot "High Pointe Pond #102" located east of Tower Road and north of 72nd Avenue was master planned to reduce flows to historic conditions in the West Fork Second Creek. Originally, this pond was planned further downstream, adjacent to Peña Boulevard; however 404 permitting required a bridge rather than a culvert under Peña. Open channel improvements will be required to serve as conveyance from future development areas into the West Fork of Second Creek. These improvements will be required as development occurs to adequately convey flows to the culvert upstream of 72nd Avenue on the West Fork of Second Creek.

Project C: Second Creek Grade Control
Channel stabilization is required on about 18,000 lineal feet of the West Fork Second Creek. The channel will be graded from steep unstable banks to a channel with sloped overbanks and with a top width of about 40 to 45 feet. An estimated 35 drop structures are also proposed to stabilize the channel by shallowing the existing grade.

Developed Conditions Hydrology:

BASIN 3501-01

Design Point	Contributing Basins	Tributary Area (acres)	Peak Discharge 2-Year (cfs)	5-Year (cfs)	100-Year (cfs)
44	44	1163	546	982	2943
140	69, 71-77,166,167,168,170,172,266,267,268,270,272,366,368,369,466	2131	304	542	1819
142	69, 71-77,166,167,168,170,172,266,267,268,270,272,366,368,369,466	2131	305	544	1817
143	69, 71-74,166,167,168,170,172,266,267,268,270,272,366,368,369,466	1588	294	516	1424
144	69, 71,72,166,167,168,170,172,266,267,268,270,272,366,368,369,466	1385	294	511	1249
700	69, 71,166,167,168,170,266,267,268,270,366,368,369,466	1163	271	482	1084
701	72	110	17	25	103



FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\active\apps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/25/2009, ron_ramold

Basin 3700-01 (First Creek – Peña Corridor)

Existing Basin Description:
The First Creek drainage basin is located south of DIA and crosses Peña Boulevard just north of 56th Avenue. West of Peña Boulevard, First Creek flows through the southeastern portion of the Rocky Mountain Arsenal. First Creek enters Rocky Mountain Arsenal with an incised, low flow channel and wide floodplain.

Basin 3700-01 is entirely within the City & County of Denver and has been defined as the area within the wide Peña Boulevard corridor that will not experience further development. However, a portion of this basin extends upstream to the outlet of the regional Green Valley Ranch Golf Course detention pond. This basin is 2.23 square miles and will include future development. General imperviousness is 8% along Peña Boulevard, and about 65% further upstream on First Creek.

Identified Drainage Problems/Deficiencies:
The Peña Boulevard corridor is a wide area for the new roadway and contains sites planned for regional detention before outfalling into the Rocky Mountain Arsenal. The basin is actively being developed in accordance with current drainage criteria, which is the 100-year storm event. Therefore, no existing deficiencies have been identified.

Proposed Capital Improvements:
Urban Drainage & Flood Control District prepared drainage master plans prior to development of the basin and has required incorporation of regional water quality and detention into land planning. All development in the First Creek drainage basin must detain and treat water quality on-site or in regional ponds since runoff will flow into the Rocky Mountain Arsenal. The Arsenal has strict agreements for the quantity and quality of stormwater runoff into the federal property.

Two regional detention facilities are planned for within this basin, within the Peña Boulevard corridor.

<u>Project A: Blue Grama Draw Detention Pond</u>
A 269 acre-foot detention pond is planned at the outfall of Blue Grama Draw into the Peña Boulevard corridor. A 250' setback from the centerline of Peña is planned to reserve room for the future light rail/commuter train corridor. This pond will serve to detain flows from upstream development areas, and to provide historical releases into First Creek before it enters the Rocky Mountain Arsenal. This pond will also receive diverted flows from the main channel of First Creek, to detain flows of the main channel before releasing them back to the creek upstream of Peña Boulevard.

<u>Project B: Dogwood Gulch Detention Pond</u>
This 17.7 acre-foot detention pond will sit to the east of Peña Boulevard, at the outfall of Dogwood Gulch to the Peña Boulevard corridor. A 250' setback from the centerline of Peña is planned to reserve room for the future light rail/commuter train corridor. This detention pond will meter flows out to an open channel to the south, which will be routed through the planned Blue Grama Draw detention pond before outfalling to First Creek immediately upstream of Peña.

Master Plan Agreements:
Many documents and agreements have been compiled for the First Creek Drainage Basin which specifies 100-year discharges and storage volumes. Therefore, nothing in this master plan shall take precedence over those agreements or specified discharges. This study was completed for the purposes of analyzing initial storm flows for the 2- and 5-year events. Agreement 99-03.11, dated January 25, 2001, states the following for the Dogwood Gulch Detention Pond (#813) and the Blue Grama Draw Pond (#305):

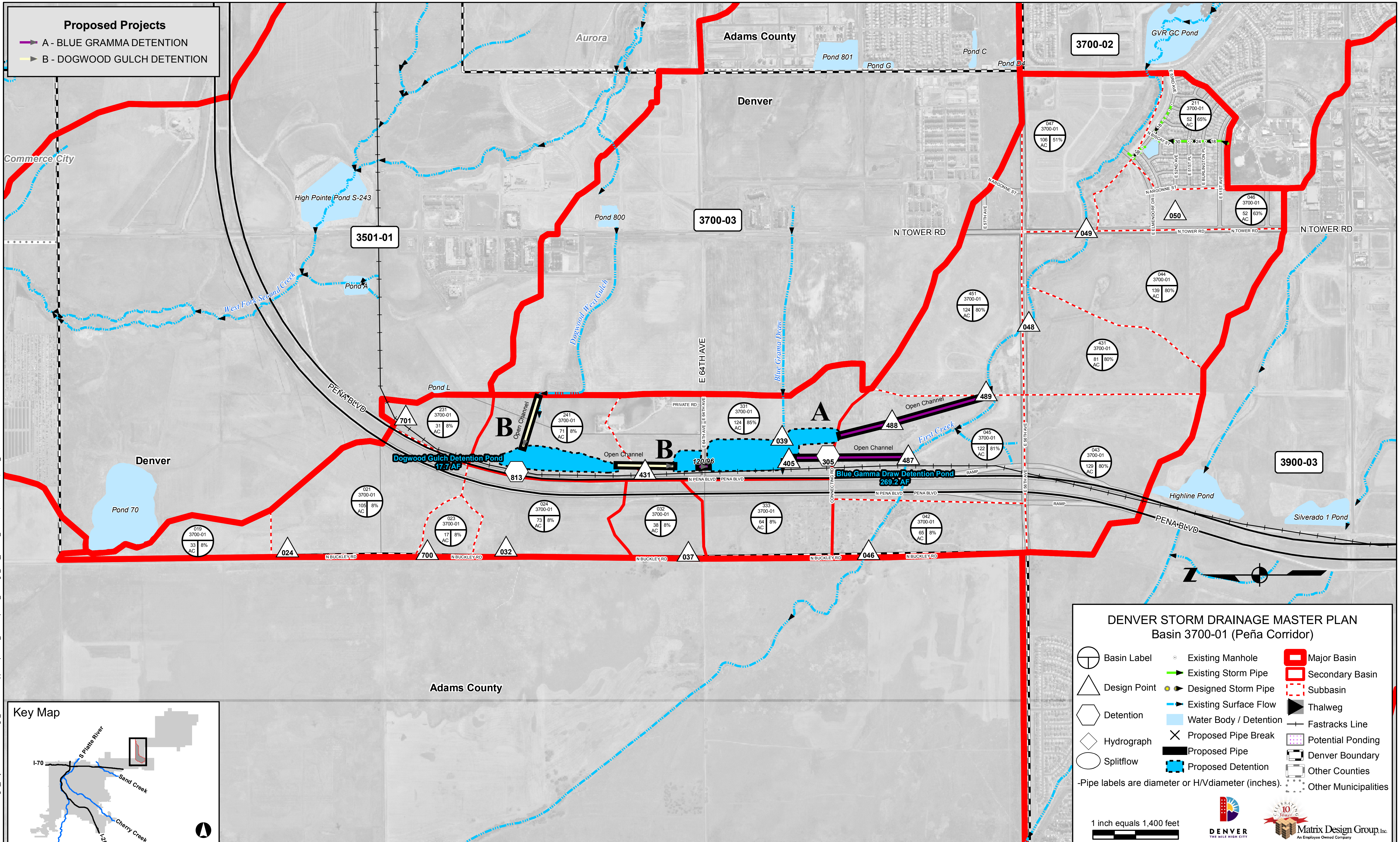
Master Plan Design Parameters

ID No.	Peak Inflow (cfs)	Peak Outflow (cfs)	Volume (AF)	Jurisdiction
305	2027	1929	269	Denver
813	213	83	18	Denver

Developed Conditions Hydrology:
The following table is provided for 2- and 5-year discharges. 100-year flows shown only for comparison purposes. Refer to agreements and Urban Drainage & Flood Control District master plans for specific discharges.

<u>BASIN 3700-01</u>

Design Point	Tributary Area	Peak Discharge		
		2-year	5-year	100-year
	(acres)	*(cfs)*	*(cfs)*	*(cfs)*
24	136	3	11	125
32	73	4	8	121
37	38	2	4	60
39	1584	96	142	917
46	19324	668	1547	4715
48	16953	1078	1595	4516
49	16733	1075	1588	4509
50	52	38	56	142
405	1867	543	862	1975
431	282	23	29	84
487	19065	668	1660	4717
488	0	435	699	1707
489	17076	1079	1600	4516
700	18	0	2	25
701	31	1	3	47


Proposed Projects
A - BLUE GRAMMA DETENTION
B - DOGWOOD GULCH DETENTION
DENVER STORM DRAINAGE MASTER PLAN
Basin 3700-01 (Peña Corridor)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,400 feet
Key Map
Aurora
Adams County
Denver
Commerce City
3501-01
3700-02
3700-03
3900-03
Dogwood Gulch Detention Pond
17.7 AF
Blue Gamma Draw Detention Pond
269.2 AF
Open Channel
PENA BLVD
N TOWER RD
N BUCKLEY RD
E 64TH AVE
High Pointe Pond S-243
Pond 70
Pond 800
Pond 801
Pond L
Pond A
Highline Pond
Silverado 1 Pond
GVR GC Pond
West Fork Second Creek
Dogwood West Gulch
Blue Grama Draw
First Creek
A
B

Basin 3700-02 (First Creek – Green Valley Ranch)

Existing Basin Description:
Basin 3700-02 is primarily within the City & County of Denver, but includes some area within Adams County. The basin includes area within Denver that is tributary to the regional Green Valley Ranch Golf Course Detention Pond, also known as the "Himalaya Pond". This basin is being developed by Green Valley Ranch and includes 2.12 square miles. First Creek runs through this basin, and bisects Green Valley Ranch, which consists of medium density, single-family residences. General imperviousness has been master planned as 70%; however, actual imperviousness is lower and has been used in the 2009 Master Plan Update.

Identified Drainage Problems/Deficiencies:
The basin is actively being developed in accordance with current drainage criteria, which is the 100-year storm event. Therefore, no existing deficiencies have been identified.

Proposed Capital Improvements:
Urban Drainage & Flood Control District prepared drainage master plans prior to development of the basin and has required incorporation of regional water quality and detention into land planning. All development in the First Creek drainage basin must detain and treat water quality on-site or in regional ponds since runoff will flow into the Rocky Mountain Arsenal. The Arsenal has strict agreements for the quantity and quality of stormwater runoff into the federal property.

There are no further planned improvements for the basin, beyond the capital construction required for the Green Valley Ranch development.

Master Plan Agreements:
Many documents and agreements have been compiled for the First Creek Drainage Basin which specifies 100-year discharges and storage volumes. Therefore, nothing in this master plan shall take precedence over those agreements or specified discharges. This study was completed for the purposes of analyzing initial storm flows for the 2- and 5-year events. Agreement 99-03.11, dated January 25, 2001, states the following for the "Green Valley Ranch Golf Course Pond" or the "Himalaya Pond" (#808):

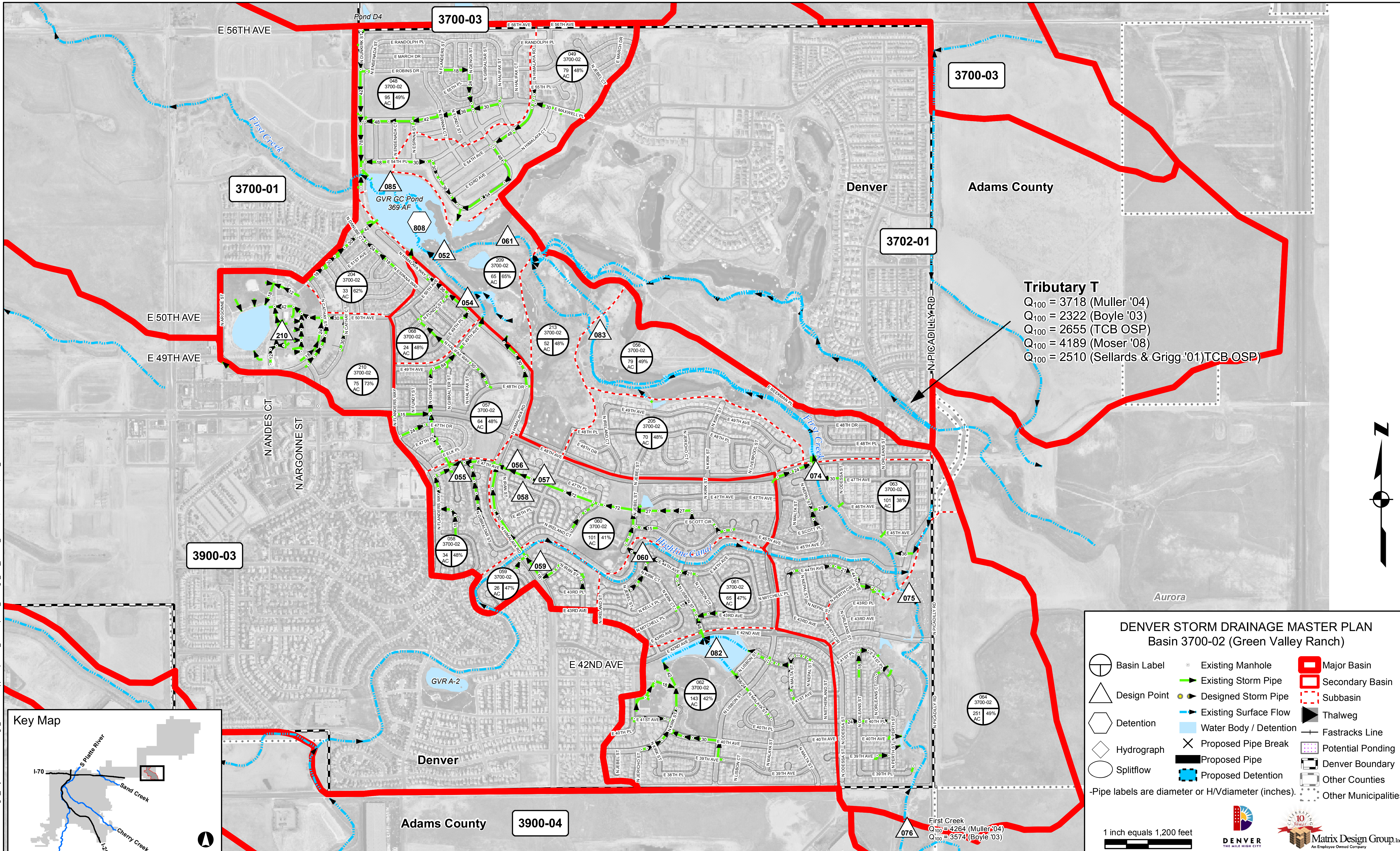
Master Plan Design Parameters				
ID No.	**Peak Inflow (cfs)**	**Peak Outflow (cfs)**	**Volume (AF)**	**Jurisdiction**
808	4857	4306	263	Denver

However, the pond was constructed with 369 acre-feet of storage, rather than the 263 acre-feet per the agreement.

Developed Conditions Hydrology:
The following table is provided for 2- and 5-year discharges. 100-year flows shown only for comparison purposes. Refer to agreements and Urban Drainage & Flood Control District master plans for specific discharges.

BASIN 3700-02

Design Point	Tributary Area	Peak Discharge		
		2-year	**5-year**	**100-year**
	(acres)	*(cfs)*	*(cfs)*	*(cfs)*
52	16252	1124	1610	5237
54	434	161	239	806
55	370	144	213	756
56	336	130	192	691
57	309	118	173	631
58	26	13	19	64
59	26	13	21	67
60	208	94	134	510
61	15794	1113	1598	5210
74	9626	477	767	3248
75	9525	478	782	3368
76	9274	469	797	3575
82	143	67	110	393
83	9775	474	739	3212
85	16524	1119	1616	5249
210	75	61	87	216
703	9827	474	739	3210



DENVER STORM DRAINAGE MASTER PLAN
Basin 3700-02 (Green Valley Ranch)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
Matrix Design Group, Inc.
Tributary T
Q_{100} = 3718 (Muller '04)
Q_{100} = 2322 (Boyle '03)
Q_{100} = 2655 (TCB OSP)
Q_{100} = 4189 (Moser '08)
Q_{100} = 2510 (Sellards & Grigg '01)TCB OSP)
First Creek
Q_{100} = 4264 (Muller '04)
Q_{100} = 3574 (Boyle '03)
3700-03
3700-01
3702-01
3900-03
3900-04
Denver
Adams County
Aurora
E 56TH AVE
E 50TH AVE
E 49TH AVE
E 42ND AVE
N ANDES CT
N ARGONNE ST
N PICADILLY RD
Pond D4
GVR GC Pond
369 AF
GVR A-2
First Creek
Highline Canal
Key Map
S Platte River
Sand Creek
Cherry Creek
I-70
I-25
FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activeapps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/24/2009, ron_ramold

Basin 3700-03 (First Creek – Dogwood & Blue Grama Tribs.)

Existing Basin Description:
Basin 3700-03 is located within the City & County of Denver and Adams County. This basin has been defined as the area draining to the Dogwood Gulch Tributary and the Blue Grama Draw Tributary. This basin is 2.61 square miles and is actively being developed. The subdivisions of "Denver International Business Center", "HighPointe", "SingleTree at DIA" are within this drainage basin. General imperviousness, at full development, will be around 65%.

Identified Drainage Problems/Deficiencies:
The basin is actively being developed in accordance with current drainage criteria, which is the 100-year storm event. Therefore, no existing deficiencies have been identified.

Proposed Capital Improvements:
Urban Drainage & Flood Control District prepared drainage master plans prior to development of the basin and has required incorporation of regional water quality and detention into land planning. All development in the First Creek drainage basin must detain and treat water quality on-site or in regional ponds since runoff will flow into the Rocky Mountain Arsenal. The Arsenal has strict agreements for the quantity and quality of stormwater runoff into the federal property.

Multiple detention ponds are planned throughout the basin in conjunction with development, both on Dogwood Gulch and Blue Grama Draw.

Project A: Dogwood Gulch Pond 812
This 13.1 acre-foot detention pond will be constructed as development occurs. It will be located immediately to the east of the Peña Boulevard corridor, between 66th and 68th Avenues. This pond will serve to regulate increased flows from the development back into Dogwood Gulch as it enters the Peña corridor.

Project B: Blue Grama Draw Pond 815
This 39.1 acre-foot detention pond will be constructed as development occurs. It will be located immediately to the east of the Peña Boulevard corridor, between 60th and 64th Avenues. This pond will serve to regulate increased flows from the development back into Blue Grama Draw as it enters the Peña corridor.

Project E: Blue Grama Draw Pond 802
This 32.3 acre-foot detention pond will be constructed as development occurs. It will be located immediately to the east of Tower Road, between 60th and 64th Avenues. This pond will serve to regulate increased flows from the development back into Blue Grama Draw before crossing Tower Road.

Project G: Blue Grama Draw Pond 816
This 51.6 acre-foot detention pond will be constructed as development occurs. It will be located immediately to the north of 60th Avenue and to the west of the Highline Canal in Adams County. This pond will serve to regulate increased flows from the development back into Blue Grama Draw.

Project H: Blue Grama Draw Pond 826
This 22.9 acre-foot detention pond is partially constructed. It will be located immediately to the south of 60th Avenue, and will eventually be on both sides of Argonne Street. This pond will serve to regulate increased flows from the development back into Blue Grama Draw. Currently only a portion of this pond at the east side of Argonne Street is constructed, as only a portion of the tributary area is developed. The other portion of this pond at the west side of Argonne Street will be constructed to offer an additional 11 acre-foot service levels for the future development.

Open Channel Improvements
Generally, this basin requires a series of open channel improvements associated with each detention pond to serve as conveyance channels for both Dogwood Gulch and Blue Grama Draw. These open channel improvements, and associated culvert crossings, will be required as development occurs.

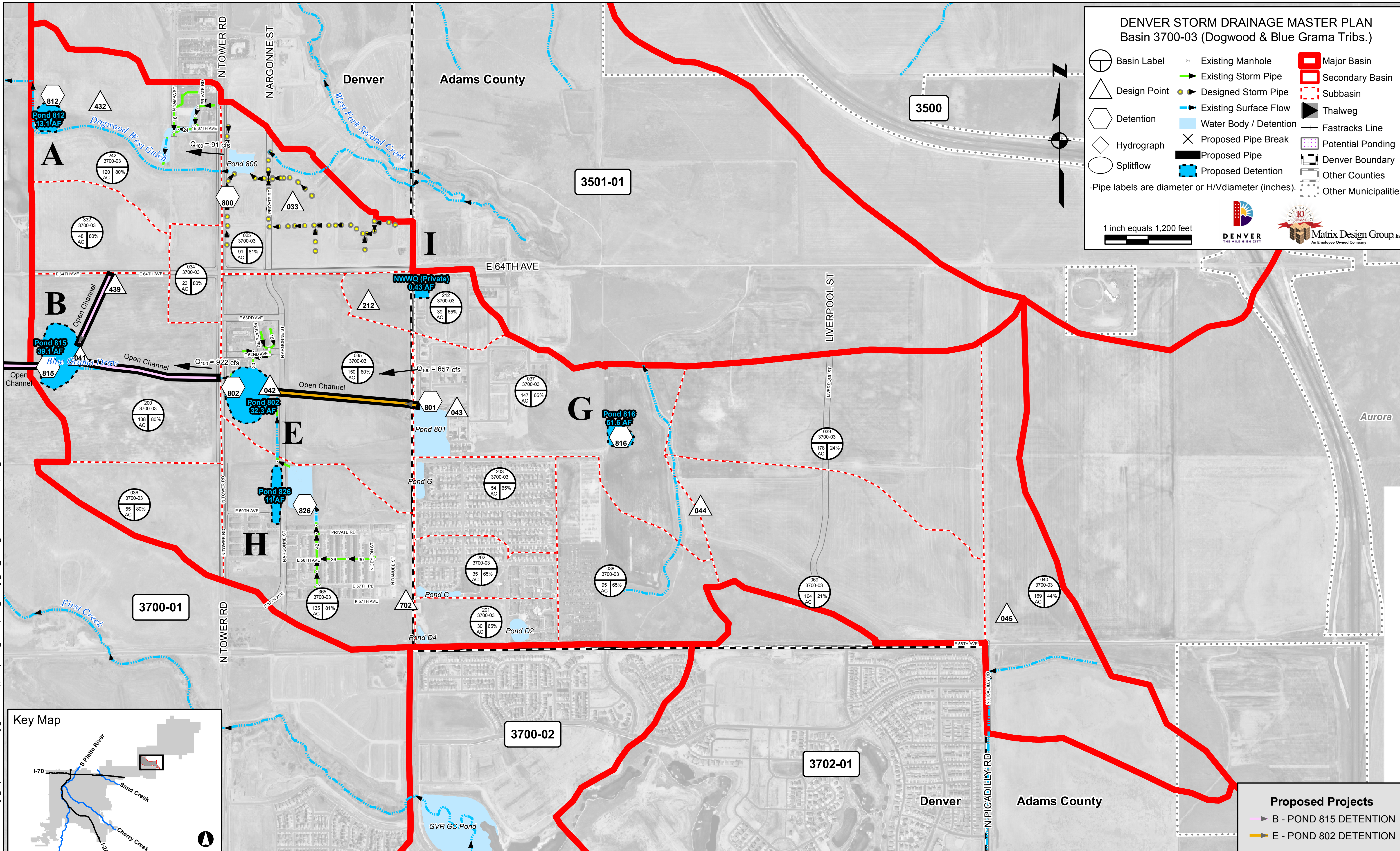
Master Plan Agreements:
Many documents and agreements have been compiled for the First Creek Drainage Basin which specifies 100-year discharges and storage volumes. Therefore, nothing in this master plan shall take precedence over those agreements or specified discharges. This study was completed for the purposes of analyzing initial storm flows for the 2- and 5-year events. Agreement 99-03.11, dated January 25, 2001, states the following:

Master Plan Design Parameters				
ID No.	Peak Inflow (cfs)	Peak Outflow (cfs)	Volume (AF)	Jurisdiction
800	419	91	11	Denver
801	1226	655	20	Aurora
802	982	920	33	Denver
812	444	216	13	Denver
815	1095	999	39	Denver
816	864	438	51	Aurora
826	589	180	23	Denver

Developed Conditions Hydrology:
The following table is provided for 2- and 5-year discharges. 100-year flows shown only for comparison purposes. Refer to agreements and Urban Drainage & Flood Control District master plans for specific discharges.

BASIN 3700-03

Design Point	Tributary Area	Peak Discharge		
		2-year	5-year	100-year
	(acres)	*(cfs)*	*(cfs)*	*(cfs)*
33	91.1	74	110	283
41	1460.2	174	264	976
42	1196.8	168	253	903
43	753.6	143	217	631
44	511.5	71	131	705
45	169.3	81	133	452
85	16523.6	1119	1616	5249
212	39.2	28	42	110
432	211.4	102	152	393
439	70.4	57	85	221
702	65.6	48	72	185



DENVER STORM DRAINAGE MASTER PLAN
Basin 3700-03 (Dogwood & Blue Grama Tribs.)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.
Denver
Adams County
3500
3501-01
3700-01
3700-02
3702-01
Aurora
E 64TH AVE
N TOWER RD
N ARGONNE ST
LIVERPOOL ST
N PICADILLY RD
Dogwood West Gulch
West Fork Second Creek
Blue Grama Draw
First Creek
Open Channel
Q_{100} = 91 cfs
Q_{100} = 922 cfs
Q_{100} = 657 cfs
Pond 812 13.1 AF
Pond 815 39.1 AF
Pond 802 32.3 AF
Pond 826 11 AF
Pond 816 51.6 AF
NWWQ (Private) 0.43 AF
Pond 800
Pond 801
Pond G
Pond C
Pond D2
Pond D4
GVR GC Pond
A
B
E
G
H
I
Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
Proposed Projects
B - POND 815 DETENTION
E - POND 802 DETENTION

Basin 3702-01 (First Creek – Tributary "T")

Existing Basin Description:
Basin 3702-01 is defined as the portion of Denver draining to the channel known as Tributary "T", which enters Denver near N. Picadilly Road and E. 48th Place. This basin is also extends into Adams County. The basin area is 1.48 square miles and will include future development and the Green Valley Ranch Golf Course. Overall master planned imperviousness is about 70%.

This tributary extends further upstream beyond the limits of this basin into Adams County. The upper reaches of Tributary "T" basin have been master planned for development under the direction of Urban Drainage & Flood Control District by Wright Water Engineers in 1990, Turner, Collie & Braden in 2000, Mueller Engineering in 2003. In addition, development engineers have also studied the basin and include Martin & Martin in 1998, Vestal Engineering in 2004, and Stantec in 2005. There are also other development engineers that have also completed studies of the basin.

Identified Drainage Problems/Deficiencies:
The basin is actively being developed in accordance with current drainage criteria, which is the 100-year storm event. Therefore, no existing 2- and 5-year deficiencies have been identified.

Proposed Capital Improvements:
Urban Drainage & Flood Control District prepared drainage master plans prior to development of the basin and has required incorporation of regional water quality and detention into land planning. All development in the First Creek drainage basin must detain and treat water quality on-site or in regional ponds since runoff will flow into the Rocky Mountain Arsenal. The Arsenal has strict agreements for the quantity and quality of stormwater runoff into the federal property.

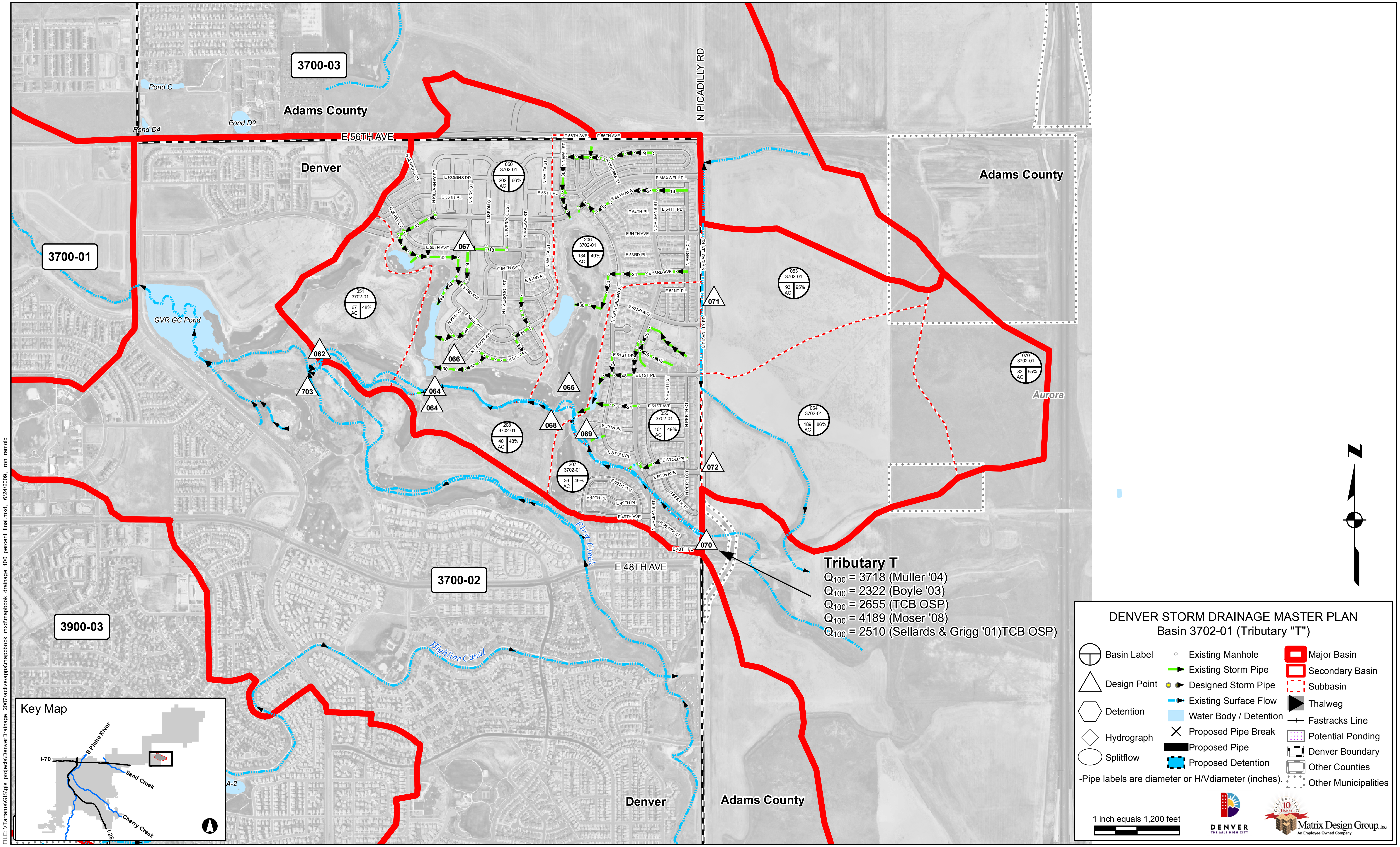
There are no further planned improvements for the basin, beyond the capital construction required for the Green Valley Ranch development.

Master Plan Agreements:
Many documents and agreements have been compiled for the First Creek Drainage Basin which specifies 100-year discharges and storage volumes. Therefore, nothing in this master plan shall take precedence over those agreements or specified discharges. This study was completed for the purposes of analyzing initial storm flows for the 2- and 5-year events.

Developed Conditions Hydrology:
The following table is provided for 2- and 5-year discharges. 100-year flows shown only for comparison purposes. Refer to agreements and Urban Drainage & Flood Control District master plans for specific discharges.

BASIN 3702-01

Design Point	Tributary Area	Peak Discharge		
		2-year	5-year	100-year
	(acres)	*(cfs)*	*(cfs)*	*(cfs)*
62	5967.9	695	1097	2973
64	5901	692	1108	2984
65	133.6	60	94	302
66	202.2	152	224	589
68	5658.6	673	1091	2914
69	101.2	59	94	301
70	5388.3	840	1257	3062
71	93.3	128	176	349
72	364.9	402	576	1178


DENVER STORM DRAINAGE MASTER PLAN
Basin 3702-01 (Tributary "T")
Tributary T
Q_{100} = 3718 (Muller '04)
Q_{100} = 2322 (Boyle '03)
Q_{100} = 2655 (TCB OSP)
Q_{100} = 4189 (Moser '08)
Q_{100} = 2510 (Sellards & Grigg '01)TCB OSP)
3700-03
3700-01
3700-02
3900-03
Adams County
Denver
Aurora
E 56TH AVE
E 48TH AVE
N PICADILLY RD
Pond C
Pond D2
Pond D4
GVR GC Pond
First Creek
Highline Canal
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
Key Map
S Platte River
Sand Creek
Cherry Creek
I-70
I-25
Matrix Design Group, Inc.
DENVER
FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activelapps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/24/2009, ron_ramold

Basin: 3900-01 (Irondale Gulch - Stapleton)

Existing Basin Description:
This basin is located within Section 10 of the former airport, Stapleton Redevelopment site (City & County of Denver) and partially within the Rocky Mountain Arsenal (Adams County). The basin is a tributary to Irondale Gulch, which is tributary to the South Platte River. The basin consists of about 140 acres and is currently undeveloped, except for former runways and storage of crushed concrete. The basin was similarly defined in the 1989 Denver Drainage Master Plan, but included more land within the Arsenal north of Irondale Gulch in Adams County. Topography within the basin is characterized by generally flat terrain. Discharge from this basin flows to the north (downstream) into the Rocky Mountain Arsenal.

Irondale Gulch does not have an improved channel to the South Platte River, and therefore runoff in the basin is controlled by detention and retention ponds. There are also limitations to discharges into the Arsenal. The redevelopment of Stapleton will include detention to control runoff.

Identified Drainage Problems/Deficiencies:
In general, there are currently no trunk storm pipes within this basin. Depressions between the runways have captured stormwater runoff and directed it via overland flow into Irondale Gulch.

Discharges from this basin into the Rocky Mountain Arsenal must be limited to historic conditions. The previous study for this basin was the 1995 ***Stapleton Area Outfall Systems Plan*** (OSP) by Urban Drainage & Flood Control District and McLaughlin Water Engineers, which set the discharge for existing and developed conditions as shown.

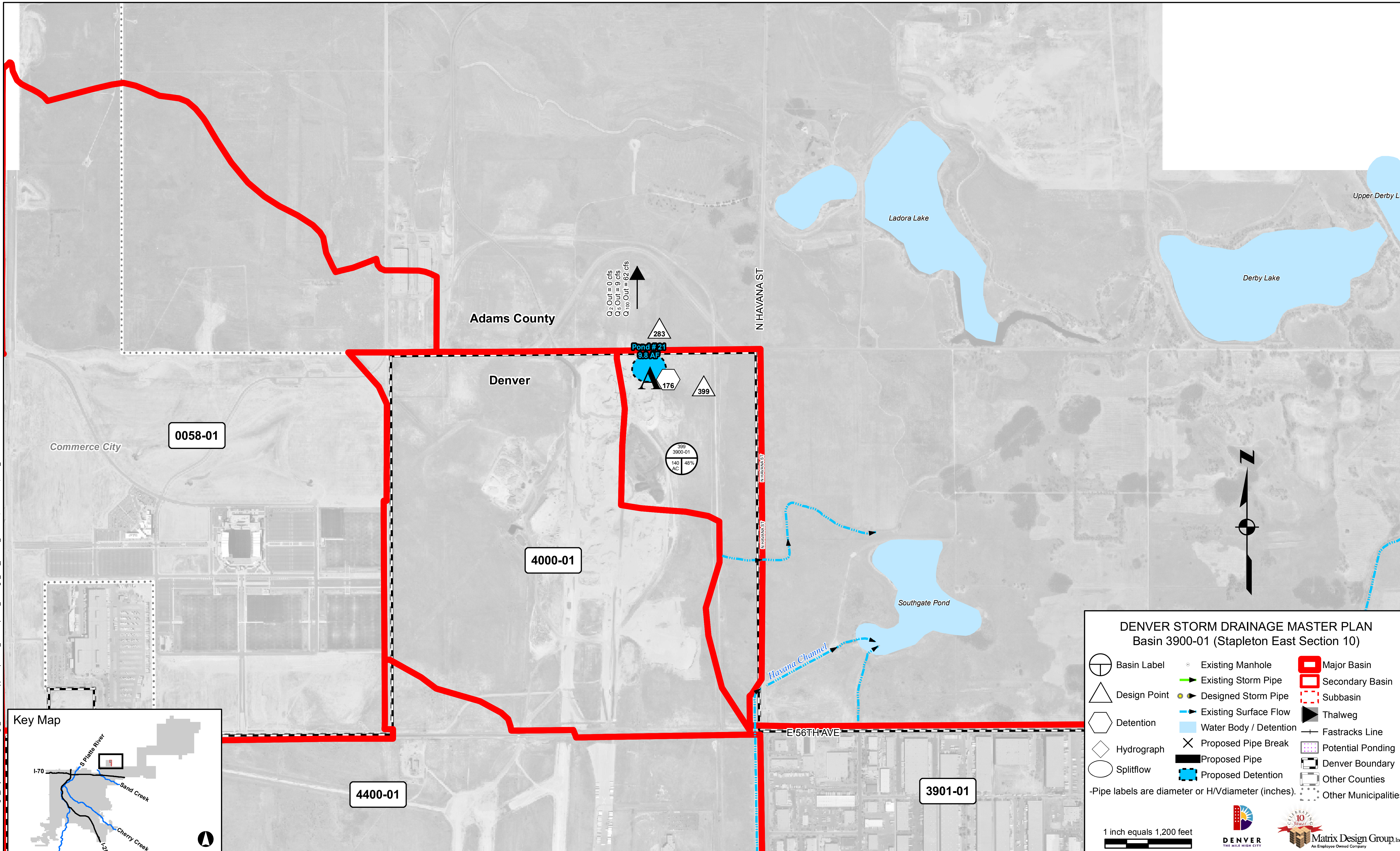
Potential Improvements:
The Stapleton Development Master Plan includes a detention pond, which will be constructed in this basin at the Denver border commensurate with development, to limit discharges to historic conditions. Proposed detention pond (Pond #176) is at the border of the Rocky Mountain Arsenal. This pond is estimated to be about 10 acre-feet and will release into the Arsenal at the defined historic rates.

Developed Conditions Hydrology:

Basin 3900-01

Allowable Discharges from Denver to the Rocky Mountain Arsenal	Design Point	Peak Discharge 2-Year (cfs)	5-Year (cfs)	10-Year (cfs)	50-Year (cfs)	100-Year (cfs)
OSP Existing Conditions	210*	3	5	7	50	94
OSP Developed Conditions	270*	9	9	11	29	62
Stapleton Master Plan	283**	16	22	25	53	65

**Reference: Urban Drainage & Flood Control District, "Stormwater Outfall Systems Plan - Stapleton Area," July 1995.*
***Reference: BRW, Inc. "Stapleton Infrastructure Master Plan - Section 5," March 2001.*


DENVER STORM DRAINAGE MASTER PLAN
Basin 3900-01 (Stapleton East Section 10)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.
Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
Adams County
Denver
Commerce City
0058-01
4000-01
4400-01
3901-01
N HAVANA ST
E 56TH AVE
Havana Channel
Ladora Lake
Derby Lake
Upper Derby Lake
Southgate Pond
Pond # 21
9.8 AF
283
176
399
A
399
3900-01
140 AC
48%
Q_2 Out = 0 cfs
Q_5 Out = 9 cfs
Q_{100} Out = 62 cfs

Basin 3900-02 (Irondale Gulch – East Montbello)

Existing Basin Description:
This basin is located fully within the Montbello neighborhood in the City and County of Denver. The boundaries of this basin are 56th Avenue to the north, Chambers Road to the east, the northern boundary of Basin 3901-01 to the south, and Peoria Street to the west. The basin consists of about 1,220 acres and is fully developed with residential neighborhoods. Low flows are conveyed in open channels and pipe systems, while higher flows are conveyed overland through the streets. Topography is characterized by generally flat terrain and there are no large, regional detention facilities internally within the basin. Discharge from the basin flows generally northerly through a series of concrete channels and pipes until crossing under 56th Avenue. A regional detention facility, known as the "Havana Pond" or "Southgate Pond" is located on the Rocky Mountain Arsenal property north of 56th Avenue. Beyond that pond, flows also enter Ladora Lake and Lake Mary on the Arsenal property. Very little flow is discharged to Irondale Gulch from Lake Mary, except in large events.

This basin currently has 7 storm pipes which cross north under 56th Avenue. East of Peoria Street is a storm pipe running along Revere Street discharging flows under 56th Avenue at design point 40. There are other minor storm pipes under 56th Avenue to each side of design point 40, but all flows from the contributing area within Basin 3900-02 were modeled to enter the RMA at design point 40. Further east of design point 40 is design point 51. Flow is collected in a storm pipe system and discharged to an open channel along Uvalda Street. Those flows are conveyed under 56th Avenue to the RMA. Other pipe systems discharge at design points 48 and 49 into a ditch on the north side of 56th Avenue. Basin 3900-04 flows into Basin 3900-02. Upstream runoff, attenuated in the Chambers I pond, flows into Basin 3900-02 at Chambers Rd and 48th Ave.

Identified Drainage Problems/Deficiencies:
This drainage basin is essentially fully developed with single-family residential properties. By Denver criteria, the initial storm is a 2-year event for residential areas. The "Irondale Gulch Stormwater Outfall Systems Plan and Preliminary Design Report," dated May 1990 by Wright Water Engineers states, "The Montbello area currently suffers from a lack of adequate capacity for major floods. The existing channels have the capacity of around the 5- to 10-year flood."

The concrete trapezoidal channels and storm pipe systems that are currently in place apparently had a design goal to convey the 10-year flow. However, due to changes that occurred during construction, some systems are oversized, while others are undersized. Specifically, the concrete trapezoidal channel in 53rd Avenue was likely planned to extend further east past Chambers. However, as-built conditions direct all stormwater east of Chambers easterly into Parkfield Lake.

Potential Improvements:
The 1990 study was completed to upgrade all facilities within the Montbello Area to 100-year capacity. The greatest constraint was the undersized road crossings over the open channels. By reconstructing these crossings, major conveyance facilities would be able to convey larger storm events. In areas where additional capacity is required, the 1990 study proposed replacing the sloping walls with vertical concrete walls to establish a rectangular concrete channel within the right-of-way of the existing channel. However, the recommended improvements have not been constructed. A recommendation was also made in the 1990 study to change the bottoms of the existing concrete channels to wetlands for water quality benefits. However, these changes have not been implemented.

There has been greater emphasis on detention to reduce flows to the capacity of existing systems. As upstream development has occurred, detention has been required to keep the flood peaks from increasing above existing levels.

Project A: E 53rd Ave Improvements and Project B: E Maxwell Pl Improvements:
The 1990 Urban Drainage & Flood Control District study focused on major drainageway conveyance. Improvements needed beyond those evaluated in the previous study are additional storm drain laterals. These laterals are suggested to reduce flows in streets during minor events and reduce ponding and cross street flow.

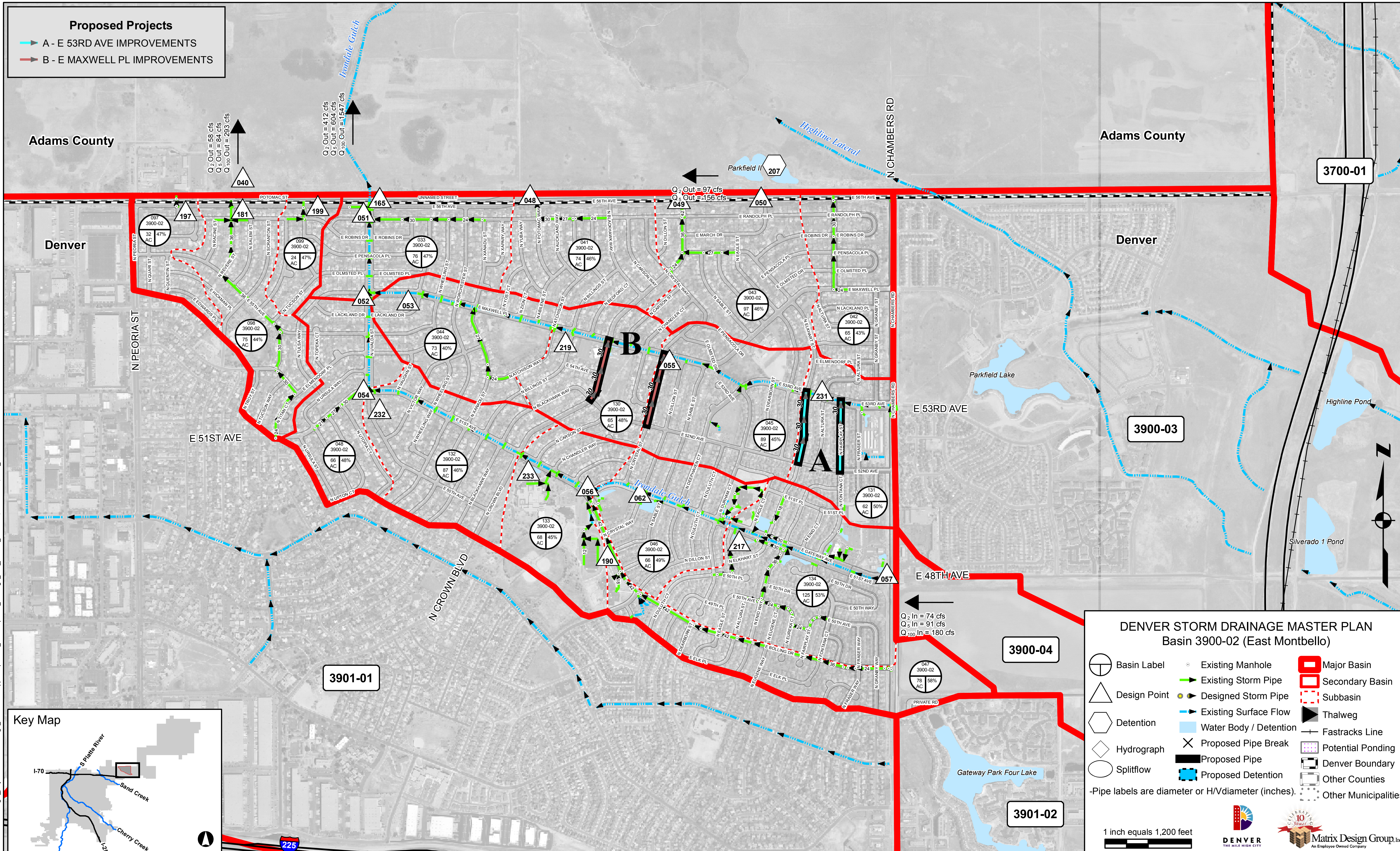
Master Plan Agreements:
Many documents and agreements have been compiled for the Irondale Gulch Drainage Basin which specifies 100-year discharges and storage volumes. Therefore, nothing in this master plan shall take precedence over those agreements or specified discharges. This study was completed for the purposes of analyzing initial storm flows for the 2- and 5-year events.

Existing Hydrology:

BASIN: 3900-02

Design Point	Contributing Basins	Tributary Area (Ac.)	2-Year (cfs) (1)	5-Year (cfs) (1)	100-Year (cfs)(2)
40	D181, D197, D199	131	**58**	84	293
48	D49, B41	2,133	**94**	155	285
49	D50, B43	2,059	**95**	156	275
50	D552, B42	1,963	**97**	156	141
51	D52, D165, B33	4,063	**412**	604	1547
52	D53, D54	1,854	**345**	514	1232
53	D219, B44	289	**116**	173	500
54	D232, B48	1,565	**229**	341	738
55	D231, B45	151	**71**	104	306
56	D62, D190	1,345	**150**	217	440
57	D515	1,076	**74**	91	180
62	D217, B46	1,267	**119**	172	181
165	D48	2,133	**93**	155	269
181	B98	75	**30**	44	
190	B47	78	**36**	52	
197	B97	32	**15**	22	
199	B99	24	**14**	20	
217	D57, B134	1,201	**92**	133	
219	D55, B130	216	**98**	145	
231	B131	62	**34**	48	
232	D233, B132	1,499	**207**	303	
233	D56, B133	1,412	**176**	255	

Numbers in bold are used for CIP sizing for residential land use.
D = Design Point, B = sub Basin
(1) Q2 and 5 results are based on a restudy of the basin for this Master Plan.
(2) Q100 results are based on 2003 model, approved by UDFCD.


Proposed Projects
A - E 53RD AVE IMPROVEMENTS
B - E MAXWELL PL IMPROVEMENTS
Adams County
Denver
Irondale Gulch
Highline Lateral
N CHAMBERS RD
N PEORIA ST
E 51ST AVE
E 53RD AVE
E 48TH AVE
N CROWN BLVD
Parkfield Lake
Highline Pond
Silverado 1 Pond
Gateway Park Four Lake
3700-01
3900-03
3900-04
3901-01
3901-02
Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
DENVER STORM DRAINAGE MASTER PLAN
Basin 3900-02 (East Montbello)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER THE MILE HIGH CITY
Matrix Design Group, Inc.
An Employee Owned Company

Basin 3900-03 (Irondale Gulch - Parkfield)

Existing Basin Description:
This basin contains the **Tower Outfall Lateral** and the **Highline Lateral** and is located through three neighborhoods in the City and County of Denver: **Parkfield**, **Denver Connection**, and **Green Valley Ranch**. The boundaries of this basin are 56th Avenue and the southern boundary of the First Creek basin to the north, the middle of the Green Valley Ranch neighborhood to the east, the northern boundary of Basin 3900-04 and 38th Avenue to the south, and Chambers Road to the west. The basin consists of about 1,898 acres and is partially developed with residential neighborhoods, with plans for commercial and residential developments in the near future. Low flows are conveyed through storm pipes and open channels to regional detention facilities including Parkfield Lake, Parkfield II Lake, Highline Pond, Silverado I Pond and two Green Valley Ranch detention facilities. High flows are conveyed through some of the storm pipe system and overland through the streets to the detention areas. Topography is characterized by generally flat terrain with runoff discharge flowing generally to the northwest toward Parkfield II Lake in the northwest corner of 56th & Chambers.

Identified Drainage Problems/Deficiencies:
The information provided for use in the current models indicates that the Highline pond exceeds the allowable surface acreage according to an internal memo between Denver, Aurora, and Denver International Airport (DIA) which sets the maximum pond acreage to 7.6 acres. After discussions with members of the Urban Drainage and Flood Control District, in preparation of the 2005 Storm Master Drainage Plan, it is understood that the pond was constructed to meet the original requirements of 7.6 acres. As-constructed information has not yet been provided to update the model and determine if the discharge also meets requirements.

The channel downstream of the Highline Pond, to the west of Peña Boulevard, will need to be monitored to determine how the channel is being impacted by erosion from pond discharges.

Potential Improvements:
All improvements proposed in the 2005 Master Plan have been built out. There’s no more potential capital improvement was proposed for this basin within the City of Denver reach.

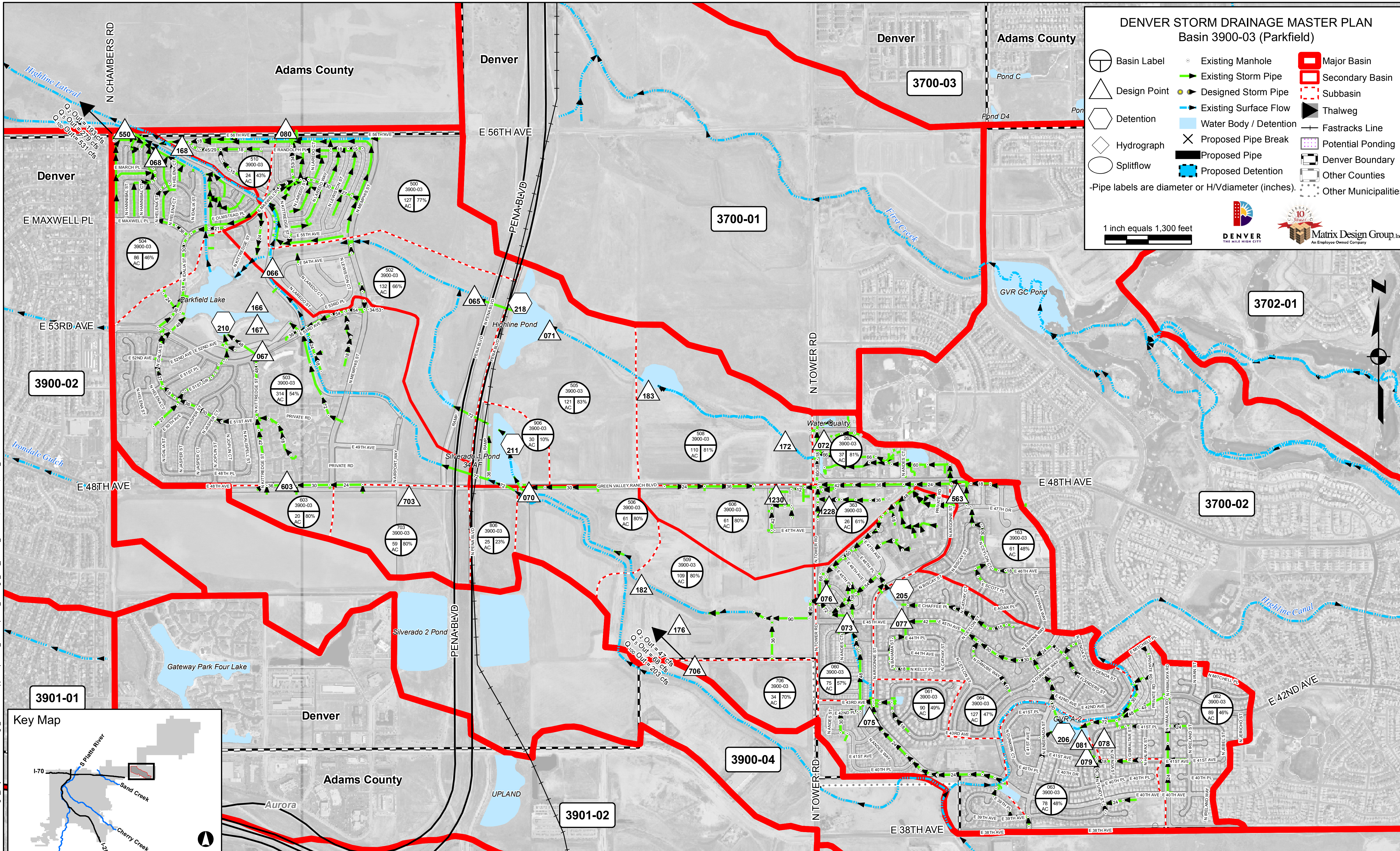
Developed Conditions Hydrology:

BASIN 3900-03

Design Point	Contributing Basins	Tributary Area (Ac.)	2-Year (cfs) (1)	5-Year (cfs) (1)	100-Year (cfs)(2)
65	D70, D71	1,135	271	378	715
66	D65, B502	1,267	288	410	866
67	D603, D703, B503	394	322	463	873
68	D167, D168, B504	1,898	169	245	531
70	D182, B506, B806, B906	718	179	275	776
71	D183, B505	417	276	419	1075
72	D1228, B263	125	88	129	432
73	D75, D77, B60	384	68	99	452
75	B61	90	47	71	
76	D73	459	115	168	447
77	B62, B64	294	60	92	276
78	B62	89	37	58	
79	B63	78	40	58	
80	B500	127	144	203	187
81	D78, D79	167	78	116	
166	D66	1,267	280	402	851
167	D67, D166	1,661	356	514	1296
168	D180, B510	151	135	193	296
172	D72, D1230	186	166	235	686
176	D76, D706	493	89	135	471
182	D176, B509	602	184	271	
183	D172, B508	296	206	302	
550	D68	1,963	193	279	531
563	B163	61	32	48	176
603	B603	20	49	70	247
703	B703	59	141	201	168
706	B706	34	47	68	203
1228	B363	26	20	30	
1230	B606	61	88	124	

D = Design Point, B = sub Basin

(1) Q2 and 5 results are based on a restudy of the basin for this Master Plan.
(2) Q100 results are based on 2003 model, approved by UDFCD.


DENVER STORM DRAINAGE MASTER PLAN
Basin 3900-03 (Parkfield)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,300 feet
DENVER
Matrix Design Group, Inc.
Adams County
Denver
3700-03
3700-01
3702-01
3700-02
3900-02
3900-04
3901-01
3901-02
E 56TH AVE
E 48TH AVE
E 38TH AVE
E 42ND AVE
E 53RD AVE
E MAXWELL PL
N CHAMBERS RD
N TOWER RD
PENA BLVD
Highline Lateral
Highline Canal
First Creek
Irondale Gulch
Parkfield Lake
Highline Pond
Silverado 1 Pond
34 AF
Silverado 2 Pond
Gateway Park Four Lake
GVR GC Pond
Water Quality
Pond C
Pond D4
UPLAND
Aurora
Key Map
S Platte River
Sand Creek
Cherry Creek
I-70
I-25

Basin 3900-04 (Irondale Gulch – Majestic Commercenter)

Existing Basin Description:
This basin contains the **Bolling Drive Tributary** and is located in the City and County of Denver and the City of Aurora. The boundaries of this basin are the southern boundary of Basin 3900-03 to the north, Picadilly Road to the east, the northern boundary of Basin 3901-02 and Union Pacific Realty Company to the south and Chambers Road to the west. The basin consists of about 1,157 acres and is mostly undeveloped with plans for residential, commercial and industrial developments in the near future. The future subdivisions along the Bolling Drive Tributary include Denver Connection, Gateway Park and Majestic Commercenter. This tributary also passes through the Peña Boulevard right-of-way. Low flows are currently conveyed through open channels to regional detention facilities including Chambers I Pond, Silverado II Pond, and the two Majestic Commercenter ponds. High flows are conveyed through the same open channels to the detention areas. Topography is characterized by generally flat terrain with flows discharging generally to the northwest toward the Chambers I pond.

Runoff from the City of Aurora flows into the City and County of Denver near design point 352. A Gateway Park residential development will be constructed upstream of this design point within the City of Aurora. Runoff from the Majestic Commercenter will flow through the Gateway Park development.

Identified Drainage Problems/Deficiencies:
The Majestic Commercenter development hydrologic model has been adopted for this study without revision. In 2003, Boyle Engineering created an updated model for UDFCD based on information provided by the City of Aurora. That model information was adopted unchanged at the direction of Aurora, although the base topographic mapping was poor. The information was transcribed into Denver's GIS without edits. It was noted that during the current model update, certain basin areas and model routing from the original information provided by the City of Aurora could be remodeled to more accurately match the proposed conditions. It is recommended that the Majestic Commercenter area be reviewed again to more accurately represent the flows entering the City and County of Denver.

Potential Improvements:
Storm drain improvements will be constructed commensurate with development to meet current drainage criteria of 100-year systems.

Project B: E Bolling Dr Improvements
An open channel will be needed during development of the area to direct flows from the Silverado II Ponds to the existing Chambers I Detention Pond. This channel should be designed for the 100-year event.

Project C: Himalaya Rd Outfall
An open channel will be needed during development of the area to convey flows from Aurora's Majestic Commercenter to the Silverado II Detention Ponds and into Denver. This channel should be stabilized and designed for the 100-year event.

Master Plan Agreements:
Many documents and agreements have been compiled for the Irondale Gulch Drainage Basin which specifies 100-year discharges and storage volumes. Therefore, nothing in this master plan shall take precedence over those agreements or specified discharges. This study was completed for the purposes of analyzing initial storm flows for the 2- and 5-year events.

Agreement 93-04.05, dated April 16, 1995 specifies cost sharing agreements, land use, and the 100-year discharges and storage volumes for Irondale Gulch. In Basin 3900-04, the Majestic Commercenter Ponds (Aurora Business Center Ponds), and Silverado II Ponds are regulated by this agreement as follows:

Master Plan Design Parameters				
ID No.	**Peak Inflow (cfs)**	**Peak Outflow (cfs)**	**Detention Volume (AF)**	**Jurisdiction**
Aurora Business Center	N/A	393	17	Aurora
Silverado II	863	244	65	Denver

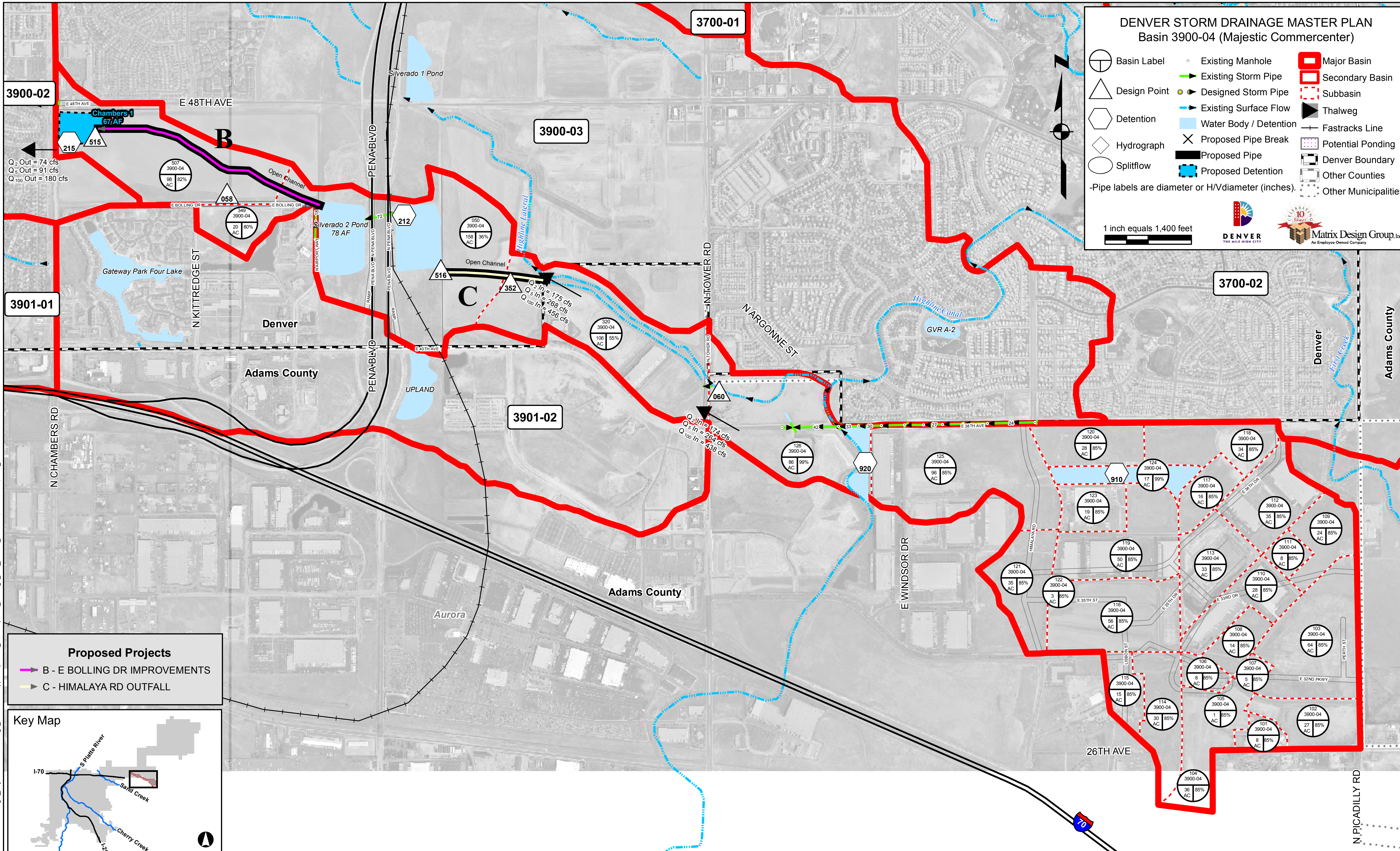
Developed Conditions Hydrology:

BASIN HYDROLOGY: 3900-04

Design Point	Contributing Basins	Tributary Area (Ac.)	2-Year (cfs) (1)	5-Year (cfs) (1)	100-Year (cfs)(2)
58	D516, D358	977	116	164	255
60	B101, B102, B103, B104, B105, B106, B107, B108, B109, B110, B111, B112, B113, B114, B115, B116, B117, B118, B119, B120, B121, B122, B123, B124, B125, B126	694	174	264	438
352	D60, B320	800	175	268	456
515	D58, B507	1,076	135	194	296
516	D352, B50	957	173	274	462

D = Design Point, B = sub Basin

(1) Q2 and 5 results are based on a restudy of the basin for this Master Plan.
(2) Q100 results are based on 2003 model, approved by UDFCD.


DENVER STORM DRAINAGE MASTER PLAN
Basin 3900-04 (Majestic Commercenter)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,400 feet
DENVER
Matrix Design Group, Inc.
Proposed Projects
B - E BOLLING DR IMPROVEMENTS
C - HIMALAYA RD OUTFALL
Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
3900-02
3900-03
3901-01
3901-02
3700-01
3700-02
E 48TH AVE
Chambers 1
67 AF
Q₂ Out = 74 cfs
Q₅ Out = 91 cfs
Q₁₀₀ Out = 180 cfs
Open Channel
Silverado 1 Pond
Silverado 2 Pond
78 AF
Gateway Park Four Lake
N KITTREDGE ST
Denver
Adams County
PENA BLVD
UPLAND
Highline Lateral
Q₂ In = 175 cfs
Q₅ In = 268 cfs
Q₁₀₀ In = 456 cfs
N TOWER RD
N ARGONNE ST
Q₂ In = 174 cfs
Q₅ In = 264 cfs
Q₁₀₀ In = 438 cfs
Highline Canal
GVR A-2
First Creek
N CHAMBERS RD
E WINDSOR DR
Aurora
26TH AVE
N PICADILLY RD
70

Basin 3901-01 (Irondale Gulch – West Montbello)

Existing Basin Description:
This basin is located mostly within the City and County of Denver. The boundaries of this basin are 56th Avenue and the southern boundary of Basin 3900-02 to the north, Havana Street to the west, I-70 to the south and Chambers Road to the East. The basin consists of about 2,096 acres and is mostly developed with industrial warehouses in the western portion of the basin and residential neighborhoods in the eastern portion of the basin. Low flows are conveyed within a pipe and channel system, while higher flows are conveyed overland through channels and streets. Topography is characterized by generally flat terrain, and there are no regional detention facilities within the basin. Discharge from the basin flows generally to the east and north.

This basin discharges to the Rocky Mountain Arsenal (RMA) at two points along 56th Avenue. Beginning at the western end near N. Havana Street, runoff from Basin 3901-01 is collected in an open channel along the west side of N. Havana Street, crosses 56th Avenue and flows under N. Havana Street to the Havana Detention Pond. The design point for this flow to the RMA is 74. Just to the east of design point 74 is design point 11 where flows from Basin 3901-01 are collected in a storm pipe system and are conveyed under 56th Avenue, and discharged into an open channel to the Southgate Pond (also known as the Havana Detention Pond).

Identified Drainage Problems/Deficiencies:
This drainage basin is essentially fully developed with single-family residential properties and commercial/industrial properties. By Denver criteria, the initial storm is a 2-year event for residential areas, and 5-year for commercial/industrial. The "Irondale Gulch Stormwater Outfall Systems Plan and Preliminary Design Report," dated May 1990 by Wright Water Engineers states, "The Montbello area currently suffers from a lack of adequate capacity for major floods. The existing channels have the capacity of around the 5- to 10-year flood." In general, the concrete trapezoidal channels can convey flows except for a few areas.

Potential Improvements:
The 1990 study was completed to upgrade all facilities within the Montbello Area to 100-year capacity. The greatest constraint was the undersized road crossings over the open channels. By reconstructing these crossings, major conveyance facilities would be able to convey larger storm events.

Project A: 18 Inch Upgrades
Pipes smaller than 18" are allowed only if they are less than 75 feet and only convey flows from one inlet. These upgrades meet current criteria and provide improved maintenance.

Project B: E 45th Ave Improvements
This is an example where the open channel and road crossings cannot convey the developed 5-year flows. The channel can be replaced with a 2-102"x48" RCBC from the Havana crossing to Ironton then a 120"x 60" RCBC is proposed to continue upstream and terminate at approximate 800 feet upstream of Design Point 2. For further upstream, the 84", 78" and 72" RCP were proposed to upgrade the existing pipe to convey the 5-year discharge while 80% full.

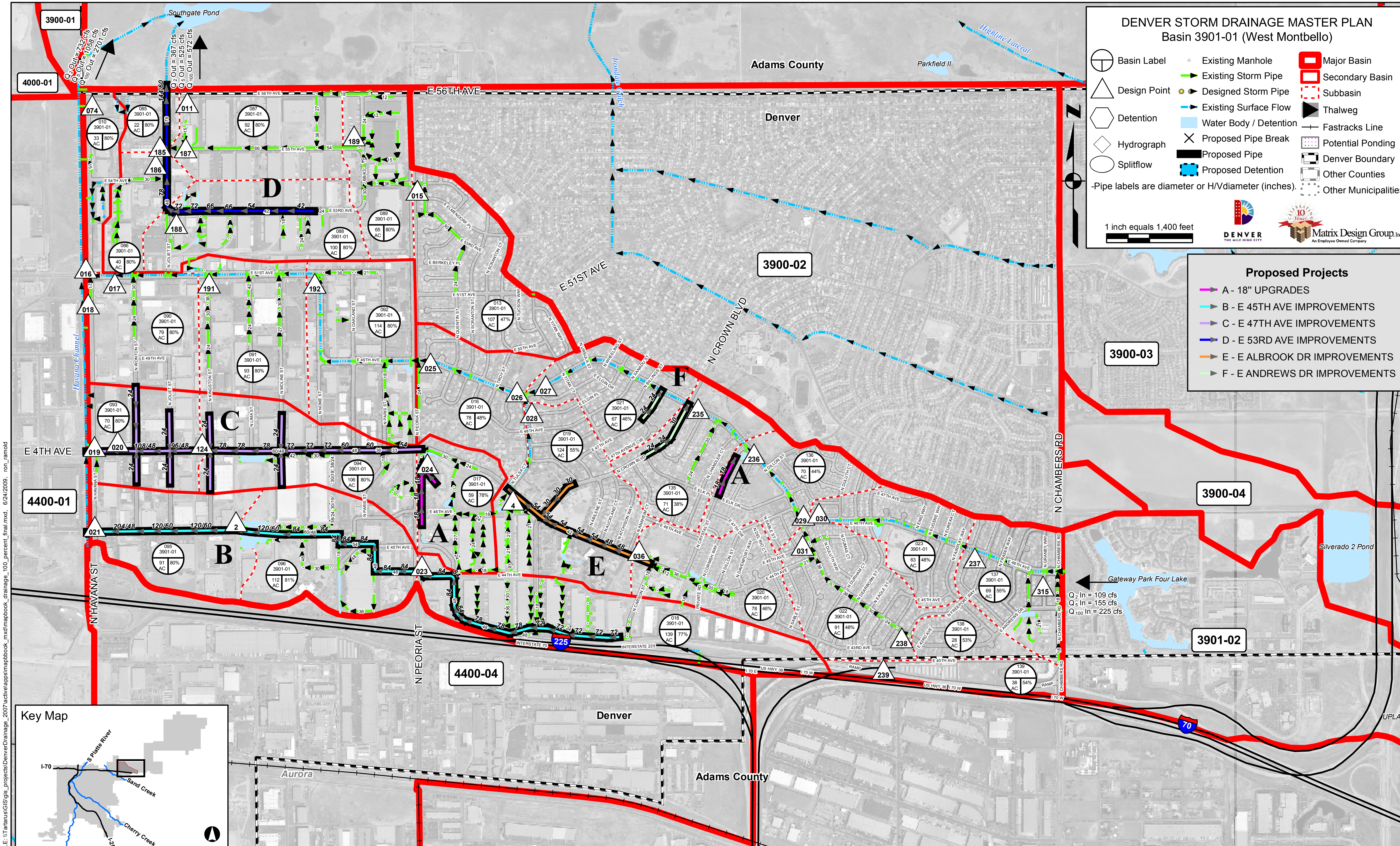
Project C: E 47th Ave Improvements
The channel and road crossings cannot convey the developed 5-year flows. The existing box culvert is also not adequate to convey 5-year flows. The channel can be replaced with a 108"x48" RCBC in 47th Avenue from Havana to Joliet, and a 96"x48" RCBC from Joliet to Kingston. Upstream of the intersection of 47th Avenue and Kingston Street to Design Point 24, the existing 60"x48" RCBC and 48" RCP are also not capable of conveying the 5-year discharge. New 78", 72", 60" and 54" RCP are proposed to upgrade the existing system. Additional laterals should be constructed to reduce street flow.

Project D: E. 53rd Ave Improvements
The existing 78" pipe is not adequate to convey 5-year flows and must be replaced with a 108" equivalent. The UDFCD outfall system plan assumed some of this flow would be conveyed to the Havana Lateral, but actually discharges to the RMA, therefore, this study found higher flows to this outfall.
Project E: E. Albrook Dr Improvements
Existing storm pipe must be upsized to convey runoff to the concrete trapezoidal channels.
Project F: E. Andrews Dr Improvements
Additional storm laterals should be constructed to reduce runoff in the street during minor storm events.
Existing Hydrology:

BASIN HYDROLOGY: 3901-01

Design Point	Contributing Basins	Tributary Area (Ac.)	2-Year (cfs) (1)	5-Year (cfs) (1)	100-Year (cfs)(2)
2	D23, B96	251	348	505	
4	D36	79	37	54	
11	D185, B85	424	367	525	572
15	B13	107	46	67	182
16	D17, D18	2,276	877	1222	2532
17	D191, B90	1,700	398	539	1294
18	D19	576	498	746	1362
19	D20, D21	576	689	1006	1520
20	D124, B93	235	255	372	713
21	D2, B95	342	442	630	807
23	B18	139	238	339	194
24	B17	59	81	115	138
25	D26, B16	1,414	323	476	1145
26	D27, D28	1,336	301	450	1150
27	D235, B21	1,134	209	310	746
28	D4, B19	202	103	152	417
29	D30, D31	927	146	214	502
30	D237, B23	769	67	96	277
31	D238, B22	158	81	118	261
36	B20	79	41	60	289
74	D16, B10, B29(100-yr)	2,310	732	1058	2701
124	D24, B94	165	192	274	
185	D186, D187	403	378	540	
186	D188, B86	139	163	234	
187	D189, B87	264	215	306	
188	B88	100	142	203	
189	D15, B89	171	117	169	
191	D192, B91	1,622	388	514	
192	D25, B92	1,528	379	476	
235	D236, B135	1,067	195	284	
236	D29, B136	997	173	250	
237	D315, B137	707	44	67	
238	D239, B138	66	38	54	
239	B139	39	22	31	
315	D435	638	29	57	220

D = Design Point, B = Sub Basin
(1) Q2 and 5 results are based on a restudy of the basin for this Master Plan.
(2) Q100 results are based on 2003 model, approved by UDFCD.


DENVER STORM DRAINAGE MASTER PLAN
Basin 3901-01 (West Montbello)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
-Pipe labels are diameter or H/Vdiameter (inches).
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
1 inch equals 1,400 feet
DENVER
Matrix Design Group, Inc.
Proposed Projects
A - 18" UPGRADES
B - E 45TH AVE IMPROVEMENTS
C - E 47TH AVE IMPROVEMENTS
D - E 53RD AVE IMPROVEMENTS
E - E ALBROOK DR IMPROVEMENTS
F - E ANDREWS DR IMPROVEMENTS
Adams County
Denver
3900-01
4000-01
3900-02
3900-03
3900-04
3901-02
4400-01
4400-04
Southgate Pond
Parkfield II
Highline Lateral
Havana Channel
Silverado 2 Pond
Gateway Park Four Lake
E 56TH AVE
E 51ST AVE
E 4TH AVE
N CROWN BLVD
N CHAMBERS RD
N HAVANA ST
N PEORIA ST
Aurora
UPLAND
Key Map
I-70
S Platte River
Sand Creek
Cherry Creek
I-25
FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activeapps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/24/2009, ron_arnold

Basin 3901-02 (Irondale Gulch – Gateway)

Existing Basin Description:
This basin contains the Montbello Tributary and is located in the City and County of Denver and Aurora. The boundaries of this basin are the southern boundary of Basin 3900-04 to the north, Tower Road to the east, Chambers Road to the west, and I-70 to the south. The basin consists of about 621 acres and is partially developed with the Gateway Park development and Union Pacific Realty. This tributary also passes through the Peña Boulevard right-of-way. Low flows are currently conveyed through storm pipes and open channels to regional detention facilities including the three Chambers II ponds, and the three Upland ponds. High flows are conveyed through open channels and through the streets to the detention areas. Topography is characterized by generally flat terrain with flows discharging generally to the west and northwest toward the three Chambers II ponds.

Drainage from the City of Aurora crosses a boundary into the City and County of Denver within this drainage basin at design points 437 and 431.

Identified Drainage Problems/Deficiencies:
This is a newly developed basin and drainage infrastructure has been designed for the 100-year event. Therefore, no 2- and 5-year drainage deficiencies have been identified.

Potential Improvements:
Necessary drainage capital improvements will be constructed by the developer to meet current drainage criteria.

Agreement 93-04.05, dated April 16, 1995 specifies cost sharing agreements, land use, and the 100-year discharges and storage volumes for Irondale Gulch. In Basin 3901-02, the Upland Detention Ponds, and Chambers II Pond are regulated by this agreement as follows:

Master Plan Design Parameters				
ID No.	**Peak Inflow (cfs)**	**Peak Outflow (cfs)**	**Detention Volume (AF)**	**Jurisdiction**
Upland Detention Pond	948	56	42	Aurora UP Realty
Chambers II	663	219	32	Denver UP Realty

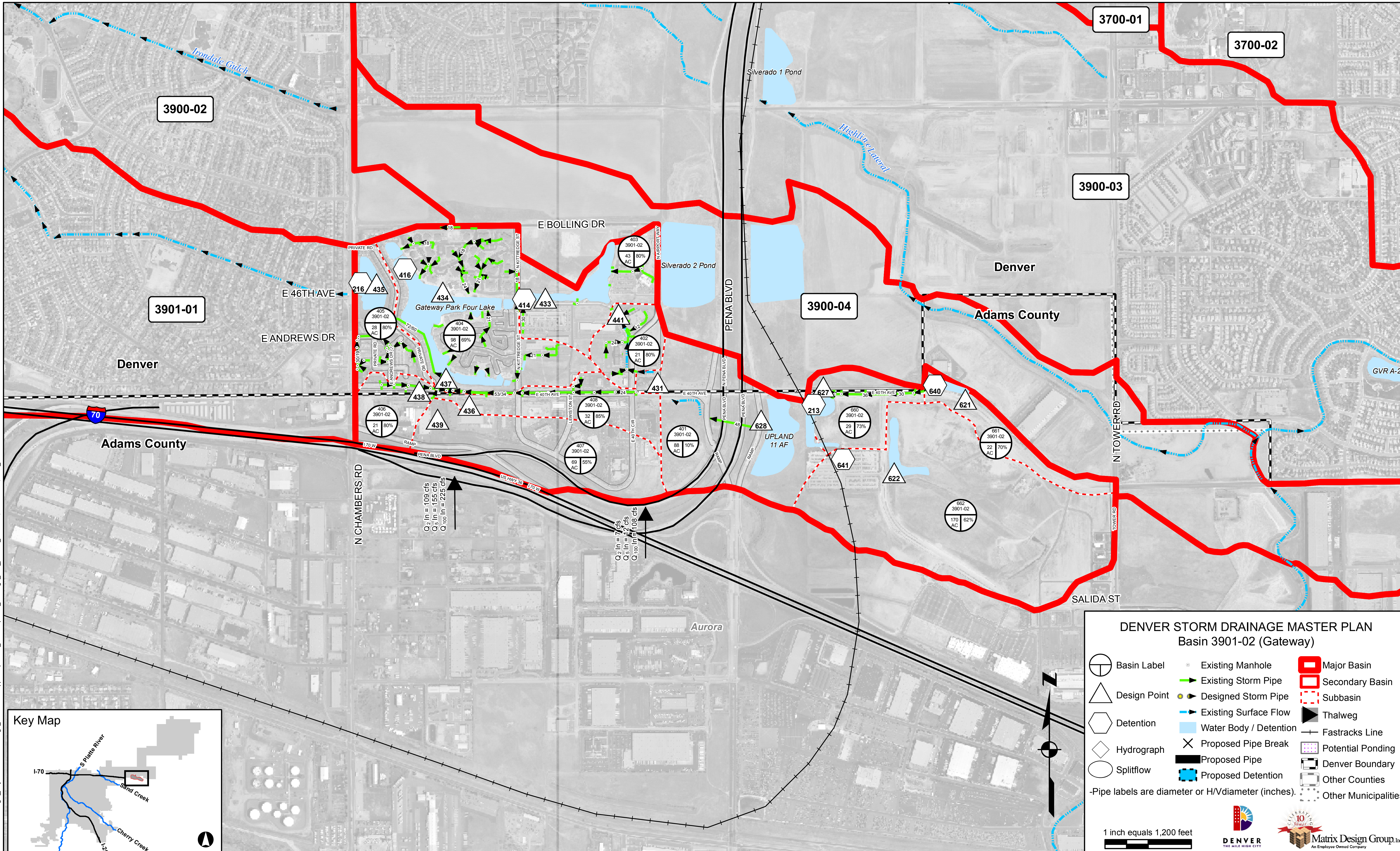
Developed Conditions Hydrology:

BASIN HYDROLOGY: 3901-02

Design Point	Contributing Basins	Tributary Area (Ac.)	2-Year (cfs) (1)	5-Year (cfs) (1)	100-Year (cfs)(2)
431	D628, B401	326	7	12	108
433	D441, B403	390	88	125	291
434	D433, B404	488	110	158	440
435	D434, D437, B405	638	139	200	310
436	B408	32	48	68	174
437	D436, D438, D439	122	109	155	225
438	B406	21	28	40	63
439	B407	69	41	59	119
441	D431, B402	346	28	40	117
621	B661	22	24	35	143
622	B662	170	159	228	605
627	D621, D622, B660	238	73	105	517
628	D627	238	7	12	92

D = Design Point, B = sub Basin

(1) Q2 and 5 results are based on a restudy of the basin for this Master Plan.
(2) Q100 results are based on 2003 model, approved by UDFCD.



DENVER STORM DRAINAGE MASTER PLAN
Basin 3901-02 (Gateway)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
3700-01
3700-02
3900-02
3900-03
3900-04
3901-01
Denver
Adams County
Aurora
Irondale Gulch
Highline Lateral
Silverado 1 Pond
Silverado 2 Pond
Gateway Park Four Lake
UPLAND
11 AF
GVR A-2
E BOLLING DR
E 46TH AVE
E ANDREWS DR
N CHAMBERS RD
PENA BLVD
N TOWER RD
SALIDA ST
Q_2 In = 109 cfs
Q_5 In = 155 cfs
Q_{100} In = 225 cfs
Q_2 In = 7 cfs
Q_5 In = 17 cfs
Q_{100} In = 108 cfs

Basin: 4000-01 (Stapleton West Section 10)

Existing Basin Description:
This basin known as ***Section 10*** on the Stapleton site is a tributary to the South Platte River, and is located entirely in the City & County of Denver. The basin consists of about 498 acres and is currently undeveloped, except for former runways and storage of crushed concrete. Topography within the basin is characterized by generally flat terrain. The surrounding area to the north (downstream) of the site is the Rocky Mountain Arsenal.

The basin was loosely defined in the 1989 Denver Drainage Master Plan and included a portion of north Stapleton (south of 56th), as well as Adams County (west of Section 10). Basin 4400-01 includes all area south of 56th Avenue in accordance with the approved Drainage Master Plan for the Stapleton Redevelopment site, dated March 2001. Therefore, the remainder of this basin lies north of 56th Avenue and south of 64th Avenue.

Identified Drainage Problems/Deficiencies:
In general, there are currently no trunk storm pipes within this basin. Depressions between the runways captured stormwater runoff.

Discharges from this basin into the Rocky Mountain Arsenal must be limited to historic conditions. The previous study for this basin was the 1995 ***Stapleton Area Outfall Systems Plan*** (OSP) by Urban Drainage & Flood Control District and McLaughlin Water Engineers, which set the following discharge for existing and developed conditions:

Basin 4000-01

Allowable Discharges from Denver to the Rocky Mountain Arsenal	Design Point	Peak Discharge 2-Year (cfs)	5-Year (cfs)	10-Year (cfs)	50-Year (cfs)	100-Year (cfs)
OSP Existing Conditions	10*	8	11	12	24	29
OSP Developed Conditions	272*	72	72	72	76	82
Stapleton Master Plan	282**	8	10	10	11	11

**Reference: Urban Drainage & Flood Control District, "Stormwater Outfall Systems Plan - Stapleton Area," July 1995.*
***Reference: BRW, Inc. "Stapleton Infrastructure Master Plan - Section 5," March 2001.*

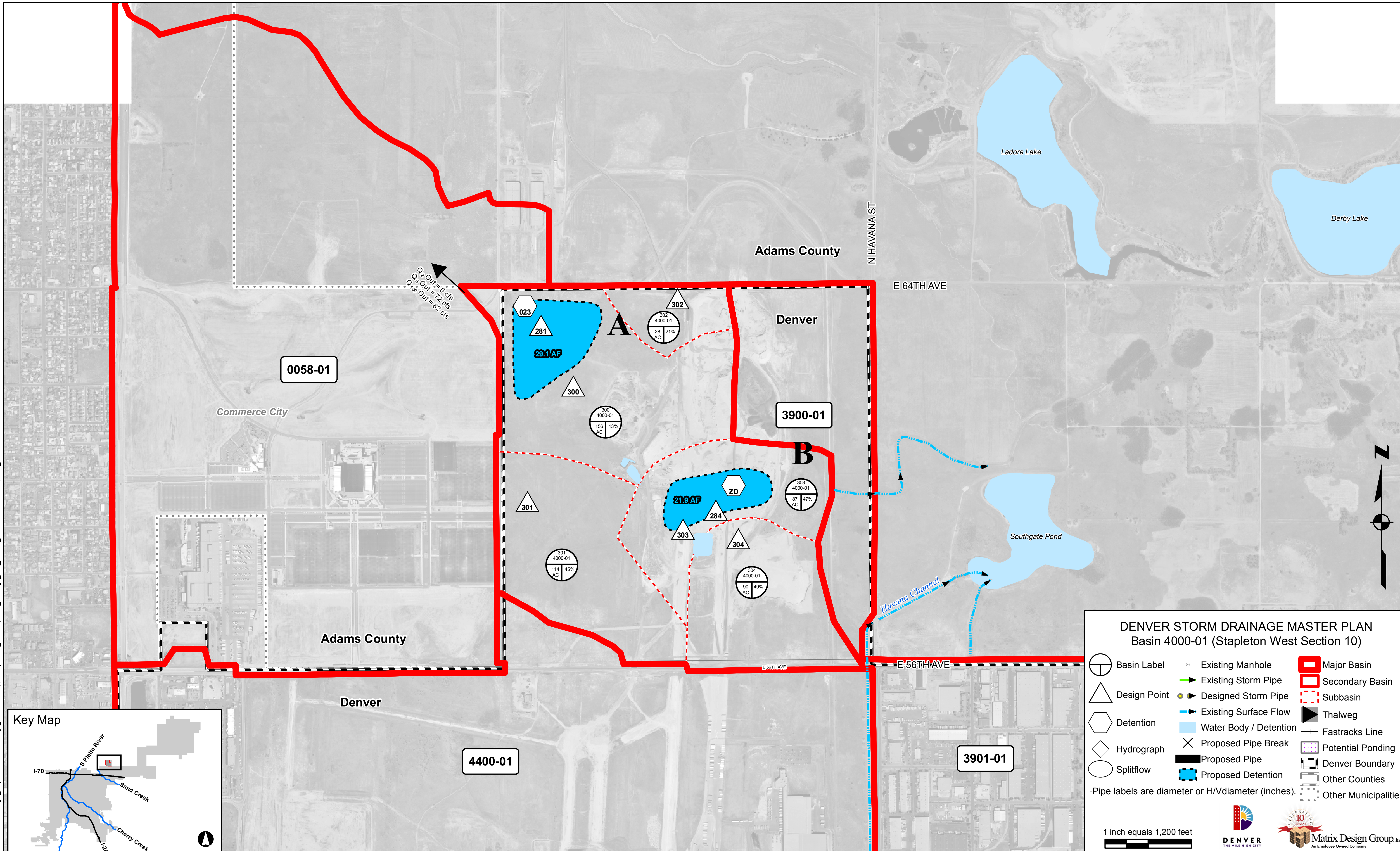
Potential Improvements:
100-year retention facilities will be constructed commensurate with development for this basin. Establishing new outfalls through the Rocky Mountain Arsenal would violate previous agreements.

The proposed land plan calls for more development than previously included in the “Green Book” and OSP. Accordingly, a zero discharge lake (Pond ZD) is proposed to fully store runoff from the 100-year, 24-hour storm. This retention pond will receive runoff from 187.5 acres and must store approximately 22 acre-feet of runoff in a 100-year event.

A second retention pond (Pond #23) is proposed in the northwest corner of Section 10 to control releases into the Rocky Mountain Arsenal. This pond is estimated to be about 29 acre-feet and will release at the defined historic rates.

Developed Conditions Hydrology:

Design Point	Contributing Basins	Tributary Area (acres)	Peak Discharge 2-Year (cfs)	5-Year (cfs)	100-Year (cfs)
303	303	87.2	10	23	192
304	304	100.3	61	92	287
284	303, 304	187.5	71	115	479
300	300	148.2	33	63	272
301	301	133.6	43	71	265
302	302	28.5	14	22	69
281	300, 301, 302	310.3	74	129	550
282	300, 301, 302, 303, 304	497.8	8	10	11



Q2 Out = 0 cfs
Q5 Out = 72 cfs
Q100 Out = 82 cfs
Adams County
N HAVANA ST
E 64TH AVE
Denver
0058-01
3900-01
Commerce City
A
B
023
281
29.1 AF
300
302
301
303
304
284
ZD
21.9 AF
Ladora Lake
Derby Lake
Southgate Pond
Havana Channel
E 56TH AVE
Adams County
Denver
4400-01
3901-01
Key Map
I-70
S Platte River
Sand Creek
Cherry Creek
I-25
DENVER STORM DRAINAGE MASTER PLAN
Basin 4000-01 (Stapleton West Section 10)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.

Basin: 4300-03 (Clear Creek – North of I-70)

Existing System Description:
This basin drains to Clear Creek and is generally bound by Regis Boulevard on the south, Clear Creek on the north and west, and Alcott Street on the east. A 60" RCP drains into the basin from the south from basin 4309-01 (Berkeley Lake) and continues through Willis Case Golf Course and then along Sheridan Boulevard to Clear Creek. The southern half of the basin is located within the City of Denver and drains to an existing 36-inch system in 52nd Avenue The northern half is outside of the City and drains to the north into Clear Creek. The majority of the basin is residential, but also includes Regis University and Willis Case Golf Course.

Drainage Deficiencies:
The 12-inch pipe in Federal, which continues to its outfall in Arvada, is undersized.

The majority of trunk drainage systems in the residential portions of this basin are adequately sized for a 2-year event.

Proposed Capital Improvements:

Project A: N. Federal Blvd. Outfall
Replacing the 12-inch pipe in Federal with a 24- to 30-inch line within Denver's jurisdiction will provide a 5-year level of service. Extending the system to the north into Arvada and the outfall at Clear Creek will require a 30- to 48-inch line to be coordinated with the City of Arvada.

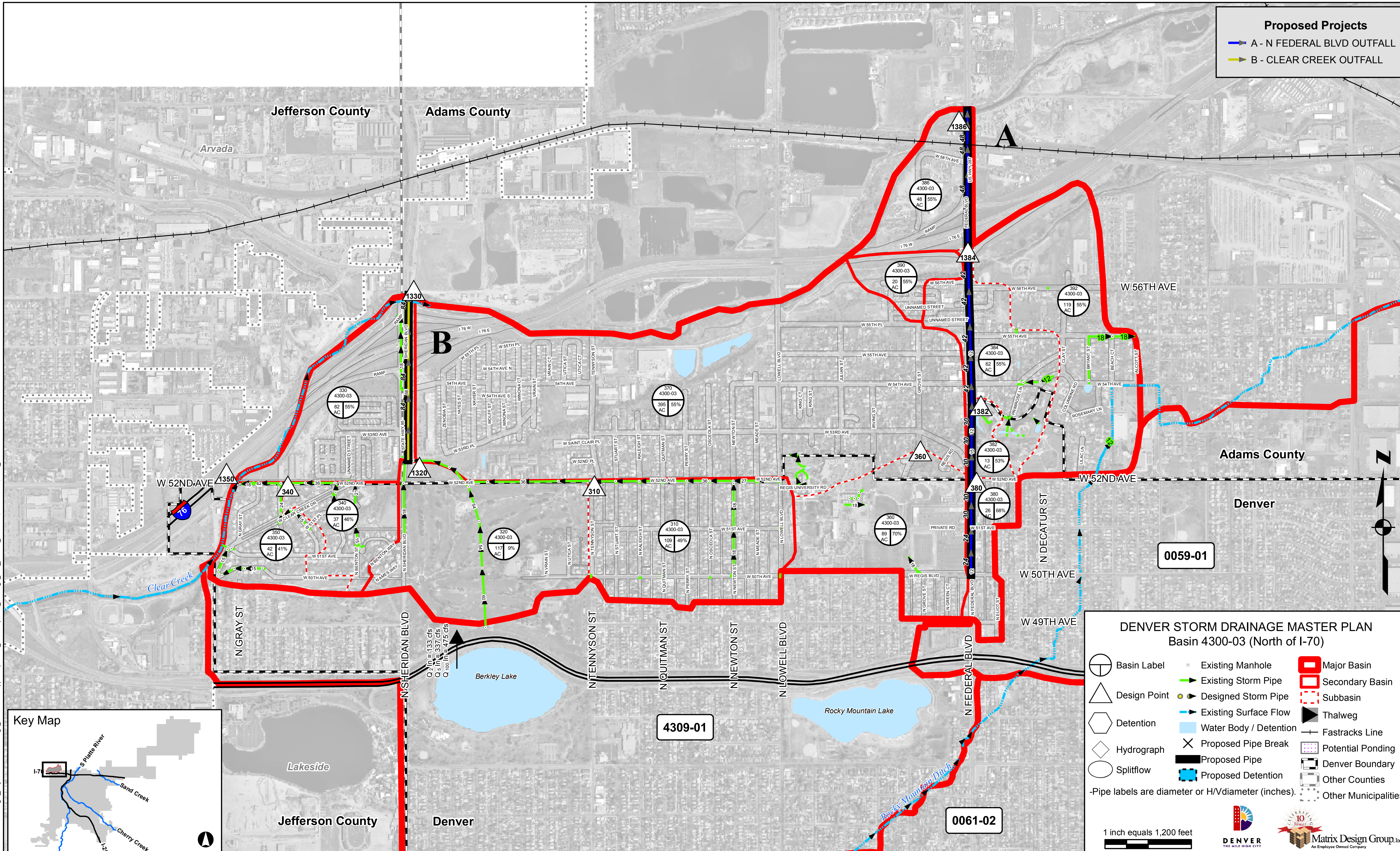
Project B: Clear Creek Outfall
The existing City and County of Denver storm drain outfall in Sheridan Boulevard should be upsized to better convey flows to Clear Creek. This is outside the City and County of Denver; however Denver has a 30' wide easement for its existing drain in Sheridan Boulevard on to Clear Creek.

Existing Hydrology:

In 2005, the City of Denver revised the UDFCD 2003 *Rocky Mountain Ditch Outfall Systems Planning Study* (OSP). Results from the re-study have been incorporated into this Master Plan. The following hydrologic results are derived from models developed for the Denver Master Plan for areas north of I-70, while the 2005 OSP re-study model was used for areas south of I-70.

BASIN 4300-03

Design Point	Contributing Basins	Tributary Area *(acres)*	Peak Discharge 2-Year *(cfs)*	5-Year *(cfs)*	100-Year *(cfs)*
310	310	109	71	135	359
340	340	37	24	47	129
360	360	89	90	145	337
380	380	26	25	40	95
1190	Berkeley Lake	1035	133	337	475
1320	Berkeley Lake, 310, 320	1261	191	448	979
1330	Berkeley Lake, 310, 320, 330	1342	190	464	1089
1350	340, 350	79	45	83	245
1382	380, 382	39	33	56	140
1384	380, 382, 384	101	71	128	337
1386	380, 382, 384, 386	149	83	154	445



FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activeapps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/24/2009, ron_arnold

Basin: 4309-01 (Berkeley Lake)

Existing System Description:
This basin drains to Clear Creek and is generally bound by Sheridan Boulevard on the west, Regis Boulevard on the north, 35th Avenue on the South, and the Rocky Mountain Ditch on the east. Approximately half of the basin drains to the intersection of Sheridan Boulevard and I-70, while the other half drains to the Tennyson Street and I-70 intersection. Runoff from these two intersections is conveyed via large storm sewer systems around Berkeley Lake and to the north across I-70. Currently, storm pipes carry water around Berkeley Lake and do not discharge directly into the lake. Proposed improvements originally recommended in the 2003 *Rocky Mountain Ditch Outfall Systems Planning Study* (OSP) included a new 60” RCP that would discharge into the lake and alleviate the Sheridan Boulevard and I-70 system. However, the 2003 OSP was re-studied by the City of Denver in 2005, and the proposed 60” RCP was determined to be unnecessary because the existing system was found to be adequate. It should be noted that the lake was not constructed as a detention facility, but inadvertent detention does occur.

Drainage Deficiencies:
The 2005 OSP re-study found the existing drainage system to be adequate basin-wide.

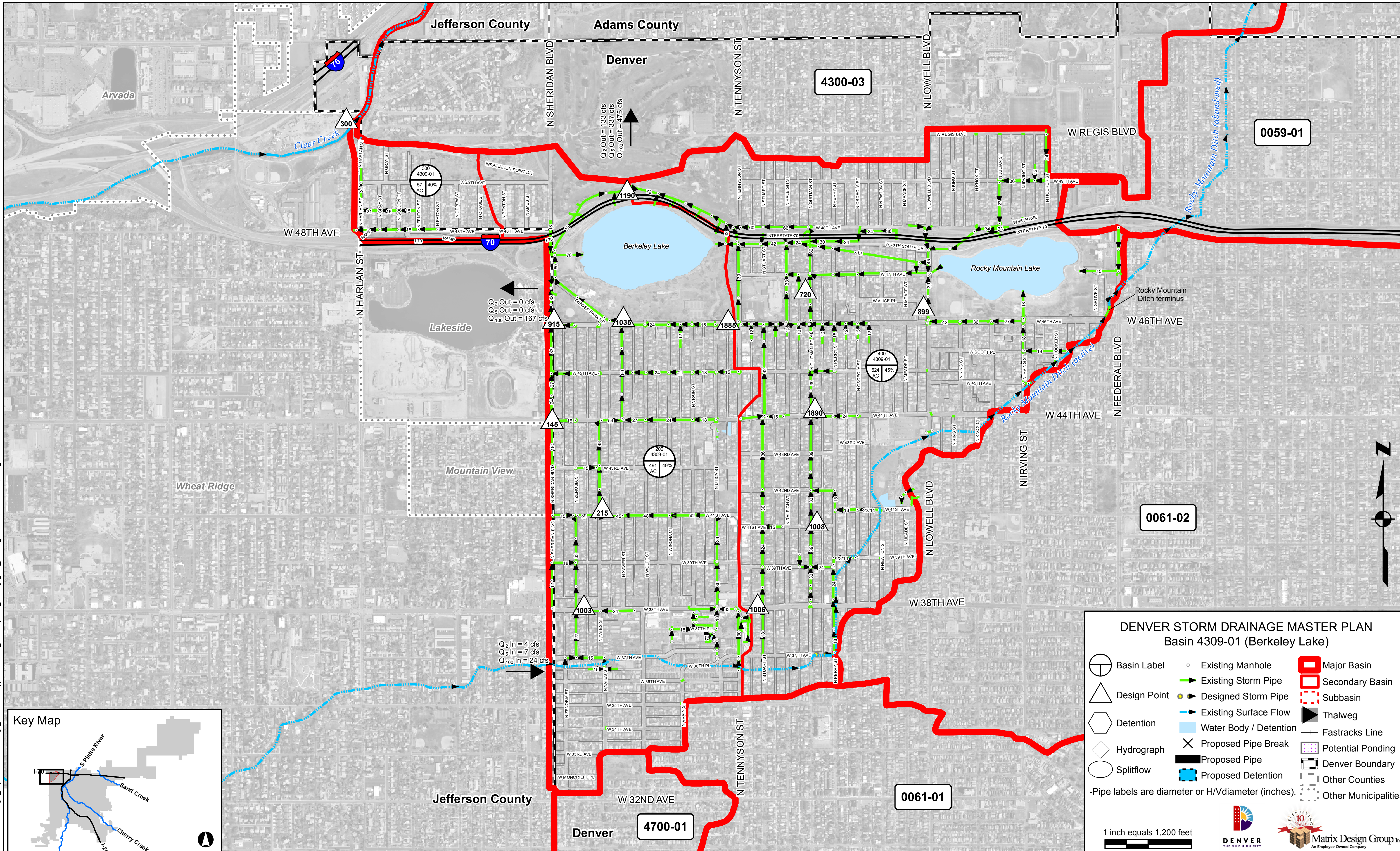
Proposed Capital Improvements:
Based upon the OSP re-study, there are no capital improvements proposed in this basin.

Existing Hydrology:

The 2003 OSP has been re-studied by the City of Denver (2005). Results from the new study have been incorporated into this Master Plan and are summarized in the following table.

BASIN 4309-01

Design Point	Peak Discharge				
	2-Year *(cfs)*	5-Year *(cfs)*	10-Year *(cfs)*	25-Year *(cfs)*	100-Year *(cfs)*
145	13	19	24	49	115
215	65	108	132	205	259
284	17	28	35	58	73
720	58	87	94	116	129
899	32	44	44	44	44
915	26	63	110	341	629
1003	22	35	43	73	107
1006	9	15	19	33	66
1008	25	42	52	95	167
1013	31	58	78	160	297
1035	120	195	212	274	344
1037	149	235	278	511	800
1885	42	74	96	147	222
1890	51	74	78	89	105


DENVER STORM DRAINAGE MASTER PLAN
Basin 4309-01 (Berkeley Lake)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
Key Map
Jefferson County
Adams County
Denver
Arvada
Wheat Ridge
Mountain View
Lakeside
Berkeley Lake
Rocky Mountain Lake
Clear Creek
Rocky Mountain Ditch (abandoned)
Rocky Mountain Ditch (active)
Rocky Mountain Ditch terminus
4300-03
0059-01
0061-02
0061-01
4700-01
W 48TH AVE
W REGIS BLVD
W 46TH AVE
W 44TH AVE
W 38TH AVE
W 32ND AVE
N SHERIDAN BLVD
N HARLAN ST
N TENNYSON ST
N LOWELL BLVD
N FEDERAL BLVD
N IRVING ST
Q_2 Out = 133 cfs
Q_5 Out = 337 cfs
Q_{100} Out = 475 cfs
Q_2 Out = 0 cfs
Q_5 Out = 0 cfs
Q_{100} Out = 167 cfs
Q_2 In = 4 cfs
Q_5 In = 7 cfs
Q_{100} In = 24 cfs
300
1190
915
1035
1885
720
899
145
1890
215
1008
1003
1006
S Platte River
Sand Creek
Cherry Creek

Basin 4400-01 (North Stapleton)

Existing System Description:
This basin consists of 3,183 acres (4.97 square miles) and will be mostly re-built with the redevelopment of Stapleton. ***Blueprint Denver*** shows the entire basin within the City & County of Denver as an "Area of Change". The portion of this basin within Adams County does not receive or contribute drainage from or to Denver, and therefore has generally been ignored for this study. All drainage from this basin will outfall to Sand Creek.

The majority of North Stapleton historically drained to the Rocky Mountain Arsenal to the north, however the creation of a Sand Creek outfall near Quebec and I-270 changed this flow pattern. Large regional stormwater infrastructure has been built recently as part of the "Northfields Mall" development. This infrastructure includes a 9'x7' box culvert in 49th Avenue and a 66" pipe in 45th Avenue as well as a 75 acre-foot detention facility near Quebec and I-270. Drainage from the "Northfields Mall" development drains to this detention facility and then through the new outfall under I-270 to Sand Creek. Currently, drainage for the undeveloped areas north of I-70 flows to the north into the Rocky Mountain Arsenal. Drainage from the I-70 corridor and south of I-70 flows into Sand Creek.

Drainage Deficiencies:
The Sand Creek floodplain significantly encumbers the site between Sand Creek and I-70. FEMA Flood Insurance Rate Maps (FIRM) for the Stapleton site shows large floodplain areas resulting from Sand Creek breaching levees along the river edge. I-70 is also shown as being inundated during a 100-year flood event in Sand Creek. The Sand Creek floodplain will eventually become more confined via implementation of the Sand Creek Master Plan channel improvements.

The King Soopers and Catellus sites exist west of and adjacent to Havana. Since no major outfall exists today for the area, 100-year retention has been constructed. Runoff is metered out through small storm drains to allow the ponds to dry between storms.

Proposed Capital Improvements:
There have been a number of previous studies that have established the framework for management of stormwater at the site, including the *Outfall Systems Plan-Stapleton Area* (OSP), prepared by McLaughlin Water Engineers for the City & County of Denver and the Urban Drainage & Flood Control District in 1995, the *Stapleton Sitewide Infrastructure Master Plan* prepared by Turner, Collie and Braden in 1996, and the *Infrastructure Master Plan* prepared by BRW, Inc in December 2000 and approved by Denver Wastewater in April 2001. The most current document is the *North Stapleton Infrastructure Master Plan* prepared by Matrix Design Group, Inc., and approved by Denver Wastewater in December 2006.

There are two outfall locations designated for the site, a 36-inch and a 84-inch pipe crossing under I-270. A majority of the site is intended to drain through the proposed North Stapleton open space corridor, which will extend from 56th Avenue southwest to the Northern Regional Detention Facility #102 at approximately 51st Avenue and Spruce Street. The southern portion of the North Stapleton site will drain to the Southern Regional Detention Facility #100. Water quality and quantity detention will be provided in each detention facility prior to conveyance of attenuated flows to Sand Creek. A combined outfall will serve these two facilities, with an 84-inch crossing of I-270 and Quebec Street to Sand Creek. Thirty-five sub-basins containing a total of 1476 acres contribute flow to the 84-inch outfall to Sand Creek. The US Postal Service site is modeled as one sub-basin, and conveys flow in a 36-inch storm sewer to the 84-inch outfall prior to crossing I-270. Additionally, the realigned Quebec Street corridor adjacent to the project connects into the 84-inch outfall, and discharges to Sand Creek. A sump at 56th and Spruce will drain to Sand Creek with minimal hydraulic head. This area will overdetain for a restricted release. Five sub-basins containing a total of 158 acres contribute flow to the detention pond location, including one future outfall from an area north of 56th Avenue.

North of I-70, detention ponds are sized per the criteria used in the OSP: the 100-year storm event defines the quantity detention. An allowable release rate of 0.85 cfs per acre is allowed north of I-70 (Type "A" soils, SCS classification). As part of a value engineering approach for infrastructure developments within North Stapleton, multiple storage and release combinations were evaluated in the 2006 North Stapleton IMP update. Due to the high cost of installation of large diameter culverts under I-270, the proposed plan restricts 100-year discharge to 325cfs, with a corresponding on-site detention volume of 248AF and a unit discharge of 0.20 cfs/acre. An emergency spillway to Sand Creek does not exist for the regional detention pond at Quebec and I-270 due to development west of the site. Approximately ten feet of freeboard between the 100-yr WSE and the developments with the Northfield Center have been allowed for to accommodate for the lack of an emergency spillway.

The proposed capital improvement projects for this basin are listed below:

<u>Project A: East 56th Avenue Improvements.</u> This project consists of an open channel along E 56th Avenue, a 15.8 AF detention pond and a 36-inch diameter pipe that will run south along E 53rd Place and Spruce Street and connect to recently constructed 36-inch outfall crossing under I-270. There is approximately 169 acres tributary to this detention pond. The outlet for the pond is the 36-inch pipe which eventually crosses under I-270 and into Sand Creek.

<u>Project B: East 51st Avenue Outfall.</u> This project consists of two open channels, a series of laterals connecting to the southern open channel and a 61 AF detention pond. One of the open channels runs in between proposed 55th Avenue and proposed 54th Avenue in a large open space area. The other open channel runs in a divided median in proposed 51st Avenue. There is approximately 500 acres tributary to this detention pond. The outlet for the pond ties into the existing 84-inch pipe which crosses under I-270.

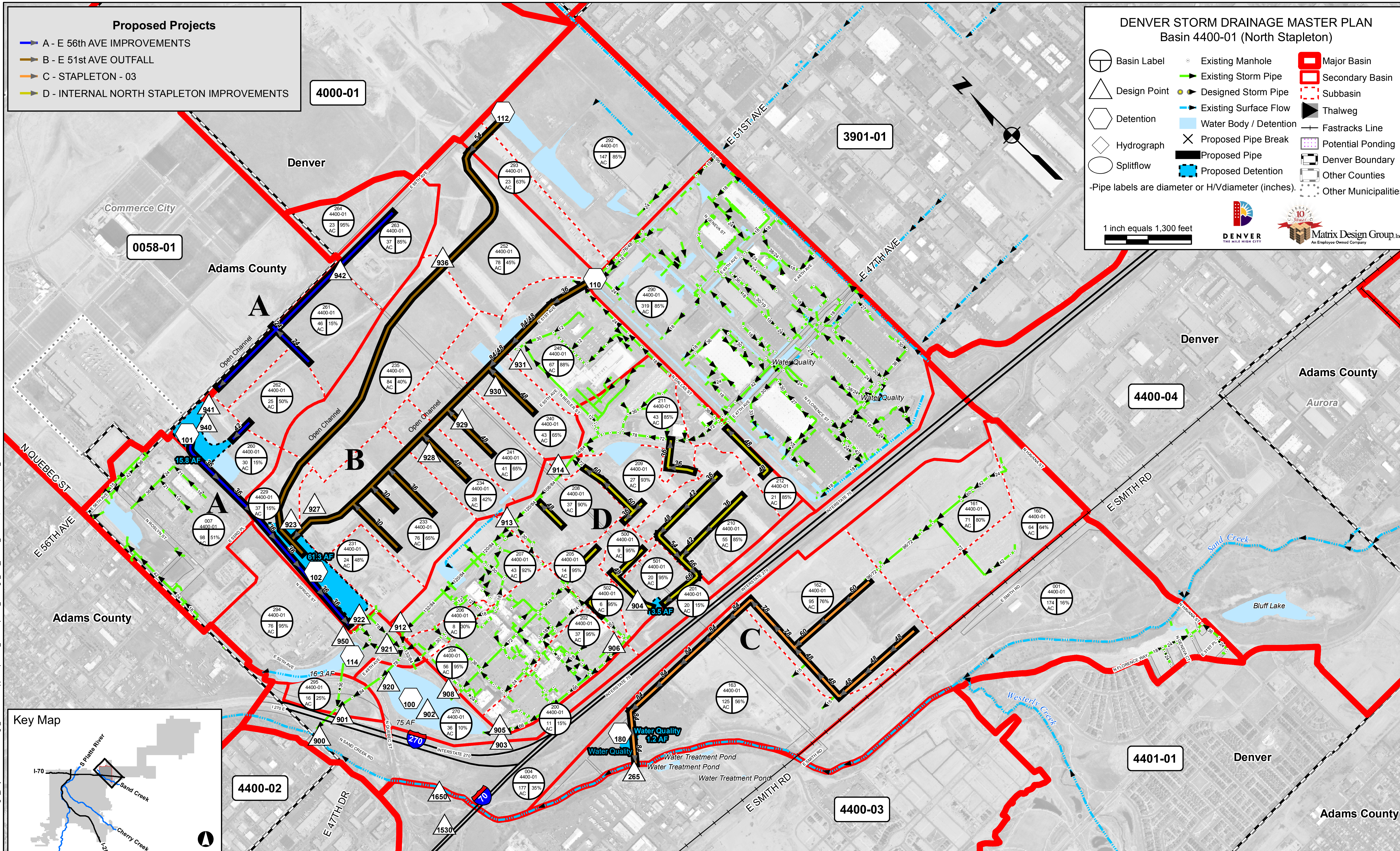
<u>Project C: Stapleton 03.</u> South of I-70 and north of Sand Creek, the area is envisioned to discharge to Sand Creek to the west through a singular outfall point from sub-basin 160, although final grading may render a second outfall location as a reasonable alternative. This south central area is comprised of four sub-basins draining a total of 358 acres. Regional water quality treatment is proposed at the outfall(s).

<u>Project D: Internal North Stapleton Improvements.</u> Immediately west of the existing "Northfield Mall", this area is intended to drain to the existing regional detention facility located at Quebec and I-270 via the recently constructed 9'x7' box storm sewer in 49th Avenue and the 66" storm sewer in 45th Avenue. This project consists of a storm sewer network ranging in size from 36-inch to 66-inch. There is a 3.5 AF throttling detention pond located at the upstream end of the 45th Avenue outfall to handle flows beyond the capacity of the pipe. This pond was required to attenuate the 100-year storm because a grading change directed more flow to the 45th Avenue outfall than it was originally intended to handle. All of the proposed pipes either tie to this detention pond, the existing storm sewer in 47th Avenue, or the 9'x7' box storm sewer in 49th Avenue.

Existing Hydrology:

<u>BASIN 4400-01</u>

Design Point	Contributing Basins	Tributary Area	Peak Discharge		
			2-Year	5-Year	100-Year)
		(acres)	(cfs)	(cfs)	(cfs)
110	290	290	147	147	147
112	292	292	20	20	20
265	160,161,162,163	358	294	395	838
900	200-502	1657	160	201	326
902	200-202,204-212,270,500-502	443	510	727	1415
922	229,231,233-235,240,241,245,252,290,292,293	960	136	159	221
940	260,261,262,263,264	158	59	91	309


DENVER STORM DRAINAGE MASTER PLAN
Basin 4400-01 (North Stapleton)
Proposed Projects
A - E 56th AVE IMPROVEMENTS
B - E 51st AVE OUTFALL
C - STAPLETON - 03
D - INTERNAL NORTH STAPLETON IMPROVEMENTS
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,300 feet
DENVER
Matrix Design Group, Inc.
Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
4000-01
3901-01
0058-01
4400-04
4400-02
4400-03
4401-01
Denver
Adams County
Commerce City
Aurora
E 51ST AVE
E 47TH AVE
E 56TH AVE
N QUEBEC ST
E SMITH RD
E 47TH DR
Sand Creek
Westerly Creek
Bluff Lake
Water Treatment Pond
Water Quality
Open Channel
15.8 AF
61.3 AF
16.3 AF
75 AF
13.5 AF
1.2 AF
A
B
C
D

Basin 4400-02 (Quebec Corridor)

Existing System Description:
This basin includes a mix of industrial and residential land uses to the west of Stapleton along Quebec. It consists of 2,824 acres (4.41 square miles) and is fully built-out with older neighborhood residential in the upper reaches and commercial in the lower reaches. ***Blueprint Denver*** shows the entire basin as an "Area of Stability", inferring that Basin 4400-02 is not an area of future land use change. All drainage from this basin outfalls to Sand Creek or the South Platte River.

Drainage Deficiencies:
The existing drainage system has capacity to convey less than the 1-year storm event to the outfall. Rainfall runoff in excess of the storm drain capacity has a history of ponding in the sump and flat areas. Major drainage problems have been experienced in the sump area near Smith Road and Grape Street. Shallow ponding also occurs on adjacent flat commercial properties because of water being built up behind the railroad and I-70. Specific deficiencies include:

- Local drainage conveyance problems exist in Basin 70 between Forest Street and Grape Street.
- Drainage to the south of Smith Road requires improved conveyance via Dahlia Street; the lack of an adequate outfall causes ponding of up to 4 feet in depth and creation of an urban floodplain along Stapleton Boulevard.
- A localized sump condition exists at Martin Luther King Jr. Boulevard and Eudora Street, with flooding reported as early as the 1960's.

An extensive area of flood hazards have been identified within Basins 0060-01 and 4400-02, related primarily to ponding behind railroad tracks, I-70, and other sumps in the lower portions of each basin.

Proposed Capital Improvements:
Drainage improvements in these basins should be viewed primarily to achieve the minimum performance objectives for residential and commercial areas (2- and 5-year system capacities) established for the Denver stormwater program. Proposed capital improvements include:
<u>Project A: 36th Avenue Improvements</u> A new 2-year storm drain system is needed in 36th Avenue and will connect to the Proposed 84" in Dahlia St., Project 0060-01-F1.

<u>Project B1: 38th Avenue and Holly Street Collector</u> A new storm drain network is needed to convey the 2-year flows from Project B2, 38th Avenue and Holly Street Collector Extension, and sub basin 120 to Project D, 38th Avenue Interceptor.

<u>Project B2: 38th Avenue and Holly Street Collector Extension</u> This proposed system extends from Project B1, 38th Avenue and Holly Street Collector, up the basin to E 17th Avenue to collect flows from sub basins 10, 20, 30, 50 and 80 with sizes ranging from 18-inches to 78-inches.

<u>Project C: Leyden Street Improvements</u> A 48-inch storm drain is proposed in Leyden Street from E. 35th Avenue to E 38th Avenue to convey the 2-year storm event.

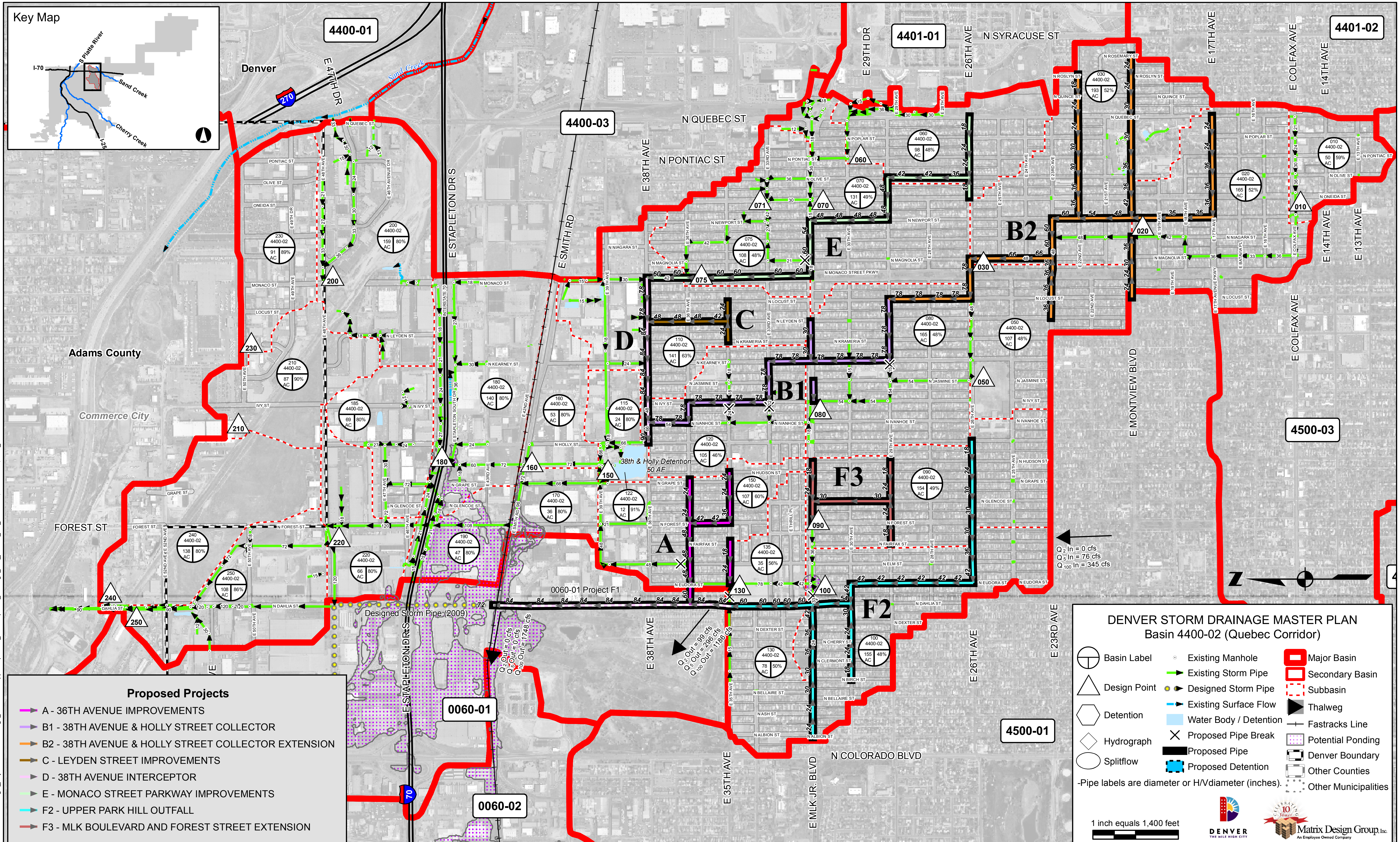
<u>Project D: 38th Avenue Interceptor</u> A new 5-year storm drain system is needed in 38th Avenue from N. Monaco Street Parkway to Holly St with sizes ranging from 78-inches to 90-inches, to deliver storm runoff to the 38th and Holly detention basin.

<u>Project E: Monaco Street Parkway Improvements</u> A new storm drain network is needed to convey the 2-year flows from sub basins 60, 70 and 75. A 60-inch pipe is needed at the confluence with Proposed Project D at the intersection of E 38th Avenue and Monaco Street Parkway. This proposed system extends up the basin to E 16th Avenue with sizes ranging from 18-inches to 60-inches.

<u>Project F2: Upper Park Hill Outfall</u> A new storm drain network is needed to convey the 2-year flows from sub basins 90, 100, 130 and 135. A 60-inch pipe is needed at the confluence with Proposed Project F1 from Basin 4400-02 at the intersection of E 35th Avenue and Dahlia Street. This proposed system extends up the basin to E 26th Avenue with sizes ranging from 18-inches to 60-inches. The design concept for the alignment of this project should take into consideration utilizing a one block segment of 78" storm drain constructed in 2007 from E. 33rd Avenue to E. 35th Avenue in conjunction with the Dahlia Square redevelopment, and relieving the sump condition at MLK Boulevard and Eudora Street.

<u>Project F3: MLK Boulevard and Forest Street Extension</u> A new 2-year storm drain system is needed in MLK Boulevard, Glencoe Street, and E 29th Avenue. This proposed system would connect to the existing storm sewer at the intersection of MLK Boulevard and Forest Street.

Design Point / Flow Element	**Contributing Basins**		**Discharge**		
		Area	**Q2-yr**	**Q5-yr**	**Q100-yr**
		(acres)	(cfs)	(cfs)	(cfs)
2	10,20,30,50, 60, 70, 75, 80, 110, 115, 120, 122	1804	475	736	2433
10	10	50	41	70	174
20	20	165	121	222	578
21	10,20	215	146	261	673
30	30	193	98	178	478
31	10,20,30	408	195	356	1026
50	50	107	55	103	283
51	10,20,30,50	515	217	407	1221
60	60	98	57	108	295
70	70	131	110	207	553
80	80	165	87	164	451
90	90	154	74	138	377
100	100	155	100	189	510
110	110	141	158	266	646
115	115	24	34	51	111
118	113	24	39	181	237
120	120	105	71	136	374
122	122	12	19	28	57
130	130	78	45	83	223
135	135	35	24	42	108
150	150	107	98	167	421
151	10,20,30,50, 60, 70, 75, 80, 110, 115, 120, 122	1326	241	241	2385
160	160	53	76	114	249
170	170	36	51	76	166
180	180	140	177	266	586
185	185	69	100	151	328
190	190	47	67	101	220
200	200	159	234	351	767
210	210	87	97	141	298
220	220	66	95	142	311
230	230	91	115	168	355
240	240	138	168	254	561
242	241	475	254	406	1086



Key Map
I-70
S Platte River
Sand Creek
Cherry Creek
I-25
Denver
Adams County
Commerce City
FOREST ST
4400-01
4400-03
4401-01
4401-02
4500-03
4500-01
0060-01
0060-02
E 47TH DR
N QUEBEC ST
N PONTIAC ST
N SYRACUSE ST
E 29TH DR
E 26TH AVE
E 17TH AVE
E COLFAX AVE
E 14TH AVE
E 13TH AVE
E 38TH AVE
E STAPLETON DR S
E SMITH RD
E MONTVIEW BLVD
E 23RD AVE
E 35TH AVE
E MLK JR. BLVD
N COLORADO BLVD
38th & Holly Detention 50 AF
0060-01 Project F1
Designed Storm Pipe (2009)
A
B1
B2
C
D
E
F2
F3
Proposed Projects
A - 36TH AVENUE IMPROVEMENTS
B1 - 38TH AVENUE & HOLLY STREET COLLECTOR
B2 - 38TH AVENUE & HOLLY STREET COLLECTOR EXTENSION
C - LEYDEN STREET IMPROVEMENTS
D - 38TH AVENUE INTERCEPTOR
E - MONACO STREET PARKWAY IMPROVEMENTS
F2 - UPPER PARK HILL OUTFALL
F3 - MLK BOULEVARD AND FOREST STREET EXTENSION
DENVER STORM DRAINAGE MASTER PLAN
Basin 4400-02 (Quebec Corridor)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,400 feet
DENVER
Matrix Design Group, Inc.

Basin 4400-03 (Stapleton)

Existing System Description:
This basin consists of 563 acres (0.88 square miles) and is being, or will be, nearly completely re-built with the redevelopment of Stapleton. ***Blueprint Denver*** shows the portion of the basin west of Quebec Street as an "Area of Change." All drainage from this basin will outfall to Sand Creek.

Drainage Deficiencies:
Drainage currently is conveyed through a random network of storm drains. These pipes will be upsized and replaced commensurate with redevelopment.

Proposed Capital Improvements:
There have been a number of previous studies that have established the framework for management of stormwater at the site, including the *Outfall Systems Plan-Stapleton Area* (OSP), prepared by McLaughlin Water Engineers for the City & County of Denver and the Urban Drainage & Flood Control District in 1995, and the *Stapleton Sitewide Infrastructure Master Plan* prepared by Turner, Collie and Braden in 1996. The *Infrastructure Master Plan* prepared by BRW, Inc in December 2000 and approved by Denver Wastewater in April 2001 evaluated infrastructure needed to support redevelopment of the former Stapleton International Airport into the variety of uses envisioned in the previous Forest City Stapleton Preliminary Concept Plan.

South of I-70, the requirement for quantity detention has been waived. The waiver was granted by Denver Public Works-Wastewater Management Division via a letter dated June 2, 2000. Formerly, 10-year detention was required for the Stapleton site south of I-70; however, with the waiver, only water quality detention is required, provided that the full 100-year storm is conveyed directly to the receiving major drainageway without impact to downstream properties. Therefore, all new Stapleton drainage systems are designed for 100-year capacity.

For design purposes, Type 'B' soils are assumed for the Stapleton site south of Sand Creek. This classification affects infiltration rates and detention release rates.

There are two outfalls into Sand Creek, located between Westerly Creek and Quebec Street/I-70.

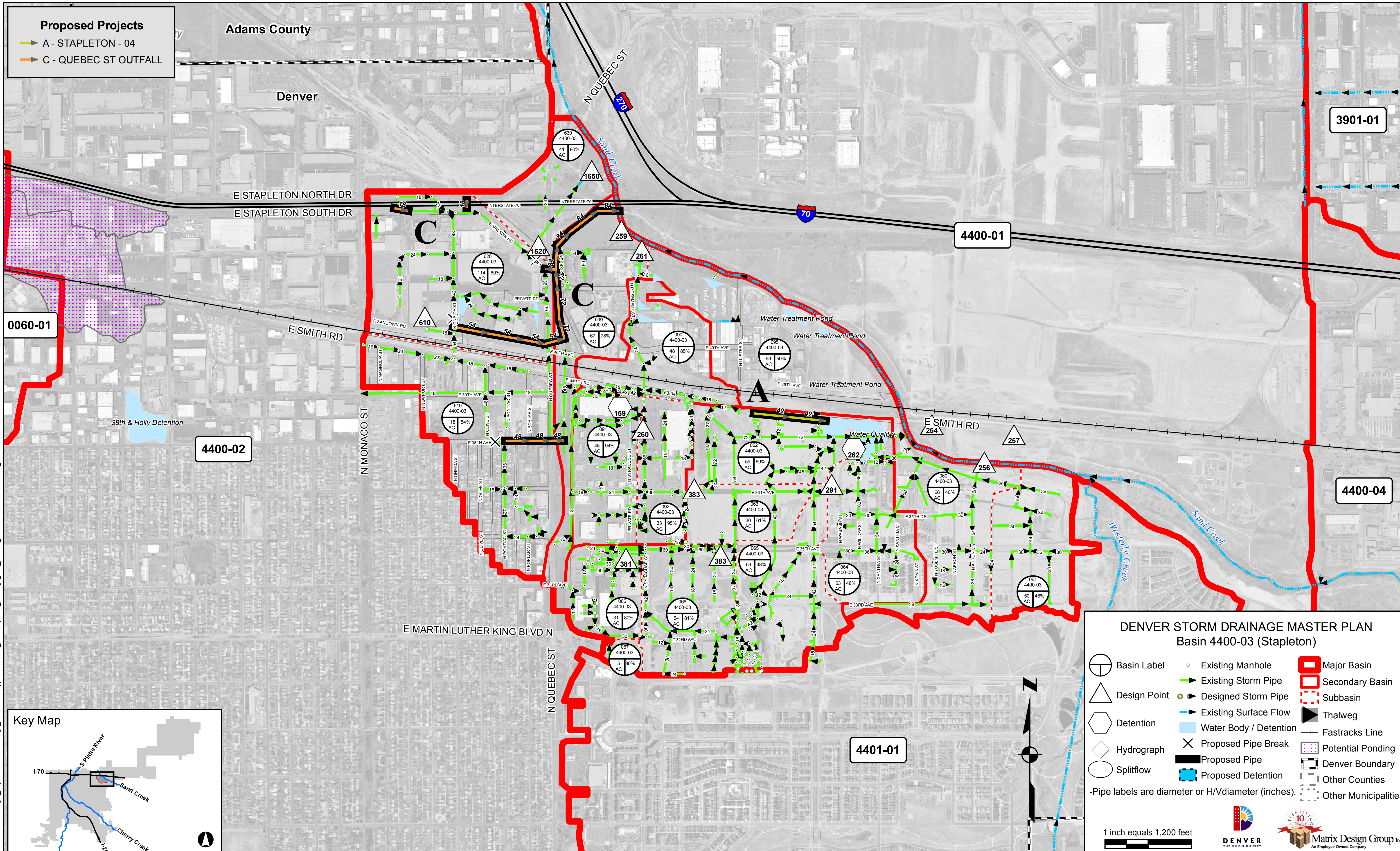
<u>Project A: Stapleton – 04</u> A 42-inch storm drain is proposed along northern edge of sub-basin 062. Approximately 20 tributary acres will be conveyed to the existing regional water quality pond.

<u>Project C: Quebec Street Outfall</u> A new 84-inch outfall is proposed between I-70 and Smith Road east of Quebec. Additionally, a new 48-inch pipe in E. 38th Avenue is proposed to divert runoff from North Pontiac Street to the existing 48-inch pipe in Quebec Street, which will reduce the burden on the existing 54-inch crossing under I-70 near North Oneida Street. This new storm drain will be constructed commensurate with the reconstruction of Quebec Street.

Existing Hydrology:

BASIN 4400-03

Design Point	Contributing Basins	Tributary Area	Peak Discharge		
			2-Year	5-Year	100-Year
		(acres)	*(cfs)*	*(cfs)*	*(cfs)*
256	60,61	101	60	106	291
261	90,91,92	127	117	224	467
262	62-68	293	270	428	1064
610	610	118	109	194	503
1520	610,620	232	222	373	933
1650	610,620,630	274	258	418	1092



FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activeapps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/24/2009, ron_rarnold

Basin 4400-04 (East Stapleton)

Existing System Description:
This basin consists of 1,219 acres (1.9 square miles). A portion of this basin is within Aurora. The Denver portion (Stapleton site and north of Sand Creek and south of I-70) is an "Area of Change" according to ***Blueprint Denver***. The Stapleton redevelopment site is scheduled to be completely re-built by the developer, Forest City.

All drainage from this basin will outfall into Sand Creek. The area north of Sand Creek south of I-70 was divided by the railroad tracks along Smith Road. The area north of Smith Road currently drains to an existing 84-inch outfall at Havana Street. The area south of Smith Road drains to open channels directly to Sand Creek. Currently, there are only three known outfalls into Sand Creek within this basin:

- 72-inch from Aurora from the south through the Stapleton site
- 84-inch in Havana from the north, collecting drainage along Railroad Track and Havana
- Open channel in Aurora from the north

Type B soils are assumed south of Sand Creek for hydrologic calculations and detention design.

Drainage Deficiencies:
Drainage on the Stapleton site is currently informal with few storm drains, relying upon infiltration, evaporation and sheet flow to drain the site to Sand Creek. A 72-inch storm drain from Aurora currently flows north though the Stapleton site and discharges to Bluff Lake. This 72-inch pipe can convey only runoff up to the 5-year event. The 100-year flow will split out of this basin by flowing in an open channel constructed along the southern Stapleton boundary at 26th Avenue, and discharging into Westerly Creek.

Drainage from the Denver jail and other commercial/industrial properties between railroad track and I-70 is conveyed to Sand Creek in the existing 84-inch pipe. This pipe has capacity for the 2-year discharge. Runoff in excess of a 2-year event will back-up against Smith Road and the railroad tracks.

Drainage from the I-70 corridor flows in a storm pipe system parallel to I-70 into Sand Creek.

Proposed Capital Improvements:
The framework for stormwater management at the Stapleton site has been set by the *Outfall Systems Plan-Stapleton Area* (OSP), prepared by McLaughlin Water Engineers for the City & County of Denver and the Urban Drainage & Flood Control District in 1995. The *Infrastructure Master Plan* prepared by BRW, Inc in December 2000 and approved by Denver Wastewater in April 2001 was prepared to evaluate infrastructure needed to support redevelopment of the former Stapleton International Airport. Redevelopment will include drainage infrastructure to convey the full 100-year storm to Sand Creek. In addition, regional water quality treatment will be provided in accordance with Urban Drainage & Flood Control District Volume 3.

Project A: Stapleton – 06 To achieve a 5-year system for the commercial area north of Smith Road, and to preserve the existing storm drain in the area, a new outfall is proposed along the Denver County line at Lima Street. This new 12' x 4' box culvert will provide the additional outfall capacity for subbasins 10, 11, 20, 21, 40 and a portion of subbasin 30 to be protected from ponding up to a 5-year event.

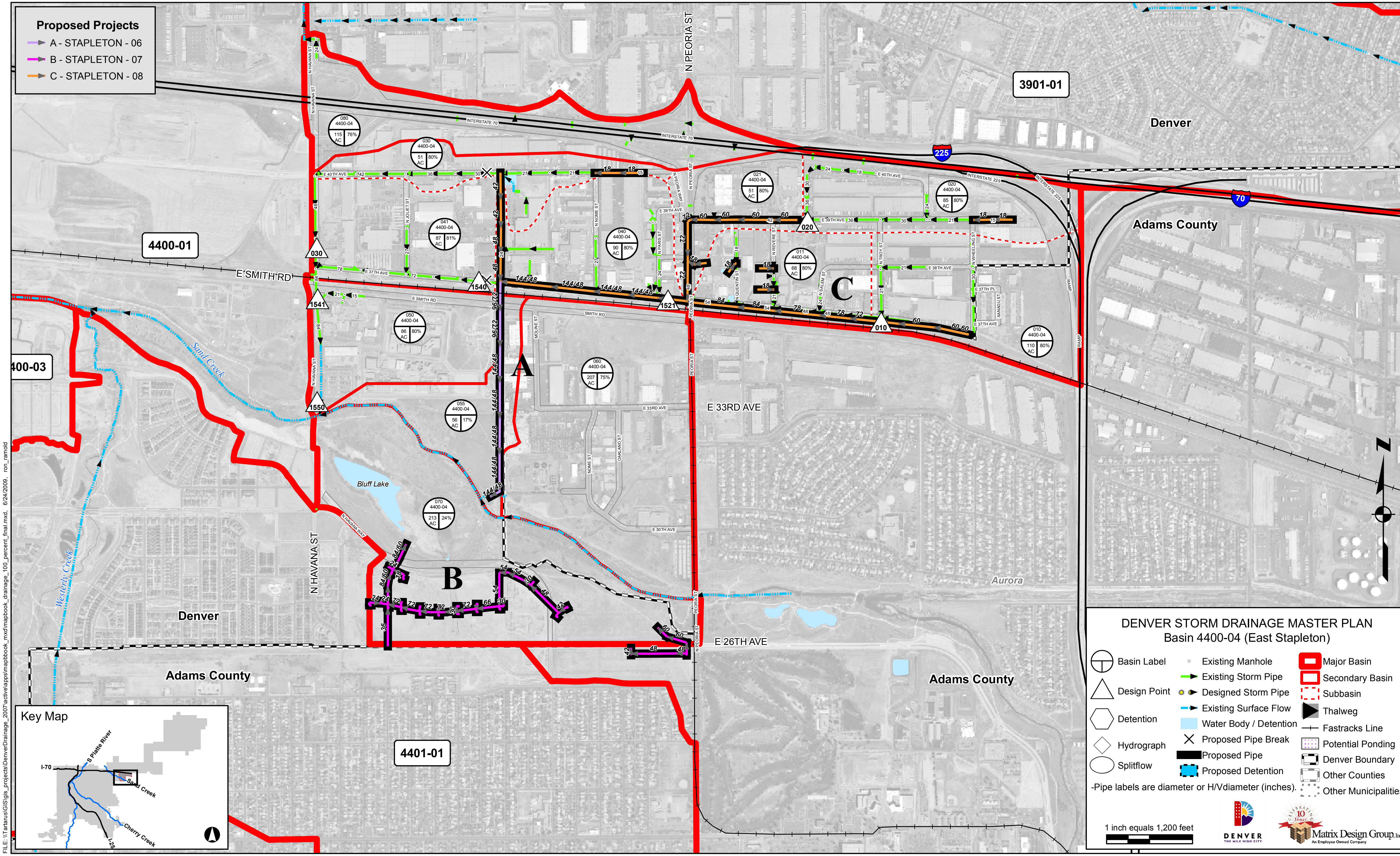
Project B: Stapleton – 07 Discussions with Denver Parks Department indicated that they have interest in the development of Bluff Lake (in the southeastern portion of the Stapleton site) for limited use as a water quality pond. This lake was formerly fed by Sand Creek via an irrigation-style channel, but this water supply is no longer active. Management plans for Bluff Lake propose to enhance its use as a public amenity and to encourage wetlands restoration. Therefore, additional water supply is desired for the structure. Proposed grading plans for the Stapleton site direct stormwater flows to Bluff Lake to enhance its water volume. A new 7'x 5' box culvert is proposed to discharge into Bluff Lake for regional water quality treatment. Storm drainage pipes in this area will be constructed commensurate with development.

Project C: Stapleton – 08 This project connects to Project A and extends the lateral network further into the basin. Existing 48- and 54-inch laterals will be upsized to 72- and 84-inch pipes, respectively, to provide a 5-year level of service

Existing Hydrology:

BASIN 4400-04

Design Point	Contributing Basins	Tributary Area	Peak Discharge		
			2-Year	5-Year	100-Year
		(acres)	(cfs)	(cfs)	(cfs)
10	10	110	161	242	529
20	20	85	93	140	310
30	30	51	45	68	155
1521	10-21	313	298	438	1029
1530	30	51	45	68	155
1540	10-21,40	404	303	457	1168
1541	10-41	542	379	568	1470
1550	10-50	628	455	659	1695


Proposed Projects
A - STAPLETON - 06
B - STAPLETON - 07
C - STAPLETON - 08
3901-01
4400-01
400-03
4401-01
Denver
Adams County
N PEORIA ST
N HAVANA ST
E SMITH RD
E 33RD AVE
E 26TH AVE
Sand Creek
Westerly Creek
Bluff Lake
Aurora
A
B
C
DENVER STORM DRAINAGE MASTER PLAN
Basin 4400-04 (East Stapleton)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.
Key Map
I-70
S Platte River
Sand Creek
Cherry Creek
I-25

Basin: 4401-01 (Westerly Creek – South Stapleton)

Existing System Description:
This basin drains to Westerly Creek and is generally bound by Quebec Street on the west, Montview Boulevard on the south, Peoria Street on the east and Sand Creek/Martin Luther King Boulevard on the north. The portion of this basin in Denver is located within the Stapleton Redevelopment property, with the exception of the southeast portion of the basin located in Aurora. The basin size is 3.01 square miles. Most of the basin is comprised of residential neighborhoods, with commercial/retail areas located near the arterial roadways. ***Blueprint Denver*** identifies the portion of the drainage basin within Denver as an “Area of Change” with the exception of a small existing residential area south of E. 23rd Avenue and west of Syracruse.

The portion of the basin in Stapleton was reconstructed between years 2000 to 2005 with 100-year conveyance systems. Each outfall includes a regional water quality pond at the end of pipe before discharging into Westerly Creek. Water quality ponds are located on the west bank at 23rd Avenue, 26th Avenue, 29th Avenue, Martin Luther King Boulevard and 33rd Avenue. Water quality ponds are located on the east bank at 29th Avenue and Martin Luther King Boulevard. A 20.4 acre-foot regional constructed wetland detention basin capturing runoff from 181 acres is located within the “East-West Linear Park” at Stapleton, located along 26th Avenue at Central Park Boulevard.

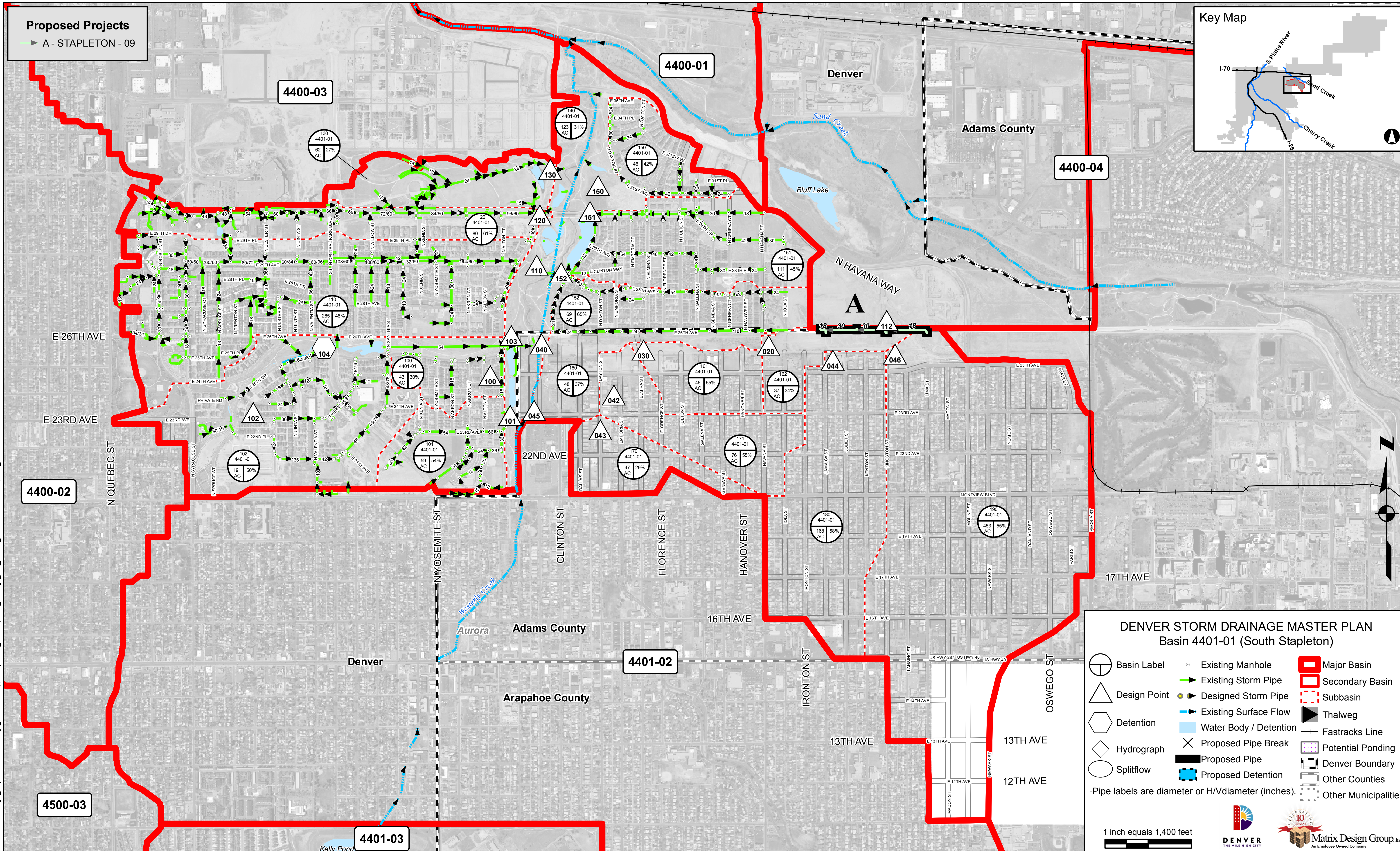
The portion of the basin in Aurora has historically drained to Bluff Lake via a 72” storm drain. However, this has capacity for only the 5-year storm event, and flows in excess of the capacity have historically been trapped against the former Stapleton Airport runways and directed in an open channel along 26th Avenue to Westerly Creek. The 26th Avenue channel was studied as a part of Stapleton Planning Area 4 and has been improved to adequately convey the full 100-year storm to Westerly Creek.

Drainage Deficiencies:
All drainage problems within Denver are being accounted for in the redevelopment of Stapleton. Overflow from Aurora’s system is following the historic path and is being directed to Westerly Creek in an improved channel along 26th Avenue.

Proposed Capital Improvements:
Project A: Stapleton 09
This project includes capital improvements by the developer for 100-year storm systems throughout out the Stapleton development.

Existing Hydrology:

Design Point / Flow Element	Basin Parameters						Discharge		
	Area	Length	Dist to Centroid	% Imp.	Slope	Tc	Q2-yr	Q5-yr	Q100-yr
	(acres)	(mi)	(mi)	(%)	(ft/ft)	(min)	(cfs)	(cfs)	(cfs)
20	715						-	-	1687
30	740						-	-	1744
40	856						-	-	1839
42							-	-	282
43							-	-	183
44							-	-	1656
45							-	-	160
46							-	-	1295
100	43	0.4527	0.2125	30	0.003	23	17	41	128
101	60	0.4816	0.2186	54	0.006	24	43	78	201
102	191	0.8671	0.4232	50	0.011		133	247	654
103	191						112	131	124
104	191						133	247	654
110	265	1.5350	0.6991	48	0.006		115	215	598
112							-	-	288
120	80	1.3360	0.6621	61	0.005	49	44	73	187
130	62	0.6752	0.3343	27	0.003	38	16	41	134
140	124	0.2369	0.1174	31	0.018		79	195	595
150	46	0.4184	0.1206	42	0.010	22	27	54	153
151	111	0.7368	0.3656	45	0.008		64	126	347
152	69	0.7983	0.3766	65	0.007	33	53	87	211
160	48			37			-	-	-
161	46			55			-	-	-
162	37			34			-	-	-
170	47			29			-	-	-
171	76			55			-	-	-
180	168			58			-	-	-
190	453			55			-	-	-



Proposed Projects
A - STAPLETON - 09
Key Map
I-70
S Platte River
Sand Creek
Cherry Creek
I-25
4400-01
4400-03
4400-04
4400-02
4401-02
4401-03
4500-03
Denver
Adams County
Aurora
Arapahoe County
Sand Creek
Westerly Creek
Bluff Lake
Kelly Pond
N HAVANA WAY
A
E 26TH AVE
E 23RD AVE
N QUEBEC ST
N YOSEMITE ST
CLINTON ST
FLORENCE ST
HANOVER ST
IRONTON ST
OSWEGO ST
22ND AVE
17TH AVE
16TH AVE
13TH AVE
12TH AVE
DENVER STORM DRAINAGE MASTER PLAN
Basin 4401-01 (South Stapleton)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,400 feet
DENVER
THE MILE HIGH CITY
Matrix Design Group, Inc.
An Employee Owned Company
FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\active\apps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/24/2009, ron_ramold

Basin: 4401-02 (Westerly Creek – 11th Avenue to Montview)

Existing System Description:
This basin drains to Westerly Creek and is generally bound by Quebec Street on the west, Montview Boulevard on the north, Peoria Street on the east and 11th Avenue on the south. The basin is located between the Stapleton Redevelopment property and the Lowry Redevelopment property. The west portion of the basin is in Denver and the east portion is in Aurora, with Westerly Creek running south to north down the center of the basin. The basin is comprised of residential neighborhoods with commercial/retail areas located near the arterial roadways.

There are several existing storm sewer systems in roadways that discharge in three locations directly to Westerly Creek. A 15” pipe in Richthofen Place with an existing capacity of 6 cfs drains 42 acres with a 5-year runoff of 39 cfs. A 48” pipe in 13th Avenue with an existing capacity of 80 cfs drains a 130 acre area with a proposed 5-year runoff of 146 cfs. A 60” pipe in Montview Boulevard with an existing capacity of 138 cfs drains 290 acres with a 5-year runoff of 299 cfs.

Kiowa Engineering Corp is completing a Major Drainageway Planning project for Westerly Creek under the direction of the Urban Drainage & Flood Control District and the City & County of Denver. The study is resolving the drainage basin boundary near 6th Avenue & Dayton Street during a major storm event.

Drainage Deficiencies:
- The 15” pipe draining Basin 210 has a capacity of 6 cfs, while the 2-year flow to the pipe is 20 cfs.
- The 60” pipe draining Basins 260 and 261 has a capacity of 138 cfs, while the 2-year flow is 164 cfs.

Proposed Capital Improvements:
This basin requires improvements primarily to the outfalls since the lateral network is currently sufficient with the new pipes designed by Denver.

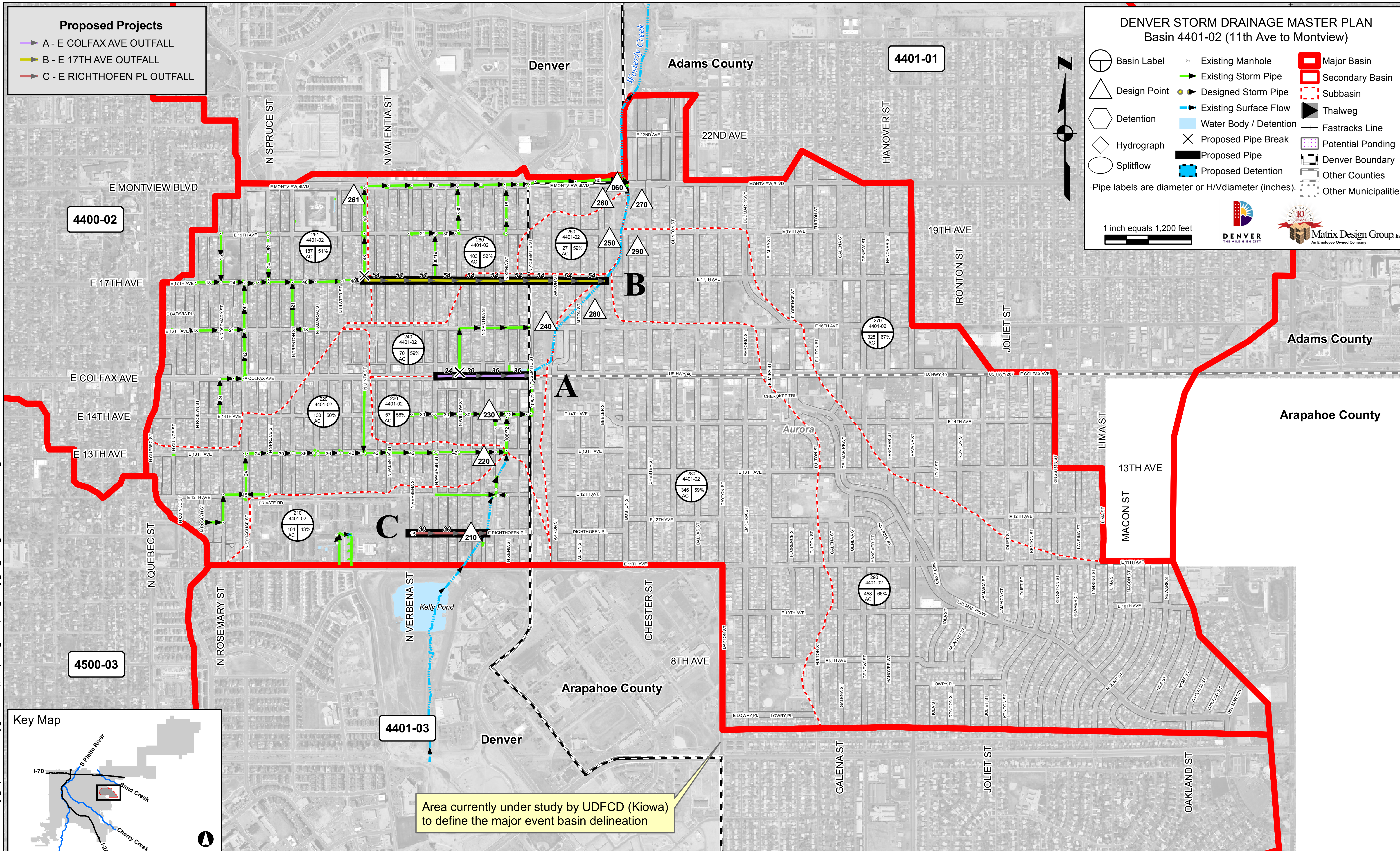
Project A: E. Colfax Ave Outfall Colfax Avenue is a major transportation corridor through the basin with few existing storm drainage facilities. An improvement is required at the outfall to Westerly Creek to convey localized storm runoff.

Project B: E. 17th Ave Outfall The combined flows of Basins 260 and 261 exceed the allowable capacity of the 60” pipe in Montview Boulevard. A new 54” outfall in 17th Avenue from Uinta Street to Westerly Creek will drain 131 acres from Basins 261 and 260. The 2-year flow from the new drainage area will be 83 cfs, with the 80% capacity of a 54” pipe at 0.5% of 112 cfs.

Project C: E. Richthofen Pl. Outfall The 15” outfall in Richthofen Place needs to be improved to convey a 2-year flow of 20 cfs. Upsizing the pipe to 30” from Verbena Street to Westerly Creek will provide an 80% capacity of 28 cfs at a slope of 0.7%.

Existing Hydrology:

Design Point	Contributing Basins	Tributary Area	Peak Discharge		
		(acres)	2-Year	5-Year	100-Year
			(cfs)	(cfs)	(cfs)
60	261, 260	290	164	299	757
61	261	187	107	196	499
210	210	104	49	97	276
220	220	130	79	146	390
230	230	57	43	76	193
240	240	70	60	104	257
250	250	27	24	41	103
260	260	103	57	104	277
261	261	187	117	213	569
270	270	328	213	347	846
280	280	346	242	417	1055
290	290	458	488	800	1886


Proposed Projects
A - E COLFAX AVE OUTFALL
B - E 17TH AVE OUTFALL
C - E RICHTHOFEN PL OUTFALL
DENVER STORM DRAINAGE MASTER PLAN
Basin 4401-02 (11th Ave to Montview)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.
Denver
Adams County
Adams County
Arapahoe County
Arapahoe County
Denver
Aurora
4401-01
4400-02
4500-03
4401-03
A
B
C
E MONTVIEW BLVD
E 17TH AVE
E COLFAX AVE
E 14TH AVE
E 13TH AVE
22ND AVE
19TH AVE
13TH AVE
8TH AVE
N SPRUCE ST
N VALENTIA ST
HANOVER ST
IRONTON ST
JOLIET ST
LIMA ST
MACON ST
N QUEBEC ST
N ROSEMARY ST
N VERBENA ST
CHESTER ST
GALENA ST
OAKLAND ST
Westerly Creek
Kelly Pond
Area currently under study by UDFCD (Kiowa) to define the major event basin delineation
Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25

Basin: 4401-03 (Westerly Creek - Lowry)

Existing System Description:
This basin drains to Westerly Creek and is generally bound by Quebec Street on the west, 11th Avenue on the north, Dayton Street/Havana Street/Peoria Street on the east and Alameda Avenue on the south. The basin is entirely within the Lowry Redevelopment property, except for one offsite subbasin to the east. The majority of the basin is in Denver; a small portion of the northeast corner of Lowry and the offsite subbasin are in Aurora. The portion of the drainage basin within Denver is identified as an "Area of Change" in ***Blueprint Denver.***

Westerly Creek runs from south to north down the center of the basin. Westerly Creek Dam Pond (500-year detention capacity) is located in the southeast corner of the basin and Kelly Road Dam (100-year detention capacity) is located in the north. The basin is comprised of a mix of residential neighborhoods, commercial areas, golf course and open space.

The redevelopment of Lowry included 100-year capacity storm drains. The hydrology for this basin was studied in detail in a report titled "Lowry Master Drainage Plan" (December 1998) to design 100-year capacity systems.

The discharge from Westerly Creek Dam is a 48" RCP storm drain with a 7"W x 48"H restrictor orifice. An open channel of Westerly Creek exists between Westerly Creek Dam and Kelly Road Dam to capture and convey local runoff. Most Lowry storm drains outfall to Westerly Creek north of the 6th Avenue alignment.

Regional water quality treatment occurs within Westerly Creek Dam and Kelly Road Dam.

Drainage Deficiencies:
All drainage problems were accounted for in the redevelopment of Lowry per the Lowry Master Drainage Plan (December 1998).

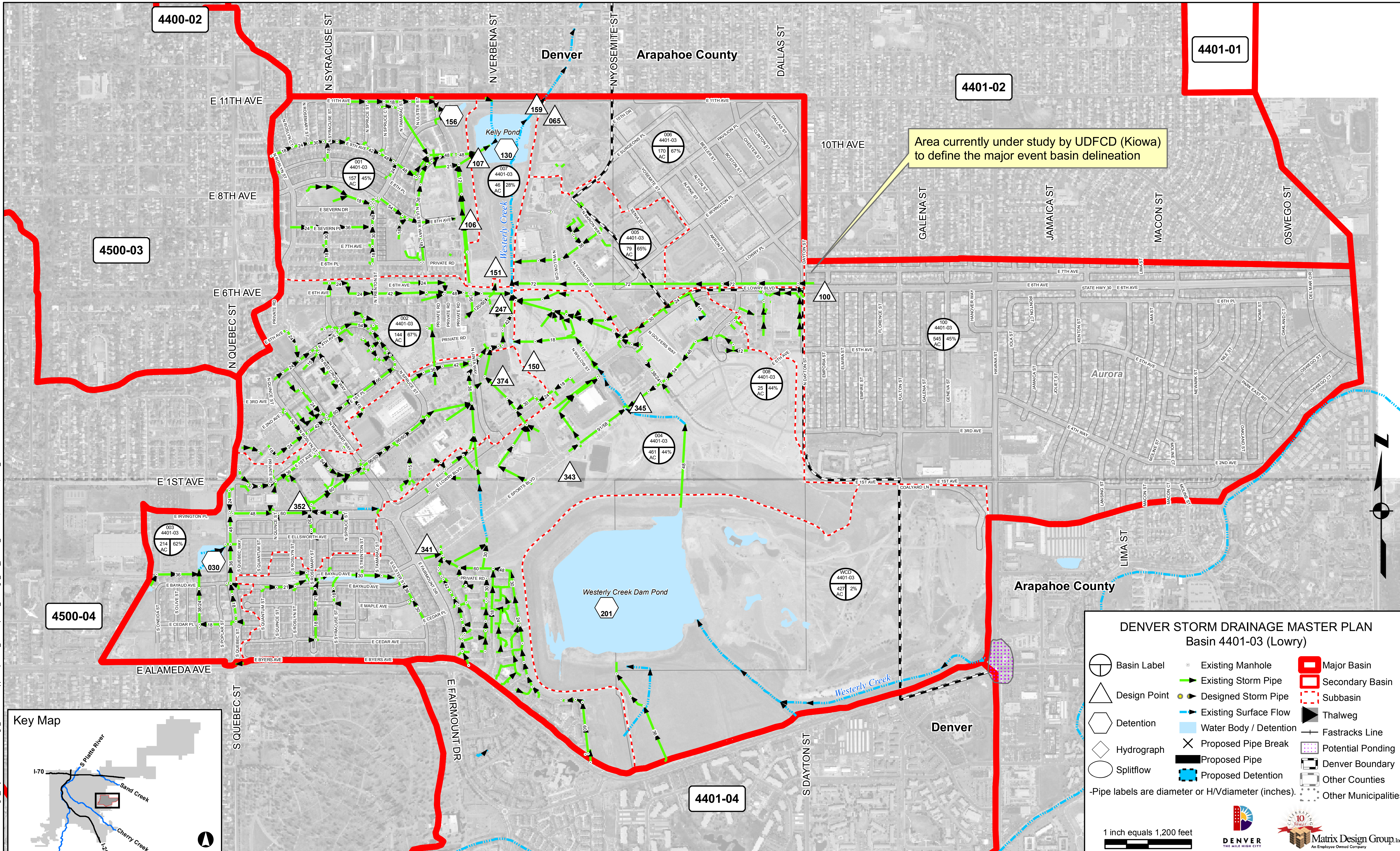
Proposed Capital Improvements:
No capital improvements are proposed for this basin. The developer is providing 100-year storm systems throughout out the Lowry development.

Existing Hydrology:

HYDROLOGIC SUMMARY TABLE: BASIN 4401-03

Design Point / Flow Element	Tributary Area	Peak Discharge		
		2-year	5-year	100-year
	(acres)	(cfs)	(cfs)	(cfs)
001	157			
002	144			
003	198			
004	461			
005	79			
006	170			
007	46			
008	25			
WCD	427			
30	64		16	20
100	506		391	1121
106	71		85	104
107	60		69	98
130	1591		80	98
150	625		461	1311
151	1382		964	2326
156	24		9	108
159	1780		308	710
201*	5946		48	48
202			48	48
247	102		174	396
341	160		165	452
343	243		225	569
345	423		332	924
352	95		53	135
374	180		213	486

*Area input from the USACE study. "Westerly Creek Dam and Kelly Road Dam – Water Control Manual"



FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activeapps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/24/2009, ron_ramold

Basin: 4401-04 (Westerly Creek – South of Alameda)

Existing System Description:
This basin drains to Westerly Creek and is generally bound by Alameda Avenue on the north, Havana Street on the east and Evans Avenue on the south. The basin is located south of the Lowry Redevelopment property. The northern portion of the basin is in Denver and the remainder is located in Aurora but drains into Denver. The Highline Canal runs west to east across the northern portion of the basin. The basin is comprised of a mix of residential neighborhoods with commercial/retail areas located near the arterial roadways.

The two major existing storm sewer trunk systems are located in Havana Street and Dayton Street, draining a majority of the basin to the Westerly Creek Dam Pond. There are several additional pipes crossing Alameda conveying flows from the south to the Westerly Creek Dam Pond area. Basins 410, 411 and 412 drain via storm sewer to the privately-owned Windsor Lake, which then discharges into the Highline Canal.

Drainage Deficiencies:
- The 54" storm pipe draining Basins 410, 411 and 412 has the capacity to convey approximately 108 cfs, while the 2-year and 5-year flows are 239 cfs and 379 cfs, respectively, at Design Point 113.
- The 72" storm sewer in Dayton Street has the capacity to convey approximately 255 cfs, while the 2-year and 5-year design flows for the system are 354 cfs and 560 cfs, respectively.
- Ponding occurs at the intersection of Mississippi and Havana.
- The 66" storm sewer in Havana Street has the capacity to convey approximately 238 cfs, while the 2-year and 5-year design flows for the system are 267 cfs and 431 cfs, respectively, at Design Point 420.

Proposed Capital Improvements:
This basin requires improvements primarily to the outfalls since the lateral network is currently adequate.

Project A: S. Alton St. Improvements The 54" outfall near Mississippi and Alton needs to be improved to convey a 2-year flow of 239 cfs. Adding a new 66" pipe in Alton from Mississippi south and connecting the existing system from Aurora to this new pipe will help alleviate the flows from the existing 54" line. The existing 54" line would continue to convey flows from 64 acres, with a 5-year flow of 85 cfs. The new 66" line will convey flows from the remaining 253 acres, most of which is in Aurora. Adding a large regional detention pond in Aurora would greatly help reduce the flows and pipe sizes needed in Denver.

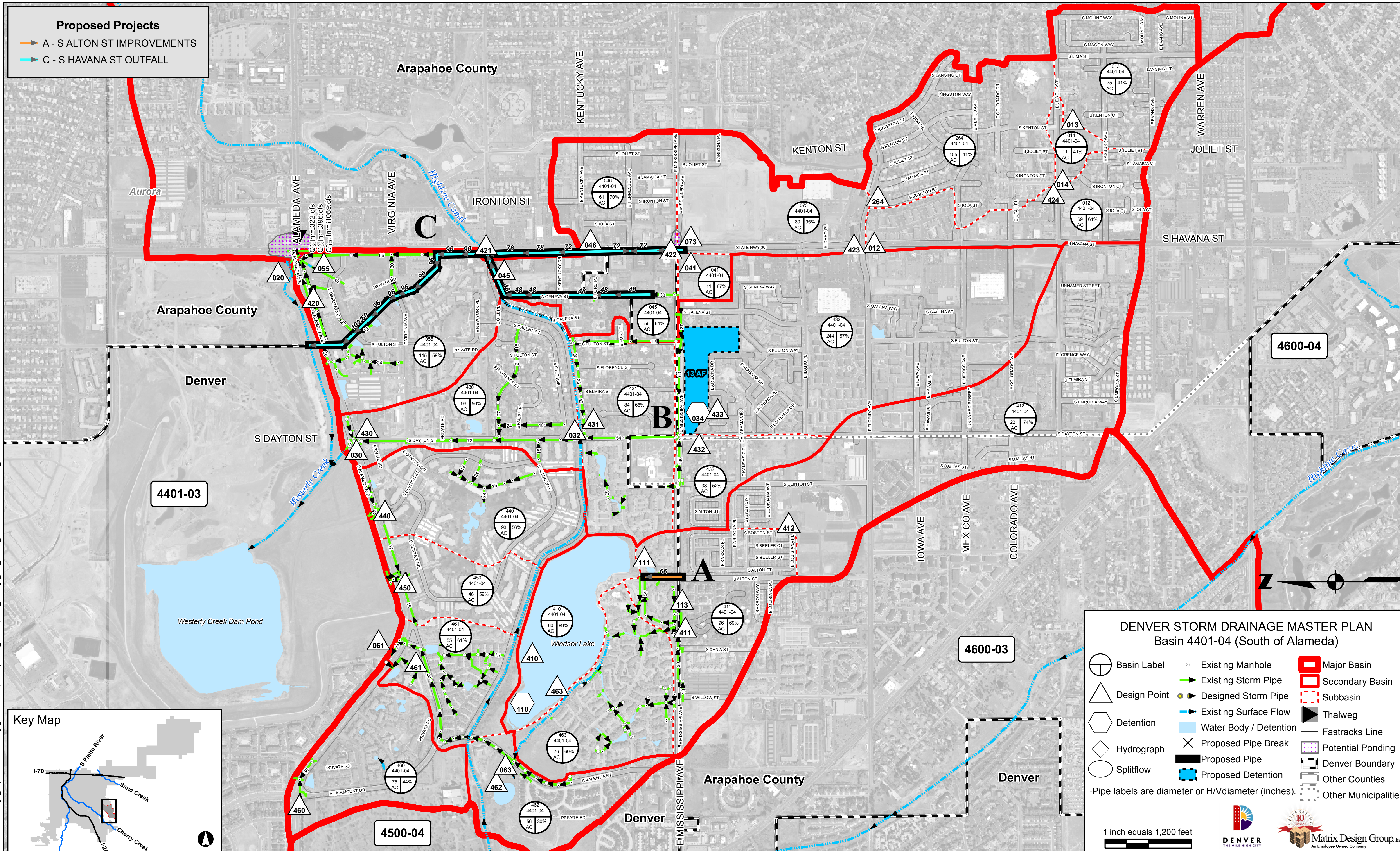
Project B: East Mississippi Detention The 72" outfall in Dayton Street needs to be improved to convey a 5-year flow of 560 cfs. One option would be to increase the pipe size to 90" from Mississippi to the outfall. The preferred option (shown on the adjacent page) is to provide detention at the vacant lot in the southeast corner of Mississippi and Dayton. This parcel is located within Aurora. This has an estimated cost of $1 million, excluding land acquisition.

Project C: S. Havana St. Outfall The 66" outfall in Havana Street needs to be improved to convey a 5-year flow of 431 cfs. In addition, frequent ponding occurs at the intersection of Mississippi and Havana. Increasing the existing pipe to a 90" pipe and extending it up Havana to Mississippi would provide 5-year conveyance and alleviate the flooding at the Mississippi and Havana intersection.

Existing Hydrology:

HYDROLOGIC SUMMARY TABLE: BASIN 4401-04

Design Point	Contributing Basins	Tributary Area (acres)	Peak Discharge 2-Year (cfs)	5-Year (cfs)	100-Year (cfs)
12	12	69	51	79	210
13	13	75	34	56	202
14	14	11	6	10	34
20	12, 13, 14, 41, 45, 46, 55, 73, 264	583	268	427	1378
30	430, 431, 432, 433	462	354	560	1427
31	431, 432, 433	366	303	470	1176
32	431, 432, 433	366	376	579	1314
33	432, 433	282	309	470	1043
34	433, 432, 431	282	326	489	1060
41	41	11	17	24	51
45	45	56	46	70	186
46	46	61	59	89	224
55	55	115	78	123	351
61	461, 462	111	64	110	316
62	462	56	13	33	127
63	462	56	19	47	156
73	73	80	110	156	321
110	410, 411, 412, 463	452	311	507	1288
111	411, 412	317	223	360	911
112	411, 412	317	223	360	911
113	411, 412	317	239	379	930
264	264	105	48	81	289
410	410	60	87	124	249
411	411	96	95	153	359
412	412	221	193	302	699
420	12, 13, 14, 41, 45, 46, 55, 73, 264	583	267	431	1371
421	12, 13, 14, 41, 45, 46, 73, 264	468	248	389	1175
422	12, 13, 14, 41, 73, 264	351	198	308	913
423	12, 13, 14, 264	260	114	189	649
424	13, 14	86	37	62	228
425	12, 13, 14, 41, 45, 46, 73, 264	468	219	352	1119
426	12, 13, 14, 41, 45, 46, 55, 73, 264	583	268	427	1378
430	43	96	66	117	303
431	431	84	81	132	314
432	432	38	26	47	124
433	433	245	300	442	936
440	440	93	58	103	267
450	450	47	42	70	174
460	460	75	41	82	230
461	461	55	55	94	231
462	462	56	19	47	156
463	463	76	62	104	257
496	12, 13, 14, 41, 73, 264	351	177	281	870
497	12, 13, 14, 264	260	102	175	625
498	264	105	46	77	280
499	13, 14	86	26	47	189
1013	13	75	32	54	195
1412	412	221	174	277	667


Proposed Projects
A - S ALTON ST IMPROVEMENTS
C - S HAVANA ST OUTFALL
DENVER STORM DRAINAGE MASTER PLAN
Basin 4401-04 (South of Alameda)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
Key Map
Arapahoe County
Denver
Aurora
Westerly Creek Dam Pond
Windsor Lake
Highline Canal
Westerly Creek
4401-03
4500-04
4600-03
4600-04
S HAVANA ST
S DAYTON ST
IRONTON ST
KENTON ST
JOLIET ST
ALAMEDA AVE
VIRGINIA AVE
KENTUCKY AVE
E MISSISSIPPI AVE
IOWA AVE
MEXICO AVE
COLORADO AVE
WARREN AVE
A
B
C
13 AF

Basins: 4500-01, -03, -04 (Montclair)

Existing System Description:
The Montclair Basin contains a total land area of approximately 6,054 acres and includes planning basins 4500-01, 03, and 04. The upstream basin limit of the fully-developed basin is located at the southeast at the Fairmont Cemetery located near the intersection of South Quebec Street and East Alameda Avenue. Land use varies within the basin from primarily residential in the upper reaches to commercial and industrial in the lower reaches. City Park, an approximately 320 acre urban park that contains the Denver Zoological Gardens, the Denver Museum of Nature & Science, and the City Park Golf Course, is located near the center of the planning basin. Stormwater runoff flows northwest through the basin in an extensive system of existing storm sewer pipes. Surcharged flows are conveyed overland via the network of City streets. The basin discharges to the South Platte River through a main outfall, an 10' x 10' (120" x 120") reinforced concrete box culvert, located in Globeville Park, approximately 500 feet northeast of the intersection of 38th and Arkins Streets. A second smaller outfall (24-inch) pipe discharges to the South Platte River near 38th Street.

See the write up for Basin 4500-03 for the results table showing the existing condition hydrologic analysis.

Drainage Deficiencies:

Approximately 93,637 feet of existing storm sewer pipes were identified as deficient, with about 40% of them having less than 50 percent of the required design capacity. On average, existing pipe systems located within the Montclair Basin provide a conveyance capacity of approximately 39% of the 100-year event when flowing at 100% capacity. This means that the existing Montclair Basin storm drain system has the ability to convey stormwater runoff resulting from a storm larger than the 2-year event but less then the 5-year event.

In addition, numerous areas within the Montclair Basin do not contain a storm sewer pipe network. These areas currently rely on the streets to convey stormwater runoff to the nearest inlet and pipe system. Section 7.3 of the Denver Storm Drainage Design and Technical Criteria Manual states that local and collector streets can convey stormwater without curb overtopping during the minor event. Areas were identified within the Montclair Basin that likely exceeds the allowable minor event street capacity. Approximately 2,490 acres of land within the Montclair Basin are estimated to exceed the allowable street conveyance capacity during the minor event and require storm drain systems.

Numerous sump areas exist within the basin, and several flooding incidents have been documented by the City & County of Denver. Most notably, the Coca Cola bottling plant located near the intersection of N. Race Street and 38th Avenue has reported frequent flooding at their facility. Also, frequent street flooding is reported along east 17th Avenue, on the south side of City Park, and at E. 8th Avenue and Niagara Street. During large storm events, flooding has been reported in E. Severn Place between Jersey Street and Jasmine Street and stormwater surging out of manholes along Hale Parkway has been reported.

Proposed Capital Improvements:

The majority of the proposed system improvements consist of approximately 19 acre-feet of detention storage in the City Park soccer fields, and approximately 193,831 feet (36.7 miles) of storm sewer pipes/box culverts.

<u>Project A: E. 33rd Avenue System</u>
The 33rd Avenue project is located just north of City Park and includes land tributary to Martin Luther King Drive and 33rd Street. Primary upgrades within the project basin include a replacement trunk line along 33rd Avenue that beings at Williams Street and extends up the basin along Martin Luther King Drive, 31st Avenue, and Monroe Street. The proposed trunk line located along 23rd Avenue in the City Park Project intercepts peak flows from subbasins 430 and 440 and conveys the flow to the City Park Soccer Field detention storage facility. This diversion eliminates the need to replace a portion of the existing trunk line system that extends in a southeasterly direction from 29th and Monroe Street to 23rd Avenue and Dahlia Street.

<u>Project B: 38th Street System</u>
The 38th Street project is the smallest of the Montclair Basin projects with only approximately 54 acres of contributing land. The project is located at the South Platte River just west of the major basin outfall and is hydrologically disconnected from the rest of the Montclair Basin. Proposed improvements include a trunk line located along 38th Street and two small laterals to service currently unsewered commercial areas.

<u>Project C: 40th Avenue System</u>
The 40th Avenue project is located at the downstream end of the project basin. The upstream portion of the project begins near the intersection of 38th Avenue and Harrison Street and extends downstream to the storm sewer trunk line located at the intersection of High Street and 40th Avenue. The major upgrade within the project is a proposed 8' x 8' RCBC to replace the existing 69-inch storm drain located along 40th Avenue.

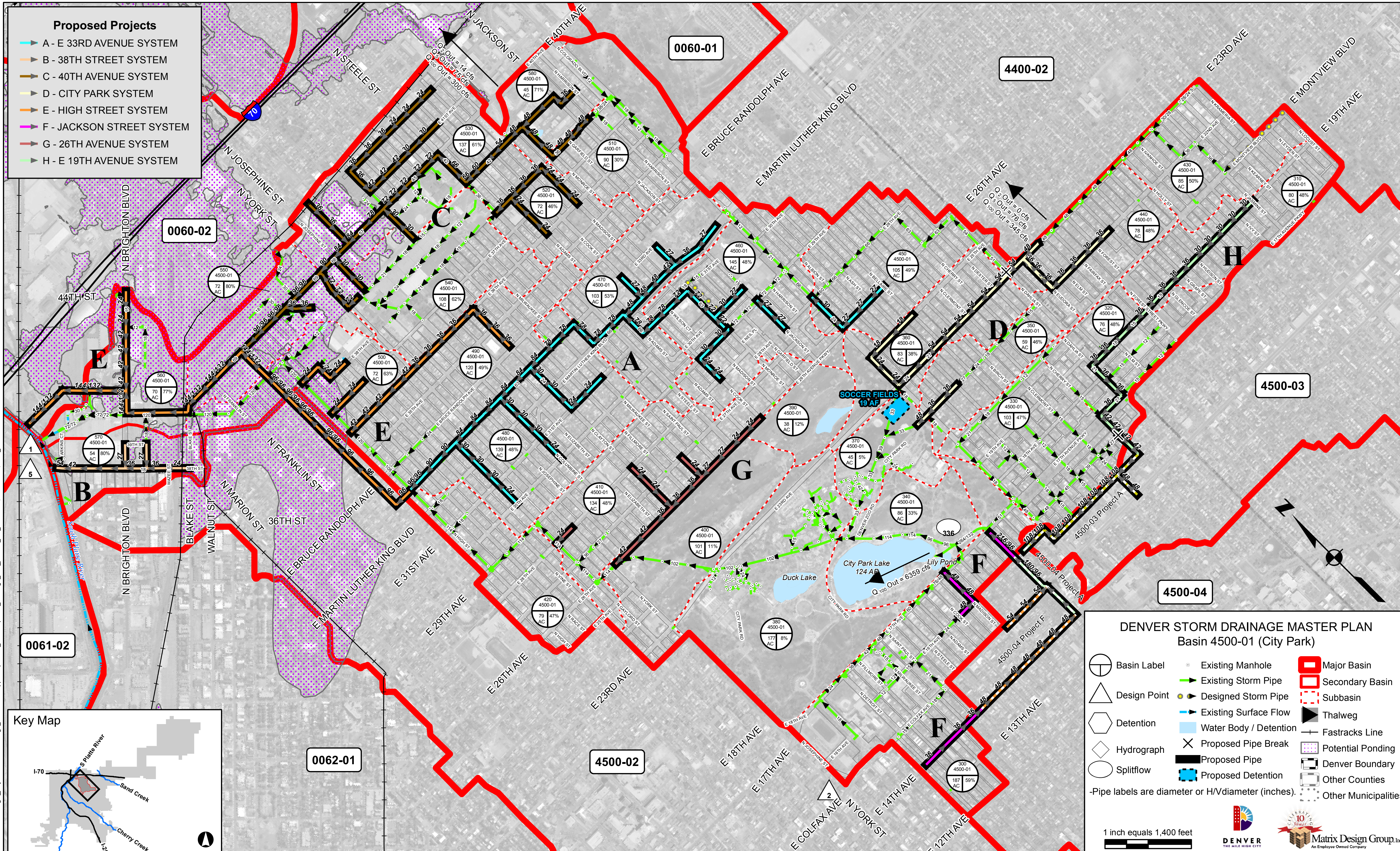
<u>Project D: City Park System</u>
This project contains City Park and residential areas located just east of the park. The proposed capital improvement modifies City Park to provide additional detention storage volume. Storage is to be provided in two locations within the Park; City Park's Ferril Lake which was recently constructed and proposed storage in ballfields located near the northeast corner of the Park. The reduction in peak flows resulting from the detention storage under this alternative eliminates the need to upgrade the existing Denver Zoo trunk line. The project also includes a proposed trunk line located along 23rd Avenue to intercept peak flows from subbasins 430 and 440 located in the 33rd Avenue Project.

<u>Project E: High Street System</u>
The High Street Project contains the existing major outfall system for the Montclair Basin. The project is comprised of commercial/industrial lands in the lower reaches and residential areas in the upper reaches. The High Street Project contains the existing major outfall system for the Montclair Basin located along High Street. The primary upgrade within the project is a proposed 11' x 12' RCBC outfall to the South Platte River that would be aligned along the north side of the Pepsi Bottling Plant. The main trunk line would then extend upstream along 40th Street to a crossing under the Union Pacific Railroad yard. The trunk line would continue east in 40th Avenue to Williams Street, where it would head south, parallel to the existing trunk line located in High Street. A parallel line was selected over direct replacement for this alternative because of the reduced peak flows resulting from the detention storage in City Park.

<u>Project F: Jackson Street System</u>
The Jackson Street project is to construct one block of storm drain in Jackson Street from E. 17th Avenue to E. 16th Avenue to serve as the outfall for Project 4500-04-A. It also includes a new drain in Madison from 17th Avenue to 16th Avenue as well as the upper portion of a new drain in E. 14th Avenue from Clayton to St. Paul.

<u>Project G: 26th Avenue System</u>
The 26th Avenue Project is located just at the north boundary of City Park and included land tributary to Gaylord street and 26th Avenue. The major improvement is the proposed new RCP in the 26th Avenue and lateral in Milwaukee Street, Clayton Street and 28th Avenue.

<u>Project H: E. 19th Avenue System</u>
The E. 19th Avenue system collects runoff in E. 19th Avenue from Jasmine Street, conveying it to E. 16th Avenue and Cherry Street to connect with Project 4500-03-A, 16th Avenue System.


Proposed Projects
A - E 33RD AVENUE SYSTEM
B - 38TH STREET SYSTEM
C - 40TH AVENUE SYSTEM
D - CITY PARK SYSTEM
E - HIGH STREET SYSTEM
F - JACKSON STREET SYSTEM
G - 26TH AVENUE SYSTEM
H - E 19TH AVENUE SYSTEM
DENVER STORM DRAINAGE MASTER PLAN
Basin 4500-01 (City Park)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,400 feet
DENVER
Matrix Design Group, Inc.
Key Map
0060-01
4400-02
0060-02
4500-03
4500-04
0061-02
0062-01
4500-02
City Park Lake
124 AF
Duck Lake
Lily Pond
SOCCER FIELDS
19 AF
4500-03 Project A
4500-04 Project A
4500-04 Project F
N BRIGHTON BLVD
N JOSEPHINE ST
N YORK ST
N STEELE ST
N JACKSON ST
E 40TH AVE
E BRUCE RANDOLPH AVE
E MARTIN LUTHER KING BLVD
E 26TH AVE
E 23RD AVE
E MONTVIEW BLVD
E 19TH AVE
44TH ST
36TH ST
N FRANKLIN ST
N MARION ST
BLAKE ST
WALNUT ST
E 31ST AVE
E 29TH AVE
E 18TH AVE
E 17TH AVE
E COLFAX AVE
N YORK ST
E 14TH AVE
E 13TH AVE
E 12TH AVE

Basin: 4500-03 (Park Hill-Colfax)

Project A: 16th Avenue System

The 16th Avenue project is located in the southeast portion of the Montclair Basin and collects stormwater runoff in a trunk line that runs along 16th Avenue and ends at Harrison Street near the southeast corner of City Park. This project contains approximately 194 acres of primarily residential land but includes commercial lands located along Colfax Boulevard. Subbasins within the project include 280 – 290. The primary upgrade within the project is a replacement trunk line located along 16th Avenue and extending up through the project, and one lateral line to service currently unsewered areas.

Project B: Glencoe Street System

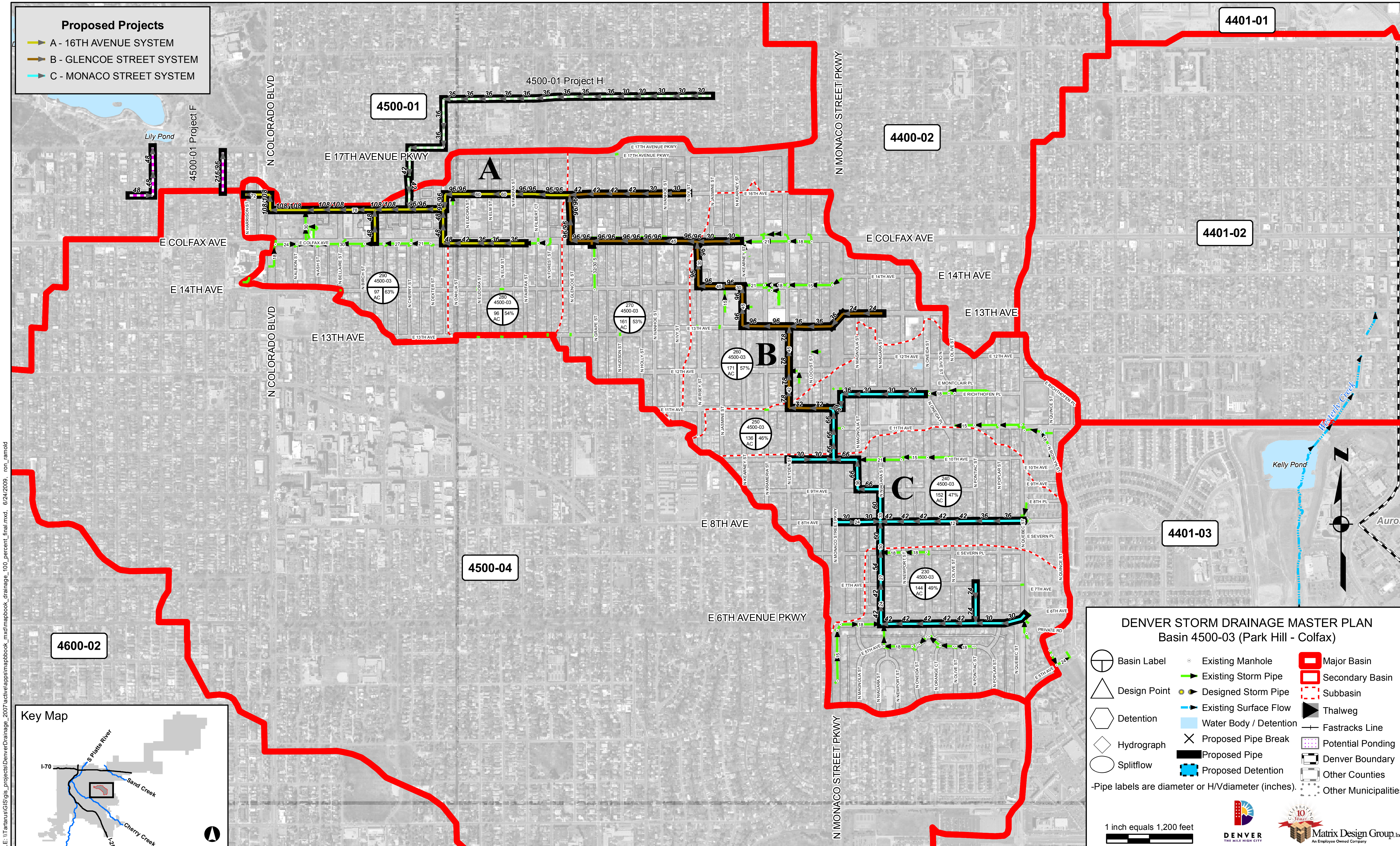
The Glencoe Street project trunk line starts at the upstream end of 16th Avenue project and zigzags along Glencoe Street, Colfax Avenue, Jersey Street, 14th Avenue, Kearney Street, 13th Avenue, Leyden Street, 11th Avenue and ends at the intersection of 11th Avenue and Monaco Street Parkway. Approximately 350 acres of land contributes stormwater runoff within the project including subbasins 260, 270 and a portion of 250. The major of the land within the project bounds is residential but includes commercial lands locates along Colfax Boulevard. The primary upgrade within the project is a replacement of trunk line and two lateral lines to service currently unsewered area.

Project C: Monaco Street System

The Monaco Street project has a trunk line starts at the intersection of Monaco Street and 11th Avenue and zigzags along Monaco Street, 10th Avenue, Magnolia Street, 9th Avenue, Niagara Street to end at the intersection of Niagara Street and 6th Avenue Parkway. There are three laterals in 6th Avenue, 8th Avenue and 10th Avenue to service unsewered areas. Approximately 432 acres of land contributes stormwater runoff within the project includes subbasins 230, 240 and a portion of 250. The majority of land within the project bounds is residential. The primary upgrade within this project is a replacement of trunk line.

MONTCLAIR BASINS 4500-01,4500-03, 4500-04 (Existing Condition)

Routing Element	Contributing Basins	Tributary Area (acres)	Peak Discharge Q2-yr (cfs)	Peak Discharge Q5-yr (cfs)	Peak Discharge Q100-yr (cfs)
1020	10,20	220	6	39	224
1030	10-30	377	83	164	536
1035	10-40	482	16	25	522
1050	50	103	62	126	381
1070	10-70	701	116	226	686
1090	10-90	832	163	323	1008
1100	10-100	920	174	346	1141
1110	10-130	1327	366	710	2270
1120	120	131	95	153	466
1130	120130	271	164	305	902
1150	10-150	1498	413	801	2651
1160	10-160	1607	429	848	2816
1180	180	154	112	223	605
1190	180190	249	183	328	982
1195	10-200, split	2027	617	1184	3861
1198	split from 10-200	Split	197	765	3432
1200	10-200	2027	391	391	391
1210	10-210	2168	439	509	809
1230	230	144	88	171	509
1240	230240	296	173	343	1030
1250	230-250	432	176	359	1192
1260	230-260	603	231	471	1563
1270	230-270	763	273	552	1862
1280	230-280	859	268	542	1901
1290	10-290	3297	997	1922	6492
1300	10-340	3829	495	518	6693
1310	310	80	28	55	174
1320	310320	155	54	108	350
1330	310-330	259	106	212	629
1335	10-290, 310-330	3556	1091	2097	7061
1340	10-340	86	452	616	6359
1360	350360	142	58	112	364
1370	10-370	4015	547	642	6857
1380	10-380	4192	556	688	6793
1390	390	38	3	14	68
1400	10-400	4330	565	733	6945
1410	10-410	4464	602	782	6627
1430	430	85	50	92	228
1441	430,440 minus 441 split	163	93	100	100
1442	430,440 minus 441 split	163	74	89	96
1450	430-450 minus 441 split	267	116	176	336
1460	430-460 minus 441 split	412	178	299	756
1470	430-470 minus 441 split	515	202	346	968
1480	10-480, minus 441 split	5197	842	1207	7132
1490	10-490, minus 441 split	5318	824	1210	6808
1500	10-550, minus 441, 585 split	5914	1055	1581	7173
1510	510	90	28	66	215
1515	510, 580, minus 585 split	135	60	63	63
1520	510, 520, minus 585 split	207	91	113	234
1530	510-540	452	213	342	901
1540	540	108	111	188	451
1560	10-560, minus 441, 585 split	5984	1074	1621	7175
1	10-560, minus 441, 585 split	6000	1074	1621	7175
5	570	54	60	91	202
336	10-330	3829	1395	2626	7422
605	split from 430, 440 into basin 4400-02	Split	0	76	345
641	split from 510, 580 into basin 4400-02	Split	14	75	330



Proposed Projects
A - 16TH AVENUE SYSTEM
B - GLENCOE STREET SYSTEM
C - MONACO STREET SYSTEM
4500-01
4500-01 Project H
4500-01 Project F
Lily Pond
4400-02
4401-01
4401-02
4401-03
4500-04
4600-02
A
B
C
N COLORADO BLVD
N MONACO STREET PKWY
E 17TH AVENUE PKWY
E COLFAX AVE
E 14TH AVE
E 13TH AVE
E 8TH AVE
E 6TH AVENUE PKWY
Kelly Pond
Westerly Creek
Aurora
Arapahoe County
Key Map
I-70
S Platte River
Sand Creek
Cherry Creek
I-25
DENVER STORM DRAINAGE MASTER PLAN
Basin 4500-03 (Park Hill - Colfax)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.

Basin: 4500-04 (Park Hill-6th Avenue)

Project A: Jackson St. System This project starts at E. 16th Avenue, connecting to Project 4500-01-F. It extends upstream in Jackson Street from E. 16th Avenue to E. 12th Avenue where it goes east in 12th Avenue to Colorado Boulevard. It serves as the outlet for Projects B, F and G.

Project B: Hale Parkway System
Hale Parkway lies in a historic drainage swale and is subject to significant surface flows and storm drain surcharging. The Hale Parkway Project is located in Hale Parkway between Colorado Boulevard and 8th Avenue with approximately 264 acres of contributing area. The project contains commercial lands in the reaches along Hale Parkway to E. 8th Avenue, with the remainder being residential areas. Subbasins 150 – 170 and part of 140 are included within the project. The project includes an extensive network of proposed pipe systems, including an 8' x 11' (96" x 132") box culvert trunk line that begins at E. 12th Avenue and Colorado Boulevard and extends upstream along Hale Parkway.

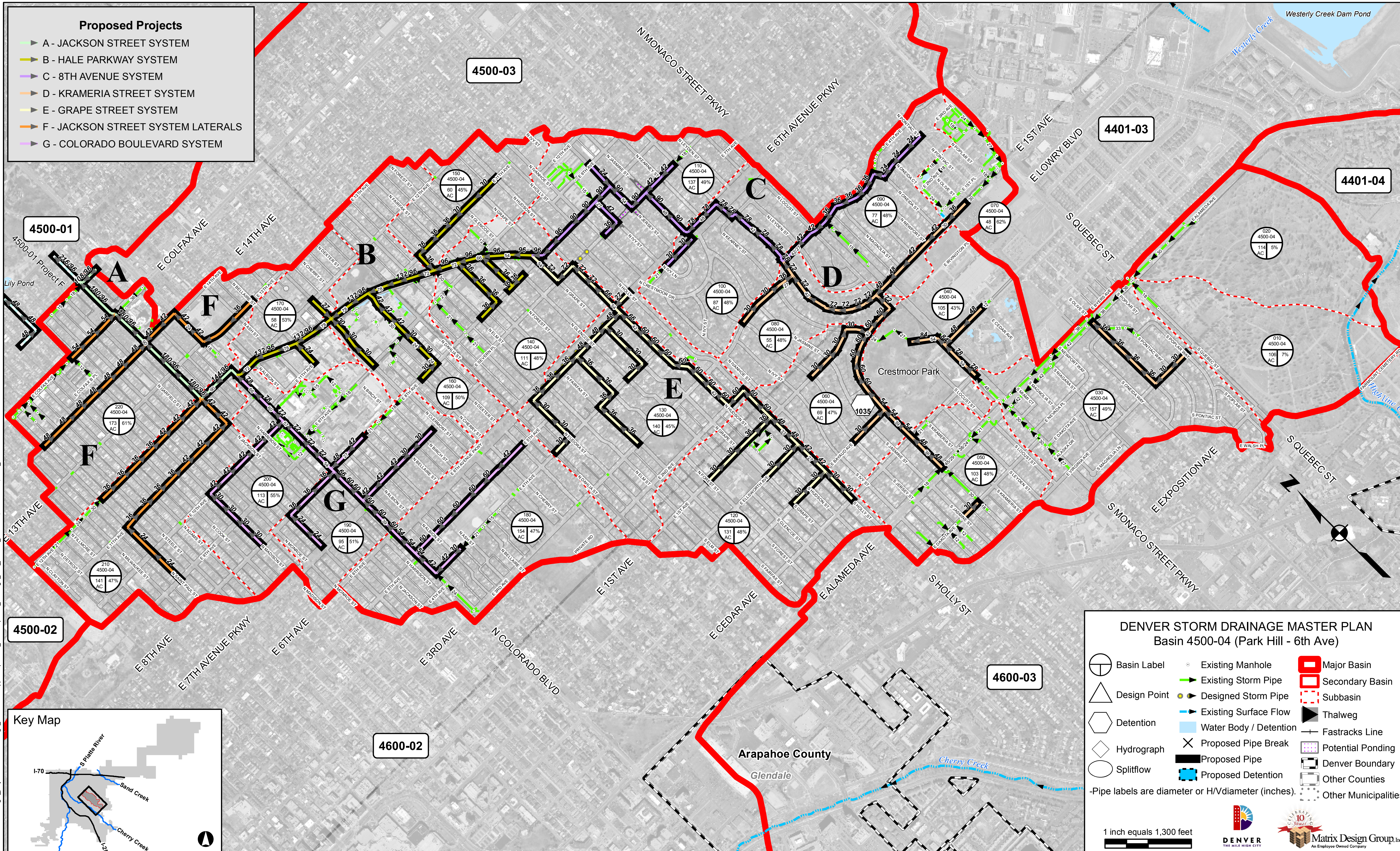
Project C: 8th Avenue System
The 8th Avenue project is located in the eastern portion of Basin 4500-04 and collects stormwater runoff in a trunk line that zigzags along 8th Avenue, Jersey Street, Severn Pl., Jasmine Street, 6th Avenue, Krameria Street, and 4th Avenue. The project contains approximately 301 acres of primarily residential land including subbasins 90 – 110. The primary upgrade within this project is a replacement trunk line and several laterals.

Project D: Krameria Street System
This project is located at the south portion of the basin 4500-04 and is primarily residential area and park area. The project contains approximately 773 acres of contributing area including sub-basins 10 – 80. The primary upgrade is the replacement of trunk line that runs along Krameria Street and Kearney Street and several laterals to service the unsewered areas.

Project E: Grape Street System
This project is located at the central portion of the basin 4500-04 and is primarily residential. The project includes approximately 345 acres of contributing area including subbasins 120, 130 and a portion of 140. The primary upgrade is the replacement of trunk line that runs along Grape Street and Holly Street between 8th Avenue and E. Cedar and several laterals to service the unsewered areas.

Project F: Jackson Street System Laterals
This project is located at the most north portion of the basin 4500-04 and is primarily residential area and commercial districts located along Colorado Boulevard. The primary improvement is to upgrade the existing laterals which are located in Colfax Avenue and 12th Avenue and proposed new laterals to be constructed in 14th Avenue and 11th Avenue to service the unsewered area.

Project G: Colorado Boulevard System
The Colorado Boulevard project is located in the northwest portion of the basin 4500-04 and collects stormwater runoff in a trunk line that runs along Colorado Boulevard. The tributary area is approximately 362 acres including subbasins 180,190, 200. The land use in this project bounds is primarily residential area with commercial districts are located along Colorado Boulevard. Primary improvement within this project includes a replacement of the trunk line in Colorado Boulevard and several new laterals to service the unsewered area.



FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activeapps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/24/2009, ron_ramold

Basin 0062-01/4500-02 (36th & Downing)

Existing System Description:
This basin includes a mix of industrial, commercial and residential land uses, and includes 2,574 tributary acres (4.02 square miles). The basin is fully built-out with older neighborhood residential in the upper reaches and commercial in the lower reaches. This basin includes Lower Downtown, Coors Field, rail yards, and a number of existing residential neighborhoods. It is characterized by terrace topography in the upper portions of the basin and near flat outfalls near the South Platte River. This condition results in inadvertent detention near the basin headwaters and surcharge of storm sewers in lower reaches.

Currently, most of the drainage (nearly 75% of the basin) outfalls through one 81-inch storm pipe at 36th Street. Design Point 1560 shows that 1,936 acres are tributary to this one outfall. This pipe has approximately 476 cfs capacity, but the hydrology indicates the flow will be 1,024 cfs in a 2-year event, and 1,727 cfs in a 5-year event (design flow). There are opportunities for regional water quality treatment off the existing 81-inch pipe near the South Platte outfall since it currently can convey a ½-inch rainfall (WQCV) over such a large developed basin area.

Drainage Deficiencies:
The existing drainage system has less than a 1-year capacity. Rainfall runoff in excess of the storm drain capacity has a history of ponding in the sump and flat areas. Many of the existing storm drains surcharge out the manholes during large storm events. Major drainage problems have been experienced in this basin, particularly north of Coors Field.

During a major storm event, split flow conditions exist in the basin, whereby storm runoff is exported and imported out and into this basin. For split flow condition, see the Hydrologic and Hydraulic Draft Report for Denver Union Station – 100-year Flood Protection by PB Americas, Inc., October 17, 2008 and the East Corridor Master Plan by PBS&J attached in the Technical Appendices.

Proposed Capital Improvements:
This basin requires improvements primarily to the outfall since the lateral network is currently extensive in this basin. The outfall should have 5-year capacity, whereas the lateral network through the residential areas should have a 2-year capacity.

The existing 81-inch outfall is undersized, and additional outfalls are needed to relieve the burden on the existing pipe. Constructing two new outfalls in this basin will reduce the tributary area of the existing outfall. Five major drainage projects are proposed for this basin as described below:

Project A: 31st Street Outfall includes a completely new 114-inch outfall in 31st Street. This proposed storm drain will continue up the basin in Downing Street and branch into new laterals around Children's Hospital. The existing pipe will be cut and plugged to provide additional capacity in the downstream system where the new pipe crosses the existing storm pipe. Work on this project should begin at the outfall and extend upward to improve the level of drainage service in the basin.

Project B: 27th Street Improvements includes maximizing the use of the newly constructed 108-inch pipe in 29th Street for the Coors Field Parking Lot. Currently, the tributary area to the pipe is only 88 acres. The outfall will extend up 27th Street and then Washington Street and Clarkson Street with a 96-inch pipe transitioning down to smaller pipe up into the basin. This project also includes a new upsized pipe network in Market Street south of 27th Street and a new box and pipe network in Champa St south of 27th Street.

Project C: 36th Street Outfall includes replacing the existing outfall from an 78-inch pipe to a 102-inch pipe. Efforts were made to preserve this pipe by sending more stormwater to new outfalls, however, this became impractical, and the existing outfall must be replaced or a parallel pipe constructed.

Project D: East 33rd Avenue System includes balancing out the remainder of the basin tributary to the existing outfall. A new 42-inch pipe at 33rd and Downing Street will disconnect the existing pipe and convey runoff to the large 81-inch pipe in Downing. In addition, existing small storm drains are proposed to be replaced with 18-inch pipes to meet current drainage criteria and reduce maintenance.

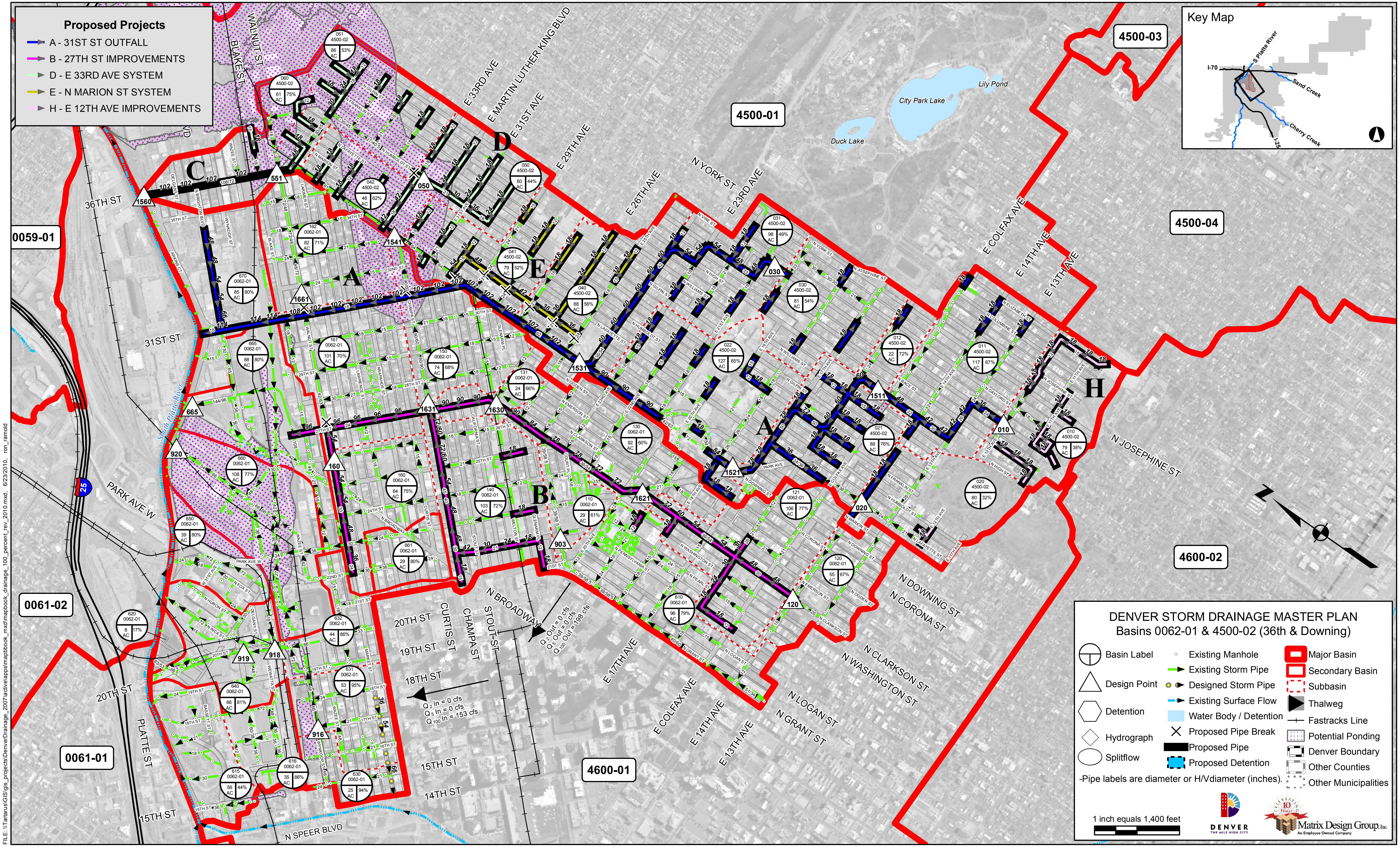
Project E: North Marion Street System includes balancing out the remainder of the basin tributary to the existing 36th Street outfall. A new pipe in Marion between 25th and 30th Avenues that varies from 48-inch to 36-inch will collect six laterals and convey runoff to the existing 64-inch pipe in Downing. Marion was selected as an appropriate alignment due to the apparent absence of existing utilities in the street corridor. In addition, existing small storm drains are proposed to be replaced with 18-inch pipes to meet current drainage criteria and reduce maintenance.

Project H: E. 12th Ave Improvements include replacing existing small pipes with 18-inch diameter pipes to meet current drainage criteria, improve collection/conveyance and reduce maintenance problems.

BASIN 0062-01, 4500-02 Existing Hydrology:

Design Point Minor Event Model	**Design Point** Overland Flow Model (PBS&J)	**Contributing Basins** Minor Event Model	**Tributary Area** Minor Event Model *(acres)*	**Peak Discharge*** **2-Year** *(cfs)*	**5-Year** *(cfs)*	**100-Year** *(cfs)*
10	NA	10	79	48	102	NA
20	NA	20	80	38	88	NA
30	NA	30	81	72	128	NA
50	NA	50	60	38	75	NA
120	NA	120	55	64	104	NA
160	NA	160	64	70	108	NA
551	36	10-51,110-162,610	1875	1021	1717	**2702**
610	NA	610	96	135	205	NA
615	NA	615	56	33	65	NA
616	NA	616	35	52	76	NA
665	NA	665	88	94	142	NA
903	1120	610	96	135	205	**370**
920	NA	630, 631, 632, 640	190	224	327	NA
1320	NA	10-20	298	176	343	NA
1510	1660	110, 120, 121, 610	286	279	430	**1245**
1511	10	10,11	196	167	283	**542**
1521	NA	10-21	386	260	467	NA
1531	1530	10-31	692	421	641	**1716**
1541	NA	10-41,110-150,610	1436	847	1378	NA
1560	NA	10-60,110-162,610	1936	1024	1727	NA
1630	NA	110-130,610	378	354	560	NA
1631	1640	110-140,610	504	426	680	**1612**
1661	NA	160,161	165	163	260	NA

* 100-year discharge in **bold** represents analysis based on "overland" drainage paths determined from topography (see East Corridor Master Plan by PBS&J). Other events (2-year, 5-year, and remaining 100-year) are analyzed based on existing pipe network flow paths.



Proposed Projects
A - 31ST ST OUTFALL
B - 27TH ST IMPROVEMENTS
D - E 33RD AVE SYSTEM
E - N MARION ST SYSTEM
H - E 12TH AVE IMPROVEMENTS
Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
City Park Lake
Duck Lake
Lily Pond
4500-01
4500-03
4500-04
4600-01
4600-02
0059-01
0061-02
0061-01
36TH ST
31ST ST
PARK AVE W
20TH ST
15TH ST
PLATTE ST
N SPEER BLVD
E 33RD AVE
E MARTIN LUTHER KING BLVD
E 31ST AVE
E 29TH AVE
E 26TH AVE
E 23RD AVE
N YORK ST
E COLFAX AVE
E 14TH AVE
E 13TH AVE
E 17TH AVE
N JOSEPHINE ST
N DOWNING ST
N CORONA ST
N CLARKSON ST
N WASHINGTON ST
N LOGAN ST
N GRANT ST
N BROADWAY
CURTIS ST
CHAMPA ST
STOUT ST
20TH ST
19TH ST
18TH ST
15TH ST
14TH ST
WALNUT ST
BLAKE ST
South Platte River
Q_2 In = 0 cfs
Q_5 In = 0 cfs
Q_{100} In = 153 cfs
Q_2 Out = 0 cfs
Q_5 Out = 0 cfs
Q_{100} Out = 198 cfs
DENVER STORM DRAINAGE MASTER PLAN
Basins 0062-01 & 4500-02 (36th & Downing)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,400 feet
DENVER THE MILE HIGH CITY
Matrix Design Group, Inc. An Employee Owned Company
FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activeapps\mapbook_mxd\mapbook_drainage_100_percent_rev_2010.mxd, 6/23/2010, ron_ramold

Basin 4600-01 (Central Business District)

Existing System Description:
This basin consists of 1,709 acres (2.67 square miles) and is fully built-out within the Central Business District. The basin extends from 6th Avenue to the confluence with South Platte River along the Cherry Creek corridor. ***Blueprint Denver*** shows the downtown area subject to change. Only the small residential neighborhoods south of Colfax and west of Cherry Creek are shown as being “Areas of Stability”.

All formal drainage facilities from this basin outfall into Cherry Creek, but surface flows from the Downtown area drain to the South Platte River. Intercepted stormwater is discharged in at least 42 separate storm drainage outfalls into Cherry Creek. Some of the more major outfalls include:

- 16’x 4’ box culvert from the Pepsi Center
- 10’x 5’ box culvert recently constructed for the Convention Center up to 14th & Stout
- 96-inch pipe outfalling at 14th & Market Street draining large pipe in Larimer Street
- 54-inch pipe from Delgany Street
- 8’x5’ box culvert outfall recently constructed for 14th Avenue up to 13th Avenue and Delaware Street

The storm drain infrastructure consists of a network of separate outfalls and laterals in most streets. A grid pattern of laterals exists in the downtown area. As street improvements are constructed, inlets have been improved to current standard designs. Drainage from downtown is constrained by the elevation of the Cherry Creek floodplain elevation, which generally reduces capacity and creates sump or surcharge conditions during major storm events.

Drainage Deficiencies:
In general, the existing drainage system has capacity to convey the 2 to 5 to 100-year storm event to Cherry Creek. Redevelopment and current drainage criteria has required the construction of 100-year capacity outfalls, or at the least to construct the largest storm pipe possible.

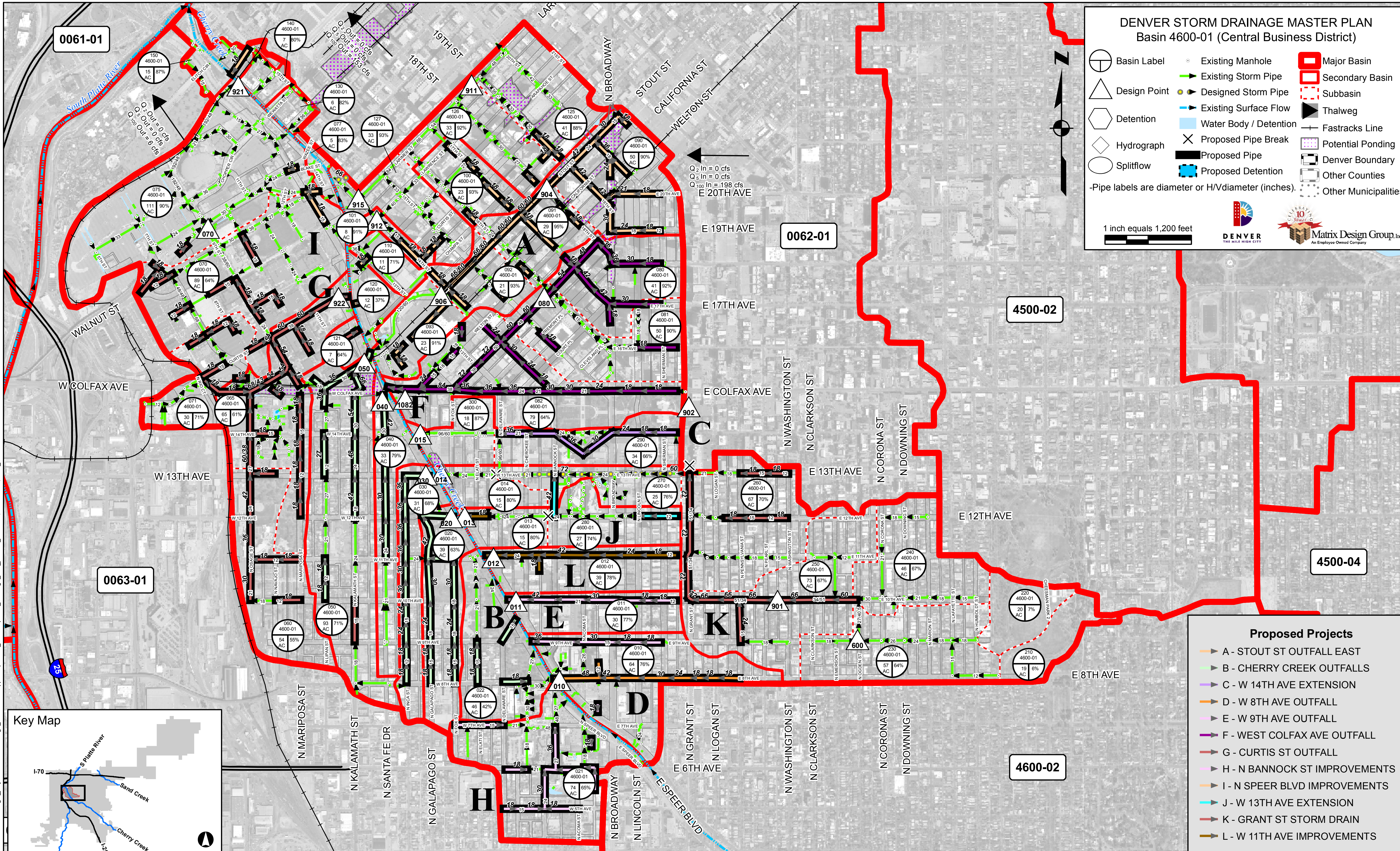
Proposed Capital Improvements:
This basin requires improvements primarily by increasing the capacity of the outfalls and lateral network. Outfalls through the commercial areas (and especially the Central Business District) should have a minimum 5-year capacity. Few opportunities exist for detention in this densely developed basin. Therefore, improvements have generally included upsizing conveyance facilities. Proposed projects include:

Project A: Stout Street Outfall A new 5-foot x 10-foot box culvert has recently been installed as part of redevelopment of the Convention Center to create an expanded outfall to Cherry Creek. The tributary sub-basins (90-93) comprise 103 acres that routes drainage directly via a 54-inch storm sewer to Stout & 14th Street. Split flow caused by limited capacity drains upgradient and local topography increases the tributary area to the new outfall to 287 acres. Improvements are needed to intercept this runoff and utilized the capacity of the new box culvert outfall.
Project B: Cherry Creek Outfalls Existing outfalls have 1-2 year capacity and should be upsized to 5-year capacity by criteria. In addition, all 12 and 15-inch pipes should be replaced with 18-inch pipes.
Project C: West 14th Avenue Extension A proposed 36-inch storm drain in 14th Avenue north of Delaware Street will improve the capacity of the existing 24-inch pipe.
Project D: West 8th Avenue Outfall The outfalls in 8th Street north of Cherry Creek should be upsized from and existing 24-inch pipe to a 48-inch pipe to provide 5-year protection.
Project E: West 9th Avenue Outfall The existing outfall in 9th Street north of Cherry Creek should be upsized from a non-standard 26-inch pipe (shown in the GIS) to a 36-inch pipe to provide 5-year protection.
Project F: West Colfax Avenue Outfall A new 84-inch outfall in Colfax north of Cherry Creek will replace the existing 38-inch outfall and provide 5-year capacity.
Project G: Curtis Street Outfall Basins 60 and 65 currently drain 119 acres via an existing 39-inch pipe. Upsizing this outfall to a 60-inch pipe would provide 5-year storm capacity. Alternatively, detention in Lincoln Park was considered to avoid upsizing the outfall. However, current land use in the park, existing trees and the ridge topography in the park have prompted the consideration of conveyance over detention.
Project H: N Bannock St Improvements Existing 12- and 15-inch pipes are proposed to be replaced with 18-inch pipes to meeting current drainage criteria and reduce maintenance.
Project I: N Speer Blvd Improvements Existing 12- and 15-inch pipes are proposed to be replaced with 18-inch pipes to meeting current drainage criteria and reduce maintenance.
Project J: West 13th Avenue Extension This is the upstream portion of 14th Avenue Outfall Project. This storm drain will capture runoff from 283.3 acres that were previously tributary to the storm pipe in Grant Street that in the past has outfalled to the South Platte River at 36th Street and conveys it to Cherry Creek. A proposed 60-inch pipe east of Broadway, transitioning to a 72-inch west of Broadway will replace the existing 24-inch storm drain and provide 5-year capacity. This project intercepts the existing storm drain in Grant Street at E. 13th Avenue, providing relief to the downstream system in Grant Street.
Project K: Grant Street Storm Drain This project collects runoff from the existing storm drains in 9th and 10th Avenues at Ogden Street and delivers runoff in a 5-year event to Project J in 13th Avenue. This project also includes upsizing the existing storm drain in Grant Street from 10th to 13th Avenue.
Project L: West 11th Avenue Improvements The existing outfall at the intersection of 11th Avenue and Speer Boulevard is capable of conveying storm runoff up to 5 year event, however, the existing pipes in the 11th Avenue east of Speer Boulevard are undersized and needed to be replaced with RCP ranging in size from 24-inch diameter to 48-inch diameter.

Hydrology Summary:
BASIN 4600-01

Design Point Minor Event Model	Design Point Overland Flow Model	Contributing Basins Minor Event Model	Tributary Area Minor Event Model (acres)	Peak Discharge Q2-yr (cfs)	Q5-yr (cfs)	Q100-yr (cfs)
10		10	64	70	109	246
11		11	30	41	62	139
12		12	39	47	72	160
13		13	15	19	29	65
14		14	15	19	29	64
20		20	39	32	54	132
30		30	31	25	41	97
40		40	33	37	56	125
50		50	93	96	152	351
70	NA	70	89	96	160	**NA**
80	NA	80	41	69	99	**NA**
904	NA	610,90	146	81	117	**NA**
906	1791*	610,80,81,90,91,92	287	99	126	**209***
911	NA	610,90,125	187	63	95	**NA**
912	NA	610,80,81,90,91,92,100,101	318	35	42	**NA**
915	1241*	610,80,81,90-92,100,101,125-127	425	147	213	**361***
921	1540**	70, 71, 75	230.3	234	327	**830****
922	1510**	60,65	118.5	73	121	**72****
1082	1590	80-82	170.2	157	201	**326**

Note: 100-year discharge in bold represents analysis based on "overland" drainage paths determined from topography. Other events (2-year, 5-year, and remaining 100-year) are analyzed based on existing pipe network flow paths. Since several pipe networks do not follow overland drainage paths, this differing approach in modeling could create significant differences in peak flow distribution between storm events.
* 100-year discharge results from Hydrologic and Hydraulic Draft Report for Denver Union Station – 100-year Flood Protection by PB Americas, Inc., October 17, 2008.
**100-year discharge results from the 4600-01 Major Event Model.


DENVER STORM DRAINAGE MASTER PLAN
Basin 4600-01 (Central Business District)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.
Proposed Projects
A - STOUT ST OUTFALL EAST
B - CHERRY CREEK OUTFALLS
C - W 14TH AVE EXTENSION
D - W 8TH AVE OUTFALL
E - W 9TH AVE OUTFALL
F - WEST COLFAX AVE OUTFALL
G - CURTIS ST OUTFALL
H - N BANNOCK ST IMPROVEMENTS
I - N SPEER BLVD IMPROVEMENTS
J - W 13TH AVE EXTENSION
K - GRANT ST STORM DRAIN
L - W 11TH AVE IMPROVEMENTS
Key Map
0061-01
0062-01
0063-01
4500-02
4500-04
4600-02
E 20TH AVE
E 19TH AVE
E 17TH AVE
E COLFAX AVE
E 13TH AVE
E 12TH AVE
E 8TH AVE
E 6TH AVE
W COLFAX AVE
W 13TH AVE
WALNUT ST
N BROADWAY
N LINCOLN ST
E SPEER BLVD
N GRANT ST
N LOGAN ST
N WASHINGTON ST
N CLARKSON ST
N CORONA ST
N DOWNING ST
N MARIPOSA ST
N KALAMATH ST
N SANTA FE DR
N GALAPAGO ST
STOUT ST
CALIFORNIA ST
WELTON ST
18TH ST
19TH ST
South Platte River
Cherry Creek
Sand Creek
I-70
I-25

Basin 4600-01/0062-01 (Central Business District) (Alternative 100-Year Basin)

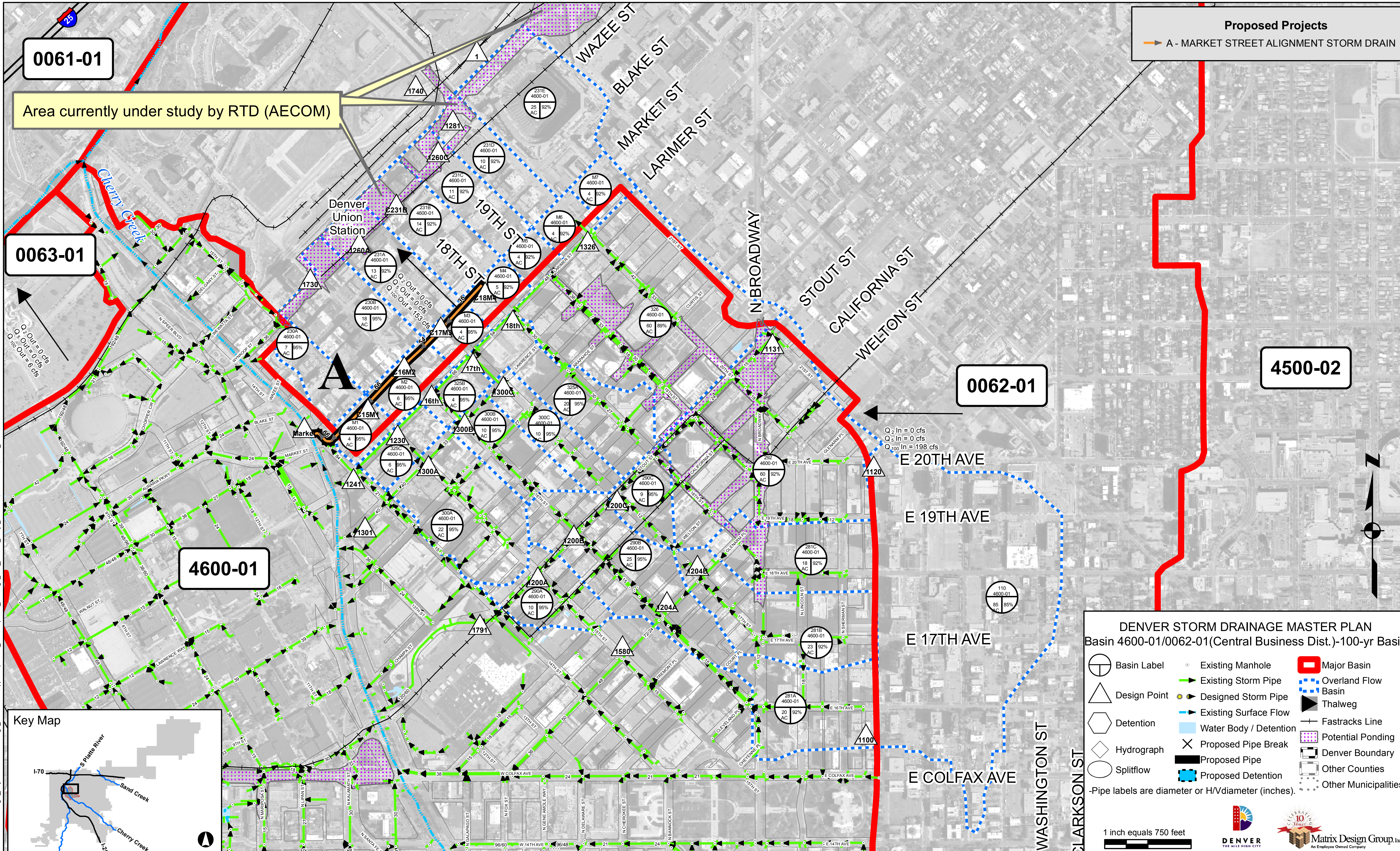
Alternative System to Protect Denver Union Station: Rainfall runoff in excess of the storm drain capacity has a history of ponding in the sump and flat areas of downtown. It could be argued that the Central Business District should have a higher level of storm drain capacity.

A 100-year storm drain system was proposed in the Hydrologic and Hydraulic Draft Report for Denver Union Station (DUS) 100-yr Flood Protection by PB Americas, Inc., October 17, 2008 (Please see Appendix A of the Basin 4600-01 Technical Appendices). The purpose of the proposed Denver Union Station 100-yr Flood Protection is to provide a system to convey runoff from the downtown area to remove flow from Wynkoop Street. The existing storm drain system in downtown Denver has the capacity to convey somewhere between the 2-year and 5-year storm event. Flow in excess of the existing system will continue as overflow and is conveyed west (toward DUS) in the streets. The proposed system would collect the excess runoff from east of Market Street and convey it to Cherry Creek. By collecting the overflow at Market Street, the existing storm drain in Wynkoop Street will have the capacity to convey the majority of the 100-year runoff from the area between Wynkoop Street and Market Street.

As of this publication, RTD which is the lead agency for DUS has contracted with AECOM to conduct an analysis if the potential ponding in front of DUS and areas to the north and east. The RTD study may identify additional improvement options that reduce ponding at DUS.

Hydrologic Summary Table:
Basin 4600-01 Major Event Model (Downtown – PB)

Concentration Point	Peak Discharge Q_{100}
1	483.0
1080	131.0
1100	94.0
1120	368.0
1131	385.0
1230	379.0
1281	884.0
1326	502.0
1730	143.0
1740	401.0
1200A	280.0
1200B	235.0
1200C	242.0
1204A	115.0
1204B	185.0
1241O	361.0
1260A	244.0
1260B	368.0
1260C	398.0
1300A	157.0
1300B	64.0
1300C	179.0
1301O	46.0
1580O	62.0
16th	264.0
1791O	209.0
17th	278.0
18th	169.0
C15M1	31.0
C16M2	44.0
C17M3	91.0
C18M4	79.0


Proposed Projects
A - MARKET STREET ALIGNMENT STORM DRAIN
0061-01
Area currently under study by RTD (AECOM)
0063-01
0062-01
4500-02
4600-01
Denver Union Station
Cherry Creek
A
WAZEE ST
BLAKE ST
MARKET ST
LARIMER ST
19TH ST
18TH ST
N BROADWAY
STOUT ST
CALIFORNIA ST
WELTON ST
E 20TH AVE
E 19TH AVE
E 17TH AVE
E COLFAX AVE
N WASHINGTON ST
CLARKSON ST
Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
DENVER STORM DRAINAGE MASTER PLAN
Basin 4600-01/0062-01(Central Business Dist.)-100-yr Basin
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Overland Flow Basin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 750 feet
DENVER
Matrix Design Group, Inc.

Basin 4600-02 (Cherry Creek Mall)

Existing System Description:
This basin consists of 2,928 acres (4.58 square miles) and is fully built-out. The basin extends from Colorado Boulevard to 6th Avenue along the Cherry Creek corridor and includes the Denver Country Club and the Cherry Creek Mall in the center of the basin. ***Blueprint Denver*** shows the area bounded by Colorado Boulevard, 6th Avenue, York Street and Cherry Creek as an "Area of Change." The remainder (over two-thirds of the basin) is shown as being an "Area of Stability".

All drainage from this basin outfalls to Cherry Creek. Intercepted stormwater is discharged in over 24 separate storm drainage outfalls into Cherry Creek. Some of the more major outfalls include:

- 5'x8' box culvert at 1st and N. Downing Parkway
- 56-inch pipe at 1st and Marion Street
- 66-inch pipe from Cherry Creek Mall at University Boulevard and Cherry Creek
- 60-inch pipe from the east side of the Cherry Creek Mall near Steele Street.
- 3'x 8' box culvert in Steele Street.
- 48"x76" elliptical pipe in Colorado Boulevard north of Cherry Creek
- 66-inch pipe at Garfield Street and Cherry Creek
- 42-inch pipe from University Boulevard south of Cherry Creek
- 72-inch pipe from Washington Street south of Cherry Creek draining 618 acres

Drainage Deficiencies:
Storm drain infrastructure in this basin has undersized outfalls and incomplete networks of storm drain laterals. The Cherry Creek North area (north of the mall) has been prone to flooding and frequent complaints. Basins north of the Denver Country Club (Basins 80, 85, 90, 91, 92 and 100) still comprise 270 acres that drain to an undersized existing 56-inch storm sewer and a drainage study has been initiated to investigate this area in greater detail for both the minor and major (100-year) storm events. Portions of basins 230 through 260 have been re-directed by pipe flow to Cherry Creek, diverting flow from the topographic I-25 basin. This creates a *split-flow* condition that causes shallow overland flooding during major storm events where the storm sewer capacity is exceeded.

Proposed Capital Improvements:
Denver Water Board no longer uses the portion of City Ditch pipeline north of Cherry Creek between Denver Country Club and City Park. Reuse of this line was evaluated for the potential to provide stormwater conveyance or underground detention; however, it was found to have very little benefit for drainage. The reach from 8th Avenue south to Cherry Creek has potential reuse as a storm drain if inlets are connected to the pipeline. The average slope is 1% in this reach, which could provide a new outfall with approximately 40 cfs capacity. However, half the reach (from Speer to 5th Avenue) appears to be lower than Cherry Creek, thereby creating outfall problems.

The following projects are proposed to raise the level of service and meet current drainage criteria:

<u>Project A: Downing Street Outfall</u> Construct a new 48-inch outfall at Downing south of Cherry Creek to take some burden off the existing 72-inch pipe in Washington Street draining 578 acres (DP 1760), and provide adequate outlets for existing sumps in the alleys south of Alameda between Lafayette and Franklin.

<u>Project C: East 5th Avenue Outfall</u> Construct additional storm drains in Broadway discharging into Cherry Creek to alleviate known ponding problems.

<u>Project D: East 6th Avenue Outfall</u> Upsize the existing 39-inch outfall to a 72-inch pipe.

<u>Project E: East Cedar Avenue</u> Extend laterals on existing storm drains into the neighborhood.

<u>Project G: East Exposition Improvements</u> Extend the local storm sewer network starting at the existing drain at E. Center and S. Williams, extending upstream in Cedar, Vine and Exposition past Milwaukee.

<u>Project H: Colorado Boulevard Outfall</u> Construct a new 5' x 3' box culvert outfall in Colorado Blvd.

<u>Project I: University Outfall</u> The existing storm drain system north of the Cherry Creek Mall is often overwhelmed. A new 60-inch outfall in University is necessary to prevent nuisance flooding and provide the standard 5-year level of service. Also included in this project is a trunk line in E. 4th Avenue and laterals in N. Detroit Street, E. 5th Avenue and E. 6th Avenue. This alignment was identified in the Cherry Creek Neighborhood Drainage Study by PBS&J.

<u>Project J: 5th Avenue Improvements</u> An existing 24-inch storm drain system in 5th Avenue should be replaced with a new 42-inch pipe.

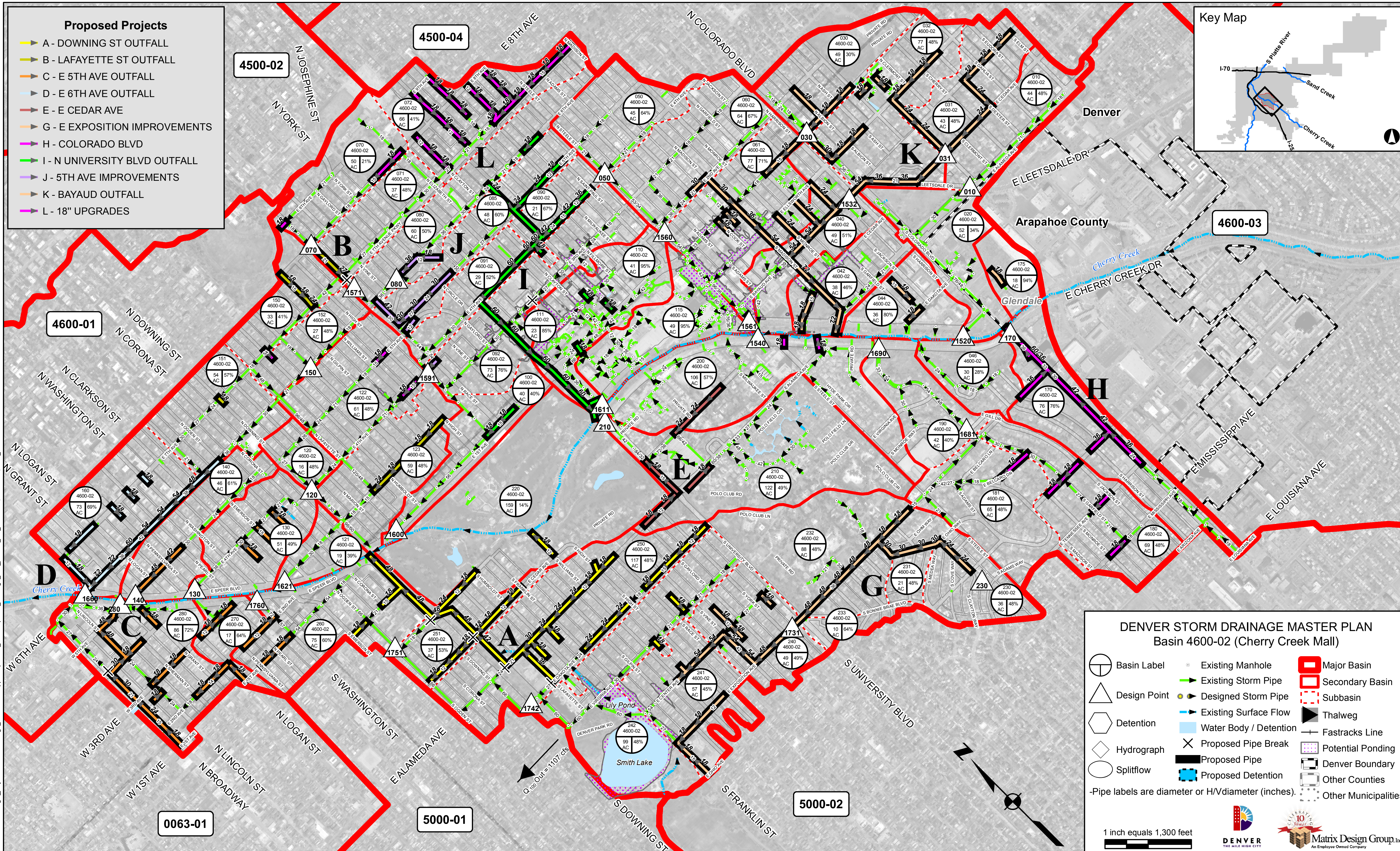
<u>Project K: Bayaud Outfall</u> This project includes trunk lines in N. Madison Street and E. Bayaud Avenue and laterals extending up into the basin as far east as S. Elm Street. The trunk main in S. Madison Street was proposed in the Cherry Creek Neighborhood Drainage Study by PBS&J.

<u>Project L: 18" Upgrades</u> Existing 12-inch and 15-inch pipes in 7th & 8th Avenues are proposed to be upgraded with 18-inch pipe to meet current criteria, improve conveyance and reduce maintenance.

<u>BASIN 4600-02</u>

Design Point Minor Event	**Design Point** Overland Flow	**Contributing Basins** Minor Event Model	**Tributary Area** Minor Event (acres)	**Peak Discharge** Q2-yr (cfs)	Q5-yr (cfs)	Q100-yr (cfs)
10	*See PBS&J Model	10	44	28	53	See PBS&J Model
30	*See PBS&J Model	30	49	20	48	See PBS&J Model
31	*See PBS&J Model	31	43	26	49	See PBS&J Model
50	*See PBS&J Model	50	45	39	66	See PBS&J Model
72		72	66	44	91	256
80	*See PBS&J Model	80	60	39	73	See PBS&J Model
120		120	16	11	21	56
130		130	51	36	68	184
140		140	46	37	63	156
170		170	76	67	104	239
210		210	122	82	154	409
230	*See Overland Flow Model	230	36	22	42	See Overland Flow Model
280		280	86	89	141	326
1520	*See PBS&J Model	10,20	96	45	83	See PBS&J Model
1532		30-32	169	86	174	507
1540	*See PBS&J Model	30-40	218	83	168	See PBS&J Model
1560		50,60	109	105	173	389
1561	*See PBS&J Model	50-61	185	149	229	See PBS&J Model
1571		70,71,72,150	185	84	162	490
1591	*See PBS&J Model	80,85,90,91	158	117	193	See PBS&J Model
1600		80,85,90,91,92,100	270	141	240	685
1611	*See PBS&J Model	110, 111	65	93	131	See PBS&J Model
1621		120, 121	35	17	35	90
1623		70,71,72,122,123,150,152	332	144	241	729
1660		151, 160	127	107	175	398
1681		180181	133	90	168	463
1690		180-190	175	110	185	545
1731	*See Overland Flow Model	230, 231, 232, 233	155	94	167	See Overland Flow Model
1742	*See Overland Flow Model	230-242	360	158	266	See Overland Flow Model
1751	*See Overland Flow Model	230-251	514	211	349	See Overland Flow Model
1760	*See Overland Flow Model	230-260	589	211	359	See Overland Flow Model

* 100-year discharge analyses based on overland drainage paths determined from topography were done in separated models, 5000-01 Overland Flow Model & Cherry Creek Drainage Basin Implementation Study by PBS&J. Other events (2-year, 5-year, and remaining 100-year) are analyzed based on existing pipe network flow paths. Since several pipe networks do not follow overland drainage paths, this differing approach in modeling could create significant differences in peak flow distribution between storm events.


Proposed Projects
A - DOWNING ST OUTFALL
B - LAFAYETTE ST OUTFALL
C - E 5TH AVE OUTFALL
D - E 6TH AVE OUTFALL
E - E CEDAR AVE
G - E EXPOSITION IMPROVEMENTS
H - COLORADO BLVD
I - N UNIVERSITY BLVD OUTFALL
J - 5TH AVE IMPROVEMENTS
K - BAYAUD OUTFALL
L - 18" UPGRADES
Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
4500-04
4500-02
4600-01
4600-03
5000-01
5000-02
0063-01
Denver
Arapahoe County
Glendale
Cherry Creek
E CHERRY CREEK DR
E LEETSDALE DR
N COLORADO BLVD
E MISSISSIPPI AVE
E LOUISIANA AVE
S UNIVERSITY BLVD
S FRANKLIN ST
S DOWNING ST
E ALAMEDA AVE
S WASHINGTON ST
N LOGAN ST
N LINCOLN ST
N BROADWAY
W 1ST AVE
W 3RD AVE
W 6TH AVE
N GRANT ST
N WASHINGTON ST
N CLARKSON ST
N CORONA ST
N DOWNING ST
N YORK ST
N JOSEPHINE ST
E 8TH AVE
Smith Lake
Lily Pond
Q 100 Out = 1107 cfs
DENVER STORM DRAINAGE MASTER PLAN
Basin 4600-02 (Cherry Creek Mall)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,300 feet
DENVER
THE MILE HIGH CITY
Matrix Design Group, Inc.
An Employee Owned Company

Basin 4600-03 (Upper Cherry Creek)

Existing System Description:
This basin consists of 3,563 acres (5.57 square miles) and is one of the newer development regions of the entire study area. For this reason, outfalls generally have more capacity than some of the older sections of the City. Nonetheless, many of the outfalls do not meet current drainage criteria and laterals need to be extended further up into the basin. The lower reach of this basin is outside Denver limits in the City of Glendale. The upper reaches of the basin are in Aurora. All drainage from this basin outfalls to Cherry Creek downstream of the Cherry Creek dam.

Most of this basin has been developed into neighborhood residential and parks. ***Blueprint Denver*** shows the entire basin as an "Area of Stability". No areas have been identified as "Areas of Change".

This basin is characterized by smaller tributaries to Cherry Creek with travel paths generally less than 1 mile to each outfall. This reach of the Cherry Creek basin includes the Goldsmith Gulch outfall; however, the Phase I Study Area excludes areas tributary to Goldsmith Gulch. Intercepted stormwater is discharged in at least 19 separate storm drainage outfalls. Major outfalls larger than 36-inch include the following:

- 54-inch in Birch Street south of Cherry Creek with 80 tributary acres (DP 250)
- 60-inch in Cherry Street south of Cherry Creek with 98 tributary acres (DP 240)
- 72-inch in Cherry Street north of Cherry Creek with 135 tributary acres (DP 1621)
- 72-inch in Exposition Avenue north of Cherry Creek with 599 tributary acres (DP 1611)
- 42-inch in Kentucky Avenue south of Cherry Creek with 45 tributary acres (DP 220)
- 42-inch in Mississippi Avenue south of Cherry Creek with 248 tributary acres (DP 1701)
- 36-inch in Honey Avenue south of Cherry Creek with 206 tributary acres (DP 1671)
- 42-inch through Garland Park north of Cherry Creek with 32 tributary acres (DP 70)
- 34"x53" elliptical near Niagara Street north of Cherry Creek with 62 acres (DP 60)
- 72-inch in Florida Avenue north of Cherry Creek with 532 tributary acres (DP 1551)
- 42-inch in Oneida Avenue south of Cherry Creek with 41 tributary acres (DP 160)
- 60"x38" elliptical near Quebec Street north of Cherry Creek with 88 acres (DP 20)

The existing storm drain infrastructure consists of a numerous large outfalls. Priority improvements in this basin are to extend the laterals further up into the basin. Next priority is to upsize outfall for the standard level of service. No opportunities for regional detention were identified in this basin.

Recent drainage infrastructure improvements by Denver in this basin include implementation of the 1989 Master Plan project known as "Virginia Village." This project included extending storm drains into the neighborhood south of Cherry Creek between Holly and Monaco Streets.

Drainage Deficiencies:
Localized drainage problems have been reported according to the complaints database. The most significant is located in the parking lot of a shopping plaza on the east side of S. Oneida north of E. Tennessee.

Proposed Capital Improvements:

Project A: E. Exposition Avenue Outfall includes upsizing the existing 72-inch outfall to 84-inch and extending laterals on existing outfalls (Exposition and North Cherry Streets). Storm pipes should also be extended north of Leetsdale Drive.

Project B: Forest Street Outfall includes upsizing the existing 42-inch outfall to a 48-inch pipe and then into a 4'x4' box culvert near Potenza Park. The project also includes extending the laterals further into the basin.

Project C: Holly Street Outfall includes a new 36-inch outfall west of the Garland Park.

Project D: Honey Way Outfall includes replacing 12 and 15-inch pipes with 18-inch pipes. Most of the major drainage improvements have recently been constructed in this area.

Projects E: Florida Avenue Outfall includes re-routing and existing storm drain to a new outfall in Quebec Street, north of Cherry Creek. The project includes replacement of an existing 24-inch outfall with a 66-inch pipe. Improvements include extension of the storm drain lateral network further into the basin. Large stub-outs have been shown at the City limits for Aurora to extend. This project should be undertaken if and when S. Quebec Street Improvements are done.

Project F: Oneida Street Outfall includes extension of the storm lateral network to reduce potential ponding at the intersection of Oneida and Mexico.

Project G: Vale Drive Outfall includes a new outfall east of the Historic Four Mile Park. Currently, runoff is collected in the residential neighborhood streets and a formal pipe outfall is necessary.

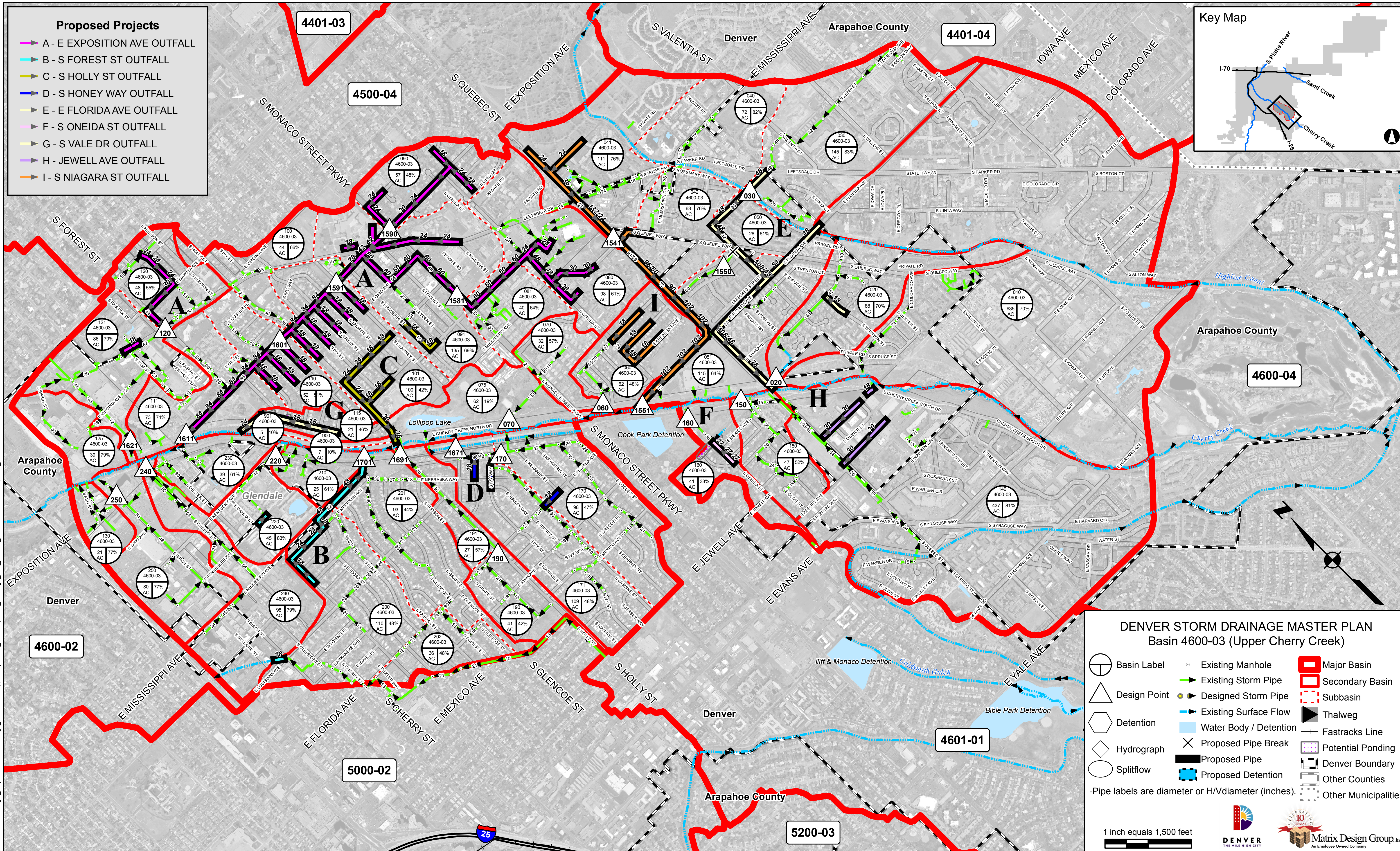
Project H: Jewell Avenue Outfall A new outfall is proposed in Quebec Street south of Cherry Creek. This pipe begins in Jewell Avenue and discharges via a 42-inch pipe.

Project I: Niagara Street Outfall includes replacement of an existing 72-inch outfall with a 90-inch pipe. Improvements include extension of the storm drain lateral network further into the basin, primarily along Quebec Street. This project should be undertaken if and when Quebec Street Improvements are completed.

Existing Hydrology:

BASIN 4600-03

Design Point	Contributing Basins	Tributary Area (acres)	Peak Discharge Q2-yr (cfs)	Q5-yr (cfs)	Q100-yr (cfs)
20	20	87.8	85	136	318
30	30	145.4	209	311	667
60	60	61.7	40	77	207
70	70	32.4	30	52	132
120	120	48.3	46	81	205
150	150	47.2	34	62	165
160	160	41.2	15	35	109
170	170	97.7	60	114	308
190	190	40.6	25	51	143
220	220	44.9	61	91	197
240	240	98.2	132	199	439
250	250	79.6	88	135	304
1541	40,41	183	258	376	825
1550	30,50	171.8	225	344	762
1551	30-51	532.3	366	596	1,584
1581	80,81	137.8	112	197	518
1590	80-90	195.1	109	198	588
1591	80-91	329.7	245	395	1,066
1601	80-101	473.5	306	527	1,462
1610	80-110	525.8	332	580	1,622
1611	80-111	598.5	355	616	1,807
1621	120-121	134.8	139	215	479
1670	70	32.4	26	43	120
1671	170, 171	206.4	119	225	641
1701	200, 201, 202	240	145	273	810



DENVER STORM DRAINAGE MASTER PLAN
Basin 4600-03 (Upper Cherry Creek)
Proposed Projects
A - E EXPOSITION AVE OUTFALL
B - S FOREST ST OUTFALL
C - S HOLLY ST OUTFALL
D - S HONEY WAY OUTFALL
E - E FLORIDA AVE OUTFALL
F - S ONEIDA ST OUTFALL
G - S VALE DR OUTFALL
H - JEWELL AVE OUTFALL
I - S NIAGARA ST OUTFALL
Key Map
I-70
S Platte River
Sand Creek
Cherry Creek
I-25
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,500 feet
DENVER
THE MILE HIGH CITY
Matrix Design Group, Inc.
An Employee Owned Company
4401-03
4401-04
4500-04
4600-02
4600-04
4601-01
5000-02
5200-03
Denver
Arapahoe County
Glendale
Lollipop Lake
Cook Park Detention
Iliff & Monaco Detention
Bible Park Detention
Highline Canal
Cherry Creek
Goldsmith Gulch
S FOREST ST
S MONACO STREET PKWY
S QUEBEC ST
E EXPOSITION AVE
S VALENTIA ST
E MISSISSIPPI AVE
IOWA AVE
MEXICO AVE
COLORADO AVE
E JEWELL AVE
E EVANS AVE
E YALE AVE
S HOLLY ST
S GLENCOE ST
E MEXICO AVE
S CHERRY ST
E FLORIDA AVE
E MISSISSIPPI AVE
EXPOSITION AVE

Basin: 4600-04 (Cherry Creek Reservoir)

Existing System Description:
There are numerous existing outfalls into Cherry Creek in this basin. The major outfalls east of Cherry Creek include a 72” in Dartmouth Avenue and a 60” adjacent to the Highline Canal. Major outfalls west of Cherry Creek include a 66” drain in Havana Street that ties into an open channel tributary to Cherry Creek, a 68”x 43” box in Yosemite Street, and a 53”x34” box in Yale Avenue.

Major outfalls west of Cherry Creek that are currently being designed are a 72” in Girard Avenue and an 8’x3’ RCB between Chester Court and Dayton Court.

There are three detention ponds within this major basin. The first is located at the intersection of Hampden Ave and Dayton Street in the Hampden Town Center. An outflow hydrograph from this point (Hydrograph output Pond 201 in the Amended Master Drainage Report for Hampden Town Center by Turner Collie Braden, Revised August 13, 2002) was input into the hydrologic model from the “Hampden Heights Area – Flood Investigation and Improvement Plan” by Matrix Design Group and PBS&J. The second detention pond is also located near the intersection of Hampden Ave and Dayton Street The storage / discharge relationship for this pond was also found in the “Hampden Heights Area – Flood Investigation and Improvement Plan”. The third detention basin is located on the Kennedy Ball Fields near the intersection of S. Parker Rd. and Dartmouth Avenue The storage / discharge relationship for this pond was determined from the as-built plans and Denver’s 2004 topographic mapping. The detention pond located on the Kennedy Ballfield was not designed for a 100-year storm event. In a major storm event, flows will overtop the west end of detention basin and flow overland through the John F. Kennedy Golf Course to Cherry Creek. Excerpts from the “Hampden Heights Area – Flood Investigation and Improvement Plan” and calculations for the Kennedy Ball Field pond can be found in the Technical Appendix for this basin.

Drainage Deficiencies:
The storm drain system beginning just south of the intersection of Parker Road and Dartmouth Avenue is undersized for handling the 2-year flows even with the Kennedy Ballfield detention basin. An area of approximately 462 acres (DP 250) drains to the upper portion of the system and an area of 637 acres (DP 280) drains to the lower portion of the system. The upper portion of the system consists of 54-inch storm pipe with capacity for 249 cfs. The 2-year flow for this reach is 314 cfs. The lower portion of the system is also a 54-inch storm pipe with a capacity of 279 cfs and a design flow for the 5-year event is 451 cfs.

A majority of the deficiencies identified in the 2005 master plan, will be alleviated with construction of the newly designed storm drain mainlines in Eastman Avenue and Girard Avenue which are currently programmed in the City’s Capital Improvement Program.

Proposed Capital Improvements:

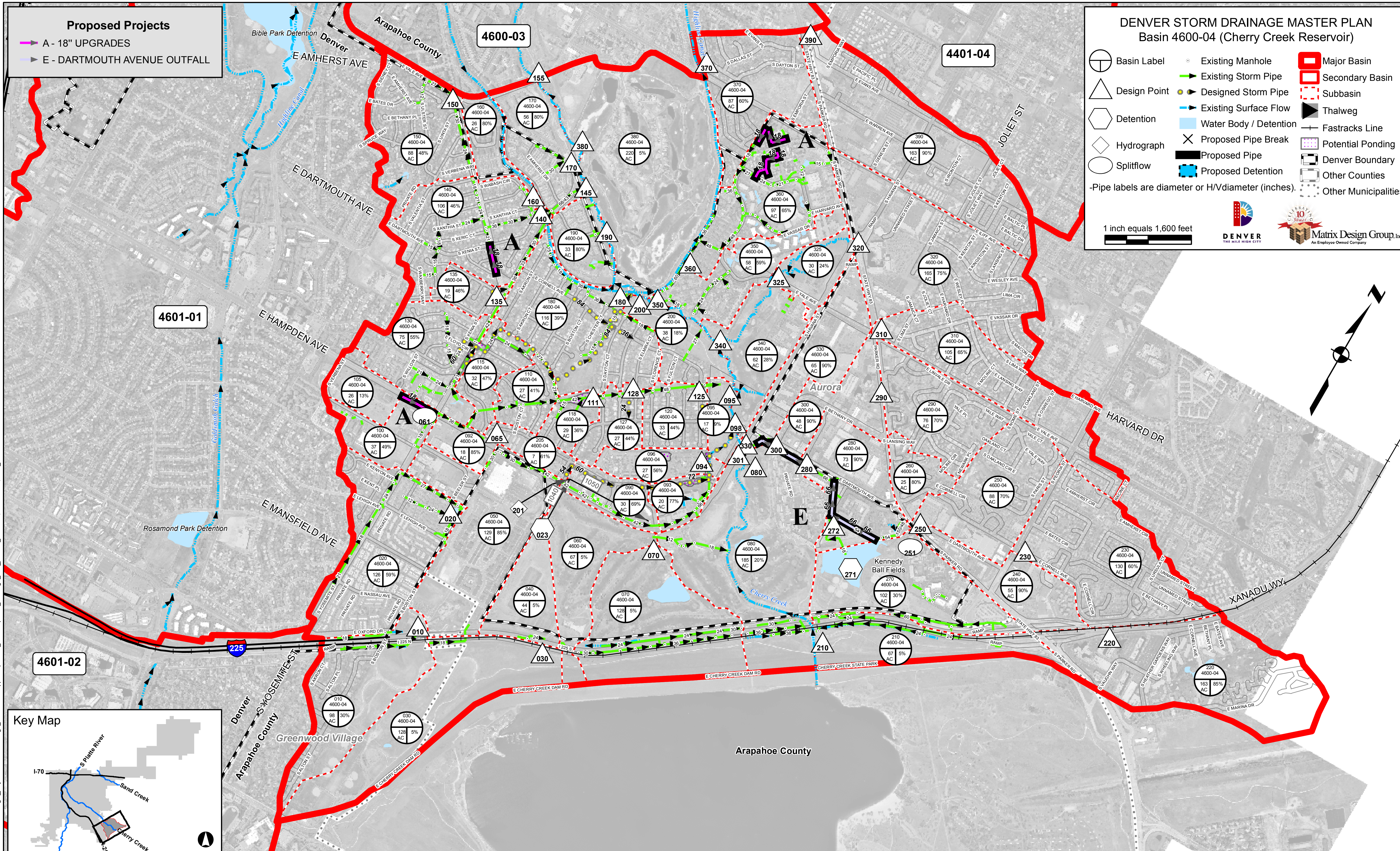
Project A: 18-Inch Upgrades Upsizing various pipes to the City’s 18-inch minimum diameter is proposed to meet current drainage criteria.

Project E: Dartmouth Ave. Outfall The 54”/60”/66”/72” system in Dartmouth Avenue east of Cherry Creek needs to be improved to convey a 2-year flow of 314 cfs in the upper reaches and a 5-year flow of 451 cfs in the lower reaches. Several of the undersized reaches of pipe in this system are propose to be upsized.

Existing Hydrology:

BASIN 4600-04

Design Point	Contributing Basins	Tributary Area (acres)	Peak Discharge 2-Year (cfs)	5-Year (cfs)	100-Year (cfs)
10	10	98	31	73	233
20	20	126	125	215	541
23	40	44	0	8	33
30	30	129	3	27	128
61	100, 105	63	27	56	171
65	92	81	26	39	100
70	30, 60, 70	324	10	98	431
80	80	185	29	90	326
94	10, 20, 40, 50, 90, 92, 93, 96, 205	209	98	161	386
95	95	17	1	8	33
98	10, 20, 40, 50, 90, 92, 93, 96, 205	209	94	152	379
111	100, 105, 118	29	36	74	148
125	100, 105, 118, 120, 127	89	60	104	279
128	100, 105, 118, 127	57	49	92	219
135	135	19	12	24	65
140	135, 140	126	85	163	456
145	135, 140	126	86	168	459
150	150	88	53	99	268
155	150	88	51	96	256
160	160	26	29	43	96
170	170	56	80	120	262
180	180	116	73	155	448
190	190	33	46	69	152
200	200	38	7	25	90
201	10, 20, 50	0	33	33	33
210	210	67	4	34	145
220	220	163	237	349	741
230	230	130	119	204	501
250	220, 230, 240, 250, 260	462	455	671	1,589
251	220, 230, 240, 250, 260	462	453	667	1,591
271	270, 251	102	19	24	32
272	220, 230, 240, 250, 251, 260, 270	564	323	331	340
280	220, 230, 240, 250, 260, 270, 280	637	395	451	618
290	290	76	67	108	253
300	220, 230, 240, 250, 260, 270, 280, 290, 300	760	507	627	970
301	220, 230, 240 250, 260, 270, 280, 290, 300	760	499	640	982
310	310	105	97	161	386
320	310, 320	271	256	411	971
325	310, 320, 325	300	254	419	1,030
330	330	65	78	113	238
340	310, 320, 325, 340	362	241	419	1,105
350	350, 360	155	141	237	568
360	360	97	98	162	391
370	370	87	77	132	324
380	380	220	9	83	372
390	390	163	216	314	657
1050	10, 20, 40, 50	44	33	38	65


DENVER STORM DRAINAGE MASTER PLAN
Basin 4600-04 (Cherry Creek Reservoir)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,600 feet
DENVER THE MILE HIGH CITY
Matrix Design Group, Inc.
Proposed Projects
A - 18" UPGRADES
E - DARTMOUTH AVENUE OUTFALL
4600-03
4401-04
4601-01
4601-02
Arapahoe County
Denver
Aurora
Greenwood Village
E AMHERST AVE
E DARTMOUTH AVE
E HAMPDEN AVE
E MANSFIELD AVE
HARVARD DR
XANADU WAY
JOLIET ST
S YOSEMITE ST
Bible Park Detention
Rosamond Park Detention
Kennedy Ball Fields
Cherry Creek
E CHERRY CREEK DAM RD
Key Map
S Platte River
Sand Creek
Cherry Creek
I-70
225

Basin: 4601-01 (Lower Goldsmith Gulch)

Existing System Description:
This portion of Goldsmith Gulch basin has a total drainage area of about 4.04 square miles. It is the lower portion of Goldsmith Gulch from I-25 and I-225 to Cherry Creek. The basin is located in the southeast Denver metropolitan area within the City and County of Denver. The main stream of Goldsmith Gulch starting from Orchard Road and continuing northward is tributary to Cherry Creek. The confluence with Cherry Creek is located near Monaco Boulevard. The entire basin extends from Cherry Creek about 8 miles southeast to Arapahoe Road. Seventeen roads and highways cross the gulch, along with the Highline Canal.

Drainage Deficiencies:
Many improvements and regional detention facilities have been constructed on Goldsmith Gulch that have minimized the flood hazard risk to structures. Only a few structures are located within the floodplain. Localized drainage problems occur in the residential area within basins 590, 610, 440 and 360.

Chronic flooding is reported in the parking lot of apartments located downstream of the existing detention basin at East Iliff and South Monaco. Increased capacity in the detention pond located within Bible Park was investigated and rejected due to lack of community support. Further study is underway for capacity enhancements at the E. Iliff and S. Monaco detention pond.

Additionally, chronic flooding has occurred on the west side of South Holly between Evans and Jewell. Drainage improvements are currently in design and will be constructed in conjunction with the S. Holly Street Improvements.

Proposed Capital Improvements:
This basin requires improvements primarily to upsize the existing storm sewer system from a 2-year capacity to a 5-year capacity.

Project A: 18-inch Upgrades Several existing storm sewers are required within the basin in order to meet Denver's stormwater criteria.

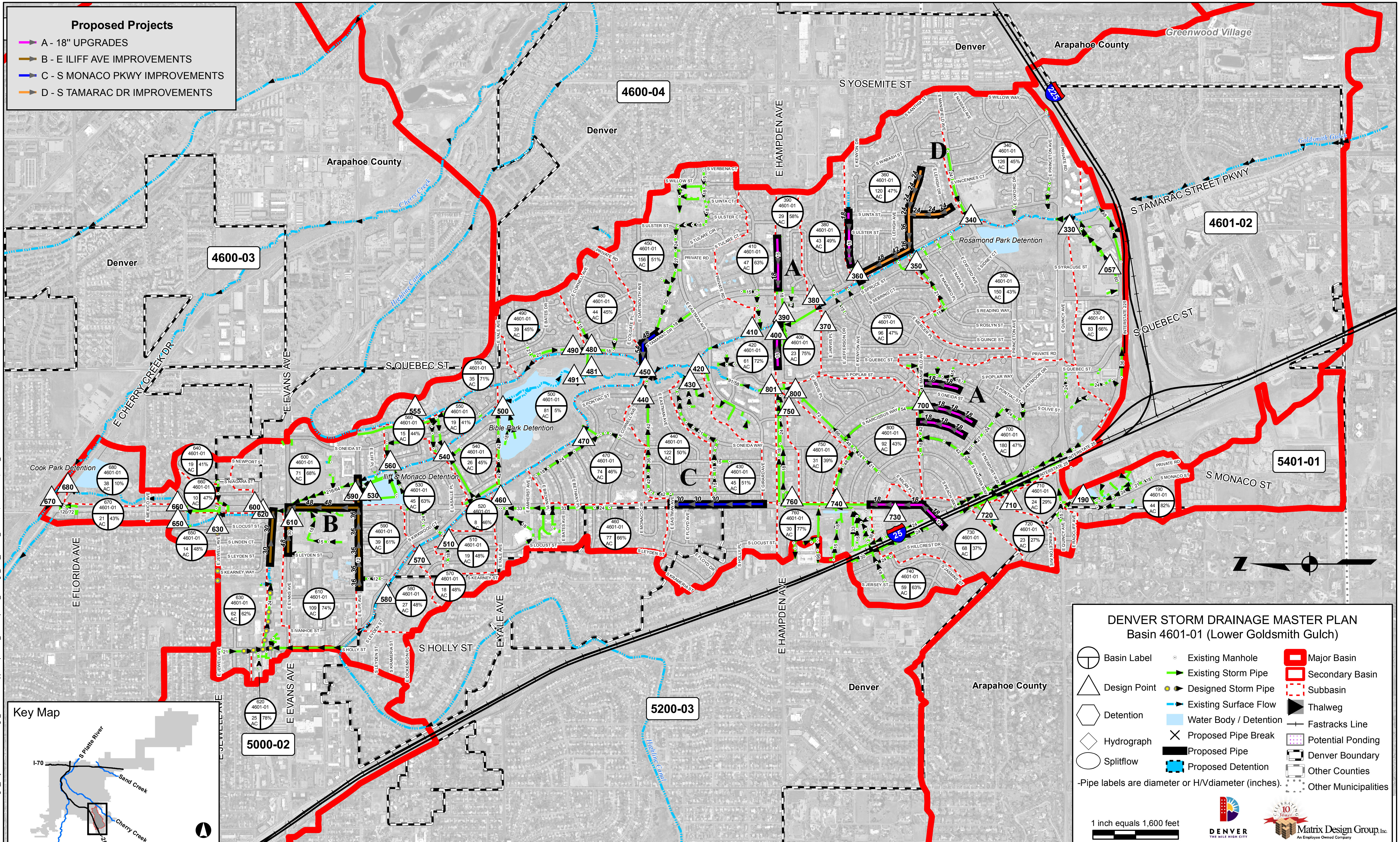
Project B: E. Iliff Avenue includes upsizing the existing lateral between Leyden Street and S. Monaco Parkway. This upgrade is required to meet the City's requirements for service to a commercial area. Similarly, a new storm sewer will be extended along E. Iliff Avenue from Kearney Street east to S. Monaco Parkway and connect to the existing storm sewer system that outfalls to Goldsmith Gulch. The system will extend up S. Monaco Parkway and connect to the proposed storm sewer in E. Iliff Avenue. This system is required to meet the City and County of Denver's minimum requirements for commercial areas.

Project C: S. Monaco Parkway Improvements requires a new 30-inch storm sewer to extend south along S. Monaco Parkway to E. Girard Avenue The system will include upsizing the existing system on E. Dartmouth Avenue from S. Monaco Parkway east to Goldsmith Gulch. The systems will meet Denver's minimum criteria for both residential and commercial developments

Project D: S. Tamarac Drive Improvements. A 2-year capacity system is required to adequately drain the residential area. A 24-inch lateral will be extended to the south along S. Uinta Street. A 48-inch storm sewer will be extended to and along S. Tamarac Drive to the north. The storm sewer will outfall to Goldsmith Gulch at S. Kenyon Drive and S. Tamarac Drive.

Existing Hydrology:

Design Point	Contributing Basins	Tributary Area	Peak Discharge		
			2-Year	5-Year	100-Year
		(acres)	(cfs)	(cfs)	(cfs)
57	T-REX INPUT HYDROGRAPH		30	42	81
330	330,TREX	83	103	168	410
340	340	126	76	150	409
350	350	150	65	128	370
360	360	120	77	147	397
370	370	96	58	111	300
380	380	43	26	49	131
390	390	29	22	38	96
400	400	23	39	61	138
410	410	47	37	62	152
420	420	61	60	94	218
430	430	45	27	49	131
440	440	122	68	124	336
450	450	156	109	202	533
460	460	77	58	95	231
470	470	74	47	91	249
480	480	44	29	55	154
490	490	39	24	46	128
491	480,490	83	51	102	96
500	500	81	5	47	201
510	510	19	13	25	67
520	520	8	5	10	28
530	530	45	49	85	214
540	540	26	18	34	95
550	550	19	11	23	66
555	555	35	32	50	117
560	560	15	9	18	51
570	570	18	11	20	55
580	580	27	17	31	85
590	590	39	32	54	132
600	600	71	67	108	256
610	610	109	137	216	491
620	620	25	27	41	93
630	630	62	50	85	209
640	640	19	11	23	66
650	650	14	10	19	51
660	660	10	7	14	38
670	670	21	10	21	59
680	680	38	4	21	83
700	700	180	95	180	497
710	710	24	8	19	60
720	720	23	8	19	62
730	730	68	29	63	186
740	730,740	112	75	139	379
750	750	31	14	29	86
760	760	30	32	49	110
800	800	92	40	79	226
801	700,710,720,730,740,750,760,800	492	252	487	1349


Proposed Projects
A - 18" UPGRADES
B - E ILIFF AVE IMPROVEMENTS
C - S MONACO PKWY IMPROVEMENTS
D - S TAMARAC DR IMPROVEMENTS
4600-04
4600-03
4601-02
5401-01
5200-03
5000-02
Denver
Arapahoe County
Greenwood Village
S YOSEMITE ST
E HAMPDEN AVE
S TAMARAC STREET PKWY
S QUEBEC ST
S MONACO ST
E CHERRY CREEK DR
E EVANS AVE
E FLORIDA AVE
E JEWELL AVE
E YALE AVE
S HOLLY ST
Rosamond Park Detention
Bible Park Detention
Iliff & Monaco Detention
Cook Park Detention
Cherry Creek
Highline Canal
Goldsmith Gulch
A
B
C
D
Key Map
I-70
S Platte River
Sand Creek
Cherry Creek
DENVER STORM DRAINAGE MASTER PLAN
Basin 4601-01 (Lower Goldsmith Gulch)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,600 feet
DENVER
Matrix Design Group, Inc.

Basin: 4601-02 (Middle Goldsmith Gulch)

The Goldsmith Gulch basin encompasses an area of 7.8 square miles from Arapahoe Road northwest to the confluence with Cherry Creek. Many channel improvements have been completed along Goldsmith Gulch to reduce the potential of flood damage. The channel has been stabilized and regional parks have been constructed in the floodplain. 100-year regional detention facilities have been constructed along the channel in Wallace Park upstream of I-225. Channel slopes are generally mild with several newer drop structures along the reach.

The upper portion of Goldsmith Gulch includes the recent I-25 TREX construction site. New storm sewer and detention facilities drain the I-225 and I-25 interchange to Goldsmith Gulch.

Existing System Description:
This section of the Goldsmith Gulch basin has a total drainage area of about 1.3 square miles. It is located in the southeast Denver metropolitan area and is entirely within the City and County of Denver. The main stem of Goldsmith Gulch flows under I-225 at DTC Boulevard and continues into the Lower Goldsmith Gulch Basin, which is tributary to Cherry Creek. The entire basin extends from Cherry Creek about 8 miles southeast to Arapahoe Road. Seventeen roads and highways cross the gulch along with the Highline Canal.

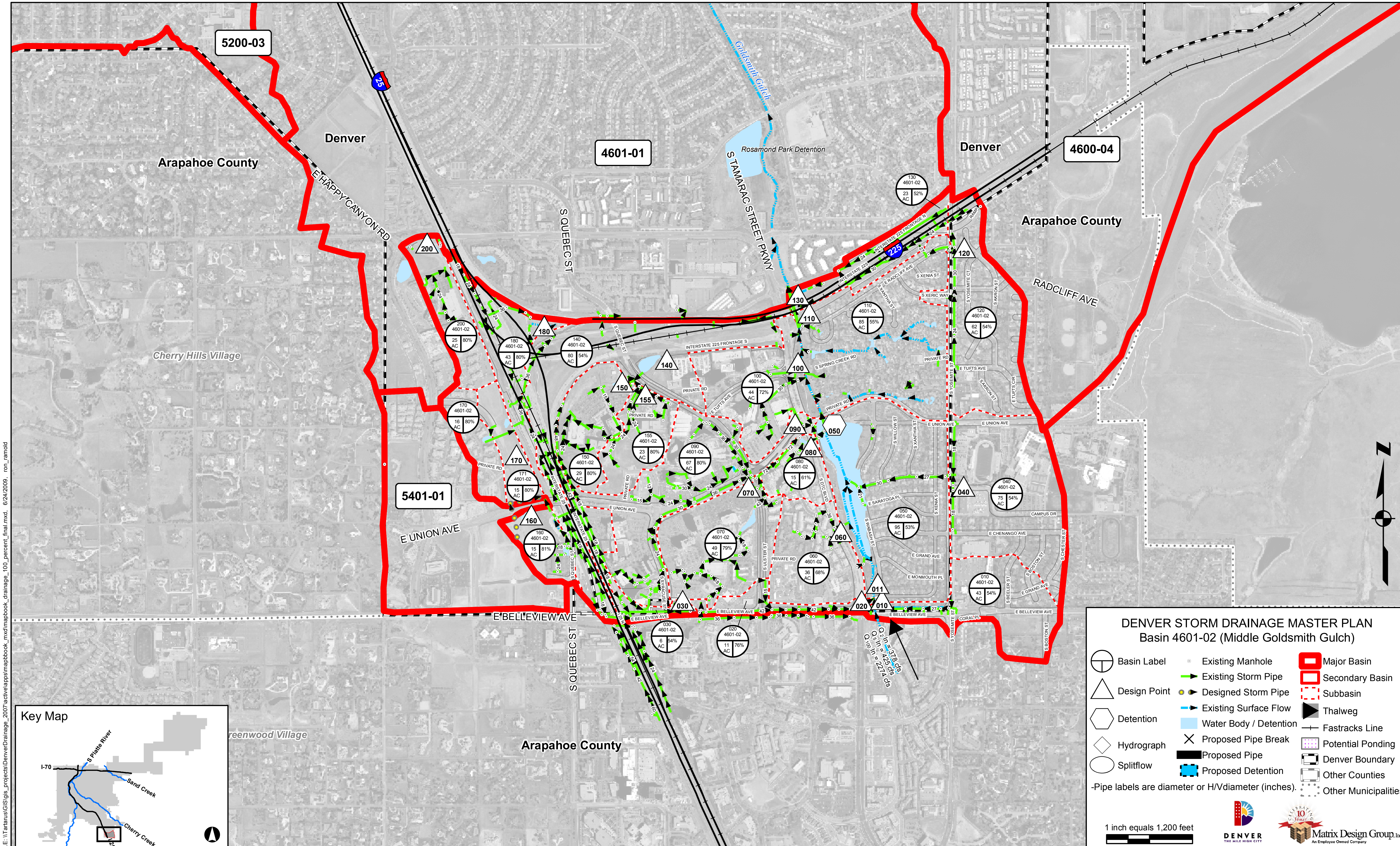
Drainage Deficiencies:
The drainage facilities within this basin are newer with the construction of the TREX project along the I-25 and I-225 corridors. The facilities within the Denver Tech Center are also relatively new and no drainage problems have been identified.

Proposed Capital Improvements:
No storm drain capital improvements are proposed for this basin. Development in the area is relatively recent adhering to current drainage criteria. Major drainageway improvements are under the jurisdiction of the Urban Drainage & Flood Control District and have not been evaluated under this master plan.

Existing Hydrology:

BASIN 4601-02

Design Point	Contributing Basins	Tributary Area	Peak Discharge		
			2-Year	5-Year	100-Year
		(acres)	*(cfs)*	*(cfs)*	*(cfs)*
10	10	43	31	56	144
11	10,20,30	61	46	80	203
20	20	11	1	0	76
30	30	6	0	0	54
40	40	75	54	96	248
50	10,20,30,40,50,60,70,80	300	261	433	1039
60	60	36	35	56	132
70	70	49	60	91	202
80	80	15	14	24	59
90	90	67	1	0	80
100	100	44	43	69	159
110	110	85	1	0	55
120	120	62	42	75	195
130	130	23	14	26	70
140	140	80	56	99	258
150	150	29	40	60	131
155	155	23	31	47	103
160	160	15	21	31	68
170	170	16	0	0	80
171	170, 171	31	39	60	131
180	180	43	39	59	132
190	190	44	57	85	185
200	200	25	29	44	97


5200-03
Denver
Arapahoe County
E HAPPY CANYON RD
4601-01
S QUEBEC ST
S TAMARAC STREET PKWY
Goldsmith Gulch
Rosamond Park Detention
Denver
4600-04
Arapahoe County
RADCLIFF AVE
Cherry Hills Village
5401-01
E UNION AVE
E BELLEVIEW AVE
S QUEBEC ST
Arapahoe County
Greenwood Village
INTERSTATE 225 FRONTAGE S
200
180
140
130
120
110
100
090
080
070
060
050
040
030
020
011
010
150
155
160
170
Q 2 in = 378 cfs
Q 5 in = 425 cfs
Q 100 in = 2274 cfs
Key Map
I-70
S Platte River
Sand Creek
Cherry Creek
I-25
DENVER STORM DRAINAGE MASTER PLAN
Basin 4601-02 (Middle Goldsmith Gulch)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER THE MILE HIGH CITY
Matrix Design Group, Inc.
An Employee Owned Company
FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activelaps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/24/2009, ron_ramold

Basin: 4700-01 (Sloan's Lake)

Existing System Description:
This basin drains to the South Platte River and is generally between Colfax and 32nd Avenues and extends westerly from the South Platte River to Garrison Street. Approximately half of the basin (eastern) is located within the City of Denver, while the western half is within the cities of Lakewood, Wheat Ridge, and Edgewater. The areas outside of Denver drain to two specific crossing points under Sheridan Boulevard at 24th Avenue and 18th Avenue (Sloan's Lake Lateral). Sloan's Lake occupies approximately 176 acres and is located just east of Sheridan Boulevard. It receives stormwater runoff from the majority of the basin and provides significant detention volume for flooding events. Below the lake, a 24-inch storm sewer system conveys outflow from the lake and localized drainage to the South Platte River. The basin within Denver is almost completely residential with the exception of Sloan's Lake Park, some commercial areas along Sheridan Boulevard, Federal Blvd, Colfax Avenue, and Invesco Field.

Drainage Deficiencies:
Sloan's Lake is effective in reducing peak flow rates to drainage systems lower in the basin. The lake reduces peak flow rates from about 2,904 cfs to 166 cfs during the 100-year event. However, the existing system below the lake cannot sufficiently handle localized stormwater runoff. The existing 24- to 54-inch trunk line draining this basin below Sloan's Lake is undersized for the 5-year event. The 54-inch outfall along Colfax Avenue can convey 124 cfs, while the 5-year design flow is 359 cfs (DP 1030). If detention in the Lake were increased to reduce flows to the lower system, the need to upsize the outfall for local drainage would still exist.

The existing pipe in Colfax Avenue west of Federal Boulevard is undersized for the 5-year event.

The small systems draining 17th Avenue, which discharge into Sloan's Lake, do not adequately drain the roadway during the 2-year event.

The existing system that wraps around the eastern edge of Sloan's Lake and drains 20th Avenue is undersized for the 2-year event.

Proposed Capital Improvements:

<u>Projects A and B: N. Stuart St. Outfall and N. Wolfe St. Outfall</u> Two 18-inch laterals are proposed to provide additional inlets and drainage facilities for 17th Avenue.

<u>Projects C1 and D: W 16th Ave. and W. Colfax Ave. Improvements</u> Upsizing the South Platte outfall with an 84-inch pipe is proposed, while a 42-inch pipe is recommended higher in the basin just below the Sloan's Lake outlet facility. Upsizing the storm sewer in Colfax Avenue between Knox Court and Federal Boulevard is proposed to upgrade the system to a 5-year capacity.

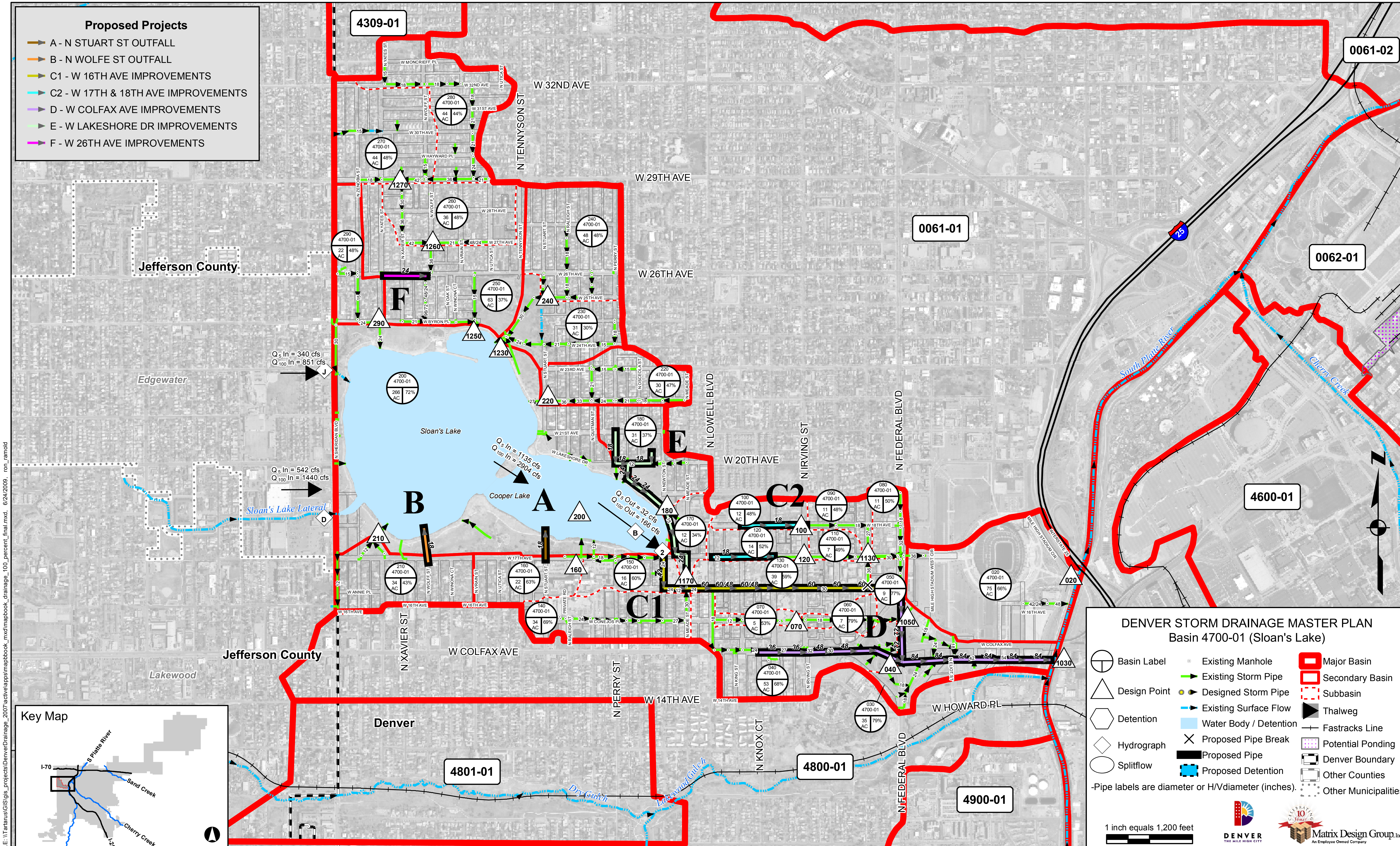
<u>Projects C2: W 17th Ave. and W. 18th Ave. Improvements</u> Upsize the existing 12-inch and 15-inch storm pipes in W. 17th Avenue from N. Julian Street to N. Lowell Boulevard and from N. Irving Street to N. King Street respectively to meet current drainage criteria and reduce maintenance.

<u>Project E: W. Lakeshore Dr. Improvements</u> The system draining 20th Avenue east of Sloan's Lake should be upsized to handle the 2-year event.

<u>Project F: W. 26th Avenue Improvements</u> A 24-inch lateral is proposed in 26th Avenue to convey the 2-year storm event.

Existing Hydrology:
<u>**BASIN 4700-01**</u>

Design Point	Contributing Basins	Tributary Area	Peak Discharge	
			2-Year	5-Year
		(acres)	*(cfs)*	*(cfs)*
20	20	75	73	120
40	40	53	47	77
70	70	5	4	7
100	100	12	9	17
120	120	14	11	19
160	160	22	21	35
180	180	31	15	33
200	200	266	205	323
210	210	34	21	41
220	220	31	18	34
240	240	48	30	57
290	290	22	14	26
1030	Off Site, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180	2,714	217	359
1050	Off Site, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180	2,626	156	261
1130	Off Site, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180	2,603	137	233
1170	Off Site, 140, 150, 160, 170, 180,	2,509	97	154
1230	230, 240	79	41	79
1250	250, 260, 270, 280	186	88	170
1260	260, 270, 280	124	73	130
1270	270, 280	88	49	95


Proposed Projects
A - N STUART ST OUTFALL
B - N WOLFE ST OUTFALL
C1 - W 16TH AVE IMPROVEMENTS
C2 - W 17TH & 18TH AVE IMPROVEMENTS
D - W COLFAX AVE IMPROVEMENTS
E - W LAKESHORE DR IMPROVEMENTS
F - W 26TH AVE IMPROVEMENTS
4309-01
0061-02
0061-01
0062-01
4600-01
4801-01
4800-01
4900-01
W 32ND AVE
W 29TH AVE
W 26TH AVE
W 20TH AVE
W COLFAX AVE
W 14TH AVE
W HOWARD PL
N TENNYSON ST
N LOWELL BLVD
N IRVING ST
N FEDERAL BLVD
N XAVIER ST
N PERRY ST
N KNOX CT
Jefferson County
Edgewater
Lakewood
Denver
Sloan's Lake
Cooper Lake
Sloan's Lake Lateral
South Platte River
Cherry Creek
Dry Gulch
Lakewood Gulch
Q_5 In = 340 cfs
Q_{100} In = 851 cfs
Q_5 In = 542 cfs
Q_{100} In = 1440 cfs
Q_5 In = 1135 cfs
Q_{100} In = 2904 cfs
Q_5 Out = 32 cfs
Q_{100} Out = 166 cfs
A
B
C1
C2
D
E
F
Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
DENVER STORM DRAINAGE MASTER PLAN
Basin 4700-01 (Sloan's Lake)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
THE MILE HIGH CITY
Matrix Design Group, Inc.
An Employee Owned Company
FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activeapps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/24/2009, ron_arnold

Basin: 4700-01 (Sloan's Lake 100-Year)

Existing System Description:
Sloan's Lake is effective in reducing peak flow rates to drainage systems lower in the basin. The lake reduces peak flow rates from about 2,904 cfs to 166 cfs during the 100-year event. However, the existing system below the lake cannot sufficiently handle localized stormwater runoff.

Drainage Deficiencies:
There is an existing FEMA regulatory floodplain from the outlet of Sloan's Lake to the South Platte River. The 100-year regulatory floodplain downstream of Sloan's Lake does not inundate buildings, however, it does touch some private parcels thereby sometimes triggering the need to purchase Flood Insurance. The streets mostly contain flows beyond the capacity of the existing storm drains in the 100-year event. An analysis was done as part of the 2009 Master Plan update to determine what size facilities would be needed in W. 16th Avenue, Federal Boulevard, and W. Colfax Avenue to convey the entire 100-year flow rate. The 100-year flow rates used for the analysis and the proposed sizing calculations can be seen in Table 1.2 in the Technical Appendix.

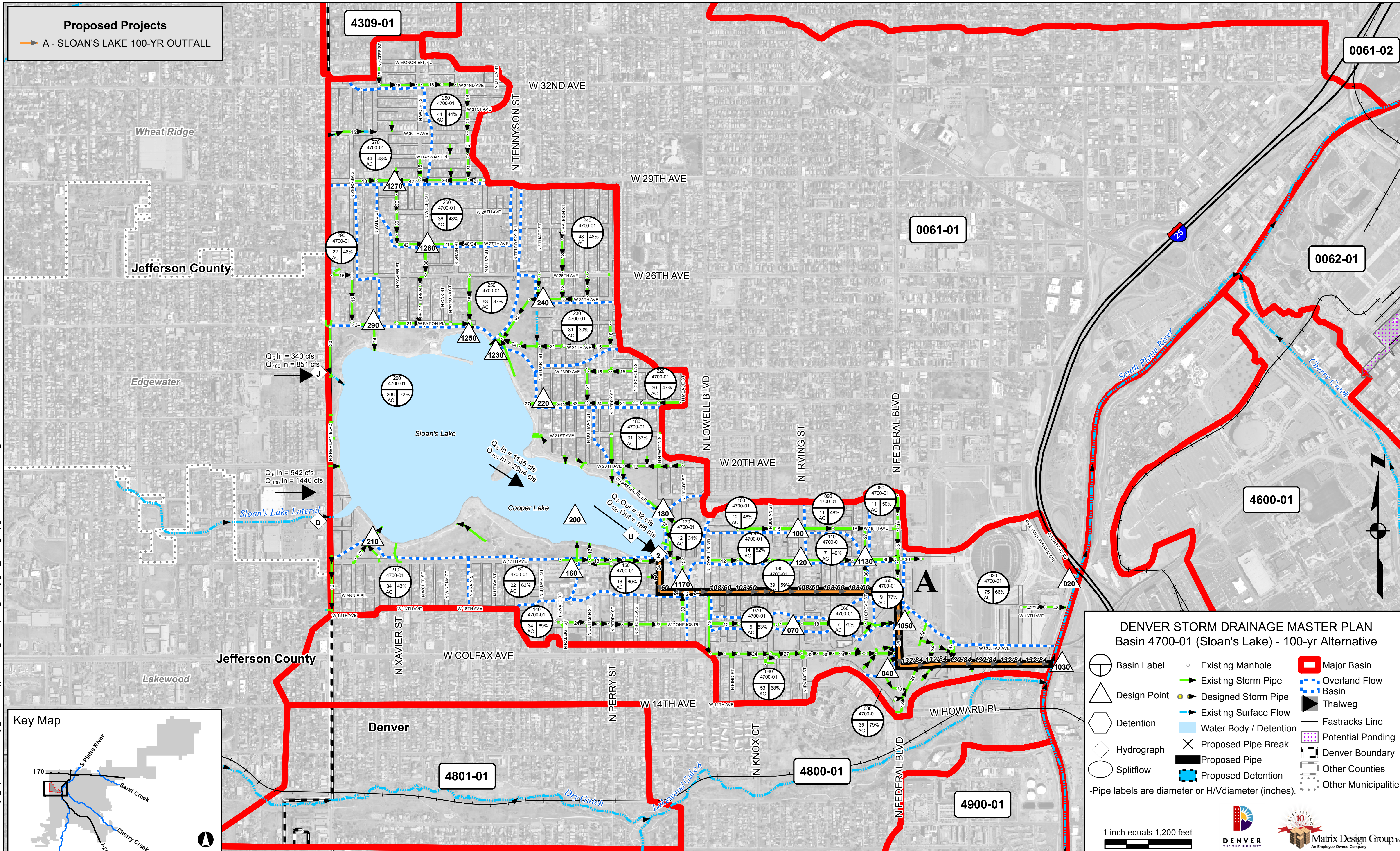
Proposed Capital Improvements:

Projects A: Sloan's Lake 100-Year Outfall The proposed facility needed at the outfall of Sloan's Lake in N. Newton Street to convey the 100-year flow is a 60" pipe into a 9' x 5' box culvert in 16th Avenue and Federal Boulevard. At Colfax Avenue, the size is increased to an 11' x 7' box culvert. These proposed sizes convey the entire 100-year event without utilizing the capacity of the street above.

Existing Hydrology:

BASIN 4700-01

Design Point	Contributing Basins	Tributary Area (acres)	Peak Discharge 100-Year (cfs)
20	20	75	284
40	40	53	183
70	70	5	18
100	100	12	45
120	120	14	51
160	160	22	86
180	180	31	99
200	200	266	768
210	210	34	116
220	220	31	93
240	240	48	153
290	290	22	70
1030	Off Site, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180	2,714	962
1050	Off Site, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180	2,626	698
1130	Off Site, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180	2,603	626
1170	Off Site, 140, 150, 160, 170, 180,	2,509	377
1230	230, 240	79	240
1250	250, 260, 270, 280	186	513
1260	260, 270, 280	124	368
1270	270, 280	88	259


Proposed Projects
A - SLOAN'S LAKE 100-YR OUTFALL
4309-01
0061-02
0061-01
0062-01
4600-01
4801-01
4800-01
4900-01
W 32ND AVE
W 29TH AVE
W 26TH AVE
W 20TH AVE
W COLFAX AVE
W 14TH AVE
W HOWARD PL
N TENNYSON ST
N LOWELL BLVD
N IRVING ST
N FEDERAL BLVD
N XAVIER ST
N PERRY ST
N KNOX CT
Wheat Ridge
Jefferson County
Edgewater
Lakewood
Denver
Sloan's Lake
Cooper Lake
Sloan's Lake Lateral
South Platte River
Cherry Creek
Dry Gulch
Lakewood Gulch
Q5 In = 340 cfs
Q100 In = 851 cfs
Q5 In = 542 cfs
Q100 In = 1440 cfs
Q5 In = 1135 cfs
Q100 In = 2904 cfs
Q5 Out = 32 cfs
Q100 Out = 166 cfs
A
Key Map
I-70
S Platte River
Sand Creek
Cherry Creek
I-25
DENVER STORM DRAINAGE MASTER PLAN
Basin 4700-01 (Sloan's Lake) - 100-yr Alternative
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Overland Flow Basin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.

Basins 4800-01 & 4801-01 (Lakewood & Dry Gulches)

Existing System Description:
Lakewood Gulch is a major drainageway with a 16 square mile watershed, and Dry Gulch is a north bank tributary to Lakewood Gulch. The gulches begin in Lakewood and discharge runoff into the South Platte River at 14th Avenue. Only about 10% of the total tributary area is within the City & County of Denver. Lakewood Gulch has 756 acres (1.18 square miles) tributary, and Dry Gulch has 248 acres (0.39 square miles) tributary within the City & County of Denver. The basins are long, narrow basins running west to east, generally along 6th Avenue and Colfax Avenue.

The basins within Denver are fully built-out primarily with neighborhood residential, except for commercial along arterial transportation corridors. ***Blueprint Denver*** shows linear corridors along Dry Gulch and Colfax as "Areas of Change." These are proposed light rail and other transit oriented improvements that are anticipated in these basins in the future. The residential neighborhood is shown as an "Area of Stability".

All drainage from these basins outfalls into the South Platte River. Runoff generally flows down the relatively steep roadways into these major drainageways. Relatively little storm pipe is necessary in these basins due to the capacity of the streets to convey stormwater. Intercepted stormwater in the pipes is discharged in small, local storm drainage outfalls to the drainageways. The only large outfall is a 39-inch drain from Colfax Avenue discharging into Lakewood Gulch at Lowell Boulevard.

The condition and capacity of the inlets to intercept all the runoff is unknown at this time, but it is assumed that they will perform adequately with proper maintenance.

Unique to this basin is the need to evaluate roadway bridge crossings for conveyance of the flood events. Urban Drainage & Flood Control District has evaluated improvements in two studies completed in 1979. The following roadway/railway crossings occur on these drainageways:

Lakewood Gulch:
1. Sheridan Boulevard
2. Wolff Street
3. Tennyson Street
4. Perry Street
5. 10th Avenue
6. Two Railroad Bridges
7. Knox Street
8. Federal Boulevard
9. Decatur Street
10. Canosa Street

Dry Gulch:
1. Sheridan Boulevard
2. Two Railroad Bridges
3. Perry Street

Drainage Deficiencies:
Storm pipe deficiencies are minimal in this area due to the relatively steep slopes and the existing underground pipe network. Culverts and bridges are the greatest concern in these drainage basins. On May 14, 2007, a two-year old boy was swept away in Lakewood Gulch as he and his mother took refuge from hail in the Decatur Bridge/Culvert. Plans have been prepared to build a new outfall and replace the Decatur structure with a 100-year capacity bridge, scheduled for 2011. The Canosa Street bridge will be demolished. The proposed open channel will contain the 100-year flood and eliminate out-of-channel bank flooding.

Proposed Capital Improvements:
This area represents an important corridor for the future FasTracks West Corridor transportation system. Plans are underway by RTD, the City of Denver and the Urban Drainage and Flood Control District to "realign" Lakewood Gulch from N. Decatur Street to the South Platte River in order to convey and contain the 100-year flood. There is a confined floodplain relating to Dry Gulch, however bridges need to be adequately sized to ensure that the rail facilities are not adversely impacted. Other minor pipe improvements include the following:

Project A: N. Stuart Street To improve drainage conveyance on Colfax Avenue, a new outfall is proposed into Dry Gulch. This can be completed by connecting to the existing 33-inch pipe in Colfax and outfalling with a new 48-inch pipe in Stuart Street to Dry Gulch. This maximizes the re-use of existing pipe and improves the outfall capacity.

Project B: N. Knox Court Another new outfall is proposed in Knox Court with a 24-inch pipe outfalling to Lakewood Gulch.

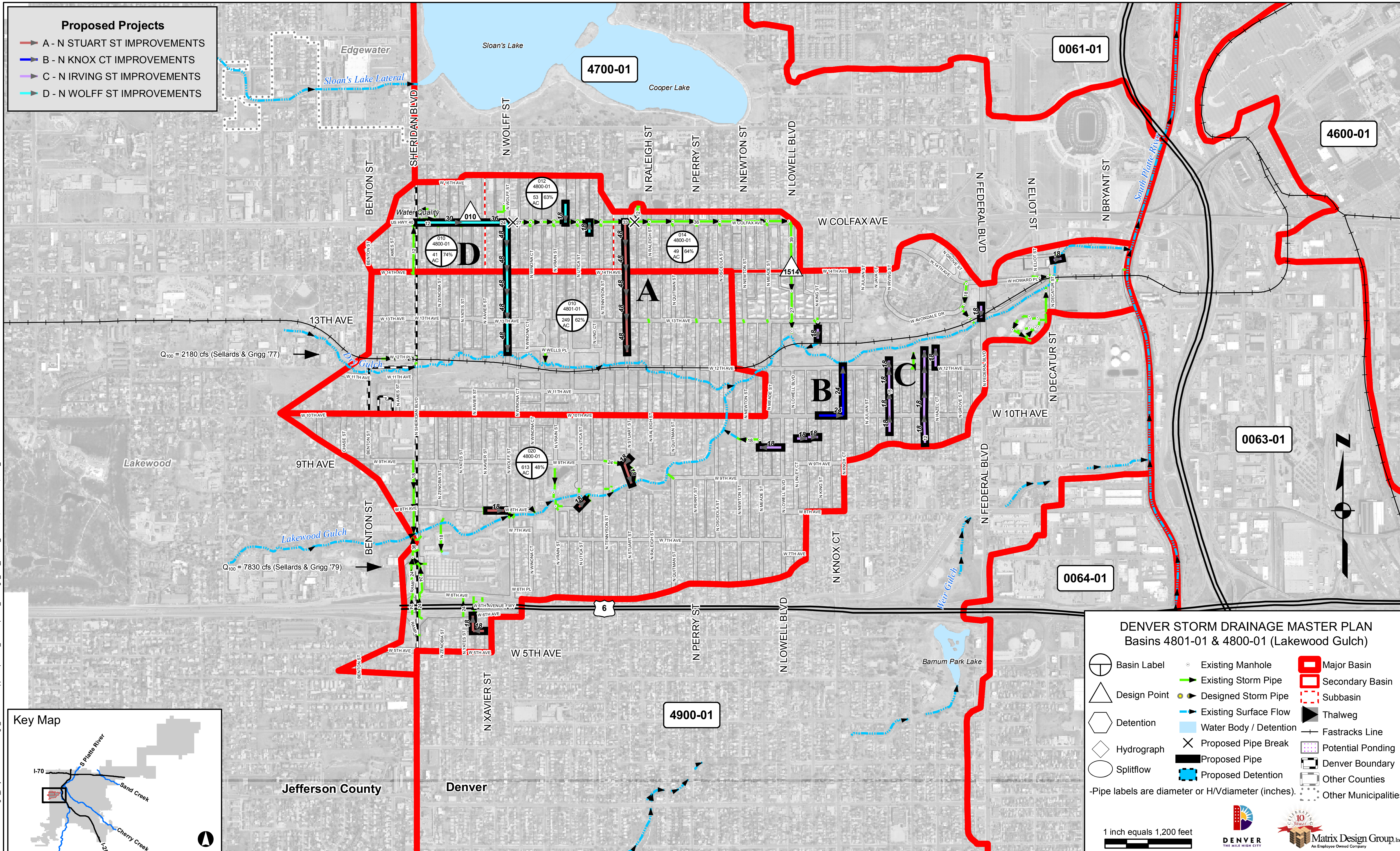
Project C: N. Irving Street Existing small storm drains will be replaced with 18-inch pipe to meet current drainage criteria.

Project D: N. Wolff Street To improve drainage conveyance on Colfax Avenue, existing pipe can be replaced and a new outfall is proposed into Dry Gulch. A new 48-inch outfall in Wolff Street is proposed to Dry Gulch.

Existing Hydrology:

BASIN 4800-01

Design Point	Contributing Basins	Tributary Area	Peak Discharge		
			2-Year	5-Year	100-Year
		(acres)	(cfs)	(cfs)	(cfs)
10	10	41	52	82	185
1514	10,12,14	143	96	163	442



FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activelapps\mapbook_mxt\mapbook_drainage_100_percent_final.mxd, 6/24/2009, ron_ramold

Basin: 4900-01 (Weir Gulch)

Existing System Description:
Much of the Weir Gulch basin is located to the west and upstream of the City of Denver. The upper basin originates near Alameda Parkway and Green Mountain Drive in Lakewood. The portion of the basin located within the City of Denver is east of Sheridan Boulevard and generally lies as a long, narrow basin following the drainageway between the Center Avenue/ Sheridan Boulevard intersection at the southwestern end to the outfall at the South Platte near 9th Ave at the northeastern end. The 1st Avenue Tributary and Dakota Avenue Tributary are two drainageways which outfall to Weir Gulch within the Denver basin.

Weir Gulch has many man-made improvements and is contained underground or in a 3-sided concrete box culvert open on the surface in many areas. There is little native riparian vegetation along these flood control improvements. The neighborhood has generally oriented their houses and yards away from the channel.

The lower reach contains Barnum Lake south of 6th Avenue. This lake has been used for fishing derbies. Barnum Lake, located south of 6th Avenue has been improved to contain the 100-year storm within the Weir Gulch channel. The open park area north of 6th Avenue, known as the Federal Boulevard Detention Reservoir, is designed to reduce the 25-year flow to a 10-year flow or less. The lower Weir Gulch channel from Federal to the South Platte River outfall has capacity for the 10-year storm.

Most of the upper and central basin within Denver is comprised of residential neighborhoods. The lower portion of the basin is made up of commercial and industrial facilities along the South Platte.

Drainage Deficiencies:
The 42” to 54” system in Irving Street draining 208 tributary acres is undersized for the 2-year event.

No major drainage complaints have been reported in this basin outside the regulatory floodplain due to the relatively steep gradient toward the receiving drainageway and lack of sumps or flat areas. This basin generally meets Denver drainage criteria for the 2-year storm event in residential areas. Flooding that occurs along the main Weir Gulch drainageway and the 1st Avenue and Dakota Avenue Tributaries is considered within a “regional drainageway” under the jurisdiction of the UDFCD and not included for analysis within the scope of this report.

Proposed Capital Improvements:

Project A: N. Yates St. Improvements A 24” lateral is proposed to provide 2-year storm drainage to the 4th Avenue/Yates Street residential area.

Project B: S. Julian St. Outfall A new outfall along Julian Street and Ellsworth Avenue is proposed to reduce loading to the Irving Street system. The new system will drain the northern half of sub-basin 50, while the existing system in Irving Street will continue to drain the southern half of the sub-basin.

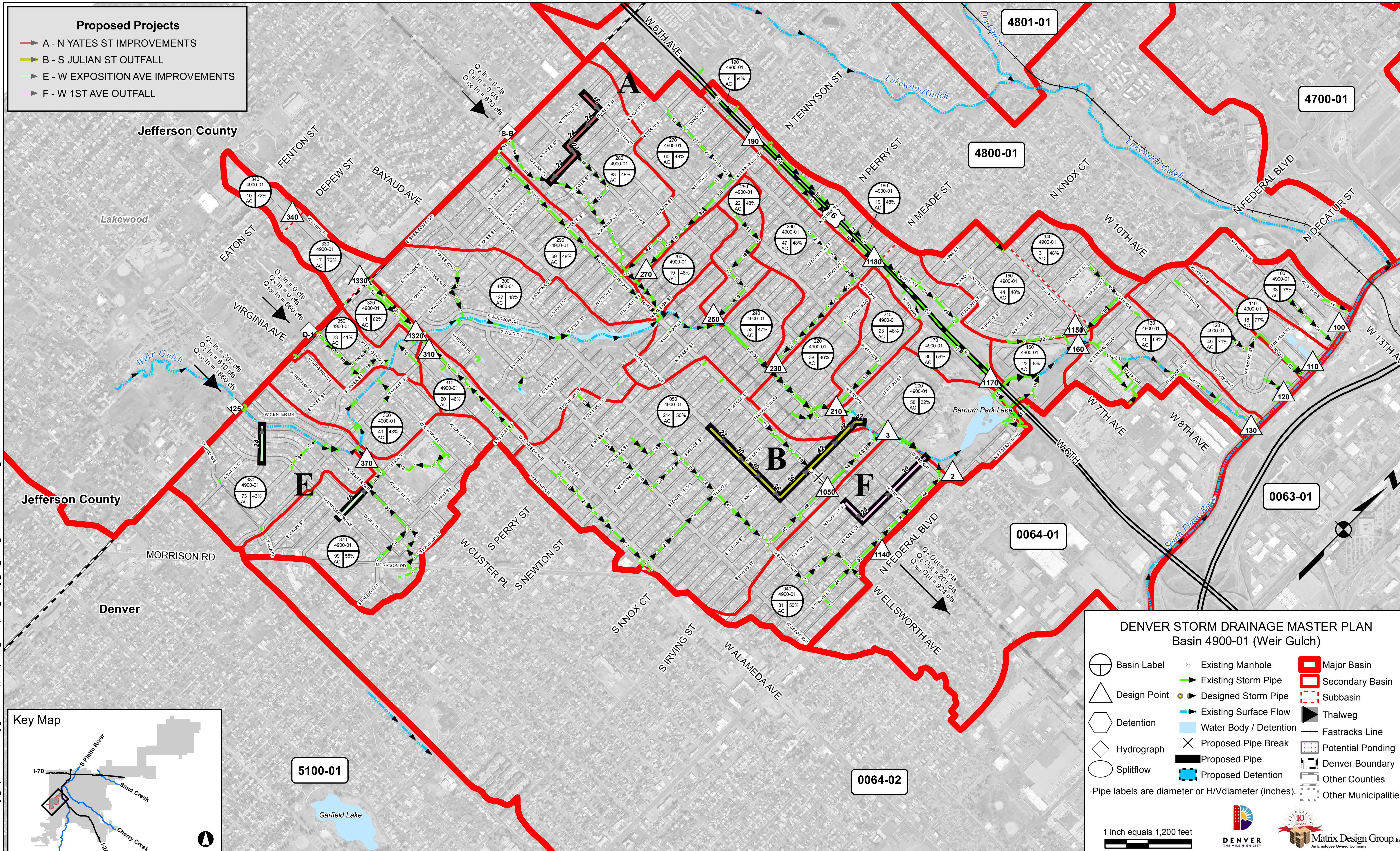
Project E: W. Exposition Ave. Improvements Small 18” to 24” laterals are proposed in Utica and Xavier Streets to improve localized drainage in the vicinity of Exposition Avenue.

Project F: W. 1st Ave. Improvements A 24” lateral is proposed along 1st Avenue that turns north along N. Hazel, that transitions to a 30” pipe to outfall at Weir Gulch & 3rd Avenue.

Existing Hydrology:

BASIN 4900-01

Design Point	Contributing Basins	Tributary Area	Peak Discharge		
			2-Year	5-Year	100-Year
		(acres)	*(cfs)*	*(cfs)*	*(cfs)*
2	split	split	76	76	76
3	split	split	139	139	139
100	100	33	37	57	128
110	110	18	19	29	65
120	120	49	50	79	182
130	130	45	41	67	158
190	190	7	6	10	26
210	210	23	13	25	67
230	230	47	25	47	128
250	250	22	13	24	65
270	270	60	29	55	151
310	310	20	12	23	65
340	340	10	12	19	44
370	370	99	101	183	459
1050	50	split	169	311	845
1140	40	split	81	277	1,000
1150	50	214	30	172	706
1170	170, 180, 190	62	44	77	187
1180	180, 190	26	17	30	79
1320	320, 330, 340	39	39	62	152
1330	330, 340	27	28	46	109


Proposed Projects
A - N YATES ST IMPROVEMENTS
B - S JULIAN ST OUTFALL
E - W EXPOSITION AVE IMPROVEMENTS
F - W 1ST AVE OUTFALL
Jefferson County
Lakewood
Denver
Weir Gulch
Lakewood Gulch
Dry Gulch
South Platte River
Barnum Park Lake
Garfield Lake
W 6TH AVE
N TENNYSON ST
N PERRY ST
N MEADE ST
N KNOX CT
N FEDERAL BLVD
N DECATUR ST
W 10TH AVE
W 13TH AVE
W 7TH AVE
W 8TH AVE
FENTON ST
DEPEW ST
BAYAUD AVE
EATON ST
VIRGINIA AVE
MORRISON RD
W CUSTER PL
S PERRY ST
S NEWTON ST
S KNOX CT
S IRVING ST
W ALAMEDA AVE
W ELLSWORTH AVE
4801-01
4800-01
4700-01
0063-01
0064-01
0064-02
5100-01
Q 2 In = 0 cfs
Q 5 In = 0 cfs
Q 100 In = 670 cfs
Q 2 In = 0 cfs
Q 5 In = 0 cfs
Q 100 In = 660 cfs
Q 2 In = 302 cfs
Q 5 In = 619 cfs
Q 100 In = 860 cfs
Q 2 Out = 5 cfs
Q 5 Out = 201 cfs
Q 100 Out = 924 cfs
DENVER STORM DRAINAGE MASTER PLAN
Basin 4900-01 (Weir Gulch)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.
Key Map
I-70
S Platte River
Sand Creek
Cherry Creek
I-25

Basin 5000-01 (West Washington Park)

Existing System Description:
This basin consists of 788 acres (1.23 square miles) and is fully built-out with older neighborhood residential in the upper reaches and commercial in the lower reaches. ***Blueprint Denver*** shows the commercial areas west of Broadway as "Areas of Change." The residential neighborhood is shown as "Areas of Stability". All drainage from this basin outfalls to the South Platte River. Intercepted stormwater is discharged in at least 13 storm drainage outfalls, which are comprised of the following:

- 54-inch with 616 tributary acres in Center Street, or 78% of basin 5000-01 (Design Point 1543)
- 42-inch for the I-25 & Santa Fe intersection
- 30-inch for the Santa Fe & Alameda intersection
- 30-inch for the Alameda & I-25 intersection
- 36-inch for the Santa Fe & Kalamath intersection
- 30-inch for the Santa Fe & Kalamath intersection
- 2-24-inch for local I-25 drainage
- 2-18-inch for local I-25 drainage
- 3-15-inch for local I-25 drainage

The storm drain infrastructure consists of a detailed network of laterals in most streets. A grid pattern of laterals is collected in Pennsylvania and Broadway streets. The inlets are old sandstone/granite catch basins with limited capacity due to design and numerous asphalt overlays throughout the years. As improvements and handicap ramps are installed in the neighborhood, these inlets are being replaced with current standard inlets. Many of these old inlets must be replaced to improve collection efficiency. Drainage from the I-25 basin is constrained by the elevation of the South Platte River and I-25, which generally reduces capacity and creates sump or surcharge conditions during major storm events.

Drainage Deficiencies:
The existing drainage system has capacity to convey an approximately 1-year storm event to the South Platte River. Rainfall runoff in excess of the storm drain capacity has a history of ponding in the sump and flat areas. Major drainage problems have been experienced in the sump on Alameda at the Santa Fe intersection. Two large potential ponding areas occur in the flat commercial areas due to runoff backing up behind the railroad and I-25.

Proposed Capital Improvements:
The existing lakes at Washington Park could be reconfigured to act as "peaking" facilities by detaining stormwater only in major events when the pipe capacity is exceeded.

This basin requires improvements primarily to the outfall since the lateral network is currently extensive in this basin. Storm pipes through the commercial areas should have 5-year capacity, whereas the lateral network through the residential areas should have at least a 2-year capacity.

<u>Project A: 18" Upgrades</u> Existing 12- and 15-inch pipes along Dakota and Virginia Avenues are proposed to be replaced with 18-inch pipes to meeting current drainage criteria and reduce maintenance.

<u>Project B: Center Avenue Outfall</u> For the minor storm, (5-year event) a 9'x 5' box culvert along the Center Street projected alignment from the South Platte River to Pennsylvania Street would replace the existing system, improving drainage conveyance. This system gradually reduces in size to a 60" pipe at Pennsylvania Street. This alignment was selected as the most efficient route; however, Center Street west of Broadway is not City-owned and therefore a drainage easement will be required. Alternatively, a different alignment could be selected or a possible parallel pipe to the existing system. Regardless of alignment, a new crossing under the railroad tracks and I-25 is necessary. This new outfall should be considered during the proposed I-25 improvements. CDOT has completed a design for a new storm outfall associated with future improvements to I-25 from Broadway past Santa Fe/Kalamath to Alameda.

<u>Project C: Dakota Avenue Improvements</u> Existing small storm drains, east of Pennsylvania Street between Ellsworth Avenue and Tennessee Avenue, will be replaced with 18-inch pipe to meet current drainage criteria as the minimum pipe size on collector drains.

<u>Project D: Alameda & Santa Fe Outfall</u> The sump at Alameda Avenue and Santa Fe Drive is a chronic flood problem area and will require construction of an enlarged outfall to the South Platte River across I-25. Currently, the storm drain at the point of the sump is 18-inch, which should be upsized to a 30-inch pipe. A 42-inch pipe is proposed at the outlet of this system. This project should be coordinated with I-25 improvements by CDOT.

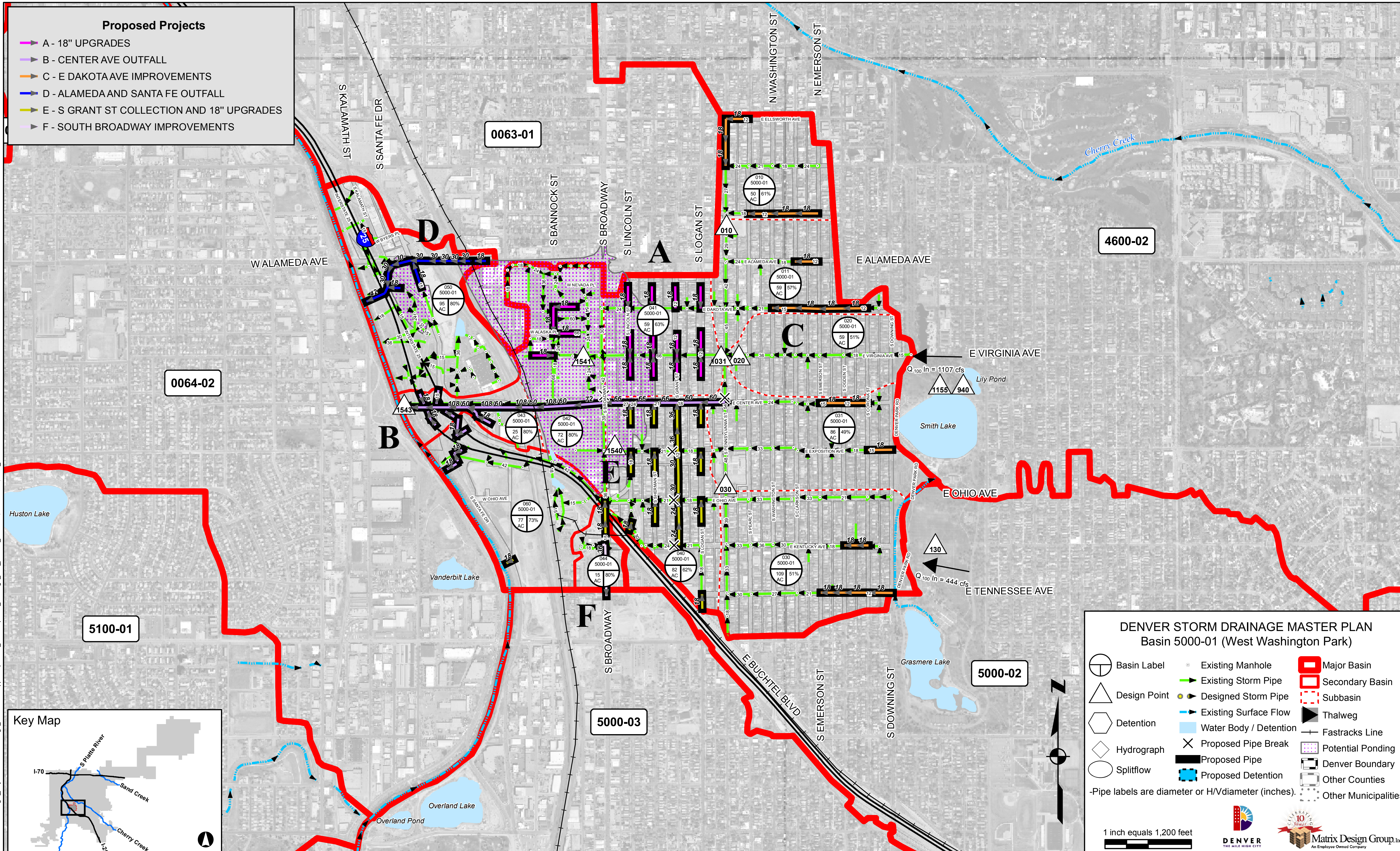
<u>Project E: S. Grant St. Collection & 18" Upgrades</u> Existing small storm drains are proposed to be replaced with 18-inch pipes to meet current drainage criteria and reduce maintenance. Also, a new 36-inch collector drain in Grant Street is proposed that ties into the proposed Center Avenue outfall. This new collector will reduce historic flooding in Broadway by capturing sheet flow runoff. Grant Street was selected as the preferred alignment for the collector since it has the fewest existing utilities. Construction in Broadway is discouraged to avoid disruption to arterial traffic flow and existing utilities.

<u>Project F: South Broadway Improvements</u> This new 36-inch pipe was proposed in the drainage report for the "South Broadway from Arizona Avenue to Kentucky Avenue" project. This proposed pipe will convey the 5-year storm event to Proposed Project F in Major Basin 5000-03.

Existing Hydrology:

<u>BASIN 5000-01</u>

<u>Design Point</u> Minor Event Model	<u>Contributing Basins</u> Minor Event Model	<u>Tributary Area</u> Minor Event Model *(acres)*	<u>Peak Discharge</u> 2-Year *(cfs)*	5-Year *(cfs)*
10	10	50	42	71
20	20	59	40	73
30	30	109	77	143
1031	10-31	363	223	371
1541	10-41	519	296	511
1543	10-43	616	348	581



Proposed Projects
A - 18" UPGRADES
B - CENTER AVE OUTFALL
C - E DAKOTA AVE IMPROVEMENTS
D - ALAMEDA AND SANTA FE OUTFALL
E - S GRANT ST COLLECTION AND 18" UPGRADES
F - SOUTH BROADWAY IMPROVEMENTS
DENVER STORM DRAINAGE MASTER PLAN
Basin 5000-01 (West Washington Park)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.
Key Map
I-70
S Platte River
Sand Creek
Cherry Creek
I-25
0063-01
0064-02
4600-02
5100-01
5000-02
5000-03
W ALAMEDA AVE
E ALAMEDA AVE
E VIRGINIA AVE
E OHIO AVE
E TENNESSEE AVE
S KALAMATH ST
S SANTA FE DR
S BANNOCK ST
S BROADWAY
S LINCOLN ST
S LOGAN ST
N WASHINGTON ST
N EMERSON ST
S EMERSON ST
S DOWNING ST
E BUCHTEL BLVD
Cherry Creek
Smith Lake
Lily Pond
Grasmere Lake
Huston Lake
Vanderbilt Lake
Overland Lake
Overland Pond
Q 100 In = 1107 cfs
Q 100 In = 444 cfs
A
B
C
D
E
F
010
020
030
031
130
940
1155
1540
1541
1543

Basin 5000-01 (West Washington Park 100-Year Alternative)

Drainage Deficiencies:
Ponding is predicted from the BNSF Railroad tracks on the west, S. Sherman Street on the east, Alameda on the north and E. Ohio on the South. This includes the existing large retail plaza at the southwest corner of Alameda and Broadway as well as the RTD Park-N-Ride area near Alameda and Cherokee. During a 100-year storm, runoff beyond the capacity of the existing pipe networks enters the basin from the east estimated to be 1,551 cfs and it enters along the entire eastern boundary of the major basin. The combined effect from runoff in the 5000-01 basin and off-site flow from basins 4600-02 and 5000-02 results in a 100-year flow of 2,532 cfs at the outfall.

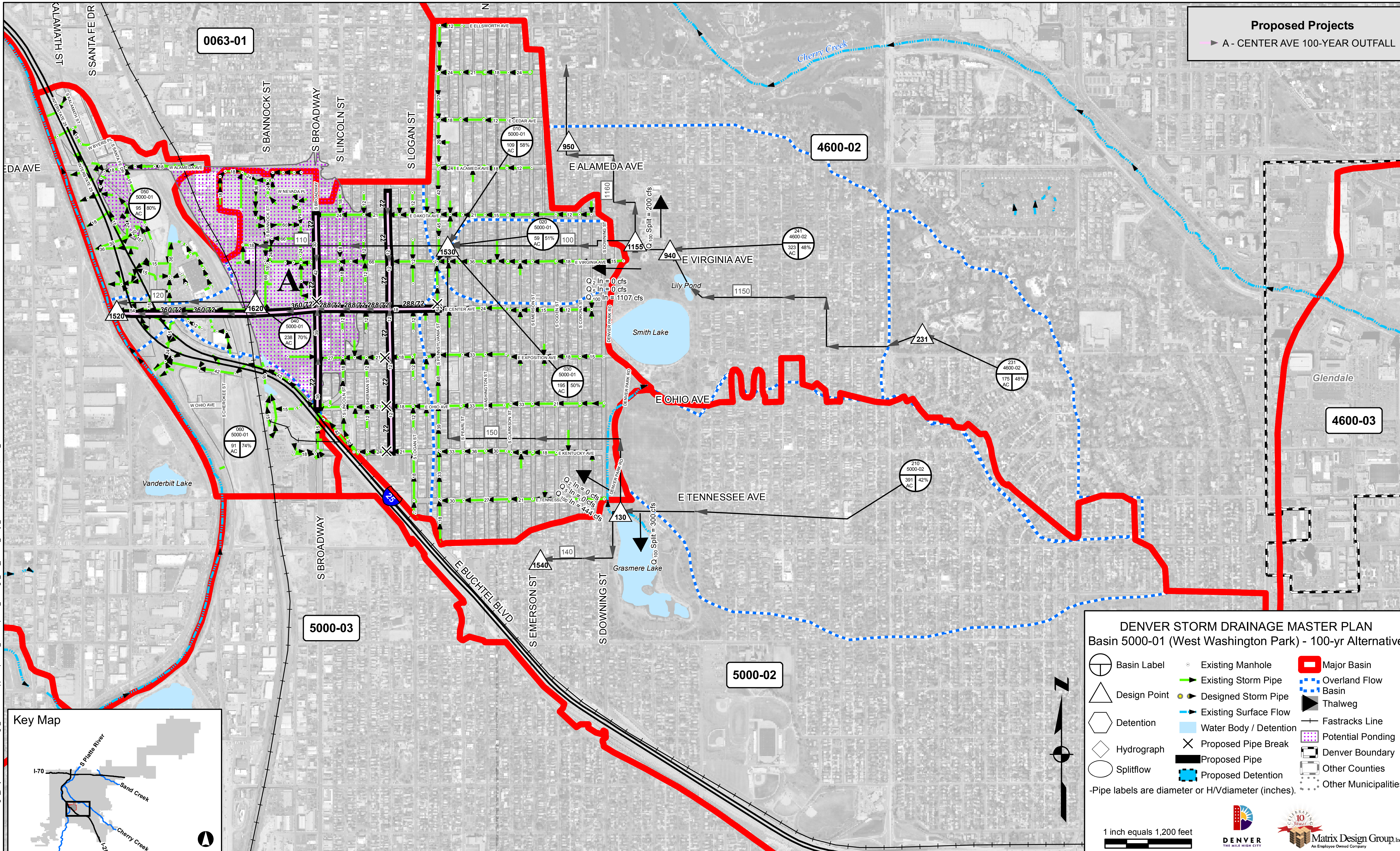
Proposed Capital Improvements:

Project A: Center Avenue 100-year Outfall A 100-year drainage system would cross under I-25 and the railroad tracks at Center Avenue; therefore, a box culvert system would be more appropriate than an open channel system. A triple 10'x6' box culvert constructed from the outfall to the South Platte River to S. Broadway then reducing in size to a double 12'x6' box culvert from S. Broadway to S. Pennsylvania Street would convey the 100-year flow. In addition, new 72-inch laterals and inlets in S. Broadway and S. Grant Street would be required to capture the 100-year runoff (see Alternative 100-Year map on the facing page). CDOT has completed a design for a new storm drain outfall associated with improvements to I-25 from Broadway, past Santa Fe/Kalamath to Alameda. It is recommended that this outfall drain project be coordinated with CDOT's improvements to I-25 from Broadway to Alameda as well as the redevelopment of the shopping plaza at the south west corner of Alameda and Broadway.

Existing Hydrology:

BASIN 5000-01 MAJOR EVENT MODEL

Design Point / Flow Element	Contributing Basins	Tributary Area	Peak Discharge
			100-yr
		(acres)	(cfs)
10	10	109	433
20	20	59	191
30	30	195	721
40	40	238	918
50	50	95	453
60	60	91	363
100	231,241 minus pipe flow	split	1,107
110	10,20,30,210,231,241 minus pipe flow	363	2,066
120	10,20,30,40,210,231,241 minus pipe flow	602	2,532
130	210	391	943
140	pipe flow from 210	391	300
150	210 minus pipe flow	split	444
210	210	391	943
231	231	176	731
241	241	323	1,047
940	231,241	500	1,484
950	231,241	500	200
1150	231	176	495
1155	231,241	500	1,484
1160	pipe flow from 231,241	500	200
1520	10,20,30,40,210,231,241 minus pipe flow	602	2,532
1530	10,20,30,210,231,241 minus pipe flow	363	2,169
1540	pipe flow from 210	391	300
1620	10,20,30,40,210,231,241 minus pipe flow	602	2,540



FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activeapps\mapbook_mxd\mapbook_drainage_100_percent_100yr_final.mxd. 6/24/2009. ron_rarnold

Basin 5000-02 (University and Mexico North)

Existing System Description:
This basin is tributary to the South Platte River. In general this basin is located east of the South Platte River. This basin consists of 1,817 acres (2.84 square miles) and includes residential and commercial properties.

Much of the basin has adequate storm sewers for the 2 and 5 year return periods but lacks adequate protection for the 100-year return period.

Drainage Deficiencies:
In sub-basin 200 there is flooding at Florida Avenue and Franklin Street on the west side of South High School. The street on the west side of South High School receives overflow from Veterans Park. High flood flows on Florida Avenue can enter the I-25 corridor through an offset in the sound walls. The street flow depths in University Boulevard are non-compliant with Denver criteria primarily north of Iowa Avenue.

The primary problem in sub-basin 300 is the amount of flow that is carried in Mexico Avenue. The low point in the Mexico Avenue profile is at Madison Street. Stormwater flows do not release from this low point until the depth of ponding heads up enough to flow southward to Montana Place where the flow can come back to the Cook Street intake sump. The break in the sound wall near the Cook Street intake allows for excess flow to enter the I-25 corridor when the capacity of the Cook Street intake structure has been surcharged.

In sub-basin 400 between Evans Avenue and Warren Avenue there are non-compliant depths of street flooding. The 42-inch storm sewer in Jewell Avenue is undersized.

Potential Ponding Areas:
An area of potential ponding has been identified within sub-basin 100 at the intersection of Tennessee and Franklin near Washington Park. Ponding occurs for storms in excess of the 5-year storm and several homes around the intersection could be inundated during a 100-year storm.

Proposed Capital Improvements:
Project A: Dahlia St. and Asbury Avenue The Dahlia Street Interceptor begins at the existing 48" storm drain at Dahlia and Jewell and extends upstream in Dahlia to Asbury, then east in Asbury to S. Franklin St.

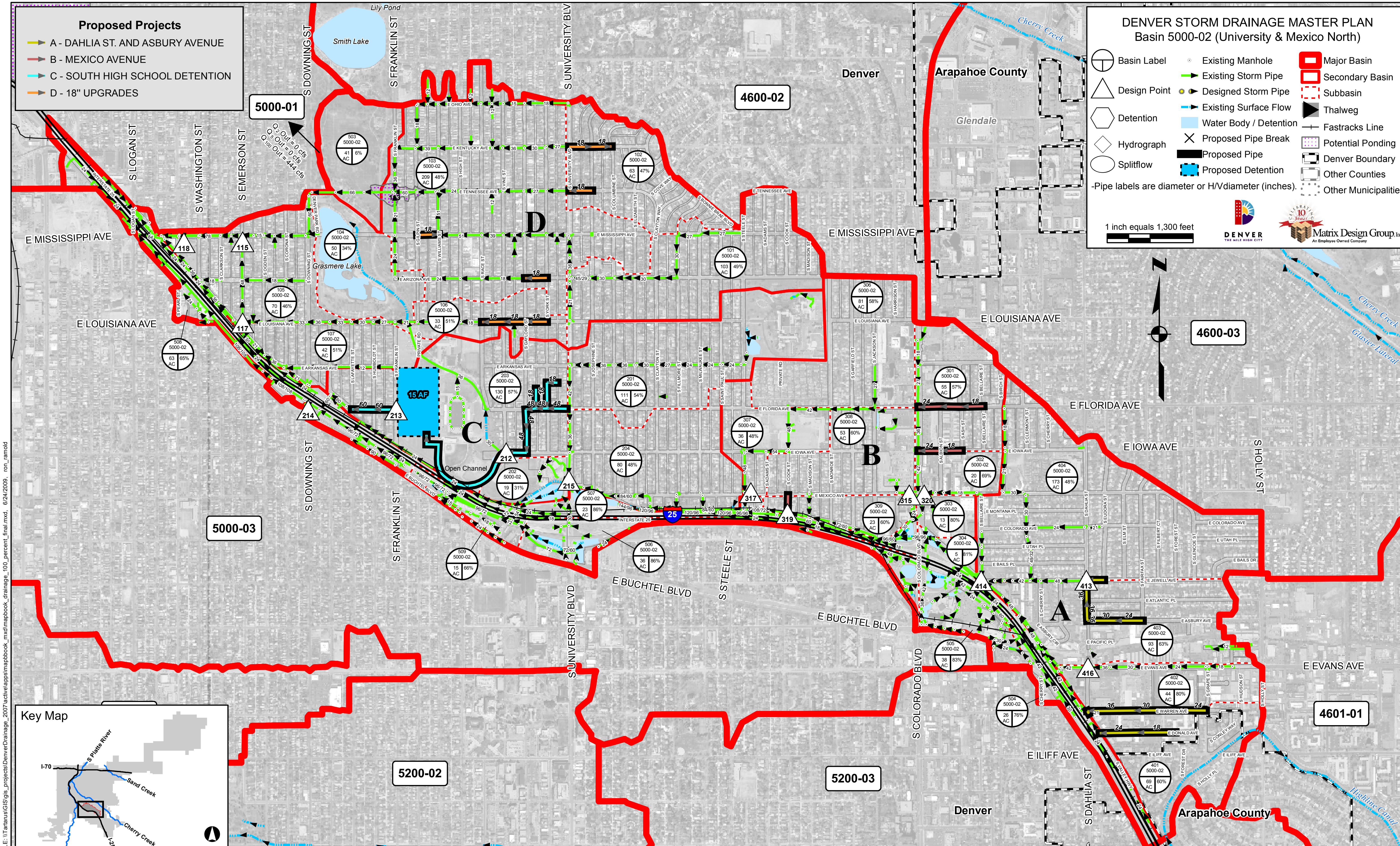
Project B: Mexico Avenue 18 and 24-inch RCP collectors are proposed in Florida Avenue and Iowa Avenue to meet street flow criteria for the initial storm.

Project C: South High School Detention Install 1650 linear feet of 48" RCP and inlets in Florida Avenue east of South High School and Gaylord Street to meet criteria for the initial storm (2-year). For the major storm (100-year) the proposed project involves detention at South High School. 15 acre-feet of storage for the 100-year event is required at South High School. The outlet from the detention pond is a 60-inch that connects to the Lafayette intake structure in Florida Avenue.

Project D: 18-Inch Upgrades Upsizing various pipes to the City's 18-inch minimum diameter is proposed to meet current drainage criteria.

Existing Hydrology:

Design Point	Contributing Basins	Tributary Area (acres)	Peak Discharge 2-Year (cfs)	5-Year (cfs)	100-Year (cfs)
113	101, 102, 103	371	156	271	288
115	101, 102, 103, 105, 106, 107	517	72	146	326
117	106, 107	88	44	87	235
118	101, 102, 103, 105, 106, 107	517	228	420	600
212	201, 202	129	4	51	486
213	201, 202, 203	260	39	95	293
215	204	85	82	139	304
315	301, 302, 303	108	0	0	144
317	306, 307	86	33	68	206
319	301, 302, 303, 306, 307, 308	278	106	193	655
320	301, 302, 303	108	125	195	430
413	401, 402	104	27	32	229
414	401, 402, 403, 404	338	198	376	1097
416	401, 402	104	54	83	409


DENVER STORM DRAINAGE MASTER PLAN
Basin 5000-02 (University & Mexico North)
Proposed Projects
A - DAHLIA ST. AND ASBURY AVENUE
B - MEXICO AVENUE
C - SOUTH HIGH SCHOOL DETENTION
D - 18" UPGRADES
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,300 feet
DENVER
THE MILE HIGH CITY
Matrix Design Group, Inc.
Key Map
5000-01
4600-02
4600-03
5000-03
5200-02
5200-03
4601-01
Denver
Arapahoe County
Glendale
Smith Lake
Lily Pond
Grasmere Lake
15 AF
Open Channel
E MISSISSIPPI AVE
E LOUISIANA AVE
E FLORIDA AVE
E IOWA AVE
E BUCHTEL BLVD
E EVANS AVE
E ILIFF AVE
S UNIVERSITY BLVD
S DOWNING ST
S FRANKLIN ST
S LOGAN ST
S WASHINGTON ST
S EMERSON ST
S STEELE ST
S COLORADO BLVD
S HOLLY ST
S DAHLIA ST
Cherry Creek
Highline Canal
Q Out = 0 cfs
Q Out = 0 cfs
Q 100 Out = 444 cfs
FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activelapps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/24/2009, ron_ramold

Basin 5000-03 (University and Mexico South)

Existing System Description:
This basin is tributary to the South Platte River and located along the east bank. This basin consists of 1,464 acres (2.29 square miles) and includes residential, industrial and commercial properties.

For the 2005 Storm Drainage Master Plan, Sellards and Grigg utilized Smith Environmental, Inc. (SEI) to conduct a search of federal, state, and local environmental databases for the area within the University and Mexico Basin to identify sites where hazardous substances, petroleum products, and other deleterious substances may have been released or disposed. These environmental conditions have the potential to impact the design and construction of storm sewers, ponds, and associated structures.

The radium disposal site, SW Shattuck Chemical Company at 1805 South Bannock Street, has been remediated and the aquifer will be monitored to verify that groundwater contaminants naturally attenuate in the soils over time. The groundwater plume extends in a northwest direction towards Overland Lake. The major contaminants of concern are uranium and molybdenum. The existing storm sewer that parallels Santa Fe Drive is also known to contain contaminated water, possibly from groundwater infiltration within the Shattuck plume area. It is recommended that any new storm drains installed within or near the contaminant plume be fitted with seals to prevent groundwater infiltration.

Drainage Deficiencies:
Broadway itself is the most significant damage corridor in the Basin. Broadway receives large storm flows from the east and the street crown for Broadway is generally at a higher elevation than the finish floor elevations for the commercial establishments on the east side of Broadway. The result is that the street crown in Broadway acts as a dam that inundates the commercial establishments along the east side of Broadway for relatively low return period events. Other areas of the basin do not meet street flow criteria for the major storm event and need to be upsized. The Florida Outfall and storm drainage improvements associated with the programmed South Broadway Reconstruction project will mitigate flooding along South Broadway from Arizona to Colorado Boulevard.

The Harvard Gulch Floodplain extends into Basin 5000-03 and 53 parcels located in the University and Mexico South Basin are affected. Flooding is predicted to be shallow (less than three feet deep) and enters the basin from Major Basin 5200-01 to the south. The Harvard Gulch FHAD floodplain extends as overland flow through the Overland Golf Course to the South Platte River.

Potential Ponding Areas:
An area of potential ponding has been identified at the intersection of Williams Street and Colorado Avenue 100-year runoff to the Williams Street sump results in 4.5 feet of ponding in the sump. An option for improving the flooding at the Williams Street sump would be to formalize the detention storage. However, the grading depth is limited to the elevation of the Williams Street lateral, only a few feet below the existing sump elevation. Shallow detention storage would encumber a large area and require acquisition of several properties. The area is likely to redevelop in the near future due to proximity to the light rail station and Denver University. Given information of flood depths, appropriate measures can be taken by property owners to mitigate flood damages with flood proofing.

Proposed Capital Improvements:

Project A: S. Broadway Extension A 42-inch to 48-inch, 5-year capacity, storm sewer is proposed in South Broadway from Iowa Avenue to Colorado Avenue. The proposed pipe will connect to the designed and programmed 72-inch at Broadway and Iowa Avenue.

Project B: E. Iowa Avenue Extension A new storm drain network is needed to convey the 5-year flows from sub basins 813, 814, 817, 820, 823 and 826. A 54-inch pipe is proposed from the designed and programmed 72" drain in Broadway at Iowa extending east in Iowa Avenue from Broadway to Logan, continuing up Logan Street to Asbury Avenue with pipe sizes ranging from 54-inches to 36-inches. This proposed project will extend west in Asbury Avenue to Corona Street with pipe sizes ranging from 30 to 18-inches.

Project C: S. Washington Street Drain A new storm drain network is proposed in Washington Street from Colorado Avenue to Louisiana Avenue to convey the 5-year flows. The proposed project will proceed west in Louisiana Avenue to Logan St., then north in Logan to connect to the existing storm drain in Mississippi which can accept these flows since it was disconnected from the I-25 drainage system during the I-25 TREX improvements.

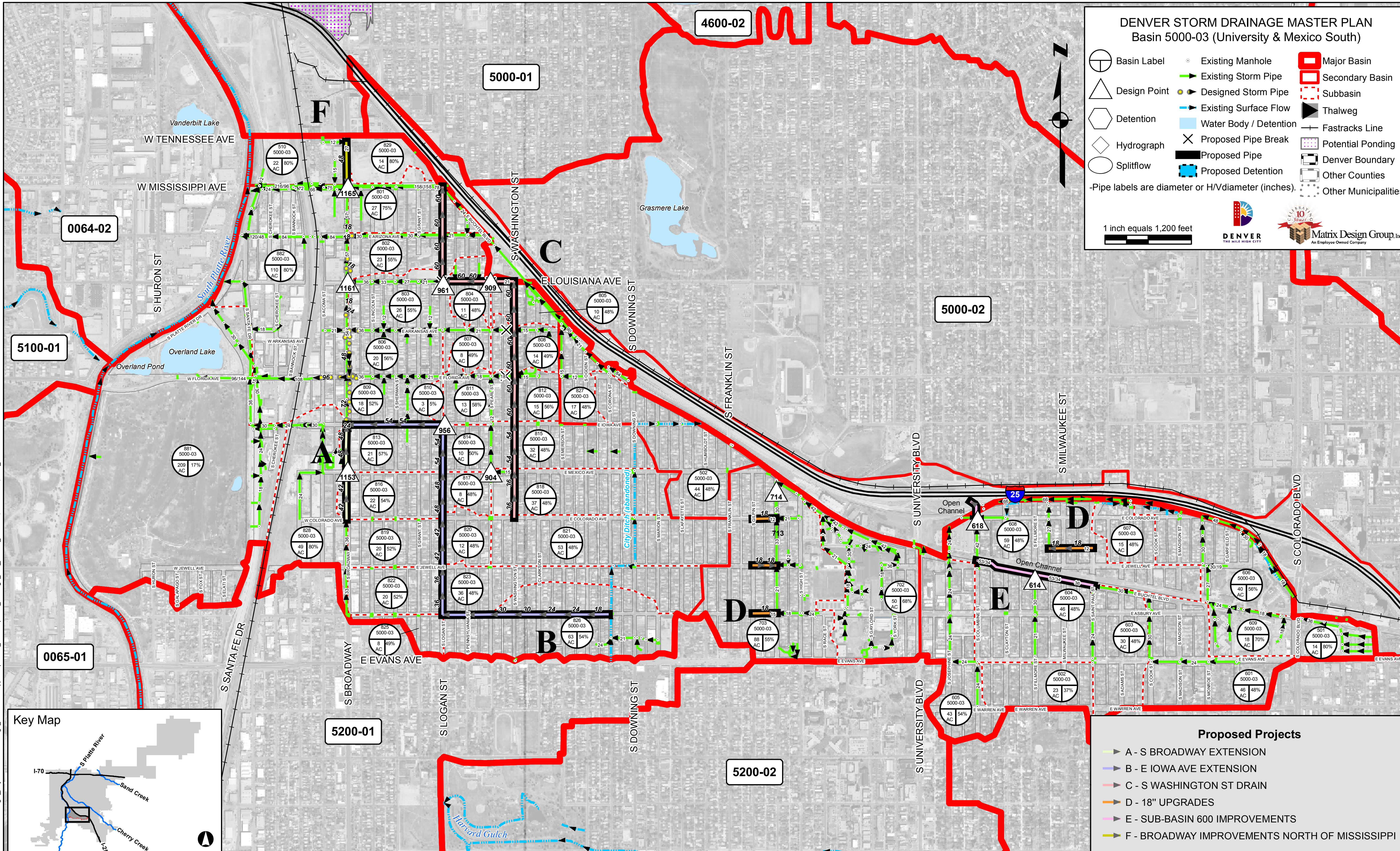
Project D: 18-Inch Upgrades Upsizing various pipes to the City's 18-inch minimum diameter is proposed to meet current drainage criteria.

Project E: Sub-Basin 600 Improvements Enlarge the inlet capacity in Milwaukee Street south of Colorado Avenue to prevent clogging and reduce flood depths. Remove cross culverts under railroad embankment. Provide an improved roadside channel along South Buchtel with regular series of inlets connected to the existing storm drainage system in South Buchtel. Remove the existing 6-ft by 3-ft box culvert outfall from Columbine Street Grade an open channel extension to the T-REX southeast University detention basin. Provide a low-head scupper type entrance to the open channel from Columbine Street Grade an overflow spillway from the Colorado Avenue pond to the open channel extension. Modify the outlet works of the Colorado Avenue pond to provide a standard water quality outlet.

Project F: Broadway Improvements North of Mississippi The existing 27-inch brick storm sewer between Mississippi and Tennessee is not adequate to convey the 5-year storm event to the Mississippi interceptor and a new 48-inch RCP will be parallel to the existing 27-inch brick storm sewer, which will be abandoned in place. A short section of this existing brick sewer at the southern end will need to be removed in order to connect into the Mississippi interceptor at the same location.

Existing Hydrology

Design Point	Contributing Basins	Tributary Area	Peak Discharge		
			2-Year	5-Year	100-Year
		(acres)	(cfs)	(cfs)	(cfs)
614	601, 602, 603, 604, 609	165	70	146	436
618	601, 602, 603, 604, 605, 608, 609	258	118	239	694
713	701, 703	92	40	82	70
714	701, 702, 703	164	69	112	264
904	818	182	56	121	365
909	805	270	38	77	224
956	814	52	25	57	229
961	804	353	52	106	321
1153	816	75	89	184	502
1161	803	161	133	209	490
1165	801	218	150	224	537
1402	Split Flow	0	24	63	250
1404	828	49	34	49	143


DENVER STORM DRAINAGE MASTER PLAN
Basin 5000-03 (University & Mexico South)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.
Proposed Projects
A - S BROADWAY EXTENSION
B - E IOWA AVE EXTENSION
C - S WASHINGTON ST DRAIN
D - 18" UPGRADES
E - SUB-BASIN 600 IMPROVEMENTS
F - BROADWAY IMPROVEMENTS NORTH OF MISSISSIPPI
4600-02
5000-01
5000-02
0064-02
5100-01
0065-01
5200-01
5200-02
W TENNESSEE AVE
W MISSISSIPPI AVE
E LOUISIANA AVE
E EVANS AVE
S HURON ST
S SANTA FE DR
S BROADWAY
S LOGAN ST
S WASHINGTON ST
S DOWNING ST
S FRANKLIN ST
S UNIVERSITY BLVD
S MILWAUKEE ST
S COLORADO BLVD
Vanderbilt Lake
Overland Lake
Overland Pond
Grasmere Lake
South Platte River
City Ditch (abandoned)
Harvard Gulch
Open Channel
Key Map
I-70
S Platte River
Sand Creek
Cherry Creek
I-25
FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activeapps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/25/2009, ron_ramold

Basin 5100-01 (Sanderson Gulch)

Existing System Description:
Sanderson Gulch is located in the southwest metropolitan area through portions of the City & County of Denver, the City of Lakewood and Jefferson County. Sanderson Gulch starts at the top of Green Mountain and extends east to the South Platte River just north of West Florida Avenue. The basin is currently fully developed and is primarily residential with some commercial. The Sanderson Gulch Basin has a total drainage area of approximately 7.6 square miles. For this study, only tributary basins to Denver's system were analyzed and includes approximately 5.6 square miles.

Drainage Deficiencies:
Development occurred in this area of Denver about the same time floodplain development criteria was developed for the City. Land development was required to preserve wide open spaces along the floodplains of Sanderson Gulch. However, many of the roadway culverts have 10-year capacity, thereby causing flooding at road intersections and placing some households within the floodplain. Low in the basin near the outfall to the South Platte River, commercial and industrial development in this basin has encroached into the gulch. The existing systems draining basins 670 and 680 lower in the basin at the Mississippi/Mosier Place outfall are adequate for the 2-year storm. However, the potential for flooding of properties during the 5-year and 100-year storm is high due to the limited capacity of the drainageway.

Basin 630 drains to an existing 54-inch storm sewer within Mississippi Avenue and flows east to Pecos Street. The system was designed to convey 310 cfs to Sanderson Gulch. This system is undersized for the 2-year storm event and in a 100-year event, 1,267 cfs would flow in the remnant of Mississippi Gulch located east of S. Pecos at W. Mosier Place. A 100-year alternative is identified on the next pages and the City of Denver has retained Matrix Design Group to conduct additional analysis to evaluate alternative conveyance systems to address this issue.

Also, basins 405, 410, 420, 430 comprise 157 acres that is served by an existing 24-inch storm sewer system draining along Mississippi Avenue. The 2-year base flow is approximately 52 cfs. It appears that this outfall is undersized and the upstream network appears deficient for adequately intercepting flows.

Basins 230 and 240 comprise 108 acres that is drained by an existing 21-inch storm sewer. The storm sewer capacity is not able to handle the 2-year storm flows.

Proposed Capital Improvements:
Structure improvements to the channel and roadway culverts can reduce flood hazard areas. Proposed improvements for the channel are not included in this study.

<u>Project A: 18-inch Upgrades</u> This upgrade is recommended to meet the City and County of Denver's Criteria.

<u>Project B: S. Carlan St. Outfall</u> The outfall will provide drainage to the surrounding neighborhood and commercial areas. The upstream portion should be sized for the 5-year frequency storm. The storm sewer will extend along Arkansas Avenue to S. Carlan Street and will outfall to Sanderson Gulch.

<u>Project C: S. Decatur Outfall</u> A 2-year frequency storm sewer is required from Sanderson Gulch upstream to Mexico Avenue and Colorado Avenue Laterals will be required at each intersection as shown on the plan.

<u>Project D: S. Federal Blvd. Outfall</u> This 54-inch outfall will be sized to handle the 5-year frequency storm. The existing storm sewer is undersized due to the surrounding commercial property.

<u>Project E: S. Navajo St. Outfall</u> requires a proposed drainage facility to serve the residential area in basin 670 and 680 in the minor event. The upgrade to the existing storm sewer will provide a 5-year frequency storm sewer system and meet Denver's criteria for the upstream area; however, properties east/downstream of Pecos at Mosier Place would be subject to flooding in a major event as noted in "Drainage Deficiencies" above. Refer to the 100-year Alternatives Analysis for additional information.

<u>Project F: S. Quitman St. Improvements</u> A proposed 24-inch storm sewer in S. Quitman will connect to the existing storm sewer at Arkansas Avenue and extend north to Arizona Street This will provide a 2-year frequency storm sewer to service the residential area.

<u>Project G: S. Tejon St. Outfall</u> Currently, no storm sewer exists in this area to service the residential and commercial areas. A 5-year capacity, 48-inch storm sewer is proposed.

<u>Project H: S. Tennyson St. Improvements</u> A proposed 7' x 4' box culvert will be connected to the existing storm sewer at Florida Avenue and S. Tennyson Street The proposed storm sewer requires upsizing the existing storm sewer. The new portion will provide service to the surrounding residential area.

<u>Project I: S. Utica Outfall</u> The lower section of this outfall will be sized for the 5-year frequency storm. This system will accept flows from Project H and will include a new lateral extending west along Florida Avenue Both systems will be sized for the 5-year frequency storm. The existing storm sewer within Utica will be replaced.

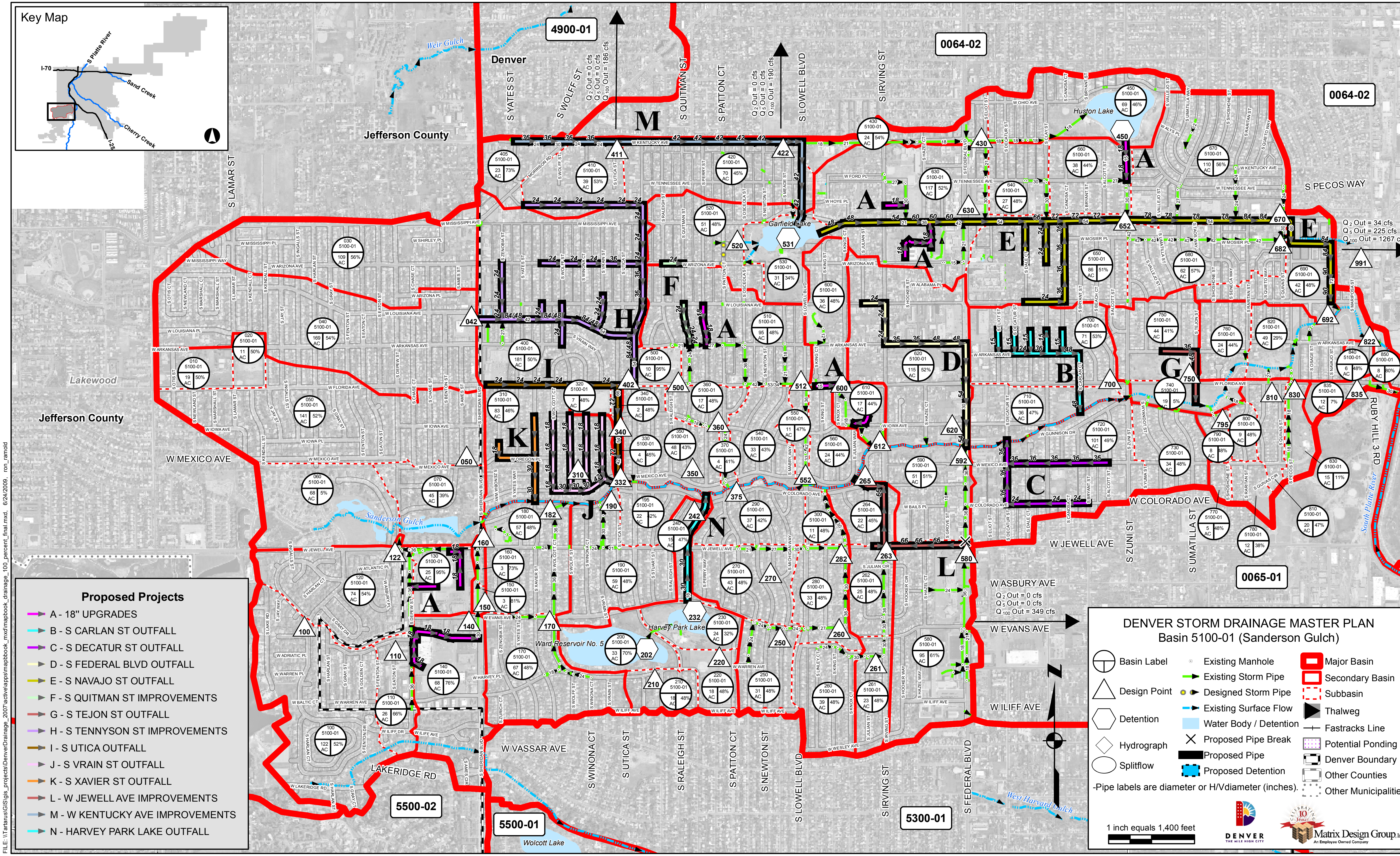
<u>Project J: S. Vrain St. Outfall</u> A new storm sewer and laterals are proposed to service the surrounding neighborhood upstream of the outfall. This storm sewer can be a 2-year frequency system.

<u>`Project K: S. Xavier St. Outfall</u> The proposed storm sewer will extend from Sanderson Gulch up to Iowa Avenue. The storm sewer will provide a 2-year level of service for the residential neighborhood. A lateral will be extended along Oregon Place to Zenobia St.

<u>Project L: W. Jewell Avenue Improvements</u> The proposed 66-inch outfall will upsize the existing storm sewer's capacity in Irving St and W. Jewell Avenue to a 5-year capacity. New 5-year capacity storm sewer is proposed to extend east along W. Jewell Avenue to Federal Boulevard

<u>Project M: W. Kentucky Avenue Outfall</u> A new outfall system is proposed along Kentucky Avenue to intercept runoff from basins 405, 410 and 420. This system will be sized for the 5-year storm. Currently there is no existing storm sewer in Kentucky Avenue During the 100-year frequency storm however, runoff from these basins exceed the capacity in W. Kentucky Avenue and will flow to Basin 0064-02. (See the following 100-year Alternative Plan.)

<u>Project N: Harvey Park Lake Outfall</u> A new 30-inch outfall system is proposed in S. Quitman Street to intercept flows from Basins 230 and 240 which is currently drained by an undersized 21-inch storm sewer.



Key Map
I-70
S Platte River
Sand Creek
Cherry Creek
I-25
Denver
Jefferson County
Lakewood
4900-01
0064-02
0065-01
5500-02
5500-01
5300-01
Q 2 Out = 0 cfs
Q 5 Out = 0 cfs
Q 100 Out = 186 cfs
Q 2 Out = 0 cfs
Q 5 Out = 0 cfs
Q 100 Out = 190 cfs
Q 2 Out = 34 cfs
Q 5 Out = 225 cfs
Q 100 Out = 1267 cfs
W ASBURY AVE
Q 2 Out = 0 cfs
Q 5 Out = 0 cfs
Q 100 Out = 349 cfs
W MEXICO AVE
W COLORADO AVE
W JEWELL AVE
W EVANS AVE
W ILIFF AVE
W VASSAR AVE
LAKERIDGE RD
S PECOS WAY
RUBY HILL 3 RD
S LAMAR ST
S YATES ST
S WOLFF ST
S QUITMAN ST
S PATTON CT
S LOWELL BLVD
S IRVING ST
S FEDERAL BLVD
S ZUNI ST
S UMATILLA ST
S WINONA CT
S UTICA ST
S RALEIGH ST
S NEWTON ST
Weir Gulch
Sanderson Gulch
West Harvard Gulch
South Platte River
Huston Lake
Garfield Lake
Harvey Park Lake
Ward Reservoir No. 5
Wolcott Lake
Proposed Projects
A - 18" UPGRADES
B - S CARLAN ST OUTFALL
C - S DECATUR ST OUTFALL
D - S FEDERAL BLVD OUTFALL
E - S NAVAJO ST OUTFALL
F - S QUITMAN ST IMPROVEMENTS
G - S TEJON ST OUTFALL
H - S TENNYSON ST IMPROVEMENTS
I - S UTICA OUTFALL
J - S VRAIN ST OUTFALL
K - S XAVIER ST OUTFALL
L - W JEWELL AVE IMPROVEMENTS
M - W KENTUCKY AVE IMPROVEMENTS
N - HARVEY PARK LAKE OUTFALL
DENVER STORM DRAINAGE MASTER PLAN
Basin 5100-01 (Sanderson Gulch)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,400 feet
DENVER THE MILE HIGH CITY
Matrix Design Group, Inc.
FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activeapps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/24/2009, ron_rarnold

Basin: 5100-01 (Sanderson Gulch) 100-Year Alternative

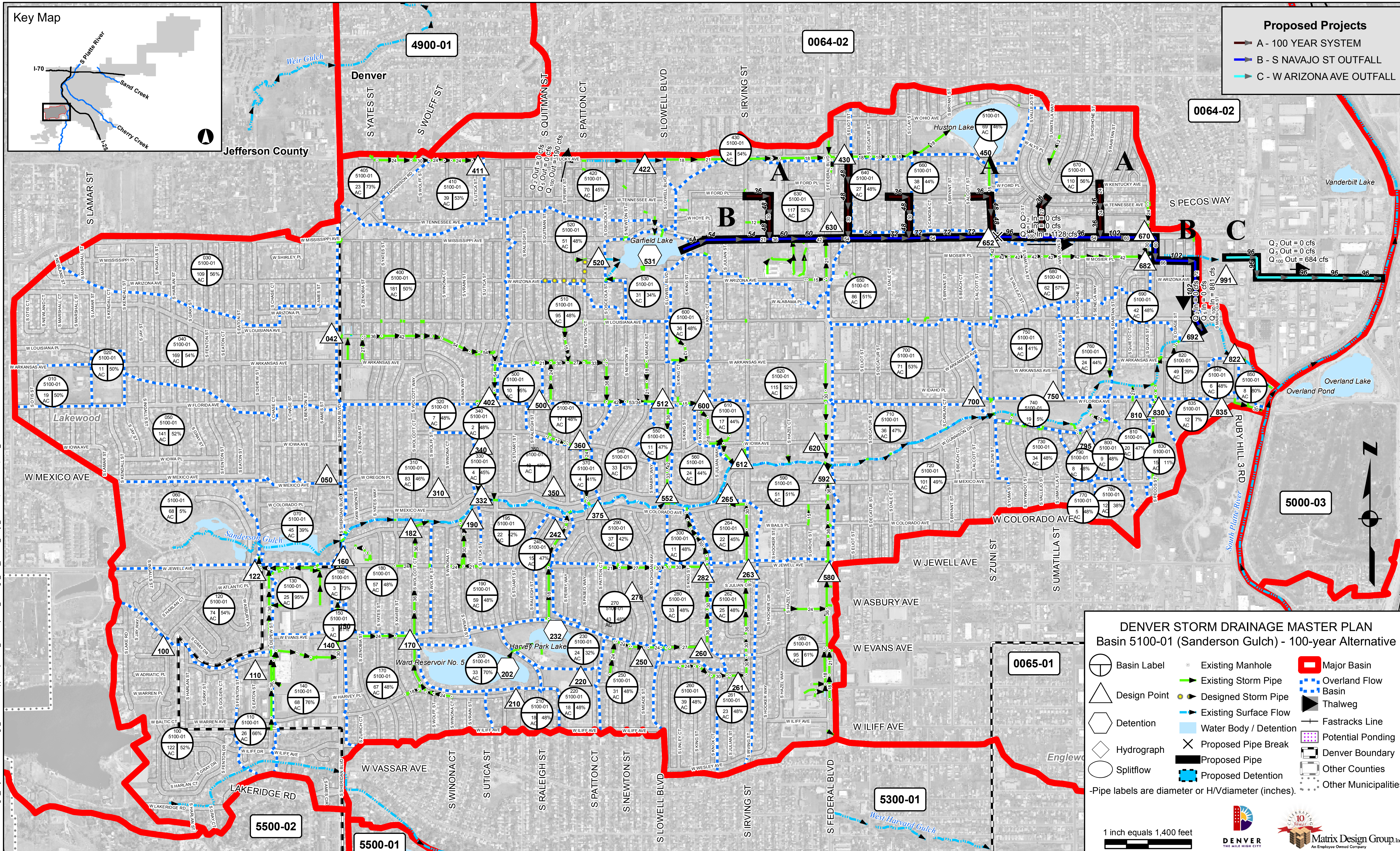
A 100-year conveyance alternative proposed for the gulch along Mosier Place adjacent to Mississippi Avenue. The 2005 Storm Drainage Master Plan considered a 100-year regional detention pond on the property directly downstream of Mosier Place at South Quivas; however, it is felt that a pond in this location would be too close to the South Platte River's 100-year floodplain to provide significant flood hazard reduction and infrastructure cost savings since it is close to the outfall.

Alternative 100 Year System:
Project B: S. Navajo St. Outfall This alternative will route flows in excess of 684 cfs directly to Sanderson Gulch through an upgraded proposed Navajo Street outfall.

Project C: West Arizona Avenue Outfall A new storm drain would extend from a recently constructed 8' x 6' RCBC at S. Mariposa Street which has a capacity of 684 cfs and outfall to the South Platte River as shown on the alternative plan. The existing storm sewer laterals would also be upsized as shown in Project A. Special consideration should be given to this alternative due to the proximity of the South Platte River 100-year floodplain.

BASIN 5100-01

Design Point	Contributing Basins	Tributary Area	Peak Discharge		
			2-Year	5-Year	100-Year
		(acres)	*(cfs)*	*(cfs)*	*(cfs)*
42	30,40	278	249	441	1143
50	10,20,50	171	104	192	508
100	100	122	92	169	437
110	110	26	26	42	101
122	100,110,120,130	247	177	313	821
140	140	68	76	118	266
150	140,150	71	81	127	284
160	140,150,160	74	80	130	301
170	170	67	42	79	214
182	170,180	125	76	144	366
190	190	59	35	67	181
202	200,210	51	48	80	195
210	210	18	13	25	69
220	220	18	12	23	63
232	200,210,220,230	93	55	94	237
242	232,240	108	58	104	273
250	250	31	19	36	97
260	260	40	24	45	121
261	261	24	14	27	72
263	260,261,262	89	46	78	143
265	260,261,262,264	111	55	91	195
270	270	44	27	51	137
282	250,270,280	108	68	121	336
310	310	83	46	88	242
332	30,40,190,320,330,340,400	531	292	540	1561
340	30,40,340,400	461	270	494	1410
350	350	48	24	48	135
360	360	17	13	24	65
375	360,370	21	14	28	75
402	30,40,400	459	272	494	1396
411	405,410	63	52	89	221
422	405,410,420	133	50	97	225
430	405,410,420,430	157	52	103	92
450	450	69	39	77	218
500	500	10	15	21	44
512	500,510	105	86	163	430
520	520	51	31	59	159
531	520,530	82	3	6	19
552	500,510,550	117	83	158	431
580	580	95	97	165	408
592	580,590	146	121	208	231
600	600	34	28	54	143
612	600,610	51	33	66	187
620	620	115	70	127	338
630	405,410,420,430,520,530,630	356	109	196	506
652	405,410,420,430,520,530,630,640,650,660	507	223	393	1128
670	405,410,420,430,520,530,630,640,650,660,670	617	293	463	1382
682	405,410,420,430,520,530,630,640,650,660,670,680	679	332	523	1565
692	405,410,420,430,520,530,630,640,650,660,670,680,690	721	320	345	432
700	700	71	51	91	238
750	750	44	27	55	159
795	770,790	13	9	17	46
810	810	20	13	26	70
822	820	49	20	47	148
830	830	15	2	7	29
835	835	12	0	5	23
991	split	split	34	225	1267



FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activelaps\mapbook_mxd\mapbook_drainage_100_percent_100yr_final.mxd, 6/24/2009, ron_ramold

Basin: 5200-01 (Harvard Gulch Lower Basin)

Existing System Description:
Harvard Gulch is a right-bank tributary of the South Platte River draining a 7.43 square mile basin located in south-central Denver. According to UDFCD Drainage Basin Description Maps (UDFCD, 1990), the Harvard Gulch basin is subdivided into a "lower" and "upper" basin designated as 5200-01 and 5200-02, respectively. To accommodate presentation of mapping information for the 2005 and 2009 Master Plan updates, the upper basin was further divided into two basins, 5200-02 and 5200-03. The following discussion focuses on the lower basin, followed by a discussion of the middle and upper basins.

Land use in the 0.85 square mile lower basin is predominately residential with commercial development along major transportation corridors (Broadway and Santa Fe Drive) and industrial use between the Regional Transportation District Light Rail/Southern Pacific Railroad lines and Delaware Street. The basin is nearly fully developed with Rosedale Park and Community Gardens the only remaining significant open space. ***Blueprint Denver*** has identified a 60 acre industrial/commercial zone located between Logan and Sherman Streets as an "Area of Change."

The Harvard Gulch major drainageway consists of a 14' x 9' RCBC extending easterly from the South Platte River 4,000 feet beneath Wesley to Logan. The initial combination of City owned and private storm drain system is comprised of approximately 37,100 feet of storm sewers ranging from 4- to 180- inches in diameter that convey initial storm flows (2- or 5-year frequency events) to Harvard Gulch. Two initial storm drain systems convey flow directly to the South Platte River via outfalls located at Asbury and Evans Avenues.

Drainage Deficiencies
The floodplain that was determined in the Harvard Gulch Flood Hazard Area Delineation Study (UDFCD, 1979) was overlaid on the City and County of Denver's parcel layer and it was estimated that 1,100 parcels would be inundated by a 100-year frequency storm event on Harvard Gulch and Dry Gulch (a tributary to Harvard Gulch) due to major drainageway box culvert conveyance capacity limitations. It was estimated that 574 of the 1,100 inundated parcels are located in the Harvard Gulch Lower Basin west of S. Logan Street Approximately 45% of the parcels within the Harvard Gulch 100-year floodplain occur between Santa Fe Drive and S. Logan Street, where the channel is underground. Flooding is predicted to be shallow (less than three feet deep) and occurs along the entire Harvard Gulch drainageway and extends to the northwest, into Major Basin 5000-03, as overland flow through the Overland Golf Course to the South Platte River.

Master Plan hydrologic modeling (UDSWM) concluded that the majority of the initial storm drain system does not to meet City level of service criteria. Localized flooding has also been noted at the siphons located at street intersections where capacity is periodically restricted by an accumulation of debris and sediment.

Proposed Capital Improvements
Drainage system improvements were developed using the City's level of service criteria to address identified capacity deficiencies. For the major drainageway, proposed improvements were designed to provide 100-year frequency storm event level of service as part of the 2005 Master Plan. The sizes of the improvements for the major drainageway were not reanalyzed as part of the 2009 Master Plan update. The decision was made not to reanalyze the 100-year improvements for the major drainageway because a detailed Outfall System Planning Study is currently underway by Matrix Design Group, Inc. For the initial storm drain system, a 2- or 5-year event level of service criteria was used to size facilities for residential or commercial/industrial land uses, respectively. Due to the lack of appropriate open land uses, initial storm drain improvements focused on upgrading conveyance capacity only, whereas major drainageway facilities considered both conveyance and detention alternatives.

It was determined as part of the 2005 Master Plan that potential detention sites within the Harvard Gulch basin do not have capacity to sufficiently reduce 100-year event peak flows alone, resulting in the need to expand existing, major drainageway conduits. Therefore, the detention alternative, Alternative 2, includes some conveyance system improvements as well as detention. The conveyance alternative, Alternative 1, assumes that the 100-year event peak flow is fully contained to the South Platte River.

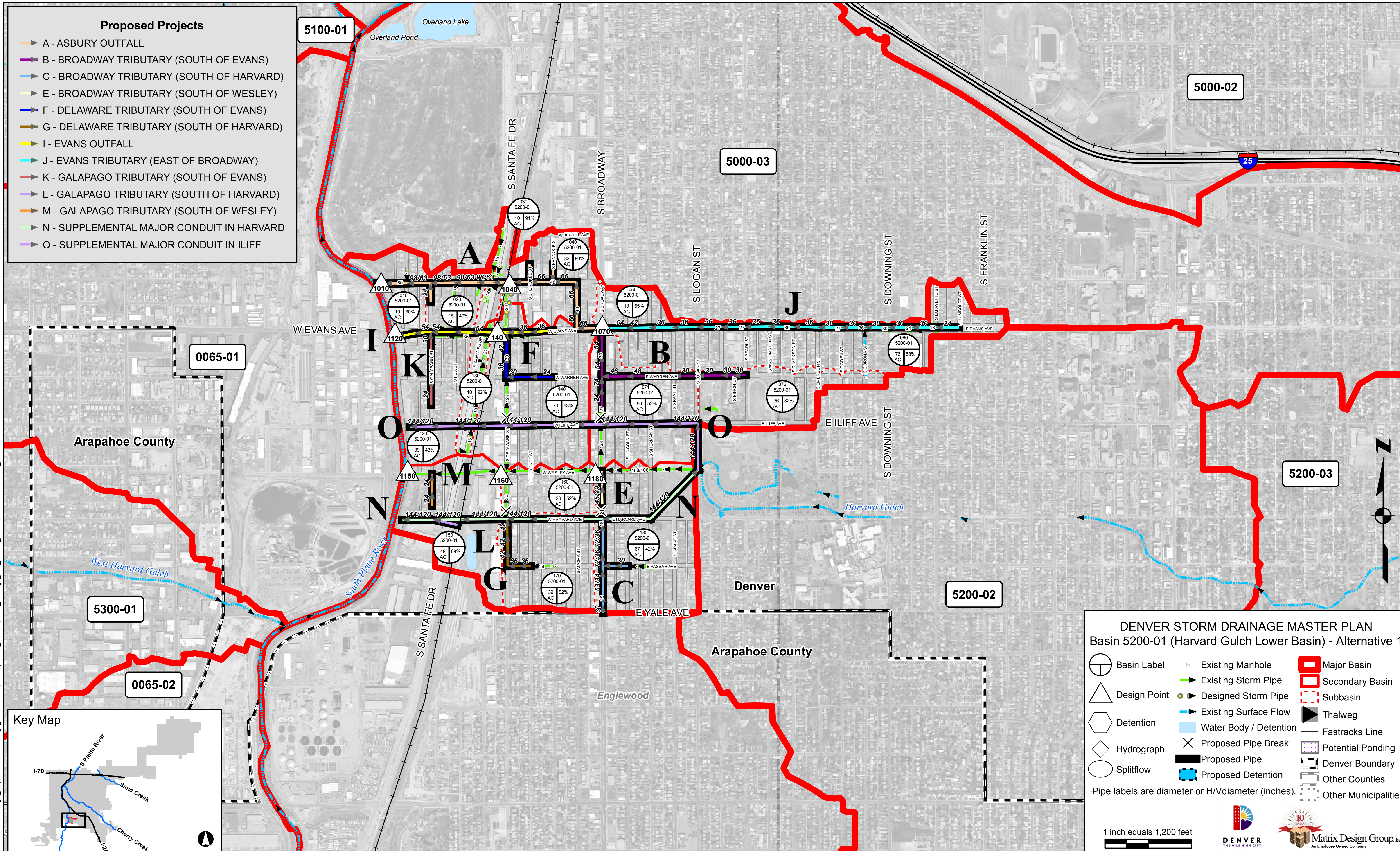
The proposed initial storm drain improvements were essentially the same for both major drainageway alternatives with minor differences in outfall alignments and proposed pipe sizes where they connect to the major drainageway conduits. The differences in both the major drainageway improvements and the initial storm drain improvements can be seen on the Alternative 1 and Alternative 2 maps. Alternatives were evaluated based on hydraulic performance, constructability, cost, aesthetics, environmental considerations, and public safety considerations.

For the conveyance alternative, Alternative 1, it was determined as part of the 2005 Master Plan that proposed improvements consist of supplementing the capacity of the existing box culvert in Wesley Avenue by constructing two new 10-foot by 12-foot box culverts, one in Harvard Avenue, Proposed Project N, and the other in Iliff Avenue, Proposed Project O. These facilities are estimated to cost $29.5 million. The initial storm drain systems were reevaluated as part of the 2009 Master Plan update and approximately 20,930 feet of new and replacement pipelines are proposed for the initial storm drain system, the remainder of the proposed projects, projects A through M, and are estimated to cost $15.0 million. The cost opinion for the conveyance alternative (including initial storm drain facilities) total $44.5 million.

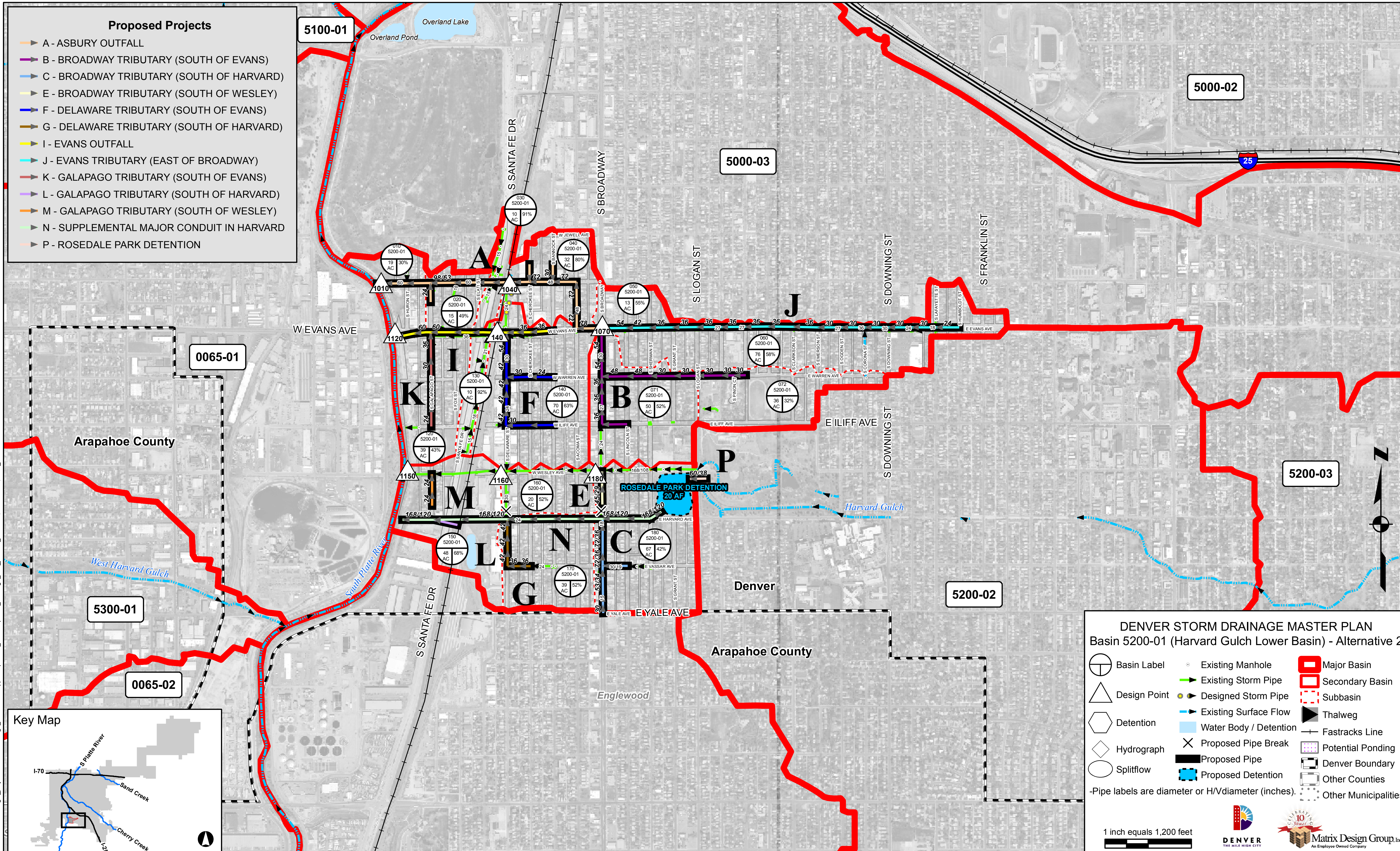
It was determined as part of the 2005 Master Plan that opportunities for detention in the Harvard Gulch basin were limited to Rosedale Park. Other sites were considered too small. A sculpted basin design is proposed in Alternative 2 for Rosedale Park that could provide up to 20 acre feet of detention as well as enhance riparian habitat and offer a natural appearance. To meet the 100-year level of service with Rosedale Park detention, the major drainageway conveyance would need to be supplemented with a 14' x 10' RCBC in Harvard Avenue. The cost opinion for the detention facility, Proposed Project P, is $6.0 million and $14.0 million for the new Harvard Avenue box culvert Proposed Project N. The initial storm drain systems were re-evaluated as part of the 2009 Master Plan update and the initial storm drain system improvements include 23,115 feet of new and replacement pipeline at an estimated cost of $16.8 million. The detention alternative cost opinion totals $36.8 million.

Basin 5200-01 – Summary of Hydrologic Modeling Results

Design Point/ Conveyance Element	Contributing Basin	Tributary Area (acre)	Peak Discharge 2-Year (cfs)	Peak Discharge 5-Year (cfs)
140	140	70.1	61	113
1010	1021, 10	251.6	139	242
1040	1071, 40	207.7	113	211
1070	1072, 50, 60, 71	175.5	99	204
1120	1131, 120	118.5	90	172
1150	150	48.5	45	80
1160	160, 1170	58.9	38	80
1180	180	66.6	35	80


Proposed Projects
A - ASBURY OUTFALL
B - BROADWAY TRIBUTARY (SOUTH OF EVANS)
C - BROADWAY TRIBUTARY (SOUTH OF HARVARD)
E - BROADWAY TRIBUTARY (SOUTH OF WESLEY)
F - DELAWARE TRIBUTARY (SOUTH OF EVANS)
G - DELAWARE TRIBUTARY (SOUTH OF HARVARD)
I - EVANS OUTFALL
J - EVANS TRIBUTARY (EAST OF BROADWAY)
K - GALAPAGO TRIBUTARY (SOUTH OF EVANS)
L - GALAPAGO TRIBUTARY (SOUTH OF HARVARD)
M - GALAPAGO TRIBUTARY (SOUTH OF WESLEY)
N - SUPPLEMENTAL MAJOR CONDUIT IN HARVARD
O - SUPPLEMENTAL MAJOR CONDUIT IN ILIFF
5100-01
5000-02
5000-03
0065-01
0065-02
5300-01
5200-01
5200-02
5200-03
Overland Lake
Overland Pond
S SANTA FE DR
S BROADWAY
S LOGAN ST
S DOWNING ST
S FRANKLIN ST
W EVANS AVE
E ILIFF AVE
E YALE AVE
Harvard Gulch
West Harvard Gulch
South Platte River
Arapahoe County
Denver
Englewood
Key Map
I-70
S Platte River
Sand Creek
Cherry Creek
I-25
DENVER STORM DRAINAGE MASTER PLAN
Basin 5200-01 (Harvard Gulch Lower Basin) - Alternative 1
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER THE MILE HIGH CITY
Matrix Design Group, Inc.

This page left intentionally blank.


Proposed Projects
A - ASBURY OUTFALL
B - BROADWAY TRIBUTARY (SOUTH OF EVANS)
C - BROADWAY TRIBUTARY (SOUTH OF HARVARD)
E - BROADWAY TRIBUTARY (SOUTH OF WESLEY)
F - DELAWARE TRIBUTARY (SOUTH OF EVANS)
G - DELAWARE TRIBUTARY (SOUTH OF HARVARD)
I - EVANS OUTFALL
J - EVANS TRIBUTARY (EAST OF BROADWAY)
K - GALAPAGO TRIBUTARY (SOUTH OF EVANS)
L - GALAPAGO TRIBUTARY (SOUTH OF HARVARD)
M - GALAPAGO TRIBUTARY (SOUTH OF WESLEY)
N - SUPPLEMENTAL MAJOR CONDUIT IN HARVARD
P - ROSEDALE PARK DETENTION
5100-01
Overland Lake
Overland Pond
5000-02
5000-03
0065-01
5300-01
0065-02
5200-03
5200-02
S SANTA FE DR
S BROADWAY
S LOGAN ST
S DOWNING ST
S FRANKLIN ST
W EVANS AVE
E ILIFF AVE
E YALE AVE
Arapahoe County
Denver
Englewood
Harvard Gulch
West Harvard Gulch
South Platte River
ROSEDALE PARK DETENTION
20 AF
Key Map
DENVER STORM DRAINAGE MASTER PLAN
Basin 5200-01 (Harvard Gulch Lower Basin) - Alternative 2
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.

Basin: 5200-02 (Harvard Gulch Middle Basin)

Existing System Description:
Harvard Gulch is a right-bank tributary of the South Platte River draining a 7.43 square mile basin located in south-central Denver. The following discussion focuses on drainage system description, deficiencies and proposed capital improvements for the entire middle basin, 5200-02.

Land use in the 2.75 square mile middle basin is primarily residential with commercial development along major transportation corridors (University Boulevard, Hampden, and Evans Avenues). The southern portion of the basin is located in unincorporated Arapahoe County, City of Englewood, and Cherry Hills Village. Approximately 2.0 square miles of the Harvard Gulch basin lies outside of the City and County of Denver municipal boundary.

Harvard Gulch, McWilliams, and DeBoer Parks are located along the Harvard Gulch major drainageway.

The middle basin includes two major drainageways: Harvard Gulch and Dry Gulch. The Harvard Gulch drainageway consists of open channel throughout Harvard Gulch Park (from Logan Street to Ogden Street). Upstream of Ogden Street to Downing Street is a 14½' x 10' underground box conduit. Upstream of Downing Street to Race Street, the major drainageway for Harvard Gulch consists of an open trapezoidal section of concrete channel. Upstream of Race Street is a natural channel in DeBoer Park.

The Dry Gulch drainageway is comprised of 700 feet of 2 parallel 68"x 43" by buried elliptical pipe, and 800 feet of 72-inch buried circular pipe extending south from Harvard Gulch Park to the southern City boundary. Additional buried circular pipe ranging in size from 72-inch to 33-inch extends into Arapahoe County to Girard Avenue near the southern boundary of the watershed.

Drainage Deficiencies:
The floodplain delineated in the Harvard Gulch Flood Hazard Area Delineation study (UDFCD, 1979) was overlaid on the City and County of Denver's parcel layer and it was estimated that 333 parcels would be inundated by the Harvard Gulch 100-year floodplain in the middle basin of Harvard Gulch (5200-02) and 61 parcels would be inundated by the Dry Gulch 100-year floodplain due to major drainageway capacity limitations. Flooding is predicted to be greater than 3 feet deep, and extends the entire Harvard Gulch and Dry Gulch drainageways within the City's municipal boundary. Approximately twenty percent of parcels within the Harvard Gulch 100-year floodplain occur between Downing Street and Race Street, where the channel is concrete-lined or underground. Flood problems are less frequent upstream of Race Street, confined primarily to properties adjacent to the open channel.

Other drainageway deficiencies in Harvard Gulch occur at bridge crossings and closed conduit inlets where backwater effects create upstream flood conditions. Several flow restrictions exist in the Harvard Gulch major drainageway that cause overbank 100-year flows. These include constrictions at:

- Madison Avenue
- Entrance to the concrete trapezoidal channel at Race Street at the west end of DeBoer Park
- Bridge crossings of the concrete trapezoidal channel from Race Street to Downing Street
- Culvert entrance at Logan Street
- Culvert entrance at Downing Street

Many of these flow limiting facilities were sized for a 25-year event, but more recent analysis indicates capacities are closer to a 10-year event or less (Gingery Associates FHAD, December 1979).

Master Plan hydrologic modeling (UDSWM) concluded that the majority of the initial storm drain system does not to meet City level of service criteria. Localized flooding has also been noted at siphons where capacity is periodically restricted by an accumulation of debris and sediment.

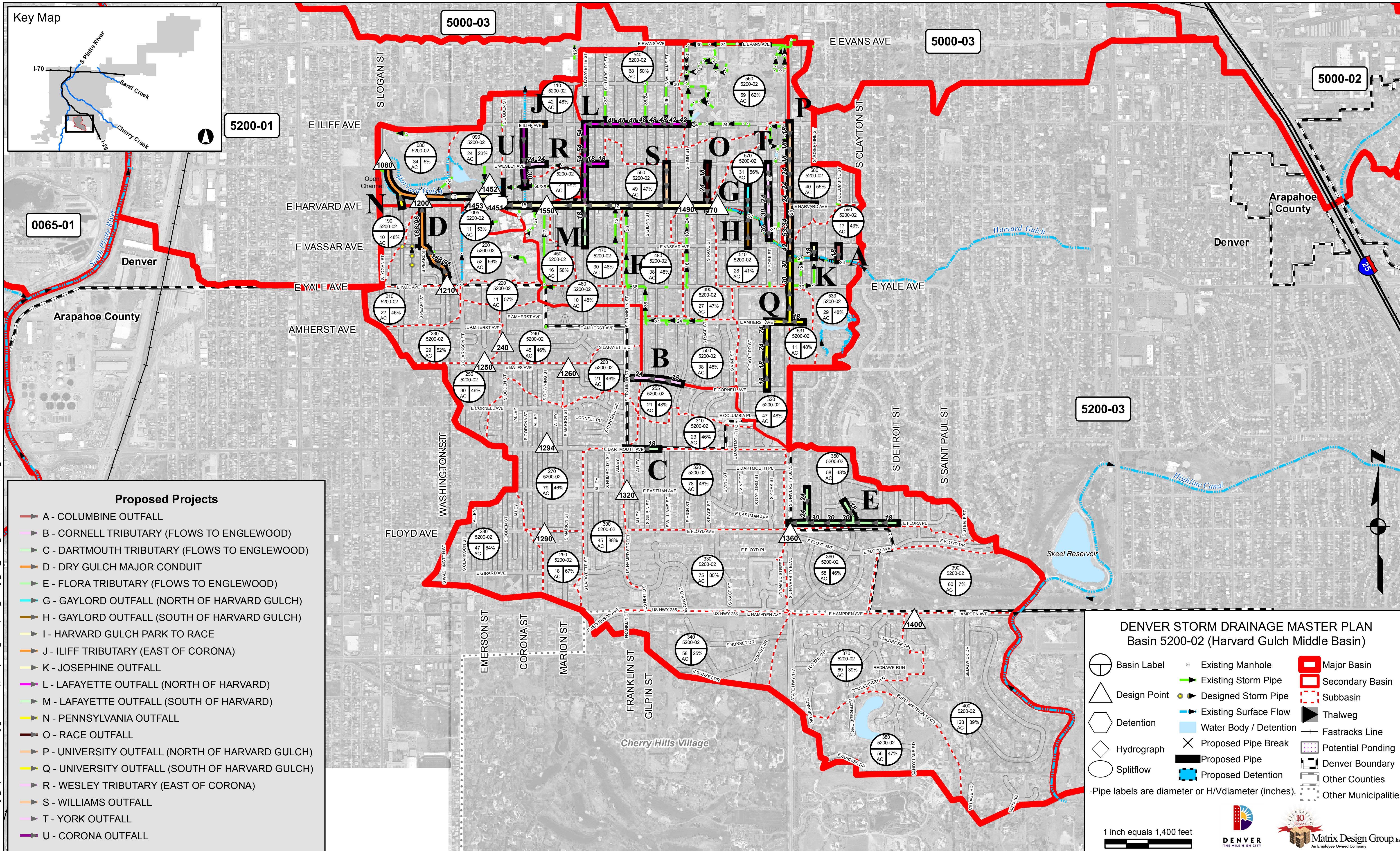
A summary of hydrologic model peak flow predications at key basin locations is presented in the table below.

Basin 5200-02 – Key Basin Location Summary of Hydrologic Modeling Results

Design Point/ Conveyance Element	Contributing Basin	Tributary Area	Peak Discharge	
			2-Year	5-Year
		(acre)	(cfs)	(cfs)
240	240	45.1	27	59
255	255	21.4	13	27
560	560	59.4	55	103
1110	100, 110	53.6	33	69
1200	1091, 1211, 200	1312.4	407	933
1210	1231, 210, 220	1182.2	393	910
1250	1271, 250, 1261	1076.2	374	857
1290	1280, 290	65.3	64	117
1294	1293, 1310	924.6	341	777
1320	1331, 320	790.7	260	644
1360	1391, 350, 360, 1371	637.0	199	527
1400	400, 1385, 1431	333.7	128	313
1480	480	75.9	44	95
1540	1560, 540	127.6	94	181
1593	520, 531	57.7	36	76

Proposed Capital Improvements:
Drainage improvements in this basin are primarily recommended to achieve the minimum performance objectives as described in Denver's Drainage Criteria; 2-year and 5-year systems for residential and commercial areas respectively. However, for the major drainageway channel, proposed improvements were designed to provide 100-year frequency storm event level of service as part of the 2005 Master Plan to reduce or eliminate the regulatory floodplain through the area of development. A detailed Outfall System Planning Study in 2009 is being produced by Matrix Design Group, Inc. and is not included in this Master Plan. To meet these requirements, most of the existing storm drain network will need to be replaced. These improvements can be phased in smaller projects following the completion of the major project components. Proposed capital improvements include:

- Construction of storm drains in local roads shown to improve interception of minor storm event runoff and conveyance within neighborhoods.
- Approximately 1,500 feet of the Dry Gulch drainageway extending from Yale Avenue to Harvard Avenue will be replaced with a 14'x 8' RCBC conduit. A composite channel and two drop structures in Harvard Gulch Park are required to accommodate these proposed improvements.
- Harvard Gulch Park to Race consists of replacing the concrete channel from Race Street to Downing Street, the closed conduit from Downing Street to Ogden Street, and the natural channel 1000-feet east of Ogden Street (in Harvard Gulch Park) with a double 14'x 10' RCBC. Replacing the natural channel in Harvard Gulch Park with 1000-feet of closed conduit will allow three acres of park land to be reclaimed for public use, and will eliminate the need for a walled, concrete-lined channel.



DENVER STORM DRAINAGE MASTER PLAN
Basin 5200-02 (Harvard Gulch Middle Basin)
Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
Proposed Projects
A - COLUMBINE OUTFALL
B - CORNELL TRIBUTARY (FLOWS TO ENGLEWOOD)
C - DARTMOUTH TRIBUTARY (FLOWS TO ENGLEWOOD)
D - DRY GULCH MAJOR CONDUIT
E - FLORA TRIBUTARY (FLOWS TO ENGLEWOOD)
G - GAYLORD OUTFALL (NORTH OF HARVARD GULCH)
H - GAYLORD OUTFALL (SOUTH OF HARVARD GULCH)
I - HARVARD GULCH PARK TO RACE
J - ILIFF TRIBUTARY (EAST OF CORONA)
K - JOSEPHINE OUTFALL
L - LAFAYETTE OUTFALL (NORTH OF HARVARD)
M - LAFAYETTE OUTFALL (SOUTH OF HARVARD)
N - PENNSYLVANIA OUTFALL
O - RACE OUTFALL
P - UNIVERSITY OUTFALL (NORTH OF HARVARD GULCH)
Q - UNIVERSITY OUTFALL (SOUTH OF HARVARD GULCH)
R - WESLEY TRIBUTARY (EAST OF CORONA)
S - WILLIAMS OUTFALL
T - YORK OUTFALL
U - CORONA OUTFALL
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,400 feet
DENVER THE MILE HIGH CITY
Matrix Design Group, Inc.
An Employee Owned Company
5000-03
5000-02
5200-01
5200-03
0065-01
E EVANS AVE
E ILIFF AVE
E HARVARD AVE
E VASSAR AVE
E YALE AVE
AMHERST AVE
FLOYD AVE
S LOGAN ST
S CLAYTON ST
S DETROIT ST
S SAINT PAUL ST
WASHINGTON ST
EMERSON ST
CORONA ST
MARION ST
FRANKLIN ST
GILPIN ST
Harvard Gulch
Highline Canal
Skeel Reservoir
Cherry Hills Village
Arapahoe County
Denver
South Platte River
FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activeapps\mapbook_mxt\mapbook_drainage_100_percent_final.mxd, 6/24/2009, ron_ramold

Basin: 5200-03 (Harvard Gulch Upper Basin)

Existing System Description:
Land use in 3.84 square mile upper basin is primarily residential with commercial development along major transportation corridors (Colorado Boulevard, I-25, Hampden and Yale Avenue). The southern portion of the basin is located in unincorporated Arapahoe County and Cherry Hills Village. Arapahoe County enclaves exist along the eastern boundary of the upper basin (Holly Hills) and are bounded by the Harvard Gulch drainageway, Dahlia Street, and I-25. Approximately 2.0 square miles of the Harvard Gulch basin lies outside of the City and County of Denver municipal boundary.

Porter Hospital and Denver University campus are also located within the upper basin. ***Blueprint Denver*** has identified 168 acres as "Areas of Change". These are centered in commercial areas located at Evans Avenue and Colorado Boulevard, and the area bounded by Yale Avenue to the north and I-25 to the south. There is no industrial land use in the upper basin.

The south and east portions of the basin is traversed by the Highline Canal which intercepts some initial storm flows from basin headwater tributaries in the existing condition. However, it is stated in Section 3.3.4.1 of the City and County of Denver's Storm Drainage Design and Technical Criteria, that "Irrigation facilities such as ditches and reservoirs shall not be used as drainage facilities…" Because of this, initial storm flows were modeled as being conveyed across the Highline Canal to the downstream storm drain network.

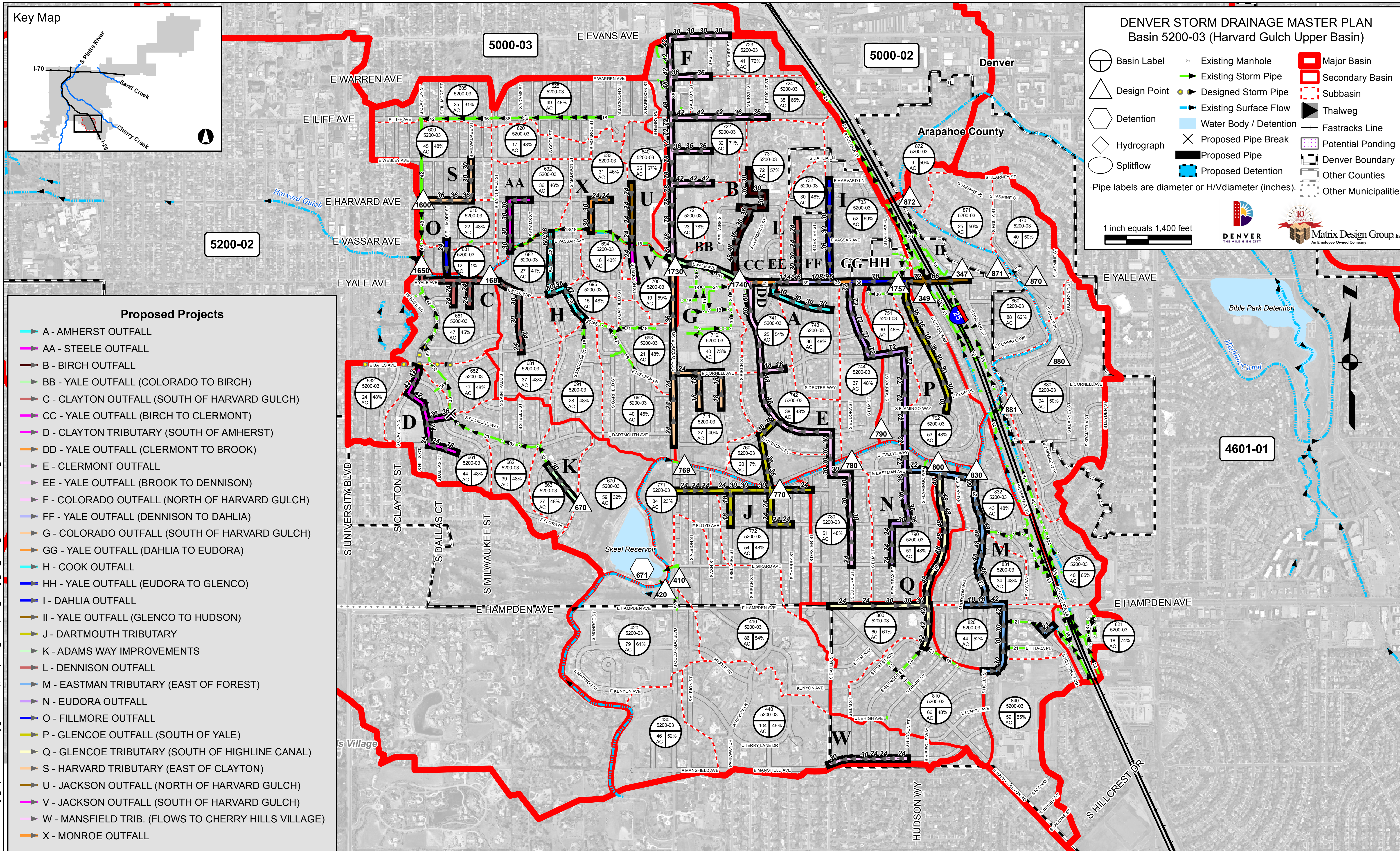
Drainage Deficiencies:
The floodplain delineated in the Harvard Gulch Flood Hazard Area Delineation study (Gingery Associates, UDFCD, 1979) was overlaid on the City and County of Denver's parcel layer and it was estimated that 79 parcels would be inundated by the Harvard Gulch 100-year floodplain in the upper basin of Harvard Gulch (5200-03). The most pressing need is for an improved/upsized drainage system in Yale Avenue east of Colorado Boulevard to replace the existing 18" to 42" pipe and provide and outfall for future drains extending upstream into the basin. This would best be achieved after improvements to the downstream portions of Harvard Gulch are completed in order to remove properties west of Colorado from the 100-year floodplain so as not to exacerbate flooding downstream.

Proposed Capital Improvements:
Drainage improvements in this basin are primarily recommended to achieve the minimum performance objectives as described in Denver's Drainage Criteria; 2-year and 5-year systems for residential and commercial areas respectively. To meet these requirements, most of the existing storm drain network will need to be replaced. These improvements can be phased in smaller projects following the completion of the major project components. Proposed capital improvements include:

- Construction of storm drains in local roads shown to improve interception of minor storm event runoff and conveyance within neighborhoods.
- Yale Avenue Outfall consists of an upsized box culvert and upsized reinforced concrete pipe in Yale Avenue between the outfall to the open channel west of Colorado Boulevard and Hudson Street. A reinforced concrete box culvert is needed west of Colorado Boulevard to Dahlia Street to convey the 5-yr flow including flows that currently discharge to the Highline Canal. An upsized pipe is needed east of Dahlia Street to Hudson Street to convey the 5-yr flow including flows that currently discharge to the Highline Canal.

Basin 5200-03 – Key Basin Location Summary of Hydrologic Modeling Results

Design Point/ Conveyance Element	Contributing Basin	Tributary Area	Peak Discharge	
			2-Year	5-Year
		(acre)	(cfs)	(cfs)
347	870, 871, 872, 880	167	113	234
349	348, 1881, 860	295	211	418
410	410	86	52	103
420	420	79	74	139
605	1625, 605	74	37	79
620	620	17	11	23
670	670, 1675	224	27	72
671	410, 420	165	0	0
760	760, 1770	74	36	82
769	771	34	9	29
770	772	54	35	74
780	780	51	37	79
790	790, 1800	382	225	429
800	800, 1810, 1830	322	199	389
810	810	66	41	87
820	1841, 1820, 820	121	88	173
830	1821, 832	197	126	254
840	840	59	44	86
881	881	40	31	56
1430	1440, 430	150	99	219
1600	1601, 1620, 600	137	73	157
1660	1670, 662	290	57	138
1662	661, 652, 532, 1663	375	98	229
1688	1689, 695	104	60	131
1692	1693, 691	89	53	113
1730	712, 721, 731, 1732, 1741, 1761	1418	797	1576
1733	1734, 722	108	120	219
1735	1736, 723	76	97	172
1740	1751, 1742, 741	1104	618	1218
1743	742, 1763, 1780	163	89	186
1752	1753, 732, 743	916	524	1015
1754	744, 1755	850	500	936
1756	1349, 751, 733	431	310	611
1757	1758, 752	349	242	483
1762	711, 1769	71	27	73
1822	1823, 831	155	104	208



FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\active\apps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/30/2009, ron_arnold

Basin: 5300-01 (West Harvard Gulch)

Existing System Description:
The West Harvard Gulch Basin has a total drainage area of approximately 1.44 square miles. West Harvard Gulch flows east through Denver to its confluence with the South Platte River and is generally bounded by Wesley Avenue on the north, Sheridan Boulevard on the west, Bates Avenue on the south and the South Platte River on the east. The basin elevations range from 5536 feet to 5250 feet. West Harvard Gulch is within Englewood from Pecos to Zuni. The basin is currently fully developed with the exception of a few scattered vacant lots. Ruby Hill borders West Harvard Gulch directly to the north and Dartmouth borders West Harvard Gulch directly to the south. The channel is deeply incised and generally contains the 100-year floodplain. Few structures are located within the regulatory floodplain.

Drainage Deficiencies:
Basins 10 and 30 totaling 54 acres drains to an existing 21-inch storm sewer that exceeds the 2-year flow capacity of 30 cfs. A relatively flat residential/commercial area along Yale and Amherst Avenues currently has no storm sewer facilities. The existing 42" storm sewer in Irving Street does not have the 2-year flow capacity of 88 cfs. The existing storm sewers in S. Decatur Street, S. Clay Street, and Zuni Street do not have the 5-year flow capacity.

Proposed Capital Improvements:

Project A: 18-inch Upgrades The upgrades are proposed to meet minimum storm sewer size criteria.

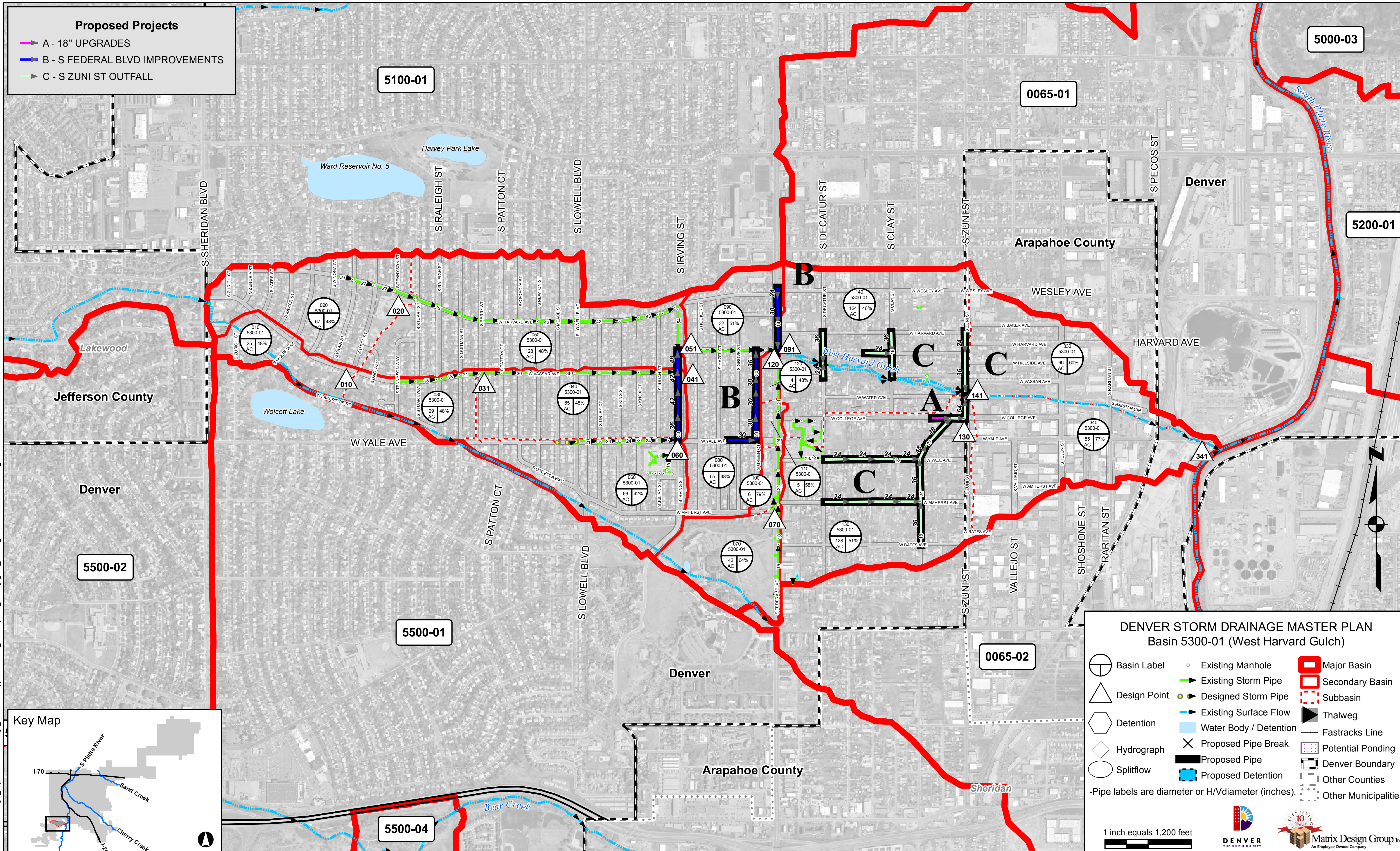
Project B: S. Federal Blvd. Improvements An existing storm sewer system within South Green Court is undersized for the 2-year storm. A 30-inch to 36-inch, 2-year capacity storm sewer is proposed to convey storm flows to West Harvard Gulch. Upsizing the storm sewers shown on the plan within Federal Boulevard will increase capacity to the 5-year storm. Upsizing the storm sewers in Irving Street will increase capacity to the 2-year storm.

Project C: S. Zuni Street Outfall Upsizing the storm sewers to serve the residential and commercial areas in Basins 130 and 140 to adequately drain the area and meet the City and County of Denver's criteria. The new system would be a 5-year capacity storm sewer and would include S. Decatur Street, S. Clay Street, and two Zuni Street outfalls. The S. Zuni Street outfall extends into S. Bryant Street and has fingers extending west in W. Yale Avenue and W. Amherst Avenue to convey the 5-year event.

Existing Hydrology:

BASIN 5300-01

Design Point	Contributing Basins	Tributary Area	Peak Discharge	
			2-Year	5-Year
		(acres)	*(cfs)*	*(cfs)*
10	10	25	15	28
20	20	67	39	73
31	10,30	54	30	58
41	31,40	184	88	171
51	41,50	379	187	364
60	60	66	35	71
70	70	42	41	67
91	51,70,80,90,100,110,120	522	271	514
100	70,100	48	43	74
120	70,100,110,120	57	49	83
130	130	128	91	168
141	130,140	252	167	316
341	141,330,340	150	115	184



Proposed Projects
A - 18" UPGRADES
B - S FEDERAL BLVD IMPROVEMENTS
C - S ZUNI ST OUTFALL
5100-01
0065-01
5000-03
5200-01
Denver
Arapahoe County
Jefferson County
Lakewood
Ward Reservoir No. 5
Harvey Park Lake
Wolcott Lake
S SHERIDAN BLVD
S RALEIGH ST
S PATTON CT
S LOWELL BLVD
S IRVING ST
S DECATUR ST
S CLAY ST
S ZUNI ST
S PECOS ST
WESLEY AVE
HARVARD AVE
W YALE AVE
VALLEJO ST
SHOSHONE ST
RARITAN ST
West Harvard Gulch
South Platte River
Bear Creek
Sheridan
5500-01
5500-02
5500-04
0065-02
Key Map
S Platte River
Sand Creek
Cherry Creek
I-70
I-25
DENVER STORM DRAINAGE MASTER PLAN
Basin 5300-01 (West Harvard Gulch)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.

Basin: 5401-01 (Greenwood Gulch)

Existing System Description:
This basin drains to Greenwood Gulch via Prentice Gulch in Greenwood Village. The basin generally follows Monaco Street from Union Avenue on the north to Belleview Avenue on the south. The basin is located in the southwestern corner of the Denver city limits and is generally known as "The 165 Subdivision." The basin is primarily comprised of business and commercial buildings with lesser amounts of multi-family residential in the north part of the basin. There is an existing golf course in the east part of the basin.

There are major existing storm sewer trunk systems in Monaco Street that convey flows from the east to three separate detention ponds on the western edge of the basin. The storm sewer system branches up Belleview Avenue and Union Avenue. Approximately half of the basin is currently undeveloped with plans to develop in the near future. The existing Mountain View Golf property is currently being studied as part of the proposed Belleview Station Transit Oriented Development project. The golf course will be developed into very high-density residential, commercial and retail parcels in the future. Improvements to the detention pond at Monaco and Belleview will be made when the Belleview Station TOD property is developed.

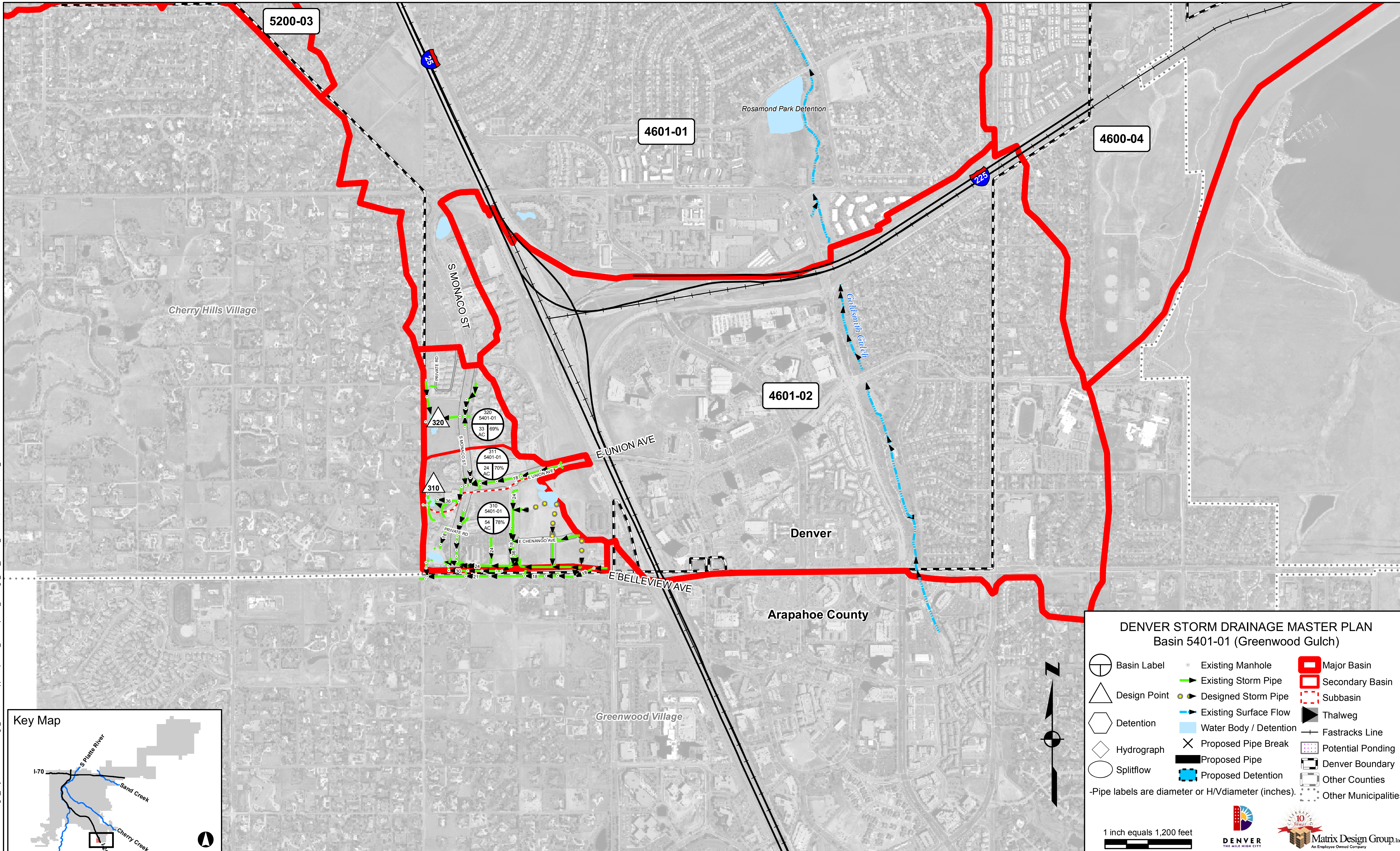
Drainage Deficiencies:
The storm sewer system in Monaco Street appears adequate for conveying flows to the existing detention ponds. There appear to be no significant drainage problems with the systems.

Proposed Capital Improvements:
There are no required improvements for this basin.

Existing Hydrology:

BASIN 5401-01

Design Point	Contributing Basins	Tributary Area	Peak Discharge		
			2-Year	5-Year	100-Year
		(acres)	*(cfs)*	*(cfs)*	*(cfs)*
310	310	54	58	89	199
311	311	24	24	38	89
320	320	33	39	63	146



5200-03
4601-01
4600-04
4601-02
Rosamond Park Detention
Cherry Hills Village
S MONACO ST
Goldsmith Gulch
E UNION AVE
E BELLEVIEW AVE
Denver
Arapahoe County
Greenwood Village
320
310
PRIVATE RD
E CHENANGO AVE
Key Map
I-70
S Platte River
Sand Creek
Cherry Creek
DENVER STORM DRAINAGE MASTER PLAN
Basin 5401-01 (Greenwood Gulch)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
THE MILE HIGH CITY
Matrix Design Group, Inc.
An Employee Owned Company

Basin: 5500-01 (Bear Creek - Fort Logan)

Existing System Description:
This basin begins at the confluence of Bear Creek with the South Platte River. The western side of the basin is bounded by Sheridan Boulevard. The basin extends north and south from the banks of Bear Creek. Travel distances are generally less than 1½ miles. Much of the upper basin is comprised of residential neighborhoods. Fort Logan comprises much of the central portion of the basin. Fort Logan includes cemetery facilities, undeveloped tracts and the medical facilities centered around the intersection of Lowell Boulevard and Oxford Avenue. Much of the lower portion of the basin is located within the City of Sheridan. The lower portion of the basin is made up residential areas, and commercial and industrial facilities.

Drainage Deficiencies:
- Lowell Boulevard north of Kenyon Avenue receives runoff from approximately 352 tributary acres but does not have a formalized storm sewer system.
- The Utica Street Storm Sewer (DP 380) has capacity for the 2-year event; however, flows are backing up against the embankment for Hampden Avenue warranting a 5-year system in this location.
- The system draining basins 400, 420, and 430 (180 acres) in Knox Court is undersized and cannot convey the 5-year flow of 218 cfs (element 1430). The system currently has capacity for approximately 100 cfs.
- Extensive portions of residential areas in the northwest area of the basin lack formalized storm sewer systems. The roadways are relatively steep allowing for good stormwater conveyance, but nuisance flows traveling long distances could pose a problem.
- Flows from basins 21, 22, and 23 cross over Kenyon Avenue and onto the Mullen High School property. Flows from this basin are very small (22 cfs for the 5-year), however, they may be a nuisance as they cross over Kenyon Avenue without any structure and directly flow to Mullen High School.

Proposed Capital Improvements:

Project A: 18-Inch Upgrades Upsizing various pipes to the city's 18-inch minimum diameter is proposed to meet current drainage criteria.

Project B: S. Lowell Blvd. Outfall A 72" storm sewer is proposed along Lowell Boulevard to Kenyon Avenue and a 54" storm sewer is proposed along Kenyon Avenue to Pond 60 to accept runoff from the eastern portion of Ft. Logan Cemetery. The system should collect flows from the Cemetery's open channels and pond that were recently constructed.

Project C: S. Utica St Improvements A 66" storm sewer is proposed along W. Hamilton Place to collect the excess flow that can not be conveyed by the existing 60" storm sewer crossing of Hampton Avenue at Utica Street A 84" storm sewer is proposed to replace the existing 54" storm sewer at Raleigh Street and Hampton Avenue to accept the increased flow which is diverted from Utica Street through the proposed 66" storm sewer. The proposed system will provide a 5-year level of service.

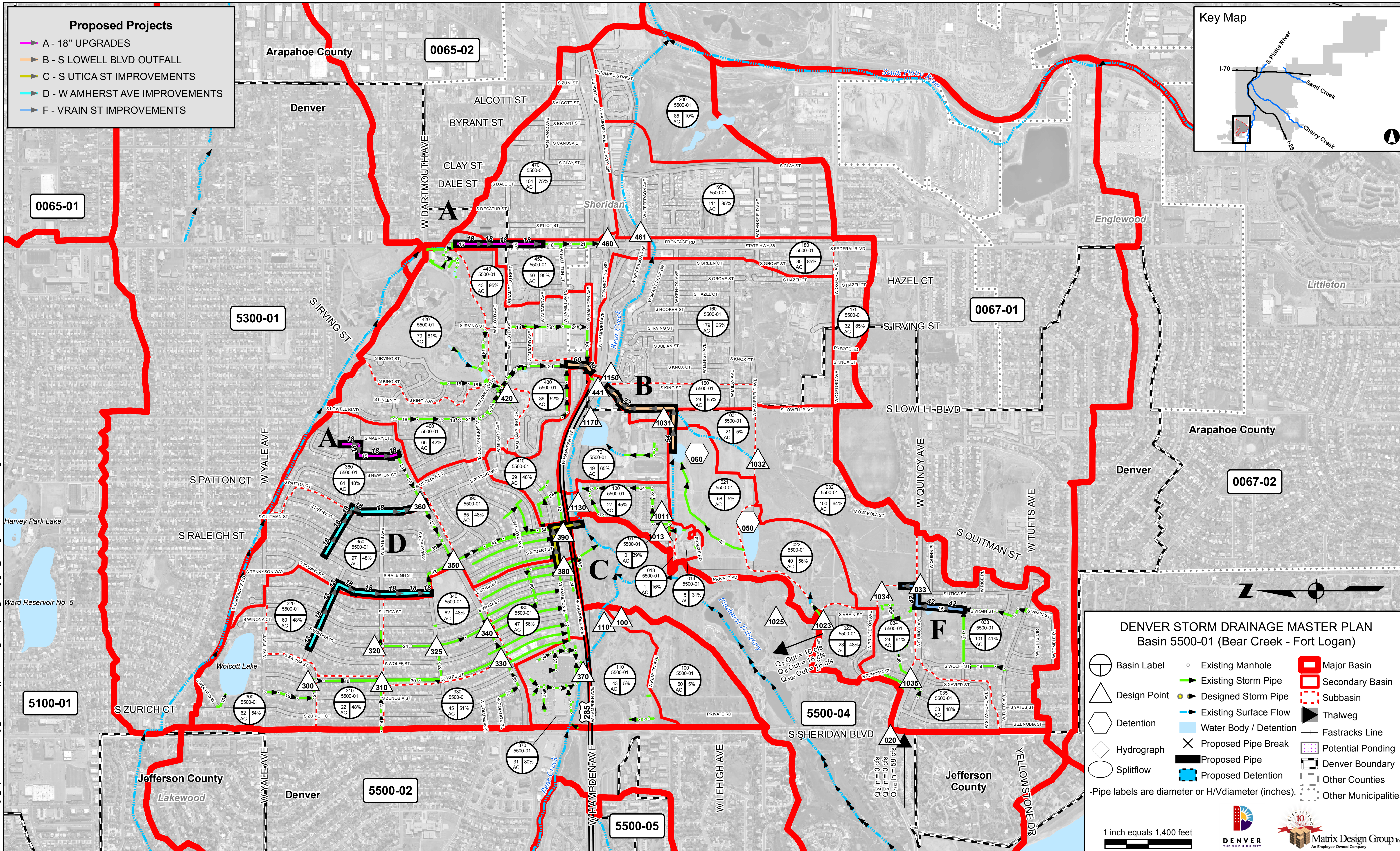
Project D: W. Amherst Avenue Improvements Small 18" laterals are proposed along Amherst Ave., Stuart St., and Patton Ct. to convey nuisance flows through residential areas.

Project F: Vrain Street Improvements An existing pipe at the north end of Vrain Street should be upsized to a 42" system to convey the 2-year event to Ft. Logan Cemetery.

Existing Hydrology:

BASIN 5500-01

Design Point	Contributing Basins	Tributary Area	Peak Discharge		
			2-Year	5-Year	100-Year
		(acres)	*(cfs)*	*(cfs)*	*(cfs)*
33	33 (Ft. Logan Study Basin C3, Developed)	101	52	108	308
50	22,23	63	8	9	13
60	21,22,23	121	10	23	82
100	100	50	3	26	113
110	110	43	2	23	99
300	300	62	45	81	208
310	300, 310	84	58	107	284
320	320	60	38	73	195
325	300, 310, 320	144	88	164	465
330	330	45	29	54	143
340	300, 310, 320, 330, 340	250	146	273	781
350	350, 360	159	103	197	526
360	360	61	37	69	188
370	370	31	44	66	144
380	300, 310, 320, 330, 340, 380 (diversion)	297	177	320	904
390	350, 360, 390 (diversion 300, 310, 320, 330, 340, 380)	521	177	432	1445
420	400, 420	144	103	187	483
430	400, 420, 430	180	122	229	612
441	400, 410, 420, 430, 440	253	195	330	870
1011	11	0.3	0	2	6
1013	13,14	6	2	4	13
1023	23	23	16	29	80
1031	31,32,33,34,35,220	352	143	279	864
1032	32,33,34,35,220	331	144	274	839
1034	33,34,35,220	231	93	182	556
1035	220,35	107	22	41	172
1130	11,13,14,130	34	16	32	90
1150	31,32,33,34,35,150,220	376	158	305	942
1170	21,22,23,170	171	54	91	227



Proposed Projects
A - 18" UPGRADES
B - S LOWELL BLVD OUTFALL
C - S UTICA ST IMPROVEMENTS
D - W AMHERST AVE IMPROVEMENTS
F - VRAIN ST IMPROVEMENTS
Key Map
South Platte River
Sand Creek
Cherry Creek
I-70
I-25
Arapahoe County
Denver
Sheridan
Englewood
Littleton
Jefferson County
Lakewood
Harvey Park Lake
Ward Reservoir No. 5
Wolcott Lake
Bear Creek
Pinehurst Tributary
0065-02
0065-01
5300-01
0067-01
0067-02
5100-01
5500-02
5500-04
5500-05
S LOWELL BLVD
S SHERIDAN BLVD
W HAMPDEN AVE
W DARTMOUTH AVE
W YALE AVE
W QUINCY AVE
W TUFTS AVE
W LEHIGH AVE
YELLOWSTONE DR
S IRVING ST
S PATTON CT
S RALEIGH ST
S ZURICH CT
S QUITMAN ST
HAZEL CT
ALCOTT ST
BYRANT ST
CLAY ST
DALE ST
DENVER STORM DRAINAGE MASTER PLAN
Basin 5500-01 (Bear Creek - Fort Logan)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,400 feet
DENVER
Matrix Design Group, Inc.

Basin: 5500-02 (Upper Bear Creek)

Existing System Description:
This basin drains to Bear Creek and is generally bound by Lakeridge Road in Lakewood on the north, Quincy Avenue on the south, Wadsworth Boulevard on the west, and Sheridan Boulevard on the east. The land use within the basin is comprised of a mixture of single family residential, multi family residential, commercial, school, parks, and Pinehurst Country Club.

Drainage Deficiencies:
The majority of this basin is newer construction compared to other areas of Denver. Most deficiencies are relatively minor and cause only nuisance flow problems.

Proposed Capital Improvements:

Project A: 18-Inch Upgrades Upsizing various pipes to the city's 18-inch minimum diameter is proposed to meet current drainage criteria.

Project B: S. Newland Street Outfall A 24" to 36" system is proposed in Newland Street to convey nuisance flows through residential areas.

Project C: S. Sheridan Blvd. Outfall A new/upsized outfall is proposed in Sheridan Boulevard extending up to Yale Avenue. The system will convey the 2-year storm through mostly residential areas.

Project D: S. Webster St. Outfall Collecting a large tributary drainage area from an undeveloped portion of Lakewood, the existing storm sewer in Webster Street should be upsized and extended from a 30" system to a 6' x 4' RCBC. The proposed storm sewer will better serve both residential and commercial areas east of Wadsworth Boulevard.

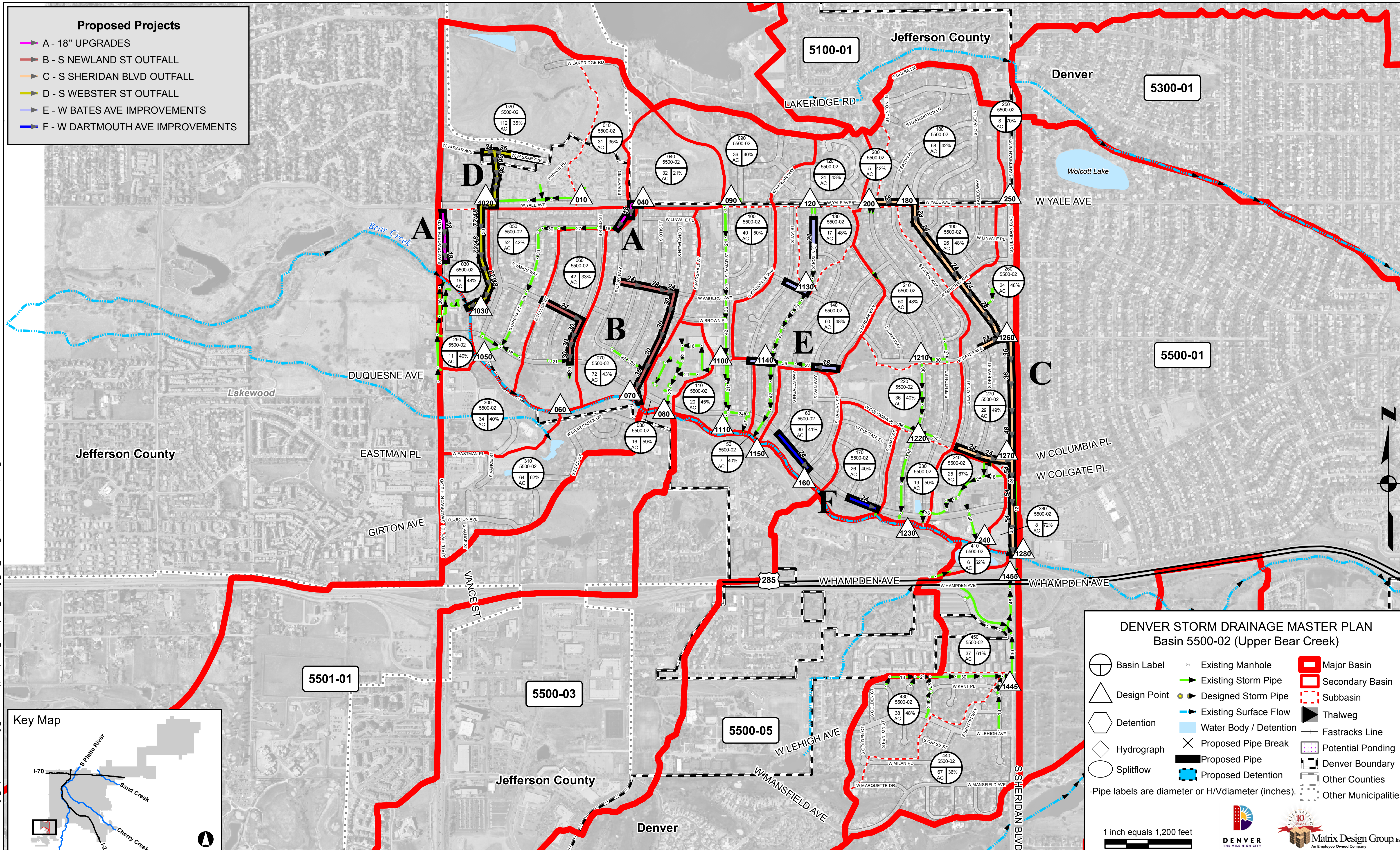
Project E: W. Bates Ave. Improvements Minor lateral extensions are proposed along Bates Avenue to address localized street flows in residential areas.

Project F: W. Dartmouth Ave. Improvements Minor lateral extensions are proposed along Dartmouth Avenue to address localized street flows in residential areas.

Existing Hydrology:

Basin 5500-02

Design Point	Contributing Basins	Tributary Area	Peak Discharge		
			2-Year	5-Year	100-Year
		(acres)	*(cfs)*	*(cfs)*	*(cfs)*
10	10	31	16	35	104
40	40	32	7	22	78
60	60	42	17	39	121
70	70	72	39	78	219
80	80	16	15	26	66
90	90	36	19	38	112
140	140	60	38	73	195
160	160	30	18	37	104
180	180	68	35	71	201
200	200	5	3	6	17
250	250	8	8	14	32
1020	10, 20	143	81	174	521
1030	10, 20, 30	163	86	192	573
1050	40, 50	84	29	63	183
1100	90, 100	77	44	86	233
1110	90, 100, 110	97	56	102	298
1130	120, 130	40	24	49	136
1150	120, 130, 140, 150	107	57	114	335
1210	180, 190, 200, 210	149	77	152	444
1220	180, 190, 200, 210, 220	185	90	185	545
1230	180, 190, 200, 210, 220, 230	204	90	183	580
1260	250, 260	32	23	42	111
1270	250, 260, 270	62	37	72	200
1280	250, 260, 270, 280	69	39	74	216
1445	430, 440	105	50	103	295
1455	430, 440, 450	142	82	149	429


Proposed Projects
A - 18" UPGRADES
B - S NEWLAND ST OUTFALL
C - S SHERIDAN BLVD OUTFALL
D - S WEBSTER ST OUTFALL
E - W BATES AVE IMPROVEMENTS
F - W DARTMOUTH AVE IMPROVEMENTS
DENVER STORM DRAINAGE MASTER PLAN
Basin 5500-02 (Upper Bear Creek)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.
Key Map
I-70
S Platte River
Sand Creek
Cherry Creek
I-25
Jefferson County
Denver
Lakewood
5100-01
5300-01
5500-01
5501-01
5500-03
5500-05
Wolcott Lake
Bear Creek
LAKERIDGE RD
W YALE AVE
DUQUESNE AVE
EASTMAN PL
GIRTON AVE
VANCE ST
W HAMPDEN AVE
W COLUMBIA PL
W COLGATE PL
W LEHIGH AVE
W MANSFIELD AVE
S SHERIDAN BLVD
285
A
B
C
D
E
F

Basin: 5500-03 (Academy Park)

Existing Basin Description:
The Academy Park Tributary Watershed is a developed area in the southwestern portion of the Denver metropolitan area adjacent to the intersection of Wadsworth Boulevard and Hampden Avenue (Highway 285). Three governmental entities; the City of Lakewood, the City and County of Denver, and Jefferson County each have jurisdiction over a portion of this watershed. Wadsworth Boulevard and Hampden Avenue are both very large streets in this area and both serve as drainage boundaries. The watershed covers an area of approximately 380 acres. The Henry's Lake Drainageway crosses through the watershed in pipes which run under Wadsworth, through the northwest corner of the watershed and under Hampden Avenue. The Warrior Ditch enters the watershed in a siphon that crosses under Wadsworth just south of Jefferson Avenue, and exits the watershed near Colorado Academy.

The areas west of Pierce Street and south of Hampden Avenue are mostly commercial development, and the areas east of Pierce Street and north of Hampden Avenue have developed as single-family residential areas.

Drainage Deficiencies:
The watershed has three defined outfalls. The first outfall system drains the areas enclosed by Wadsworth Boulevard, Teller Street, Hampden Avenue, and Mansfield Street, and outfalls to the Henry's Lake Drainageway just before it is conveyed under Hampden Avenue. The second outfall in the watershed drains the rest of the area south of Hampden Avenue and west of Pierce Street to the intersection of Pierce and Hampden Avenue. The third outfall drains the areas east of Pierce Street and south of Hampden Avenue.

The drainage concentrated at each of these points normally reaches Bear Creek through a system of sufficient capacity to carry the stormwater from the areas south of Hampden Avenue during large runoff events. The capacity of the Henry's Lake Drainageway downstream of Hampden Avenue is limited by the existing pipe under Hampden Avenue. Stormwater flows during small events from areas upstream of the Warrior Ditch are intercepted by the ditch and conveyed out of the watershed to the east. Runoff exceeding the ditch capacity flows north along Pierce Street.

The existing detention facilities in the watershed are not included in the baseline hydrologic model as they are not publicly owned or maintained.

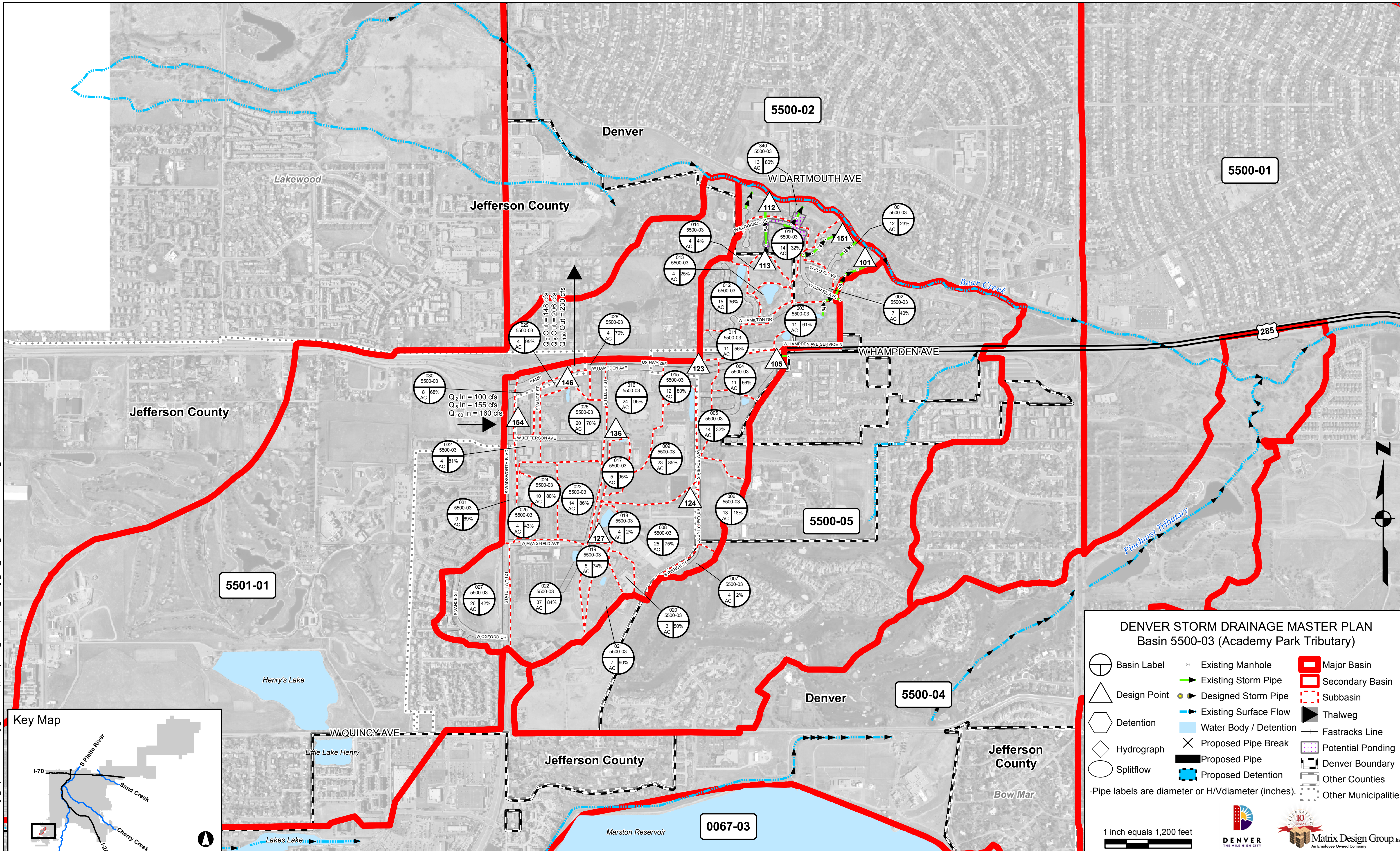
Proposed Capital Improvements:

The majority of this basin lies outside the City of Denver, with only the outfall located within the City boundaries. An improvement project has recently been constructed at the outfall, and no further improvements are proposed within Denver.

Existing Hydrology:

BASIN 5500-03

Design Point	Peak Discharge		
	2-Year *(cfs)*	**5-Year** *(cfs)*	**100-Year** *(cfs)*
101	59	85	190
105	46	63	148
112	181	288	886
113	183	295	893
123	165	246	758
124	148	208	408
127	97	148	318
136	26	38	80
146	157	225	455
151	17	29	91
154	100	155	160



DENVER STORM DRAINAGE MASTER PLAN
Basin 5500-03 (Academy Park Tributary)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.
Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
5500-02
5500-01
5500-05
5500-04
5501-01
0067-03
285
Denver
Jefferson County
Lakewood
Bow Mar
W DARTMOUTH AVE
W HAMPDEN AVE
W QUINCY AVE
Bear Creek
Pinehurst Tributary
Henry's Lake
Little Lake Henry
Lakes Lake
Marston Reservoir
Q2 In = 100 cfs
Q5 In = 155 cfs
Q100 In = 160 cfs
Q2 Out = 148 cfs
Q5 Out = 206 cfs
Q100 Out = 230 cfs

Basin: 5500-04 (Bear Creek – Marston Lake North)

Existing System Description:
This basin drains to Bear Creek via the Marston Lake North Channel and is generally bound by Stanford Avenue on the north, Wadsworth Boulevard on the east, Belleview Avenue on the south and Kipling Street on the west. The majority of the basin is located in Denver with the western edges lying in Lakewood. The Bowles Lateral crosses the basin from the northwest corner to the southeast corner, eventually flowing into Bowles Reservoir No. 1. Several storm sewers discharge into the Bowles Lateral, which flows roughly 80% full in the summer. There is a concrete weir adjacent to the ditch near Gar Way that diverts overflow from the ditch to the storm sewer system that discharges into Lakes Lake. Lakes Lake is in the northern portion of the basin. The Marston Lake North Channel originates at Lakes Lake, flows east to a detention pond on the east side of Wadsworth Boulevard, then runs along the north side of Marston Reservoir, eventually discharging into Bear Creek. Multiple storm sewers throughout the basin convey flows to the Marston Lake North Channel. The basin is comprised of primarily residential neighborhoods with commercial/retail areas located near Wadsworth Boulevard.

Drainage Deficiencies:

- Several of the basins drain directly to the Bowles Lateral. To avoid potential disputes with the ditch companies concerning water rights and possible under grounding of the ditches, it would be preferable to create a storm sewer system independent of the Bowles Lateral.
- The 36” storm sewer system draining Design Point 100 and Basin 31 is undersized.
- The 42” storm pipe between Design Points 600 and 702 has the capacity to convey approximately 90 cfs, while the 2-year and 5-year flows are 117 cfs and 192 cfs, respectively.
- On April 11, 2005, the property at 4693 S. Hoyt Street was flooded when the stormwater detention pond behind the home overtopped. Damage consisted of flooding in the backyard, water entering the house, flowing through the dining area and into the lower den, bedroom, bathroom and crawlspace. The kitchen was also flooded and snowmelt flowed around both sides of the home and through the garage.

Proposed Capital Improvements:

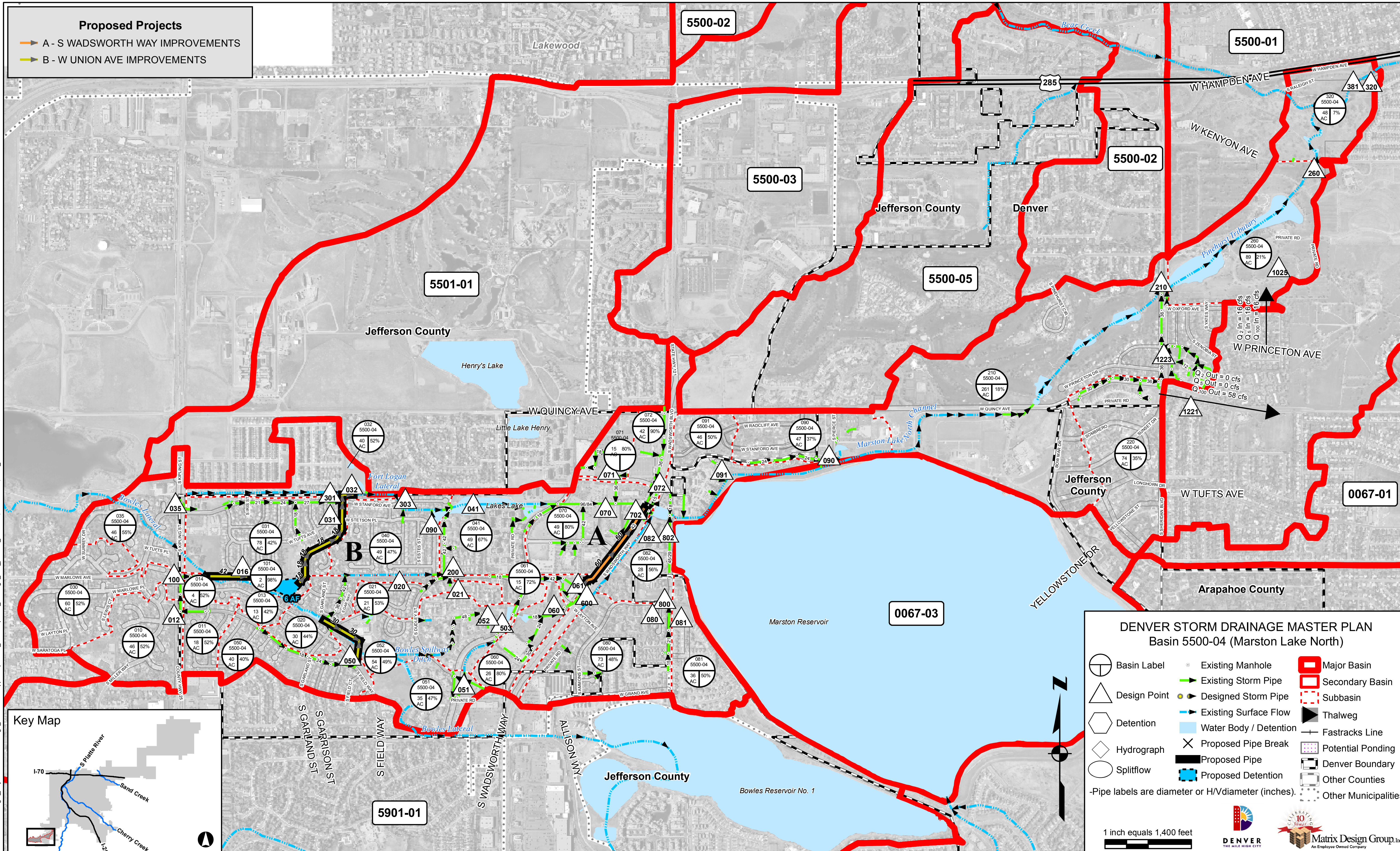
Project A: South Wadsworth Way Improvements Increase the size and/or capacity of the storm system in Wadsworth from Union Avenue to the Marston Lake North Channel.

Project B: W. Union Ave. Improvements Disconnect the Glenbrook Detention Basin outflow from the Bowles Lateral Ditch. Also, evaluate the potential to extend the 30” pipe that currently discharges into the Bowles Lateral Ditch near Field Way and Wagontrail Drive east to the storm sewer system in Dudley Street to disconnect from the Bowles Lateral Ditch. Upsize the existing 1.5 ac-ft detention pond in Village West Park with a new 4.5 ac-ft natural areas detention pond. The new detention pond has a required 100 year detention volume of 4.5 acre feet (added to 1.5 acre feet from the existing pond for a total detention volume of 6.0 acre feet) and an 18” outlet pipe. The 18” outlet RCP is to be built from the new detention pond, north in Garrison Street to an existing manhole in Stanford Avenue. The existing 36” RCP between the existing manhole in Stanford Avenue and the Marston Lake North Drainageway is to be upsized to 42” RCP and the existing outfall to Marston Lake North Drainageway to be re-built as required.

Existing Hydrology:

HYDROLOGIC SUMMARY TABLE: BASIN 5500-04

Design Point / Flow Element	Contributing Basins	Discharge		
		Q2-yr (cfs)	Q5-yr (cfs)	Q100-yr (cfs)
10	10	33	61	160
11	11	12	22	59
12	10, 11	45	85	222
13	13	8	17	47
14	14	2	4	12
15	14 & Diversion flow from 10, 11, 30	53	55	63
16	101, 14 & Diversion flow from 10, 11, 30	58	61	72
20	20	15	30	84
21	21	15	27	71
30	30	40	73	191
31	31	42	85	238
32	32	24	44	117
35	32	36	63	163
40	40	34	64	176
41	41	56	91	216
50	50	18	38	110
51	51	26	49	133
52	52	34	64	170
60	60	33	50	110
61	61	15	24	56
70	70	57	86	192
71	71	21	32	69
72	72	50	73	154
80	80	44	83	225
81	81	28	52	138
82	82	22	39	99
90	90	25	54	160
91	91	38	71	187
100	30,11, 10	81	150	414
101	101	4	5	11
105	30,11, 10	30	99	363
200	21, 20	30	57	154
251	21, 20	30	57	155
301	31, 35	78	141	395
303	32, 31, 35	95	183	505
350	35	36	57	157
352	31, 35	72	139	388
354	32, 31, 35	96	181	495
503	52, 51, 50	73	141	358
550	50	16	34	89
551	51	24	47	120
552	52, 51, 50	71	128	355
600	52, 51, 50, 61, 60	117	192	507
651	52, 51, 50, 61, 60	103	183	501
702	52, 51, 50, 61, 60, 72, 71, 70	223	347	870
800	81, 80	70	132	353
802	81, 80, 82	92	167	456
851	81, 80	71	129	359
1010	10	33	63	163
1011	10, 11	43	79	223
1014	14 & Diversion flow from 10, 11, 30	54	56	63
1020	220	31	70	202



Proposed Projects
A - S WADSWORTH WAY IMPROVEMENTS
B - W UNION AVE IMPROVEMENTS
DENVER STORM DRAINAGE MASTER PLAN
Basin 5500-04 (Marston Lake North)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,400 feet
DENVER
Matrix Design Group, Inc.
Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
5500-02
5500-01
5500-03
5500-05
5501-01
0067-01
0067-03
5901-01
Lakewood
Jefferson County
Denver
Arapahoe County
Henry's Lake
Little Lake Henry
Marston Reservoir
Bowles Reservoir No. 1
Marston Lake North Channel
Pinehurst Tributary
Bear Creek
Bowles Lateral
Fort Logan Lateral
Bowles Spillway Ditch
Lakes Lake
W HAMPDEN AVE
W KENYON AVE
W PRINCETON AVE
W QUINCY AVE
W TUFTS AVE
YELLOWSTONE DR
S GARLAND ST
S GARRISON ST
S FIELD WAY
S WADSWORTH WAY
ALLISON WY
Q 2 Out = 0 cfs
Q 5 Out = 0 cfs
Q 100 Out = 58 cfs
Q 2 In = 16 cfs
Q 5 In = 16 cfs
Q 100 In = 16 cfs
FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activelaps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/25/2009, ron_ramold

Basin: 5500-05 (Pinehurst Tributary)

Existing System Description:
The Pinehurst Tributary Watershed is a mostly developed area in the southwestern portion Denver west of Sheridan Boulevard and mostly south of Hampden Avenue. Three governmental entities; the City of Lakewood, the City and County of Denver, and Jefferson County each have jurisdiction over a portion of the watershed. The basin covers an area of approximately 460 acres (0.7 square miles). Land use consists of single family residential, multi family residential, commercial, school, and Pinehurst Country Club and golf course.

The existing major drainage system consists of storm sewers and open channel in the areas from Quincy Street downstream across the golf course. The runoff from this upstream drainage system is conveyed to Woody's Pond located southeast of Colorado Academy. Woody's Pond drains to a storm sewer that runs down Harlan Street to the upstream end of an open channel. The channel then runs through some private properties and the Tall Pines and Pebble Creek apartment complexes. From the downstream end of the open channel, the runoff is carried in a 48-inch pipe under Highway 285 to Bear Creek.

Two smaller outfalls exist in the basin: a 30-inch storm sewer along Fenton Street, and a 24-inch pipe draining a portion of the Tall Pines apartment complex.

The 1999 Pinhurst Tributary OSP has been incorporated into this report to address future development and previously proposed drainage improvements.

Drainage Deficiencies:
Historically, drainage problems have been identified along Harlan Street, east of Colorado Academy. The storm sewer conveyance system downstream (north) of Woody's Pond was undersized and has caused flooding to several homes along Harlan Street during events greater than the 5-year frequency.

Proposed Capital Improvements:
In order to address known flooding issues along Harlan Street, improvements have been recently constructed on the Colorado Academy property west of Harlan Street. A second detention pond was constructed at the northeast corner of the property, and an additional storm sewer has been installed west of Harlan Street. Other minor improvements were made to local drainage systems in the area.

Projects A, B, C, and G: Foothills GC Improvements and Pierce Way Detention Upstream (south) of Colorado Academy, improvements to an existing berm are proposed to protect the Pinehurst Village II condominium complex. The berm is located on the golf course property and will be owned and maintained by the Pinehurst Golf Course.

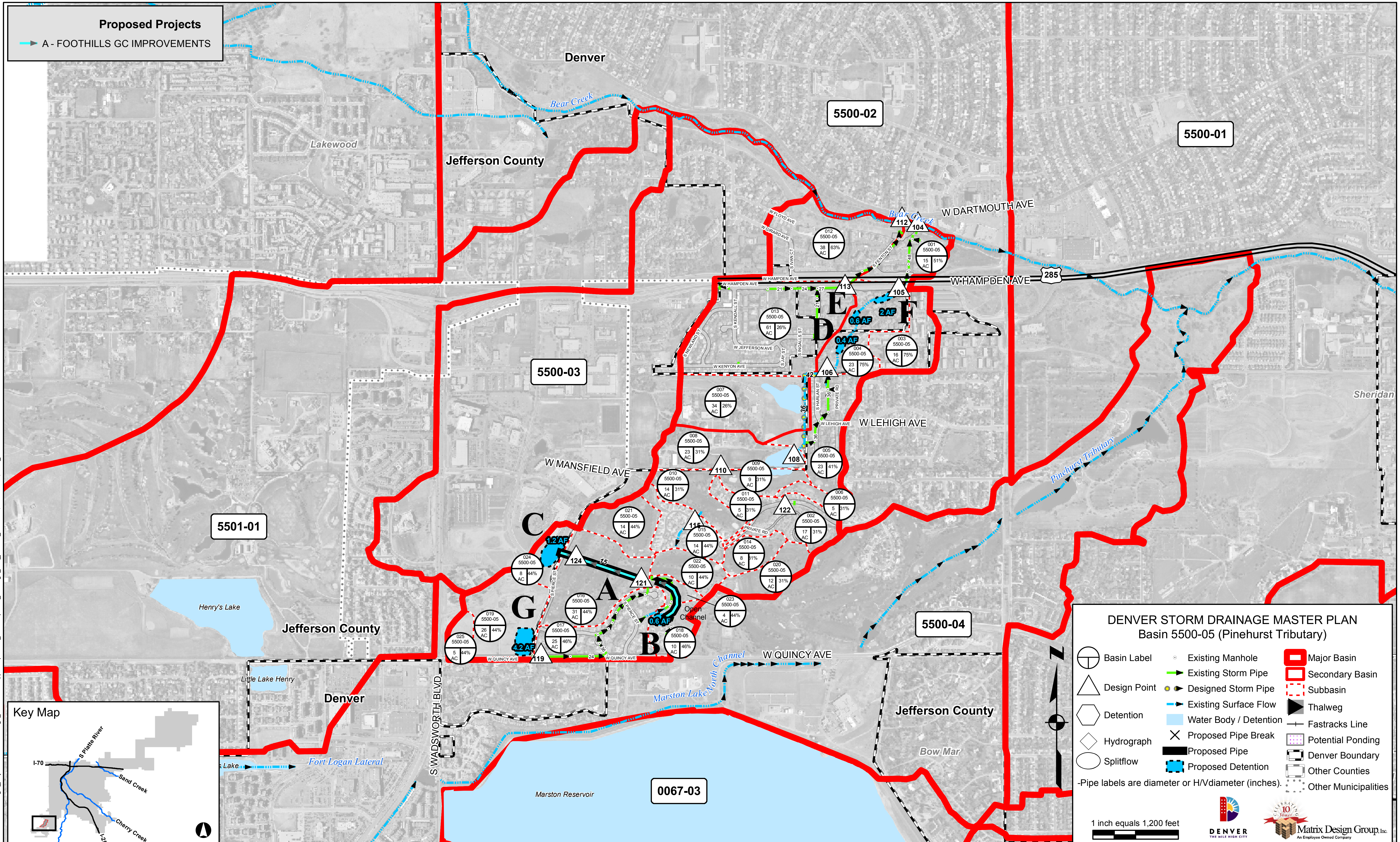
Development related detention ponds are proposed within the Cities of Lakewood and Denver in the upper reaches of the basin. Small conduits and open channels are proposed to drain these detention facilities across the golf course to the main channel. These improvements are to be development driven.

Projects D, E, and F: S. Harlan St. Detention Small on-line detention ponds are proposed along the Pinehurst Tributary south of Hampden Avenue. The ponds were proposed in the 1999 OSP study and will attenuate peak flows to the Hampden Avenue crossing and the existing 48" outfall to Bear Creek.

Existing Hydrology:

BASIN 5500-05

Design Point	Peak Discharge 2-Year *(cfs)*	5-Year *(cfs)*	100-Year *(cfs)*
104	50	76	270
105	50	77	271
106	38	59	132
108	30	46	232
110	21	35	184
112	51	67	126
113	36	58	155
115	20	30	161
119	2	3	24
121	26	41	113
122	24	37	99
124	1	1	6



FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activelapps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/25/2009, ron_arnold

Basin: 5501-01 (Henry's Lake)

Existing System Description:
Henry's Lake Basin lies within the southwest portion of the Denver Metropolitan area and is a tributary to Bear Creek. The Henry's Lake Basin drains generally in a northeasterly direction. The upper end of the basin is located immediately west of Kipling Street at Quincy Avenue. The confluence with Bear Creek is located just east of Pierce Street. The basin is rural, large lot residential, and has no definitive channel.

The basin area tributary to Bear Creek is 1.33 square miles (850 acres). The total length of the basin is approximately 3.58 miles for a slope of 75-feet per mile (1.4%). The drainageway lies almost entirely within the City of Lakewood and Jefferson County. A small portion of the watershed near Henry's Lake lies within the City and County of Denver.

Henry's Lake has flood storage of approximately 18 acre-feet, and affords considerable downstream protection and flood peak reduction. The greatest reduction in peak flows occurs for the more frequent storms (2- to 10-years). Henry's Lake is also very effective as a detention facility for the extreme events (50- to 100-year).

Drainage Deficiencies:
Two irrigation ditches traverse the study area, the Warrior Ditch and the Marston Lake North Channel. The ditches carry integration water between the basins adjacent to Henry's Lake Basin. Urbanization of the basin has resulted in increased runoff collected by the ditches and subsequent overtopping. Some of the ditch has been piped, but a substantial portion of the Warrior Ditch remains open channel.

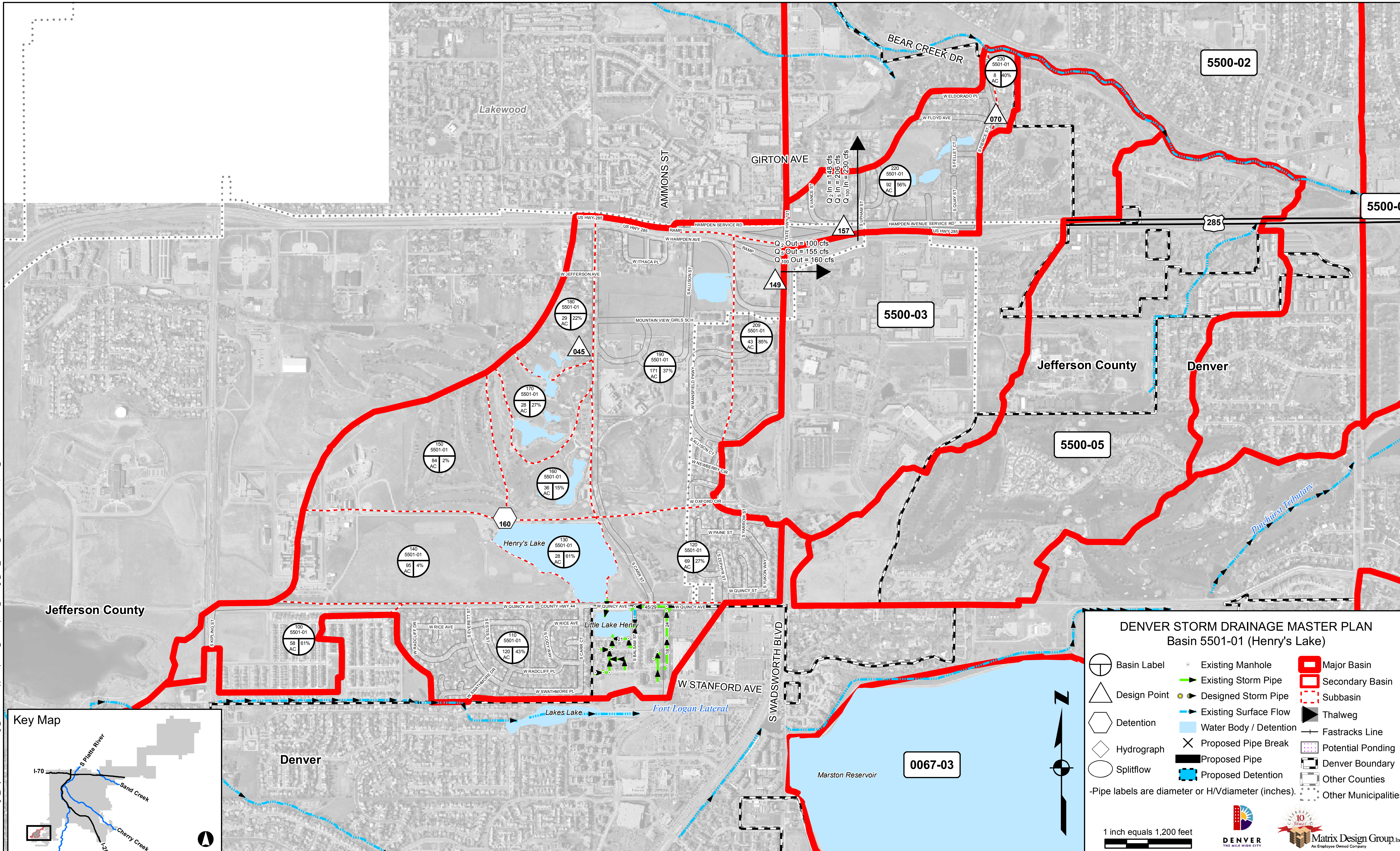
The drainageway consists of a 76" x 48" Horizontal Elliptical Reinforced Concrete Pipe (HERCP) culvert beneath Hampden Avenue. The 72" x 44" CMP beneath Wadsworth Boulevard discharges into an open top concrete vault ("bubbler"). Exiting from the vault is a smaller 48" RCP storm sewer. During the more intense storms, the headwater at the Hampden Avenue culvert overtops the frontage road, causing a flow split to the east.

Proposed Capital Improvements:
No improvements are proposed for this basin within the City of Denver reach.

Existing Hydrology:

BASIN 5501-01

Design Point	Peak Discharge		
	2-Year *(cfs)*	5-Year *(cfs)*	100-Year *(cfs)*
45	33	61	412
70	191	285	585
149	129	216	634
157	148	206	230
160	19	43	364



DENVER STORM DRAINAGE MASTER PLAN
Basin 5501-01 (Henry's Lake)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,200 feet
DENVER
Matrix Design Group, Inc.
Key Map
5500-02
5500-01
5500-03
5500-05
0067-03
Lakewood
Jefferson County
Denver
Henry's Lake
Little Lake Henry
Lakes Lake
Marston Reservoir
Fort Logan Lateral
BEAR CREEK DR
GIRTON AVE
AMMONS ST
W STANFORD AVE
S WADSWORTH BLVD
Q2 In = 148 cfs
Q5 In = 206 cfs
Q100 In = 230 cfs
Q2 Out = 100 cfs
Q5 Out = 155 cfs
Q100 Out = 160 cfs

Basin: 5901-01 (Coon Creek)

Existing System Description:
This basin drains to Coon Creek and is generally bound by Belleview Avenue on the north, Sheridan Boulevard on the east, Bowles Avenue on the south and Kipling Street on the west. The majority of the basin is located in Jefferson County and the Denver city limits line zigzags in and out of the basin. Coon Creek flows in a southeasterly direction through the middle of the basin. Three major reservoirs are located within the basin: Bowles Reservoir No. 1, Grant B Reservoir and Grant C Reservoir. The basin is comprised of a mix of residential neighborhoods with commercial/retail areas located near the arterial roadways, a golf course, a large ballfield complex, and several reservoirs. Most of the flows are conveyed directly to Coon Creek via relatively small storm sewer systems in the roadways. Basins 60, 61 and 64 drain to Grant B Reservoir, Basins 62 and 63 drain to Bowles Reservoir No. 1, and Basins 70, 71 and 72 drain to Grant C Reservoir.

Since only a small portion of the basin is in Denver, there are few Denver-owned public outfalls. Between Estes Street and Wadsworth Boulevard there are several outfalls into Coon Creek. From the north, there are a 12-inch outfall, an 18-inch outfall, a 24-inch outfall, and a 36-inch outfall; from the south, there are two 18-inch outfalls, and two 30-inch outfalls. There are several pipe networks within the City of Denver that discharge into Grant B Reservoir and Grant C Reservoir. A few pipes that drain directly to the Bowles Reservoirs are owned and maintained by others.

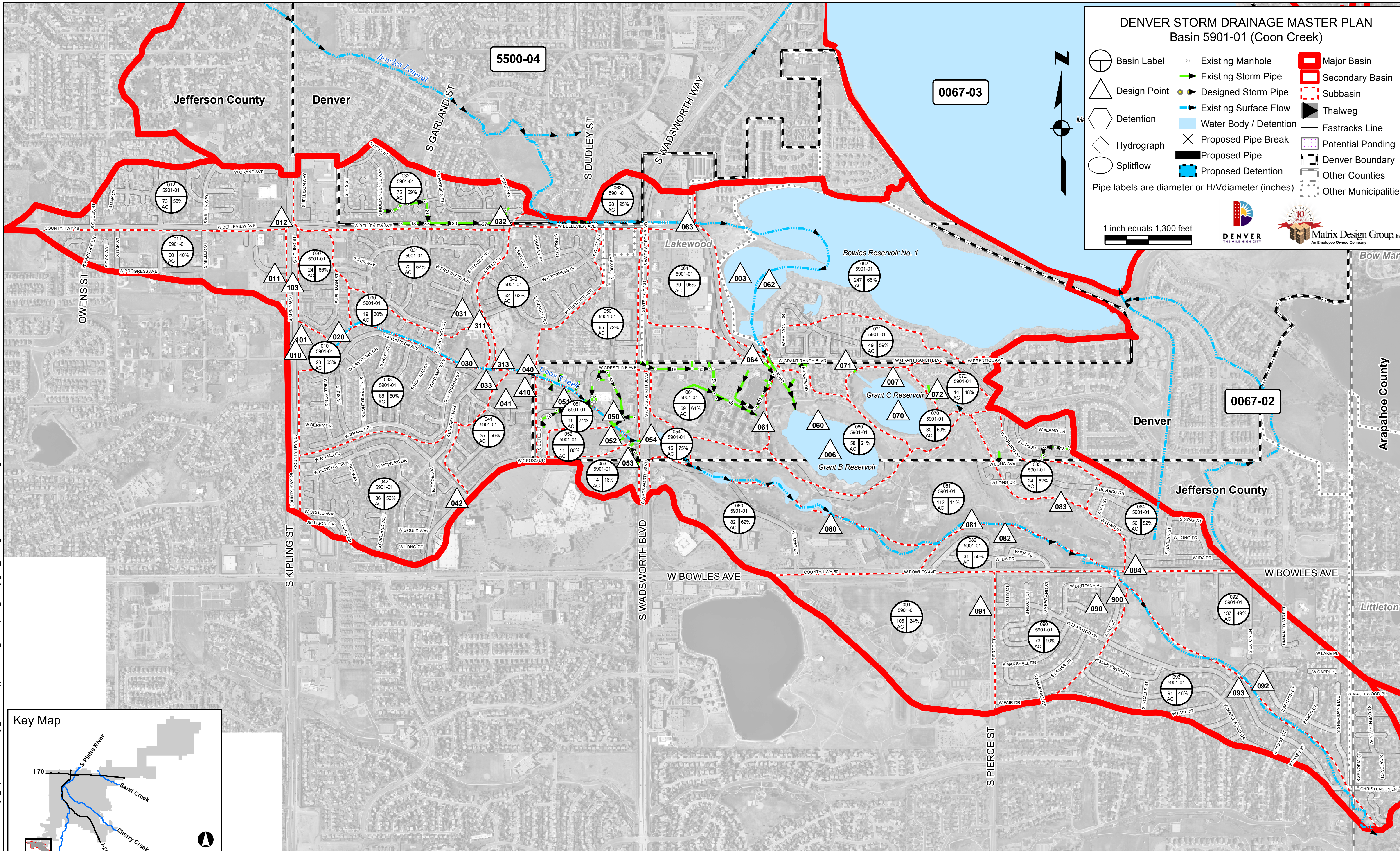
Drainage Deficiencies:
Development in this basin is relatively new. There appear to be no significant drainage problems with the systems located with the City of Denver.

Proposed Capital Improvements:
There are no required improvements for this basin within the City & County of Denver.

BASIN 5901-01

Design Point	Contributing Basins	Tributary Area	Peak Discharge		
		(Acres)	2-Year	5-Year	100-Year
			(cfs)	(cfs)	(cfs)
3	62,63	274	306	510	1185
6	60, 61, 64	166	121	215	507
7	70, 71, 72	93	75	138	339
10	10	23	19	33	76
11	11	60	26	57	155
12	12	73	47	84	204
20	20	24	23	39	91
30	30	20	7	18	54
31	31	72	48	91	226
32	32	72	52	92	222
33	33	88	50	96	245
40	40	62	54	96	220
41	41	35	25	47	123

Design Point	Contributing Basins	Tributary Area (Acres)	Peak Discharge 2-Year	Design Point	Contributing Basins
42	42	86	58	111	275
50	50	65	66	108	240
51	51	15	17	29	65
52	52	11	14	23	48
53	53	14	2	8	27
54	54	15	16	26	57
60	60	58	15	47	151
61	61	69	49	85	196
62	62	247	263	452	1058
63	63	28	43	64	128
64	64	39	58	86	173
70	70	30	30	53	126
71	71	49	40	72	168
72	72	14	10	20	52
80	80	82	89	154	368
81	81	112	22	120	396
82	82	31	26	50	125
83	83	24	15	29	72
84	84	56	33	62	156
90	90	73	97	146	298
91	91	105	34	97	307
92	92	137	182	344	945
93	93	91	71	139	364
101	10, 11, 12	155	86	166	416
102	11, 12	132	70	138	351
103	11, 12	132	72	140	349
104	12	73	47	86	204
310	31, 32	143	89	168	417
311	31, 32	143	89	168	414
312	32	72	46	85	210
313	31, 32	143	89	168	417
410	41, 42	121	68	135	345
411	42	86	49	97	251
640	64	39	58	85	169
710	71	49	39	74	171
900	90, 91	178	114	202	521
901	91	105	22	70	242


DENVER STORM DRAINAGE MASTER PLAN
Basin 5901-01 (Coon Creek)
Basin Label
Design Point
Detention
Hydrograph
Splitflow
Existing Manhole
Existing Storm Pipe
Designed Storm Pipe
Existing Surface Flow
Water Body / Detention
Proposed Pipe Break
Proposed Pipe
Proposed Detention
Major Basin
Secondary Basin
Subbasin
Thalweg
Fastracks Line
Potential Ponding
Denver Boundary
Other Counties
Other Municipalities
-Pipe labels are diameter or H/Vdiameter (inches).
1 inch equals 1,300 feet
DENVER
Matrix Design Group, Inc.
5500-04
0067-03
0067-02
Jefferson County
Denver
Lakewood
Bowles Reservoir No. 1
Grant C Reservoir
Grant B Reservoir
Coon Creek
Bowles Lateral
Arapahoe County
Bow Mar
Littleton
OWENS ST
S KIPLING ST
S WADSWORTH BLVD
S WADSWORTH WAY
S GARLAND ST
S DUDLEY ST
S PIERCE ST
W BOWLES AVE
Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
FILE: \\Tartarus\GIS\gis_projects\DenverDrainage_2007\activelapps\mapbook_mxd\mapbook_drainage_100_percent_final.mxd, 6/24/2009, ron_rarnold