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CITY AND COUNTY OF DENVER

STORM DRAINAGE MASTER PLAN

September 2014

DENVER
PUBLIC WORKS

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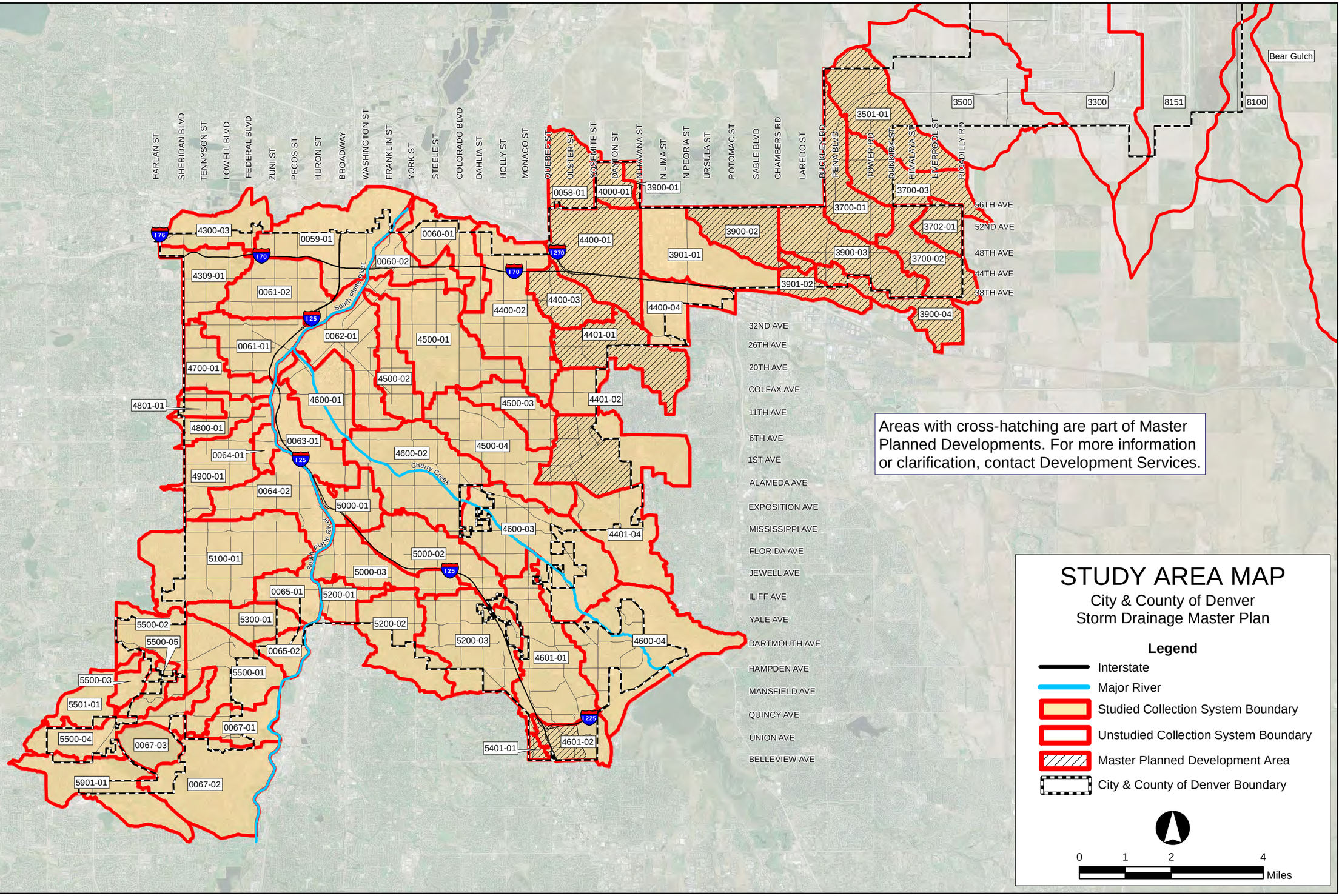

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DENVER STORM DRAINAGE MASTER PLAN

2014

PROJECT ID PC70812_908

Prepared for:

The City and County of Denver
Department of Public Works

DENVER PUBLIC WORKS

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Corrections

- Cost revised for projects (09/29/2014):
  - 3900-04-B
  - 5100-01-N
  - 5200-03-DD
- Section 1.4.2, Climate, Introductory text added (01/26/2015)

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1.0 BACKGROUND

1.1 Executive Summary

In accordance with Denver Revised Municipal Code, Division 4, Section 56-110, Denver's Storm Drainage Master Plan is updated every 5 years in order to identify and alleviate present and future drainage problems of the city. Consequently, the plan is subject to regular modifications and holders of the plan are therefore encouraged to contact the City and 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 update in accordance with DIA's independent implementation of its own storm drainage and water quality infrastructure.

Urban stormwater management within the City and 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 improvements identified herein form the basis for identifying needed storm drainage capital projects throughout the City in its Capital Improvement Program.

The total project cost to upgrade the City's storm drainage infrastructure, to meet minimum current drainage criteria in the Recommended Plan for the entire City, is estimated to be $1,478,025,513 in 2013 dollars.

This Master Plan updates and refines the previous Storm Drainage Master Plan to incorporate recently-constructed storm drainage facilities and the findings and recommendations of various studies conducted in the years following publication of the last Storm Drainage Master Plan. In addition, this update identifies topographic drainage basin boundaries and thalwegs, Potential Inundation Areas where localized flooding in excess of street drainage criteria is possible and Significant Flooding Locations reported since the year 2000. This update also identifies locations of flood control improvements needed along drainageways in studies conducted by the Urban Drainage and Flood Control District (UDFCD) in partnership with the City and County of Denver.

Drainage Basins and Thalwegs

Hydrologic modeling of the existing storm drainage system reveals that two distinct drainage basins exist: 1) Storm Drainage Collection System Basins defined by the existing storm drainage collection system catchments for minor storm conveyance designs, and 2) Topographic Drainage Basins defined by overland flow paths related to larger storm events. Both are shown in the Master Plan in order to clearly illustrate where storm drain systems direct storm runoff for the minor storm event and where larger storm events will produce surface runoff crossing collection system boundaries.

In addition, thalwegs, or natural drainage paths, are shown in order to identify the major overland flow paths that storm runoff would follow in storm events that produce runoff in excess of the existing storm drainage collection system capacities. Not all thalwegs are shown, only the most significant for each drainage basin.

Potential Inundation Areas

"Potential Inundation Areas" (PIAs) shown in the Storm Drainage Master Plan are areas where stormwater has been reported to collect in depths exceeding 12" during storm events and where various studies have identified the potential for water depths greater than 12" in a major storm event. The areas depicted represent current best-available information of these hazards. PIAs are shown so that the information is accessible to Denver residents and property owners. PIAs are not to be confused with floodplains mapped in accordance with Federal Emergency Management Agency (FEMA) guidelines for the National Flood Insurance Program (NFIP).

PIAs are identified due to more localized flooding issues and are not shown on the NFIP Flood Insurance Rate Maps and therefore flood insurance is not federally-mandated and most floodplain-specific regulations do not apply. However, it is important to note that in the absence of better-available information, the flood depths defined in PIAs may be used to determine the Finished Floor Elevations (FFE) and Minimum Lowest Opening Elevations (MLOE) for new development and re-development.

Property owners in PIAs are encouraged to implement floodproofing measures (see the City and County of Denver Flood Protection Handbook at www.denvergov.org/tabid/391460/Default.aspx) and explore the need for flood insurance since flood damages are not covered by a typical homeowner policy. A separate flood insurance policy is required to cover contents that may be damaged due to flooding. Property owners can insure their buildings and contents, and renters can insure only their contents. Additional flood insurance information is available at www.floodsmart.gov.

These areas do not reflect all such hazards throughout the City and County of Denver but represent the best available information based on flooding reports and drainage studies. Other areas may be identified in the course of additional more detailed studies and storm events.

Significant Flooding Locations

"Significant Flooding Locations" shown with red stars are locations where significant flooding and/or property damage have been reported since the year 2000 to the City and County Department of Public Works-Storm Drainage Planning, and have not yet been mitigated with storm drainage improvements. They do not reflect all reports received, only the most severe.

UDFCD Study Recommendations

The location of flood control improvements identified in Major Drainageway Planning studies and Outfall Systems Planning studies conducted by the UDFCD are identified in order to better coordinate work efforts by the Public Works storm drainage Capital Improvement Program, the Public Works bridge Capital Projects Program, Department of Parks and Recreation improvements and the UDFCD.

Hydrologic Modeling for the existing storm drainage network was conducted using the Colorado Urban Hydrograph Procedures (CUHP 2000) and the Urban Drainage Storm Water Management Model (UDSWMM) version 1.4.6 developed by the UDFCD. Modeling from more recent studies was conducted using CUHP 2005 and EPA Storm Water Management Model (EPASWMM) version 5.0.022. Results have been incorporated into this update in some drainage basins in order to retain the updated modeling from those studies. The results were then used to identify areas where

existing storm drainage systems needed to be enlarged to meet the current level of service and where new storm drainage systems were needed.

Land-Use impervious values are based on ***Blueprint Denver: An Integrated Land Use and Transportation Plan*** adopted in 2002 as a supplement to the Denver Comprehensive Plan 2000 (herein referred to as "***Blueprint Denver***"), which prepares the City for continued urbanization and redevelopment by identifying "Areas of Stability" and "Areas of Change". This information is supplemented with surface area impervious data available in Denver's GIS database.

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 and Level of Service

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 and 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.

Overview of Current System Deficiencies

The Storm Drainage Master Plan evaluates the capacity of the City's existing storm drainage system compared to predicted storm runoff rates for the minor storm event. Within a majority of the older sections of the City and County of Denver the existing storm drains provides flood protection for between a 1 and 5 year storm event. 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 drains when capacity becomes available. Complaints records maintained by the City since 2000 indicate a number of locations where surface storm runoff exceeds the City's street depth criteria of 12-inchse of flow in the gutter and significant flooding and/or property damage have been reported. For this Master Plan, only the most significant flooding locations have been identified.

Initial hydrologic models show that localized storage which exists within the City provides important flood flow attenuation and, as a result, it is important to phase improvements from downstream to upstream to avoid eliminating storage that would increase peak discharges upon downstream existing systems.

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-inch 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.

1.2 Introduction

This publication is prepared in compliance with Denver Revised Municipal Code, Division 4, Storm Drainage, Section 56-110 Master Drainage Plan. 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 and County of Denver ***Storm Drainage Design and Technical Manual.***

This Storm Master Plan updates the previous publication with new information, including:

- 2008 LiDAR topography
- Additional As-Built storm drain infrastructure data for recently constructed projects
- Topographic drainage basin boundaries and thalwegs
- Potential Inundation Areas
- Significant flooding locations
- UDFCD study recommendations

This update process includes all of the City and 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 (mi^2)	FUTURE LAND USE COMPOSITE IMPERVIOUSNESS
0058-01	South Platte River	Prairie Gateway	1.58	40.65%
0059-01	South Platte River	Globeville - Utah Junction	4.07	64.50%
0060-01	South Platte River	I-70 & Colorado Boulevard	2.14	64.42%
0060-02	South Platte River	I-70 & York	1.46	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	2.73	74.04%
0063-01	South Platte River	Central Platte Valley	2.03	73.75%
0064-01	South Platte River	1st & Federal	0.44	64.70%
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	4.21	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	First Creek & Peña Corridor	2.23	52.09%
3700-02	First Creek	First Creek - Green Valley Ranch	2.12	48.92%
3700-03	First Creek	First Creek - Dogwood & Blue Grama Tribs.	2.61	61.13%
3702-01	First Creek	First Creek - Tributary "T"	0.91	68.56%
3900-01	Irondale Gulch	Irondale Gulch - Stapleton	0.22	48.00%
3900-02	Irondale Gulch	Irondale Gulch - East Montbello	1.91	47.55%
3900-03	Irondale Gulch	Irondale Gulch - Parkfield	2.93	61.83%
3900-04	Irondale Gulch	Irondale Gulch - Majestic Commerce Center	1.85	76.52%
3901-01	Irondale Gulch	Irondale Gulch - West Montbello	3.27	66.50%
3901-02	Irondale Gulch	Irondale Gulch - Gateway	0.97	60.25%
4000-01	Rocky Mountain Arsenal	Stapleton West Section 10	0.74	34.02%
4300-03	Clear Creek	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	Westerly Creek - South Stapleton	3.01	49.09%
4401-02	Westerly Creek	Westerly Creek - 11th Avenue to Montview	1.06	59.36%
4401-03	Westerly Creek	Westerly Creek - Lowry	3.98	41.74%
4401-04	Westerly Creek	Westerly Creek - South of Alameda	2.85	65.09%
4500-01	Montclair	City Park	4.26	46.52%
4500-02	South Platte	36th & Downing	1.74	56.39%
4500-03	Montclair	Park Hill - Colfax	1.52	52.20%
4500-04	Montclair	Park Hill - 6th Avenue	3.65	45.44%
4600-01	Cherry Creek	Central Business District	2.23	72.56%
4600-02	Cherry Creek	Cherry Creek Mall	4.57	52.40%
4600-03	Cherry Creek	Upper Cherry Creek	5.60	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	Sloan's Lake	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	Weir Gulch	2.38	50.39%
5000-01	I-25 & South Platte	West Washington Park	1.23	63.66%
5000-02	I-25	University & Mexico North	2.81	54.35%
5000-03	Florida	University & Mexico South	2.29	51.24%
5100-01	Sanderson Gulch	Sanderson Gulch	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 Harvard Gulch	1.44	52.34%
5401-01	Greenwood Gulch	Greenwood Gulch	0.17	73.66%

ID	OUTFALL	NAME/LOCATION	AREA (mi^2)	FUTURE LAND USE COMPOSITE IMPERVIOUSNESS
5500-01	Bear Creek	Bear Creek – Fort Logan	3.11	53.57%
5500-02	Bear Creek	Upper Bear Creek	1.86	44.34%
5500-03	Bear Creek	Academy Park	0.60	62.66%
5500-04	Bear Creek	Bear Creek – Marston Lake North	2.23	43.98%
5500-05	Bear Creek	Pinehurst Tributary	0.71	42.08%
5501-01	Bear Creek	Henry's Lake	1.36	35.03%
5901-01	Dutch Creek	Coon Creek	3.10	53.67%
	TOTAL		**154.41**	
	AVERAGE			**56.88%**

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 issues, goals, obstacles and measures for success were identified:

Primary Drainage Issues Confronting the City

- 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.

Goals for the Master Plan Update Process

- Provide a regularly updated guidance document to identify storm drainage capital projects needed to mitigate flood risks and losses.
- 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 and new storm drain construction 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 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 and County of Denver and implementation of the concepts and tenets of ***Blueprint Denver: An Integrated Land Use and Transportation Plan***.

Threats or Obstacles Preventing Denver From Obtaining This Goal

- 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.

Appropriate Measure for Success of the Update Process

- Completion of the Master Plan with enough detail to validate or justify modification of the City's current Capital Improvement Program (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 storm drainage master plan update processes.

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 Plan Formulation

1.4.1 Geology

The City and County of Denver is built across the deepest part of the asymmetrical Denver basin. Most bedrock outcrops 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. Geologic maps clearly identify ancient and historic alluvial stream beds prior to these drainageways being filled in by development. 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.

1.4.2 Climate

Public Works staff along with our regional partners Denver Water, the Urban Drainage and Flood Control District, and the Metro Wastewater Reclamation District create Master Plans that include current climate information. The plans are updated on a periodic basis and will address the current understanding of climate impacts, mitigation, and adaptation.

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° F with a recorded high on June 25, 2012 of 105° F and a low of –30° F recorded in 1936. Diurnal temperature fluctuations usually range from 26° to 29° F for most months; however, around July daily fluctuations can be much greater. 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 15.8 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.

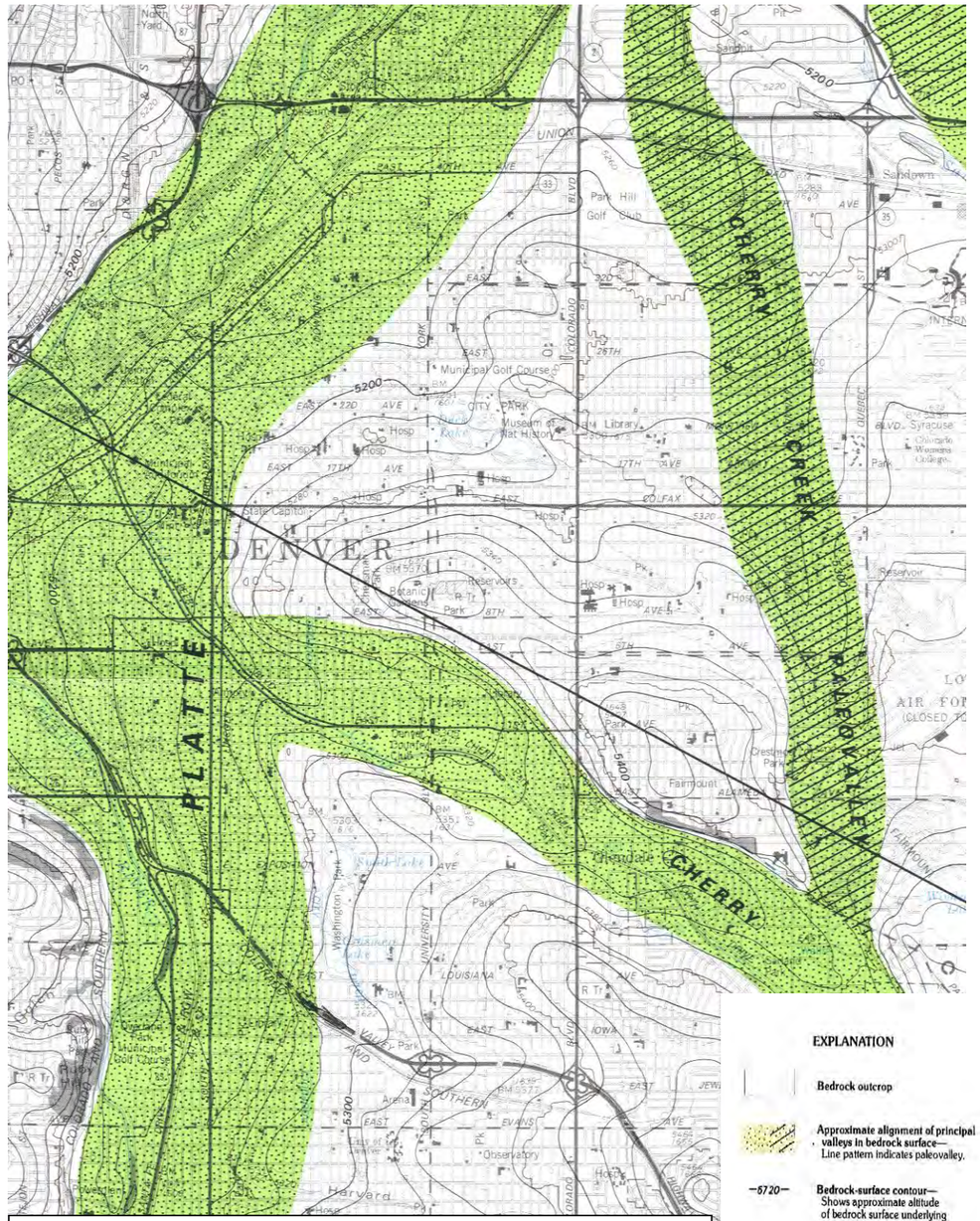


Figure 1: Geohydrology Map (Robinson 1996) of Downtown Denver showing bedrock contours and evidence of historic channel alignments. The map shows Cherry Creek once flowed through Basin 4400-02 between Quebec and Colorado Boulevard.

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.

1.4.3 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.

1.4.4 Flood History

The City and County of Denver and surrounding metropolitan areas lie within the watershed of the South Platte River. Development has occurred within the geomorphic floodplain 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 was a notable period of severe flooding around 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 for the South Platte River. 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 drainage 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 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 1,670 cfs, exceeding its prior record of 1,470 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 2,040 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 1,850 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 3,200 cfs. The Cherry Creek gage at Steele Street also set a new record at 2,350 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 4,200 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 3,480 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 2,640 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 25, 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 stormdrain. 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 Street/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 midair.

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 fireworks. 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-inch to 1.50-inch 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 the north producing heavy rainfall of 1.50-inches to 2.50-inches 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-inch to 2.5-inch 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.

April 16-18, 2009 - A big precipitation event arrived by way of a winter storm. Many streams were flowing well above normal and four stormwater detention basins recorded annual peaks, including Kelly Road Dam in Denver. Denver Fire Department rescued at least one person that became trapped between the channel walls of Cherry Creek.

May 24-25, 2009 - Heavy intense rain dropped 2-inch plus rains over central Denver. Minor flooding occurred along Lakewood Gulch through Denver, with a peak flow of 600 cfs at 10th Avenue.

June 23-25, 2009 - This storm impacted DIA and caused street flooding during rush-hour with hail that hit the northwest metro area. These storms produced strong east moving thunderstorms over Denver that caused a downpour of 1.5 to 2.4 inches in 20-45 minutes and prompted a NWS flash flood warning in this 3-day period. Four east Denver condominiums were flooded by 4 feet of water and a dog died at 5300 East Cherry Creek Drive South. Several homes flooded along East Missouri Avenue and the sump at East Tennessee Avenue and Oneida Street flooded Rainfall totals exceeded 2 inches at some locations.

July 3, 2009 - This day was the second in a 5-day series of stormy days. The National Weather Service reported that severe thunderstorms produced large hail north and east of Denver. Localized flooding was reported in central and southeast Denver including S. Glencoe south of E Yale Avenue.

Flooding on Harvard Gulch on July 3, 2009.
(Photo Courtesy Ed Done)

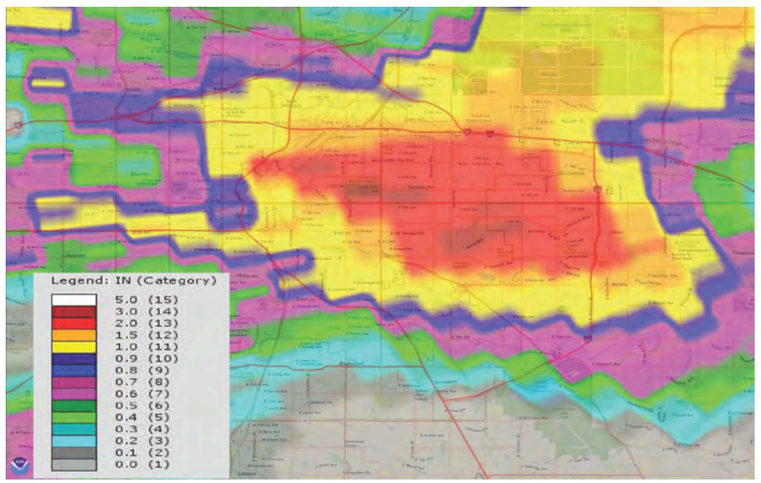
July 10, 2009 - Storms triggered many rainfall rate alarms between 8:30 and 10 p.m. in Denver, causing some minor street flooding and flooded several properties in central and east Denver.

July 20, 2009 - A supercell thunderstorm moved quickly to the south producing very intense rainfall, large hail and powerful straight line winds. Property damages from the wind and hail were high, and localized flooding was reported in east Denver. The storm duration was short but the rainfall intensities were very high.

April 21-23, 2010 - A system of strong thunderstorms produced large hail and heavy rainfall. The stormy period lasted about 48 hours, changing over to a widespread rain and snow storm with precipitation totals exceeding 2 inches at many locations. Runoff from the storms caused annual flood peaks affecting Kelly Road Dam on Westerly Creek in Denver, and Sand Creek and Cherry Creek through Denver. No serious damages occurred; however, this storm caused the largest widespread flooding event of the 2010 flood season.

August 4, 2010 - Heavy rains impacted Westerly Creek in Denver. Annual flood peaks were recorded in this drainage basin. While rainfall totals only approached 1.4 inches in this area, stations measured very high intensities.

July 7, 2011- This was the biggest rain day of 2011. Rainstorms appeared with flash flood and severe thunderstorm warnings being issued for Denver County. The heaviest total rainfall occurred in the area bounded between Alameda Avenue and I-70 from I-25 on the west to I-225 on the east. The largest storm totals exceeded 3 inches in the Westerly Creek basin located in Denver. Denver officials reported that storm sewer manholes popped their covers at over 50 locations. Numerous streets, intersections and underpasses were flooded, and dozens of properties reported flood damage across a wide swath in central and east Denver. Ferril Lake as City Park which had been modified in 2007-2008 to provide stormwater detention rose nearly 3 feet during the storm as intended. Annual peak flows were recorded for Westerly Creek in Denver.



Total Rainfall on July 7, 2011. Red Shades Indicate 2- and 3-Inches of Total Precipitation. (Courtesy of NOAA)

July 12, 2011 - Annual peaks were measured in Denver on Cherry Creek, Lakewood Gulch, Sanderson Gulch, and the South Platte River. The Sanderson Gulch and Lakewood Gulch stream gages set new records. Rain totals were mostly less than 2 inches.

July 13, 2011 - Storms caused an annual streamflow peak on Goldsmith Gulch in Denver. Damage was reported at the Boys and Girls Club in Denver's Westwood neighborhood and flooding was reported at one home in west Denver.

July 14, 2011 - Heavy rainfall occurred to the west in Denver County where annual peaks were recorded for Harvard Gulch and Goldsmith Gulch at Iliff Avenue in Denver. Flooding was reported again in Glencoe Street south of Yale Avenue.

July 7, 2012 - A late evening storm arrived the evening before and remained until the morning of July 7, affecting Denver County.

September 12, 2012 - Denver was issued a special "Cherry Creek Trail Flood Advisory" for low impact flooding due to a general wide-spread low-intensity rainfall over the region.

July 13, 2013 - Multiple thunderstorms moved through Denver during afternoon hours with rainfall totals exceeding 3 inches. The storm caused Lakewood Gulch in Denver to rise over 6 feet in a short period setting a new record for the USGS gage that has operated continuously since 1981. Localized flooding was reported at Martin Luther King Boulevard and Eudora Street.

September 9-15, 2013 - Waves of rainfall during mid-September caused significant flooding and related damage outside of Denver, especially in Aurora, Commerce City, Boulder, Jamestown, Lyons and Estes Park. Denver experienced significant rainfall and peak flows. Rainfall intensities exceeded 3 inches per hour for periods of time on September 9, 10, 12, and 15. Overall, total precipitation exceeded 12 inches in some parts of Denver. More than 5 inches fell over the Westerly Creek basin and activated the spillway at Kelly Road Dam at E 11th Avenue & S Willow Street. Floodwaters on Sand Creek caused considerable bank erosion that threatened the Metro Wastewater Treatment Plant near its confluence with the South Platte River.

East Denver Flooding on September 12, 2013. (Photo Courtesy Tony Ryan)

1.4.5 Existing Conditions

The associated *Technical Appendix* notebooks are organized by basin and include all CUHP and SWMM hydrologic and FLO-2D 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 and 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 and 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.

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 were obtained from the Urban Storm Drainage Criteria Manual, Volume 1 for the following recurrence intervals:

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 in major storm events, whereby the direction of storm drains contravenes the surface gradient. Many of the existing storm drain systems have little more than 1-year capacity, and will have 2 to 5-year capacity under 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 trans-basin diversions of flow to enable mapping of potential hazard areas under 100-year storm event conditions. Potential inundation 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-inch; however, they have not been mapped using regulatory criteria or modeling techniques and are therefore considered only a rough guide of potential inundation.

1.4.6 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 and 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 and 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. Dry weather discharges in the South Platte River through Denver generally range from 150 cfs upward to over 1,000 cfs during the spring runoff period. Average daily flows downstream of Denver 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 High Line Canal terminates at the West Fork. The sustained unused flow in the High Line 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 drains 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-inch 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 Montclair (Basin 4500)

The Montclair Drainage basin consists of approximately 9.44 square miles (6,040 acres) and is the largest storm drainage basin in Denver which does not have a surface drainageway. A survey in 1861 shows two watercourses converging at present-day East Colfax and Colorado Boulevard, then continuing northwest through present-day City Park (Ferril Lake) and onward to the South Platte River. A 1979 Geologic Map of Denver, prepared by the USGS, shows an identical pattern of alluvial soils as depicted in Figure 2. The Capitol Hill Storm District Number 1 created in the early 1900's financed construction of a large storm drain following this drainageway to convey storm flows to the South Platte River. In larger storms, runoff in excess of the drain capacity follows the original drainageway path and causes flooding at numerous locations and intersections.

2.9 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.

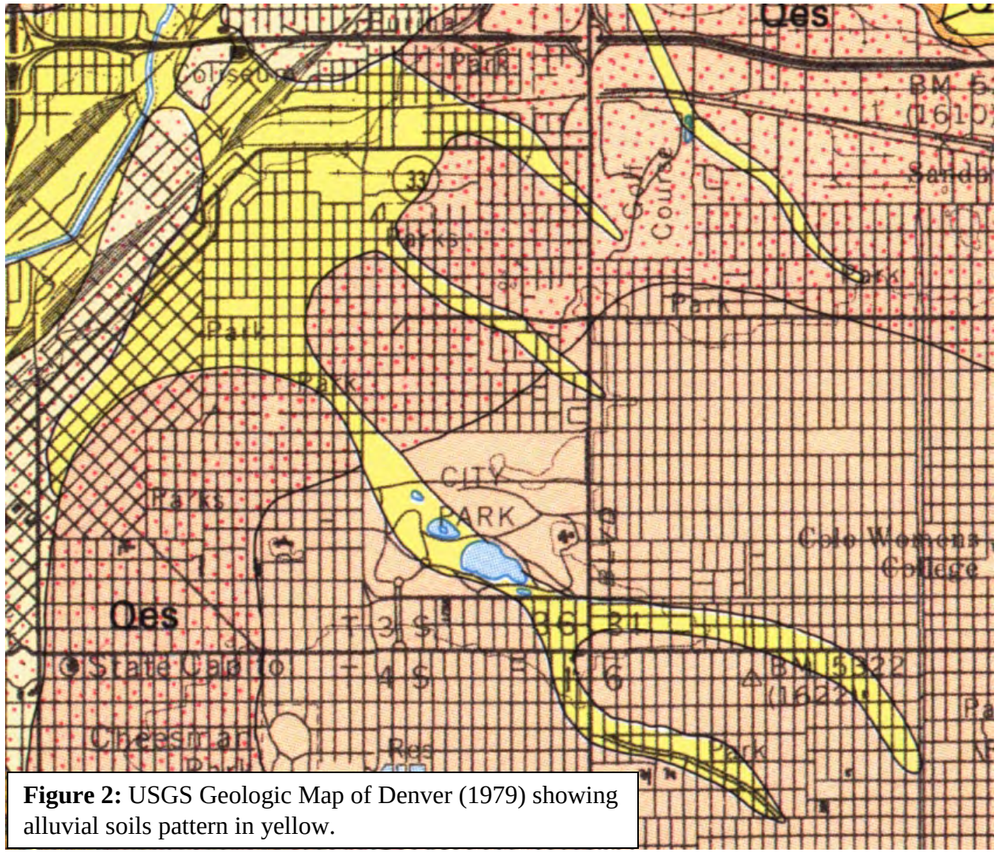


Figure 2: USGS Geologic Map of Denver (1979) showing alluvial soils pattern in yellow.

2.10 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 High Line Canal bisects Goldsmith Gulch at East Cornell Avenue. Goldsmith Gulch passes underneath the High Line 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 and detention facilities drain the I-225 and I-25 interchange to Goldsmith Gulch.

2.11 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.

2.12 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.

2.13 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.

2.14 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 and County 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.

2.15 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.

2.16 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 High Line 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 basin 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 drain system. The TREX storm drain is connected to Denver's existing storm drain system at two locations along the west side of I-25: 1) the TREX storm drain system to the south outfalls to the High Line Canal, and 2) the storm drain system to the north outfalls to the existing 36-inch storm drain within Yale Avenue.

2.17 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-inch 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.

2.18 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.

2.19 Marston Lake North (Basin 5501)

The Marston Lake drainage basin consists of approximately 2.2 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 UDFCD. 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 UDFCD 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 and County of Denver for the period 1999 to 2013 and statistically analyzed to derive regression equations that reflect typical construction practices within the City and 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 2013 dollars) are summarized below:

- Storm Drain (18 in. and < 72 in.): $ 4.27 to $5.67 per inch diameter per lineal foot
- Storm Drain (> 72 in – 120 in.): $ 5.95 to $8.89 per inch diameter per lineal foot
- Elliptical Storm Drain: 1½ times the equivalent round pipe
- Jack and Bore Pipe (≤ 48 in.): $ 27.36 per inch diameter per lineal foot
- Jack and Bore Pipe (> 48 in.): $ 100.00 per inch diameter per lineal foot
- Box Culverts: $ 600 per cy concrete, plus $0.85 per lb. steel
- Headwalls: $ 600 per cy concrete
- Manholes: $ 3,181 - $14,700 each Type A, C, B and P
- Manhole Cone floe Box Culverts: $1,800 each
- Inlets: $ 4,200 for typical 6-foot Type 14 curb opening
  Assumed four inlets constructed per manhole
- Inlet laterals: Assumed 20 feet of 18-inch RCP per inlet
- Stormwater Detention: $ 75,000 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
- Wet Utility Relocation Cost: $2,740 per crossing for sanitary sewer avoidance
  $1,370 to $27,360 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 & Engineering: 15%
- Materials Management (Limited Envi. Remediation and Disposal): 7%
- Contract Administration / Construction Management: 10%
- Contingency: 25%
- Environmental Compliance (Erosion Control, etc.) 3%

  INDIRECT COST TOTAL 73%

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 2013. In some cases, the automated costing may not match exactly hand calculated project costs shown in the individual *Technical Appendix* notebooks. However, great care has been taken to ensure these differences are within 5% or less.

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 on the following pages to show the total cost of the Recommended Plan. This consists of all the projects shown, excluding those with an asterisk (*).

Projects shown with an asterisk have been excluded from the Recommended Plan in favor of an alternative evaluated in the same drainage basin in order to provide a level of service necessary to drain or protect sump locations (0060-01, 0061-02); meet street depth criteria (4400-02, 4600-02); removing floodplain (4700-01) and other drainage considerations (0061-02, 5100-01).

The total project cost to upgrade the City's storm drainage infrastructure, to meet minimum current drainage criteria in the Recommended Plan for the entire City, is estimated to be $1,478,025,513 in 2013 dollars.

RECOMMENDED PLAN
SUMMARY OF PROJECT COSTS
BY COLLECTION SYSTEM

ID	OUTFALL	NAME/LOCATION	RECOMMENDED PLAN NOTES	CIP COST (2013 Dollars)
0058-01	South Platte River	Prairie Gateway		$0
0059-01	South Platte River	Globeville - Utah Junction		$62,253,214
0060-01	South Platte River	I-70 & Colorado Boulevard	Excludes Projects F and F1 & uses 100-year Alternative	$14,280,053
0060-01-100YR	South Platte River	I-70 & Colorado Boulevard		$6,834,404
0060-02	South Platte River	I-70 & York		$50,044,259
0061-01	South Platte River	27th & Federal		$69,285,056
0061-02	South Platte River	Highland	Excludes Projects B, H and J & uses 100-year Alternative	$70,145,923
0061-02-100YR	South Platte River	Highland		$25,199,832
0062-01	South Platte River	Lower Platte Valley		$34,581,126
0063-01	South Platte River	Central Platte Valley		$68,436,129
0064-01	South Platte River	1st & Federal		$10,284,557
0064-02	South Platte River	Valverde		$29,296,233
0065-01	South Platte River	Ruby Hill		$16,013,182
0065-02	South Platte River	Dartmouth		$492,604
0067-01	South Platte River	College View		$3,441,705
0067-02	South Platte River	West Belleview		$2,311,003
0067-03	No Outfall	Marston Lake		$0
3501-01	Second Creek	West Fork Second Creek		$17,838,865
3700-01	First Creek	First Creek & Peña Corridor		$0
3700-02	First Creek	First Creek - Green Valley Ranch		$0
3700-03	First Creek	First Creek - Dogwood & Blue Gamma Tribs.		$18,999,763
3702-01	First Creek	First Creek - Tributary "T"		$0
3900-01	Irondale Gulch	Irondale Gulch - Stapleton		$1,271,550
3900-02	Irondale Gulch	Irondale Gulch - East Montbello		$2,509,053
3900-03	Irondale Gulch	Irondale Gulch - Parkfield		$0
3900-04	Irondale Gulch	Irondale Gulch - Majestic Commerce Center		$18,094,707
3901-01	Irondale Gulch	Irondale Gulch - West Montbello		$43,779,847
3901-02	Irondale Gulch	Irondale Gulch - Gateway		$0
4000-01	Rocky Mountain Arsenal	Stapleton West Section 10		$6,617,250
4300-03	Clear Creek	Clear Creek - North of I-70		$7,681,489
4309-01	Clear Creek	Berkeley Lake		$0
4400-01	Sand Creek	North Stapleton		$0
4400-02-100YR	Sand Creek	Quebec Corridor	Recommended Street Depth Criteria Alternative	$76,510,599
4400-03	Sand Creek	Stapleton		$8,926,694
4400-04	Sand Creek	East Stapleton		$26,858,165
4401-01	Westerly Creek	Westerly Creek - South Stapleton		$1,962,249
4401-02	Westerly Creek	Westerly Creek - 11th Avenue to Montview		$4,681,400
4401-03	Westerly Creek	Westerly Creek - Lowry		$0
4401-04	Westerly Creek	Westerly Creek - South of Alameda		$14,046,203
4500-01	Montclair	City Park		$67,090,422
4500-02	South Platte	36th & Downing		$50,339,294
4500-03	Montclair	Park Hill - Colfax		$43,363,416
4500-04	Montclair	Park Hill - 6th Avenue		$81,571,195
4600-01	Cherry Creek	Central Business District		$63,347,951
4600-02	Cherry Creek	Cherry Creek Mall		$68,015,612
4600-02-100YR	Cherry Creek	Cherry Creek Mall	Recommended Street Depth Criteria Alternative	$15,488,679
4600-03	Cherry Creek	Upper Cherry Creek		$37,029,014
4600-03-100YR	Cherry Creek	Upper Cherry Creek		$11,790,690
4600-04	Cherry Creek	Cherry Creek Reservoir		$4,961,467
4601-01	Goldsmith Gulch	Lower Goldsmith Gulch		$12,141,664
4601-02	Goldsmith Gulch	Middle Goldsmith Gulch		$0
4700-01	Sloan's Lake	Sloan's Lake	Excludes Projects C1 and D & uses 100-year Alternative	$3,640,712
4700-01-100YR	Sloan's Lake	Sloan's Lake		$14,830,043
4800-01	Lakewood Gulch	12th & Federal		$8,595,513
4801-01	Dry Gulch	12th & Sheridan		$0
4900-01	Weir Gulch	Weir Gulch		$4,948,695
5000-01	I-25 & South Platte	West Washington Park		$18,439,886
5000-02	I-25	University & Mexico North		$17,570,255
5000-03	I-25	University & Mexico South		$10,387,265
5100-01	Sanderson Gulch	Sanderson Gulch	Excludes Project O & uses 100-year Alternative	$54,928,579
5100-01-100YR	Sanderson Gulch	Sanderson Gulch	Uses Project O only	$6,630,258
5200-01	Harvard Gulch	Harvard Gulch Lower Basin		$35,644,580
5200-02	Harvard Gulch	Harvard Gulch Middle Basin		$39,004,016
5200-03	Harvard Gulch	Harvard Gulch Upper Basin		$59,028,108
5300-01	West Harvard Gulch	West Harvard Gulch		$8,155,827
5401-01	Greenwood Gulch	Greenwood Gulch		$0
5500-01	Bear Creek	Bear Creek - Fort Logan		$7,407,582
5500-02	Bear Creek	Upper Bear Creek		$13,346,391
5500-03	Bear Creek	Academy Park		$0
5500-04	Bear Creek	Bear Creek - Marston Lake North		$4,172,615
5500-05	Bear Creek	Pinehurst Tributary		$3,478,670
5501-01	Bear Creek	Henry's Lake		$0
5901-01	Dutch Creek	Coon Creek		$0
			RECOMMENDED PLAN TOTAL	**$1,478,025,513**

STATEMENT OF PROBABLE COSTS IN 2013 DOLLARS

PROJECT			HARD COSTS							INDIRECT COSTS							TOTALS	
COLLECTION SYSTEM	ID	PROJECT	PIPE	MANHOLE	INLETS	ASPHALT PATCH	WET UTILITY RELOCATE	DETENTION	TOTAL CONSTRUCTION COSTS	TRAFFIC CONTROL (3%)	MOBILIZATION / DEMOBILIZATION (10%)	DESIGN & ENGINEERING (15%)	MATERIALS MANAGEMENT (7%)	CONTRACT ADMINISTRATION / CONSTRUCTION MANAGEMENT (10%)	CONTINGENCY (25%)	ENVIRONMENTAL COMPLIANCE (3%)	TOTAL	TOTAL BY COLLECTION SYSTEM
0059-01	A	48TH AVE OUTFALL (A)	$13,813,353	$468,928	$1,195,600	$1,303,220	$310,720		$17,091,821	$512,755	$1,709,182	$2,563,773	$1,196,427	$1,709,182	$4,272,955	$512,755	$29,568,850	
	B	48TH AVE OUTFALL (B)	$685,224	$7,811	$73,200	$176,832	$9,590		$952,657	$28,580	$95,266	$142,899	$66,686	$95,266	$238,164	$28,580	$1,648,098	
	C	48TH AVE OUTFALL (C)	$5,220,660	$19,800	$268,400		$42,470		$5,551,330	$166,540	$555,133	$832,700	$388,593	$555,133	$1,387,832	$166,540	$9,603,801	
	E	51ST AVENUE COLLECTION SYSTEM	$5,931,743	$432,514	$756,400	$1,057,232	$109,540		$8,287,429	$248,623	$828,743	$1,243,114	$580,120	$828,743	$2,071,857	$248,623	$14,337,252	
	J	INTERSTATE 70 OUTFALL	$2,521,971	$72,026	$536,800	$690,752	$39,730		$3,861,279	$115,838	$386,128	$579,192	$270,290	$386,128	$965,320	$115,838	$6,680,013	
	L	49TH AVE AND GRANT ST POND						$240,000	$240,000	$7,200	$24,000	$36,000	$16,800	$24,000	$60,000	$7,200	$415,200	$62,253,214
0060-01	F *	PARK HILL PHASE VI *	$1,313,488	$180,666	$317,200	$632,604	$58,870		$2,502,828	$75,085	$250,283	$375,424	$175,198	$250,283	$625,707	$75,085	$4,329,893 *	
	F1 *	PARK HILL PHASE VII *	$395,922	$63,766	$97,600	$199,272	$57,470		$814,030	$24,421	$81,403	$122,104	$56,982	$81,403	$203,508	$24,421	$1,408,272 *	
	G	50TH AVE INTERCEPTOR	$1,090,449	$137,998	$195,200	$315,540	$17,810		$1,756,997	$52,710	$175,700	$263,550	$122,990	$175,700	$439,249	$52,710	$3,039,606	
	H	COLUMBINE AND YORK UPGRADES	$748,110	$136,068	$366,000	$614,740	$87,600		$1,952,518	$58,576	$195,252	$292,878	$136,676	$195,252	$488,130	$58,576	$3,377,858	
	I	RIVERSIDE OUTFALL	$2,609,959	$30,265	$317,200		$2,740		$2,960,164	$88,805	$296,016	$444,025	$207,211	$296,016	$740,041	$88,805	$5,121,083	
	L	N COLORADO BLVD IMPROVEMENTS	$419,219	$67,587	$512,400	$285,820	$9,580		$1,294,606	$38,838	$129,461	$194,191	$90,622	$129,461	$323,652	$38,838	$2,239,669	
	M	MILWAUKEE ST IMPROVEMENTS	$97,750	$10,329	$73,200	$108,800			$290,079	$8,702	$29,008	$43,512	$20,306	$29,008	$72,520	$8,702	$501,837	$20,018,218
0060-01-100YR	F	PARK HILL PHASE VI	$1,640,688	$180,666	$317,200	$657,144	$60,240		$2,855,938	$85,678	$285,594	$428,391	$199,916	$285,594	$713,984	$85,678	$4,940,773	
	F1	PARK HILL PHASE VII	$655,500	$63,766	$97,600	$220,248	$57,470		$1,094,584	$32,838	$109,458	$164,188	$76,621	$109,458	$273,646	$32,838	$1,893,631	$6,834,404
0060-02	A	E 45TH AVE SYSTEM	$4,103,680	$611,777	$1,317,600	$2,301,564	$220,450		$8,555,071	$256,652	$855,507	$1,283,261	$598,855	$855,507	$2,138,768	$256,652	$14,800,273	
	B	N BRIGHTON BLVD OUTFALL	$5,868,869	$423,882	$732,000	$1,223,524	$93,120		$8,341,395	$250,242	$834,140	$1,251,209	$583,898	$834,140	$2,085,349	$250,242	$14,430,615	
	C	N RACE ST OUTFALL	$3,917,511	$439,062	$1,049,200	$1,524,592	$193,030		$7,123,395	$213,702	$712,340	$1,068,509	$498,638	$712,340	$1,780,849	$213,702	$12,323,475	
	D	NATIONAL WESTERN IMPROVEMENTS	$3,182,133	$236,431	$732,000	$684,340	$72,550		$4,907,454	$147,224	$490,745	$736,118	$343,522	$490,745	$1,226,864	$147,224	$8,489,896	$50,044,259
0061-01	A	19TH AND 23RD AVENUE OUTFALLS	$1,329,434	$65,852	$219,600	$350,696	$24,660		$1,990,242	$59,707	$199,024	$298,536	$139,317	$199,024	$497,560	$59,707	$3,443,117	
	B	20TH AVENUE COLLECTION SYSTEM	$1,051,395	$182,993	$780,800	$1,077,652	$152,010		$3,244,850	$97,346	$324,485	$486,728	$227,140	$324,485	$811,212	$97,346	$5,613,592	
	C	20TH AVENUE OUTFALL	$3,712,239	$261,537	$610,000	$1,130,420	$116,410		$5,830,606	$174,918	$583,061	$874,591	$408,142	$583,061	$1,457,652	$174,918	$10,086,949	
	D	24TH AVENUE COLLECTION SYSTEM	$2,392,764	$309,496	$1,244,400	$2,011,488	$308,000		$6,266,148	$187,984	$626,615	$939,922	$438,630	$626,615	$1,566,537	$187,984	$10,840,435	
	E	29TH AVENUE COLLECTION SYSTEM	$3,191,622	$484,309	$1,122,400	$2,094,612	$294,310		$7,187,253	$215,618	$718,725	$1,078,088	$503,108	$718,725	$1,796,813	$215,618	$12,433,948	
	F	7TH STREET OUTFALL	$4,374,029	$219,553	$658,800	$1,168,672	$188,920		$6,609,974	$198,299	$660,997	$991,496	$462,698	$660,997	$1,652,494	$198,299	$11,435,254	
	G	CENTRAL STREET COLLECTION AND OUTFALL SYSTEM	$1,555,858	$239,252	$829,600	$1,068,296	$266,890		$3,959,896	$118,797	$395,990	$593,984	$277,193	$395,990	$989,974	$118,797	$6,850,621	
	H	UPPER 29TH AVENUE AND UPPER ZUNI COLLECTION SYSTEM	$1,772,437	$271,191	$1,024,800	$1,661,768	$230,000		$4,960,196	$148,806	$496,020	$744,029	$347,214	$496,020	$1,240,049	$148,806	$8,581,140	$69,285,056
0061-02	A	W 34TH/35TH AVENUE COLLECTION SYSTEM	$1,849,381	$216,147	$927,200	$1,597,152	$282,000		$4,871,880	$146,156	$487,188	$730,782	$341,032	$487,188	$1,217,970	$146,156	$8,428,352	
	B *	W 34TH AVE AND LIPAN ST OUTFALL *	$4,432,880	$87,522	$292,800	$511,732	$15,070		$5,340,004	$160,200	$534,000	$801,001	$373,800	$534,000	$1,335,001	$160,200	$9,238,206 *	
	C	40TH AVENUE AND FEDERAL COLLECTION SYSTEM	$3,363,017	$475,309	$1,317,600	$2,375,028	$273,860		$7,804,814	$234,144	$780,481	$1,170,722	$546,337	$780,481	$1,951,204	$234,144	$13,502,327	
	D	42ND AVENUE AND FEDERAL COLLECTION SYSTEM	$1,255,075	$110,438	$780,800	$1,211,828	$99,970		$3,458,111	$103,743	$345,811	$518,717	$242,068	$345,811	$864,528	$103,743	$5,982,532	
	E	W 46TH AVENUE COLLECTION SYSTEM	$1,116,206	$172,696	$536,800	$893,184	$67,110		$2,785,996	$83,580	$278,600	$417,899	$195,020	$278,600	$696,499	$83,580	$4,819,774	
	F	W 47TH AVENUE COLLECTION SYSTEM	$2,303,865	$370,773	$902,800	$1,280,020	$116,390		$4,973,848	$149,215	$497,385	$746,077	$348,169	$497,385	$1,243,462	$149,215	$8,604,756	
	G	CHAFFEE PARK INTERCEPTOR	$1,793,065	$596,512	$1,073,600	$1,395,496	$153,360		$5,012,033	$150,361	$501,203	$751,805	$350,842	$501,203	$1,253,008	$150,361	$8,670,816	
	H *	FOX STREET OUTFALL *	$3,786,424	$143,003	$268,400	$547,696	$13,700		$4,759,223	$142,777	$475,922	$713,883	$333,146	$475,922	$1,189,806	$142,777	$8,233,456 *	
	I	LOWER W 38TH AVENUE COLLECTION SYSTEM	$3,344,033	$278,844	$756,400	$1,519,308	$165,650		$6,064,235	$181,927	$606,424	$909,635	$424,496	$606,424	$1,516,059	$181,927	$10,491,127	
	J *	LOWER INCA STREET COLLECTION SYSTEM UPGRADES *	$2,362,874	$281,089	$683,200	$1,273,808	$134,180		$4,735,151	$142,055	$473,515	$710,273	$331,461	$473,515	$1,183,788	$142,055	$8,191,813 *	
	K	UPPER W 38TH AVENUE COLLECTION SYSTEM	$2,156,533	$498,036	$1,098,000	$1,631,572	$191,720		$5,575,861	$167,276	$557,586	$836,379	$390,310	$557,586	$1,393,965	$167,276	$9,646,239	$95,809,398
0061-02-100YR	L	NORTHWEST SUBAREA INTERCEPTOR STORM SEWER	$11,921,236	$377,461	$683,200	$1,499,560	$84,920		$14,566,377	$436,991	$1,456,638	$2,184,957	$1,019,646	$1,456,638	$3,641,594	$436,991	$25,199,832	$25,199,832
0062-01	F	27TH ST INTERCEPTOR PHASE 1	$3,976,748	$130,598	$195,200	$349,888	$21,920		$4,674,354	$140,231	$467,435	$701,153	$327,205	$467,435	$1,168,588	$140,231	$8,086,632	
	G	27TH ST INTERCEPTOR PHASE 2	$3,298,360	$202,298	$292,800	$680,248	$106,810		$4,580,516	$137,415	$458,052	$687,077	$320,636	$458,052	$1,145,129	$137,415	$7,924,292	
	H	27TH ST INTERCEPTOR PHASE 3	$1,077,213	$237,797	$463,600	$733,432	$61,630		$2,573,672	$77,210	$257,367	$386,051	$180,157	$257,367	$643,418	$77,210	$4,452,452	
	I	27TH ST INTERCEPTOR - WALNUT/MARKET LATERAL	$568,694	$97,465	$122,000	$350,072	$10,960		$1,149,191	$34,476	$114,919	$172,379	$80,443	$114,919	$287,298	$34,476	$1,988,101	
	J	27TH ST INTERCEPTOR - CHAMPA LATERAL	$1,334,821	$112,747	$366,000	$727,880	$46,560		$2,588,008	$77,640	$258,801	$388,201	$181,161	$258,801	$647,002	$77,640	$4,477,254	
	M	GRANT ST STORM DRAIN	$2,370,375	$306,259	$610,000	$888,976	$247,740		$4,423,350	$132,700	$442,335	$663,502	$309,635	$442,335	$1,105,838	$132,700	$7,652,395	$34,581,126
0063-01	A	W 13TH AVE OUTFALL	$1,514,623	$299,223	$683,200	$952,248	$136,860		$3,586,154	$107,585	$358,615	$537,923	$251,031	$358,615	$896,538	$107,585	$6,204,046	
	B	W 7TH AVE OUTFALL	$7,397,296	$374,685	$683,200	$955,884	$36,980		$9,448,045	$283,441	$944,804	$1,417,207	$661,363	$944,804	$2,362,011	$283,441	$16,345,116	
	C	W BAYAUD AVE OUTFALL	$7,186,703	$592,293	$2,269,200	$3,179,736	$395,620		$13,623,552	$408,707	$1,362,355	$2,043,533	$953,649	$1,362,355	$3,405,888	$408,707	$23,568,746	
	D	W ELLSWORTH AVE OUTFALL	$1,193,450	$43,769	$73,200	$78,440	$12,320		$1,401,179	$42,035	$140,118	$210,177	$98,083	$140,118	$350,295	$42,035	$2,424,040	
	E	W MULBERRY PL OUTFALL	$2,535,319	$78,176	$536,800	$683,124	$94,430		$3,927,849	$117,835	$392,785	$589,177	$274,949	$392,785	$981,962	$117,835	$6,795,177	
	F	W 3RD AVE OUTFALL	$3,869,150	$253,045	$585,600	$672,548	$69,840		$5,450,183	$163,505	$545,018	$817,527	$381,513	$545,018	$1,362,546	$163,505	$9,428,815	
	G	W COLFAX AVE IMPROVEMENTS	$707,881	$148,075	$610,000	$607,620	$47,920		$2,121,496	$63,645	$212,150	$318,224	$148,505	$212,150	$530,374	$63,645	$3,670,189	$68,436,129
0064-01	A	W 3RD AVE OUTFALL	$85,595	$9,543	$73,200	$111,724	$8,220		$288,282	$8,648	$28,828	$43,242	$20,180	$28,828	$72,070	$8,648	$498,726	
	B	W 8TH AVE OUTFALL	$699,996	$21,905	$170,800	$293,460	$10,960		$1,197,121	$35,914	$119,712	$179,568	$83,798	$119,712	$299,280	$35,914	$2,071,019	
	C	W 5TH AVE OUTFALL	$2,639,959	$141,194	$610,000	$938,216	$130,060		$4,459,429	$133,783	$445,943	$668,914	$312,160	$445,943	$1,114,857	$133,783	$7,714,812	$10,284,557
0064-02	A	18" UPGRADES	$148,960	$29,415	$219,600	$194,432	$2,740		$595,147	$17,854	$59,515	$89,272	$41,660	$59,515	$148,787	$17,854	$1,029,604	
	B	S HURON ST OUTFALL	$168,103	$16,684	$97,600	$166,144	$26,010		$474,541	$14,236	$47,454	$71,181	$33,218	$47,454	$118,635	$14,236	$820,955	
	C	W ALAMEDA AVE OUTFALL	$8,197,851	$338,220	$1,073,600	$2,192,220	$308,010		$12,109,901	$363,297	$1,210,990	$1,816,485	$847,693	$1,210,990	$3,027,475	$363,297	$20,950,128	
	D	W ARIZONA AVE OUTFALL	$1,506,925	$46,969	$146,400	$270,100	$34,230		$2,004,624	$60,139	$200,462	$300,694	$140,324	$200,462	$501,156	$60,139	$3,468,000	
	E	W TENNESSEE AVE OUTFALL	$949,938	$104,338	$219,600	$450,120	$26,030		$1,750,026	$52,501	$175,003	$262,504	$122,502	$175,003	$437,506	$52,501	$3,027,546	$29,296,233
0065-01	A	18" UPGRADES	$32,490	$29,447	$48,800	$42,408			$153,145	$4,594	$15,314	$22,972	$10,720	$15,314	$38,286	$4,594	$264,939	
	B	S LIPAN ST OUTFALL	$2,374,888	$13,454	$122,000	$344,032	$38,320		$2,892,694	$86,781	$289,269	$433,904	$202,489	$289,269	$723,174	$86,781	$5,004,361	
	C	S PECOS ST AND W ILIFF IMPROVEMENTS	$1,192,639	$176,367	$390,400	$448,876	$21,900		$2,230,182	$66,905	$223,018	$334,527	$156,113	$223,018	$557,546	$66,905	$3,858,214	
	D1	W EVANS AVE IMPROVEMENTS	$878,100	$133,158	$195,200	$390,780	$23,290		$1,620,528	$48,616	$162,053	$243,079	$113,437	$162,053	$405,132	$48,616	$2,803,514	
	D2	W EVANS AVE EXTENSION	$1,146,559	$218,203	$317,200	$611,944	$65,720		$2,359,626	$70,789	$235,963	$353,944	$165,174	$235,963	$589,906	$70,789	$4,082,154	$16,013,182

STATEMENT OF PROBABLE COSTS IN 2013 DOLLARS

PROJECT			HARD COSTS							INDIRECT COSTS							TOTALS	
COLLECTION SYSTEM	ID	PROJECT	PIPE	MANHOLE	INLETS	ASPHALT PATCH	WET UTILITY RELOCATE	DETENTION	TOTAL CONSTRUCTION COSTS	TRAFFIC CONTROL (3%)	MOBILIZATION / DEMOBILIZATION (10%)	DESIGN & ENGINEERING (15%)	MATERIALS MANAGEMENT (7%)	CONTRACT ADMINISTRATION / CONSTRUCTION MANAGEMENT (10%)	CONTINGENCY (25%)	ENVIRONMENTAL COMPLIANCE (3%)	TOTAL	TOTAL BY COLLECTION SYSTEM
0065-02	A	S BRYANT ST IMPROVEMENTS	$94,300	$9,543	$73,200	$104,960	$2,740		$284,743	$8,542	$28,474	$42,711	$19,932	$28,474	$71,186	$8,542	$492,604	$492,604
0067-01	A	S QUITMAN ST IMPROVEMENTS	$290,500	$31,810	$244,000	$334,040	$31,510		$931,860	$27,956	$93,186	$139,779	$65,230	$93,186	$232,965	$27,956	$1,612,118	
	B	W UNION AVE IMPROVEMENTS	$345,185	$80,006	$292,800	$308,064	$31,510		$1,057,565	$31,727	$105,756	$158,635	$74,030	$105,756	$264,391	$31,727	$1,829,587	$3,441,705
0067-02	A	W GRAND AVE IMPROVEMENTS	$514,559	$102,943	$268,400	$406,108	$43,830		$1,335,840	$40,075	$133,584	$200,376	$93,509	$133,584	$333,960	$40,075	$2,311,003	$2,311,003
3501-01	A	HIGHPOINT OPEN CHANNEL	$4,218,000	$21,384		$36,864	$30,100		$4,306,348	$129,190	$430,635	$645,952	$301,444	$430,635	$1,076,587	$129,190	$7,449,981	
	C	SECOND CREEK GRADE CONTROL	$5,704,591	$147,136		$153,408			$6,005,135	$180,154	$600,514	$900,770	$420,359	$600,514	$1,501,284	$180,154	$10,388,884	$17,838,865
3700-03	A	IRONDALE GULCH DETENTION - 01						$975,000	$975,000	$29,250	$97,500	$146,250	$68,250	$97,500	$243,750	$29,250	$1,686,750	
	E	POND 802 DETENTION	$2,744,592	$11,074	$24,400	$27,456		$2,475,000	$5,282,522	$158,476	$528,252	$792,378	$369,777	$528,252	$1,320,630	$158,476	$9,138,763	
	G	IRONDALE GULCH DETENTION - 06						$3,000,000	$3,000,000	$90,000	$300,000	$450,000	$210,000	$300,000	$750,000	$90,000	$5,190,000	
	H	IRONDALE GULCH DETENTION - 07						$1,725,000	$1,725,000	$51,750	$172,500	$258,750	$120,750	$172,500	$431,250	$51,750	$2,984,250	$18,999,763
3900-01	A	STAPLETON - 10						$735,000	$735,000	$22,050	$73,500	$110,250	$51,450	$73,500	$183,750	$22,050	$1,271,550	$1,271,550
3900-02	A	E 53RD AVE IMPROVEMENTS	$259,960	$27,222	$146,400	$256,080	$20,550		$710,212	$21,306	$71,021	$106,532	$49,715	$71,021	$177,553	$21,306	$1,228,666	
	B	E MAXWELL PL IMPROVEMENTS	$283,054	$27,312	$170,800	$238,392	$20,550		$740,108	$22,203	$74,011	$111,016	$51,808	$74,011	$185,027	$22,203	$1,280,387	$2,509,053
3900-04	B	E BOLLING DR IMPROVEMENTS	$5,434,368					$5,025,000	$10,459,368	$313,781	$1,045,937	$1,568,905	$732,156	$1,045,937	$2,614,842	$313,781	$18,094,707	$18,094,707
3901-01	A	18" UPGRADES	$201,585	$28,629	$219,600	$231,012	$8,220		$689,046	$20,671	$68,905	$103,357	$48,233	$68,905	$172,262	$20,671	$1,192,050	
	B	E 45TH AVE IMPROVEMENTS	$8,583,270	$402,562	$780,800	$1,732,460	$197,140		$11,696,232	$350,887	$1,169,623	$1,754,435	$818,736	$1,169,623	$2,924,058	$350,887	$20,234,481	
	C	E 47TH AVE IMPROVEMENTS	$3,407,680	$217,943	$854,000	$1,517,336	$281,930		$6,278,889	$188,367	$627,889	$941,833	$439,522	$627,889	$1,569,722	$188,367	$10,862,478	
	D	E 53RD AVE IMPROVEMENTS	$2,794,394	$224,752	$366,000	$700,984	$50,650		$4,136,780	$124,103	$413,678	$620,517	$289,575	$413,678	$1,034,195	$124,103	$7,156,629	
	E	E ALBROOK DR IMPROVEMENTS	$765,939	$218,231	$341,600	$485,656	$50,670		$1,862,096	$55,863	$186,210	$279,314	$130,347	$186,210	$465,524	$55,863	$3,221,427	
	F	E ANDREWS DR IMPROVEMENTS	$230,851	$23,843	$170,800	$209,512	$8,220		$643,226	$19,297	$64,323	$96,484	$45,026	$64,323	$160,806	$19,297	$1,112,782	$43,779,847
4000-01	A	POND ZD						$3,825,000	$3,825,000	$114,750	$382,500	$573,750	$267,750	$382,500	$956,250	$114,750	$6,617,250	$6,617,250
4300-03	A	N FEDERAL BLVD OUTFALL	$1,150,444	$179,823	$463,600	$888,280	$41,060		$2,723,207	$81,696	$272,321	$408,481	$190,624	$272,321	$680,802	$81,696	$4,711,148	
	B	CLEAR CREEK OUTFALL	$1,145,000	$62,500	$122,000	$384,720	$2,740		$1,716,960	$51,509	$171,696	$257,544	$120,187	$171,696	$429,240	$51,509	$2,970,341	$7,681,489
4400-02 *	A *	39TH AVENUE/ELM STREET IMPROVEMENTS *	$1,327,564	$213,665	$366,000	$638,320	$80,770		$2,626,319	$78,790	$262,632	$393,948	$183,842	$262,632	$656,580	$78,790	$4,543,533 *	
	B1 *	38TH AVENUE & HOLLY STREET COLLECTOR *	$3,267,603	$350,859	$610,000	$1,114,884	$110,930		$5,454,276	$163,628	$545,428	$818,141	$381,799	$545,428	$1,363,569	$163,628	$9,435,897 *	
	B2 *	38TH AVENUE & HOLLY STREET COLLECTOR EXTENSION *	$3,478,174	$392,786	$1,171,200	$2,171,764	$312,110		$7,526,034	$225,781	$752,603	$1,128,905	$526,822	$752,603	$1,881,508	$225,781	$13,020,037 *	
	C *	IVANHOE/IVY STREET COLLECTOR LATERALS *	$418,657	$112,143	$292,800	$395,768	$42,470		$1,261,838	$37,855	$126,184	$189,276	$88,329	$126,184	$315,460	$37,855	$2,182,981 *	
	D *	38TH AVENUE INTERCEPTOR *	$1,480,164	$136,238	$244,000	$514,704	$121,810		$2,496,916	$74,907	$249,692	$374,537	$174,784	$249,692	$624,229	$74,907	$4,319,664 *	
	E *	39TH AVENUE INTERCEPTOR *	$1,038,028	$166,298	$244,000	$455,772	$15,070		$1,919,168	$57,575	$191,917	$287,875	$134,342	$191,917	$479,792	$57,575	$3,320,161 *	
	F2 *	UPPER PARK HILL OUTFALL *	$2,109,558	$317,338	$878,400	$1,618,004	$169,790		$5,093,090	$152,793	$509,309	$763,964	$356,516	$509,309	$1,273,272	$152,793	$8,811,046 *	$45,633,319
4400-02-100YR (street depth criteria)	A	39TH AVENUE/ELM STREET IMPROVEMENTS	$2,253,963	$357,664	$610,000	$1,171,836	$124,600		$4,518,063	$135,542	$451,806	$677,709	$316,264	$451,806	$1,129,516	$135,542	$7,816,248	
	B1	38TH AVENUE & HOLLY STREET COLLECTOR	$5,825,517	$377,244	$610,000	$1,256,008	$143,770		$8,212,539	$246,376	$821,254	$1,231,881	$574,878	$821,254	$2,053,135	$246,376	$14,207,693	
	B2	38TH AVENUE & HOLLY STREET COLLECTOR EXTENSION	$5,517,000	$572,765	$1,171,200	$2,319,072	$338,100		$9,918,137	$297,544	$991,814	$1,487,721	$694,270	$991,814	$2,479,534	$297,544	$17,158,378	
	C	IVANHOE/IVY STREET COLLECTOR	$5,169,214	$445,096	$707,600	$1,611,296	$98,630		$8,031,836	$240,955	$803,184	$1,204,775	$562,229	$803,184	$2,007,959	$240,955	$13,895,077	
	D	38TH AVENUE INTERCEPTOR	$3,457,792	$129,169	$317,200	$595,948	$294,190		$4,794,299	$143,829	$479,430	$719,145	$335,601	$479,430	$1,198,575	$143,829	$8,294,138	
	E	39TH AVENUE INTERCEPTOR	$1,119,909	$166,298	$244,000	$464,624	$15,070		$2,009,901	$60,297	$200,990	$301,485	$140,693	$200,990	$502,475	$60,297	$3,477,128	
	F2	UPPER PARK HILL OUTFALL	$3,506,906	$428,267	$878,400	$1,756,272	$171,160		$6,741,005	$202,230	$674,100	$1,011,151	$471,870	$674,100	$1,685,251	$202,230	$11,661,937	$76,510,599
4400-03	A	STAPLETON - 04	$190,000	$37,500	$73,200	$140,000			$440,700	$13,221	$44,070	$66,105	$30,849	$44,070	$110,175	$13,221	$762,411	
	C	QUEBEC ST OUTFALL	$3,066,224	$309,520	$512,400	$746,244	$84,850		$4,719,238	$141,577	$471,924	$707,886	$330,347	$471,924	$1,179,810	$141,577	$8,164,283	$8,926,694
4400-04	A	STAPLETON - 06	$3,701,832	$20,798	$146,400	$586,544	$20,530		$4,476,104	$134,283	$447,610	$671,416	$313,327	$447,610	$1,119,026	$134,283	$7,743,659	
	C	STAPLETON - 08	$7,195,165	$431,879	$1,171,200	$2,110,984	$139,620		$11,048,848	$331,465	$1,104,885	$1,657,327	$773,419	$1,104,885	$2,762,212	$331,465	$19,114,506	$26,858,165
4401-01	A	STAPLETON - 09	$234,076	$95,425	$536,800	$262,468	$5,480		$1,134,249	$34,027	$113,425	$170,137	$79,397	$113,425	$283,562	$34,027	$1,962,249	$1,962,249
4401-02	A	E COLFAX AVE OUTFALL	$182,726	$17,470	$97,600	$173,772	$23,270		$494,838	$14,845	$49,484	$74,226	$34,639	$49,484	$123,710	$14,845	$856,071	
	B	E 17TH AVE OUTFALL	$885,630	$129,069	$244,000	$494,616	$46,560		$1,799,875	$53,996	$179,988	$269,981	$125,991	$179,988	$449,969	$53,996	$3,113,784	
	C	E RICHTHOFEN PL OUTFALL	$142,844	$13,701	$97,600	$140,712	$16,440		$411,297	$12,339	$41,130	$61,695	$28,791	$41,130	$102,824	$12,339	$711,545	$4,681,400
4401-04	A	S ALTON ST IMPROVEMENTS	$175,440	$51,266	$73,200	$80,496	$10,950		$391,352	$11,741	$39,135	$58,703	$27,395	$39,135	$97,838	$11,741	$677,040	
	B	E MISSISSIPPI AVE DETENTION						$975,000	$975,000	$29,250	$97,500	$146,250	$68,250	$97,500	$243,750	$29,250	$1,686,750	
	C	S HAVANA ST OUTFALL	$4,612,557	$332,029	$585,600	$1,177,444	$45,210		$6,752,840	$202,585	$675,284	$1,012,926	$472,699	$675,284	$1,688,210	$202,585	$11,682,413	$14,046,203
4500-01	A	E 33RD AVENUE SYSTEM	$6,603,596	$677,159	$1,561,600	$2,649,996	$238,250		$11,730,601	$351,918	$1,173,060	$1,759,590	$821,142	$1,173,060	$2,932,650	$351,918	$20,293,939	
	B	38TH STREET SYSTEM	$670,326	$151,729	$244,000	$422,604	$36,970		$1,525,629	$45,769	$152,563	$228,844	$106,794	$152,563	$381,407	$45,769	$2,639,338	
	C	40TH AVENUE SYSTEM	$3,776,509	$688,028	$1,586,000	$2,202,252	$349,030		$8,601,819	$258,055	$860,182	$1,290,273	$602,127	$860,182	$2,150,455	$258,055	$14,881,148	
	D	CITY PARK SYSTEM	$1,707,771	$336,425	$805,200	$1,154,000	$121,870	$1,425,000	$5,550,266	$166,508	$555,027	$832,540	$388,519	$555,027	$1,387,566	$166,508	$9,601,961	
	E	HIGH STREET SYSTEM	$3,560,185	$182,462	$683,200	$1,080,340	$95,860		$5,602,047	$168,061	$560,205	$840,307	$392,143	$560,205	$1,400,512	$168,061	$9,691,541	
	F	JACKSON STREET SYSTEM	$460,864	$111,476	$268,400	$365,248	$88,970		$1,294,958	$38,849	$129,496	$194,244	$90,647	$129,496	$323,740	$38,849	$2,240,279	
	G	26TH AVENUE SYSTEM	$698,371	$106,496	$390,400	$667,440	$115,000		$1,977,707	$59,331	$197,771	$296,656	$138,439	$197,771	$494,427	$59,331	$3,421,433	
	H	E 19TH AVENUE SYSTEM	$939,382	$159,671	$536,800	$774,040	$87,670		$2,497,563	$74,927	$249,756	$374,634	$174,829	$249,756	$624,391	$74,927	$4,320,783	$67,090,422
4500-02	A	MARION STREET SYSTEM PHASE 1	$1,278,377	$116,407	$195,200	$320,732	$17,810		$1,928,526	$57,856	$192,853	$289,279	$134,997	$192,853	$482,132	$57,856	$3,336,352	
	B	MARION STREET SYSTEM PHASE 2	$3,418,279	$268,204	$463,600	$921,932	$60,250		$5,132,265	$153,968	$513,226	$769,840	$359,259	$513,226	$1,283,066	$153,968	$8,878,818	
	C	E 24TH AVE SYSTEM	$1,833,195	$350,522	$878,400	$1,091,804	$135,550		$4,289,471	$128,684	$428,947	$643,421	$300,263	$428,947	$1,072,368	$128,684	$7,420,785	
	D	CITY PARK WEST DRAINAGE IMPOVEMENTS	$3,604,408	$606,882	$1,586,000	$2,137,228	$294,310		$8,228,828	$246,865	$822,883	$1,234,324	$576,018	$822,883	$2,057,207	$246,865	$14,235,873	
	E	E 12TH AVE IMPROVEMENTS	$541,395	$85,887	$658,800	$642,444	$258,620		$2,187,146	$65,614	$218,715	$328,072	$153,100	$218,715	$546,786	$65,614	$3,783,762	
	K	N MARION ST LATERALS	$409,085	$52,468	$390,400	$486,948	$61,610		$1,400,511	$42,015	$140,051	$210,077	$98,036	$140,051	$350,128	$42,015	$2,422,884	
	L	E 33RD AVE LATERALS	$2,138,526	$416,446	$1,342,000	$1,745,268	$288,870		$5,931,110	$177,933	$593,111	$889,666	$415,178	$593,111	$1,482,778	$177,933	$10,260,820	$50,339,294

STATEMENT OF PROBABLE COSTS IN 2013 DOLLARS

PROJECT			HARD COSTS							INDIRECT COSTS							TOTALS	
COLLECTION SYSTEM	ID	PROJECT	PIPE	MANHOLE	INLETS	ASPHALT PATCH	WET UTILITY RELOCATE	DETENTION	TOTAL CONSTRUCTION COSTS	TRAFFIC CONTROL (3%)	MOBILIZATION / DEMOBILIZATION (10%)	DESIGN & ENGINEERING (15%)	MATERIALS MANAGEMENT (7%)	CONTRACT ADMINISTRATION / CONSTRUCTION MANAGEMENT (10%)	CONTINGENCY (25%)	ENVIRONMENTAL COMPLIANCE (3%)	TOTAL	TOTAL BY COLLECTION SYSTEM
4500-03	A	16TH AVENUE SYSTEM	$5,210,444	$174,033	$707,600	$1,200,616	$95,870		$7,388,563	$221,657	$738,856	$1,108,284	$517,199	$738,856	$1,847,141	$221,657	$12,782,213	
	B	GLENCOE STREET SYSTEM	$6,098,457	$347,566	$976,000	$1,839,756	$239,610		$9,501,389	$285,042	$950,139	$1,425,208	$665,097	$950,139	$2,375,347	$285,042	$16,437,403	
	C	MONACO STREET SYSTEM	$4,397,399	$609,792	$1,122,400	$1,824,196	$221,820		$8,175,607	$245,268	$817,561	$1,226,341	$572,292	$817,561	$2,043,902	$245,268	$14,143,800	$43,363,416
4500-04	A	JACKSON STREET SYSTEM	$3,289,045	$199,330	$463,600	$704,712	$79,430		$4,736,117	$142,084	$473,612	$710,418	$331,528	$473,612	$1,184,029	$142,084	$8,193,484	
	B	HALE PARKWAY SYSTEM	$5,238,017	$196,732	$829,600	$1,581,312	$317,520		$8,163,181	$244,895	$816,318	$1,224,477	$571,423	$816,318	$2,040,795	$244,895	$14,122,302	
	C	8TH AVENUE SYSTEM	$4,108,167	$596,485	$1,024,800	$1,533,348	$167,080		$7,429,880	$222,896	$742,988	$1,114,482	$520,092	$742,988	$1,857,470	$222,896	$12,853,692	
	D	KRAMERIA STREET SYSTEM	$4,010,347	$688,232	$1,317,600	$2,040,592	$193,050		$8,249,821	$247,495	$824,982	$1,237,473	$577,487	$824,982	$2,062,455	$247,495	$14,272,190	
	E	GRAPE STREET SYSTEM	$3,096,322	$432,379	$805,200	$1,389,690	$268,240		$5,991,831	$179,755	$599,183	$898,775	$419,428	$599,183	$1,497,958	$179,755	$10,365,868	
	F	JACKSON STREET SYSTEM LATERALS	$1,964,269	$410,438	$1,024,800	$1,548,728	$306,610		$5,254,845	$157,645	$525,484	$788,227	$367,839	$525,484	$1,313,711	$157,645	$9,090,880	
	G	COLORADO BOULEVARD SYSTEM	$3,275,566	$619,926	$1,171,200	$1,937,004	$321,610		$7,325,306	$219,759	$732,531	$1,098,796	$512,771	$732,531	$1,831,326	$219,759	$12,672,779	$81,571,195
4600-01	A	STOUT ST OUTFALL	$2,049,040	$246,875	$1,317,600	$1,425,492	$186,210		$5,225,217	$156,757	$522,522	$783,783	$365,765	$522,522	$1,306,304	$156,757	$9,039,627	
	B	CHERRY CREEK OUTFALLS	$4,353,892	$496,419	$1,537,200	$2,079,582	$407,820		$8,874,913	$266,247	$887,491	$1,331,237	$621,244	$887,491	$2,218,728	$266,247	$15,353,598	
	C	W 14TH AVE EXTENSION	$350,954	$35,145	$244,000	$347,112	$31,490		$1,008,701	$30,261	$100,870	$151,305	$70,609	$100,870	$252,175	$30,261	$1,745,052	
	D	W 8TH AVE OUTFALL	$408,554	$78,731	$244,000	$369,576	$31,510		$1,132,371	$33,971	$113,237	$169,856	$79,266	$113,237	$283,093	$33,971	$1,959,002	
	E	W 9TH AVE OUTFALL	$907,677	$76,229	$366,000	$491,180	$43,840		$1,884,926	$56,548	$188,493	$282,739	$131,945	$188,493	$471,232	$56,548	$3,260,924	
	F	WEST COLFAX AVE OUTFALL	$2,456,051	$334,167	$1,049,200	$1,705,704	$191,690		$5,736,812	$172,104	$573,681	$860,522	$401,577	$573,681	$1,434,203	$172,104	$9,924,684	
	G	CURTIS ST OUTFALL	$2,757,458	$424,743	$1,659,200	$1,889,715	$305,250		$7,036,366	$211,091	$703,637	$1,055,455	$492,546	$703,637	$1,759,092	$211,091	$12,172,915	
	H	N BANNOCK ST IMPROVEMENTS	$454,341	$103,391	$414,800	$489,196	$43,830		$1,505,558	$45,167	$150,556	$225,834	$105,389	$150,556	$376,390	$45,167	$2,604,617	
	I	N SPEER BLVD IMPROVEMENTS	$73,910	$19,086	$146,400	$96,472	$35,580		$371,448	$11,143	$37,145	$55,717	$26,001	$37,145	$92,862	$11,143	$642,604	
	J	W 13TH AVE EXTENSION	$1,133,566	$213,875	$439,200	$554,696	$80,770		$2,422,107	$72,663	$242,211	$363,316	$169,547	$242,211	$605,527	$72,663	$4,190,245	
	L	W 11TH AVE IMPROVEMENTS	$548,392	$104,614	$292,800	$414,216	$58,870		$1,418,892	$42,567	$141,889	$212,834	$99,322	$141,889	$354,723	$42,567	$2,454,683	$63,347,951
4600-02	A	DOWNING ST OUTFALL	$1,781,347	$371,053	$1,268,800	$1,742,800	$164,280		$5,328,280	$159,848	$532,828	$799,242	$372,980	$532,828	$1,332,070	$159,848	$9,217,924	
	B	LAFAYETTE ST OUTFALL LATERALS	$336,916	$68,405	$341,600	$361,782	$49,280		$1,157,983	$34,739	$115,798	$173,697	$81,059	$115,798	$289,496	$34,739	$2,003,309	
	C	E 5TH AVE OUTFALL	$1,952,770	$313,905	$1,073,600	$1,192,748	$89,050		$4,622,073	$138,662	$462,207	$693,311	$323,545	$462,207	$1,155,518	$138,662	$7,996,185	
	D	E 6TH AVE OUTFALL	$1,015,562	$168,122	$488,000	$623,152	$58,880		$2,353,716	$70,611	$235,372	$353,057	$164,760	$235,372	$588,429	$70,611	$4,071,928	
	E	E CEDAR AVE	$274,955	$49,691	$292,800	$344,476	$39,690		$1,001,612	$30,048	$100,161	$150,242	$70,113	$100,161	$250,403	$30,048	$1,732,788	
	G	E EXPOSITION IMPROVEMENTS	$1,545,470	$323,880	$854,000	$1,237,680	$202,640		$4,163,670	$124,910	$416,367	$624,550	$291,457	$416,367	$1,040,918	$124,910	$7,203,149	
	H	COLORADO BLVD	$1,160,273	$136,169	$610,000	$806,260	$69,830		$2,782,532	$83,476	$278,253	$417,380	$194,777	$278,253	$695,633	$83,476	$4,813,780	
	I	N UNIVERSITY BLVD OUTFALL	$416,457	$148,519	$512,400	$446,528	$39,710		$1,563,614	$46,908	$156,361	$234,542	$109,453	$156,361	$390,904	$46,908	$2,705,051	
	J	5TH AVE IMPROVEMENTS	$354,548	$115,324	$317,200	$343,908	$23,290		$1,154,270	$34,628	$115,427	$173,140	$80,799	$115,427	$288,568	$34,628	$1,996,887	
	K	BAYAUD OUTFALL	$6,945,416	$254,933	$2,025,200	$2,865,820	$353,280		$12,444,649	$373,339	$1,244,465	$1,866,697	$871,125	$1,244,465	$3,111,162	$373,339	$21,529,241	
	L	18" UPGRADES	$717,290	$120,878	$927,200	$827,080	$150,540		$2,742,988	$82,290	$274,299	$411,448	$192,009	$274,299	$685,747	$82,290	$4,745,370	$68,015,612
4600-02-100YR (street depth criteria)	A	E 4TH AVE OUTFALL	$6,205,903	$530,193	$707,600	$1,299,788	$209,510		$8,952,994	$268,590	$895,299	$1,342,949	$626,710	$895,299	$2,238,248	$268,590	$15,488,679	$15,488,679
4600-03	A	E EXPOSITION AVE OUTFALL	$1,662,581	$431,294	$1,439,600	$1,710,216	$294,320		$5,538,011	$166,140	$553,801	$830,702	$387,661	$553,801	$1,384,503	$166,140	$9,580,759	
	B	S HOLLY ST OUTFALL	$385,446	$43,711	$317,200	$436,676	$27,400		$1,210,433	$36,313	$121,043	$181,565	$84,730	$121,043	$302,608	$36,313	$2,094,048	
	D	S HONEY WAY OUTFALL	$235,481	$32,787	$244,000	$270,348	$12,330		$794,946	$23,848	$79,495	$119,242	$55,646	$79,495	$198,736	$23,848	$1,375,256	
	E	E FLORIDA AVE OUTFALL	$3,418,940	$181,164	$512,400	$1,140,552	$97,190		$5,350,246	$160,507	$535,025	$802,537	$374,517	$535,025	$1,337,562	$160,507	$9,255,926	
	F	S ONEIDA ST OUTFALL	$61,380	$11,090	$73,200	$64,350	$4,110		$214,130	$6,424	$21,413	$32,120	$14,989	$21,413	$53,532	$6,424	$370,445	
	G	S VALE DR OUTFALL	$97,945	$15,905	$122,000	$127,844	$9,590		$373,284	$11,199	$37,328	$55,993	$26,130	$37,328	$93,321	$11,199	$645,782	
	H	JEWELL AVE OUTFALL	$294,589	$64,364	$268,400	$257,272	$10,960		$895,585	$26,868	$89,558	$134,338	$62,691	$89,558	$223,896	$26,868	$1,549,362	
	I	S NIAGARA ST OUTFALL	$4,320,139	$221,386	$829,600	$1,554,984	$101,310		$7,027,419	$210,823	$702,742	$1,054,113	$491,919	$702,742	$1,756,855	$210,823	$12,157,436	$37,029,014
4600-03-100YR	C	TENNESSEE & ONEIDA STORM DRAIN	$4,870,222	$100,027	$610,000	$1,154,388	$80,790		$6,815,427	$204,463	$681,543	$1,022,314	$477,080	$681,543	$1,703,857	$204,463	$11,790,690	$11,790,690
4600-04	A	18" UPGRADES	$264,385	$64,406	$488,000	$345,092	$20,550		$1,182,433	$35,473	$118,243	$177,365	$82,770	$118,243	$295,608	$35,473	$2,045,608	
	E	DARTMOUTH AVENUE OUTFALL	$874,209	$170,698	$244,000	$385,600	$10,960		$1,685,467	$50,564	$168,547	$252,820	$117,983	$168,547	$421,367	$50,564	$2,915,859	$4,961,467
4601-01	A	18" UPGRADES	$707,590	$106,674	$634,400	$750,200	$119,070		$2,317,934	$69,538	$231,793	$347,690	$162,255	$231,793	$579,484	$69,538	$4,010,025	
	B	E ILIFF AVE IMPROVEMENTS	$758,851	$142,495	$317,200	$568,036	$23,290		$1,809,872	$54,296	$180,987	$271,481	$126,691	$180,987	$452,468	$54,296	$3,131,078	
	C	S MONACO STREET PKWY IMPROVEMENTS	$229,274	$23,802	$146,400	$225,852	$2,740		$628,068	$18,842	$62,807	$94,210	$43,965	$62,807	$157,017	$18,842	$1,086,558	
	D	S TAMARAC DR IMPROVEMENTS	$784,661	$111,359	$317,200	$462,304	$90,350		$1,765,874	$52,976	$176,587	$264,881	$123,611	$176,587	$441,468	$52,976	$3,054,960	
	E	E DARTMOUTH AVE IMPROVEMENTS	$216,369	$69,101	$73,200	$125,556	$12,330		$496,556	$14,897	$49,656	$74,483	$34,759	$49,656	$124,139	$14,897	$859,043	$12,141,664
4700-01	B	N WOLFF ST OUTFALL	$29,640	$3,181	$24,400	$38,688	$4,110		$100,019	$3,001	$10,002	$15,003	$7,001	$10,002	$25,005	$3,001	$173,034	
	C1 *	W 16TH AVE IMPROVEMENTS *	$1,761,757	$68,068	$414,800	$772,956	$116,390		$3,133,971	$94,019	$313,397	$470,096	$219,378	$313,397	$783,493	$94,019	$5,421,770 *	
	C2	W 17TH & 18TH AVE IMPROVEMENTS	$165,775	$25,448	$195,200	$216,380	$31,490		$634,293	$19,029	$63,429	$95,144	$44,401	$63,429	$158,573	$19,029	$1,097,327	
	D *	W COLFAX AVE IMPROVEMENTS *	$3,129,472	$83,400	$341,600	$770,800	$53,410		$4,378,682	$131,360	$437,868	$656,802	$306,508	$437,868	$1,094,670	$131,360	$7,575,118 *	
	E	W LAKESHORE DR IMPROVEMENTS	$354,395	$38,172	$292,800	$414,544	$17,810		$1,117,721	$33,532	$111,772	$167,658	$78,240	$111,772	$279,430	$33,532	$1,933,657	
	F	W 26TH AVE IMPROVEMENTS	$68,080	$32,628	$73,200	$75,776	$2,740		$252,424	$7,573	$25,242	$37,864	$17,670	$25,242	$63,106	$7,573	$436,694	$16,637,600
4700-01-100YR	A	SLOAN'S LAKE 100-YR OUTFALL	$6,635,379	$82,232	$488,000	$1,240,688	$125,980		$8,572,279	$257,168	$857,228	$1,285,842	$600,060	$857,228	$2,143,070	$257,168	$14,830,043	$14,830,043
4800-01	A	N STUART ST IMPROVEMENTS	$640,596	$79,892	$122,000	$253,008	$41,060		$1,136,556	$34,097	$113,656	$170,483	$79,559	$113,656	$284,139	$34,097	$1,966,243	
	C	18" UPGRADES	$478,030	$96,664	$707,600	$559,736	$160,110		$2,002,140	$60,064	$200,214	$300,321	$140,150	$200,214	$500,535	$60,064	$3,463,702	
	D	N WOLFF ST IMPROVEMENTS	$863,984	$110,056	$317,200	$467,368	$71,200		$1,829,808	$54,894	$182,981	$274,471	$128,087	$182,981	$457,452	$54,894	$3,165,568	$8,595,513
4900-01	A	N YATES ST IMPROVEMENTS	$186,195	$45,352	$170,800	$213,324	$13,700		$629,371	$18,881	$62,937	$94,406	$44,056	$62,937	$157,343	$18,881	$1,088,812	
	B	S JULIAN ST OUTFALL	$510,568	$103,320	$244,000	$393,008	$42,450		$1,293,346	$38,800	$129,335	$194,002	$90,534	$129,335	$323,336	$38,800	$2,237,488	
	E	W EXPOSITION AVE IMPROVEMENTS	$110,535	$14,109	$97,600	$133,512	$16,440		$372,196	$11,166	$37,220	$55,829	$26,054	$37,220	$93,049	$11,166	$643,900	
	F	W 1ST AVE OUTFALL	$193,206	$19,187	$122,000	$203,832	$27,380		$565,605	$16,968	$56,560	$84,841	$39,592	$56,560	$141,401	$16,968	$978,495	$4,948,695

STATEMENT OF PROBABLE COSTS IN 2013 DOLLARS

PROJECT			HARD COSTS							INDIRECT COSTS							TOTALS	
COLLECTION SYSTEM	ID	PROJECT	PIPE	MANHOLE	INLETS	ASPHALT PATCH	WET UTILITY RELOCATE	DETENTION	TOTAL CONSTRUCTION COSTS	TRAFFIC CONTROL (3%)	MOBILIZATION / DEMOBILIZATION (10%)	DESIGN & ENGINEERING (15%)	MATERIALS MANAGEMENT (7%)	CONTRACT ADMINISTRATION / CONSTRUCTION MANAGEMENT (10%)	CONTINGENCY (25%)	ENVIRONMENTAL COMPLIANCE (3%)	TOTAL	TOTAL BY COLLECTION SYSTEM
5000-01	A	18" UPGRADES	$1,137,110	$248,274	$1,366,400	$1,349,368	$109,580		$4,210,732	$126,322	$421,073	$631,610	$294,751	$421,073	$1,052,683	$126,322	$7,284,566	
	B	CENTER AVE COLLECTION	$1,978,354	$9,000	$122,000		$31,510		$2,140,864	$64,226	$214,086	$321,130	$149,860	$214,086	$535,216	$64,226	$3,703,694	
	D	ALAMEDA AND SANTA FE OUTFALL	$116,279	$23,016	$146,400	$120,840	$2,740		$409,275	$12,278	$40,928	$61,391	$28,649	$40,928	$102,319	$12,278	$708,046	
	E	S GRANT ST COLLECTION	$278,900	$23,802	$146,400	$264,076	$12,330		$725,508	$21,765	$72,551	$108,826	$50,786	$72,551	$181,377	$21,765	$1,255,129	
	F	SOUTH BROADWAY IMPROVEMENTS	$1,487,074	$215,415	$536,800	$727,056	$56,170	$150,000	$3,172,515	$95,175	$317,252	$475,877	$222,076	$317,252	$793,129	$95,175	$5,488,451	$18,439,886
5000-02	A	DAHLIA ST AND ASBURY AVENUE	$606,333	$92,170	$463,600	$614,776	$46,580		$1,823,459	$54,704	$182,346	$273,519	$127,642	$182,346	$455,865	$54,704	$3,154,585	
	B	MEXICO AVENUE	$206,785	$28,034	$219,600	$242,012	$27,400		$723,831	$21,715	$72,383	$108,575	$50,668	$72,383	$180,958	$21,715	$1,252,228	
	C	SOUTH HIGH SCHOOL DETENTION	$4,448,351	$182,933	$292,800	$435,852	$42,450	$1,125,000	$6,527,386	$195,822	$652,739	$979,108	$456,917	$652,739	$1,631,846	$195,822	$11,292,379	
	D	18" UPGRADES	$248,900	$67,619	$341,600	$324,880	$98,540		$1,081,539	$32,446	$108,154	$162,231	$75,708	$108,154	$270,385	$32,446	$1,871,063	$17,570,255
5000-03	B	E IOWA AVENUE EXTENSION	$110,885	$9,543	$73,200	$128,752	$27,380		$349,760	$10,493	$34,976	$52,464	$24,483	$34,976	$87,440	$10,493	$605,085	
	C	E MISSISSIPPI AVENUE - S LOGAN STREET LATERAL	$446,612	$61,969	$244,000	$403,660	$19,180		$1,175,421	$35,263	$117,542	$176,313	$82,279	$117,542	$293,855	$35,263	$2,033,478	
	D	18" UPGRADES	$151,145	$39,744	$292,800	$197,284	$47,910		$728,883	$21,866	$72,888	$109,332	$51,022	$72,888	$182,221	$21,866	$1,260,966	
	E	SUB-BASIN 600 IMPROVEMENTS	$143,980	$7,369					$151,349	$4,540	$15,135	$22,702	$10,594	$15,135	$37,837	$4,540	$261,832	
	G	S WASHINGTON ST DRAIN (100 YEAR ONLY)	$2,207,800	$253,798	$414,800	$671,700	$50,690		$3,598,788	$107,964	$359,879	$539,818	$251,915	$359,879	$899,697	$107,964	$6,225,904	$10,387,265
5100-01	A	18" UPGRADES	$616,360	$166,290	$1,073,600	$804,512	$35,620		$2,696,382	$80,891	$269,638	$404,457	$188,747	$269,638	$674,096	$80,891	$4,664,740	
	B	S CARLAN ST OUTFALL	$964,866	$166,286	$390,400	$599,968	$46,580		$2,168,100	$65,043	$216,810	$325,215	$151,767	$216,810	$542,025	$65,043	$3,750,813	
	C	S DECATUR ST OUTFALL	$564,637	$46,848	$292,800	$533,464	$56,170		$1,493,919	$44,818	$149,392	$224,088	$104,574	$149,392	$373,480	$44,818	$2,584,481	
	D	S FEDERAL BLVD OUTFALL	$811,132	$122,812	$292,800	$562,168	$86,250		$1,875,162	$56,255	$187,516	$281,274	$131,261	$187,516	$468,790	$56,255	$3,244,029	
	E	W MISSISSIPPI AVE IMPROVEMENTS	$3,510,125	$407,250	$805,200	$1,700,204	$197,120		$6,619,899	$198,597	$661,990	$992,985	$463,393	$661,990	$1,654,975	$198,597	$11,452,426	
	F	S QUITMAN ST IMPROVEMENTS	$115,920	$23,053	$170,800	$129,024	$23,290		$462,087	$13,863	$46,209	$69,313	$32,346	$46,209	$115,522	$13,863	$799,412	
	G	S TEJON ST OUTFALL	$269,652	$50,326	$97,600	$190,992	$12,330		$620,900	$18,627	$62,090	$93,135	$43,463	$62,090	$155,225	$18,627	$1,074,157	
	H	S TENNYSON ST IMPROVEMENTS	$3,258,686	$117,970	$1,000,400	$1,656,544	$165,710		$6,199,310	$185,979	$619,931	$929,896	$433,952	$619,931	$1,549,828	$185,979	$10,724,806	
	I	S UTICA OUTFALL	$943,145	$48,076	$219,600	$518,048	$52,020		$1,780,889	$53,427	$178,089	$267,133	$124,662	$178,089	$445,222	$53,427	$3,080,938	
	J	S VRAIN ST OUTFALL	$608,035	$118,101	$512,400	$721,464	$39,730		$1,999,730	$59,992	$199,973	$299,960	$139,981	$199,973	$499,932	$59,992	$3,459,533	
	K	S XAVIER ST OUTFALL	$236,814	$25,549	$170,800	$279,028	$26,030		$738,221	$22,147	$73,822	$110,733	$51,675	$73,822	$184,555	$22,147	$1,277,122	
	L	W JEWELL AVE IMPROVEMENTS	$972,034	$177,157	$244,000	$456,512	$78,010		$1,927,713	$57,831	$192,771	$289,157	$134,940	$192,771	$481,928	$57,831	$3,334,942	
	M	W KENTUCKY AVE IMPROVEMENTS	$1,131,410	$201,927	$439,200	$828,120	$53,430		$2,654,087	$79,623	$265,409	$398,113	$185,786	$265,409	$663,522	$79,623	$4,591,572	
	N	HARVEY PARK LAKE OUTFALL	$274,144			$226,380	$13,700		$514,224	$15,427	$51,422	$77,134	$35,996	$51,422	$128,556	$15,427	$889,608	
	O *	MISSISSIPPI GULCH INTERCEPTOR *	$3,681,452	$12,626	$122,000		$16,440		$3,832,518	$114,976	$383,252	$574,878	$268,276	$383,252	$958,130	$114,976	$6,630,258 *	$61,558,837
5100-01-100YR	A *	W MISSISSIPPI AVE LATERALS *	$1,151,182	$290,598	$512,400	$825,880	$113,610		$2,893,670	$86,810	$289,367	$434,050	$202,557	$289,367	$723,418	$86,810	$5,006,049 *	
	B *	W MISSISSIPPI AVE IMPROVEMENTS *	$3,689,526	$247,567	$390,400	$1,313,600	$171,090		$5,812,183	$174,365	$581,218	$871,827	$406,853	$581,218	$1,453,046	$174,365	$10,055,075 *	
	O	MISSISSIPPI GULCH INTERCEPTOR	$3,681,452	$12,626	$122,000		$16,440		$3,832,518	$114,976	$383,252	$574,878	$268,276	$383,252	$958,130	$114,976	$6,630,258	$21,691,382
5200-01	B	E WARREN AVE EXTENSION	$354,306	$44,835	$170,800	$258,288	$23,290		$851,519	$25,546	$85,152	$127,728	$59,606	$85,152	$212,880	$25,546	$1,473,129	
	E	BROADWAY RELIEF, WESLEY TO HARVARD (100-YEAR ONLY)	$551,230	$7,200	$97,600	$159,200	$15,070		$830,300	$24,909	$83,030	$124,545	$58,121	$83,030	$207,575	$24,909	$1,436,419	
	F	DELAWARE TRIBUTARY (SOUTH OF EVANS)	$174,470	$18,263	$122,000	$175,416	$32,860		$523,009	$15,690	$52,301	$78,451	$36,611	$52,301	$130,752	$15,690	$904,805	
	G	DELAWARE TRIBUTARY (SOUTH OF HARVARD)	$300,958	$86,000	$195,200	$229,012	$15,070		$826,240	$24,787	$82,624	$123,936	$57,837	$82,624	$206,560	$24,787	$1,429,395	
	I	EVANS OUTFALL	$215,954	$67,392	$97,600	$147,532	$27,380		$555,858	$16,676	$55,586	$83,379	$38,910	$55,586	$138,964	$16,676	$961,635	
	J	EVANS TRIBUTARY (EAST OF BROADWAY)	$754,811	$75,785	$366,000	$663,236	$75,330		$1,935,162	$58,055	$193,516	$290,274	$135,461	$193,516	$483,790	$58,055	$3,347,829	
	K	GALAPAGO TRIBUTARY (SOUTH OF EVANS)	$128,653	$11,115	$73,200	$132,016	$15,050		$360,034	$10,801	$36,003	$54,005	$25,202	$36,003	$90,008	$10,801	$622,857	
	M	GALAPAGO TRIBUTARY (SOUTH OF WESLEY)	$206,795	$14,524	$122,000	$105,856	$2,740		$451,915	$13,557	$45,192	$67,787	$31,634	$45,192	$112,979	$13,557	$781,813	
	O	HARVARD GULCH OUTFALL PRELIMINARY REPORT	$12,220,960	$55,481	$414,800	$47,456	$83,570		$12,822,267	$384,668	$1,282,227	$1,923,340	$897,559	$1,282,227	$3,205,567	$384,668	$22,182,523	
	P	ROSEDALE PARK DETENTION						$1,447,500	$1,447,500	$43,425	$144,750	$217,125	$101,325	$144,750	$361,875	$43,425	$2,504,175	$35,644,580
5200-02	A	COLUMBINE OUTFALL	$22,230	$4,064	$24,400	$29,016	$5,480		$85,190	$2,556	$8,519	$12,778	$5,963	$8,519	$21,298	$2,556	$147,379	
	B	CORNELL TRIBUTARY (FLOWS TO ENGLEWOOD)	$89,635	$12,724	$97,600	$109,592	$8,220		$317,771	$9,533	$31,777	$47,666	$22,244	$31,777	$79,443	$9,533	$549,744	
	C	DARTMOUTH TRIBUTARY (FLOWS TO ENGLEWOOD)	$54,085	$9,543	$73,200	$64,892	$27,360		$229,080	$6,872	$22,908	$34,362	$16,036	$22,908	$57,270	$6,872	$396,308	
	D	DRY GULCH MAJOR CONDUIT	$2,283,168	$23,859	$195,200	$365,568	$30,120		$2,897,915	$86,937	$289,792	$434,687	$202,854	$289,792	$724,479	$86,937	$5,013,393	
	E	FLORA TRIBUTARY (FLOWS TO ENGLEWOOD)	$314,102	$42,102	$292,800	$341,592	$52,020		$1,042,616	$31,278	$104,262	$156,392	$72,983	$104,262	$260,654	$31,278	$1,803,725	
	G	GAYLORD OUTFALL (NORTH OF HARVARD GULCH)	$50,025	$7,747	$48,800	$55,680	$4,110		$166,362	$4,991	$16,636	$24,954	$11,645	$16,636	$41,590	$4,991	$287,805	
	I	HARVARD GULCH PARK TO RACE	$12,279,540	$54,676	$439,200		$60,260		$12,833,676	$385,010	$1,283,368	$1,925,051	$898,357	$1,283,368	$3,208,419	$385,010	$22,202,259	
	J	CORONA OUTFALL	$178,366	$26,234	$195,200	$210,568	$9,590		$619,958	$18,599	$61,996	$92,994	$43,397	$61,996	$154,990	$18,599	$1,072,529	
	K	JOSEPHINE OUTFALL	$17,290	$4,064	$24,400	$22,568	$5,480		$73,802	$2,214	$7,380	$11,070	$5,166	$7,380	$18,450	$2,214	$127,676	
	L	LAFAYETTE OUTFALL (NORTH OF HARVARD)	$767,824	$233,894	$439,200	$474,440	$62,990		$1,978,348	$59,350	$197,835	$296,752	$138,484	$197,835	$494,587	$59,350	$3,422,541	
	M	LAFAYETTE OUTFALL (SOUTH OF HARVARD)	$60,135	$9,543	$73,200	$78,492	$1,370		$222,740	$6,682	$22,274	$33,411	$15,592	$22,274	$55,685	$6,682	$385,340	
	N	PENNSYLVANIA OUTFALL	$22,310	$1,385		$24,832	$4,110		$52,637	$1,579	$5,264	$7,896	$3,685	$5,264	$13,159	$1,579	$91,063	
	O	RACE OUTFALL	$71,085	$9,543	$73,200	$84,672	$5,480		$243,980	$7,319	$24,398	$36,597	$17,079	$24,398	$60,995	$7,319	$422,085	
	P	UNIVERSITY OUTFALL (NORTH OF HARVARD GULCH)	$375,118	$91,602	$292,800	$325,717	$23,290		$1,108,527	$33,256	$110,853	$166,279	$77,597	$110,853	$277,132	$33,256	$1,917,753	
	S	WILLIAMS OUTFALL	$62,700	$9,543	$73,200	$81,840	$6,850		$234,133	$7,024	$23,413	$35,120	$16,389	$23,413	$58,533	$7,024	$405,049	
	T	YORK OUTFALL	$138,032	$19,187	$122,000	$152,872	$6,850		$438,941	$13,168	$43,894	$65,841	$30,726	$43,894	$109,735	$13,168	$759,367	$39,004,016

STATEMENT OF PROBABLE COSTS IN 2013 DOLLARS

PROJECT			HARD COSTS							INDIRECT COSTS							TOTALS	
COLLECTION SYSTEM	ID	PROJECT	PIPE	MANHOLE	INLETS	ASPHALT PATCH	WET UTILITY RELOCATE	DETENTION	TOTAL CONSTRUCTION COSTS	TRAFFIC CONTROL (3%)	MOBILIZATION / DEMOBILIZATION (10%)	DESIGN & ENGINEERING (15%)	MATERIALS MANAGEMENT (7%)	CONTRACT ADMINISTRATION / CONSTRUCTION MANAGEMENT (10%)	CONTINGENCY (25%)	ENVIRONMENTAL COMPLIANCE (3%)	TOTAL	TOTAL BY COLLECTION SYSTEM
5200-03	A	AMHERST OUTFALL	$154,904	$19,835	$122,000	$152,592	$12,330		$461,661	$13,850	$46,166	$69,249	$32,316	$46,166	$115,415	$13,850	$798,673	
	AA	STEELE OUTFALL	$147,160	$23,940	$146,400	$149,820	$12,330		$479,650	$14,390	$47,965	$71,948	$33,576	$47,965	$119,912	$14,390	$829,796	
	B	BIRCH OUTFALL	$395,771	$72,417	$292,800	$334,320	$30,140		$1,125,448	$33,763	$112,545	$168,817	$78,781	$112,545	$281,362	$33,763	$1,947,024	
	BB	YALE OUTFALL (COLORADO TO BIRCH)	$1,169,003	$12,600	$170,800	$201,724	$36,970		$1,591,097	$47,733	$159,110	$238,665	$111,377	$159,110	$397,774	$47,733	$2,752,599	
	C	CLAYTON OUTFALL (SOUTH OF HARVARD GULCH)	$694,975	$123,774	$414,800	$513,364	$102,690		$1,849,603	$55,488	$184,960	$277,440	$129,472	$184,960	$462,401	$55,488	$3,199,812	
	CC	YALE OUTFALL (BIRCH TO CLERMONT)	$251,241	$1,800	$24,400	$46,812	$6,850		$331,103	$9,933	$33,110	$49,665	$23,177	$33,110	$82,776	$9,933	$572,807	
	D	CLAYTON TRIBUTARY (SOUTH OF AMHERST)	$347,450	$125,390	$292,800	$304,888	$34,240		$1,104,768	$33,143	$110,477	$165,715	$77,334	$110,477	$276,192	$33,143	$1,911,249	
	DD	YALE OUTFALL (CLERMONT TO BROOK)	$397,546			$74,072			$471,618	$14,149	$47,162	$70,743	$33,013	$47,162	$117,904	$14,149	$815,900	
	E	CLERMONT OUTFALL	$1,059,516	$216,975	$683,200	$829,084	$64,390		$2,853,165	$85,595	$285,316	$427,975	$199,722	$285,316	$713,291	$85,595	$4,935,975	
	EE	YALE OUTFALL (BROOK TO DENNISON)	$383,420	$3,600	$48,800	$71,440	$8,220		$515,480	$15,464	$51,548	$77,322	$36,084	$51,548	$128,870	$15,464	$891,780	
	F	COLORADO OUTFALL (NORTH OF HARVARD GULCH)	$1,700,623	$315,767	$658,800	$936,848	$113,630		$3,725,668	$111,770	$372,567	$558,850	$260,797	$372,567	$931,417	$111,770	$6,445,406	
	FF	YALE OUTFALL (DENNISON TO DAHLIA)	$477,596	$3,600	$48,800	$95,312	$5,480		$630,788	$18,924	$63,079	$94,618	$44,155	$63,079	$157,697	$18,924	$1,091,264	
	G	COLORADO OUTFALL (SOUTH OF HARVARD GULCH)	$612,094	$62,760	$439,200	$637,180	$83,510		$1,834,744	$55,042	$183,474	$275,212	$128,432	$183,474	$458,686	$55,042	$3,174,106	
	GG	YALE OUTFALL (DAHLIA TO EUDORA)	$348,218	$28,066	$48,800	$81,720	$10,960		$517,764	$15,533	$51,776	$77,665	$36,243	$51,776	$129,441	$15,533	$895,731	
	H	COOK OUTFALL	$477,395	$130,525	$195,200	$270,904	$60,220		$1,134,244	$34,027	$113,424	$170,137	$79,397	$113,424	$283,561	$34,027	$1,962,241	
	I	DAHLIA OUTFALL	$235,174	$27,769	$170,800	$220,720	$15,070		$669,533	$20,086	$66,953	$100,430	$46,867	$66,953	$167,383	$20,086	$1,158,291	
	II	YALE OUTFALL (GLENCOE TO HUDSON)	$392,083	$80,233	$146,400	$183,852	$10,960		$813,528	$24,406	$81,353	$122,029	$56,947	$81,353	$203,382	$24,406	$1,407,404	
	J	DARTMOUTH TRIBUTARY	$611,283	$87,385	$610,000	$634,724	$69,830		$2,013,222	$60,397	$201,322	$301,983	$140,926	$201,322	$503,306	$60,397	$3,482,875	
	K	ADAMS WAY IMPROVEMENTS	$95,006	$15,868	$97,600	$93,588	$1,370		$303,432	$9,103	$30,343	$45,515	$21,240	$30,343	$75,858	$9,103	$524,937	
	L	DENNISON OUTFALL	$124,939	$18,263	$122,000	$130,300	$8,220		$403,722	$12,112	$40,372	$60,558	$28,261	$40,372	$100,930	$12,112	$698,439	
	M	EASTMAN TRIBUTARY (EAST OF FOREST)	$1,218,909	$324,171	$707,600	$776,930	$117,820		$3,145,430	$94,363	$314,543	$471,814	$220,180	$314,543	$786,358	$94,363	$5,441,594	
	N	EUDORA OUTFALL	$2,051,521	$206,910	$488,000	$838,816	$73,980		$3,659,227	$109,777	$365,923	$548,884	$256,146	$365,923	$914,807	$109,777	$6,330,464	
	P	GLENCOE OUTFALL (SOUTH OF YALE)	$278,478	$35,703	$219,600	$258,416	$31,510		$823,707	$24,711	$82,371	$123,556	$57,659	$82,371	$205,927	$24,711	$1,425,013	
	Q	GLENCOE TRIBUTARY (SOUTH OF HIGHLINE CANAL)	$833,492	$208,295	$439,200	$620,524	$76,680		$2,178,191	$65,346	$217,819	$326,729	$152,473	$217,819	$544,548	$65,346	$3,768,271	
	U	JACKSON OUTFALL (NORTH OF HARVARD GULCH)	$108,445	$14,109	$97,600	$120,704	$4,110		$344,968	$10,349	$34,497	$51,745	$24,148	$34,497	$86,242	$10,349	$596,795	
	V	JACKSON OUTFALL (SOUTH OF HARVARD GULCH)	$68,885	$7,747	$48,800	$76,672	$6,850		$208,954	$6,269	$20,895	$31,343	$14,627	$20,895	$52,238	$6,269	$361,490	
	W	MANSFIELD TRIBUTARY (FLOWS TO CHERRY HILLS VILLAGE)	$157,864	$32,559	$219,600	$164,632	$23,290		$597,945	$17,938	$59,794	$89,692	$41,856	$59,794	$149,486	$17,938	$1,034,443	
	X	MONROE OUTFALL	$102,037	$16,006	$97,600	$105,032	$10,960		$331,635	$9,949	$33,164	$49,745	$23,214	$33,164	$82,909	$9,949	$573,729	$59,028,108
5300-01	A	18" UPGRADES	$24,890	$29,447	$48,800	$32,488			$135,625	$4,069	$13,562	$20,344	$9,494	$13,562	$33,906	$4,069	$234,631	
	B	S FEDERAL BLVD IMPROVEMENTS	$515,287	$157,981	$341,600	$449,000	$38,320		$1,502,188	$45,066	$150,219	$225,328	$105,153	$150,219	$375,547	$45,066	$2,598,786	
	C	S ZUNI ST OUTFALL	$1,144,235	$234,102	$634,400	$1,014,480	$49,320		$3,076,537	$92,296	$307,654	$461,481	$215,358	$307,654	$769,134	$92,296	$5,322,410	$8,155,827
5500-01	A	18" UPGRADES	$230,565	$38,172	$292,800	$300,948	$15,070		$877,555	$26,327	$87,756	$131,633	$61,429	$87,756	$219,389	$26,327	$1,518,172	
	B	S KNOX CT UPGRADE	$110,834	$57,638	$48,800	$55,784	$2,740		$275,796	$8,274	$27,580	$41,369	$19,306	$27,580	$68,949	$8,274	$477,128	
	C	S UTICA ST IMPROVEMENTS	$416,480	$72,483	$73,200	$168,844	$32,860		$763,867	$22,916	$76,387	$114,580	$53,471	$76,387	$190,967	$22,916	$1,321,491	
	D	W AMHERST AVE IMPROVEMENTS	$447,450	$60,439	$463,600	$584,040	$69,850		$1,625,379	$48,761	$162,538	$243,807	$113,777	$162,538	$406,345	$48,761	$2,811,906	
	F	VRAIN ST IMPROVEMENTS	$248,330	$106,570	$122,000	$182,980	$79,360		$739,240	$22,177	$73,924	$110,886	$51,747	$73,924	$184,810	$22,177	$1,278,885	$7,407,582
5500-02	A	18" UPGRADES	$107,730	$28,629	$219,600	$140,616	$2,740		$499,315	$14,979	$49,932	$74,897	$34,952	$49,932	$124,829	$14,979	$863,815	
	B	S NEWLAND ST OUTFALL	$513,691	$53,996	$341,600	$467,596	$46,580		$1,423,463	$42,704	$142,346	$213,519	$99,642	$142,346	$355,866	$42,704	$2,462,590	
	C	S SHERIDAN BLVD OUTFALL	$1,116,389	$153,237	$585,600	$949,640	$86,230		$2,891,096	$86,733	$289,110	$433,664	$202,377	$289,110	$722,774	$86,733	$5,001,597	
	D	S WEBSTER ST OUTFALL	$1,211,210	$53,548	$366,000	$485,360	$52,020		$2,168,138	$65,044	$216,814	$325,221	$151,770	$216,814	$542,034	$65,044	$3,750,879	
	E	W BATES AVE IMPROVEMENTS	$147,935	$48,533	$195,200	$174,382	$9,590		$575,640	$17,269	$57,564	$86,346	$40,295	$57,564	$143,910	$17,269	$995,857	
	F	W DARTMOUTH AVE IMPROVEMENTS	$44,965	$6,362	$48,800	$50,048	$6,850		$157,025	$4,711	$15,702	$23,554	$10,992	$15,702	$39,256	$4,711	$271,653	$13,346,391
5500-04	A	S WADSWORTH WAY IMPROVEMENTS	$514,608	$84,506	$146,400	$259,008	$31,470		$1,035,992	$31,080	$103,599	$155,399	$72,519	$103,599	$258,998	$31,080	$1,792,266	
	B	GLENBROOK DETENTION BASIN & S GARRISON ST IMPROVEMENTS	$402,876	$286,430	$390,400	$272,928	$23,290		$1,375,924	$41,278	$137,592	$206,389	$96,315	$137,592	$343,981	$41,278	$2,380,349	$4,172,615
5500-05	A	FOOTHILLS GC IMPROVEMENTS	$1,055,777	$15,905	$122,000	$140,740	$1,370		$1,335,792	$40,074	$133,579	$200,369	$93,505	$133,579	$333,948	$40,074	$2,310,920	
	B	FOOTHILLS GC IMPROVEMENTS - 01						$45,000	$45,000	$1,350	$4,500	$6,750	$3,150	$4,500	$11,250	$1,350	$77,850	
	C	FOOTHILLS GC IMPROVEMENTS - 02						$90,000	$90,000	$2,700	$9,000	$13,500	$6,300	$9,000	$22,500	$2,700	$155,700	
	D	S HARLAN ST DETENTION - 01						$30,000	$30,000	$900	$3,000	$4,500	$2,100	$3,000	$7,500	$900	$51,900	
	E	S HARLAN ST DETENTION - 02						$45,000	$45,000	$1,350	$4,500	$6,750	$3,150	$4,500	$11,250	$1,350	$77,850	
	F	S HARLAN ST DETENTION - 03						$150,000	$150,000	$4,500	$15,000	$22,500	$10,500	$15,000	$37,500	$4,500	$259,500	
	G	S PIERCE WAY DETENTION						$315,000	$315,000	$9,450	$31,500	$47,250	$22,050	$31,500	$78,750	$9,450	$544,950	$3,478,670

* Projects shown with an asterisk are excluded from the Recommended Plan in favor of the Alternative shown for that collection system

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Collection System	Page
0058-01	35
0059-01	37
0060-01	39
0060-02	43
0061-01	45
0061-02	47
0062-01	51
0063-01	53
0064-01	55
0064-02	57
0065-01	59
0065-02	61
0067-01	63
0067-02	65
0067-03	67
3501-01	69
3700-01	71
3700-02	73
3700-03	75
3702-01	77
3900-01	79
3900-02	81
3900-03	83
3900-04	85
3901-01	87
3901-02	89
4000-01	91
4300-03	93
4309-01	95
4400-01	97
4400-02	99
4400-03	103
4400-04	105
4401-01	107
4401-02	109
4401-03	111
4401-04	113
4500-01	115
4500-02	121
4500-03	117
4500-04	119
4600-01	123
4600-02	125
4600-03	129
4600-04	133
4601-01	137
4601-02	139
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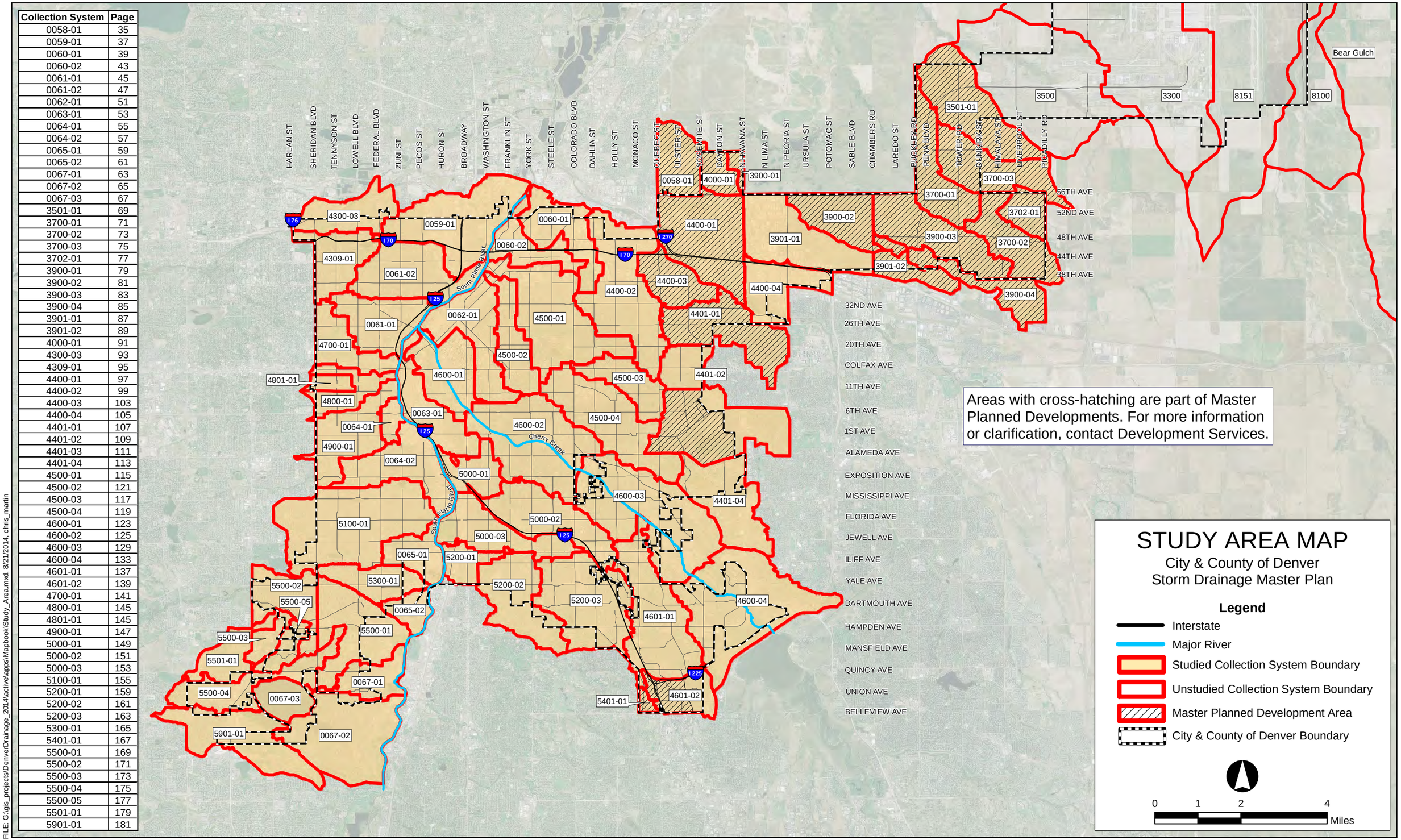

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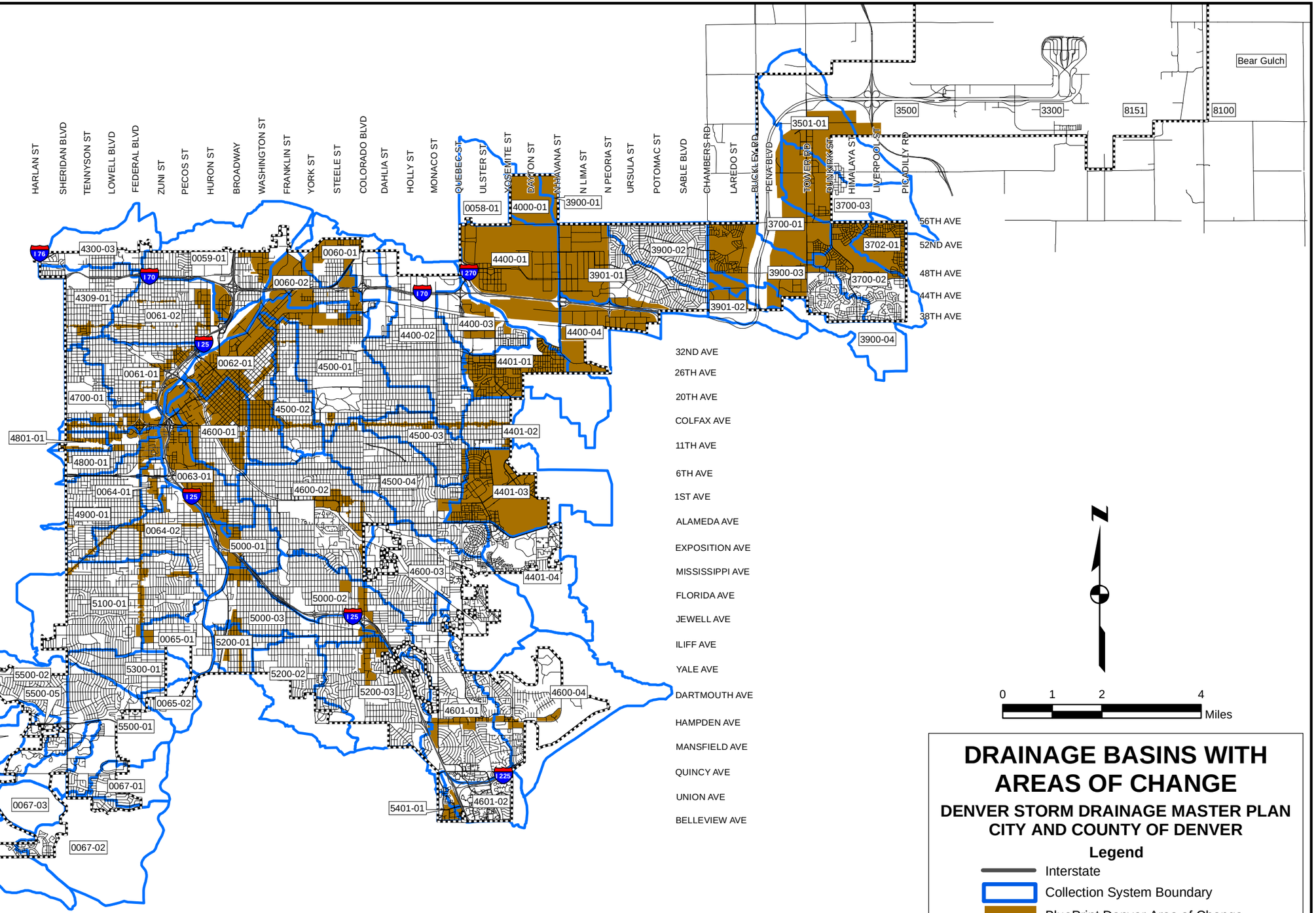

DRAINAGE BASINS WITH AREAS OF CHANGE

DENVER STORM DRAINAGE MASTER PLAN
CITY AND COUNTY OF DENVER

Legend

- Interstate
- Collection System Boundary
- BluePrint Denver Area of Change
- City & County of Denver Boundary

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Basin 0058-01 (Prairie Gateway)

Existing Basin Description:

This collection system 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 drains 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 basins 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 basins with approximately 225 acre-feet of retention storage for the 100-year, 24 hour storm event. By agreement, these retention basins discharge into the Rocky Mountain Arsenal between storms by controlled releases.

Key Map

S Platte River
I-70
Sand Creek
Cherry Creek
I-25

QUEBEC PKWY
69TH AVE
67TH AVE
64TH AVE
63RD AVE
62ND AVE
59TH AVE
58TH AVE
E 56TH AVE
E 64TH AVE
E 60TH AVE
E 59TH PL
E 57TH PL
E 56TH AVE
PRAIRIE PKWY
GATEWAY RD
QUEBEC ST
SYRACUSE ST
VICTORIA WAY
VALENTIA ST
TRENTON ST
CHAMBERS ST
N ROSLYN ST
N WABASH ST
N VALENTIA ST

48 AF
178 AF

Commerce City
Adams County
Adams County

Ladora Lake
Southgate Pond

3900-01
4000-01
4400-01
3901-01

270

N
0 650 1,300
Feet
1 inch equals 1,300 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
- Significant Flooding Location
- Proposed Detention Basin
- Existing Basin
- Potential Inundation Area
- Planned Transit Line
- Existing Transit Line
- City and County Boundary
- Other Municipalities
- Other Counties

Basin 0058-01
Prairie Gateway

Denver Storm Drainage Master Plan

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Basin 0059-01 (Globeville - Utah Junction)

Existing System Description:

This collection system basin consists of 2,602 acres (4.07 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. 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:

Drainage and flooding problems in the Globeville – Utah Junction watershed are primarily caused by undersized infrastructure and a lack of drainage infrastructure. The existing drainage systems are typically undersized for the 2-year event. The 2013 ***Globeville – Utah Junction Outfall Systems Planning Study***, by CHM2Hill for the UDFCD, provides additional detail on drainage deficiencies throughout the basin. The OSP documented that the minor storm collection system for the western portion of the basin is the watershed north of I-70. However, the OSP also confirmed that in larger storm events inflow from the Sunnyside Neighborhood south of I-70 can enter the Globeville – Utah Junction watershed from south of I-70 in the vicinity of Inca or Jason Streets. The trans-basin flow rates shown on the facing page are from the Globeville OSP, not modeling documented in the Technical Appendix.

For purposes of this Master Plan, a 100-year alternative is proposed for Basin 0061-02 to intercept this runoff in the major storm and convey it south to the South Platte River. This improvement would prevent all flows from south of I-70 from entering the Globeville – Utah Junction (0059-01) Basin.

Potential Inundation Areas:

In a major flood, I-25 creates a Potential Inundation Area at West 52nd Avenue and Bannock Street and a Potential Inundation Area at West 43rd Avenue and Cahita Ct. Potential inundation is also possible around the CDOT detention basin on the eastside of I-25, at 52nd Avenue and Broadway, and the area located at 51st Avenue and Washington Street because of topographic constraints. There's also a Potential Inundation Area in I-70 at North Pecos Street. Potential inundation is also possible in a major storm event north and east of the Argo Park detention basin located near East 49th Avenue and North Logan Street. An updated 2-dimensional analysis of Potential Inundation Areas for the Globeville – Utah Junction basin was completed for the Master Plan Update, by ICON Engineering. See the corresponding memorandum in the technical appendix for additional information.

Proposed Capital Improvements:

The following drainage improvements have been identified by the OSP and are proposed to increase the level of service to a minimum of 10-year capacity.

Project A: 48th Avenue Outfall (A)
The Project A improvement is sized based on the installation of the 100-year alternative (Project L) in basin 0061-02 (Highland Basin).This project includes upsized and new pipe along 48th Avenue and ultimately discharges into the South Platte River. This project has major crossings at the Rennick Rail Yard, I-25, Argo Park, and Washington Street.

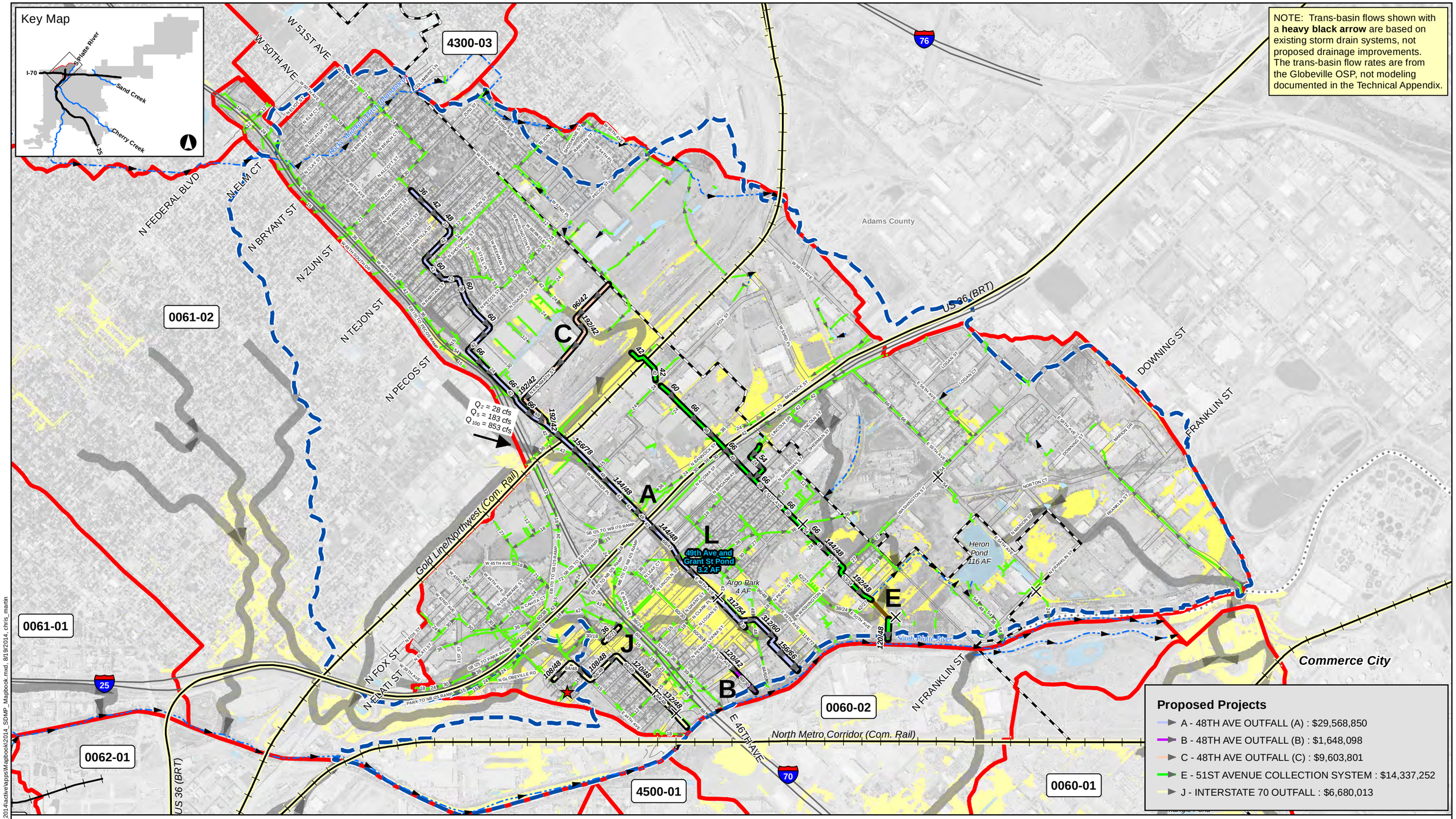
Project B: 48th Avenue Outfall (B)
This project includes a storm drain outfall along 47th Avenue from Pearl Street to the South Platte River. This outfall crosses the Denver Metro sanitary interceptor and will require the purchase of a new easement along the outfall.

Project C: 48th Avenue Outfall (C)
This project includes a storm drain outfall from West 52nd Place and Kalamath, south along Kalamath to the 48th Avenue Outfall (A) storm drain.

Project E: 51st Avenue Collection System
This project includes a storm drain outfall from the Rennick Rail Yard east along 51st Avenue to the South Platte River.

Project J: Interstate 70 Outfall
This project includes a storm drain outfall from 43rd Avenue and Lincoln Street to the South Platte River.

Project L: 49th & Grant Detention Basin
This project is a proposed 3.2 acre-foot detention basin to be located at the southwest corner of 49th & Grant. The UDFCD ***Globeville – Utah Junction Outfall Systems Planning Study*** identified alternative sizes for a 10-year storm, 100-year storm, and the inclusion of water quality treatment. The ultimate size and function will be dependent upon land constraints. Refer to the 2013 ***Globeville – Utah Junction Outfall Systems Planning Study*** for more information.



Basin 0059-01
Globeville - Utah Junction

Denver Storm Drainage Master Plan

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

Existing System Description:

This collection system basin includes a mix of industrial and residential land uses, and consists of 1,371 acres (2.14 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.

Runoff is conveyed through the basin primarily by the streets as surface flow, with several storm drain pipes also conveying water to the north. Some of the storm drain pipes terminate at the City limit or at the Park Hill (Triangle) detention basin before runoff continues into Adams County and into the South Platte River. This basin is served by two primary outfalls: a 42-inch diameter pipe along York Street, and a relatively small open channel north of the Park Hill (Triangle) detention basin running along the Union Pacific and Rock Island Railroads through Adams County.

This basin is situated at the bottom of several other major drainage basins. During major storm events, basin 0060-01 can potentially receive trans-basin surface runoff from a number of other basins, including Park Hill 4400-02, 0060-02, and Montclair 4500-01 (through 0060-02). A total of five trans-basin overland flowpaths are observed in this basin during the major-event. Three of these are inflows from basin 0060-02 at the upstream (south) portion of the basin, and two are from basin 4400-02 at the southeast portion of the basin. Specifically, inflows from 0060-02 occur along Brighton Boulevard and the BNSF Railroad; along the UPRR near I-70 and York Street; and across I-70 at Fillmore Street. Inflows from basin 4400-02 are received from the east along Smith Road near Forest Street and at the Park Hill Golf Course near 38th Avenue and Dahlia Street. A portion of the water from 4400-02 continues to flow to the east along Smith Road and into basin 0060-02, while a portion overtops the UPRR and flows north in basin 0060-01 in a major storm event.

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 at Dahlia, along Vasquez Boulevard near Sand Creek, along York Street, and at the Denver Water Recycle Plant located in Adams County just downstream of Denver's city limit. 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 Neighborhood.
- Improved conveyance (storm drain) is needed in York Street upstream of Brighton Boulevard and in the industrial zones upstream of Vasquez Boulevard.
- Drainage deficiencies at the basin's outfall to the South Platte River have been documented by Enginuity for the Urban Drainage and Flood Control District in a report titled ***Park Hill (North of Smith Road) Drainage Outfall Systems Plan, Conceptual Design Report***, dated January 24, 2012. A portion of the area included in this study lies in Adams County outside of Denver's boarders, but Denver would be a cooperating partner for the outfall, shown as Project I, since it serves as the primary outfall for much of Basins 0060-01 and 4400-02.

Potential Inundation Areas:

An extensive area of potential inundation has been identified within Basins 0060-01, 0060-02, 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 storm drain system capacities and street conveyance in larger storm events) established for the Denver stormwater program, primarily due to the high cost of retrofitting new storm drain in existing streets. Proposed capital improvements include:

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

Project F1: Park Hill Phase VII
A new 5-year storm drain system is needed in Dahlia Street. This proposed project will connect downstream to Project F at E. 38th Avenue and 4400-02 Project F2 upstream.

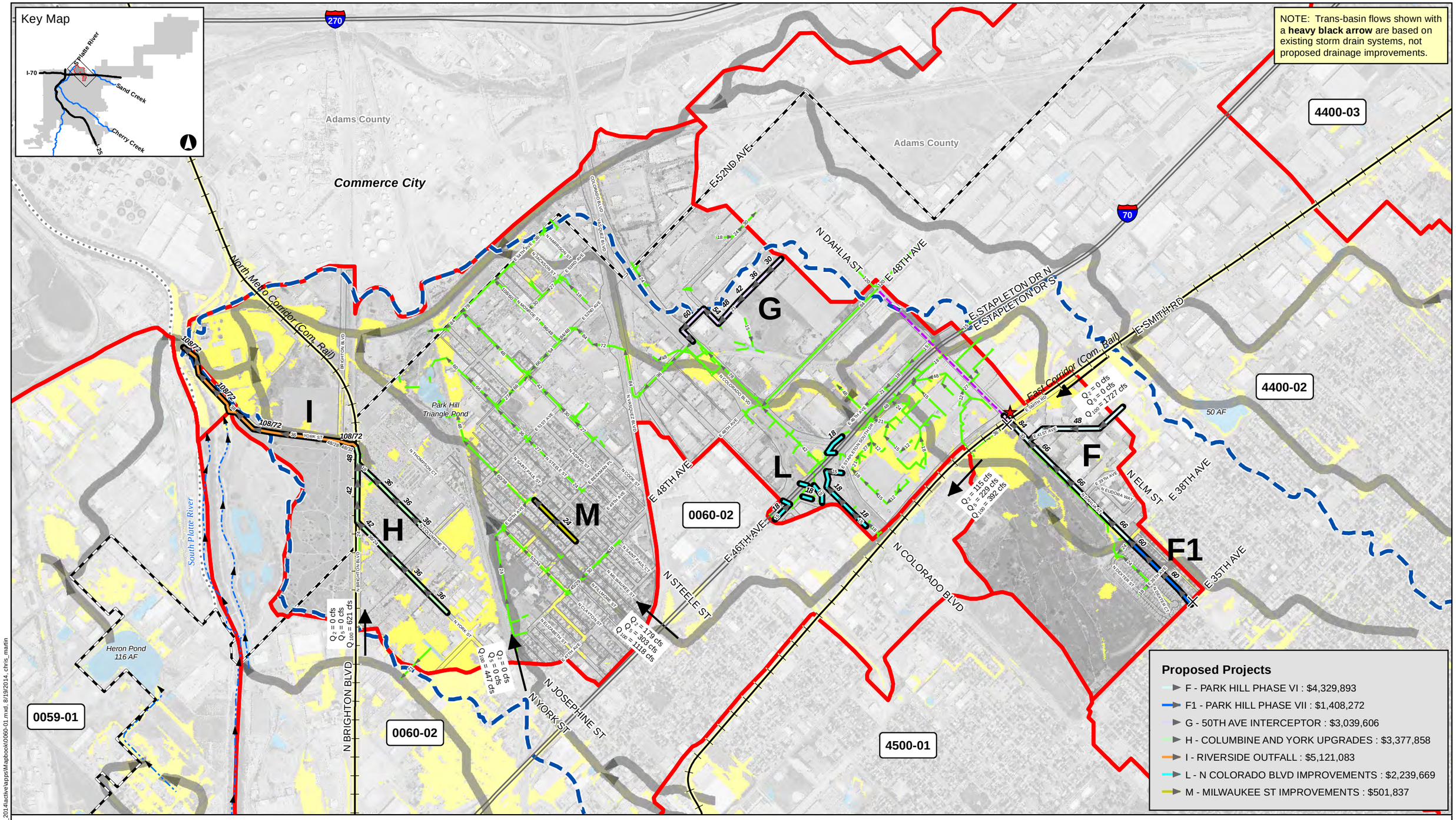
Project G: 50th Avenue Interceptor
A new storm drain system is needed in 50th Avenue. This proposed project will connect to the existing Park Hill Phase II storm drain system at 50th Avenue and Colorado Boulevard.

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 100-year 9'x6' outfall storm drain 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 and serve as an outfall for a portion of the major-event trans-basin flows that this basin receives. This project was proposed in the Urban Drainage OSP study.

Project L: N Colorado Blvd Improvements
This project includes the addition of storm drains 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.



Basin 0060-01
I-70 & Colorado Boulevard

Denver Storm Drainage Master Plan

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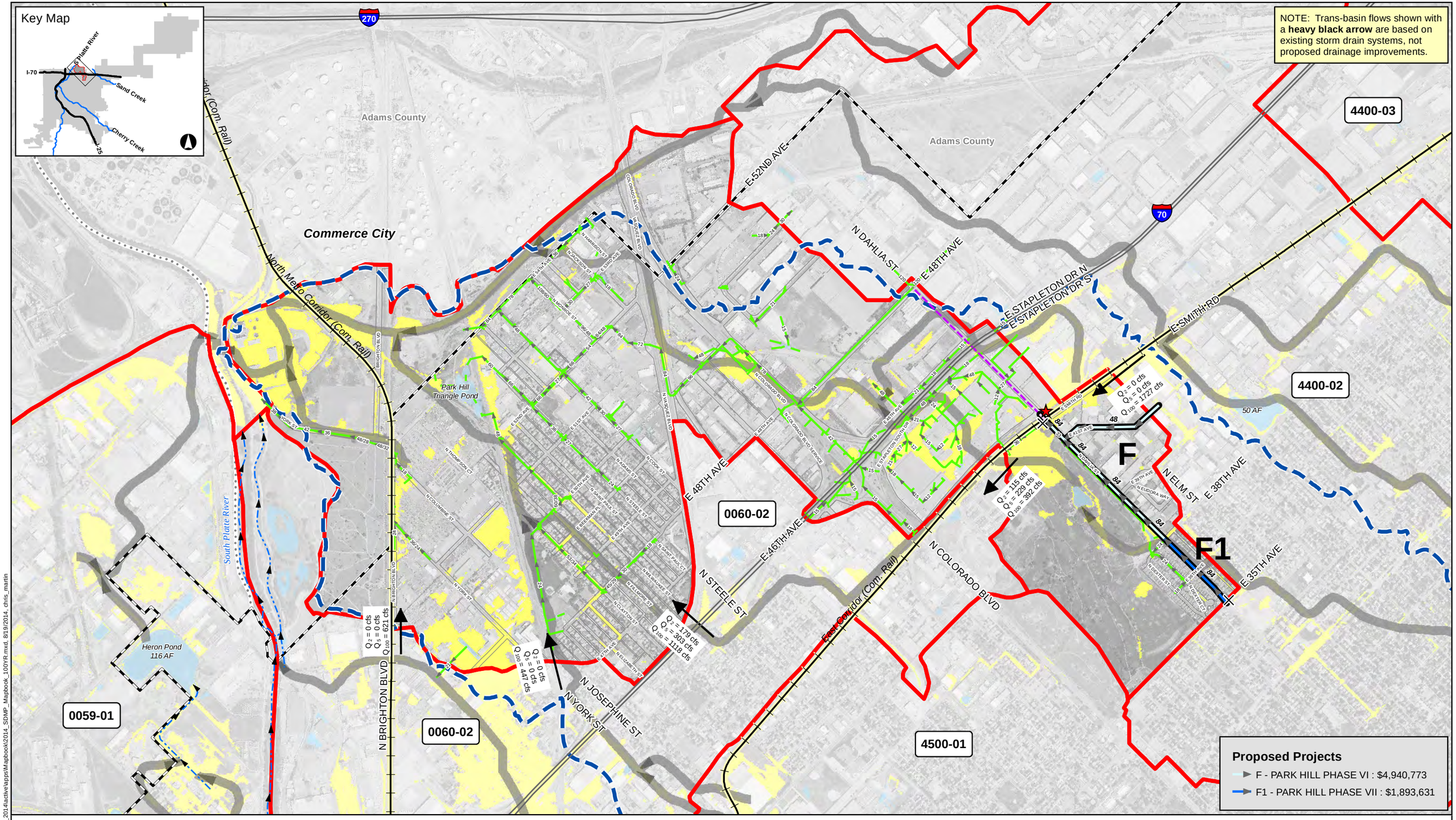
Basin 0060-01 (I-70 & Colorado Boulevard) (Alternative 100-Year Basin)

Proposed 100-Year Alternative Capital Improvements:

Project F and F1: Park Hill Phase VI & VII

Storm drain alignments shown in the 100-year alternative from Projects F and F1 are the same alignments for the minor storm. Pipe sizes have increased for the 100-year alternative in order to reduce surface runoff depths in the street to 12-inches in the gutter in accordance with Denver street-depth criteria. This analysis is based on the July 2011 ***Sand Creek (4400-02) and Upper Park Hill (0060-01, 4400-02 & 4500-01) Basins Final Drainage Study*** by Atkins. See that study for additional alternatives.



N

0 650 1,300

Feet

1 inch equals 1,300 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Topographic Basin Boundary
- 100-yr Sub-Collection System Boundary
- Thalweg
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
- Significant Flooding Location
- Proposed Detention Basin
- Existing Basin
- Potential Inundation Area
- Planned Transit Line
- Existing Transit Line
- City and County Boundary
- Other Municipalities
- Other Counties

Basin 0060-01 - 100-yr Alternative
I-70 & Colorado Boulevard

Denver Storm Drainage Master Plan

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Basin 0060-02 (I-70 & York)

Existing System Description:

This collection system 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.

Intercepted stormwater is discharged to the South Platte River via at least 12 storm drainage outfalls. However, the only one major (larger than 48inch) outfall exists at Race Court just upstream of the Burlington Ditch headgate. This outfall (Design Point 1549) locally 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 the BNSF Railroad next to Brighton Boulevard
- An elevated section of the Metro Sewer, along the South Platte River, creating a wall barrier for drainage

While this basin is locally served by several small storm drains with a master planned goal of conveying the minor 2- or 5-year event, the basin also experiences "pass through" flow from other basins during a major storm event. A total of four trans-basin overland flowpaths are observed in this basin during the major-event. Three of these are inflows from basin 4500-01 (Montclair) at the upstream (south) portion of the basin. Specifically, inflows occur at the UPRR Intermodal Facility at 40th Avenue and High Street; at 40th Avenue and York Street; and at the Market Lead just east of 40th Avenue and Madison Street. Additionally, one inflow from basin 0060-01 (originally from 4400-02) flows west along Smith Road and the UPRR, and enters this basin at the Market Lead west of Colorado Boulevard.

Some of this trans-basin major-event runoff continues through basin 0060-02 and enters basin 0060-01 at various points. These locations include along Brighton Boulevard and the BNSF Railroad, along the UPRR near I-70 and York Street, and across I-70 at Fillmore Street.

Potential Inundation Areas:

Hydraulic analysis shows areas around the National Western Stock Show Complex to be subject to potential inundation 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 inundation 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 inundation in this area.

Another area of potential inundation is the result of overland flow from the Montclair Basins (4500). Runoff in excess of the pipe capacity will enter basin 0060-02 south of I-70 near 40th Avenue and continue to flow in a northerly and northwesterly direction through the basin. Drainage improvements associated with CDOT's proposed lowering and reconstruction of I-70 will need to address this off-site runoff from Montclair. This is currently being evaluated in the ***Montclair Outfall Systems Planning Study*** by the Urban Drainage & Flood Control District (UDFCD), funded by the UDFCD and Denver.

Drainage Deficiencies:

The existing drainage system generally ponds water beyond a 2-year storm event, with significant widespread areas of potential inundation expected to occur during a 100-year event.

Proposed Capital Improvements:

The trans-basin overland flows were not taken into consideration when sizing the proposed projects identified herein. If upstream proposed projects are constructed, for the 100-year storm event, the trans-basin flows will be intercepted by the proposed systems in each basin and there will be no more trans-basin flow.

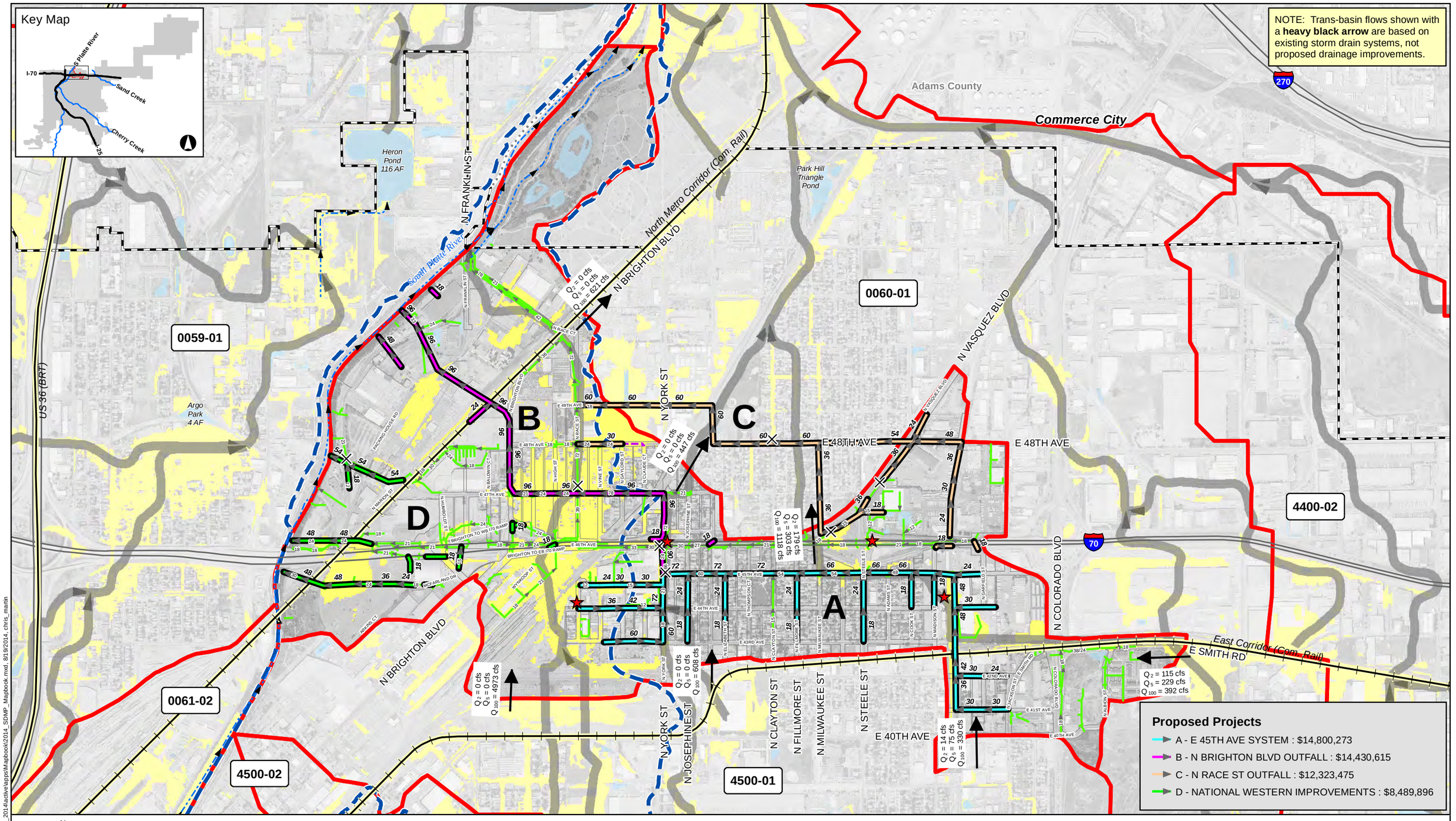
Four major storm drain projects have been proposed in this basin to increase the level of service from a 2-year capacity to a 5-year capacity.

<u>Project A: East 45th Avenue System</u>
This project 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.

<u>Project B: North Brighton Boulevard Outfall</u>
This project 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 from York Street & 45th Avenue, 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 in order to improve the level of service in the area.

<u>Project C: North Race Street Outfall</u>
This project 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 520) 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>
This project involves enlarging existing storm drain outfalls near I-70. Specifically, a 30-inch outfall south of I-70 (Design Point 610) is upsized to a 48-inch pipe. A 24-inch outfall north of I-70 (Design Point 600) is upsized to a 48-inch pipe. A 30-inch outfall north of I-70 (Design Point 590) is upsized to a 54-inch pipe. Preliminary design may consider parallel pipes for this project rather than complete replacement.



N

0 600 1,200

Feet

1 inch equals 1,200 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Topographic Basin Boundary
- Thalweg
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
- Significant Flooding Location
- Proposed Detention Basin
- Existing Basin
- Potential Inundation Area
- Planned Transit Line
- Existing Transit Line
- City and County Boundary
- Other Municipalities
- Other Counties

Basin 0060-02
I-70 & York

Denver Storm Drainage Master Plan

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Basin 0061-01 (27th and Federal)

Existing System Description:

The 27th and Federal collection system basin is located in northwest Denver. The approximate boundaries of the basin are W. 19th Avenue on the south (Sports Authority 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 1,428 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.

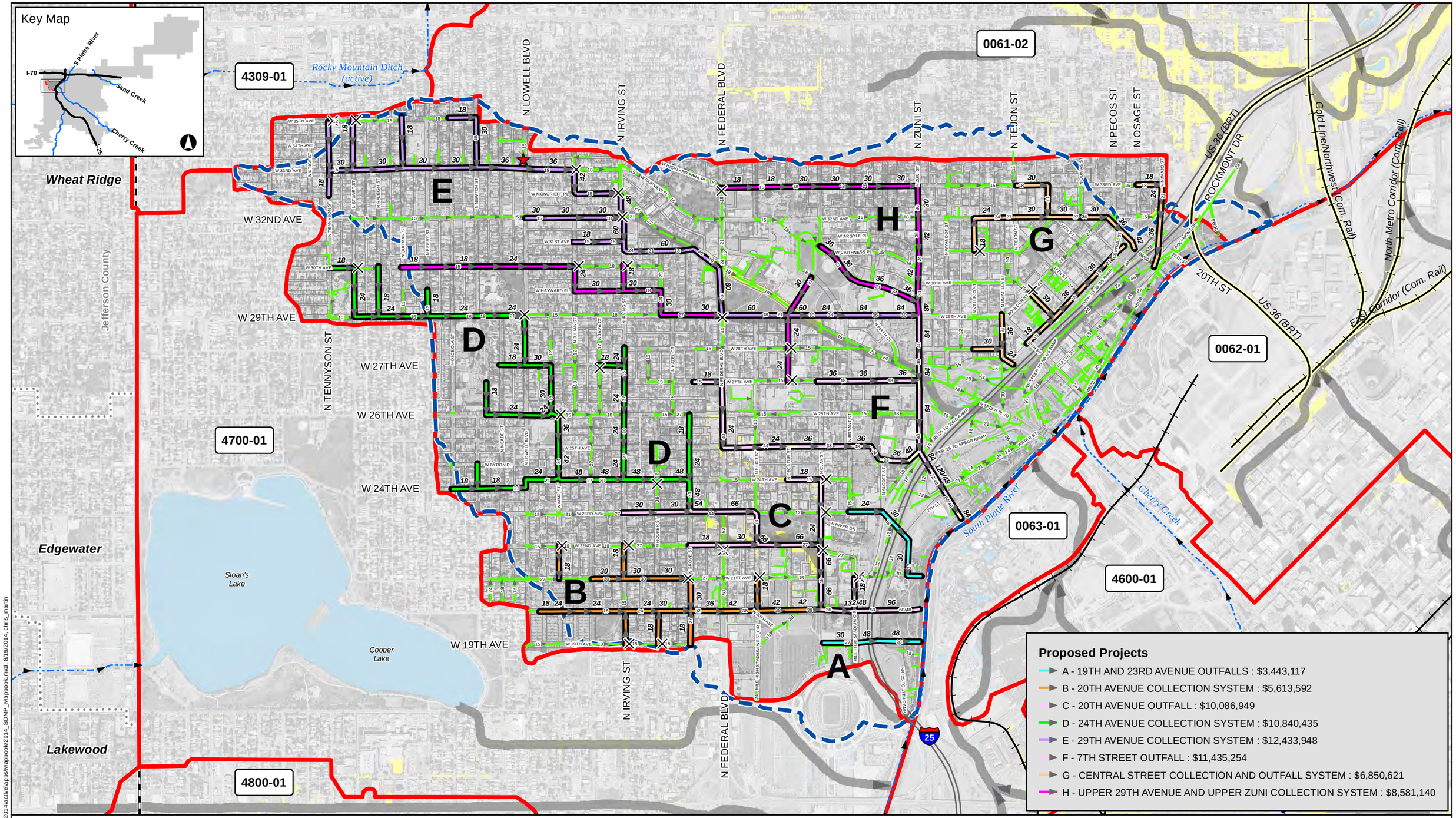
The 27th and Federal basin lies on a relatively steep area on the side of the South Platte River Valley. As a result, water tends to move quickly through the basin and generally does not produce areas of severe ponding. However, there are two major flow paths within the overall basin that do see shallow 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 southeast to the South Platte River on the eastside of 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
27th & Federal

Denver Storm Drainage Master Plan

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Basin 0061-02 (Highland)

Existing System Description:

The Highland collection system 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. Perry Street. The basin is comprised of approximately 1,909 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 of 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:

- Double 8 x 8 box culvert and a twin 7.25' x 3.5' box culvert at W. 34th Avenue and N. Kalamath 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 five major flow paths within the overall basin that do see overland flooding in larger storm events. This shallow flooding is primarily contained in the streets when a storm event exceeds the storm drain capacity. The five major flow paths, identified as thalwegs, are generally described as follows:

- Along W. 47th Avenue from near N. Pecos Street, flowing east to N. Jason Street, then northeast under I-70 and entering the Globeville – Utah Junction (0059-01) Basin.
- Beginning near 46th Avenue east of N. Jason Street, flowing south between N. Inca Street and the UPRR/BNSF railroads towards the W. 38th Avenue underpass and I-25/38th Avenue/Park Avenue West interchange.
- Beginning at the intersection of W. 44th Avenue and N. Zuni Street, flowing east in W. 44th Avenue to N. Shoshone Street, then southeast to N. Inca Street between W. 36th and W. 37th Avenues, then east and underneath I-25 crossing the railroad, thence northeast through the BNSF railroad yard.
- Beginning at the intersection of W. 41st Avenue and N. Bryant Street, flowing southeast and ultimately reaching the bank of storm drain inlets at W. 34th Avenue and N. Kalamath Street.
- Beginning at the intersection of W. 36th Avenue and N. Alcott Street, flowing northeast to W. 38th Avenue and N. Tejon Street, then east on 38th Avenue to N. Osage Street, and southeast towards the bank of storm drain inlets at W. 34th Avenue and N. Kalamath Street.

In general, much of the existing system is undersized and does not adequately convey the 2-year or 5-year design flows. The storm drain system along N. Inca Street (W83-333A and W83-333B constructed from 1988 through 1994) 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.

The 2013 ***Globeville – Utah Junction Outfall Systems Planning Study***, by CHM2Hill for the UDFCD, confirmed that in larger storm events runoff from the Sunnyside Neighborhood south of I-70 can leave the Highland Basin (0061-02) from south of I-70 in the vicinity of Jason Street and enter the Globeville – Utah Junction Basin (0059-01). The trans-basin flow rates shown on the facing page are from the Globeville OSP, not modeling documented in the Technical Appendix.

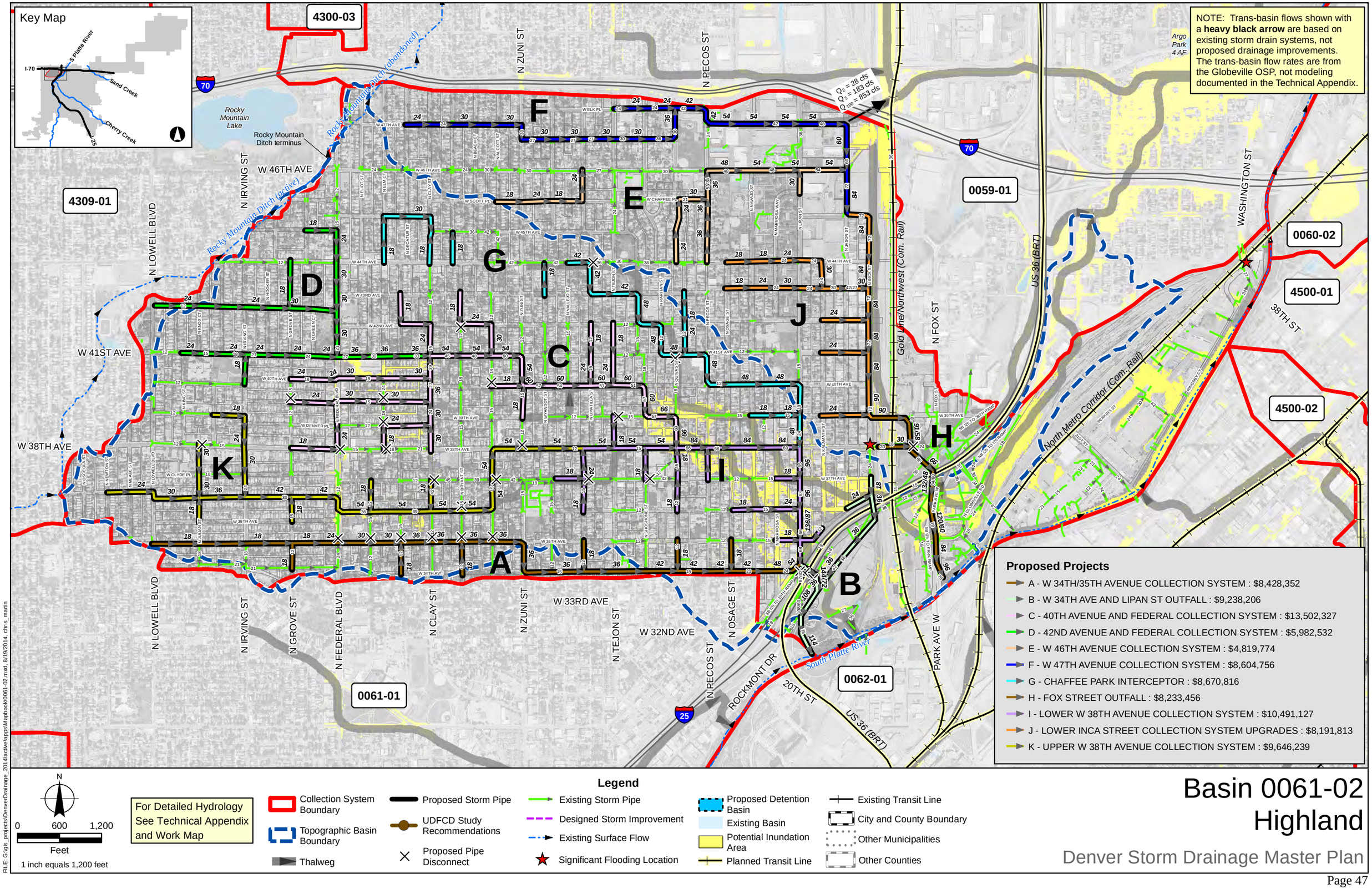
For purposes of this Master Plan, a 100-year alternative is proposed for Basin 0061-02 to intercept this runoff in the major storm and convey it south to the South Platte River. This improvement would prevent all flows from south of I-70 from entering the Globeville – Utah Junction (0059-01) Basin.

Proposed Capital Improvements:

<u>Projects A-K</u>

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 and allowing streets to convey runoff up to 12-inches deep in the gutter in larger storm events. 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.


Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
4300-03
4309-01
0059-01
0060-02
4500-01
4500-02
0061-01
0062-01
Rocky Mountain Lake
Rocky Mountain Ditch terminus
Rocky Mountain Ditch (abandoned)
Rocky Mountain Ditch (active)
Argo Park 4 AF
Q_2 = 28 cfs
Q_5 = 183 cfs
Q_{100} = 853 cfs
NOTE: Trans-basin flows shown with a heavy black arrow are based on existing storm drain systems, not proposed drainage improvements. The trans-basin flow rates are from the Globeville OSP, not modeling documented in the Technical Appendix.
W 47TH AVE
W 46TH AVE
W 45TH AVE
W 44TH AVE
W 43RD AVE
W 42ND AVE
W 41ST AVE
W 40TH AVE
W 39TH AVE
W 38TH AVE
W 37TH AVE
W 36TH AVE
W 35TH AVE
W 34TH AVE
W 33RD AVE
W 32ND AVE
N ZUNI ST
N PECOS ST
N IRVING ST
N LOWELL BLVD
N GROVE ST
N FEDERAL BLVD
N CLAY ST
N TEJON ST
N OSAGE ST
N FOX ST
WASHINGTON ST
38TH ST
US 36 (BRT)
Gold Line/Northwest (Com. Rail)
North Metro Corridor (Com. Rail)
South Platte River
ROCKMONT DR
20TH ST
PARK AVE W
F
E
G
D
J
C
H
I
K
A
B
Proposed Projects
A - W 34TH/35TH AVENUE COLLECTION SYSTEM : $8,428,352
B - W 34TH AVE AND LIPAN ST OUTFALL : $9,238,206
C - 40TH AVENUE AND FEDERAL COLLECTION SYSTEM : $13,502,327
D - 42ND AVENUE AND FEDERAL COLLECTION SYSTEM : $5,982,532
E - W 46TH AVENUE COLLECTION SYSTEM : $4,819,774
F - W 47TH AVENUE COLLECTION SYSTEM : $8,604,756
G - CHAFFEE PARK INTERCEPTOR : $8,670,816
H - FOX STREET OUTFALL : $8,233,456
I - LOWER W 38TH AVENUE COLLECTION SYSTEM : $10,491,127
J - LOWER INCA STREET COLLECTION SYSTEM UPGRADES : $8,191,813
K - UPPER W 38TH AVENUE COLLECTION SYSTEM : $9,646,239
N
0
600
1,200
Feet
1 inch equals 1,200 feet
For Detailed Hydrology See Technical Appendix and Work Map
Legend
Collection System Boundary
Topographic Basin Boundary
Thalweg
Proposed Storm Pipe
UDFCD Study Recommendations
Proposed Pipe Disconnect
Existing Storm Pipe
Designed Storm Improvement
Existing Surface Flow
Significant Flooding Location
Proposed Detention Basin
Existing Basin
Potential Inundation Area
Planned Transit Line
Existing Transit Line
City and County Boundary
Other Municipalities
Other Counties
Basin 0061-02
Highland
Denver Storm Drainage Master Plan
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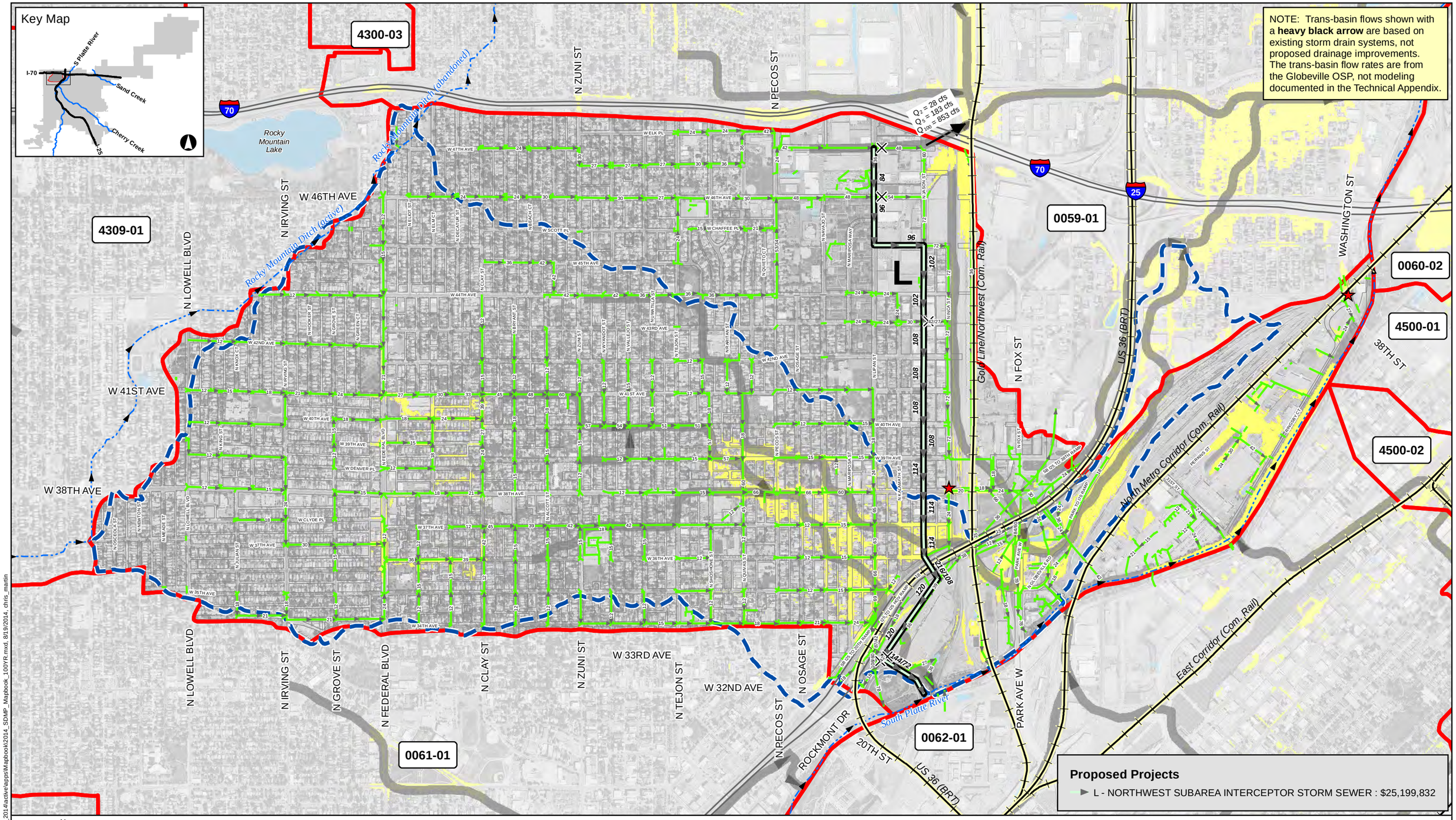
Basin 0061-02 (Highland)
(Alternative 100-Year Basin)

Proposed 100-Year Alternative Capital Improvements:

Project L: Northwest Subarea Interceptor Storm Drain

The January 2012 ***Northwest Denver Sub-Area Drainage and Transportation Study***, by WH Pacific, includes a no detention alternative (Alternative C) for a 100-year storm drain system on the east side of the basin. This improvement includes installation of 12'x6'RCB, and 84" to 120" RCP that generally follows Jason Street from West 47th Street to the South Platte River. This improvement will prevent all flows from entering the Globeville – Utah Junction (0059-01) Basin. Proposed 10-year improvements within the Globeville - Utah Junction (0059-01) Basin account for this 100-year alternative preventing any flows from traveling north of Interstate 70 or east of Interstate 25.



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0 600 1,200

Feet

1 inch equals 1,200 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Topographic Basin Boundary
- 100-yr Sub-Collection System Boundary
- Thalweg
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
- Significant Flooding Location
- Proposed Detention Basin
- Existing Basin
- Potential Inundation Area
- Planned Transit Line
- Existing Transit Line
- City and County Boundary
- Other Municipalities
- Other Counties

Basin 0061-02 - 100-yr Alternative Highland

Denver Storm Drainage Master Plan

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

Existing System Description:

These two collection system basins combined include a mix of industrial, commercial and residential land uses, and include 2,856 tributary acres (4.46 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 drains in lower reaches.

Currently, most of the drainage (nearly 75% of the basin) outfalls through one 81-inch storm pipe at 36th Street, with approximately 1,936 acres tributary to this one outfall. The existing pipe has approximately 476 cfs capacity, but the hydrology indicates the flow will be over 1,000 cfs in a 2-year event, and 1,700 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 ***31st Street & 36th Street Outfall Study and Concept Design Report***, December 2012 by Wilson and Company.

Potential Inundation Areas:

Several areas of potential inundation have been identified within the basin, mostly in areas where the streets become very flat. The areas surrounding the intersections of 36th Street/Blake Street, 31st Street/Blake Street, 32nd Avenue/Marion Street, 17th Avenue/Lafayette Street, 16th Avenue/Franklin Street, and 16th Avenue/Clarkson Street have been identified as locations where 100-year inundation depths could reach up to 3-feet in depth during a 100-year event.

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 in 36th Street 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. The ***31st Street & 36th Street Outfall Study and Concept Design Report***, completed by Wilson and Company in 2012, investigated several outfall alternatives within the basin, and the recommendations from that report are reflected in this Master Plan. Thirteen major drainage projects are proposed for this basin as described below:

Project A: Marion Street System – Phase 1 connects to the recently designed River North Outfall located in 33rd Street. The Phase 1 extension includes a new 102-inch pipe in Marion Street from 32nd Avenue to 29th Avenue. 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: Marion Street System – Phase 2 storm drain will continue up the basin with a 102-inch to 90-inch pipe in Downing Street to 21st Avenue.

Project C: East 24th Avenue System provides additional stormwater collection for the proposed trunk line in Project B. It includes a 60-inch pipe in 24th Avenue with additional lines extending up to 20th Avenue and Vine Street. This project also includes replacing existing small pipes with 18-inch diameter pipes to meet current drainage criteria, improve collection/conveyance and reduce maintenance problems.

Project D: City Park West Drainage Improvements extends into the upper basin with an 84-inch to 36-inch diameter pipe. This project also includes replacing existing small pipes with 18-inch diameter pipes to meet current drainage criteria, improve collection/conveyance and reduce maintenance problems.

Project E: East 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.

Project F: 27th Street Interceptor – Phase 1 includes maximizing the use of the existing 108-inch pipe in the Coors Field Parking Lot. Currently, the tributary area to the pipe is only 88 acres. The outfall will extend up 27th Street to Champa Street with a 96-inch pipe.

Project G: 27th Street Interceptor – Phase 2 will continue upstream in 27th Street from Champa Street to Washington Street and along Washington Street to 19th Avenue with a 90-inch to a 72-inch pipe.

Project H: 27th Street Interceptor – Phase 3 will extend along Clarkson Street from 19th Avenue to 14th Avenue with a 60-inch pipe transitioning down to smaller pipe up into the basin. This project also includes up-sized laterals in 16th Avenue.

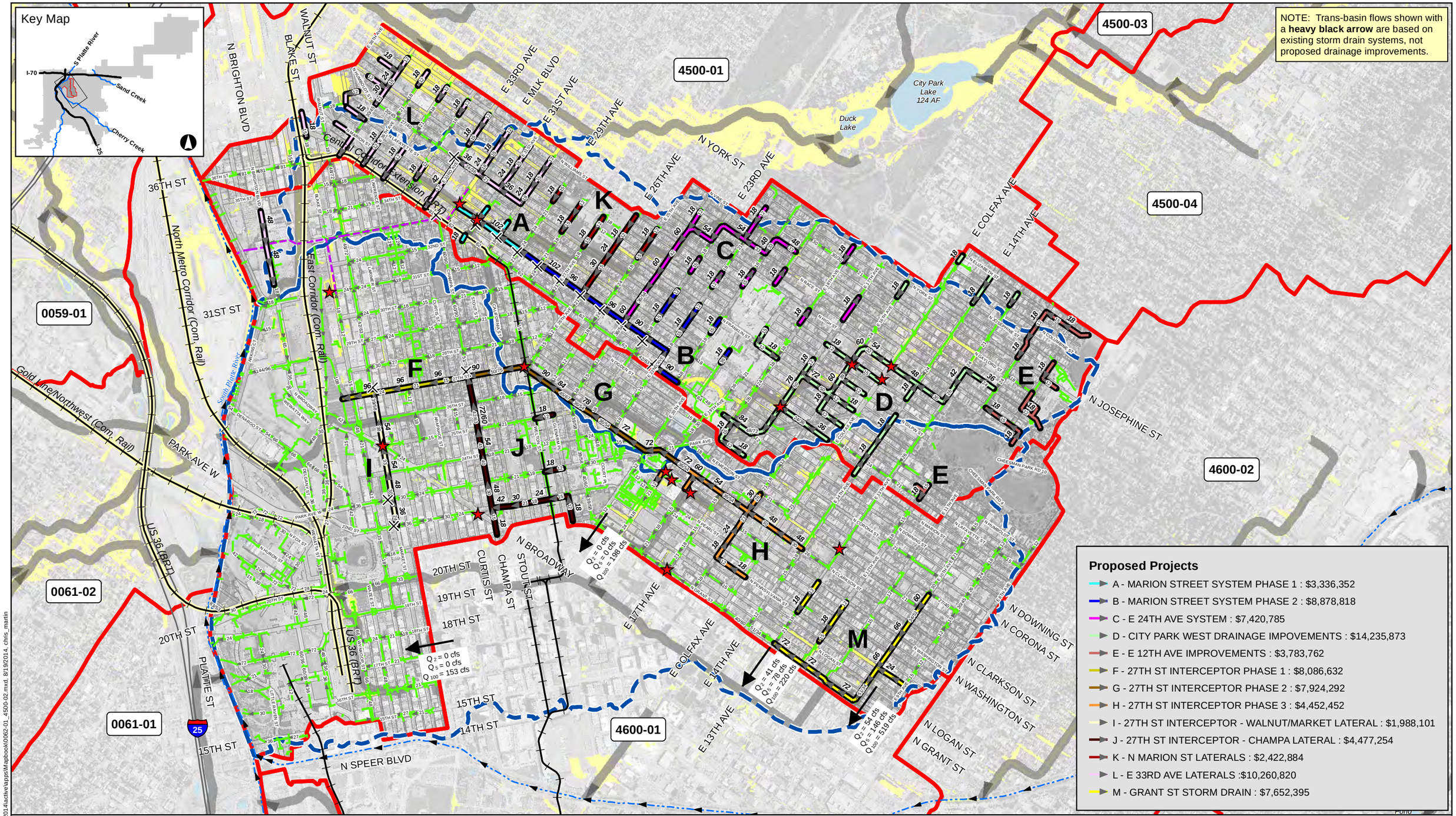
Project I: 27th Street Interceptor – Walnut/Market Lateral includes a new upsized pipe network in Walnut/Market Street south of 27th Street.

Project J: 27th Street Interceptor – Champa Lateral consists of a new box and pipe network in Champa Street south of 27th Street

Project K: North Marion Street Laterals proposes to replace the existing small storm drains east of Project A with 18-inch or larger pipes to meet current drainage criteria and reduce maintenance.

Project L: East 33rd Avenue Laterals includes a system to balance 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 in Humboldt Street and convey runoff to the existing 81-inch pipe in Downing Street, which is being relived with construction of the new outfall in 33rd Street. In addition, existing small storm drains are proposed to be replaced with 18-inch pipes to meet current drainage criteria and reduce maintenance.

Project M: Grant Street Storm Drain collects runoff from the existing storm drains in 9th and 10th Avenues at Ogden Street and delivers runoff in a 5-year event to the 13th Avenue Extension project in Basin 4600-01. This project also includes upsizing the existing storm drain in Grant Street from 10th to 13th Avenue.



Basin 0062-01 & 4500-02
Lower Platte Valley and 36th & Downing

Denver Storm Drainage Master Plan

Basin 0063-01 (Central Platte Valley)

Existing System Description:

This collection system basin consists of areas draining to the right bank of the South Platte River from Bayaud Avenue on the south to Speer Boulevard/Cherry Creek on the north and as far east as Logan Street. 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 Santa Fe, and commercial in the lower reaches. All drainage from this basin outfalls 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 was removed from the riverine floodplain by ***LOMR Case No. 12-08-0474P,*** December 17, 2012 by the completion of the South Platte River Restoration improvements.

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. Localized ponding occurs frequently at W. Ellsworth Avenue and N. 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.

Two major-event FLO-2D analyses identify the Potential Inundation Areas along Broadway, from Alameda Avenue to 5th Avenue, and another at 10th Avenue and Osage Street. The results were incorporated into the Master Plan. A trans-basin flow of 58 cfs, from the 4600-01 Basin, at 10th Avenue and Osage Street, was identified during a 100-year storm event.

Proposed Capital Improvements:

Blueprint Denver shows the majority of the basin (commercial areas) as "Areas of 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. CDOT's ***Valley Highway – Logan to 6th Avenue Record of Decision (ROD)*** dated June 2007, Section 4.9.1.4 Stormwater Drainage, noted that Denver's ***Storm Drainage Master Plan*** and subsequent drainage improvements should be considered with each phase of final design for the Valley Highway Project.

Project A: West 13th Avenue Outfall
This project 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.

Project B: West 7th Avenue Outfall
The existing 72-inch storm drain in 7th Avenue must be upsized to a 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.

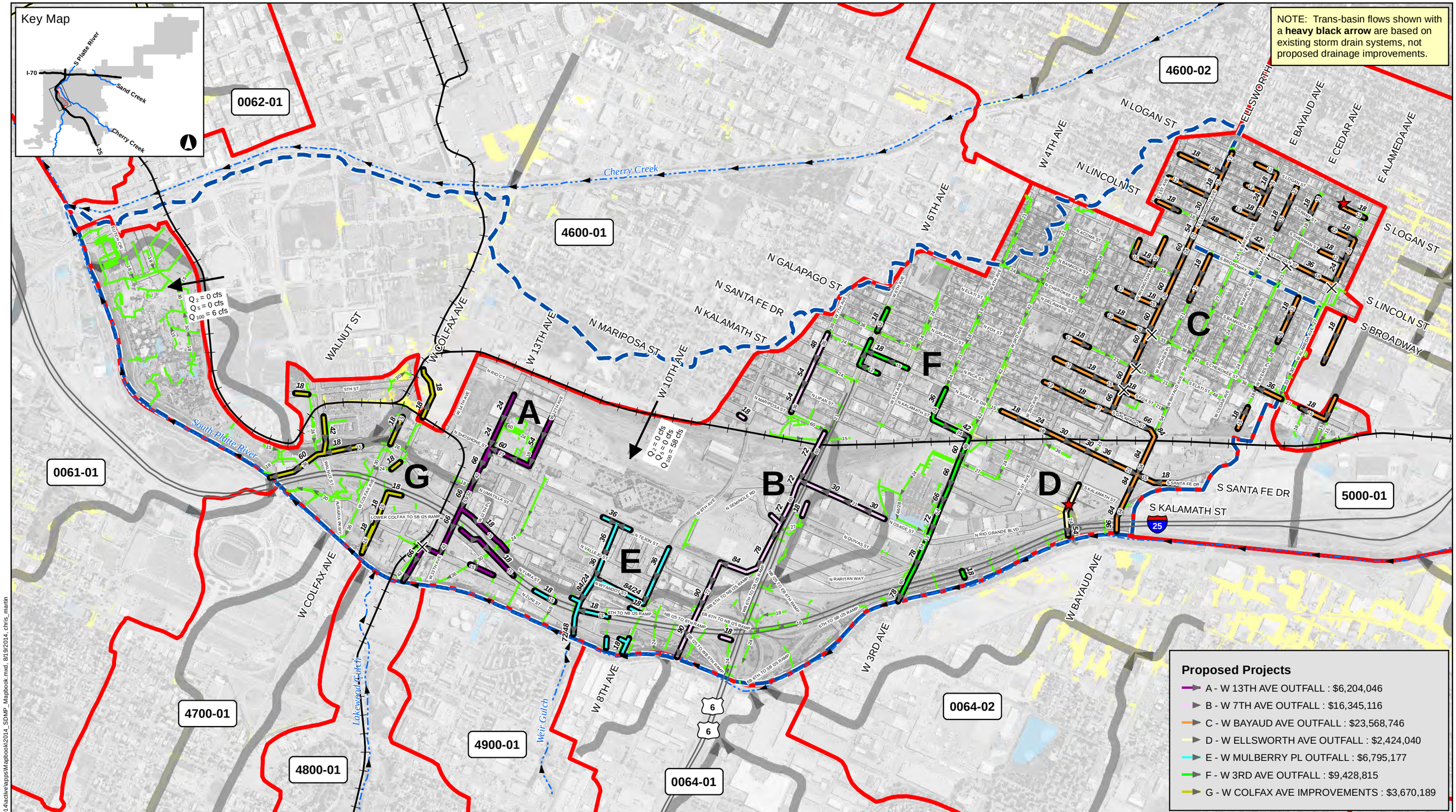
Project C: West Bayaud Avenue
The existing system has less than a 1-year event capacity. The Bayaud Avenue outfall consisting of a 54-inch pipe is proposed for replacement with an 84-inch pipe for a 5-year system. At Galapago, the proposed pipe jogs over to Ellsworth Avenue to preserve the existing trunk system upstream and extends to Logan with a lateral extending south in N. Lincoln Street to provide additional storm conveyance in this area.

Project D: West Ellsworth Avenue
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 and I-25.

Project E: West Mulberry Place
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.

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

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



Basin 0063-01
Central Platte Valley

Denver Storm Drainage Master Plan

Basin 0064-01 (1st & Federal)

Existing System Description:

This collection system 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. The basin consists of 279 acres (0.44 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 subbasins 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.

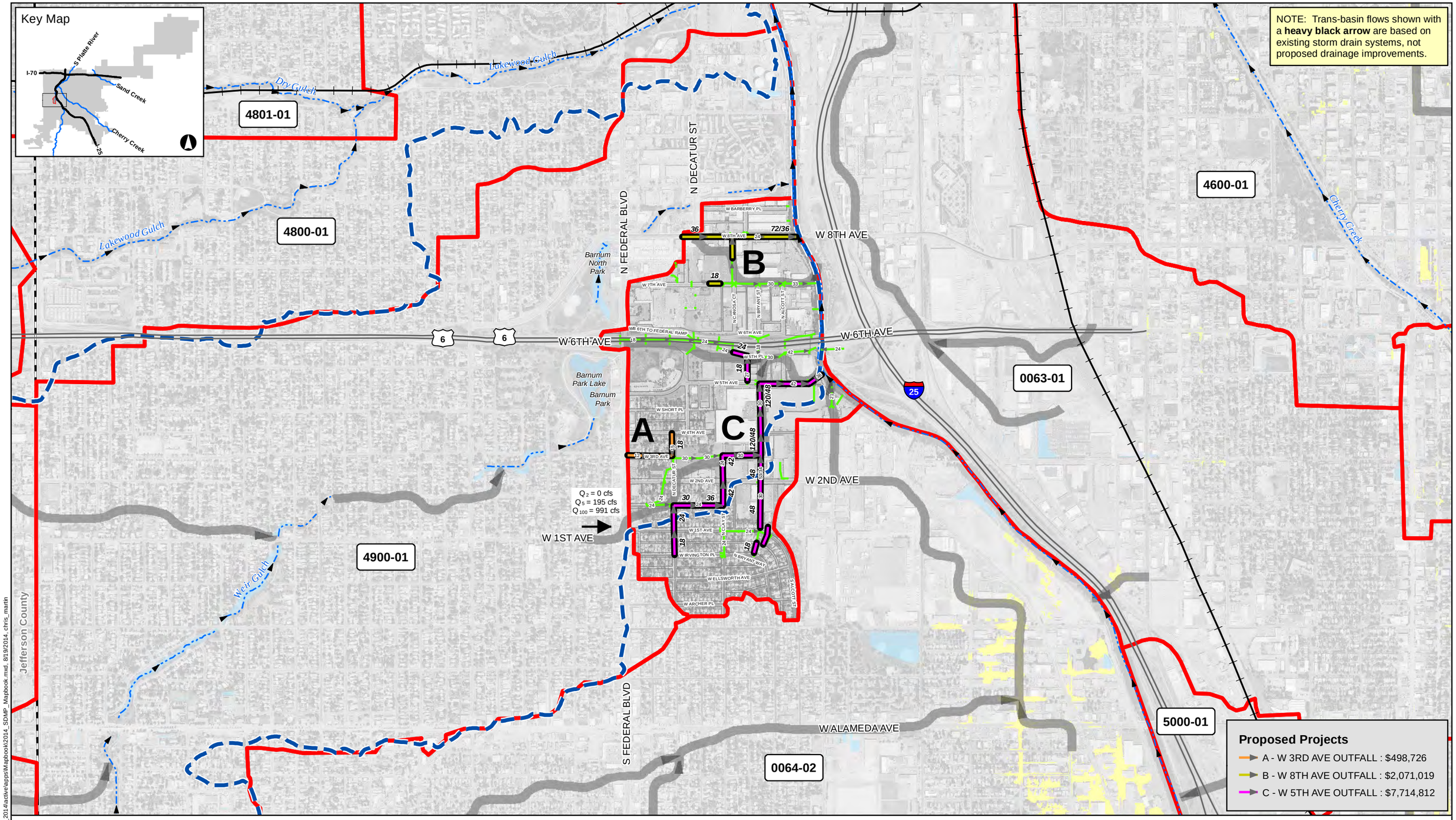
Most of the capital improvements proposed in Denver's 1989 Master Plan have been constructed. This area has been improved by construction of diversion facilities to Weir Gulch implemented since the 1989 plan.

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-inch have been upgraded to 18-inch per current criteria.

Project B: West 8th Avenue Outfall
A new 3-foot x 6-foot box culvert outfall is proposed in 8th Avenue.

Project C: West 5th Avenue Outfall
A new 4-foot x 10-foot 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



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N

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Feet

1 inch equals 1,200 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Topographic Basin Boundary
- Thalweg
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
- Significant Flooding Location
- Proposed Detention Basin
- Existing Basin
- Potential Inundation Area
- Planned Transit Line
- Existing Transit Line
- City and County Boundary
- Other Municipalities
- Other Counties

Basin 0064-01
1st & Federal

Denver Storm Drainage Master Plan

Basin 0064-02 (Valverde)

Existing System Description:

This collection system 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. The basin consists of 1,694 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 located at W. Bayaud Avenue and S. Tejon Street. Improvements have been constructed along Mississippi Avenue, which convey 310 cfs, in the minor storm, 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 of 1,026 cfs is imported into this basin via Mississippi Gulch located east of S. Pecos and W. Mosier Place. The 2013 ***Sanderson Gulch Major Drainageway Plan and Flood Hazard Area Delineation***, by Matrix Design Group for the UDFCD, evaluated a conveyance system to collect and convey the 100-year flows to Sanderson Gulch.

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-foot x 4½-foot 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-foot x 4½-foot 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 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. .

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.

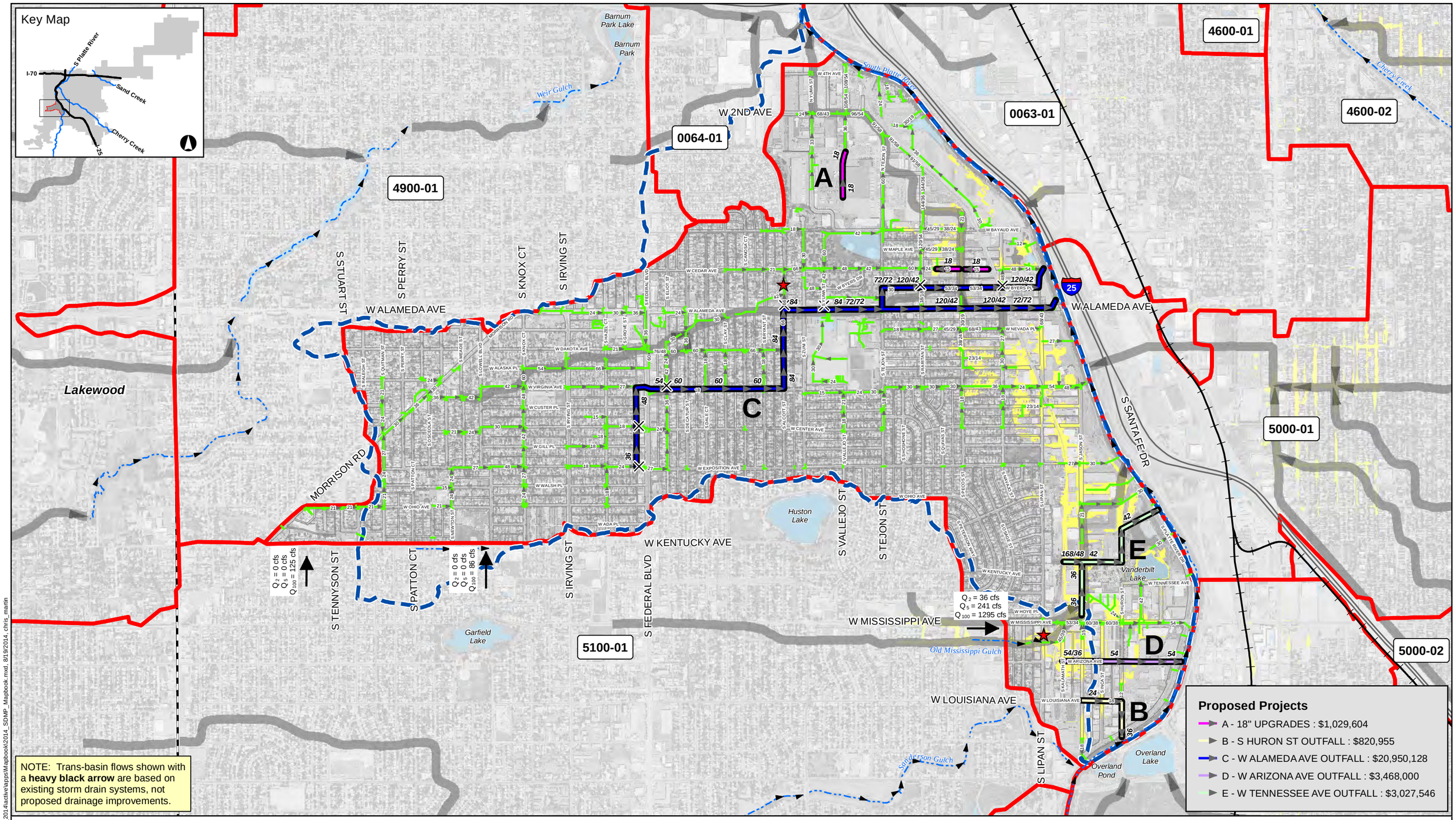
Project A: 18-Inch Upgrades
This project upsizes various pipes to the City's 18-inch minimum diameter pipe.

Project B: S. Huron St. Outfall
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.

Project C: W. Alameda Ave. Outfall
A new dual system in W Alameda Avenue and W. Byers Drive, from the South Platte River to S. Tejon Street, is proposed to provide improved drainage in this basin. Upstream of Tejon, a 6-foot x 6-foot RCB and 84-inch RCP 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 also proposed in Alcott Street between Alameda and Virginia Avenues. A proposed 60-inch pipe along Virginia Avenue will relieve the existing system in Dakota Avenue by providing additional conveyance to serve subbasins 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.

Project D: W. Arizona Ave. Outfall
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.

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



N

0 750 1,500

Feet

1 inch equals 1,500 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Topographic Basin Boundary
- Thalweg
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
- Significant Flooding Location
- Proposed Detention Basin
- Existing Basin
- Potential Inundation Area
- Planned Transit Line
- Existing Transit Line
- City and County Boundary
- Other Municipalities
- Other Counties

Basin 0064-02
Valverde

Denver Storm Drainage Master Plan

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Basin 0065-01 (Ruby Hill)

Existing System Description:

The Ruby Hill collection system 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-inch pipe to the South Platte River. Other outfalls in the basin include a 36-inch pipe in Warren, a 48-inchx72-inch 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 inundation 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 Inundation 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 drain 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 basins are located within the upper portion of the basin. The detention basins 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 drainage improvements are summarized below:

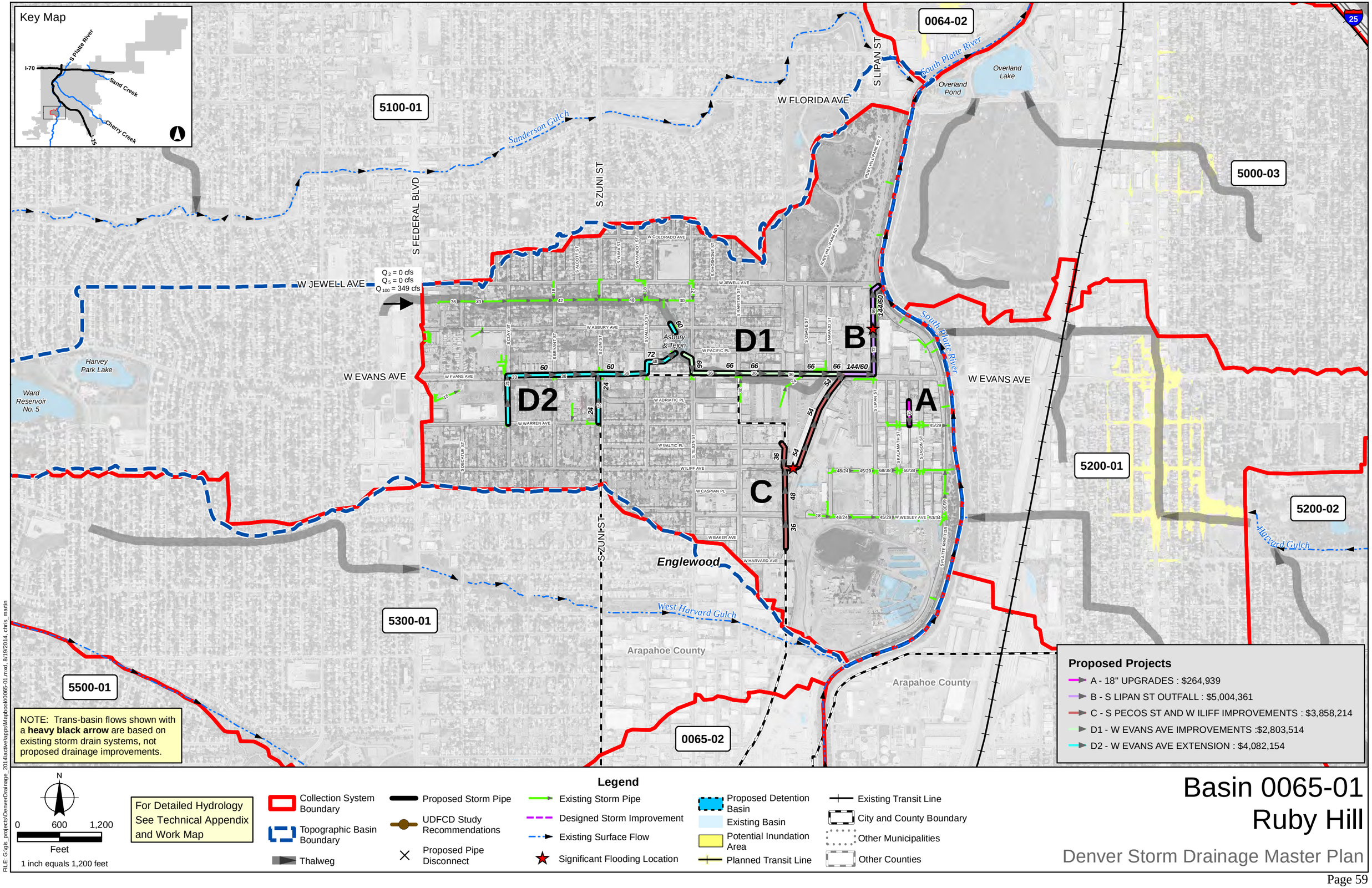
Project A: 18-inch Upgrades
This project includes upsizing an existing 15-inch storm drain lateral located within the alley between Kalamath and Jason Street to an 18-inch storm drain.

Project B: S. Lipan St. Outfall
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.

Project C: S. Pecos and W. Iliff Improvements
Construct a new 5-year storm drain 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.

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

Project D-2: W. Evans Ave. Extension
Upsize the existing storm drain facility to a 5-year capacity within Evans Avenue from the existing detention basin 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 Avenue between the two small detention basins.


Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
5100-01
Sanderson Gulch
S FEDERAL BLVD
S ZUNI ST
W FLORIDA AVE
S LIPAN ST
0064-02
South Platte River
Overland Lake
Overland Pond
5000-03
W JEWELL AVE
Q2 = 0 cfs
Q5 = 0 cfs
Q100 = 349 cfs
W COLORADO AVE
W ASBURY AVE
W EVANS AVE
W PACIFIC PL
W ADRIATIC PL
W WARREN AVE
W BALTIC PL
W ILIFF AVE
W CASPIAN PL
W BAKER AVE
W HARVARD AVE
W WESLEY AVE
Asbury & Tejon
D1
D2
A
B
C
144/60
Harvey Park Lake
Ward Reservoir No. 5
Englewood
West Harvard Gulch
Harvard Gulch
5200-01
5200-02
5300-01
5500-01
0065-02
Arapahoe County
Arapahoe County
NOTE: Trans-basin flows shown with a heavy black arrow are based on existing storm drain systems, not proposed drainage improvements.
Proposed Projects
A - 18" UPGRADES : $264,939
B - S LIPAN ST OUTFALL : $5,004,361
C - S PECOS ST AND W ILIFF IMPROVEMENTS : $3,858,214
D1 - W EVANS AVE IMPROVEMENTS :$2,803,514
D2 - W EVANS AVE EXTENSION : $4,082,154
N
0
600
1,200
Feet
1 inch equals 1,200 feet
For Detailed Hydrology See Technical Appendix and Work Map
Legend
Collection System Boundary
Topographic Basin Boundary
Thalweg
Proposed Storm Pipe
UDFCD Study Recommendations
Proposed Pipe Disconnect
Existing Storm Pipe
Designed Storm Improvement
Existing Surface Flow
Significant Flooding Location
Proposed Detention Basin
Existing Basin
Potential Inundation Area
Planned Transit Line
Existing Transit Line
City and County Boundary
Other Municipalities
Other Counties
Basin 0065-01
Ruby Hill
Denver Storm Drainage Master Plan
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Basin 0065-02 (Dartmouth)

Existing System Description:

The Dartmouth Collection System 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.

The Dartmouth collection system 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.

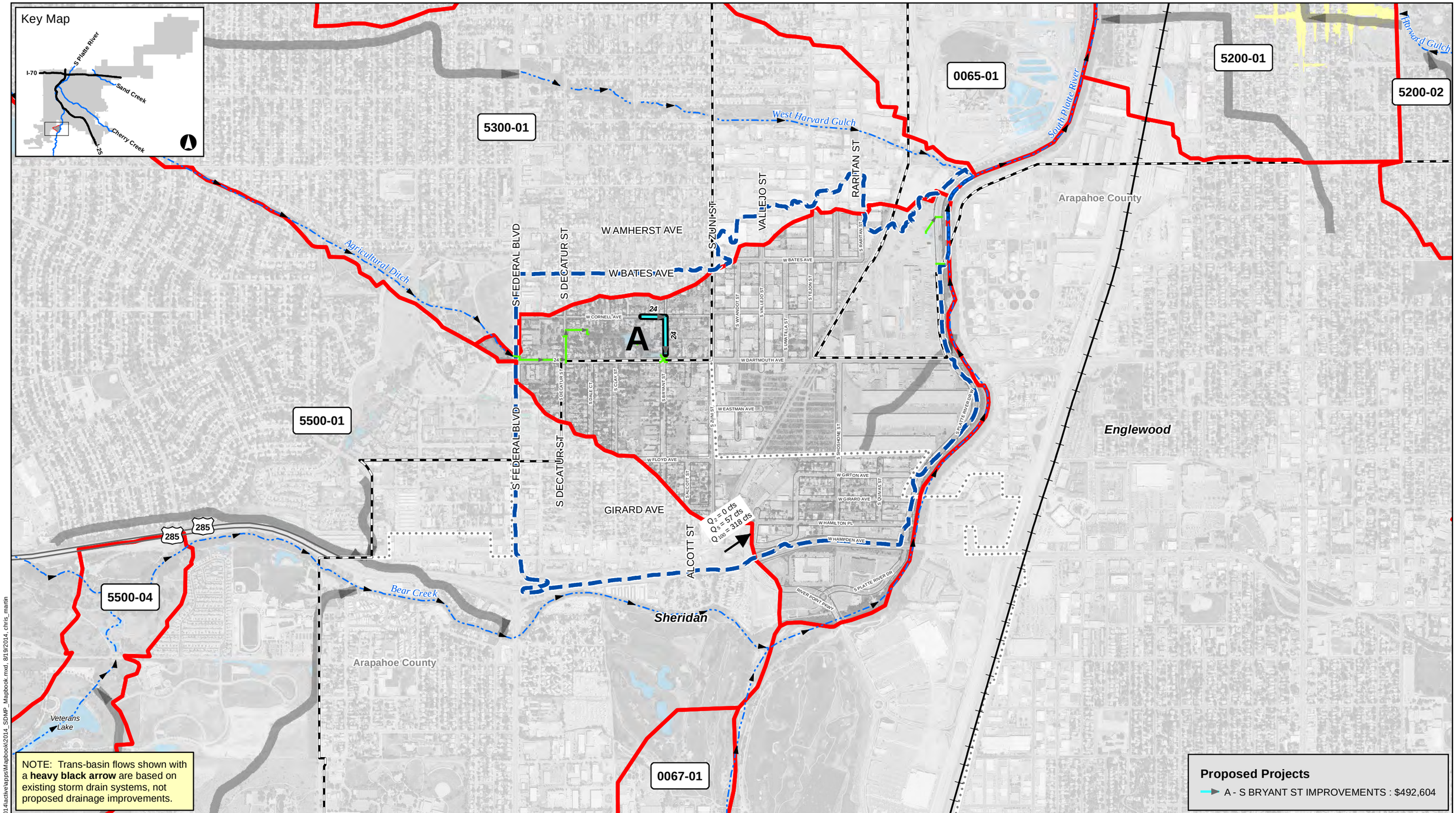
No outfall pipes in this basin are shown in the Denver GIS database since the outfall for this basin is in Englewood.

Drainage Deficiencies:

Currently this basin drains east to Englewood's storm drainage 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-inchx55-inch 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 drain is proposed.



Basin 0065-02
Dartmouth

Denver Storm Drainage Master Plan

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Basin 0067-01 (College View)

Existing System Description:

The College View Collection System Basin has a total drainage area of approximately 1.29 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 drain system within the College View Basin is adequately sized for the 2-year storm event. However, the storm drain 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 drain system and would benefit from a new lateral.

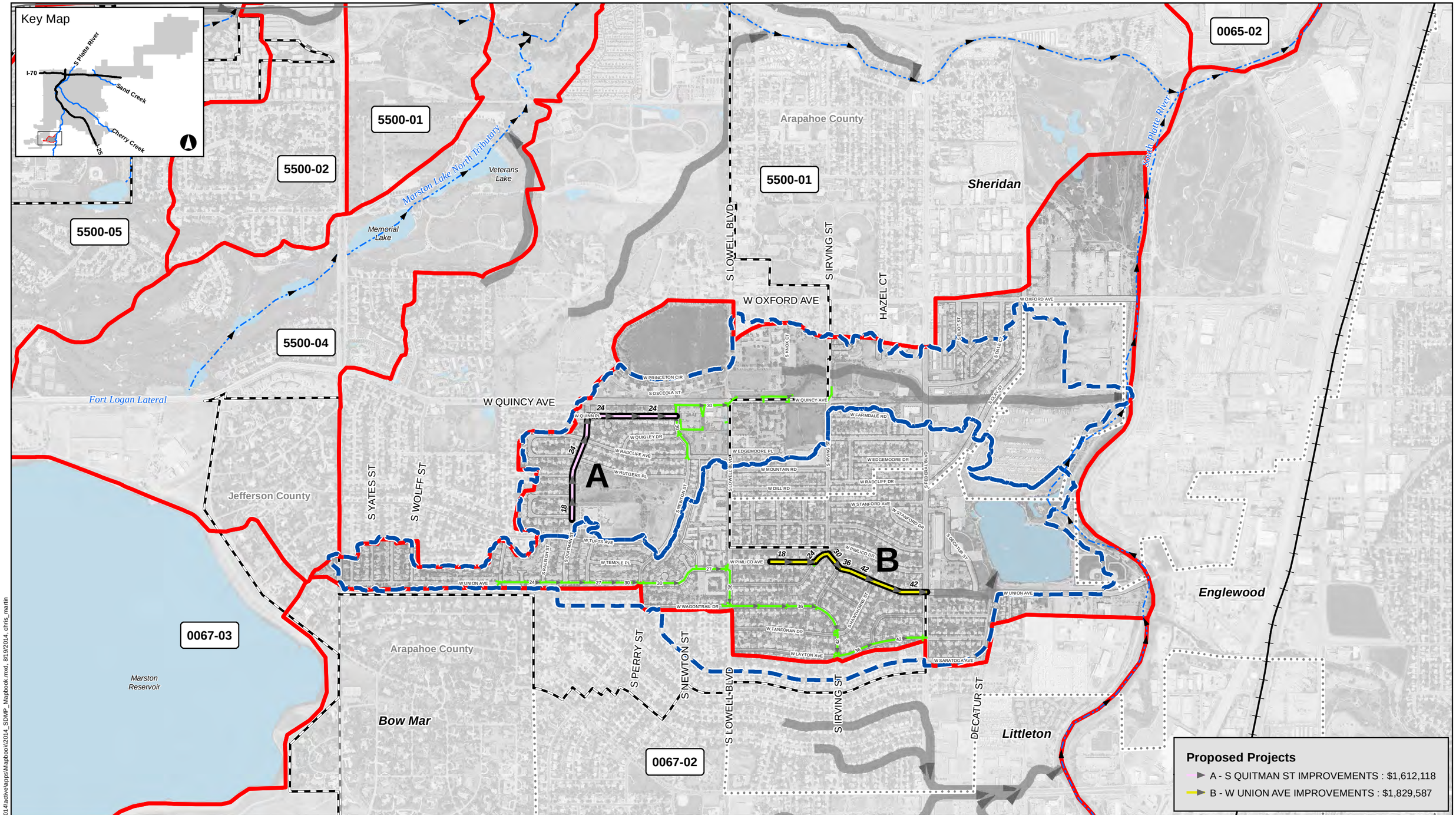
Proposed Capital Improvements:

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.

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

Project B: West Union Avenue Improvements
The existing storm drain system along West Union Avenue does not meet the minimum required performance objectives for a 5-year storm drain. Upsizing the existing storm drain system to a 42-inch 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.



N

0 600 1,200

Feet

1 inch equals 1,200 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Topographic Basin Boundary
- Thalweg
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
- Significant Flooding Location
- Proposed Detention Basin
- Existing Basin
- Potential Inundation Area
- Planned Transit Line
- Existing Transit Line
- City and County Boundary
- Other Municipalities
- Other Counties

Basin 0067-01 College View

Denver Storm Drainage Master Plan

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Basin 0067-02 (West Belleview)

Existing System Description:

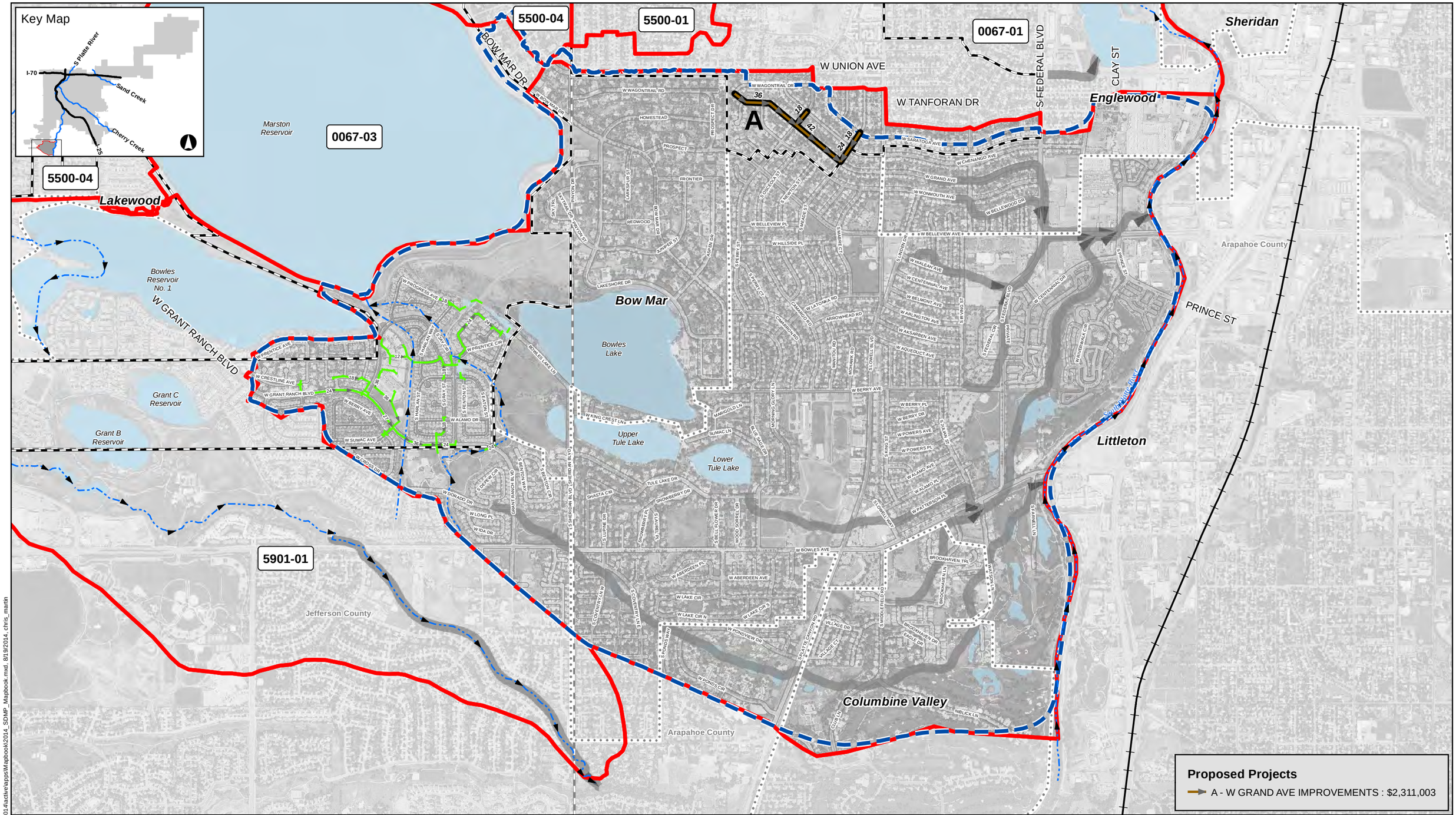
The West Belleview Collection System Basin has a total drainage area of approximately 4.21 square miles. This basin flows east through Denver and Littleton to its confluence with the South Platte River. The lower portion of this basin is outside the City and County of Denver and was not studied. The 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 drain 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 drain 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 drains. A 2-year capacity storm drain system is proposed along W. Grand Avenue and will connect to Englewood's storm drain system at W. Grand Avenue and S. Meade Street



Basin 0067-02
West Belleview

Denver Storm Drainage Master Plan

Basin 0067-03 (Marston Lake)

Existing System Description:

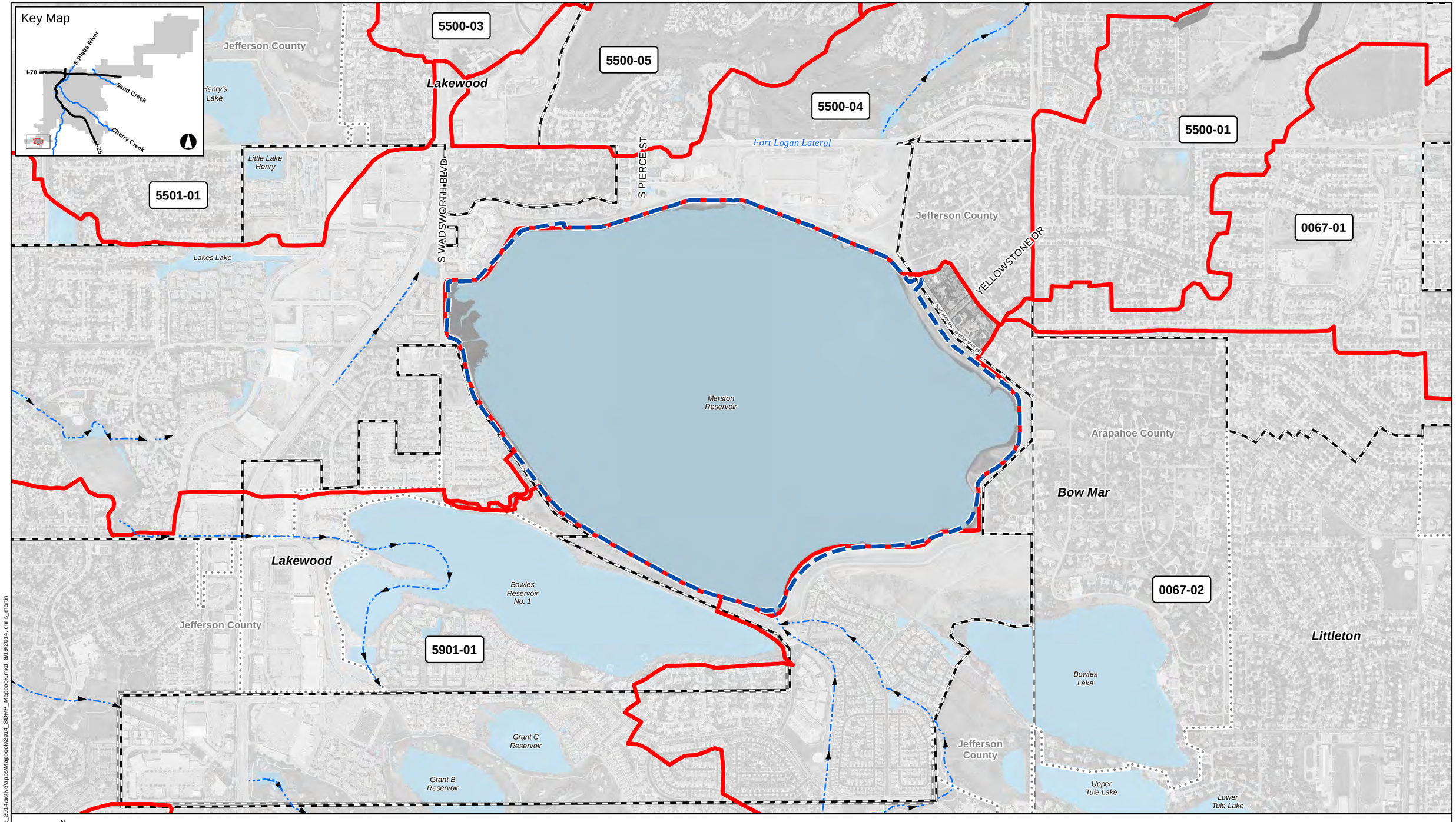
The Marston Lake Collection System Basin has a total drainage area of approximately 1.06 square miles. This basin is within Denver and has no outlet. A 12-foot high berm surrounds the reservoir, which is owned and operated by Denver Water for potable water storage, and keeps stormwater from entering 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.



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Feet

1 inch equals 1,200 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Topographic Basin Boundary
- Thalweg
- Proposed Storm Pipe
- UDFCD Study Recommendations
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- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
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- Proposed Detention Basin
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- Planned Transit Line
- Existing Transit Line
- City and County Boundary
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- Other Counties

Basin 0067-03
Marston Lake

Denver Storm Drainage Master Plan

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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 3.45 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 Collection System Basin. The land is mainly agricultural, with dryland farming and pasture in the upper reaches.

The High Line Canal terminates at the West Fork. The sustained unused flow in the High Line 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:

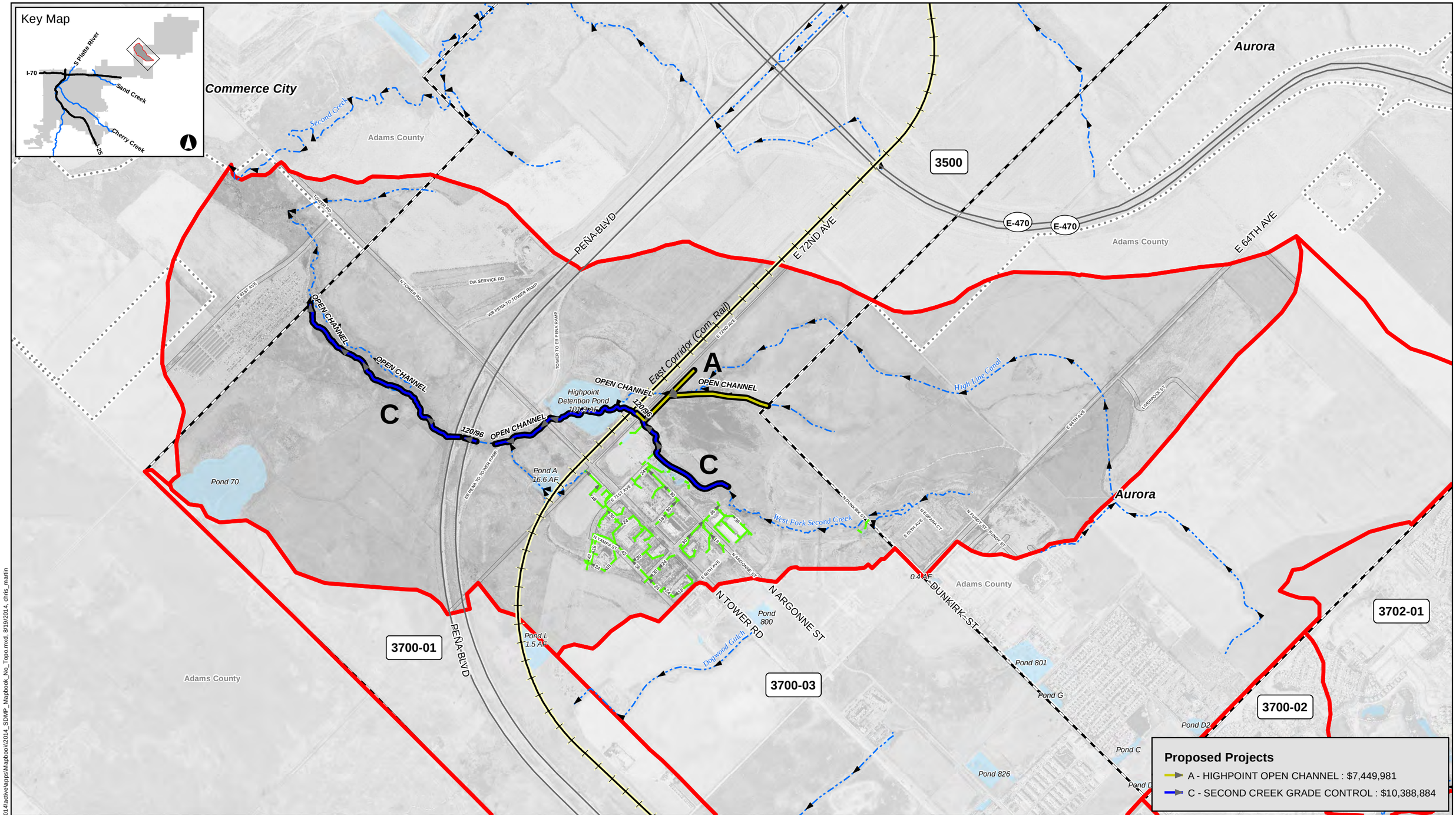
The drainage basin is currently mostly undeveloped with a low imperviousness. The ***Second Creek and Direct Flow Area 0053 Outfall Systems Planning Study, Preliminary Design*** completed by Kiowa Engineering for the Urban Drainage & Flood Control District in May 1990, assumes the upper reaches of the 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 basins 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: Highpoint Open Channel
The 101.9 acre-foot "Highpoint Pond" is located east of Tower Road and north of 72nd Avenue and was master planned to reduce flows to historic conditions in the West Fork Second Creek. 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.



0 750 1,500
Feet
1 inch equals 1,500 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
- Significant Flooding Location
- Proposed Detention Basin
- Existing Basin
- Potential Inundation Area
- Planned Transit Line
- Existing Transit Line
- City and County Boundary
- Other Municipalities
- Other Counties

Basin 3501-01
West Fork Second Creek

Denver Storm Drainage Master Plan

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Basin 3700-01 (First Creek & Peña Corridor)

Master Plan Design Parameters				
ID No.	**Peak Inflow (cfs)**	**Peak Outflow (cfs)**	**Volume (AF)**	**Jurisdiction**
305	2027	1929	269	Denver

Existing Basin Description:

The First Creek Collection System 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 and County of Denver and has been defined as the area within the wide Peña Boulevard corridor, owned by DIA, that will not experience further development. The east corridor of the light rail/commuter train was under construction east of Peña Boulevard at the time this report was published. A portion of the First Creek 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 Peña Boulevard and the new light rail/commuter train 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.

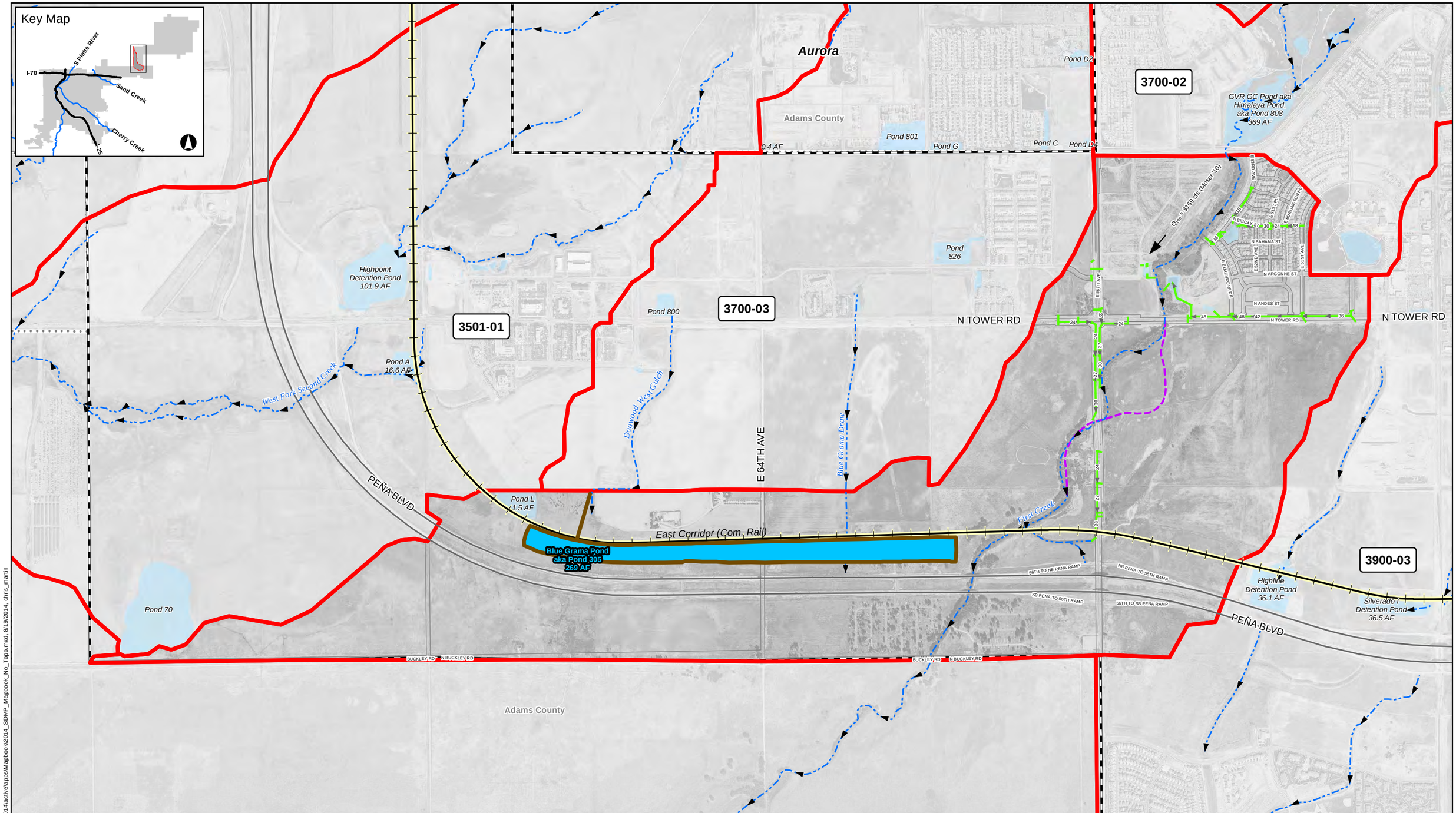
Proposed Capital Improvements:

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 basins 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. The ***First Creek (Upstream of Buckley Road) Major Drainageway Plan: Conceptual Design Report***, prepared by Moser & Associates for the UDFCD and published in August 2010, recommended channel improvements and floodplain preservation within Basin 3700-01.

Two regional detention facilities, the Blue Grama Draw detention pond and the Dogwood Gulch detention pond, were previously planned within this basin, within the Peña Boulevard corridor. The two basins have been combined into one basin, the Blue Grama Draw detention pond, as part of the RTD FasTracks East Corridor project, and further analysis is underway by the UDFCD to model these revisions, and amend UDFCD IGA No. 99-03.11 if needed.

Master Plan Agreements:

Many documents and agreements that specify 100-year discharges and storage volumes have been compiled for the First Creek Drainage Basin. 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 22, 2001, states the following for the Blue Grama Draw pond (#305):



N

0 700 1,400

Feet

1 inch equals 1,400 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
- Significant Flooding Location
- Proposed Detention Basin
- Existing Basin
- Potential Inundation Area
- Planned Transit Line
- Existing Transit Line
- City and County Boundary
- Other Municipalities
- Other Counties

Basin 3700-01
First Creek & Peña Corridor

Denver Storm Drainage Master Plan

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

Existing Basin Description:

Collection System Basin 3700-02 is primarily within the City and 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" and "Pond 808." 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 was master planned as 70% for the 2005 ***Storm Drainage Master Plan*** and in the 2009 ***Storm Drainage Master Plan*** it was lowered based on actual imperviousness. The new values have been carried forward to this Master Plan update. See ***First Creek (Upstream of Buckley Road) Major Drainageway Plan: Conceptual Design Report***, prepared by Moser & Associates for the UDFCD and published in August 2010, for flows upstream of E. 38th Avenue and N. Picadilly Road (DP 076).

Identified Drainage Problems/Deficiencies:

The basin is mostly developed and was 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 detention basins 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. The ***First Creek (Upstream of Buckley Road) Major Drainageway Plan: Conceptual Design Report*** recommended floodplain preservation within Basin 3700-02.

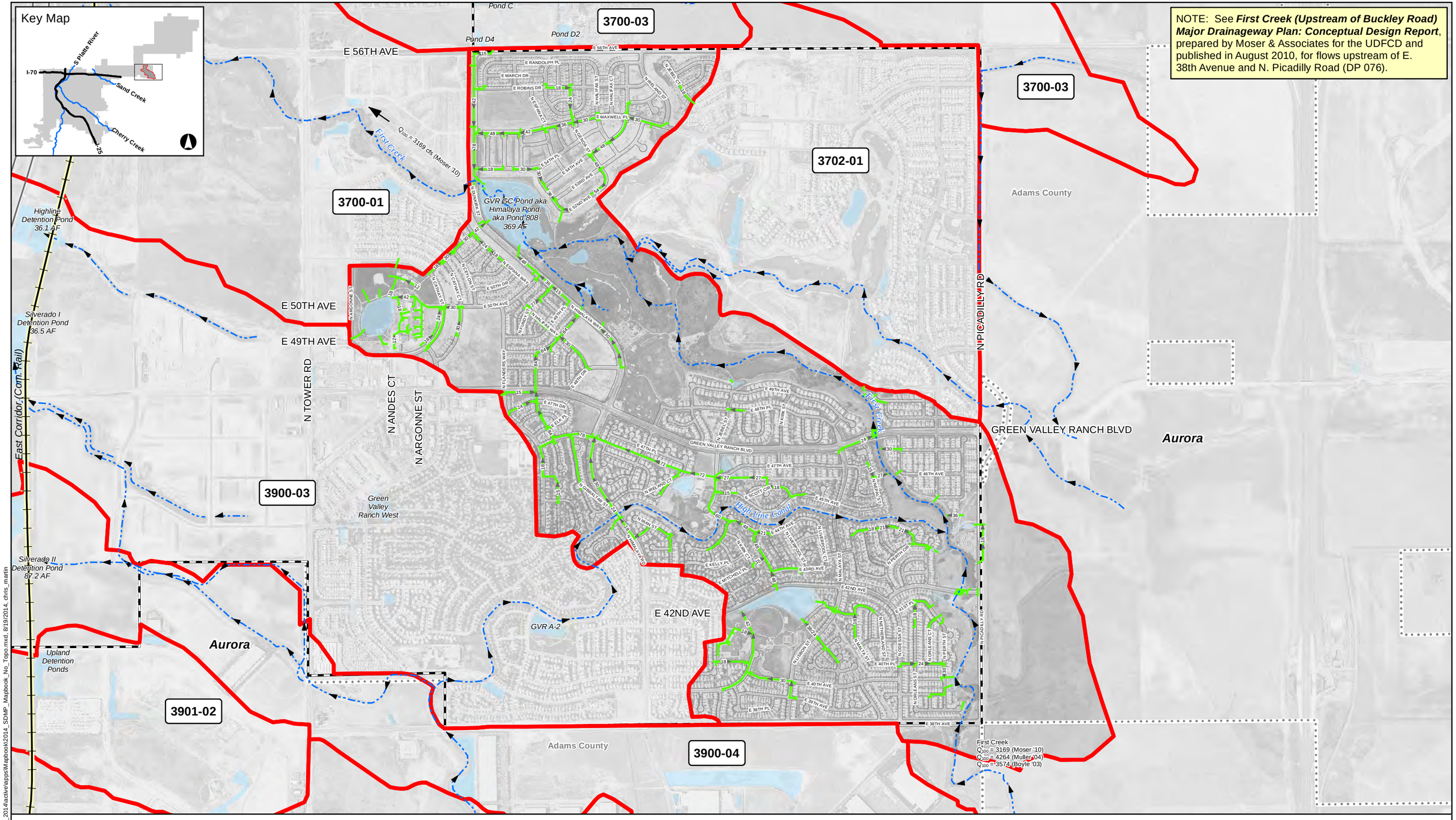
There are no additional planned improvements for the basin, beyond the capital construction required for the Green Valley Ranch development.

Master Plan Agreements:

Many documents and agreements have been compiled for the First Creek Drainage Basin. These documents specify 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 22, 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.


Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
3700-03
3702-01
3700-01
3900-03
3901-02
3900-04
Pond C
Pond D4
Pond D2
E 56TH AVE
E 50TH AVE
E 49TH AVE
E 42ND AVE
First Creek
Q100 = 3169 cfs (Moser '10)
GVR CC Pond aka Himalaya Pond aka Pond 808 369 AF
Highline Detention Pond 36.1 AF
Silverado I Detention Pond 36.5 AF
Silverado II Detention Pond 87.2 AF
Upland Detention Ponds
GVR A-2
Green Valley Ranch West
Adams County
Aurora
N TOWER RD
N ANDES CT
N ARGONNE ST
N PICADILLY RD
GREEN VALLEY RANCH BLVD
Eight Mile Canal
East Corridor (Com. Rail)
First Creek
Q100 = 3169 (Moser '10)
Q100 = 4264 (Muller '04)
Q100 = 3574 (Boyle '03)
NOTE: See First Creek (Upstream of Buckley Road) Major Drainageway Plan: Conceptual Design Report, prepared by Moser & Associates for the UDFCD and published in August 2010, for flows upstream of E. 38th Avenue and N. Picadilly Road (DP 076).
N
0 700 1,400
Feet
1 inch equals 1,400 feet
For Detailed Hydrology See Technical Appendix and Work Map
Collection System Boundary
Legend
Proposed Storm Pipe
UDFCD Study Recommendations
Proposed Pipe Disconnect
Existing Storm Pipe
Designed Storm Improvement
Existing Surface Flow
Significant Flooding Location
Proposed Detention Basin
Existing Basin
Potential Inundation Area
Planned Transit Line
Existing Transit Line
City and County Boundary
Other Municipalities
Other Counties
Basin 3700-02
Green Valley Ranch
Denver Storm Drainage Master Plan
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Basin 3700-03 (First Creek – Dogwood & Blue Grama Tribs.)

Existing Basin Description:

Collection System Basin 3700-03 is located within the City and 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," "High Point," and "Single Tree 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 detention basins 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. The ***First Creek (Upstream of Buckley Road) Major Drainageway Plan: Conceptual Design Report***, prepared by Moser & Associates for the UDFCD and published in August 2010, contained no recommendations in this basin.

Multiple detention basins 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 acre-foot detention basin 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 detention basin will serve to regulate increased flows from the development back into Dogwood Gulch as it enters the Peña corridor.

Project E: Blue Grama Draw Pond 802
This 33 acre-foot detention basin will be constructed as development occurs. It will be located immediately to the east of Tower Road, between 60th and 64th Avenues. This detention basin 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 40 acre-foot detention basin, in Aurora, will be constructed as development occurs. It will be located immediately to the north of 60th Avenue and to the west of the High Line Canal in Adams County. This detention basin will serve to regulate increased flows from the development back into Blue Grama Draw.

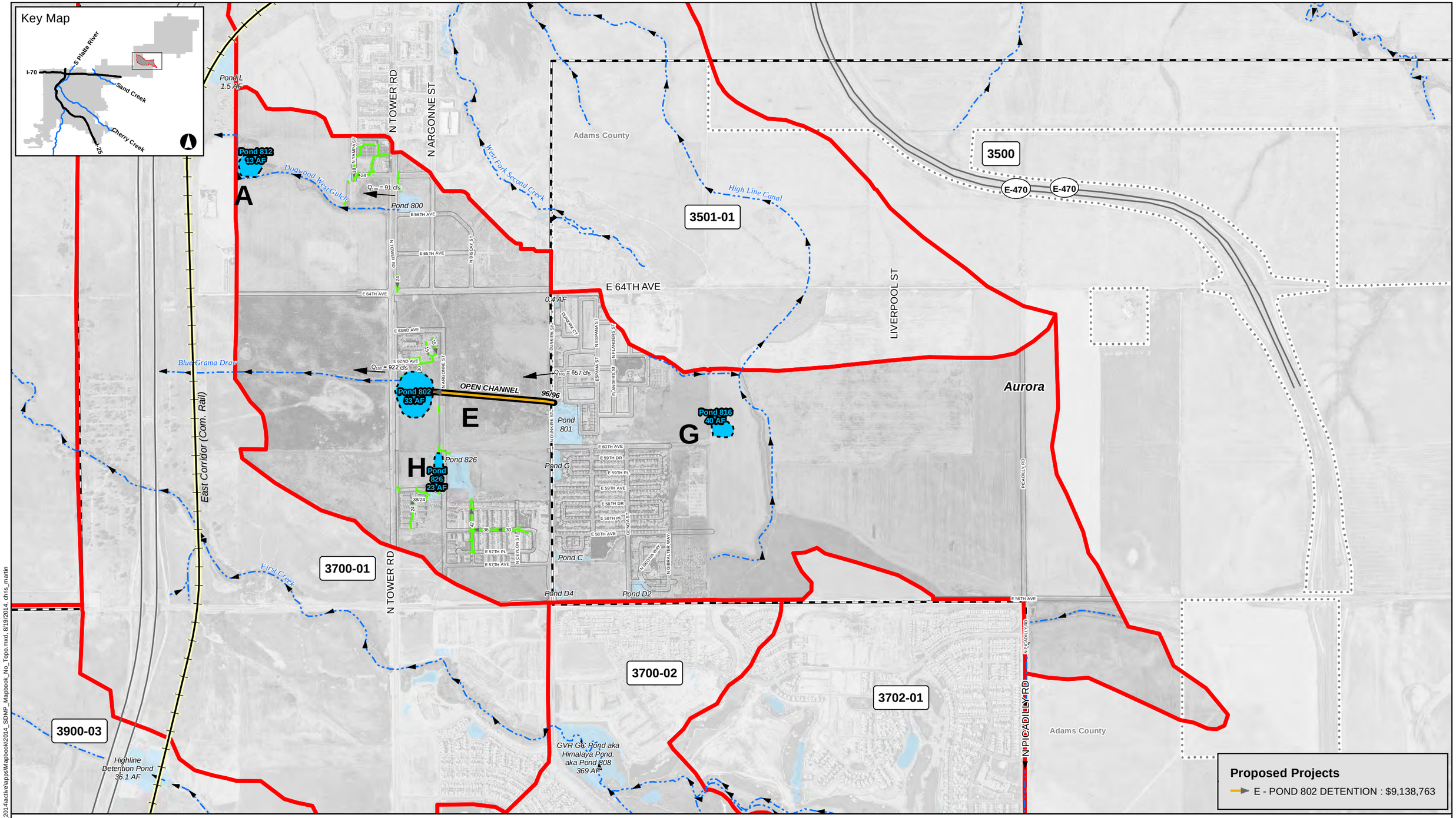
Project H: Blue Grama Draw Pond 826
This 23 acre-foot detention basin is partially constructed. It will be located immediately to the south of 60th Avenue, and will eventually be on both sides of Argonne Street. This detention basin will serve to regulate increased flows from the development back into Blue Grama Draw. Currently only a portion of this detention basin at the east side of Argonne Street is constructed, as only a portion of the tributary area is developed. The other portion of this detention basin 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 basin 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 that specify 100-year discharges and storage volumes have been compiled for the First Creek Drainage Basin. 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 2, 2001, states the following:

Master Plan Design Parameters				
ID No.	**Peak Inflow (cfs)**	**Peak Outflow (cfs)**	**Volume (AF)**	**Jurisdiction**
800	419	120	11	Denver
801	1226	655	37	Aurora
802	982	920	33	Denver
812	444	216	13	Denver
816	864	438	40	Aurora
826	589	180	23	Denver



Basin 3700-03
Dogwood & Blue Grama Tribs.

Denver Storm Drainage Master Plan

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

Existing Basin Description:

Collection System 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 0.91 square miles and will include future development and the Green Valley Ranch Golf Course. Overall master planned imperviousness is about 70%.

This tributary extends farther 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, Muller Engineering in 2003, and Moser & Associates Engineering in 2010. In addition, development engineers have also studied the basin and include Martin & Martin in 1998, Vestal Engineering in 2004, and Stantec in 2005. Other development engineers have also completed studies of the basin. See ***First Creek (Upstream of Buckley Road) Major Drainageway Plan: Conceptual Design Report***, prepared by Moser & Associates for the UDFCD and published in August 2010, for flows upstream of Green Valley Ranch Blvd. and N. Picadilly Road (DP 070).

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:

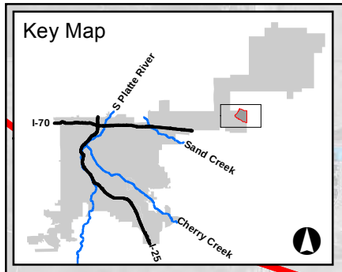
Urban Drainage & Flood Control District prepared drainage master plans prior to development of the basin and has required incorporation of regional water quality and detention into land planning. All development in the First Creek Drainage Basin must detain and treat water quality on-site or in regional detention basins 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. The ***First Creek (Upstream of Buckley Road) Major Drainageway Plan: Conceptual Design Report*** recommended floodplain preservation within Basin 3702-01.

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 that specify 100-year discharges and storage volumes have been compiled for the First Creek Drainage Basin. 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.

Key Map



NOTE: See ***First Creek (Upstream of Buckley Road) Major Drainageway Plan: Conceptual Design Report***, prepared by Moser & Associates for the UDFCD and published in August 2010, for flows upstream of Green Valley Ranch Blvd. and N. Picadilly Road (DP 070).

Pond 801
Pond G
Pond 826
Pond C
Pond D4
Pond D2
3700-03
Adams County
E 56TH AVE
N PICADILLY RD
3700-01
GVR GC Pond aka Himalaya Pond, aka Pond 808 369 AF
Adams County
Aurora
Tributary T
Q_{100} = 2492 (Moser '10)
Q_{100} = 4189 (Moser '08)
Q_{100} = 3718 (Muller '04)
Q_{100} = 2322 (Boyle '03)
Q_{100} = 2655 (TCB OSP)
Q_{100} = 2510 (Sellards & Grigg '01)
First Creek
GREEN VALLEY RANCH BLVD
Q_2 = 684 cfs
Q_5 = 1099 cfs
Q_{100} = 2492 cfs
3700-02
3900-03
Green Valley Ranch West
High Line Canal
Adams County

NOTE: Trans-basin flows shown with a **heavy black arrow** are based on existing storm drain systems, not proposed drainage improvements.

N
0 600 1,200
Feet
1 inch equals 1,200 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
- Significant Flooding Location
- Proposed Detention Basin
- Existing Basin
- Potential Inundation Area
- Planned Transit Line
- Existing Transit Line
- City and County Boundary
- Other Municipalities
- Other Counties

Basin 3702-01
Tributary "T"

Denver Storm Drainage Master Plan

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Basin 3900-01 (Irondale Gulch - Stapleton)

Existing Basin Description:

This collection system basin is located within Section 10 of the former airport, Stapleton Redevelopment site (City and 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 basins. There are also limitations to discharges into the Arsenal. The redevelopment of Stapleton will include detention to control runoff.

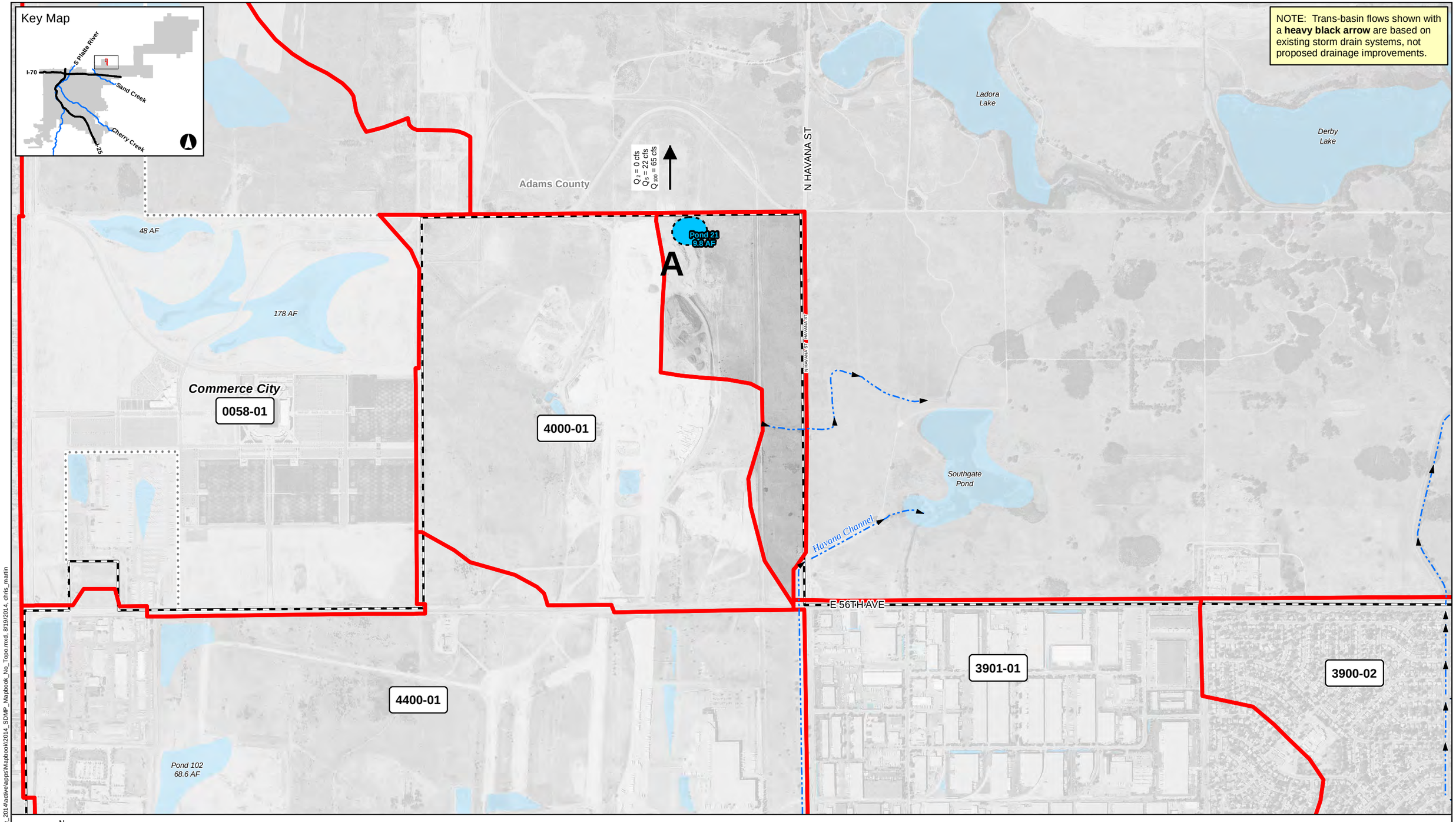
Identified Drainage Problems/Deficiencies:

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 basin, which will be constructed in this basin at the Denver border commensurate with development, to limit discharges to historic conditions. Proposed detention basin (Pond #21) is at the border of the Rocky Mountain Arsenal. This detention basin is estimated to be about 10 acre-feet and will release into the Arsenal at the defined historic rates.



N

0 600 1,200

Feet

1 inch equals 1,200 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
- Significant Flooding Location
- Proposed Detention Basin
- Existing Basin
- Potential Inundation Area
- Planned Transit Line
- Existing Transit Line
- City and County Boundary
- Other Municipalities
- Other Counties

Basin 3900-01
Stapleton

Denver Storm Drainage Master Plan

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Basin 3900-02 (Irondale Gulch – East Montbello)

Existing Basin Description:

This collection system 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 1,221 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 point, 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 that 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 Avenue.

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:

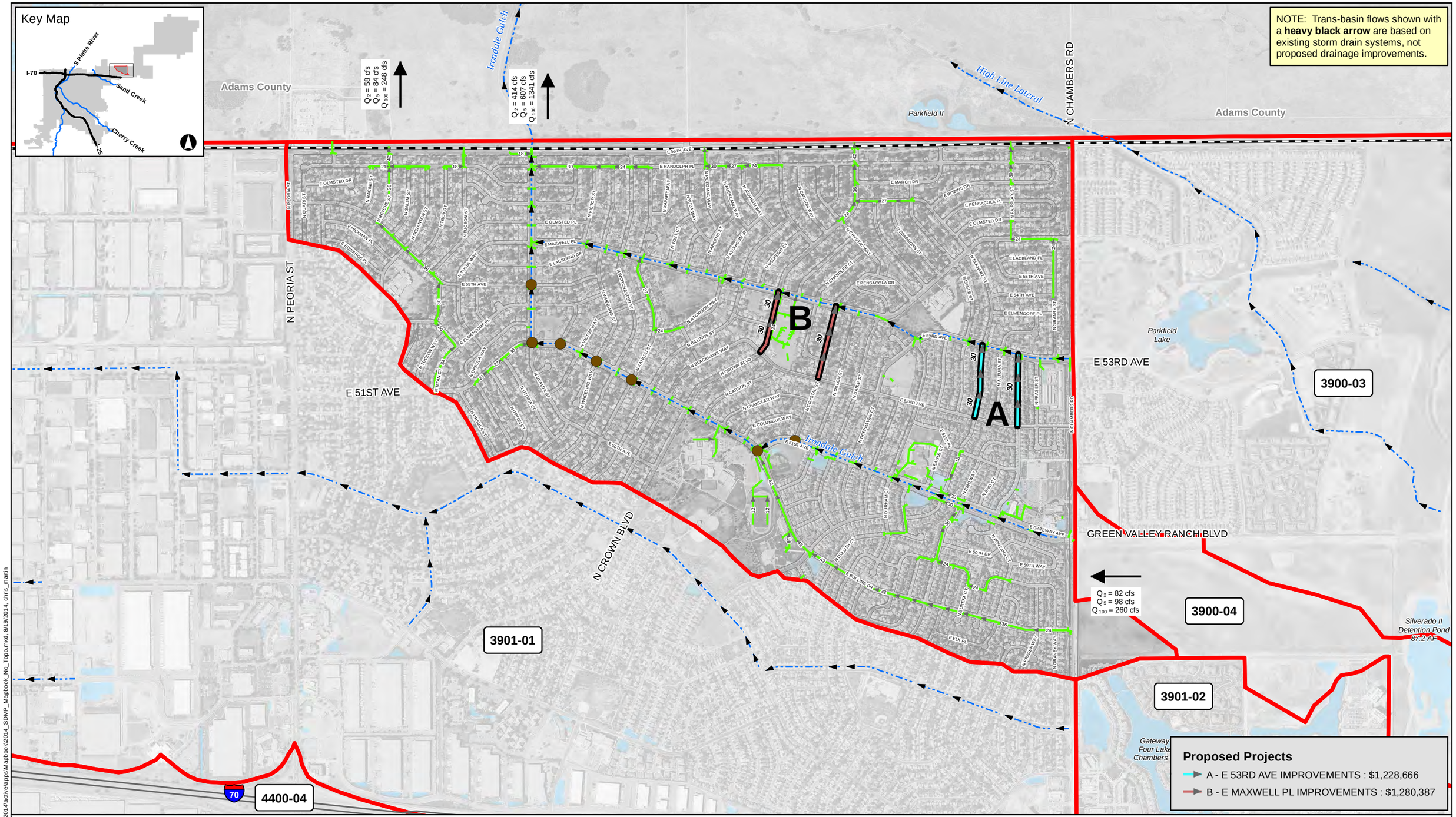
The 1990 study was completed to upgrade all facilities within the Montbello Area to 100-year capacity. The greatest constraint was the undersized road crossings over the open channels. By reconstructing these crossings, major conveyance facilities would be able to convey larger storm events. In areas 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. A site visit confirmed that four Irondale Gulch culverts along Uvalda Street have been upgraded in size; however, the remaining 7 culverts along Irondale Gulch 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.

The ***Irondale Gulch Outfall Systems Plan Conceptual Design Report*** was completed in 2011. Hydrology was updated for the entire Irondale Gulch watershed, including Basin 3900-02. The upper limit of proposed improvements in the OSP was the Denver/Adams County boundary and, therefore, no improvements were evaluated or shown in Denver.

<u>Project A: E 53rd Ave. Improvements and Project B: E Maxwell Pl. Improvements</u>
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 that specify 100-year discharges and storage volumes have been compiled for the Irondale Gulch Drainage Basin. 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. Refer to Urban Drainage & Flood Control District master plans for 100-year discharges.


Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
Adams County
Irondale Gulch
Q2 = 58 cfs
Q5 = 84 cfs
Q100 = 248 cfs
Q2 = 414 cfs
Q5 = 607 cfs
Q100 = 1341 cfs
High Line Lateral
Parkfield II
N CHAMBERS RD
Adams County
NOTE: Trans-basin flows shown with a heavy black arrow are based on existing storm drain systems, not proposed drainage improvements.
E 56TH AVE
N PEORIA ST
E 51ST AVE
E 53RD AVE
Parkfield Lake
3900-03
B
A
Irondale Gulch
N CROWN BLVD
GREEN VALLEY RANCH BLVD
Q2 = 82 cfs
Q5 = 98 cfs
Q100 = 260 cfs
3900-04
Silverado II Detention Pond 87.2 AF
3901-01
3901-02
4400-04
70
Proposed Projects
A - E 53RD AVE IMPROVEMENTS : $1,228,666
B - E MAXWELL PL IMPROVEMENTS : $1,280,387
N
0 600 1,200
Feet
1 inch equals 1,200 feet
For Detailed Hydrology See Technical Appendix and Work Map
Legend
Collection System Boundary
Proposed Storm Pipe
UDFCD Study Recommendations
Proposed Pipe Disconnect
Existing Storm Pipe
Designed Storm Improvement
Existing Surface Flow
Significant Flooding Location
Proposed Detention Basin
Existing Basin
Potential Inundation Area
Planned Transit Line
Existing Transit Line
City and County Boundary
Other Municipalities
Other Counties
Basin 3900-02
East Montbello
Denver Storm Drainage Master Plan
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Basin 3900-03 (Irondale Gulch - Parkfield)

Existing Basin Description:

This collection system 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 1,873 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 and Chambers.

Identified Drainage Problems/Deficiencies:

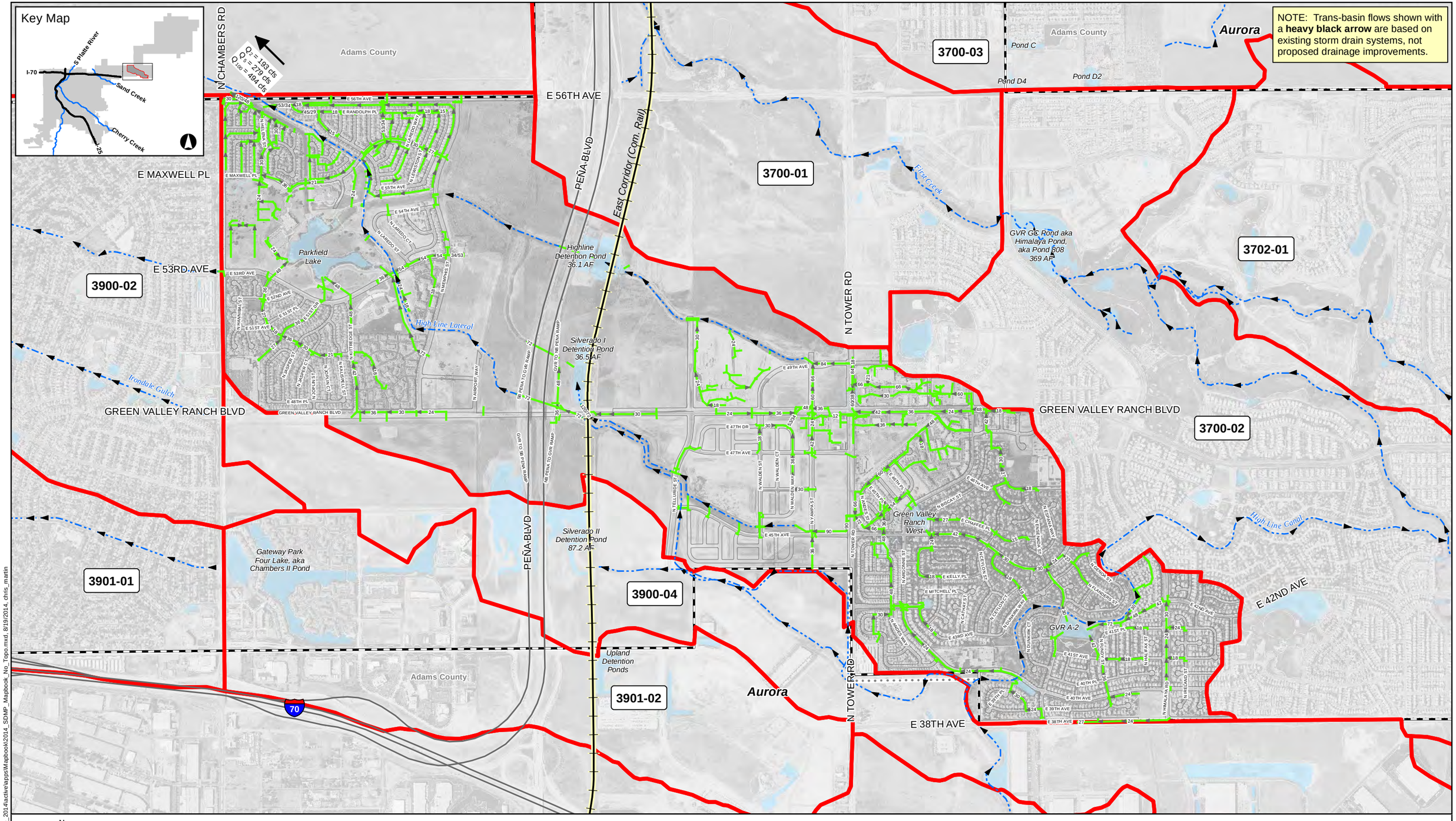
The Highline and Silverado I Ponds required modification due to impacts of the new RTD FasTracks East Corridor light rail/commuter train. The Highline Pond slightly exceeds, by 0.1 acre, the allowable surface acreage according to an internal memo between Denver, Aurora, and Denver International Airport (DIA) which sets the maximum pond acreage to 7.6 acres.

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. No additional potential capital improvements were proposed for this basin within the City and County of Denver reach.

The detention basins proposed in the ***Irondale Gulch Stormwater Outfall Systems Plan and Preliminary Design Report***, dated May 1990 by Wright Water Engineers have been constructed. The Irondale Gulch mainstem does not flow through Basin 3900-03 so no recommended crossing improvements apply to Basin 3900-03. The ***Irondale Gulch Outfall Systems Plan Conceptual Design Report*** was completed in 2011. Hydrology was updated for the entire Irondale Gulch watershed, including Basin 3900-03. The upper limit of proposed improvements in the OSP was the Denver/Adams County boundary and, therefore, no improvements were evaluated or shown in Denver.



Basin 3900-03
Parkfield

Denver Storm Drainage Master Plan

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Basin 3900-04 (Irondale Gulch – Majestic Commercenter)

Existing Basin Description:

This collection system 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 1,181 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 the 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 proposed 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.

An open channel, the Bolling Drive channel, was recently constructed downstream of Tower Road to convey flows from Aurora's Majestic Commercenter to the Silverado II detention Ponds and into Denver. The channel was designed for the 100-year event and was realigned to allow for development. A future culvert will be constructed under Tower Road by the City of Aurora.

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 proposed Chambers I detention Pond. This channel should be designed for the 100-year event.

The Silverado II detention Pond proposed in the ***Irondale Gulch Stormwater Outfall Systems Plan and Preliminary Design Report***, dated May 1990 by Wright Water Engineers has been constructed but the Chambers I Pond has not. The Irondale Gulch main stem does not flow through Basin 3900-04 so no recommended crossing improvements apply to Basin 3900-04. The ***Irondale Gulch Outfall Systems Plan Conceptual Design Report*** was completed in 2011. Hydrology was updated for the entire Irondale Gulch watershed, including Basin 3900-04. The upper limit of proposed improvements in the OSP was the Denver/Adams County boundary and, therefore, no improvements were evaluated or shown in Denver.

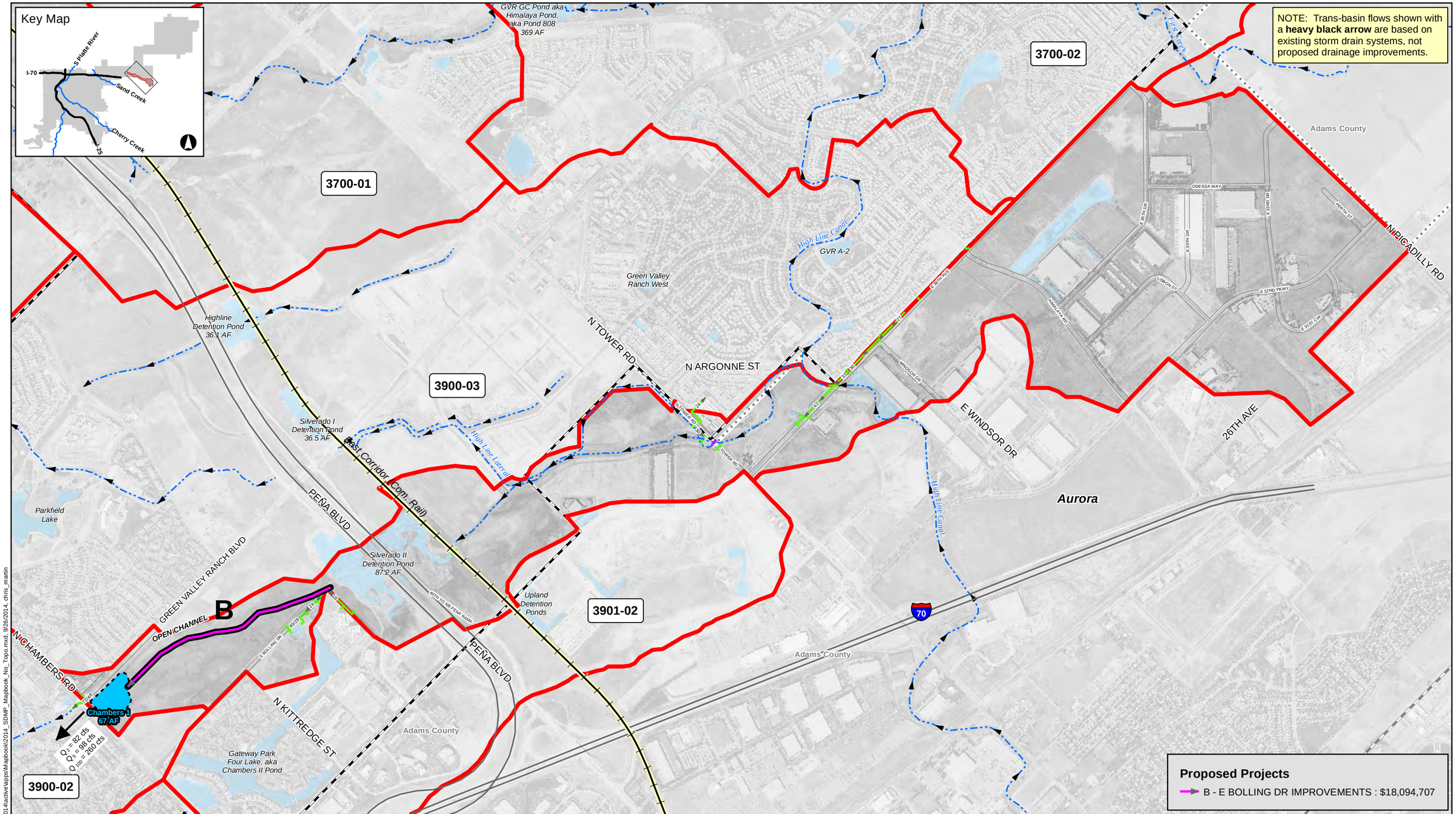
Master Plan Agreements:

Many documents and agreements that specify 100-year discharges and storage volumes have been compiled for the Irondale Gulch Drainage Basin. 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

After the 1995 agreement, the Silverado II Pond was constructed to have 87.2 acre-feet of storage. The Silverado II Pond required modification due to impacts of the new RTD FasTracks East Corridor light rail/commuter train. The East Corridor Memorandum of Understanding (MOU) between UDFCD and the Regional Transportation District (RTD) dated August 31, 2010 dictates that the required volume of the detention basin to be 87.2 acre-feet and the maximum surface area of the pond be 27.4 acres.



Basin 3900-04
Majestic Commerce Center

Denver Storm Drainage Master Plan

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Basin 3901-01 (Irondale Gulch – West Montbello)

Existing Basin Description:

This collection system 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. The ***Irondale Gulch Outfall Systems Plan Conceptual Design Report*** was completed in 2011. Hydrology was updated for the entire Irondale Gulch watershed, including Basin 3901-01. The upper limit of proposed improvements in the OSP was the Denver/Adams County boundary and, therefore, no improvements were evaluated or shown in Denver.

Project A: 18 Inch Upgrades
Pipes smaller than 18-inch 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.

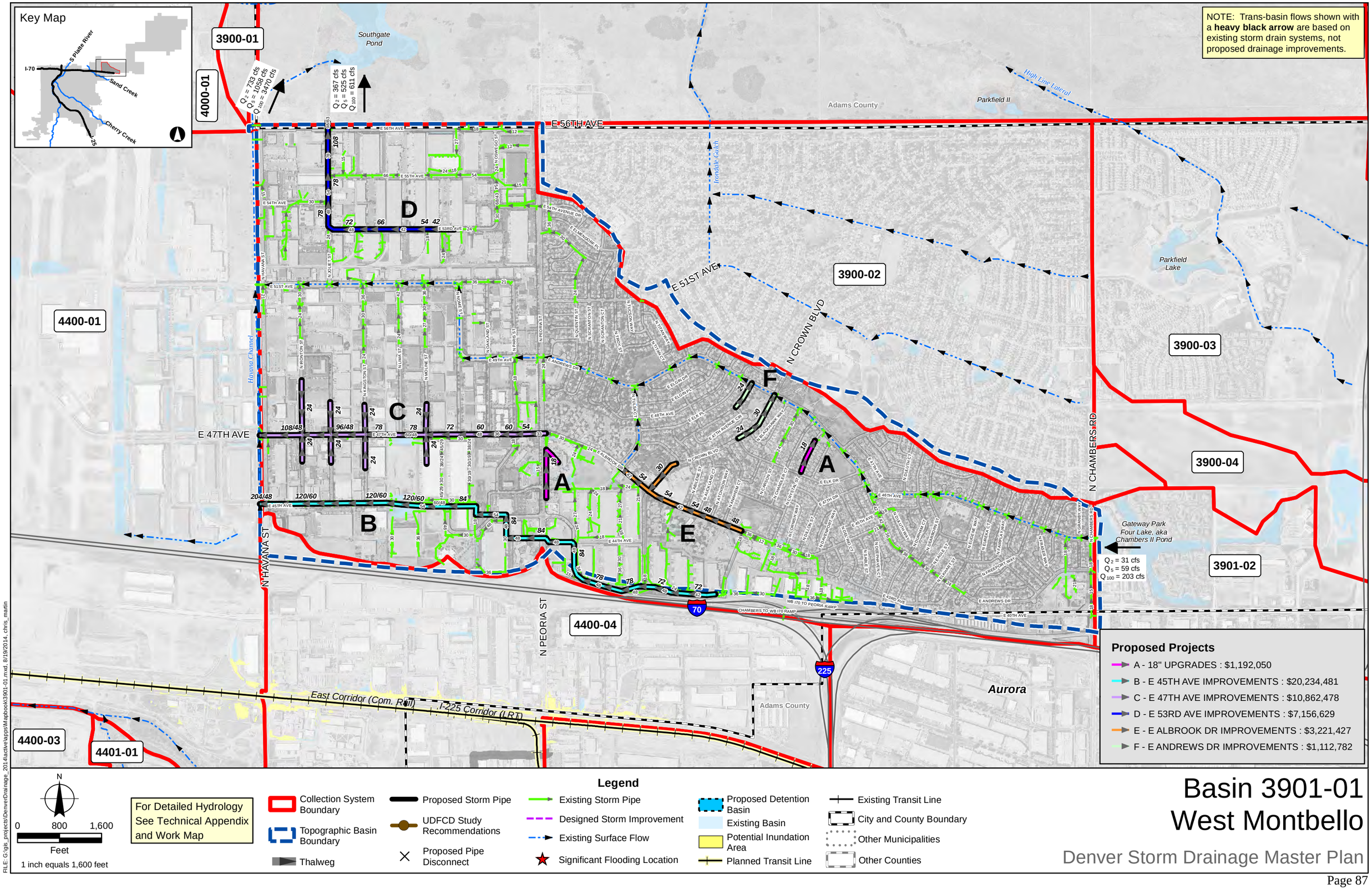
Project B: E 45th Ave. Improvements
This is an example where the open channel and road crossings cannot convey the developed 5-year flows. The channel can be replaced with a 2-102-inchx48-inch RCBC from the Havana crossing to Ironton then a 120-inchx 60-inch RCBC is proposed to continue upstream and terminate at approximate 800 feet upstream of Design Point 2. For further upstream, the 84-inch, 78-inch and 72-inch 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-inchx48-inch RCBC in 47th Avenue from Havana to Joliet, and a 96-inchx48-inch RCBC from Joliet to Kingston. Upstream of the intersection of 47th Avenue and Kingston Street to Design Point 24, the existing 60-inchx48-inch RCBC and 48-inch RCP are also not capable of conveying the 5-year discharge. New 78-inch, 72-inch, 60-inch and 54-inch 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-inch pipe is not adequate to convey 5-year flows and must be replaced with a 108-inch 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.



Basin 3901-01
West Montbello

Denver Storm Drainage Master Plan

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Basin 3901-02 (Irondale Gulch – Gateway)

Existing Basin Description:

This collection system 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:

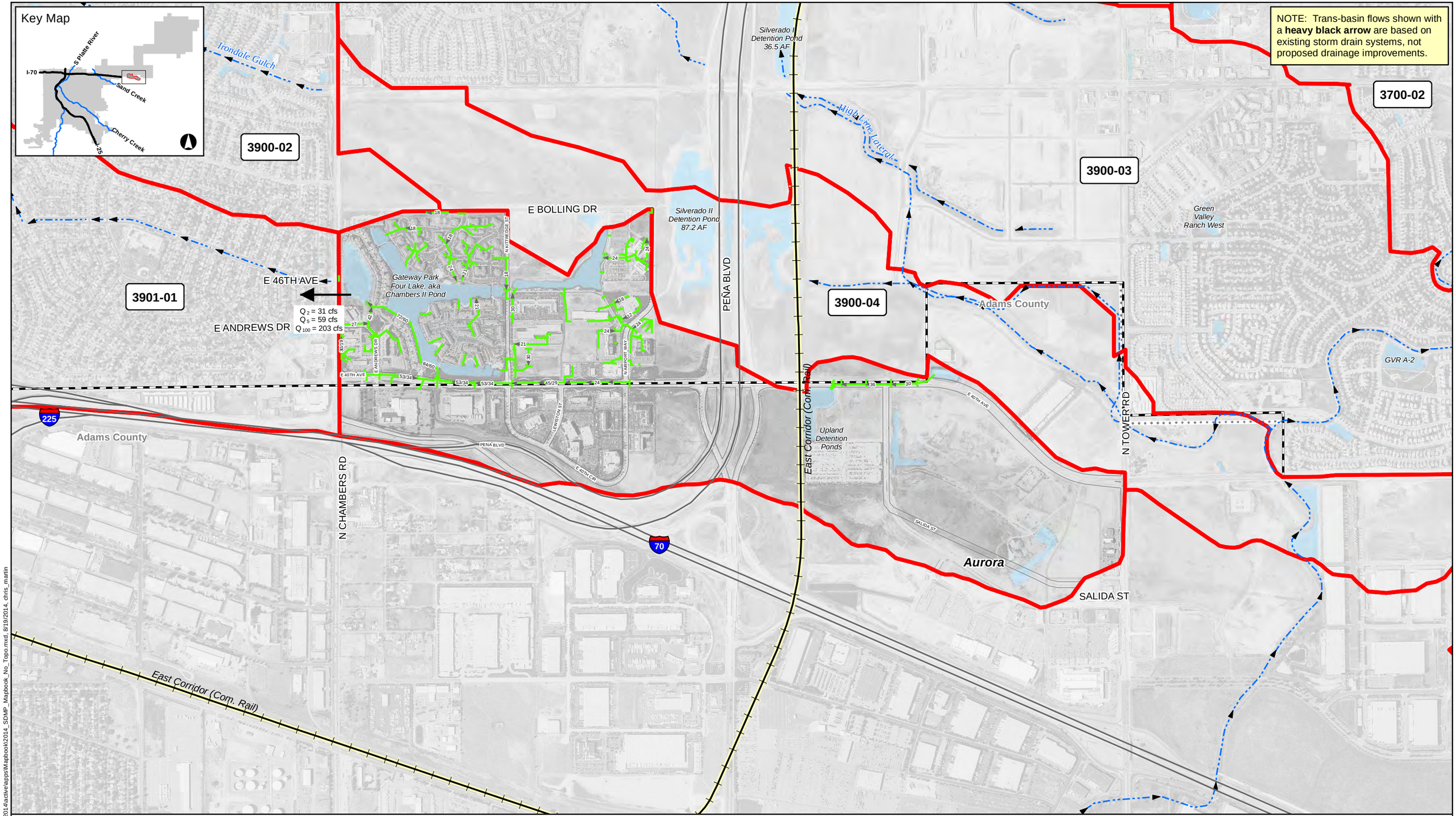
The ***Irondale Gulch Stormwater Outfall Systems Plan and Preliminary Design Report***, dated May 1990 by Wright Water Engineers showed detention basins that are regulated by later agreements, as described below. Necessary drainage capital improvements will be constructed by the developer to meet current drainage criteria.

The ***Irondale Gulch Outfall Systems Plan Conceptual Design Report*** was completed in 2011. Hydrology was updated for the entire Irondale Gulch watershed, including Basin 3901-02. The upper limit of proposed improvements in the OSP was the Denver/Adams County boundary and, therefore, no improvements were evaluated or shown in Denver.

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 Ponds	948	56	42	Aurora UP Realty
Chambers II Pond*	663	219	32	Denver UP Realty

*The Chambers II Detention Pond has been constructed and is located between E. 40th Avenue and E. Bolling Drive, east of N. Chambers Road. It is commonly known as Gateway Park Four Lake as shown on the accompanying map.



N

0 600 1,200

Feet

1 inch equals 1,200 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
- Significant Flooding Location
- Proposed Detention Basin
- Existing Basin
- Potential Inundation Area
- Planned Transit Line
- Existing Transit Line
- City and County Boundary
- Other Municipalities
- Other Counties

Basin 3901-02
Gateway

Denver Storm Drainage Master Plan

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Basin 4000-01 (Stapleton West Section 10)

Existing Basin Description:

This collection system basin known as Section 10 on the Stapleton site is a tributary to the South Platte River, and is located entirely in the City and County of Denver. The basin consists of about 476 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.*

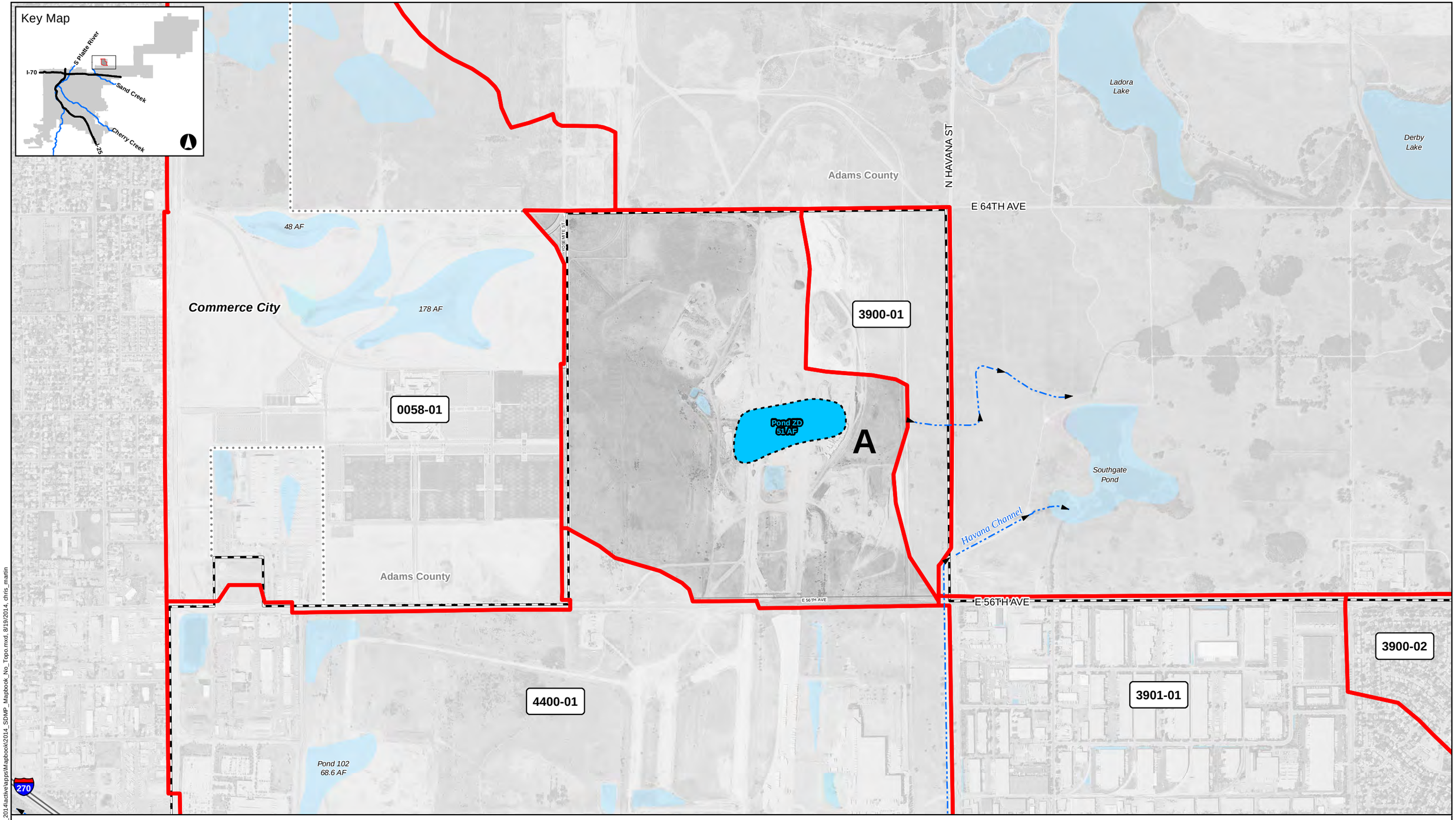
***Reference: BRW, Inc. "Stapleton Infrastructure Master Plan - Section 5," March 2001.*

Potential Improvements:

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

Project A: Pond ZD

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 basin will store approximately 51 acre-feet of runoff in a 100-year event.



Basin 4000-01
Stapleton West Section 10

Denver Storm Drainage Master Plan

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

Existing System Description:

This collection system 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-inch 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 and County 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:

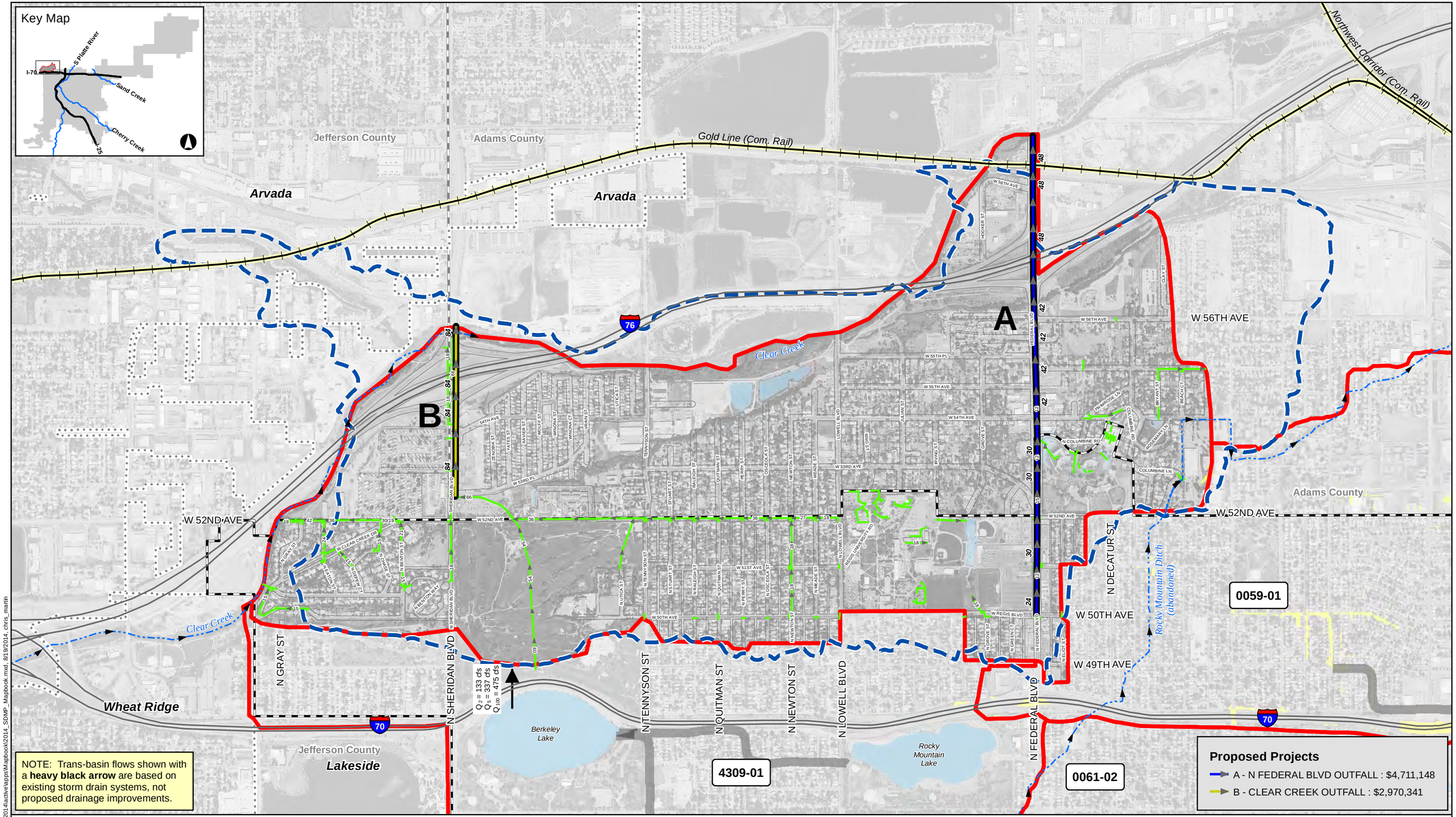
The 12-inch pipe in Federal, which continues to its outfall in Arvada, is undersized.

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.


Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
Jefferson County
Adams County
Arvada
Arvada
Gold Line (Com. Rail)
Northwest Corridor (Com. Rail)
W 58TH AVE
HOOKER ST
A
B
W 56TH AVE
W 55TH PL
W 55TH AVE
W 54TH AVE
W 53RD PL
W 53RD AVE
W 52ND AVE
W 51ST AVE
W 50TH AVE
W REGIS BLVD
W 49TH AVE
W 52ND AVE
Clear Creek
54TH AVE
W CLEAR CREEK DR
N GRAY ST
N SHERIDAN BLVD
N TENNYSON ST
N QUITMAN ST
N NEWTON ST
N LOWELL BLVD
N FEDERAL BLVD
N DECATUR ST
Rocky Mountain Ditch (abandoned)
Wheat Ridge
Jefferson County
Lakeside
Berkeley Lake
Rocky Mountain Lake
Adams County
0059-01
4309-01
0061-02
Q2 = 133 cfs
Q5 = 337 cfs
Q100 = 475 cfs
NOTE: Trans-basin flows shown with a heavy black arrow are based on existing storm drain systems, not proposed drainage improvements.
Proposed Projects
A - N FEDERAL BLVD OUTFALL : $4,711,148
B - CLEAR CREEK OUTFALL : $2,970,341
N
0 600 1,200
Feet
1 inch equals 1,200 feet
For Detailed Hydrology See Technical Appendix and Work Map
Legend
Collection System Boundary
Topographic Basin Boundary
Thalweg
Proposed Storm Pipe
UDFCD Study Recommendations
Proposed Pipe Disconnect
Existing Storm Pipe
Designed Storm Improvement
Existing Surface Flow
Significant Flooding Location
Proposed Detention Basin
Existing Basin
Potential Inundation Area
Planned Transit Line
Existing Transit Line
City and County Boundary
Other Municipalities
Other Counties
Basin 4300-03
North of I-70
Denver Storm Drainage Master Plan
FILE: G:\gis_projects\DenverDrainage_2014\active\apps\Mapbook\2014_SDMP_Mapbook.mxd 8/19/2014 chris_martin

Basin 4309-01 (Berkeley Lake)

Existing System Description:

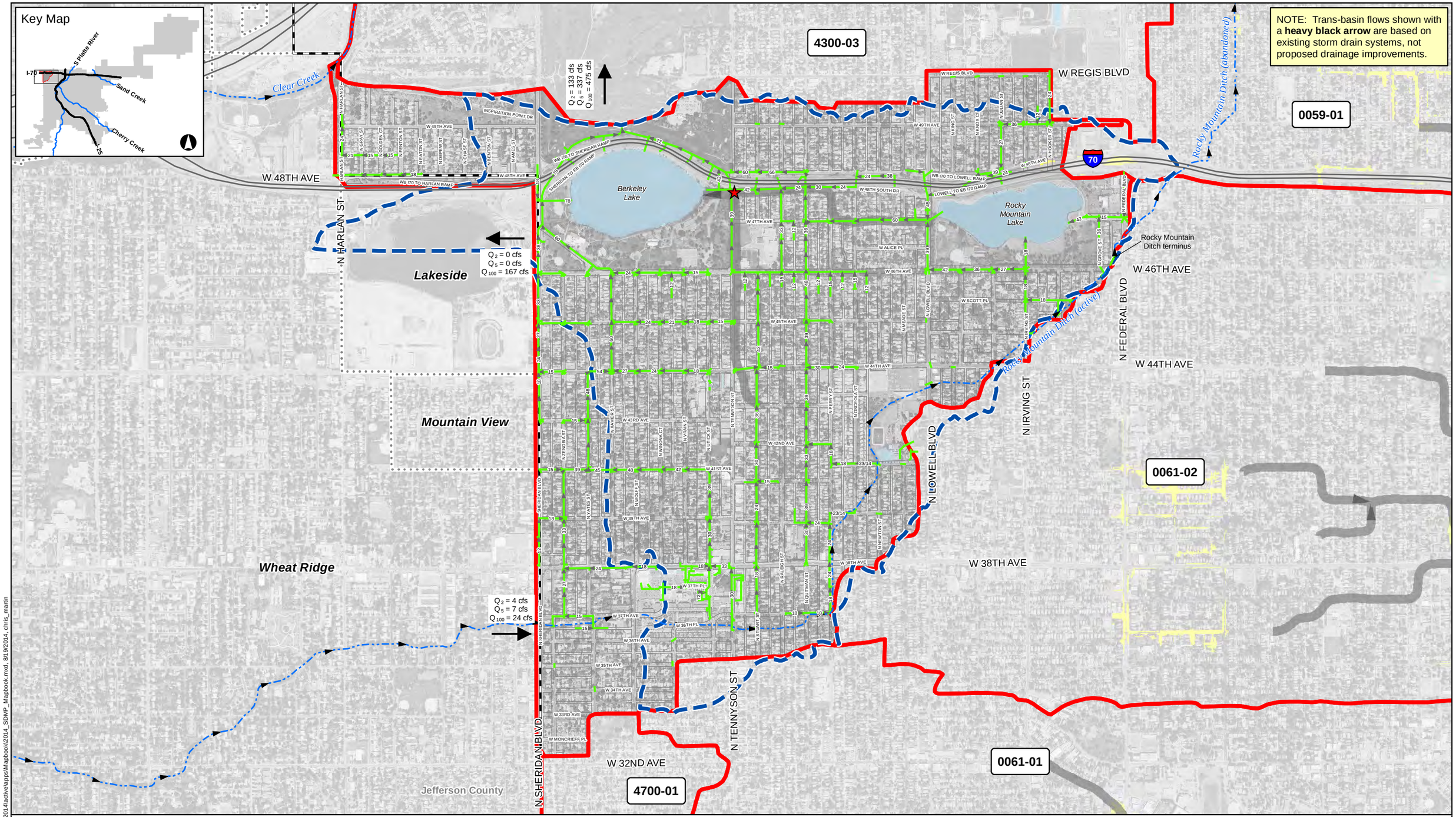
This collection system basin drains to Clear Creek and is generally bound by Sheridan Boulevard on the west, Regis Boulevard on the north, 35th Avenue on the South, and the Rocky Mountain Ditch on the east. Approximately half of the basin drains to the intersection of Sheridan Boulevard and I-70, while the other half drains to the Tennyson Street and I-70 intersection. Runoff from these two intersections is conveyed via large storm drain 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-inch 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 and County of Denver in 2005, and the proposed 60-inch 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.



N

0 600 1,200

Feet

1 inch equals 1,200 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Topographic Basin Boundary
- Thalweg
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
- Significant Flooding Location
- Proposed Detention Basin
- Existing Basin
- Potential Inundation Area
- Planned Transit Line
- Existing Transit Line
- City and County Boundary
- Other Municipalities
- Other Counties

Basin 4309-01
Berkeley Lake

Denver Storm Drainage Master Plan

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Basin 4400-01 (North Stapleton)

Existing System Description:

This collection system basin consists of 2,468 acres (3.86 square miles) and will be mostly re-built with the redevelopment of Stapleton. ***Blueprint Denver*** shows the entire basin within the City and 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-foot x 7-foot box culvert in 49th Avenue and a 66-inch 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:

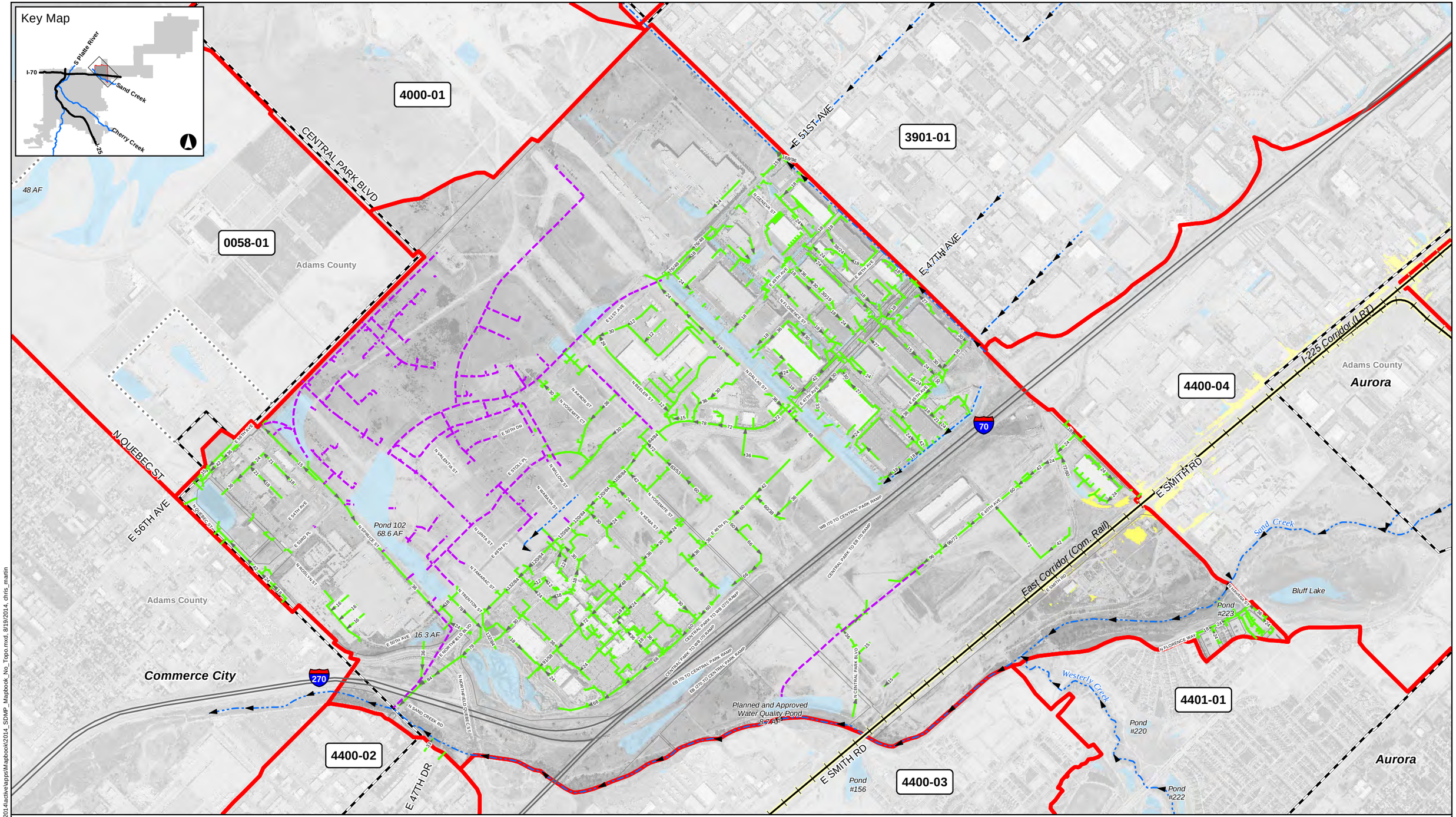
The Sand Creek floodplain significantly encumbers the site between Sand Creek and I-70. FEMA Flood Insurance Rate Maps (FIRM) for the Stapleton site shows large floodplain areas resulting from Sand Creek breaching levees along the river edge. I-70 is also shown as being inundated during a 100-year flood 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 basins to dry between storms.

Proposed Capital Improvements:

Proposed capital improvement projects for this basin are being constructed as part of the Stapleton Development, Park Creek Metropolitan District. A number of previous studies 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 and 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, the ***Infrastructure Master Plan*** prepared by BRW, Inc. in December 2000 and approved by Denver Wastewater in April 2001, and *the* ***North Stapleton Infrastructure Master Plan*** prepared by Matrix Design Group, Inc., and approved by Denver Wastewater in December 2006. The most current documents are the ***North Stapleton Infrastructure Master Plan Major Amendment No. 2*** prepared by Matrix Design Group, Inc. in January 2012 and the ***Filing 42 North Stapleton Final Drainage Report*** prepared by Matrix Design Group, Inc. in March 2013.

Subsequent to the ***2008 Storm Master Plan***, additional filings (25, 36, 37, 39, 41, 42, 43, and 44) have been submitted and approved by Denver Development Services.



0 700 1,400
Feet
1 inch equals 1,400 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
- Significant Flooding Location
- Proposed Detention Basin
- Existing Basin
- Potential Inundation Area
- Planned Transit Line
- Existing Transit Line
- City and County Boundary
- Other Municipalities
- Other Counties

Basin 4400-01
North Stapleton

Denver Storm Drainage Master Plan

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Basin 4400-02 (Quebec Corridor)

Existing System Description:

This collection system basin includes a mix of industrial and residential land uses to the west of Stapleton along Quebec. It consists of 2,822 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. Specific deficiencies include:

- 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 E. Smith Road.
- A localized sump condition exists at Martin Luther King Jr. Boulevard and Eudora Street, with flooding reported as early as the 1960's.
- A localized sump condition in the 3300 block of N. Olive Street and a 12-inch diameter storm drain causes water to pond up to the home foundations.

Potential Inundation Areas:

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 as well as generally undersized storm drainage facilities resulting in street flow depths greater than the City's drainage criteria.

Hydraulic analysis of the basin indicates the potential for storm water inundation greater than 12-inches deep in the gutter to occur at the following locations:

- Niagara Street between 19th Avenue and 26th Avenue
- Monaco Parkway between 36th Avenue and 39th Avenue
- Niagara Street between 35th Avenue and 36th Avenue
- 36th Avenue between Niagara Street and Monaco Parkway
- Ivy and Ivanhoe Streets between Martin Luther King Boulevard and 35th Avenue
- Holly Street between 35th Avenue and 39th Avenue
- 39th Avenue from Monaco Parkway to Holly Street
- Jasmine Street between 26th Avenue and 29th Avenue
- Forest Street from 39th Avenue to Smith Road
- Dahlia Street from Martin Luther King Boulevard to 38th Avenue
- Along Smith Road from Grape Street to Colorado Boulevard
- Eudora Street from 29thAvenue to 38th Avenue
- Smith Road between Dahlia Street and Forest Street

Proposed Capital Improvements:

Drainage improvements proposed in this plan primarily attempt 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 were developed during the Atkins drainage study titled ***Sand Creek (4400-02) and Upper Park Hill (0060-01, 4400-02 & 4500-01) Basins Final Drainage Study***, dated July 2011. The improvements proposed below are taken directly from the 2011 study for the minor 2- and 5-year design frequency (Alternative 1A). Additionally, a 100-year major-event design sizing alternative is included from the study (Alternative 1B).

Project A: 39th Avenue/Elm Street Improvements
The existing system along Eudora Street will be joined by a lateral in 35th Avenue and will be upsized from a 48-inch pipe to a 60-inch pipe from 36th Avenue and Elm Street to 39th Avenue and Grape Street.

Project B1: 38th Avenue and Holly Street Collector
A new storm drain network is needed to convey the 2-year flows from Project B2 - 38th Avenue and Holly Street Collector Extension, and local sub basins to Project D - 38th Avenue Interceptor. A 60-inch to 72-inch trunk line is proposed along Krameria Street, 35th Avenue, Magnolia Street, and 29th Avenue, with a few additional collection laterals proposed.

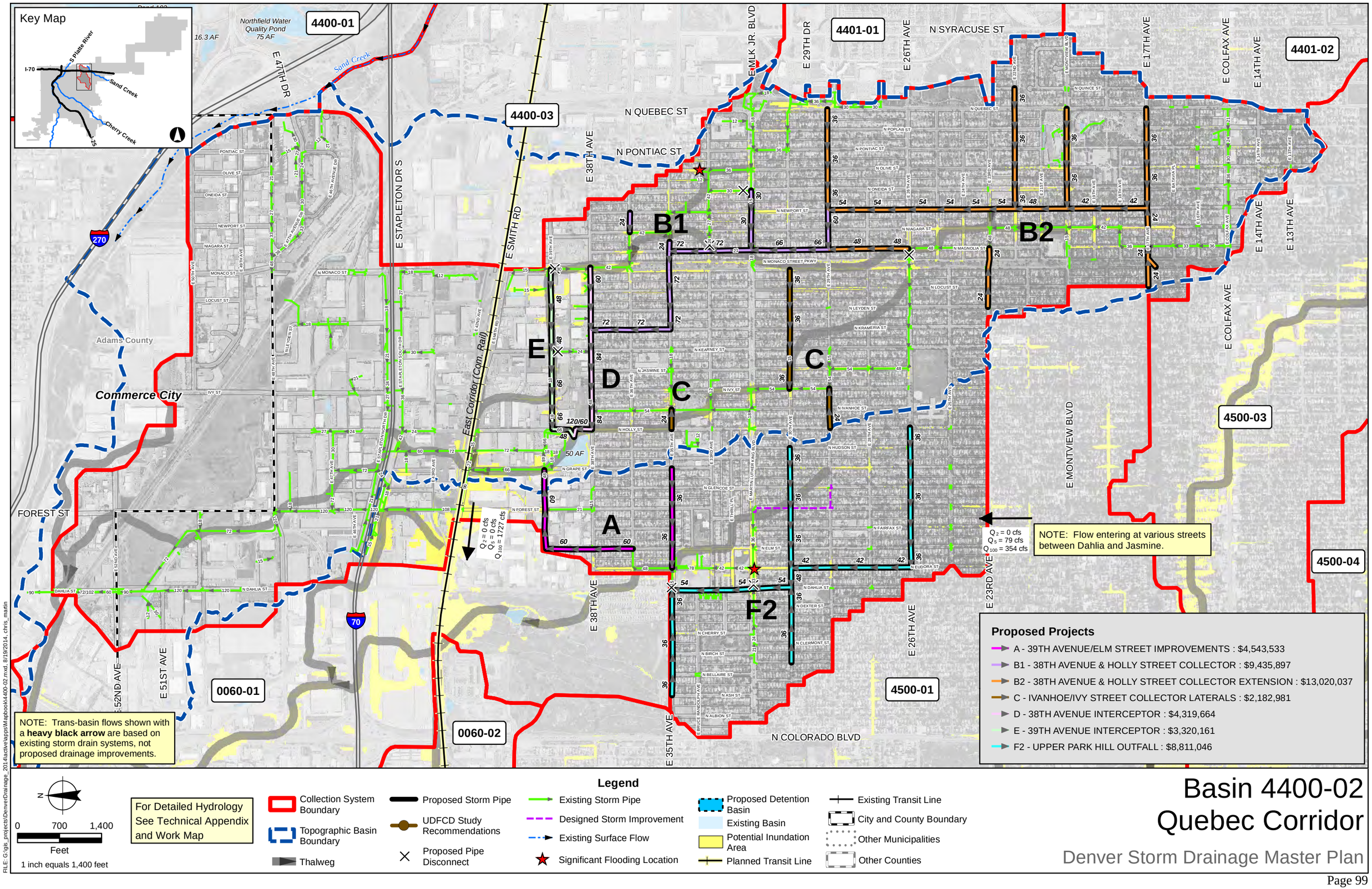
Project B2: 38th Avenue and Holly Street Collector Extension
This proposed system extends from Project B1. Flows in the existing 48-inch pipe at 26th Avenue and Magnolia Street will be routed to a proposed 48-inch pipe along Magnolia Street and connected to the 66-inch trunk line in project B1 along Magnolia Street. The existing 48-inch pipe at 26th Avenue and Magnolia Street will therefore be relieved of capacity resulting in the entire existing system along Jasmine, Ivanhoe, and Holly Streets to be capable of handling the 2-year design flows. Additional collection systems are proposed in the upper basin along Newport Street, 22nd Avenue, Montview Boulevard, and 17th Avenue.

Project C: Ivanhoe/Ivy Street Collector Laterals
This project includes minor lateral systems to increase the collection capacity of the existing system along Jasmine, Ivanhoe, and Holly Streets.

Project D: 38th Avenue Interceptor
A new 5-year storm drain system is needed in 38th Avenue from Monaco Parkway to Holly Street with sizes ranging from 10'x5' RCBC to 60-inch diameter RCP to deliver storm runoff to the 38th & Holly detention basin.

Project E: 39th Avenue Interceptor
The commercial areas south of Smith Road will be serviced by a 66-inch pipe along 39th Avenue. This 66-inch pipe is proposed to be connected to the existing 66-inch pipe at 39th Avenue and Holly Street and a 48-inch pipe running southward to the 38th & Holly detention basin through a splitter. The splitter will be designed so that the 48-inch or 60-inch (100-year alternative) pipe takes flow when the existing 66-inch pipe at 39th Avenue and Holly Street becomes full. The existing inlet to the 38th & Holly detention basin will need necessary modification to accommodate the 10-foot by 5-foot box pipe from Project D and 48-inch pipe from the north from Project E entering the 38th & Holly detention basin.

Project F2: Upper Park Hill Outfall
A new storm drain network is needed to convey the 2-year flows in the western portion of the basin. The proposed system will connect to the project 0060-01 F1, which consists of a proposed 60-inch or 84-inch (100-year alternative) system in Dahlia Street. The system will extend up into the basin with a 54-inch line along Dahlia Street, a 48-inch line in 30th Avenue, a 42-inch line in Eudora Street, and a 36-inch line in 26th Avenue, with additional collection laterals proposed in 30th Avenue.


Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
Northfield Water Quality Pond 75 AF
16.3 AF
4400-01
4400-03
4401-01
4401-02
4500-03
4500-04
4500-01
0060-01
0060-02
Sand Creek
E 47TH DR
E STAPLETON DR S
E SMITH RD
East Corridor (Com. Rail)
E 38TH AVE
N QUEBEC ST
N PONTIAC ST
E MLK JR. BLVD
E 29TH DR
E 26TH AVE
N SYRACUSE ST
E 17TH AVE
E COLFAX AVE
E 14TH AVE
E 13TH AVE
E MONTVIEW BLVD
Adams County
Commerce City
FOREST ST
E 52ND AVE
E 51ST AVE
E 35TH AVE
E 23RD AVE
N COLORADO BLVD
B1
B2
C
D
E
F2
A
50 AF
120/60
Q_2 = 0 cfs
Q_5 = 0 cfs
Q_{100} = 1727 cfs
Q_2 = 0 cfs
Q_5 = 79 cfs
Q_{100} = 354 cfs
NOTE: Flow entering at various streets between Dahlia and Jasmine.
NOTE: Trans-basin flows shown with a heavy black arrow are based on existing storm drain systems, not proposed drainage improvements.
Proposed Projects
A - 39TH AVENUE/ELM STREET IMPROVEMENTS : $4,543,533
B1 - 38TH AVENUE & HOLLY STREET COLLECTOR : $9,435,897
B2 - 38TH AVENUE & HOLLY STREET COLLECTOR EXTENSION : $13,020,037
C - IVANHOE/IVY STREET COLLECTOR LATERALS : $2,182,981
D - 38TH AVENUE INTERCEPTOR : $4,319,664
E - 39TH AVENUE INTERCEPTOR : $3,320,161
F2 - UPPER PARK HILL OUTFALL : $8,811,046
N
0 700 1,400
Feet
1 inch equals 1,400 feet
For Detailed Hydrology See Technical Appendix and Work Map
Legend
Collection System Boundary
Topographic Basin Boundary
Thalweg
Proposed Storm Pipe
UDFCD Study Recommendations
Proposed Pipe Disconnect
Existing Storm Pipe
Designed Storm Improvement
Existing Surface Flow
Significant Flooding Location
Proposed Detention Basin
Existing Basin
Potential Inundation Area
Planned Transit Line
Existing Transit Line
City and County Boundary
Other Municipalities
Other Counties
Basin 4400-02
Quebec Corridor
Denver Storm Drainage Master Plan
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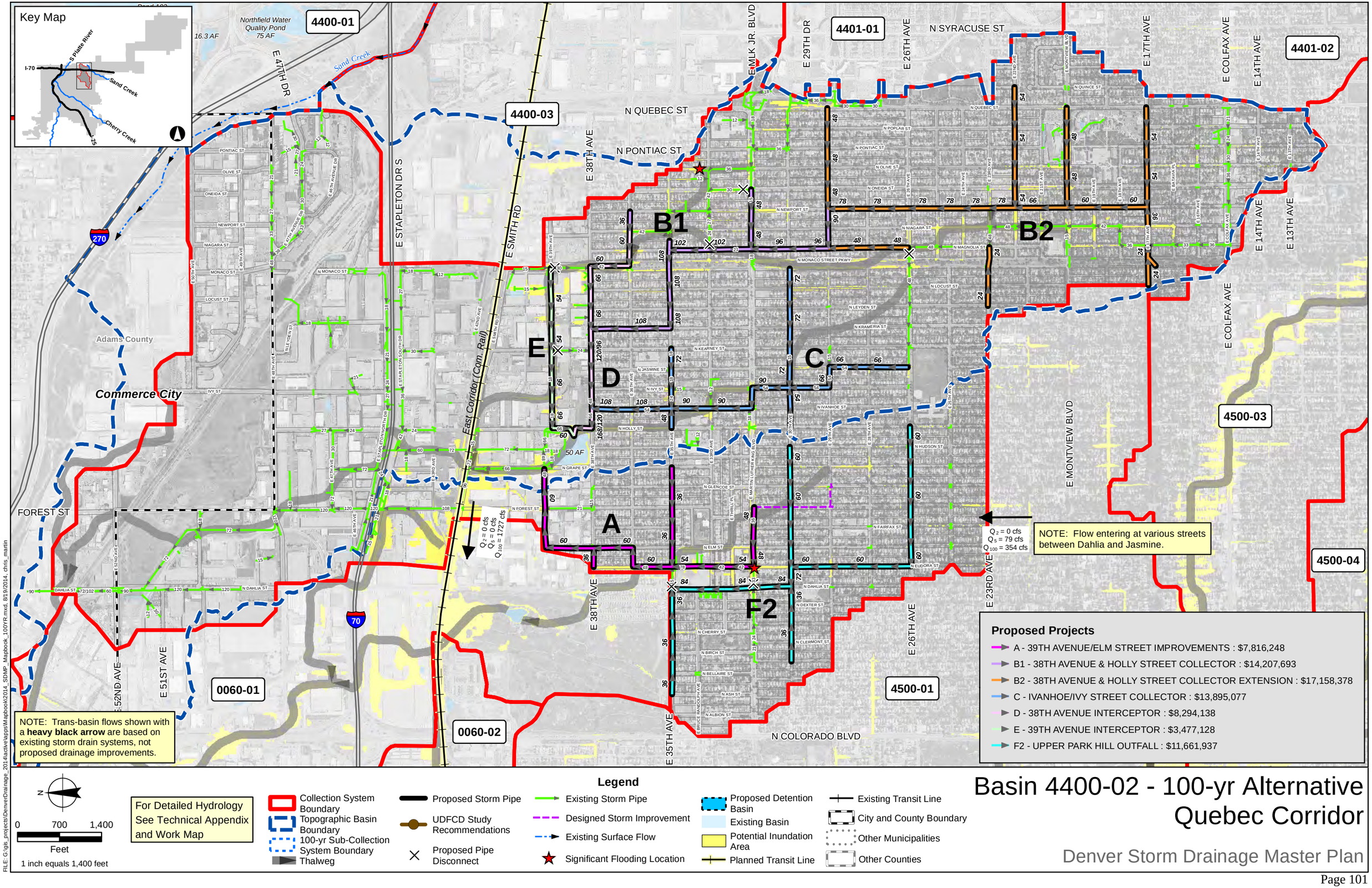
Basin 4400-02 (Quebec Corridor) (Alternative 100-Year Basin)

Proposed 100-Year Alternative Capital Improvements:

Projects A, B1, B2, C, D, E & F2

The 100-year alternative for this basin shows larger storm drain pipe sizes and some changes in storm drain alignments in order to capture more runoff in the underground storm drain system and reduce surface runoff depths in the street to 12-inches deep in the gutter in accordance with Denver's street depth criteria. These alternatives are based on analysis done in the July 2011 ***Sand Creek (4400-02) and Upper Park Hill (0060-01, 4400-02 & 4500-01) Basins Final Drainage Study*** by Atkins.


Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
Northfield Water Quality Pond 75 AF
16.3 AF
Sand Creek
4400-01
4400-03
4401-01
4401-02
4500-03
4500-04
4500-01
0060-01
0060-02
E 47TH DR
E STAPLETON DR S
E SMITH RD
East Corridor (Com. Rail)
E 38TH AVE
E 29TH DR
E 26TH AVE
E MLK JR. BLVD
E 17TH AVE
E COLFAX AVE
E 14TH AVE
E 13TH AVE
E MONTVIEW BLVD
E 23RD AVE
E 38TH AVE
E 35TH AVE
E 51ST AVE
E 52ND AVE
N QUEBEC ST
N PONTIAC ST
N SYRACUSE ST
N COLORADO BLVD
PONTIAC ST
OLIVE ST
ONEIDA ST
NEWPORT ST
NIAGARA ST
MONACO ST
LOCUST ST
IVY ST
FOREST ST
DAHLIA ST
N MONACO ST
N LEYDEN ST
N KRAMERIA ST
N KEARNEY ST
N JASMINE ST
N IVY ST
N HOLLY ST
N GRAPE ST
N FOREST ST
N ELM ST
N CHERRY ST
N BIRCH ST
N BELLAIRE ST
N ASH ST
N ALBION ST
N NEWPORT ST
N MONACO STREET PKWY
N LOCUST ST
N NIAGARA ST
N MAGNOLIA ST
N IVANHOE ST
N HUDSON ST
N GLENCOE ST
N FAIRFAX ST
N EUDORA ST
N DAHLIA ST
N DEXTER ST
N CLERMONT ST
N POPLAR ST
N OLIVE ST
N ONEIDA ST
N QUINCE ST
E BATAVIA PL
E THRILL PL
E MARTIN LUTHER KING BLVD
Adams County
Commerce City
I-270
I-70
50 AF
A
B1
B2
C
D
E
F2
Q_2 = 0 cfs
Q_5 = 0 cfs
Q_{100} = 1727 cfs
Q_2 = 0 cfs
Q_5 = 79 cfs
Q_{100} = 354 cfs
NOTE: Flow entering at various streets between Dahlia and Jasmine.
NOTE: Trans-basin flows shown with a heavy black arrow are based on existing storm drain systems, not proposed drainage improvements.
Proposed Projects
A - 39TH AVENUE/ELM STREET IMPROVEMENTS : $7,816,248
B1 - 38TH AVENUE & HOLLY STREET COLLECTOR : $14,207,693
B2 - 38TH AVENUE & HOLLY STREET COLLECTOR EXTENSION : $17,158,378
C - IVANHOE/IVY STREET COLLECTOR : $13,895,077
D - 38TH AVENUE INTERCEPTOR : $8,294,138
E - 39TH AVENUE INTERCEPTOR : $3,477,128
F2 - UPPER PARK HILL OUTFALL : $11,661,937
N
0 700 1,400
Feet
1 inch equals 1,400 feet
For Detailed Hydrology See Technical Appendix and Work Map
Legend
Collection System Boundary
Topographic Basin Boundary
100-yr Sub-Collection System Boundary
Thalweg
Proposed Storm Pipe
UDFCD Study Recommendations
Proposed Pipe Disconnect
Existing Storm Pipe
Designed Storm Improvement
Existing Surface Flow
Significant Flooding Location
Proposed Detention Basin
Existing Basin
Potential Inundation Area
Planned Transit Line
Existing Transit Line
City and County Boundary
Other Municipalities
Other Counties
Basin 4400-02 - 100-yr Alternative
Quebec Corridor
Denver Storm Drainage Master Plan
FILE: G:\gis_projects\DenverDrainage_2014\active\gpps\MapbookK2014_SDMP_Mapbook_100YR.mxd, 8/19/2014, chris_martin

Basin 4400-03 (Stapleton)

Existing System Description:

This collection system basin consists of 967 acres (1.51 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:

A number of previous studies 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 and 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.

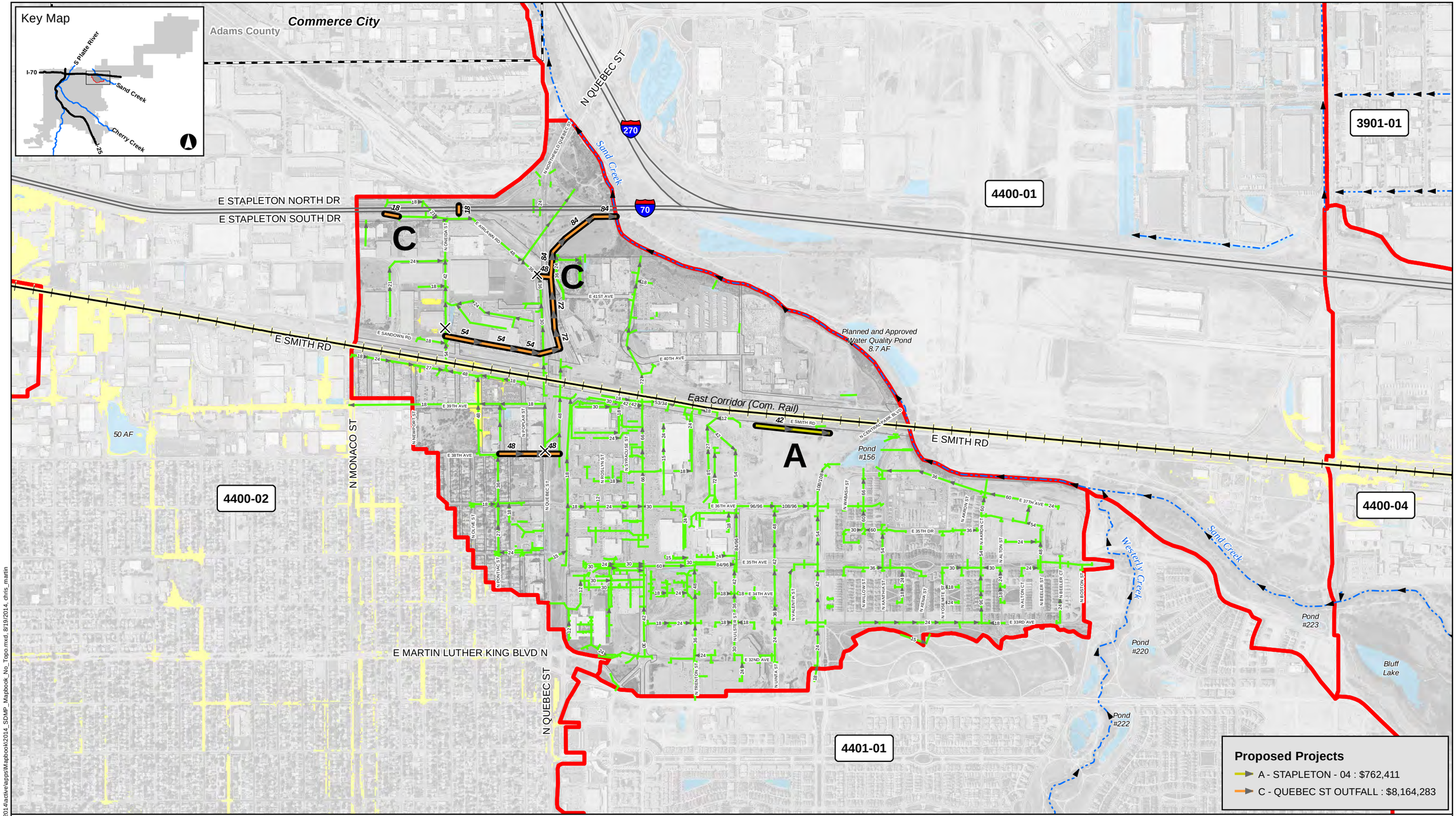
South of I-70, the requirement for quantity detention has been waived. The waiver was granted by Denver Public Works-Wastewater Management Division via a letter dated June 2, 2000. Formerly, 10-year detention was required for the Stapleton site south of I-70; however, with the waiver, only water quality 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 subbasin 062. Approximately 20 tributary acres will be conveyed to the existing regional water quality basin.

<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.


Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
Adams County
Commerce City
N QUEBEC ST
270
Sand Creek
70
E STAPLETON NORTH DR
E STAPLETON SOUTH DR
4400-01
3901-01
C
C
E 41ST AVE
E SANDOWN RD
E SMITH RD
E 40TH AVE
E 39TH AVE
E 38TH AVE
E 36TH AVE
E 35TH AVE
E 34TH AVE
E 32ND AVE
E 35TH DR
E 37TH AVE
E 33RD AVE
Planned and Approved
Water Quality Pond
8.7 AF
East Corridor (Com. Rail)
E SMITH RD
A
Pond
#156
50 AF
4400-02
N MONACO ST
E MARTIN LUTHER KING BLVD N
N QUEBEC ST
4401-01
4400-04
Westerly Creek
Sand Creek
Pond
#223
Pond
#220
Bluff
Lake
Pond
#222
Proposed Projects
A - STAPLETON - 04 : $762,411
C - QUEBEC ST OUTFALL : $8,164,283
N
0
600
1,200
Feet
1 inch equals 1,200 feet
For Detailed Hydrology
See Technical Appendix
and Work Map
Legend
Collection System Boundary
Proposed Storm Pipe
UDFCD Study Recommendations
Proposed Pipe Disconnect
Existing Storm Pipe
Designed Storm Improvement
Existing Surface Flow
Significant Flooding Location
Proposed Detention Basin
Existing Basin
Potential Inundation Area
Planned Transit Line
Existing Transit Line
City and County Boundary
Other Municipalities
Other Counties
Basin 4400-03
Stapleton
Denver Storm Drainage Master Plan
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Basin 4400-04 (East Stapleton)

Existing System Description:

This collection system basin consists of 1,219 acres (1.90 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.

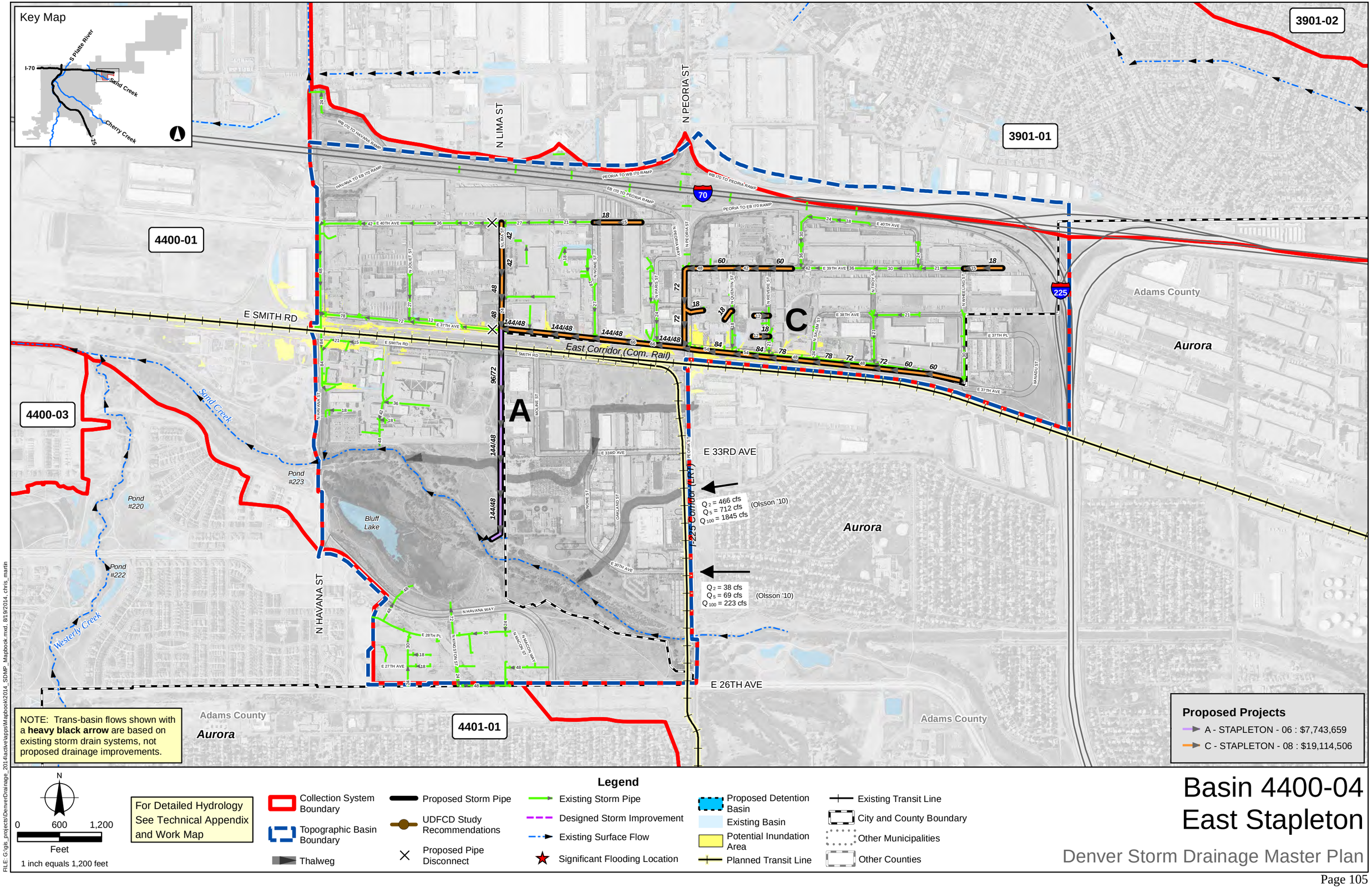
Drainage from the I-70 corridor flows in a storm pipe system parallel to I-70 into Sand Creek.

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 and 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-foot x 4-foot 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 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


Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
3901-02
3901-01
4400-01
4400-03
4401-01
N LIMA ST
N PEORIA ST
WB I70 TO HAVANA RAMP
HAVANA TO EB I70 RAMP
PEORIA TO WB I70 RAMP
EB I70 TO PEORIA RAMP
WB I70 TO PEORIA RAMP
PEORIA TO EB I70 RAMP
70
225
E 40TH AVE
E 39TH AVE
E 38TH AVE
E 37TH AVE
E 37TH PL
E SMITH RD
SMITH RD
East Corridor (Com. Rail)
E 33RD AVE
E 30TH AVE
E 28TH PL
E 27TH AVE
E 26TH AVE
N HAVANA ST
N HAVANA WAY
N JOLIET ST
N NOME ST
N PARIS ST
N QUEBEC ST
N QUINTIA ST
N TROY ST
N WHEELING ST
N 34TH ST
N KINGSTON ST
N MACON ST
N MACON WAY
MOLINE ST
NOMAS ST
OAKLAND ST
PEORIA ST
YAMADU ST
A
C
96/72
144/48
72
60
84
78
Sand Creek
Pond #223
Pond #220
Pond #222
Bluff Lake
Westerly Creek
Adams County
Aurora
Q2 = 466 cfs
Q5 = 712 cfs
Q100 = 1845 cfs
(Olsson '10)
Q2 = 38 cfs
Q5 = 69 cfs
Q100 = 223 cfs
(Olsson '10)
I-225 Corridor (LRT)
NOTE: Trans-basin flows shown with a heavy black arrow are based on existing storm drain systems, not proposed drainage improvements.
Proposed Projects
A - STAPLETON - 06 : $7,743,659
C - STAPLETON - 08 : $19,114,506
N
0 600 1,200
Feet
1 inch equals 1,200 feet
For Detailed Hydrology See Technical Appendix and Work Map
Legend
Collection System Boundary
Topographic Basin Boundary
Thalweg
Proposed Storm Pipe
UDFCD Study Recommendations
Proposed Pipe Disconnect
Existing Storm Pipe
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East Stapleton
Denver Storm Drainage Master Plan
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Basin 4401-01 (Westerly Creek – South Stapleton)

Existing System Description:

This collection system 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 Syracuse.

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 basin at the end of pipe before discharging into Westerly Creek. Water quality basins are located on the west bank at 23rd Avenue, 26th Avenue, 29th Avenue, Martin Luther King Boulevard and 33rd Avenue. Water quality basins 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-inch storm drain. However, this pipe 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.

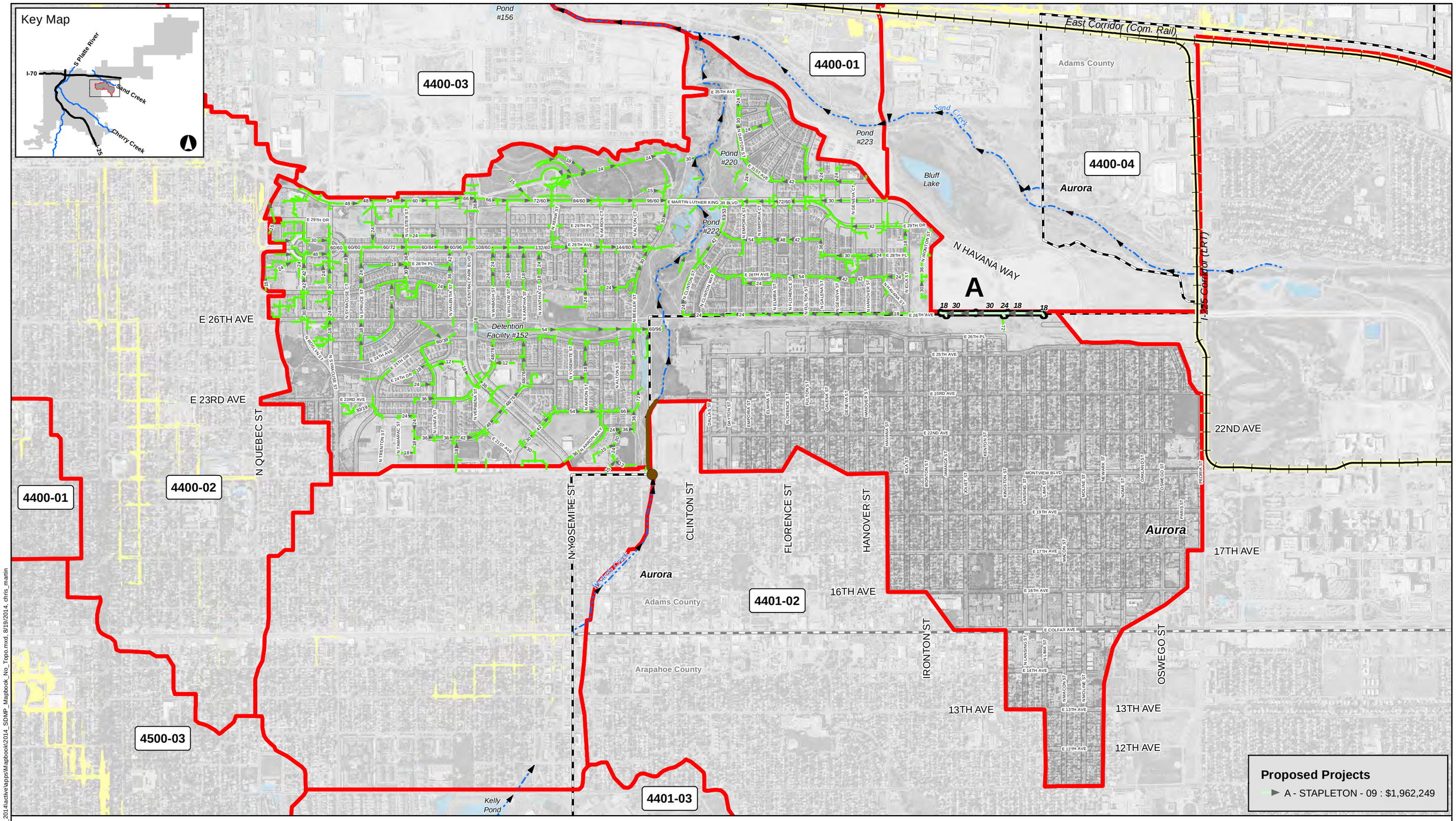
Drainage Deficiencies:

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. The City of Aurora is replacing the Montview Boulevard bridge over Westerly Creek to remove a large number of homes from the 100-year floodplain. Modifications of approximately 1,200 feet of Westerly Creek downstream of the bridge will be required as part of the project.

Proposed Capital Improvements:

<u>Project A: Stapleton 09</u>
This project includes capital improvements by the developer for 100-year storm systems throughout out the Stapleton development.

URS Company was in the process of developing a storm water master plan for the City of Aurora; however, recommendations were not available at the time this study was updated.


Key Map
S Platte River
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Sand Creek
Cherry Creek
I-25
Pond #156
4400-03
4400-01
East Corridor (Com. Rail)
Adams County
Sand Creek
Pond #223
Pond #220
Pond #222
Bluff Lake
4400-04
Aurora
E 35TH AVE
E MARTIN LUTHER KING JR BLVD
E 29TH DR
E 29TH PL
E 29TH AVE
E 28TH PL
E 28TH AVE
N HAVANA WAY
A
E 26TH AVE
E 26TH PL
E 25TH AVE
E 24TH AVE
E 24TH DR
E 23RD AVE
E 22ND AVE
22ND AVE
I-225 Corridor (LRT)
Detention Facility #152
N QUEBEC ST
4400-02
4400-01
4500-03
N YOSEMITE ST
CLINTON ST
FLORENCE ST
HANOVER ST
Aurora
Adams County
4401-02
16TH AVE
Arapahoe County
IRONTON ST
OSWEGO ST
17TH AVE
13TH AVE
12TH AVE
E COLFAX AVE
E 17TH AVE
E 16TH AVE
E 14TH AVE
E 13TH AVE
E 12TH AVE
MONTVIEW BLVD
Kelly Pond
4401-03
Proposed Projects
A - STAPLETON - 09 : $1,962,249
N
0
750
1,500
Feet
1 inch equals 1,500 feet
For Detailed Hydrology See Technical Appendix and Work Map
Legend
Collection System Boundary
Proposed Storm Pipe
UDFCD Study Recommendations
Proposed Pipe Disconnect
Existing Storm Pipe
Designed Storm Improvement
Existing Surface Flow
Significant Flooding Location
Proposed Detention Basin
Existing Basin
Potential Inundation Area
Planned Transit Line
Existing Transit Line
City and County Boundary
Other Municipalities
Other Counties
Basin 4401-01
South Stapleton
Denver Storm Drainage Master Plan
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Basin 4401-02 (Westerly Creek – 11th Avenue to Montview)

Existing System Description:

This collection system 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 drain systems in roadways that discharge in three locations directly to Westerly Creek. A 15-inch pipe in Richthofen Place with an existing capacity of 6 cfs drains 42 acres with a 5-year runoff of 39 cfs. A 48-inch 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-inch pipe in Montview Boulevard with an existing capacity of 138 cfs drains 290 acres with a 5-year runoff of 299 cfs.

Kiowa Engineering Corporation completed the ***Westerly Creek (Downstream of Westerly Creek Dam) Major Drainageway Plan***, under the direction of the Urban Drainage & Flood Control District and the City and County of Denver in 2010. URS Company was in the process of developing a storm water master plan for the City of Aurora; however, recommendations were not available at the time this study was updated.

Drainage Deficiencies:

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

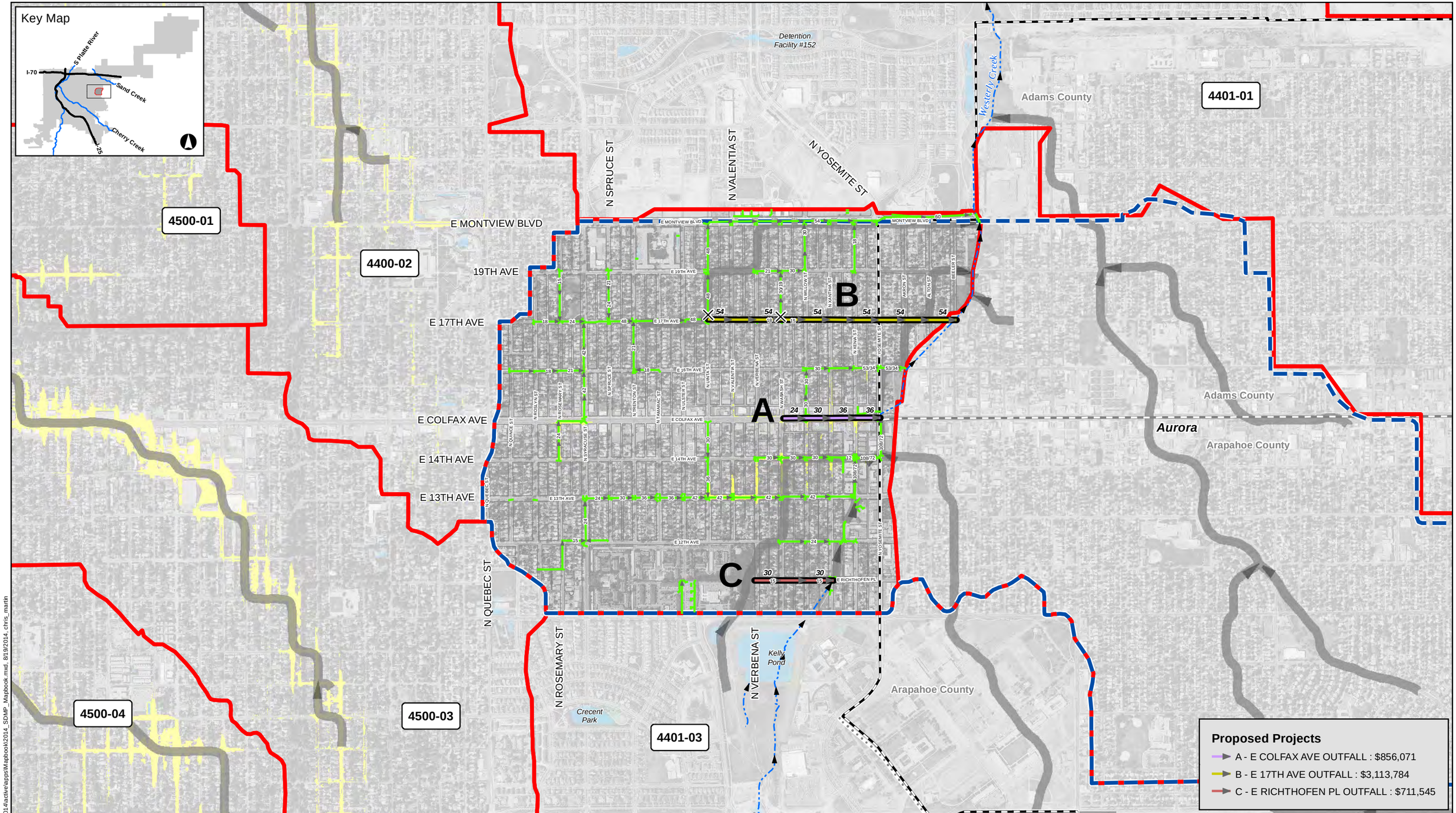
Proposed Capital Improvements:

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-inch pipe in Montview Boulevard. A new 54-inch 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-inch pipe at 0.5% of 112 cfs.

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



Basin 4401-02
11th Avenue to Montview

Denver Storm Drainage Master Plan

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Basin 4401-03 (Westerly Creek - Lowry)

Existing System Description:

This collection system basin drains to Westerly Creek and is generally bound by Quebec Street on the west, 11th Avenue on the north, Havana Street/Peoria Street on the east and Alameda Avenue on the south. A significant portion of the basin is within the Lowry Redevelopment property in Denver, and the eastern portion of the basin is 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 ***Westerly Creek Drainageway Update (Downstream of Westerly Creek Dam) Major Drainageway Plan*** (MDP) was completed by Kiowa Engineering Corporation in July 2010. The MDP re-examined the hydrology in this area and modified it. The major drainage basins were also defined by the MDP.

The discharge from Westerly Creek Dam is a 48-inch RCP storm drain with a 7-inchW x 48-inchH 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.

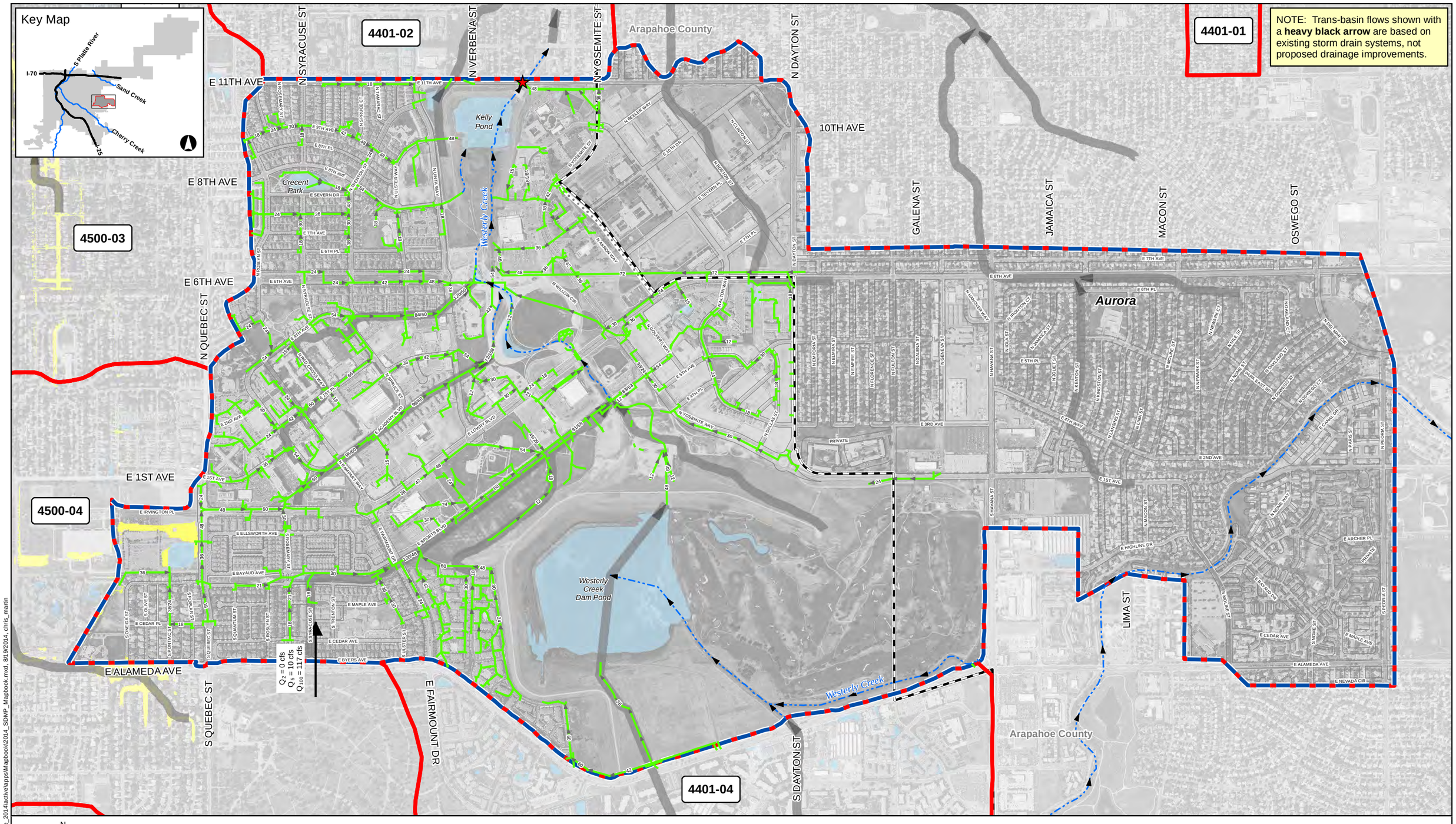
Regional water quality treatment occurs within Westerly Creek Dam and Kelly Road Dam.

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.



Basin 4401-03
Lowry

Denver Storm Drainage Master Plan

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

Existing System Description:

This collection system 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 High Line 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 drain 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 drain to the privately-owned Windsor Lake, which then discharges into the High Line Canal.

Drainage Deficiencies:

- The 54-inch 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-inch storm drain 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-inch storm drain 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.

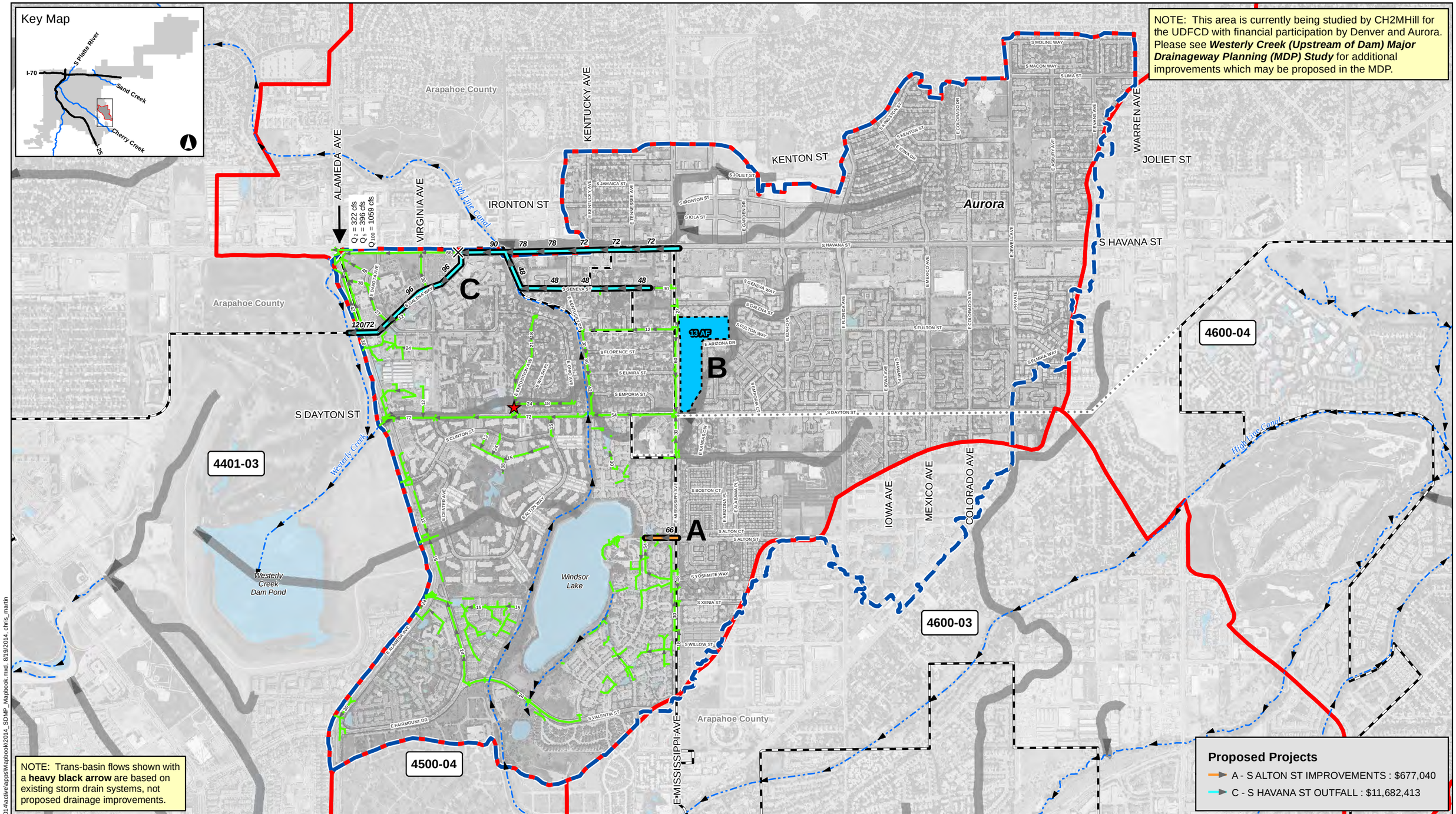
Proposed Capital Improvements:

This basin requires improvements primarily to the outfalls since the lateral network is currently adequate. At the time of this Storm Drainage Master Plan update, the UDFCD, in coordination with the City of Aurora and the City and County of Denver, is conducting a ***Westerly Creek (Upstream of Westerly Creek Dam) Major Drainageway Plan.*** The study is being prepared by CH2MHill and will evaluate regional drainage needs in this basin. This may result in the alteration of proposed capital improvements.

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

Project B: East Mississippi Detention
The 72-inch 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-inch 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.

Project C: S. Havana St. Outfall
The 66-inch 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-inch pipe and extending it up Havana to Mississippi would provide 5-year conveyance and alleviate the flooding at the Mississippi and Havana intersection.



Basin 4401-04
South of Alameda

Denver Storm Drainage Master Plan

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

Existing System Description:

The Montclair Collection System Basin contains a total land area of approximately 6,039 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 drains. Surcharged flows are conveyed overland via the network of City streets. The basin discharges to the South Platte River through a main outfall, a 10' x 10' (120-inch x 120-inch) reinforced concrete box culvert, located in Globeville Park, approximately 500 feet northeast of the intersection of 38th Streeet and Arkins Court. 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 drains 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 than the 5-year event.

In addition, numerous areas within the Montclair Basin do not contain a storm drain 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 and 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 on N. Colorado Boulevard and E. 23rd Avenue, N. Colorado Boulevard and E. 17th Avenue, E. Batavia Place and N. Clermont Street, all in Basin 4500-01. In Basin 4500-03, flooding has been reported along E. Colfax Avenue at N. Elm Street and between N. Glencoe Street and N. Ivy Street, in the sump area along E. 14th Avenue between N. Jasmine Street and N. Kearney Street, the 1100 block of N. Locust Street, the 1100 block of N. Leyden Street, the 900 block of N. Magnolia Street, and at E. 9th Avenue and N. Niagara Street. In Basin 4500-04, there have been reports of stormwater surging out of manholes along E. Hale Parkway, and repetitive flooding in the sump area along E. Severn Place between N. Jersey Street and N. Jasmine Street.

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 drain pipes/box culverts.

Project A: E. 33rd Avenue System
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 begins 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.

Project B: 38th Street System
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 collection system 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 commercial areas.

Project C: 40th Avenue System
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 drain trunk line located at the intersection of High Street and 40th Avenue. The major upgrade within the project is a proposed 8-foot x 8-foot RCBC to replace the existing 69-inch storm drain located along 40th Avenue, which is currently under construction as part of the RTD FasTracks East Corridor project up to N. Columbine Street.

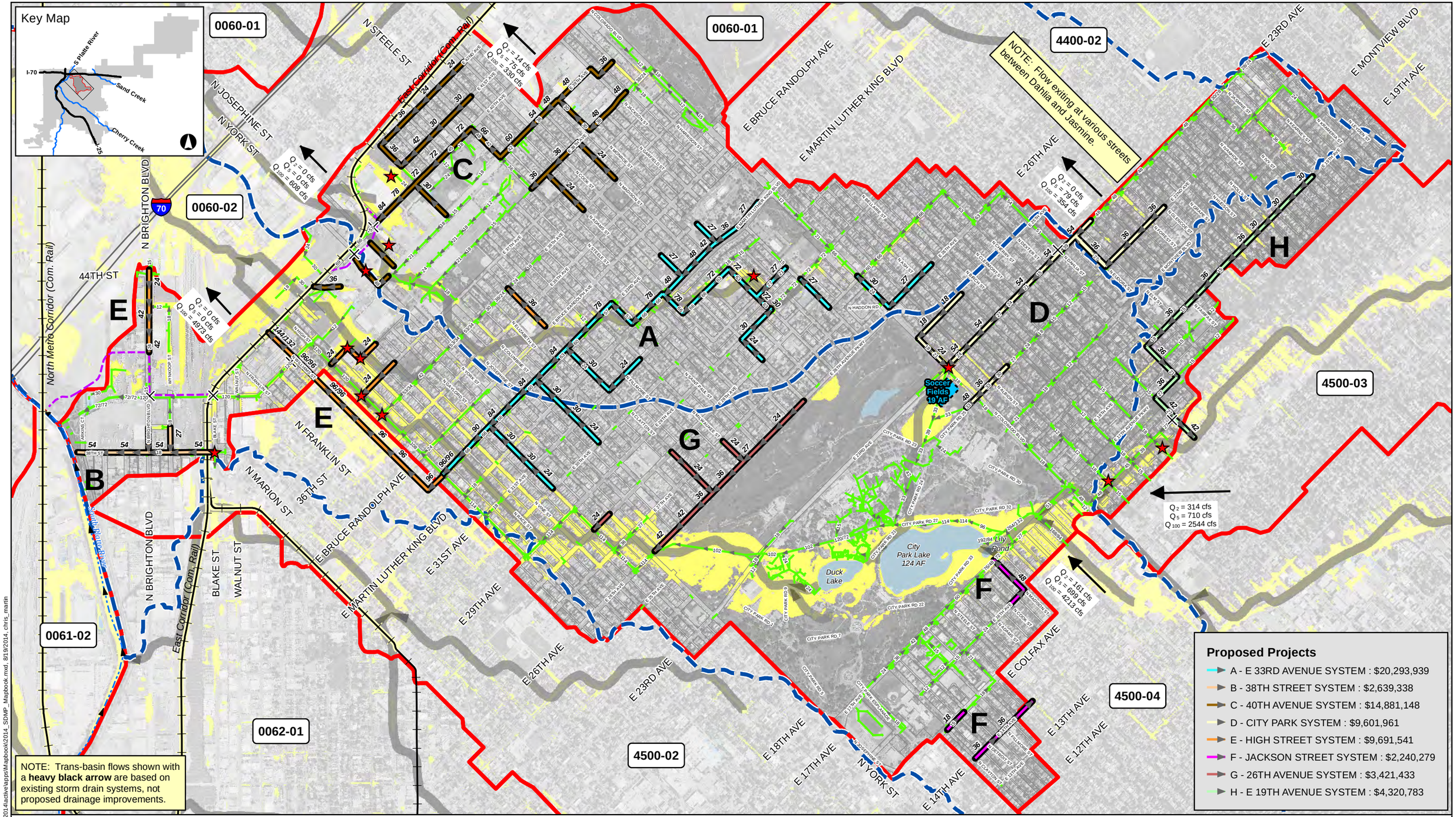
Project D: City Park System
This project contains City Park and residential areas located just east of the park. The proposed capital improvement modifies City Park to provide additional detention storage volume. Storage is to be provided in two locations within the Park; City Park's Ferril Lake, which was modified in 2007/2008 to include detention, and proposed storage in ballfields located near the northeast corner of the Park. The reduction in peak flows resulting from the detention storage 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.

Project E: High Street System
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 12-foot x 8-foot RCBC outfall to the South Platte River 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. The outfall portion up to 40th Avenue and Williams Street is currently under construction in conjunction with the UDFCD and the RTD Fastracks project.

Project F: Jackson Street System
The Jackson Street project has seen recent construction of one block of storm drain in Jackson Street, from E. 17th Avenue to E. Colfax Avenue, to serve as the outfall for Project 4500-04-A. Future portions of the project include 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, which will continue in E. 14th Avenue to N. Garfield Street as shown in Basin 4500-04.

Project G: 26th Avenue System
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 26th Avenue and the laterals in Milwaukee Street, Clayton Street and 28th Avenue.

Project H: E. 19th Avenue System
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.



Basin 4500-01
City Park

Denver Storm Drainage Master Plan

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Basin 4500-03 (Park Hill - Colfax)

Existing System Description:

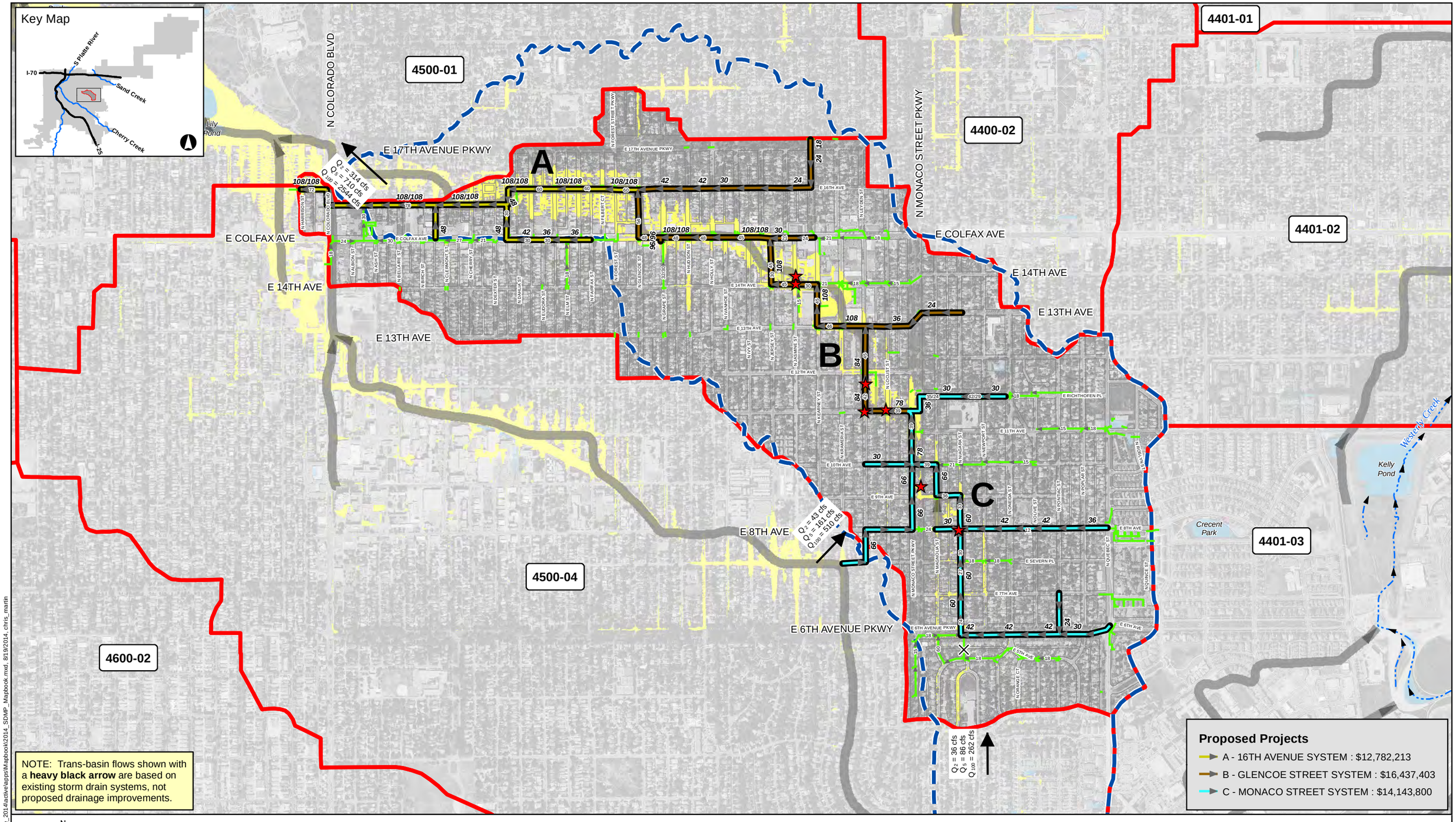
Collection System Basins 4500-03 and 4500-04 (Upper Montclair) have their own stormwater conveyance systems that eventually drain to City Park in Basin 4500-01. However, the upper reaches of these two basins share tributary area, where the existing pipe network conveys water into Basin 4500-04 along Hale Parkway, but surface flows travel north, into Basin 4500-03, from the sump area in E. Severn Place, between Jersey Street and Jasmine Street, where a split between surface flows and pipe conveyance occurs.

Proposed Capital Improvements:

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.

Project B: Glencoe Street System
The Glencoe Street project trunk line starts at the upstream end of the 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. An additional spur trunk line is proposed between 10th Avenue and Severn Place. This project will mitigate repetitive flooding at E. 14th Avenue and N. Jasmine Street, along E. 14th Avenue and the 1100 blocks of N. Locust Street and N. Leyden Street. Approximately 350 acres of land contributes stormwater runoff within the project including subbasins 260, 270 and a portion of 250. The majority of land within the project bounds is residential but includes commercial lands located along Colfax Avenue. The primary upgrade within the project is a replacement of trunk line, a new conveyance system serving the Severn Place sump, and two lateral lines.

Project C: Monaco Street System
The Monaco Street project has a trunk line starting 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. This project will mitigate flooding at 930 N. Monaco Street Parkway, flow depth exceeding street-depth criteria at 799 N. Niagara Street, and other locations in the upper portion of the collection system basin. A 66-inch RCP spur line, going east in E. 8th Avenue, will serve the sump area in E. Severn Place, between N. Jersey Street and N. Jasmine Street, to account for the flow split occurring in the 2-year and 5-year event, identified in this Master Plan update. Approximately 432 acres of land contributes stormwater runoff within the project including subbasins 230, 240 and a portion of 250. Additional surface flow enters the project from Basin 4500-04, along Niagara Street, at the upper end of the basin. A 100-year outflow from the sump at E. 5th Avenue and N. Newport Street was constructed in 2013. The majority of land within the project bounds is residential. The primary upgrade within this project is a replacement of the existing trunk line.



Basin 4500-03
Park Hill - Colfax

Denver Storm Drainage Master Plan

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

Existing System Description:

Collection Systems Basins 4500-04 and 4500-03 (Upper Montclair) have their own stormwater conveyance systems that eventually drain to City Park in Basin 4500-01. However, the upper reaches of these two basins share tributary area, where the existing pipe network conveys water into Basin 4500-04 along Hale Parkway, but surface flows travel north into Basin 4500-03 from the sump area in E. Severn Place, between Jersey Street and Jasmine Street, where a split between surface flows and pipe conveyance occurs.

Proposed Capital Improvements:

Project A: Jackson St. System This project starts at E. Colfax Avenue and N. Jackson Street, connecting to a storm drain constructed in N. Jackson Street, from E. 17th Avenue to E. Colfax Avenue, in 2012. It turns west in Colfax Avenue to Garfield Street. The system extends up Garfield Street to E. 12th Avenue, where it turns east in 12th Avenue across Colorado Boulevard to N. Albion Street. 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 N. Albion Street 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-foot x 11-foot (96-inch x 132-inch) 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 Place, 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, and will service the sump area in E. Severn Place between Jersey Street and Jasmine Street in conjunction with project 4500-03-C. This project would mitigate storm surcharging of manholes at E. 8th Avenue and N. Holly Street, and repetitive flooding in the sump in E. Severn Avenue, between N. Ivanhoe Street and N. Jasmine Street. An additional 66-inch RCP would also drain the sump area in a 5-year storm event, to Basin 4500-03, to account for the basin split flow that has been identified in this Master Plan update.

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 subbasins 10 – 80. The primary upgrade is the replacement of trunk line that runs along Krameria Street and Kearney Street and several laterals.

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, Hudson Street, and Holly Street between 8th Avenue and E. Cedar Avenue and several laterals.

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. The proposed lateral in E. 14th Avenue, going west from N. Garfield Street, continues west, to N. Clayton Street, as shown in Basin 4500-01.

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.
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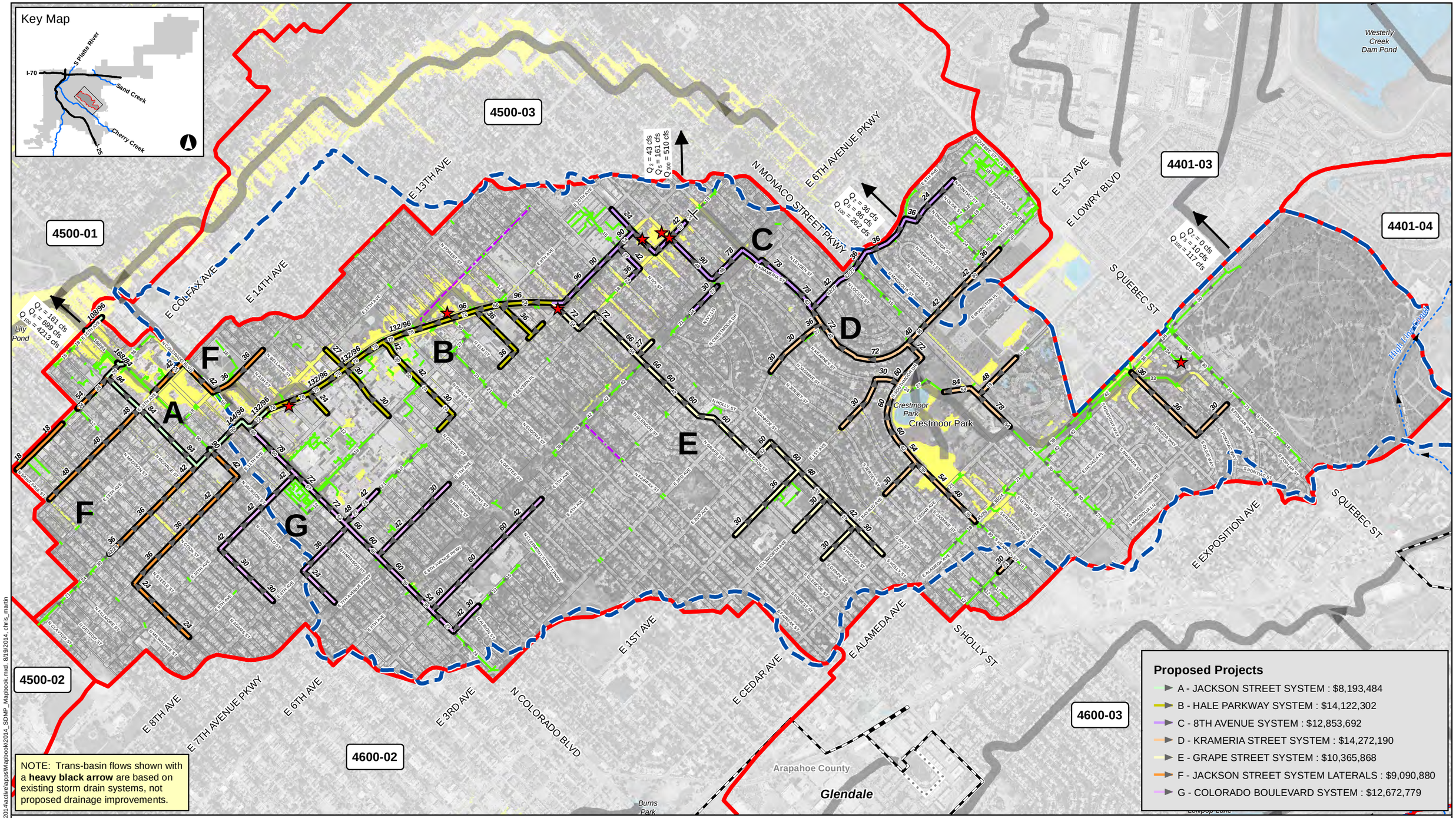

Basin 4500-04
Park Hill - 6th Avenue

Denver Storm Drainage Master Plan

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

Existing System Description:

These two collection system basins combined include a mix of industrial, commercial and residential land uses, and include 2,856 tributary acres (4.46 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 drains in lower reaches.

Currently, most of the drainage (nearly 75% of the basin) outfalls through one 81-inch storm pipe at 36th Street, with approximately 1,936 acres tributary to this one outfall. The existing pipe has approximately 476 cfs capacity, but the hydrology indicates the flow will be over 1,000 cfs in a 2-year event, and 1,700 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 ***31st Street & 36th Street Outfall Study and Concept Design Report***, December 2012 by Wilson and Company.

Potential Inundation Areas:

Several areas of potential inundation have been identified within the basin, mostly in areas where the streets become very flat. The areas surrounding the intersections of 36th Street/Blake Street, 31st Street/Blake Street, 32nd Avenue/Marion Street, 17th Avenue/Lafayette Street, 16th Avenue/Franklin Street, and 16th Avenue/Clarkson Street have been identified as locations where 100-year inundation depths could reach up to 3-feet in depth during a 100-year event.

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 in 36th Street 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. The ***31st Street & 36th Street Outfall Study and Concept Design Report***, completed by Wilson and Company in 2012, investigated several outfall alternatives within the basin, and the recommendations from that report are reflected in this Master Plan. Thirteen major drainage projects are proposed for this basin as described below:

Project A: Marion Street System – Phase 1 connects to the recently designed River North Outfall located in 33rd Street. The Phase 1 extension includes a new 102-inch pipe in Marion Street from 32nd Avenue to 29th Avenue. 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: Marion Street System – Phase 2 storm drain will continue up the basin with a 102-inch to 90-inch pipe in Downing Street to 21st Avenue.

Project C: East 24th Avenue System provides additional stormwater collection for the proposed trunk line in Project B. It includes a 60-inch pipe in 24th Avenue with additional lines extending up to 20th Avenue and Vine Street. This project also includes replacing existing small pipes with 18-inch diameter pipes to meet current drainage criteria, improve collection/conveyance and reduce maintenance problems.

Project D: City Park West Drainage Improvements extends into the upper basin with an 84-inch to 36-inch diameter pipe. This project also includes replacing existing small pipes with 18-inch diameter pipes to meet current drainage criteria, improve collection/conveyance and reduce maintenance problems.

Project E: East 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.

Project F: 27th Street Interceptor – Phase 1 includes maximizing the use of the existing 108-inch pipe in the Coors Field Parking Lot. Currently, the tributary area to the pipe is only 88 acres. The outfall will extend up 27th Street to Champa Street with a 96-inch pipe.

Project G: 27th Street Interceptor – Phase 2 will continue upstream in 27th Street from Champa Street to Washington Street and along Washington Street to 19th Avenue with a 90-inch to a 72-inch pipe.

Project H: 27th Street Interceptor – Phase 3 will extend along Clarkson Street from 19th Avenue to 14th Avenue with a 60-inch pipe transitioning down to smaller pipe up into the basin. This project also includes up-sized laterals in 16th Avenue.

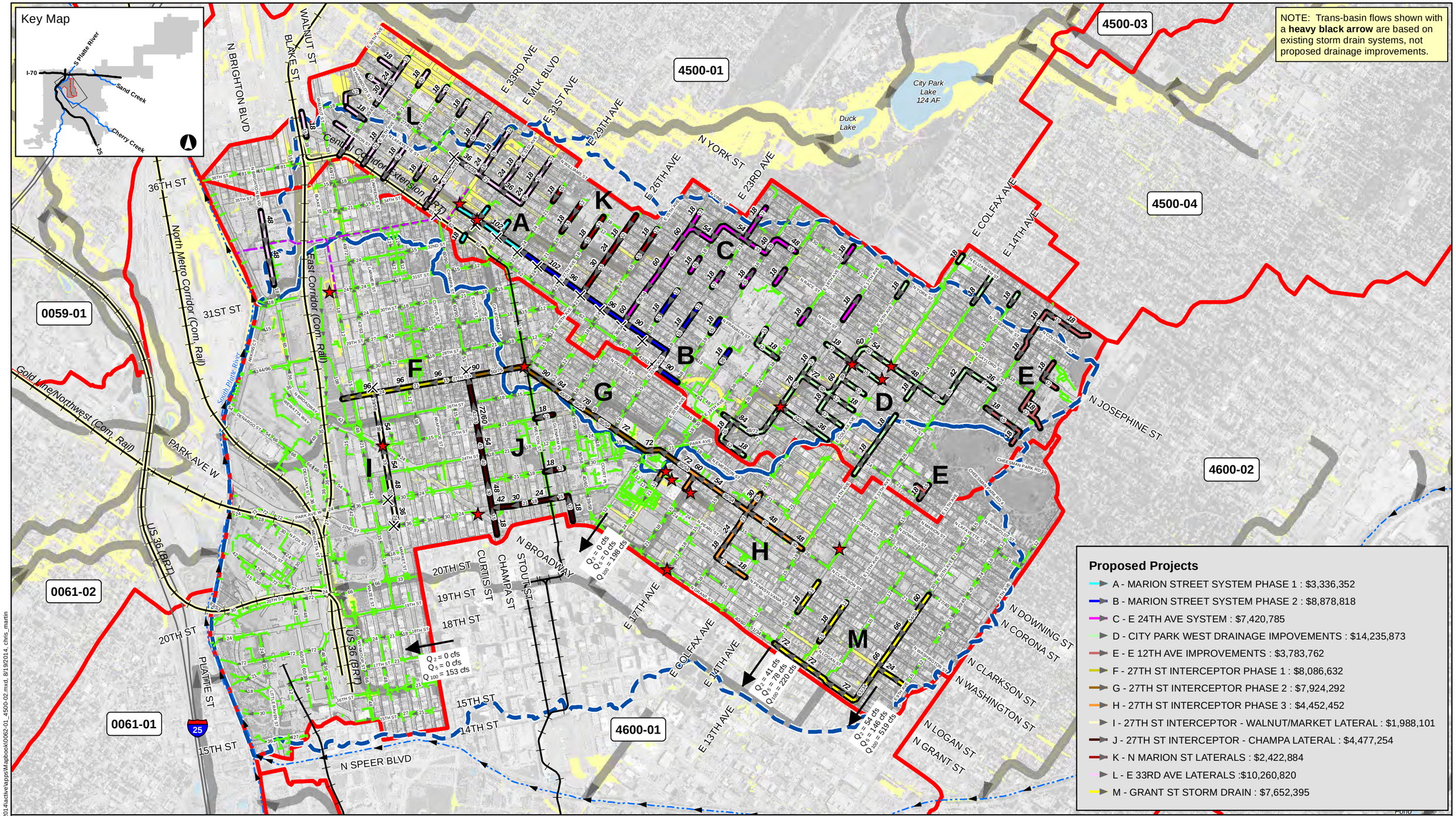
Project I: 27th Street Interceptor – Walnut/Market Lateral includes a new upsized pipe network in Walnut/Market Street south of 27th Street.

Project J: 27th Street Interceptor – Champa Lateral consists of a new box and pipe network in Champa Street south of 27th Street

Project K: North Marion Street Laterals proposes to replace the existing small storm drains east of Project A with 18-inch or larger pipes to meet current drainage criteria and reduce maintenance.

Project L: East 33rd Avenue Laterals includes a system to balance 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 in Humboldt Street and convey runoff to the existing 81-inch pipe in Downing Street, which is being relived with construction of the new outfall in 33rd Street. In addition, existing small storm drains are proposed to be replaced with 18-inch pipes to meet current drainage criteria and reduce maintenance.

Project M: Grant Street Storm Drain collects runoff from the existing storm drains in 9th and 10th Avenues at Ogden Street and delivers runoff in a 5-year event to the 13th Avenue Extension project in Basin 4600-01. This project also includes upsizing the existing storm drain in Grant Street from 10th to 13th Avenue.



Basin 0062-01 & 4500-02
Lower Platte Valley and 36th & Downing

Denver Storm Drainage Master Plan

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Basin 4600-01 (Central Business District)

Existing System Description:

This collection system basin consists of 1,427 acres (2.23 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 constructed for the Convention Center up to 14th & Stout, and extended as 84-inch pipe in Stout almost to 16th Street
- 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 constructed in 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 even the 100-year storm event to Cherry Creek. Redevelopment and current drainage criteria have required the construction of 100-year capacity outfalls, or at the least to construct the largest storm pipe possible. Two major-event FLO-2D analyses, Colfax Corridor and Downtown area, were performed through this basin and identified the Potential Inundation Area for the Master Plan Update.

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 10-foot x 5-foot box culvert was installed as part of redevelopment of the Convention Center in the mid-2000's to create an expanded outfall to Cherry Creek. Stout Street Phase II extended the storm drain to near 16th Street. Future extensions are needed to intercept runoff in the upper basin areas and utilize 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 Avenue 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 Avenue north of Cherry Creek should be upsized from a non-standard 26-inch vitrified clay pipe 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.

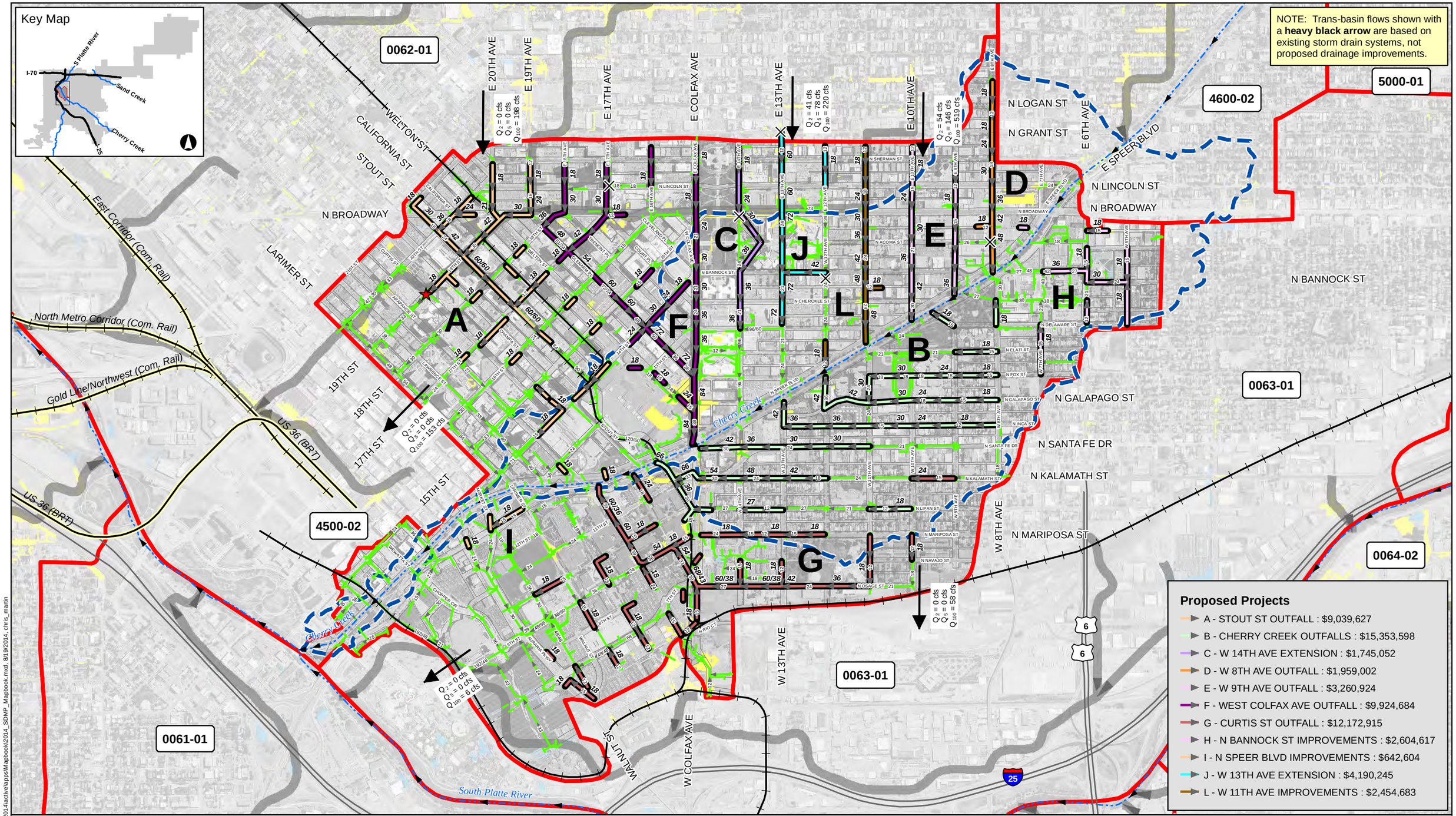
Project G: Curtis Street Outfall
Basins 60 and 65 currently drain 119 acres via an existing 39-inch pipe. Upsizing this outfall to a 60-inch pipe would provide 5-year storm capacity. Alternatively, detention in Lincoln Park was considered to avoid upsizing the outfall. However, current land use in the park, existing trees and the ridge topography in the park have prompted the consideration of conveyance over detention.

Project H: N Bannock St Improvement
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 Improvement
Existing storm drains are proposed to be replaced with larger pipes and 12- and 15-inch pipes are proposed to be replaced with 18-inch pipes to meet 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 convey it to Cherry Creek instead. 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 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.



N

0 600 1,200

Feet

1 inch equals 1,200 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Topographic Basin Boundary
- Thalweg
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
- Significant Flooding Location
- Proposed Detention Basin
- Existing Basin
- Potential Inundation Area
- Planned Transit Line
- Existing Transit Line
- City and County Boundary
- Other Municipalities
- Other Counties

Basin 4600-01
Central Business District

Denver Storm Drainage Master Plan

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Basin 4600-02 (Cherry Creek Mall)

Existing System Description:

This collection system basin consists of 2,928 acres (4.57 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-foot x 8-foot 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-foot x 8-foot box culvert in Steele Street.
- 48-inch x 76-inch 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 shopping area and west of N. Race Street (Basins 80, 85, 90, 91, 92 and 100) still comprise 270 acres that drain to an existing 56-inch storm drain in E. 1st Avenue, which outfalls to Cherry Creek at N. Marion Street. The recently designed N. University Outfall will relieve the burden of the 56-inch storm drain and offer a 2-year level of service. A drainage study called the ***4th Avenue--Williams to Lafayette Drainage Study*** was finalized in February 2012 for this area in greater detail for both the minor and major (100-year) storm events. The recommendations of this study have been incorporated into the Storm Drainage Master Plan. 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 drain 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 in 2003; 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:

Project A: Downing Street Outfall
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.

Project B: Lafayette Street Outfall Laterals
This project consists of laterals to the Lafayette Street Outfall Storm Drain constructed in 2004 (Phase I) and 2007 (Phase II). It includes upsizing the existing 21-inch storm pipe in N. Race Street to 27-inch pipe and upsizing existing 12-, 15-inch storm pipe to 18-inch pipe to meet the City's criteria.

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

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

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

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

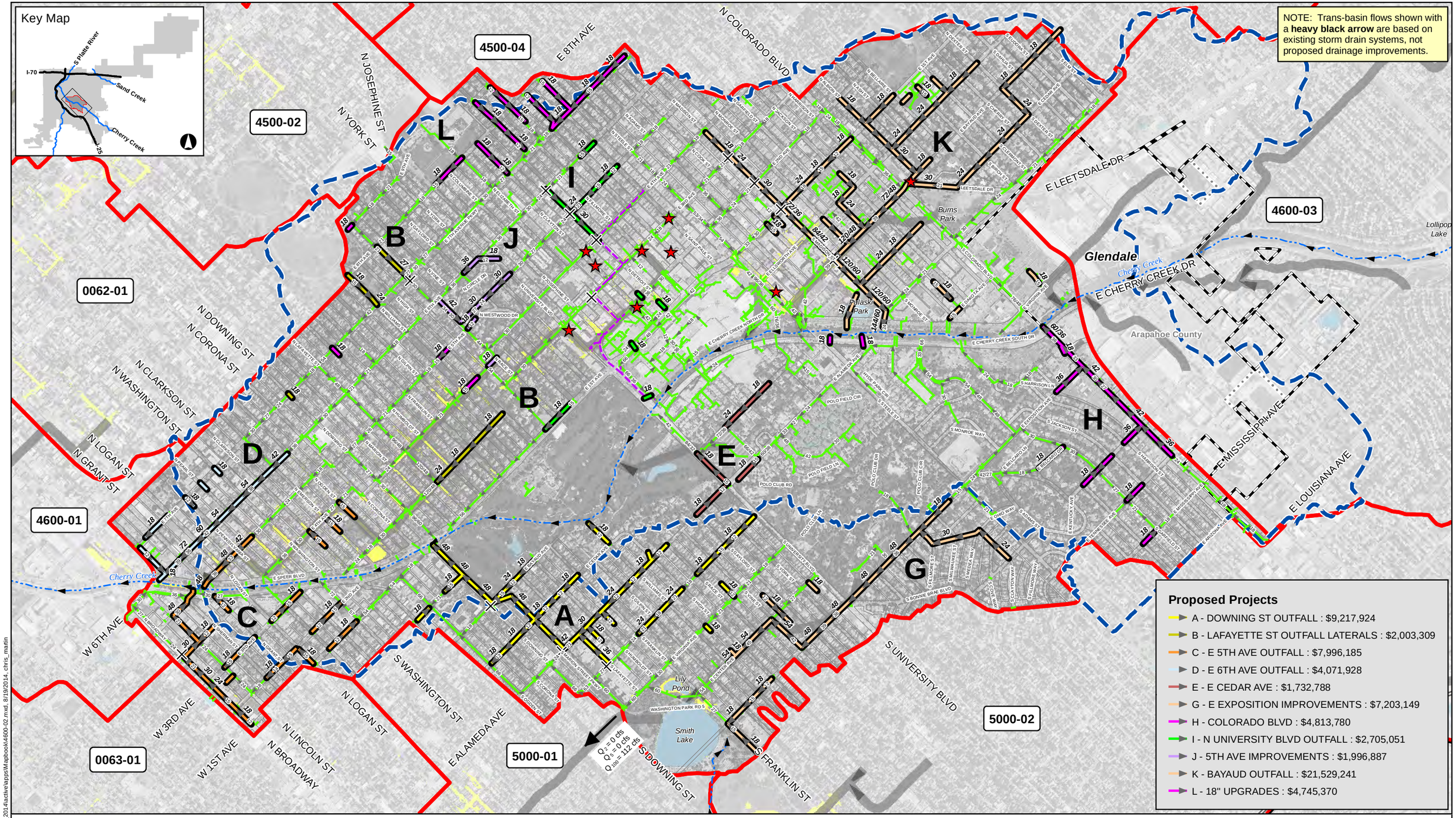
Project H: Colorado Boulevard Outfall
Construct a new 5-foot x 3-foot box culvert outfall in Colorado Boulevard.

Project I: University Outfall
The existing storm drain system north of the Cherry Creek Mall is often overwhelmed. A new outfall in University is under design for construction in 2014 in order to provide increased flood protection for the Cherry Creek North area. The proposed improvements are future lateral extensions.

Project J: 5th Avenue Improvements
Upsize existing storm drain systems to meet the City's criteria.

Project K: Bayaud Outfall
This project includes a 12-foot x 5-foot RCBC outfall and trunk lines in N. Madison Street and E. Bayaud Avenue and laterals extending up into the basin as far east as S. Farfax Street. The conceptual alignment was based on a cursory review of utilities, by Huitt-Zollars in 2012, and a recommendation to only cross Colorado Boulevard once. The trunk main in Madison Street was proposed in the 2009 ***Cherry Creek Neighborhood Drainage Study***, by PBS&J, which was used for reviewing the Huitt-Zollars conceptual alignment.

Project L: 18-inch Upgrades
Existing 12-inch and 15-inch pipes in 7th and 8th Avenues are proposed to be upgraded with 18-inch pipe to meet current criteria, improve conveyance and reduce maintenance.



Basin 4600-02
Cherry Creek Mall

Denver Storm Drainage Master Plan

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Basin 4600-02 (Cherry Creek Mall 100-Year Alternative)

Minor Storm Event:

Lafayette Street Outfall Storm Drain Phase I, was constructed in 2004, from Cherry Creek up Little Downing Street, thence east in 3rd Avenue to Lafayette Street, and north in Lafayette Street to 7th Avenue. This system was designed for a 2-year storm event. Lafayette Street Outfall Storm Drain Phase II, was constructed in 2007, in 7th Avenue, from Lafayette Street to Gaylord Street, is also designed to convey runoff in a 2-year storm event.

Upstream of the Lafayette Street Outfall Storm Drain Phase II, an existing storm drain system extends east in 7th Avenue, from Gaylord to Madison, to collect runoff from this area in the minor storm event and deliver it to the Lafayette Outfall Storm Drain system.

Another storm drain collection system, in this collection system drainage basin, starts at Cherry Creek and 1st Avenue, extending east to Race Street, and north in Race Street, to 6th Avenue, with lateral drains extending east in 6th Avenue, 5th Avenue, 4th Avenue, and 3rd Avenue to Saint Paul Street in the Cherry Creek North neighborhood.

Larger Storm Events:

In moderate and larger storm events, storm runoff will fill the existing storm drains in 7th, 6th, 5th, 4th and 3rd Avenues, and runoff in excess of the existing storm drain capacities east of University Boulevard will flow south into the Cherry Creek North shopping district. This storm runoff flows collects at 3rd and University where it can overtop University Boulevard and continue to flow to the west in 3rd Avenue to Race Street and Race Court to a historic drainage path in 4th Avenue. Runoff in excess of the existing storm drain capacities in the drainage basin west of University also flows south to the historic drainage path in 4th Avenue. Flows from these areas comingle and flow west in 4th Avenue west of University.

The ***4th Avenue Williams to Lafayette Drainage Study*** completed by PBS&J in February 2012 identified alternatives to address the drainage converging in 4th Avenue. The recommended solution shown in the Master Plan conveys the runoff in a manner that street depth criteria is met; i.e., no more than 12-inch of runoff depth in the gutter with the remaining flow conveyed in an underground storm drain to Cherry Creek

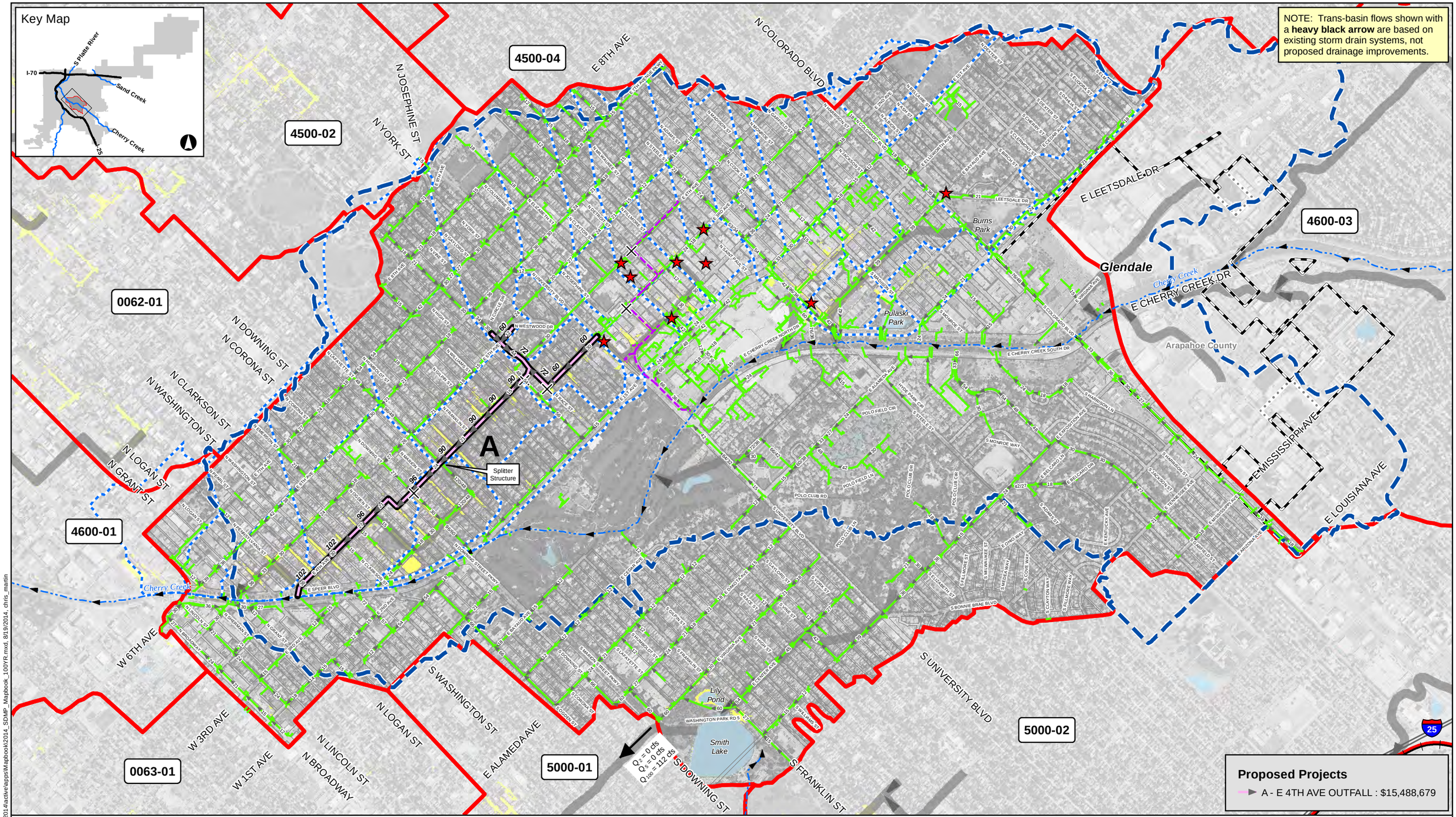
Improved Protection:

A new storm drain is being constructed in 2014/2015, called the N. University Outfall Storm Drain, in order to provide improved flood protection for the Cherry Creek North business district.

After construction of the N. University Outfall Storm Drain in 2014/2015, moderate and large storm event runoff from east of University, in excess of the storm drain capacity, will continue to overtop University at 3rd Avenue; albeit not as much as would escape prior to construction of the N. University Outfall Storm Drain. Again, this excess runoff will flow west in 3rd Avenue to Race Street and Race Court, and then flows north to 4th Avenue.

Recommendation:

Implementation of the ***4th Avenue Williams to Lafayette Drainage Study*** recommendations would need to be updated to reflect the reduced runoff reaching 4th Avenue at Race Street, as a result of the construction of the improved drainage by the N. University Outfall project, based upon the final design and construction of the N. University Boulevard Outfall Storm Drain.



For Detailed Hydrology See Technical Appendix and Work Map

0 700 1,400 Feet

1 inch equals 1,400 feet

Legend

- Collection System Boundary
- Topographic Basin Boundary
- 100-yr Sub-Collection System Boundary
- Thalweg
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
- Significant Flooding Location
- Proposed Detention Basin
- Existing Basin
- Potential Inundation Area
- Planned Transit Line
- Existing Transit Line
- City and County Boundary
- Other Municipalities
- Other Counties

Basin 4600-02 - 100-yr Alternative Cherry Creek Mall

Denver Storm Drainage Master Plan

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Basin 4600-03 (Upper Cherry Creek)

Existing System Description:

This collection system basin consists of 3,585 acres (5.60 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 includes 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-inchx53-inch 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-inchx38-inch 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.

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.

The ***Cherry Creek Stabilization Plan Update***, prepared for the UDFCD by Matrix Design Group in 2011, found that the Cherry Creek reach between Holly Street to Quebec Street contains noticeable channel instability. Visible bank erosion, channel degradation and mass wasting of the channel banks has also contributed very high sediment loads to the downstream reaches, leading to further instability. Also, the Cherry Creek reach between Quebec Street to Iliff Avenue is the most noticeably degraded. Lateral instability has eroded the channel banks and stabilizing vegetation. There are broad sandy bars and vertical cut banks with few trees and poor quality riparian vegetation. The 2002 Inventory Report described 7.0 feet of channel degradation between 1976 and 1990. The existing channel thalweg profile is approximately the same as the thalweg profile in the 1991 Study, but the channel is experiencing significant lateral migration. Many vertical cut banks are evident in the area.

Proposed Capital Improvements:

Project A: E. Exposition Avenue Outfall
This project includes extending laterals on existing outfalls and extending east of Leetsdale Drive. The existing 72-inch outfall is sufficient for protecting the residential area up to 2-year event with the incorporation of the Tennessee and Oneida Storm Drainage Alternative of the Proposed Project C.

Project B: S. Holly Street Outfall
This project is a new 36-inch lateral west of Garland Park.

Project D: Honey Way Outfall
This project includes a new 30-inch pipe and replacing 21- and 24-inch pipe in E. Florida Avenue between S. Holly Street and S. Jasmine Way to convey the split flow identified in ***S. Forest Street Outfall Final Design Report***. This project also 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
This project includes re-routing an existing storm drain to a new outfall in Quebec Street, north of Cherry Creek, and 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.

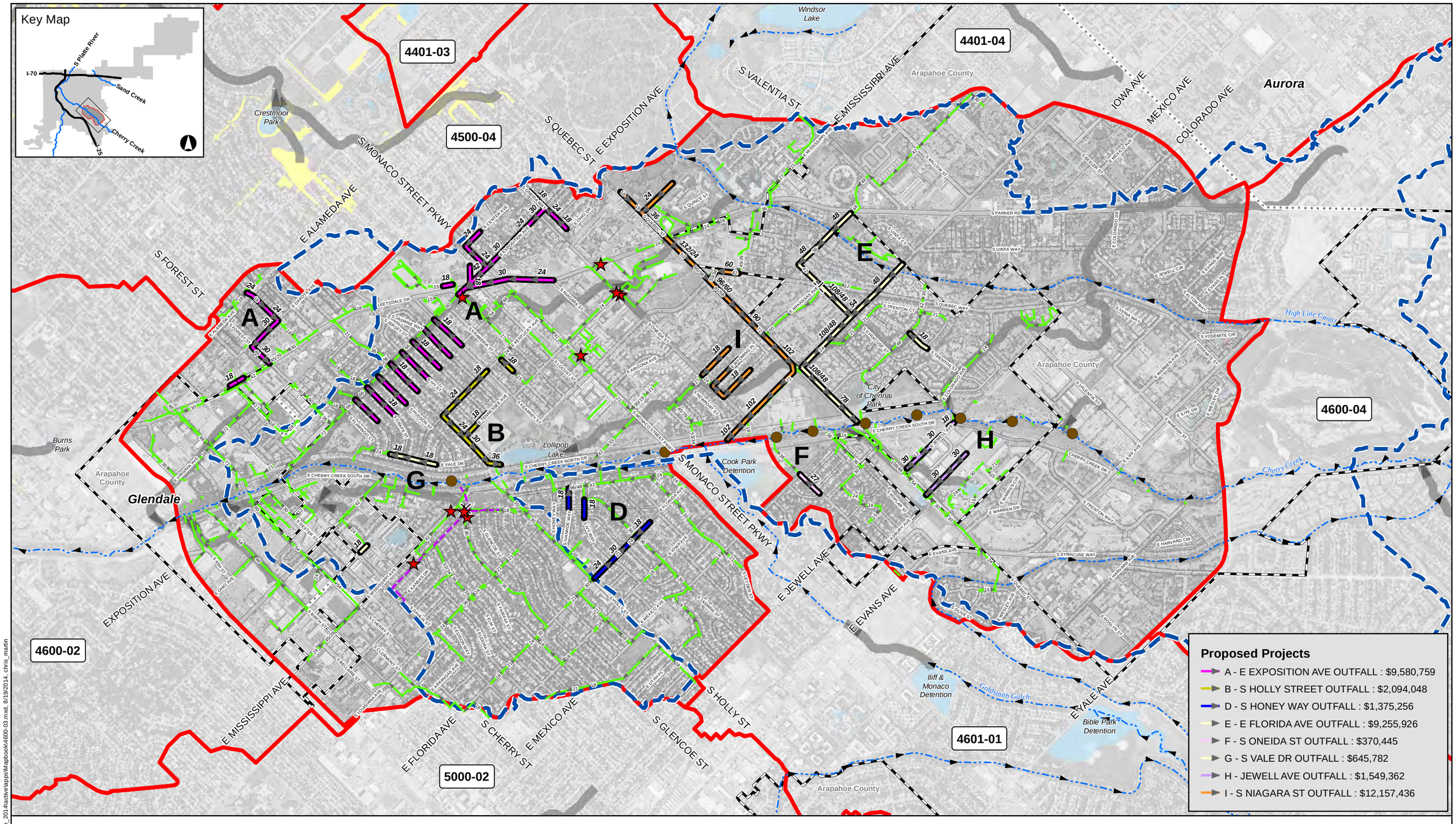
Project F: Oneida Street Outfall
This project includes extension of the storm lateral network to reduce potential inundation at the intersection of Oneida and Mexico.

Project G: Vale Drive Outfall
This project includes 18-inch pipe from Glencoe Street to E Tennessee Avenue. A new twin 30-inch outfall at the Historic Four Mile Park and a new 24-inch pipe in E. Vale Drive to S Glencoe Street were constructed in 2011

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
This project includes replacement of an existing 72-inch outfall with a 102-inch pipe and 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.

Project J: Cherry Creek Stabilization Plan
This project includes nine drop structures with heights vary from 3.4 feet to 9 feet tall were proposed in this reach to stabilize the channel invert. Two types of bank stabilization alternative, soil riprap and pre-vegetated coir and deep-rooted plantings were proposed inside this reach for protecting bank from erosion wherever is appropriate.



Basin 4600-03
Upper Cherry Creek

Denver Storm Drainage Master Plan

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Basin 4600-03 (Tennessee & Oneida Sump 100-Year Drainage Alternative)

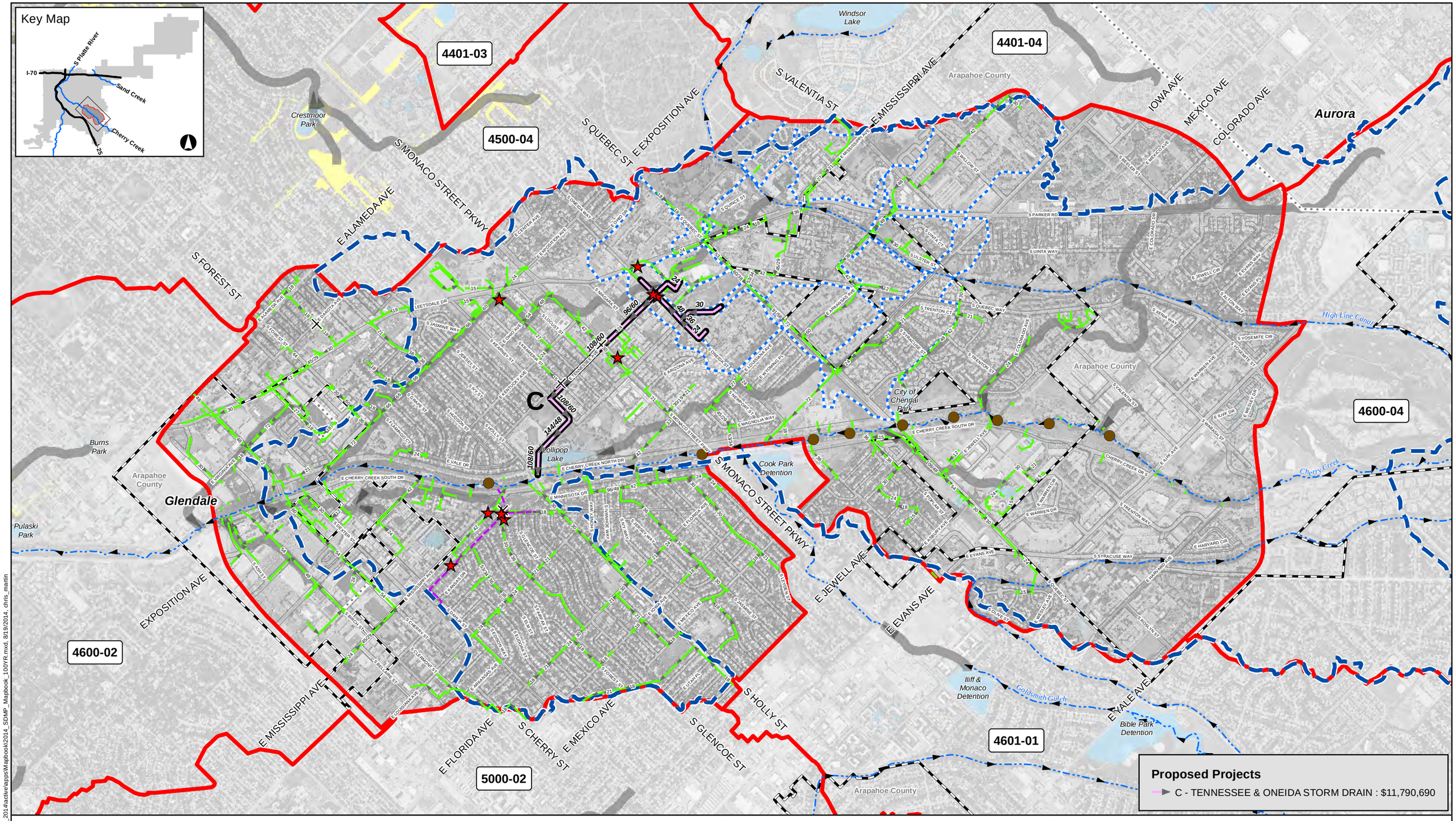
Drainage Deficiencies:

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 Street north of E. Tennessee Avenue, where a sump condition exists. On June 26, 2009, a storm of 1.4-inches in 20 minutes and 1.7-inches seen on rainfall maps caused 1 foot of flooding at the intersection of E. Florida Avenue and S. Oneida Street, and more than 2 feet of water at the low point on S. Oneida Street at E. Tennessee Ave. This area has flooded in the past.

Proposed Capital Improvements:

Felsburg Holt & Ullevig prepared the ***Tennessee & Oneida Storm Drainage Alternatives Study***, on February 9th, 2011, for the City and County of Denver Department of Public Works. In the report, an 84-inch outfall, following E. Tennessee Avenue, is the shortest and the most cost effective. This alignment was recommended as the most feasible alternative. For the Master Plan Update, the Tennessee & Oneida Storm Drainage Report was integrated into the proposed improvement and the benefit to the neighboring proposed system was also evaluated. The existing 72-inch outfall at E. Exposition Avenue is in good condition and is able to provide a 2-year storm level of protection for the residential area once the Tennessee & Oneida Storm Drainage is in place. The integrated proposed improvements are listed below.

<u>Project C: Tennessee & Oneida Storm Drain</u>
This project includes a box culvert outfall starting at Cherry Creek and extending upstream into the basin in E. Tennessee Street to the sump area at Oneida Street in order to provide 100-year flood protection at the sump and includes a new 48-inch lateral in S. Oneida Street.



Basin 4600-03 - 100-yr Alternative
Upper Cherry Creek

Denver Storm Drainage Master Plan

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Basin 4600-04 (Cherry Creek Reservoir)

Existing System Description:

This collection system basin consists of 3,675 acres (5.74 square miles). Two major storm drainage projects, Hampden Heights – Phase I (Eastman) and Hampden Heights – Phase II (Girard) have been constructed, subsequent to the 2009 ***Storm Drainage Master Plan***, to mitigate repetitive flooding issues in the Hampden Heights neighborhood.

There are numerous detention basins within this collection system basin. Many were constructed as part of the Hampden Town Center Development, in Aurora, and serve to reduce runoff in the 100-year system to a release flow rate of 56 cfs from the detention basin at the southwest corner of E. Hampden Avenue and S. Dayton Street, in accordance with an intergovernmental agreement between Denver and Aurora, executed on September 10th, 2007 (***Denver City Clerk Filing No. 2007-0103-A***). 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. Another detention basin is also located near the intersection of Hampden Avenue and Dayton Street. A detention basin is also located on the Hampden Heights Park at the northeast corner to the intersection of Dayton Street and Dayton Court. The storage / discharge relationship for these basins were found in the ***Hampden Heights Area – Flood Investigation and Improvement Plan***. The Kennedy Ball Fields, near the intersection of S. Parker Rd. and Dartmouth Avenue, also have a detention basin on site. The detention basin located on the Kennedy Ball Fields were not designed for a 100-year storm event. In a major storm event, flows will overtop the west end of the detention basin and flow overland through the John F. Kennedy Golf Course to Cherry Creek.

The Kennedy Ball Fields Detention receives runoff from a tributary area of 462 acres through a large, high capacity storm inlet located at the intersection of S. Parker Road and E. Dartmouth Avenue. Based on field observation, it appears the surface overflow from this inlet would not reach the Ball Fields Detention. A FLO-2D analysis indicates that the surface flow would cross S. Parker Road at the drive entrance approximately 680 feet northwest of the intersection of S. Parker Road and E. Dartmouth Avenue. After splitting in the private parking area, the surface flow makes its way back to Dartmouth Avenue and continues west. Details of the analysis can be found in the ***Hydrologic and Hydraulics Report for Kennedy Ball Fields Outfall*** prepared by PB Americas, Inc., for the City and County of Denver in July, 2010.

Drainage Deficiencies:

The ***Kennedy Ball Fields Outfall Hydrologic and Hydraulics Report***, prepared by PB Americas, Inc. for the City and County of Denver in July 2010, concluded that a 100-year outfall system from the Kennedy Ball Fields detention basin be constructed (see Basin 4600-04 100-Year Alternative for more information). This study also noted that runoff, which exceeds the capacity of the storm drains in S. Parker Road, will be converged west along E. Dartmouth Avenue.

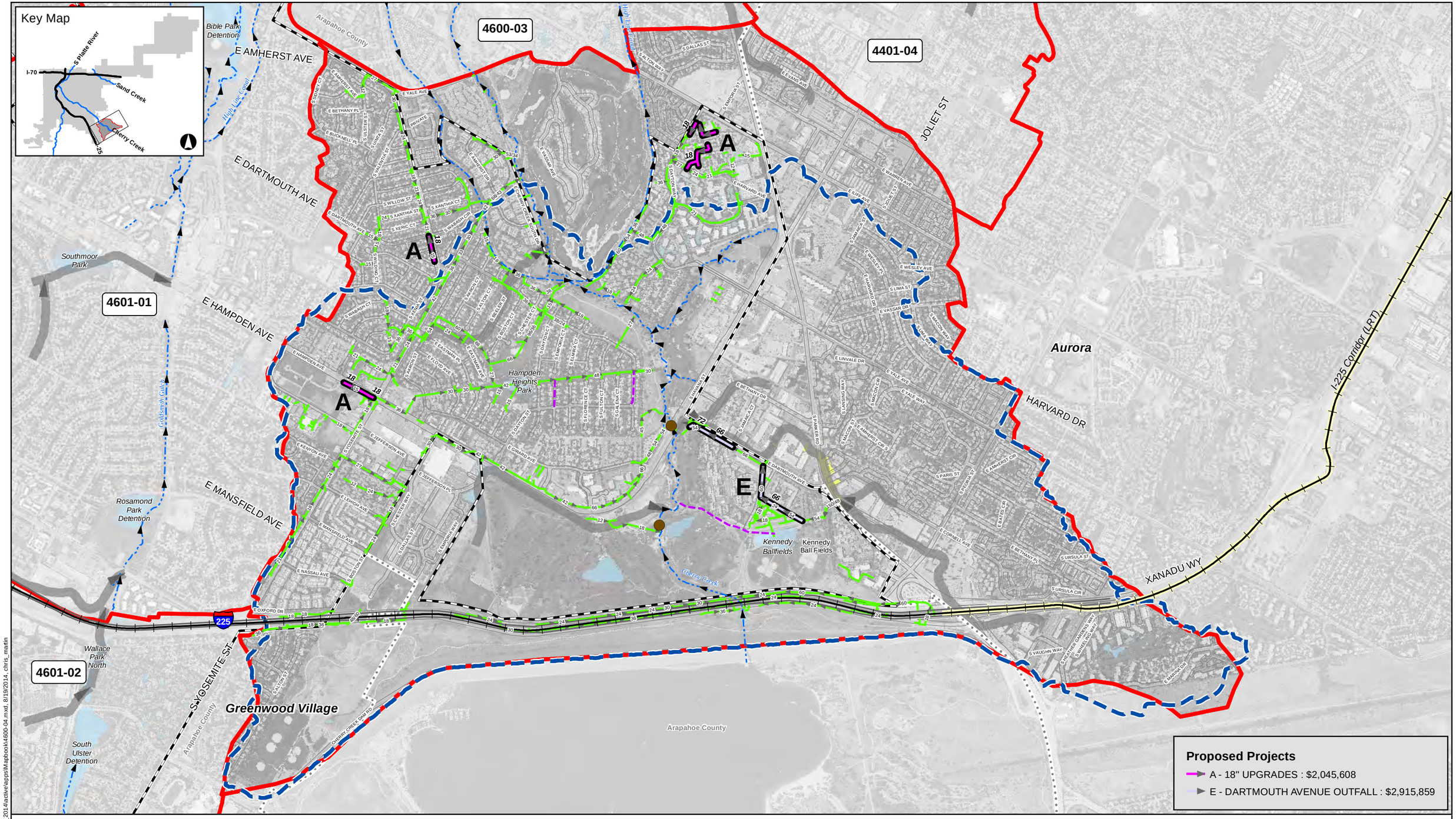
The storm drain system beginning just south of the intersection of Parker Road and Dartmouth Avenue is undersized for handling the 2-year flows even with the Kennedy Ball Fields Detention Basin. An area of approximately 462 acres (DP 250) drains to the upper portion of the system and an area of 637 acres (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.

Cherry Creek is the major drainageway through this study basin. Per the Matrix 2011 ***Cherry Creek Stabilization Plan Update***, Reach 7 extends from Havana Street to the outlet of the Cherry Creek Dam with an average channel slope between structures of 0.24%, but is experiencing degradation due to clear water scour. The channel invert lowered three feet from 1976 to 1991 at Havana Street. An additional one foot of degradation has occurred since 1991. Drop #27 was recently constructed in 2009 by re-facing the old Kenwood Dam outlet structure and creating a new plunge pool. Downstream from this pool, the channel is experiencing degradation, particularly after the flushing releases from the Cherry Creek Dam each year by the USACE.

Proposed Capital Improvements:

<u>Project A: 18-Inch Upgrades</u>
This project includes upsizing various pipes to the City's 18-inch minimum diameter is proposed to meet current drainage criteria.

<u>Project E: Dartmouth Avenue Outfall</u>
The 54-inch/60-inch/66-inch/72-inch 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.



Basin 4600-04
Cherry Creek Reservoir

Denver Storm Drainage Master Plan

Basin 4600-04 (Kennedy Ball Field 100-Year Alternative)

Existing System Description:

Currently the John F. Kennedy Park includes a public golf course and an athletic sports complex. The John F. Kennedy Municipal Golf Course consists of an eighteen (18) hole course and the sports complex, John F. Kennedy Ball Fields, includes eight (8) ball fields and open space. John F. Kennedy Park is a parcel of land currently zoned O-1, primarily retail, service, and office space. As stated earlier, the current use for this parcel is recreational facilities for use by the general public. The portion of the parcel that encompasses the ball fields and situated northeast of Cherry Creek is approximately forty-three (43) acres (ac) in area.

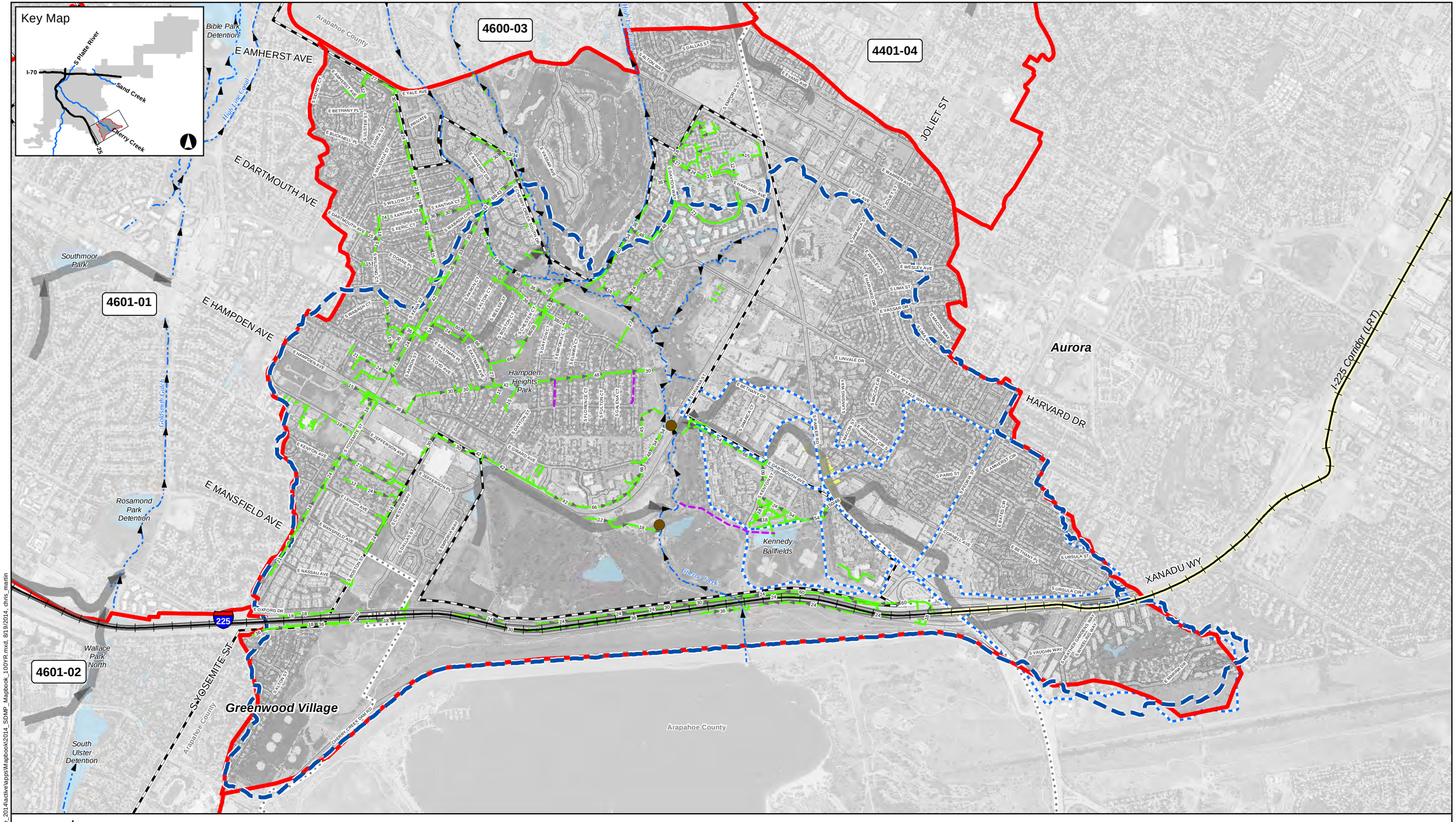
The existing Kennedy Ball Fields Detention as identified in City and County of Denver Storm Master Plan as detention facility 271 which is drained by the existing 24-inch outfall and is conveyed north to the system in Dartmouth Avenue. The existing condition requires a 46.5 ac-ft of detention volume to control the 100-year flow.

Drainage Deficiencies:

The watershed was evaluated for the City and County of Denver, by PB Americas, Inc., in a report dated July 2010 and entitled ***Kennedy Ball Fields Outfall Hydrologic and Hydraulics Report***. Based on available information, the existing stormwater detention facility has been in existence since 1976. With the development of the Broadstone Apartment Complex, a berm was constructed to prevent potential stormwater overflows from impacting the site and the multi-family residential area southwest of the project site. The detention basin and berm were not included in the uses within the lease held by Denver Parks from the United States Army Corps of Engineers (USACE). It was agreed between United States Army Corps of Engineers (USACE) and the City and County of Denver that the storage volume within the Kennedy Ball Fields would be limited to the approximate volume below the constructed berm, or 6.7 acre-feet (ac-ft).

Proposed Capital Improvements:

The drainage patterns tributary to the Kennedy Ball Fields will remain unchanged from the existing to proposed condition under this study. The proposed improvements will include a 72-inch RCP outfall to convey the maximum outflow of 464 cfs to Cherry Creek through the Kennedy Municipal Golf Course. The horizontal alignment of the proposed outfall facility will be positioned to minimize impacts to the golf course and City and County of Denver's bike / pedestrian path. The water quality/outlet structure will be designed to accommodate the existing 24-inch RCP outlet pipe and the proposed 72-inch RCP outfall. The outfall of the system into Cherry Creek will include a modified HEC-14 Colorado State University (CSU) rigid boundary basin energy dissipater that incorporates UDFCD grouted boulders. As of this report, the project has been designed and is awaiting funding for construction.



0 850 1,700
Feet
1 inch equals 1,700 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Topographic Basin Boundary
- 100-yr Sub-Collection System Boundary
- Thalweg
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
- Significant Flooding Location
- Proposed Detention Basin
- Existing Basin
- Potential Inundation Area
- Planned Transit Line
- Existing Transit Line
- City and County Boundary
- Other Municipalities
- Other Counties

Basin 4600-04 - 100-yr Alternative
Cherry Creek Reservoir

Denver Storm Drainage Master Plan

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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 High Line 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 E. Iliff Avenue and S. Monaco Street Parkway. Increased capacity in the detention basin located within Bible Park was investigated and rejected due to lack of community support. A localized sump condition exists in S. Monaco Street Parkway, south of E. Evans Avenue.

Additionally, chronic flooding has occurred on the west side of S. Holly Street between E. Evans Avenue and E. Jewell Avenue. Drainage improvements have been designed and will be constructed in 2014.

Proposed Capital Improvements:

This basin requires improvements primarily to upsize the existing storm drain system from a 2-year capacity to a 5-year capacity.

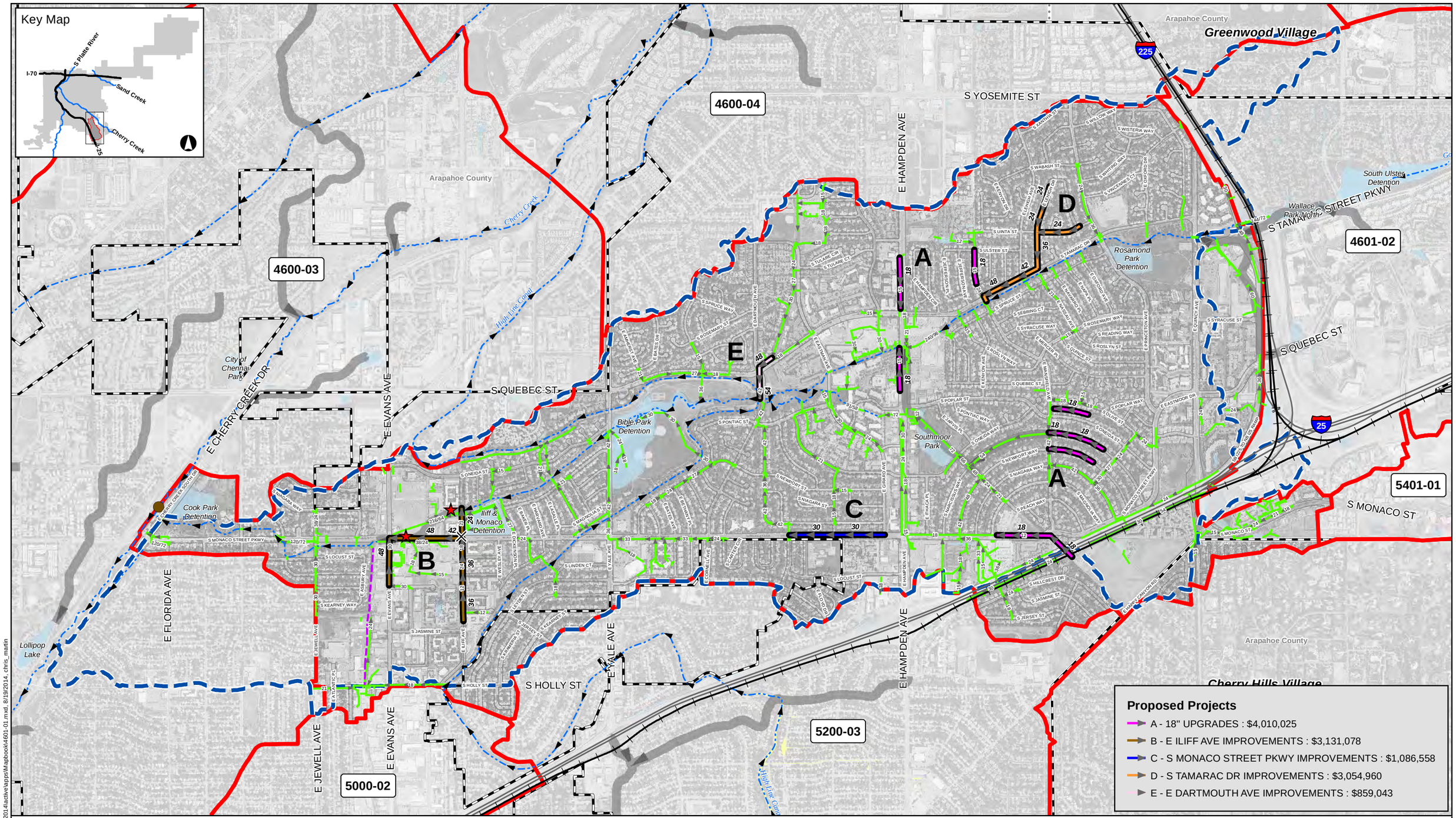
Project A: 18-inch Upgrades
This project requires several existing storm drains to be upsized within the basin in order to meet Denver's stormwater criteria.

Project B: E Iliff Avenue
This project includes upsizing the existing lateral in E. Evans between Leyden Street and S. Monaco Street Parkway. This upgrade is required to meet the City's requirements for service to a commercial area. Similarly, a new storm drain will be extended along E. Iliff Avenue from Kearney Street east to S. Monaco Street Parkway and connect to the existing storm drain system that outfalls to Goldsmith Gulch. The system will extend up S. Monaco Street Parkway and connect to the proposed storm drain 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 Street Parkway Improvements
This project requires a new 30-inch storm drain to extend south along S. Monaco Street Parkway to E. Girard Avenue. 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 drain will be extended to and along S. Tamarac Drive to the north. The storm drain will outfall to Goldsmith Gulch at E. Kenyon Avenue and S. Tamarac Drive.

Project E: E. Dartmouth Avenue Improvements
This project requires upsizing the existing 42-inch storm drain to a 54-inch storm drain, from its outfall at Goldsmith Gulch to S. Tamarac Drive, and upsizing the existing 36-inch storm drain, in Tamarac Drive, to a 48-inch storm drain, offering 2-year capacity to adequately drain the residential area.



Basin 4601-01
Lower Goldsmith Gulch

Denver Storm Drainage Master Plan

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Basin 4601-02 (Middle Goldsmith Gulch)

The Goldsmith Gulch Collection System 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 drain and detention facilities drain the I-225 and I-25 interchange to Goldsmith Gulch.

Existing System Description:

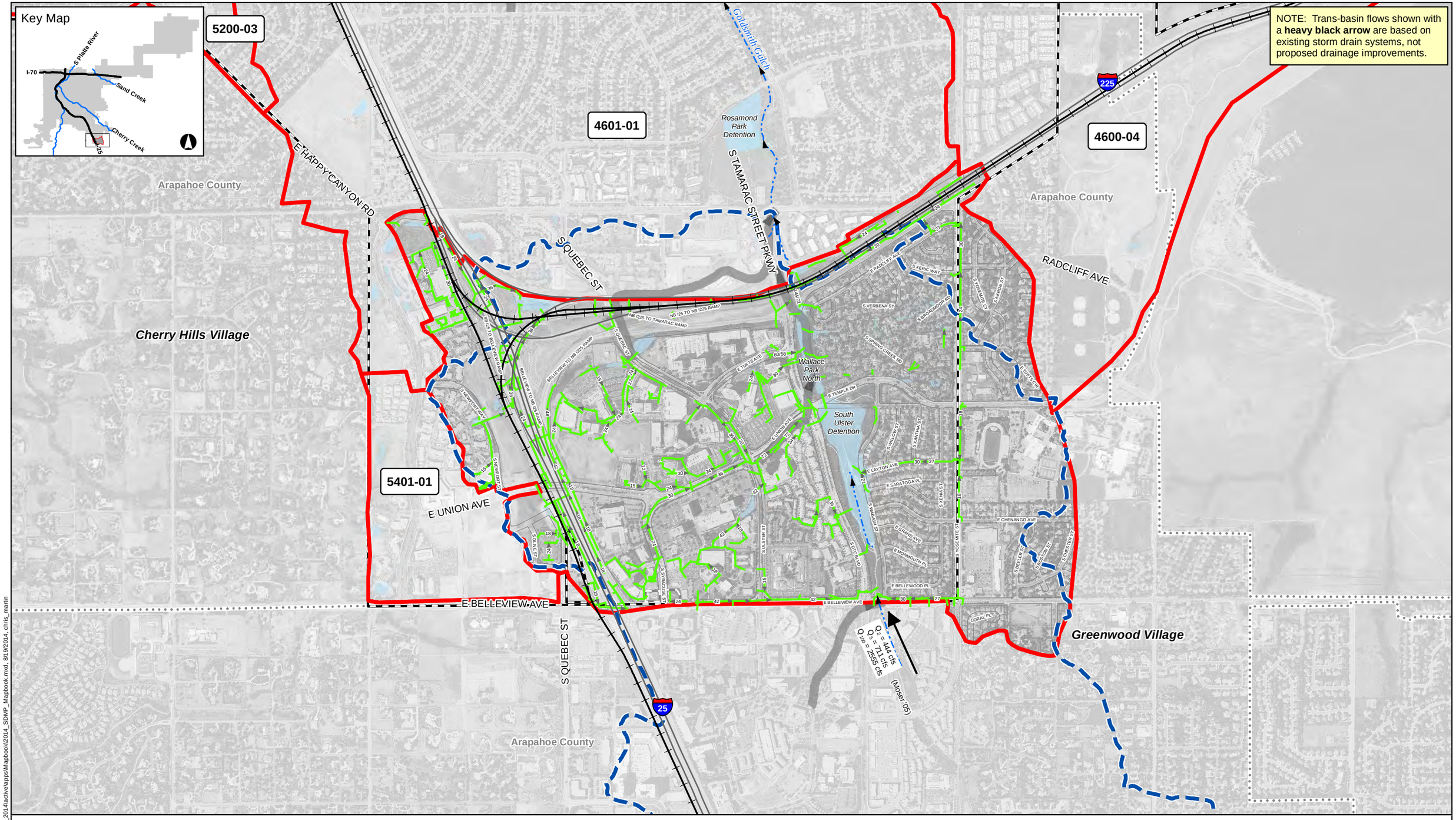
The entire basin extends from Cherry Creek about 8 miles southeast to Arapahoe Road. This section of the Goldsmith Gulch Basin has a total drainage area of about 1.34 square miles. It is located in the southeast Denver metropolitan area and is entirely within the City and County of Denver. Inflows shown for Goldsmith Gulch, at the City boundary, are from the ***Upper Goldsmith Gulch Outfall Systems Planning Conceptual Design Report*** by Moser & Associates for the UDFCD, November 2005. 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.

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.



N

0 600 1,200

Feet

1 inch equals 1,200 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Topographic Basin Boundary
- Thalweg
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
- Significant Flooding Location
- Proposed Detention Basin
- Existing Basin
- Potential Inundation Area
- Planned Transit Line
- Existing Transit Line
- City and County Boundary
- Other Municipalities
- Other Counties

Basin 4601-02
Middle Goldsmith Gulch

Denver Storm Drainage Master Plan

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Basin 4700-01 (Sloan's Lake)

Existing System Description:

This collection system 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 and County 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). These are referenced on the map as locations "J" and "D", respectively, with flow rates from the December 1977 ***Sloan's Lake Basin Major Drainageway Plan*** prepared by URS Company for the UDFCD. 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 drain 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 Boulevard, Colfax Avenue, and Sports Authority Field at Mile High Stadium. An update to the 1977 ***Sloan's Lake Major Drainageway Plan*** is currently anticipated to begin in 2015.

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 34 cfs during the 100-year event (***LOMR 92-08-04OP***, effective May 5, 1993). 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 from the local drainage area. 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:

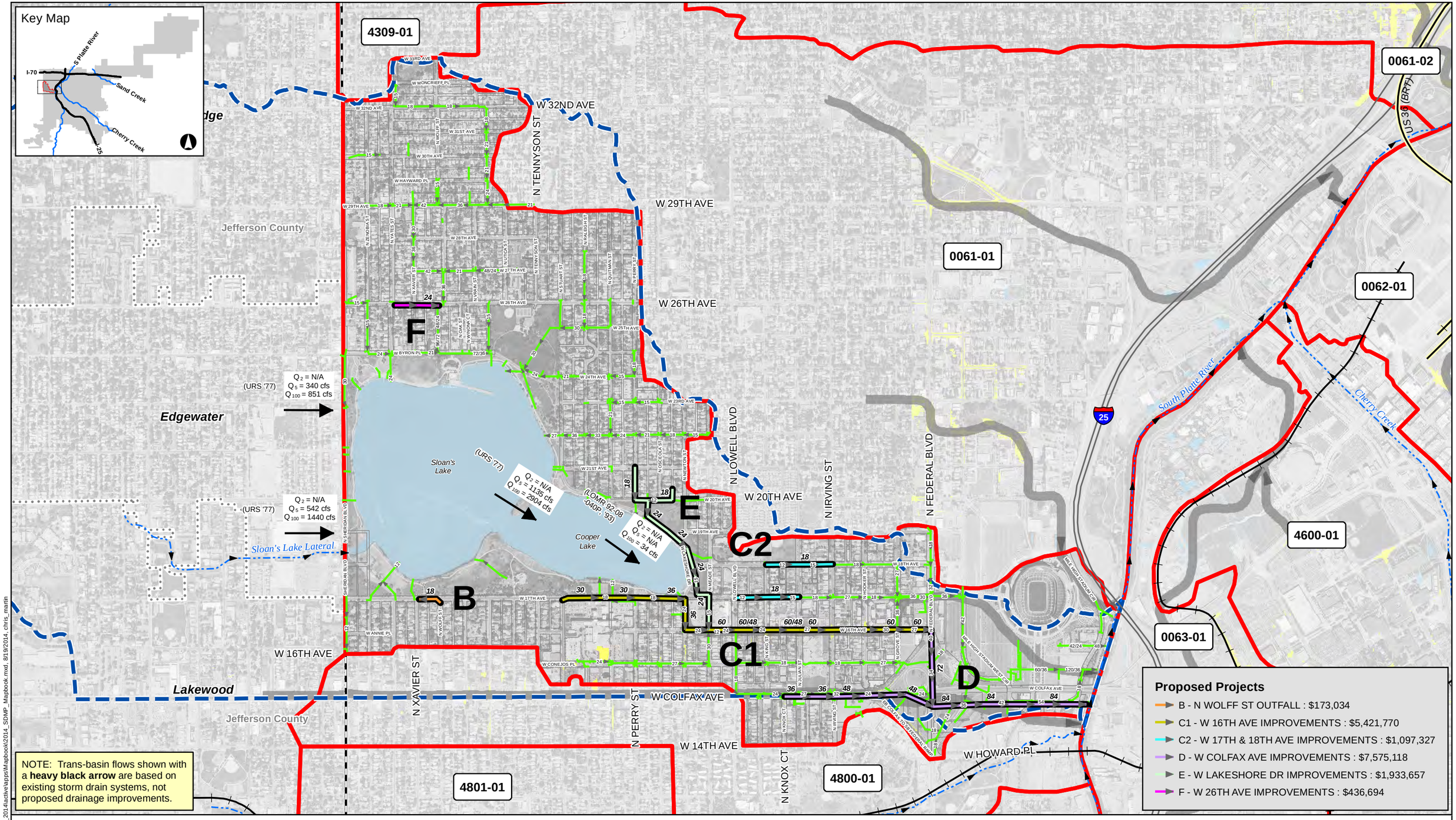
Project B: N. Wolff St. Outfall
An 18-inch lateral is proposed to provide additional inlets and drainage facilities for 17th Avenue.

Projects C1 and D: W 16th Ave. and W. Colfax Ave. Improvements
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. Upstream of the Sloan's Lake outlet upsizing the existing 15-inch and 18-inch storm pipes with 36-inch and 30-inch pipes is recommended to provide drainage facilities up to 17th Avenue and N. Stuart Street. Upsizing the storm drain in Colfax Avenue between Knox Court and Federal Boulevard is proposed to upgrade the system to a 5-year capacity.

Projects C2: W 17th Ave. and W. 18th Ave. Improvements
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.

Project E: W. Lakeshore Dr. Improvements
The system draining 20th Avenue east of Sloan's Lake should be upsized to handle the 2-year event.

Project F: W. 26th Avenue Improvements
A 24-inch lateral is proposed in 26th Avenue to convey the 2-year storm event.



Basin 4700-01
Sloan's Lake

Denver Storm Drainage Master Plan

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Basin 4700-01 (Sloan's Lake 100-Year Alternative)

Existing System Description:

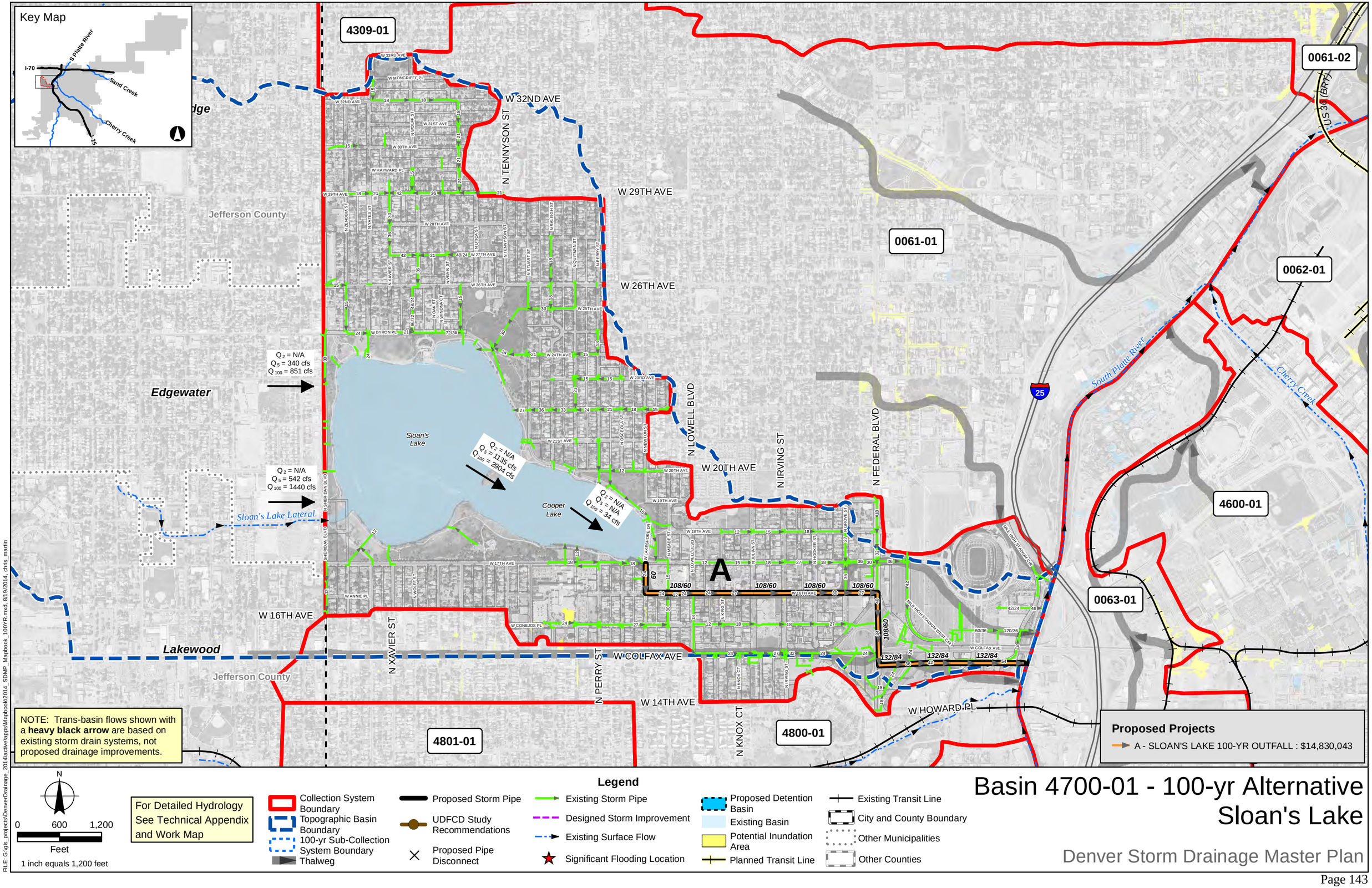
Sloan's Lake is effective in reducing peak flow rates to drainage systems lower in the collection system basin. The lake reduces peak flow rates from about 2,904 cfs to 34 cfs during the 100-year event (***LOMR 92-08-04OP***, effective May 5, 1993). However, the existing system below the lake cannot sufficiently handle stormwater runoff from the drainage watershed below the lake.

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:

<u>Projects A: Sloan's Lake 100-Year Outfal</u>
The proposed facility needed at the outfall of Sloan's Lake in N. Newton Street to convey the 100-year flow is a 60-inch pipe into a 9-foot x 5-foot box culvert in 16th Avenue and Federal Boulevard. At Colfax Avenue, the size is increased to an 11-foot x 7-foot box culvert. These proposed sizes convey the entire 100-year event without utilizing the capacity of the street above.


Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
4309-01
W 33RD AVE
W MONCRIEFF PL
W 32ND AVE
W 32ND AVE
N TENNYSON ST
W 31ST AVE
N WOLFF ST
W 30TH AVE
W HAYWARD PL
W 29TH AVE
W 29TH AVE
Jefferson County
N ZEPHYR ST
N YATES ST
W 28TH AVE
N UTICA ST
N TENNYSON ST
N RALEIGH ST
N STUART ST
N QUITMAN ST
N FERRY ST
N XAVIER ST
N WINNONA ST
W 27TH AVE
W 26TH AVE
W 26TH AVE
N OAK ST
N WYANDOT ST
W 25TH AVE
W BYRON PL
W 24TH AVE
W 23RD AVE
Edgewater
Sloan's Lake
W 21ST AVE
N OSCEOLA ST
N NEWTON ST
N LOWELL BLVD
W 20TH AVE
N IRVING ST
N FEDERAL BLVD
W 19TH AVE
Cooper Lake
W 18TH AVE
W LAKESHORE DR
N MEADE ST
N JULIAN ST
N LOWELL BLVD
N HOOKER ST
N MORRIS ST
W 17TH AVE
N SHERIDAN BLVD
W ANNIE PL
N WOLFF ST
W 16TH AVE
W CONEJOS PL
Lakewood
Jefferson County
N XAVIER ST
N PERRY ST
W COLFAX AVE
W 14TH AVE
N KNOX CT
W HOWARD PL
4801-01
4800-01
0061-02
US 36 (BRT)
0061-01
0062-01
4600-01
0063-01
South Platte River
Cherry Creek
25
A
Q2 = N/A
Q5 = 340 cfs
Q100 = 851 cfs
Q2 = N/A
Q5 = 542 cfs
Q100 = 1440 cfs
Sloan's Lake Lateral
Q2 = N/A
Q5 = 1135 cfs
Q100 = 2904 cfs
Q2 = N/A
Q5 = N/A
Q100 = 34 cfs
NOTE: Trans-basin flows shown with a heavy black arrow are based on existing storm drain systems, not proposed drainage improvements.
Proposed Projects
A - SLOAN'S LAKE 100-YR OUTFALL : $14,830,043
N
0 600 1,200
Feet
1 inch equals 1,200 feet
For Detailed Hydrology See Technical Appendix and Work Map
Legend
Collection System Boundary
Topographic Basin Boundary
100-yr Sub-Collection System Boundary
Thalweg
Proposed Storm Pipe
UDFCD Study Recommendations
Proposed Pipe Disconnect
Existing Storm Pipe
Designed Storm Improvement
Existing Surface Flow
Significant Flooding Location
Proposed Detention Basin
Existing Basin
Potential Inundation Area
Planned Transit Line
Existing Transit Line
City and County Boundary
Other Municipalities
Other Counties
Basin 4700-01 - 100-yr Alternative
Sloan's Lake
Denver Storm Drainage Master Plan
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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 and County of Denver. Lakewood Gulch has 701 acres (1.10 square miles) tributary, and Dry Gulch has 217 acres (0.34 square miles) tributary within the City and County of Denver. The collection system 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 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 and the 2013 Dry Gulch OSP. 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 Light Rail Bridges
3. Two Pedestrian Bridges
4. 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. A new open channel has been constructed by the UDFCD and Denver in order to contain the 100-year flood and eliminate out-of-channel bank flooding.

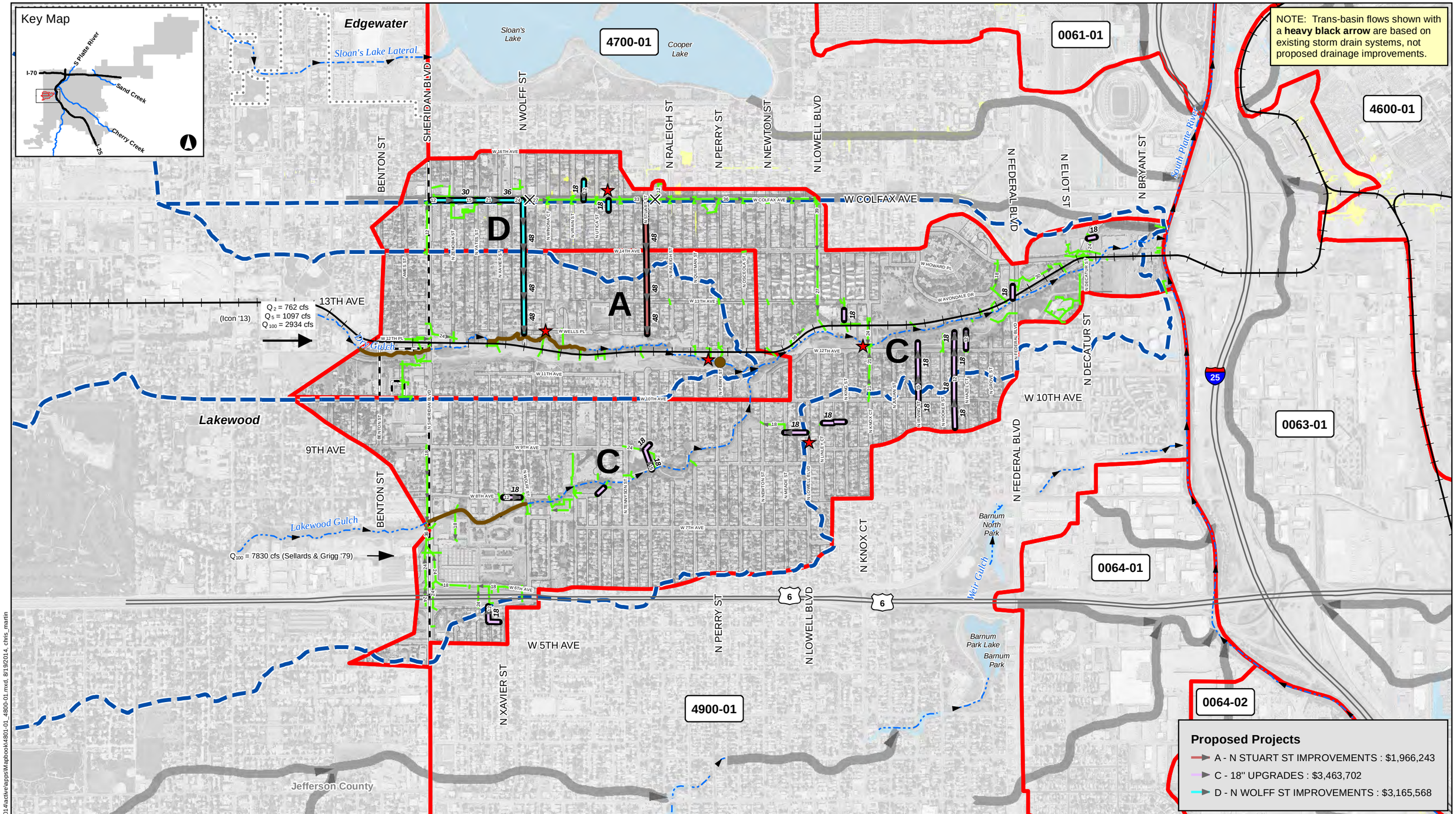
Proposed Capital Improvements:

This area represents an important corridor for the future FasTracks West Corridor transportation system. As noted above, RTD, the City and County of Denver and the UDFCD collaborated to widen and "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. Selected improvements along Dry Gulch from ICON Engineering, Inc. for the UDFCD 2013 ***Dry Gulch Outfall Systems Plan*** have been presented on the facing page map. These consist of bank stabilization along the watercourse, and the addition of another culvert, at N. Perry Street, to adequately convey the 100-year flood. Other minor pipe improvements include the following:

<u>Project A: N. Stuart Street</u>
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.

<u>Project C: 18" Upgrades</u>
Existing small storm drains will be replaced with 18-inch pipe to meet current drainage criteria. Other additional drains in the area would alleviate ponding in W. 10th Avenue and N. Federal Boulevard.

<u>Project D: N. Wolff Street</u>
To improve drainage conveyance on Colfax Avenue, existing pipe can be replaced and a new 48-inch outfall is proposed into Dry Gulch at N. Wolff Street.



N

0 600 1,200

Feet

1 inch equals 1,200 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Topographic Basin Boundary
- Thalweg
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
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- Potential Inundation Area
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- City and County Boundary
- Other Municipalities
- Other Counties

Basin 4800-01 & 4801-01 Lakewood & Dry Gulches

Denver Storm Drainage Master Plan

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Basin 4900-01 (Weir Gulch)

Existing System Description:

Much of the Weir Gulch Collection System Basin is located to the west and upstream of the City and County of Denver. The upper basin originates near Alameda Parkway and Green Mountain Drive in Lakewood. The portion of the basin located within the City and County of Denver is east of Sheridan Boulevard and generally lies as a long, narrow basin following the drainageway between the W. Center Drive / S. Sheridan Boulevard intersection at the southwestern end to the outfall at the South Platte near 9th Avenue 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.

In 2013, an update to the 1972 ***Sanderson Gulch/Weir Gulch Major Drainageway Plan*** (MDP) was initiated by Denver through the UDFCD. The MDP contains recommended improvements to Weir Gulch, as well as the First Avenue and Dakota Avenue Tributaries.

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-inch to 54-inch 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. Users are encouraged to review the ***Weir Gulch and First Avenue Tributary (downstream of Sheridan Boulevard) Major Drainageway Plan and Flood Hazard Area Delineation***, prepared for the UDFCD, prior to completing work along the main Weir Gulch drainageway.

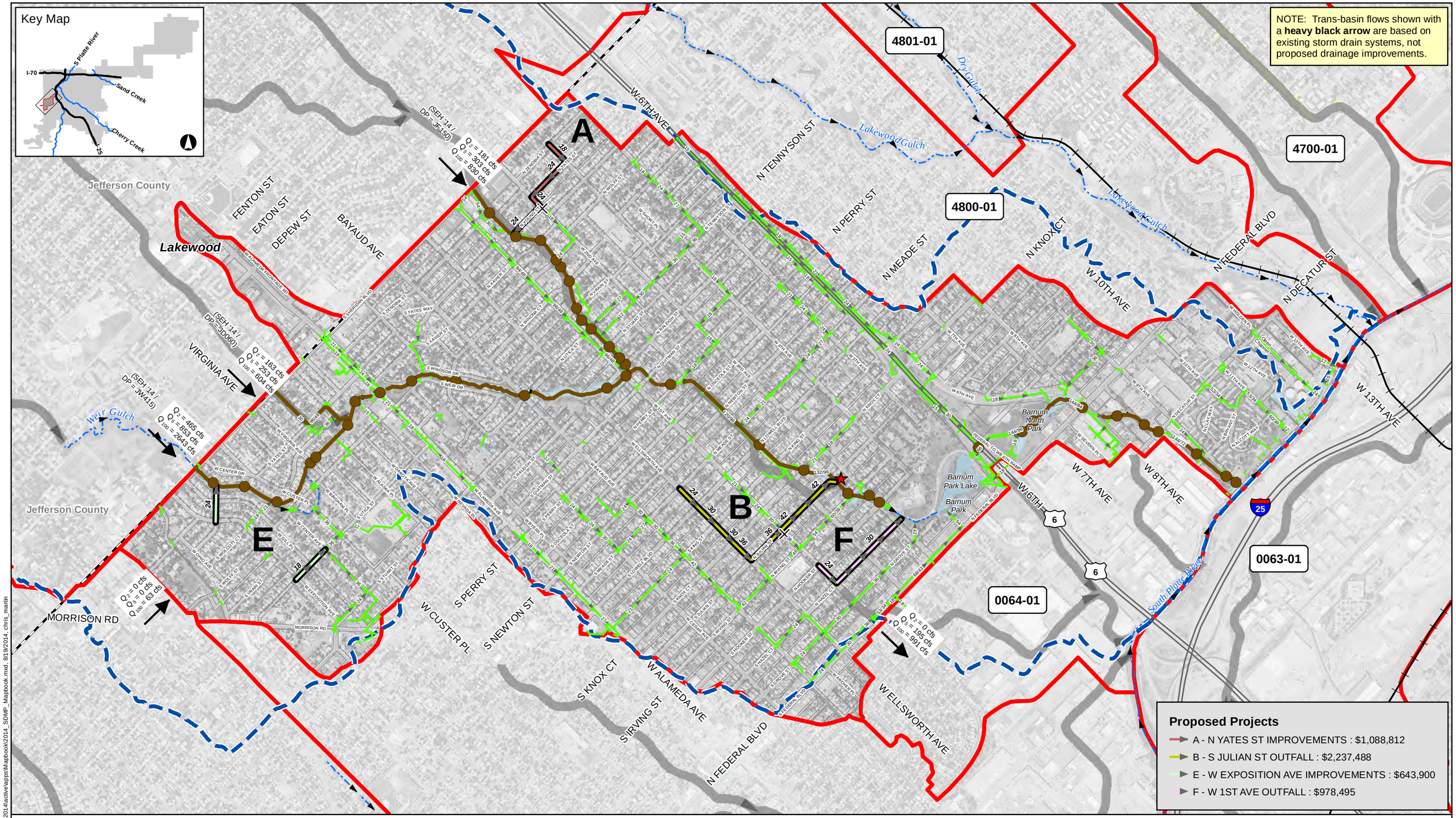
Proposed Capital Improvements:

Project A: N. Yates St. Improvements
A 24-inch 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 subbasin 50, while the existing system in Irving Street will continue to drain the southern half of the subbasin.

Project E: W. Exposition Ave. Improvements
Small 18-inch to 24-inch 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-inch lateral is proposed along 1st Avenue that turns north along N. Hazel, that transitions to a 30-inch pipe to outfall at Weir Gulch and 3rd Avenue.



0 600 1,200
Feet
1 inch equals 1,200 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Topographic Basin Boundary
- Thalweg
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
- Significant Flooding Location
- Proposed Detention Basin
- Existing Basin
- Potential Inundation Area
- Planned Transit Line
- Existing Transit Line
- City and County Boundary
- Other Municipalities
- Other Counties

Basin 4900-01
Weir Gulch

Denver Storm Drainage Master Plan

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Basin 5000-01 (West Washington Park)

Existing System Description:

This collection system 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 14 storm drainage outfalls, which are comprised of the following:

- 3-16-foot by 7-foot CDOT concrete box culverts for the Dakota Avenue Outfall and future Alameda and Santa Fe outfall
- 54-inch and 66-inch break in Center Street (projected) to the South Platte River
- 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.

The crown of Broadway acts as a dam and adjacent properties have flooded in the past. The City and County of Denver worked with Parsons Brinkerhoff and the property owners to fund, design and construct a 100-year outfall, the Dakota Avenue Outfall, from Broadway to the triple box culvert under I-25 constructed by CDOT. Storm drainage east of Broadway will be handled by the minor storm systems during smaller storm events. Runoff in larger storm events would be conveyed in the streets to the Dakota Outfall in Broadway.

Drainage Deficiencies:

Aside from the new CDOT triple box culvert under I-25 and the Dakota Avenue Outfall, the remainder of the existing drainage system has capacity to convey an approximate 1-year storm event to the South Platte River. Rainfall runoff in excess of the storm drain capacity has a history of ponding in flat areas and the sump on Alameda Avenue at the Santa Fe, where major drainage problems have been experienced. Two large potential inundation areas occur in the flat commercial areas due to runoff backing up behind the railroad and I-25.

Potential Inundation Areas:

Enginuity completed the Broadway Main Street Zoning FLO-2D analysis in October 2013 to determine the extent of flooding on Broadway. Olsson Associates completed a FLO-2D analysis to determine the flow patterns from east of Washington Park into the park and within the park. The analysis showed that water does enter the park from the east during the 100-year storm event. Inadvertent detention occurs in Smith and Grasmere Lakes, which contain the water flowing to them without spilling, and also in the central portion of the park.

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 basin currently has an extensive lateral network. 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.

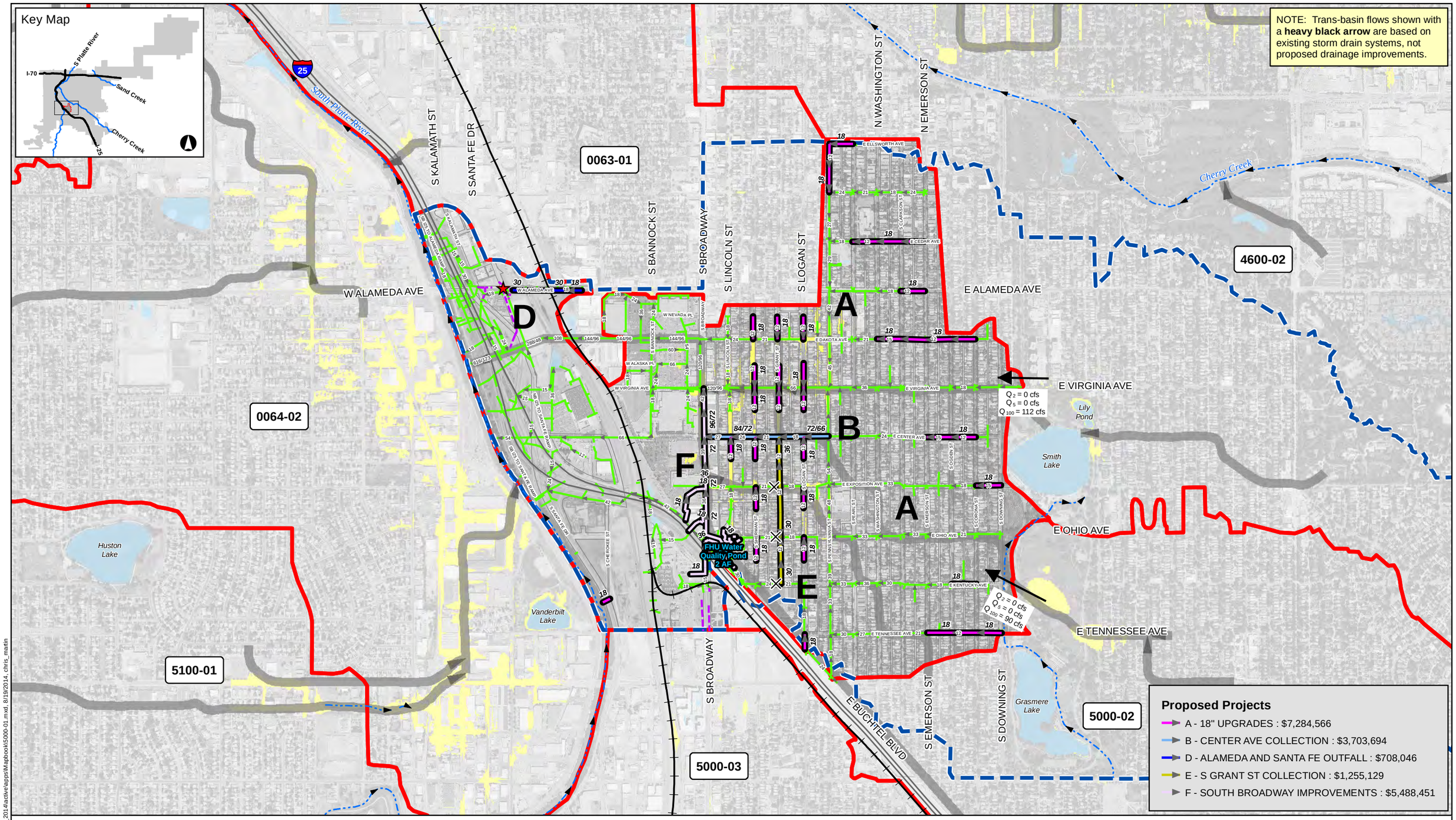
<u>Project A: 18" Upgrades</u>
Existing 12- and 15-inch pipes in Basin 5000-01will be replaced with 18-inch pipes to meet current drainage criteria and reduce maintenance.

<u>Project B: Center Avenue Collection</u>
For the minor storm, (5-year event) a 7'x 6' box culvert along the Center Street projected alignment from South Broadway to Pennsylvania Street would replace the existing storm drain system, improving drainage conveyance. This system gradually reduces in size to a 6'x5.5' box culvert at Pennsylvania Street. Alternatively, a different alignment could be selected or a possible parallel pipe to the existing system could be constructed. This proposed pipe would tie into Project F, described below.

<u>Project D: Alameda & Santa Fe Outfall</u>
The sump at Alameda Avenue and Santa Fe Drive has been a chronic flood problem area. As part of CDOT's I-25 Phase 4 Reconstruction project, Muller Engineering completed the design drawings for drainage improvements at Alameda Avenue and Santa Fe Drive on December 24, 2013. The proposed system will tie into the CDOT triple box culvert under I-25. The designed storm drain system should be extended east in Alameda Avenue in the future to reduce flooding.

<u>Project E: S. Grant St. Collection</u>
A new 30-inch to 36-inch collector drain in Grant Street is proposed that ties into the proposed Center Avenue outfall for the minor storm (5-year event). 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.

<u>Project F: South Broadway Improvements</u>
A 100-year storm drain system, in Broadway, was proposed in the Broadway Reconstruction from Exposition to Arizona project, designed by FHU. The FHU proposed storm drain system is shown tying into the smaller existing storm drain system at Exposition Avenue. In the future, the storm drain would extend from Exposition Avenue north to Center Avenue in a 72-inch pipe, where it would connect to Project B, and then extend north in an 8'x6' concrete box to the Dakota Avenue Outfall.



Basin 5000-01
West Washington Park

Denver Storm Drainage Master Plan

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Basin 5000-02 (University and Mexico North)

Existing System Description:

This collection system basin is tributary to the South Platte River. In general this basin is located on the north side of I-25 from E Mississippi Avenue & S. Washington Street, east to S. Holly Street. This basin consists of 1,798 acres (2.81 square miles) and includes residential and commercial properties.

Much of the basin has adequate storm drains for the 2- and 5-year return periods but lacks adequate protection for the 100-year return period.

Drainage Deficiencies:

Repetitive flooding occurs at the ballfields at 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 is high 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 drain in Jewell Avenue is undersized.

Potential Inundation Areas:

An area of potential inundation 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.

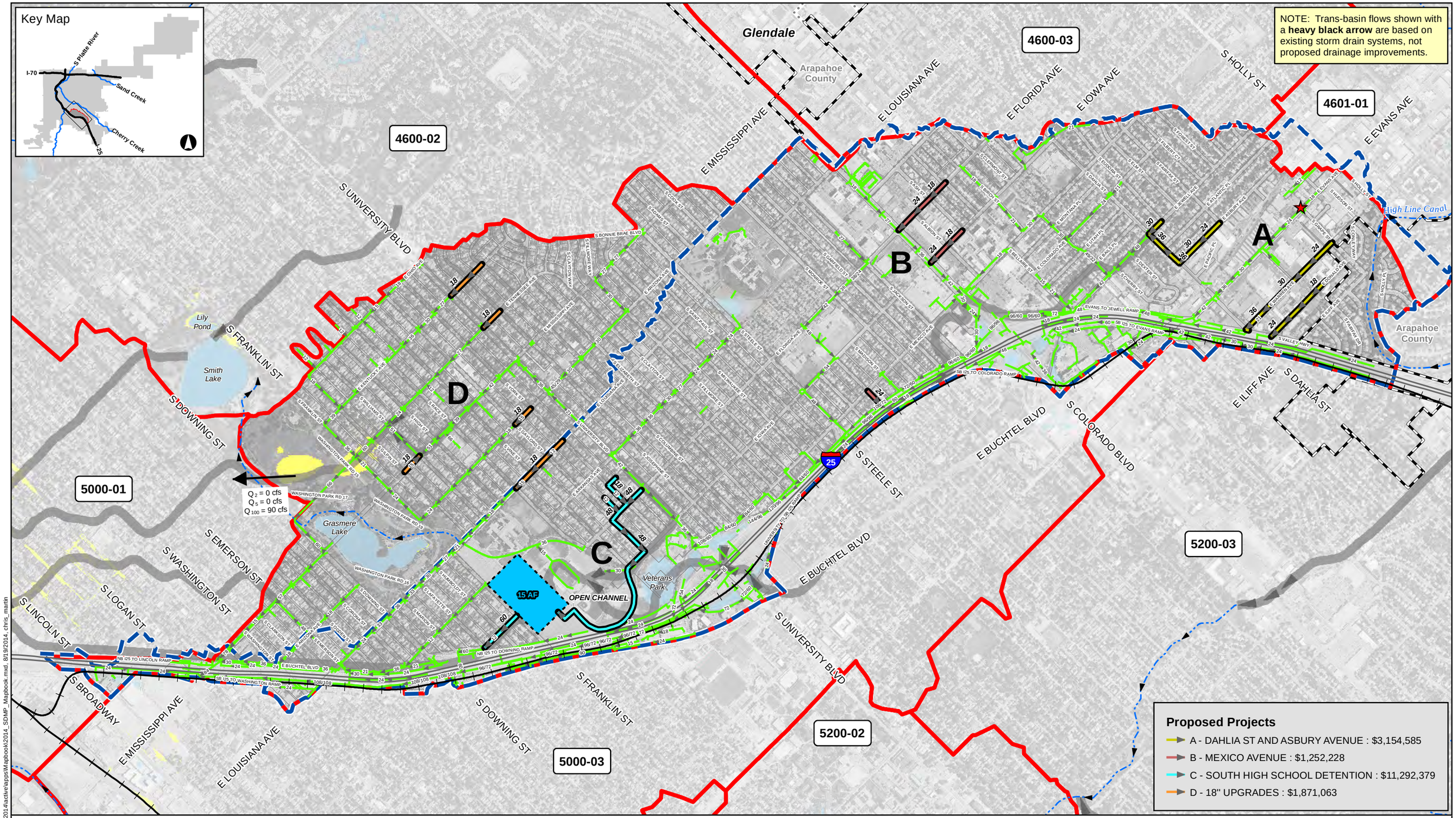
Proposed Capital Improvements:

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 basin 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.



Basin 5000-02
University & Mexico North

Denver Storm Drainage Master Plan

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Basin 5000-03 (University and Mexico South)

Existing System Description:
This collection system basin is tributary to the South Platte River and is located along the east bank between E. Evans Avenue and I-25. 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 drains, detention basins, 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 drain 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.

Creative Civil Solutions completed a detailed analysis for the 100-year storm event east of S. Washington Street. The findings were documented in the ***Major Basin Flow Study, Development #2012DOOO38***, dated January 4, 2013. The hydrology from the Creative Civil Solutions analysis was not incorporated into this Master Plan, since the master plan's focus is the 5-year storm event. The existing conditions hydrology from the ***South Broadway Reconstruction: Arizona Avenue to Iowa Avenue Final Drainage Report***, by Carter Burgess in November 2007, was incorporated into this Master Plan hydrology.

Many improvements to the Broadway storm drain network have recently been constructed. Both the South Broadway Reconstruction from Arizona Avenue to Iowa Avenue and the Florida Outfall west of Broadway, designed by Jacobs in January 2010, have been constructed. The South Broadway Reconstruction from Iowa Avenue to Wesley Avenue, designed by TSH in February 2011, has also been constructed.

The Iowa Avenue Extension – Phase I, designed by the City and County of Denver in March 2013, has been constructed and includes 54-inch to 60-inch storm drains in Logan Street from Asbury Avenue to Iowa Avenue and then in Iowa Avenue from Logan Street to Broadway.

Drainage Deficiencies:
Broadway itself was the most significant damage corridor in the basin. Broadway receives large storm flows from the east and the street crown for Broadway was 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 acted as a dam that causes inundation to 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. Most of the Broadway storm drain system improvements have now been constructed in this basin, as listed in the existing system description section. The remaining area, Broadway Reconstruction from Kentucky to Arizona, designed by NV5 in July 2013, is funded for construction in 2015.

The Harvard Gulch Floodplain extends into Basin 5000-03 and 53 parcels located west of Santa Fe Drive, north of W. Asbury Avenue in the University and Mexico South Basin are affected. Flooding is predicted to be about 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 Inundation Areas:
An area of potential inundation has been identified at the intersection of S. Williams Street and E. 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 the University of Denver. Given information of flood depths, appropriate measures can be taken by property owners to mitigate flood damages with flood proofing.

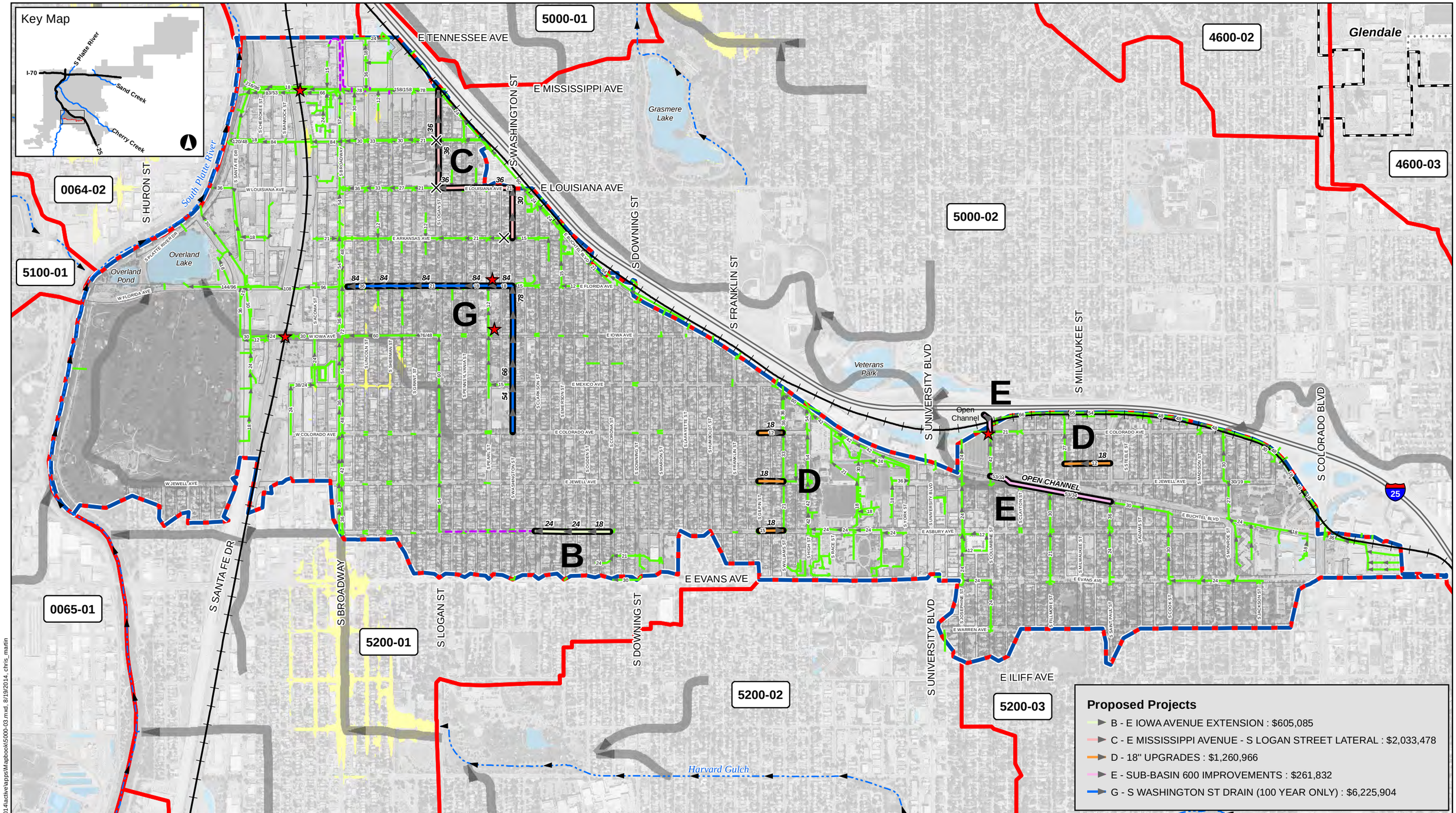
Proposed Capital Improvements:
Project B: E. Iowa Avenue Extension
The E. Iowa Avenue Extension project was broken into two phases. Phase I, as described in the existing system description section, conveys 5-year flows from sub-basins 813, 814, 817, 820, and 823 and has been constructed. Phase II will be constructed as part of the 2014 General Storm project and includes a 36-inch and 42-inch storm drain in E. Asbury Avenue from S. Clarkson Street to S. Logan Street, where it will connect to the recently constructed 54-inch storm drain. An 18-inch to 24-inch pipe is proposed to extend east in E. Asbury Avenue from the designed 36-inch pipe at S. Clarkson Street to S. Corona Street.

Project C: E. Mississippi Avenue – S. Logan Street Lateral
A new storm drain network is proposed in S. Washington Street from E. Arkansas Avenue to E. Louisiana Avenue to convey the 5-year flows. The proposed project will proceed west in E. Louisiana Avenue to S. Logan Street., then north in S. Logan Street to connect to the existing storm drain in E. Mississippi Avenue which can accept these flows since it was disconnected from the I-25 drainage system during the I-25 TREX improvements. The storm drain network will consist of 30-inch and 36-inch storm drains.

Project D: 18-Inch Upgrades
Upsizing is required, for various pipes, to the City's 18-inch minimum diameter to meet current drainage criteria.

Project E: Sub-Basin 600 Improvements
Enlarge the inlet capacity in S. Milwaukee Street south of E. Colorado Avenue to prevent clogging and reduce flood depths. Remove cross culverts under railroad embankment. Provide an improved roadside channel along E. Buchtel Boulevard with regular series of inlets connected to the existing storm drainage system in E. Buchtel Boulevard. 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 detention basin to the open channel extension. Modify the outlet works of the Colorado Avenue detention basin to provide a standard water quality outlet.

Project G: S. Washington Street Drain (100-Year Only)
A new storm drain network is proposed in S. Washington Street from E. Colorado Avenue to E. Florida Avenue and extending down E. Florida Avenue to the existing 96-inch storm drain stub-out at S. Broadway to convey 100-year flows. The 100-year storm drain network will alleviate flooding problems for businesses and properties along S. Pearl Street. The storm drain network will consist of 54-inch to 84-inch storm drains.



Basin 5000-03
University & Mexico South

Denver Storm Drainage Master Plan

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Basin 5100-01 (Sanderson Gulch)

Major Drainageway Plan:
The 2013 ***Sanderson Gulch Major Drainageway Plan and Flood Hazard Area Delineation*** (MDP), prepared by Matrix Design Group, Inc. for the UDFCD, primarily addressed improvements to the main channel of Sanderson Gulch, and also proposed a 100-year collection system, to convey Mississippi Gulch flows into Sanderson Gulch, discussed in the 100-year alternative pages.

Existing System Description:
Sanderson Gulch is located in the southwest metropolitan area through portions of the City and County of Denver, the City of Lakewood and Jefferson County. The Sanderson Gulch Watershed starts at the top of Green Mountain and extends east to the South Platte River just north of West Florida Avenue. The collection system 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 which includes approximately 5.56 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 undersized for the 5-year storm. The potential for flooding of properties during the 5-year and 100-year storm is high due to the limited capacity of the drainageway.

Design Point 682 drains to an existing 66-inch storm drain within West Mosier Place and flows east to S. Navajo Street and then south to Sanderson Gulch. 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, 1,295 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.

Proposed Capital Improvements:
Structure improvements to the channel and roadway culverts can reduce flood hazard areas. Proposed improvements for the channel and road crossings are shown in the Sanderson Gulch MDP.
Project A: 18-inch Upgrades
This upgrade is recommended to meet the City and County of Denver's Criteria.

Project B: S. Carlan St. Outfall
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 drain will extend along Arkansas Avenue to S. Carlan Street and will outfall to Sanderson Gulch.

Project C: S. Decatur Outfall
A 2-year frequency storm drain is required from Sanderson Gulch upstream to Mexico Avenue and Colorado Avenue Laterals will be required at each intersection as shown on the plan.

Project D: S. Federal Blvd. Outfall
This 54-inch outfall will be sized to handle the 5-year frequency storm. The existing storm drain is undersized due to the surrounding commercial property.

Project E: W. Mississippi Ave. Improvements
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 drain will provide a 5-year frequency storm drain system and meet Denver's criteria for the upstream area.

Project F: S. Quitman St. Improvements
A proposed 24-inch storm drain in S. Quitman will connect to the existing storm drain at Arkansas Avenue and extend north to Arizona Street. This will provide a 2-year frequency storm drain to service the residential area.

Project G: S. Tejon St. Outfall
Currently, no storm drain exists in this area to service the residential and commercial areas. A 5-year capacity, 48-inch storm drain is proposed.

Project H: S. Tennyson St. Improvements
A proposed 7-foot x 4-foot box culvert will be connected to the existing storm drain at Florida Avenue and S. Tennyson Street. The proposed storm drain requires upsizing the existing storm drain. The new portion will provide service to the surrounding residential area.

Project I: S. Utica Outfall
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 drain within Utica will be replaced.

Project J: S. Vrain St. Outfall
A new storm drain and laterals are proposed to service the surrounding neighborhood upstream of the outfall. This storm drain can be a 2-year frequency system.

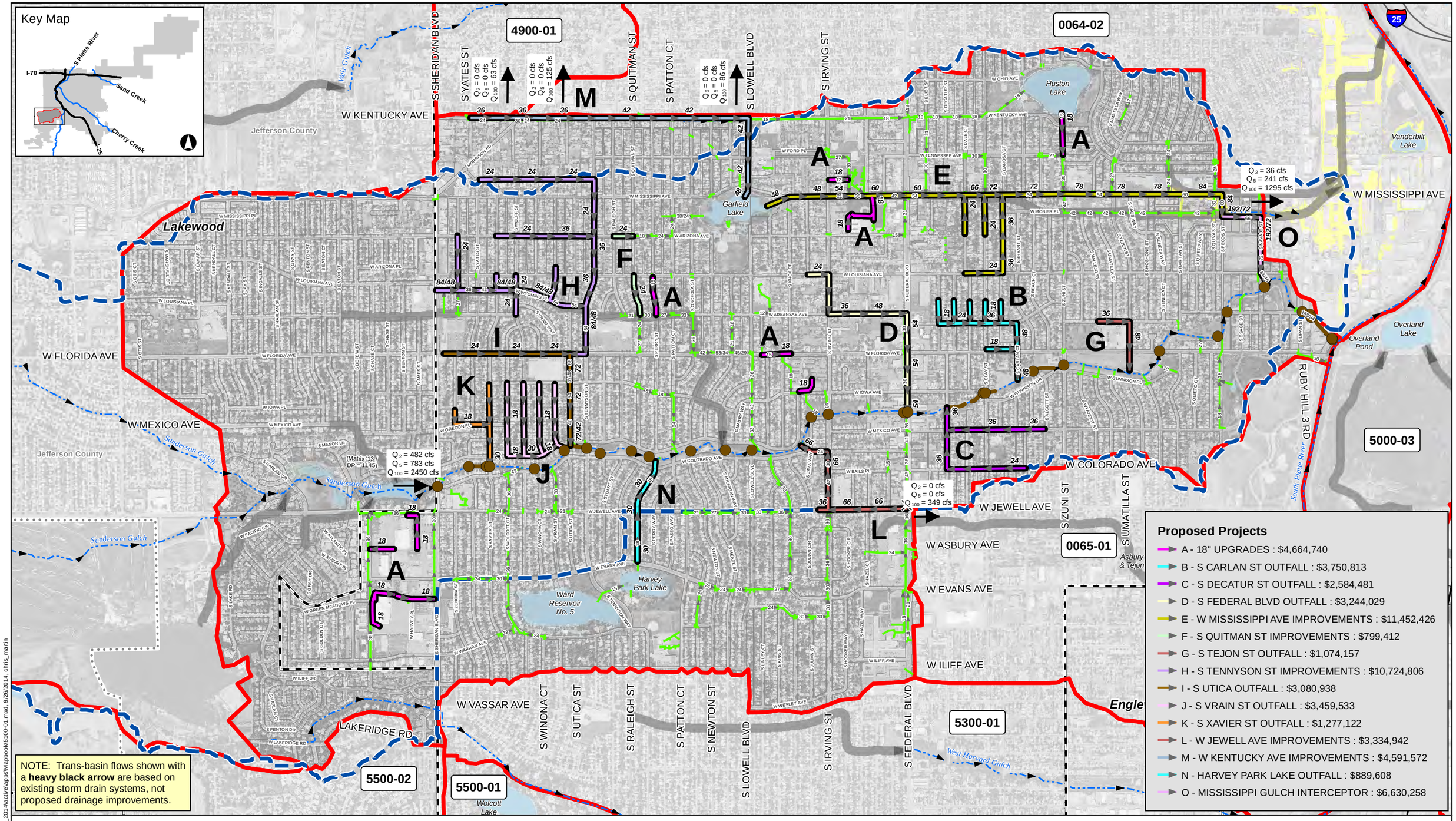
Project K: S. Xavier St. Outfall
The proposed storm drain will extend from Sanderson Gulch up to Iowa Avenue. The storm drain will provide a 2-year level of service for the residential neighborhood. A lateral will be extended along Oregon Place to Zenobia Street.

Project L: W. Jewell Avenue Improvements
The proposed 66-inch outfall will upsize the existing storm drain's capacity in Irving Street and W. Jewell Avenue to a 5-year capacity. New 5-year capacity storm drain is proposed to extend east along W. Jewell Avenue to Federal Boulevard

Project M: W. Kentucky Avenue Outfall
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 drain 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.

Project N: Harvey Park Lake Outfall
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 drain.

Project O: Mississippi Gulch Interceptor
A proposed twin 8-foot x 6-foot and quad 6-foot x 4-foot box culvert system will collect the 100-year discharges and connect the proposed inlet bank at Quivas and Mosier Place with the main channel of Sanderson Gulch as determined by the 2013 MDP for Sanderson Gulch.


Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
Weir Gulch
S SHERIDAN BLVD
4900-01
S YATES ST
Q2 = 0 cfs
Q5 = 0 cfs
Q100 = 63 cfs
Q2 = 0 cfs
Q5 = 0 cfs
Q100 = 125 cfs
M
S QUITMAN ST
S PATTON CT
Q2 = 0 cfs
Q5 = 0 cfs
Q100 = 86 cfs
S LOWELL BLVD
S IRVING ST
0064-02
W KENTUCKY AVE
Jefferson County
Huston Lake
Vanderbilt Lake
W MISSISSIPPI AVE
Q2 = 36 cfs
Q5 = 241 cfs
Q100 = 1295 cfs
Lakewood
Garfield Lake
W FLORIDA AVE
W MEXICO AVE
Sanderson Gulch
Jefferson County
(Matrix 13 / DP = 1145)
Q2 = 482 cfs
Q5 = 783 cfs
Q100 = 2450 cfs
W COLORADO AVE
W JEWELL AVE
Q2 = 0 cfs
Q5 = 0 cfs
Q100 = 349 cfs
W ASBURY AVE
0065-01
Asbury & Tejon
W EVANS AVE
W ILIFF AVE
Harvey Park Lake
Ward Reservoir No. 5
W VASSAR AVE
LAKERIDGE RD
5500-02
5500-01
Wolcott Lake
5300-01
West Harvard Gulch
Overland Pond
Overland Lake
RUBY HILL 3 RD
5000-03
South Platte River
Proposed Projects
A - 18" UPGRADES : $4,664,740
B - S CARLAN ST OUTFALL : $3,750,813
C - S DECATUR ST OUTFALL : $2,584,481
D - S FEDERAL BLVD OUTFALL : $3,244,029
E - W MISSISSIPPI AVE IMPROVEMENTS : $11,452,426
F - S QUITMAN ST IMPROVEMENTS : $799,412
G - S TEJON ST OUTFALL : $1,074,157
H - S TENNYSON ST IMPROVEMENTS : $10,724,806
I - S UTICA OUTFALL : $3,080,938
J - S VRAIN ST OUTFALL : $3,459,533
K - S XAVIER ST OUTFALL : $1,277,122
L - W JEWELL AVE IMPROVEMENTS : $3,334,942
M - W KENTUCKY AVE IMPROVEMENTS : $4,591,572
N - HARVEY PARK LAKE OUTFALL : $889,608
O - MISSISSIPPI GULCH INTERCEPTOR : $6,630,258
NOTE: Trans-basin flows shown with a heavy black arrow are based on existing storm drain systems, not proposed drainage improvements.
N
0 750 1,500
Feet
1 inch equals 1,500 feet
For Detailed Hydrology See Technical Appendix and Work Map
Legend
Collection System Boundary
Topographic Basin Boundary
Thalweg
Proposed Storm Pipe
UDFCD Study Recommendations
Proposed Pipe Disconnect
Existing Storm Pipe
Designed Storm Improvement
Existing Surface Flow
Significant Flooding Location
Proposed Detention Basin
Existing Basin
Potential Inundation Area
Planned Transit Line
Existing Transit Line
City and County Boundary
Other Municipalities
Other Counties
Basin 5100-01
Sanderson Gulch
Denver Storm Drainage Master Plan
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Basin 5100-01 (Sanderson Gulch) 100-Year Alternative

The 2005 ***Storm Drainage Master Plan*** considered a 100-year regional detention basin on the property directly downstream of W. Mosier Place at S. Quivas Street; however, a detention basin 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.

A ***Sanderson Gulch Major Drainageway Plan and Flood Hazard Area Delineation*** (MDP) was prepared in 2013, by Matrix Design Group, Inc., for the UDFCD, cosponsored by Denver. This plan primarily addressed improvements to the main channel of Sanderson Gulch, and, at the request of Denver, also proposed a 100-year collection system to convey Mississippi Gulch flows into Sanderson Gulch.

Design Point 682 drains to an existing 66-inch storm drain, within W. Mosier Place at S. Quivas Street, and flows east to S. Navajo Street, then south to Sanderson Gulch. This system was designed to convey 310 cfs to Sanderson Gulch, which, by current modeling, is undersized for even the 2-year minor storm event, allowing runoff in moderate and larger storm events to continue east to limited capacity systems downstream at S. Lipan Street and the broad industrial flat areas east of S. Lipan Street. In a 100-year event, the flow rate at Design Point 682 is 1,593 cfs; with 310 cfs flowing south to Sanderson Gulch, resulting in the remaining 1,295 cfs continuing east from S. Quivas Street, as noted at Design Point 991.

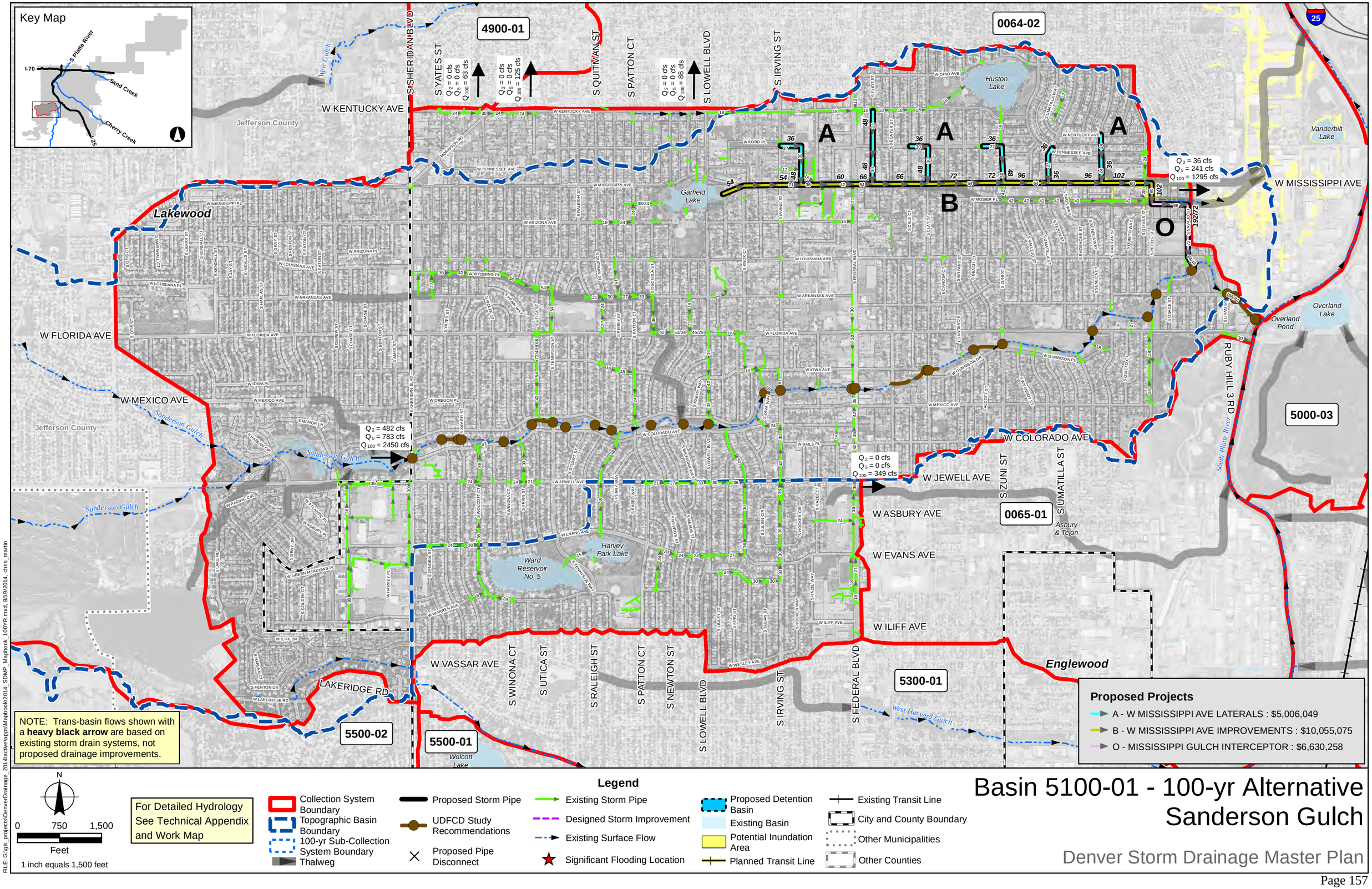
Alternative 100 Year System:

Project B: West Mississippi Avenue Improvements
This project would increase the capacity of the existing storm drain in W. Mississippi Avenue.

Project C: West Mississippi Avenue Laterals
Various laterals to collect runoff north of W. Mississippi Avenue.

Project O: Mississippi Gulch Interceptor
This alternative will route the 100-year flow runoff directly to Sanderson Gulch through an upgraded proposed W. Mississippi Avenue and Mississippi Gulch Interceptor outfall system.

The 2013 ***Sanderson Gulch MDP*** proposed a 100-year storm inlet bank at S. Quivas Street and W. Mosier Place, on property acquired by the City in September 2012, and replacing the existing 66-inch and 72-inch diameter storm drain with a twin 8-feet wide by 6-feet high reinforced box storm drain, in order to convey runoff from the 100-year storm collecting at this location down to Sanderson Gulch. This project would be constructed only after improvements are made to increase the capacity of the lower portion of Sanderson Gulch between S. Lipan Street and the South Platte River.



Basin 5100-01 - 100-yr Alternative
Sanderson Gulch

Denver Storm Drainage Master Plan

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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 Master Plan update, 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 in Wesley Avenue from the South Platte River 4,000 feet to Logan Street. The initial combination of City owned and private storm drain system is comprised of approximately 37,100 feet of storm drain 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.

Improvements to the Broadway storm drain network in this basin have recently been constructed. The South Broadway Reconstruction from Iowa Avenue to Wesley, designed by TSH in February 2011, has been constructed. In addition, the South Broadway Reconstruction from Wesley to Yale, designed by Muller Engineering in October 2008, has also been constructed.

The Asbury Outfall, designed by TSH in 2012, has been constructed from Broadway to the South Platte River to convey 5-year flows.

Drainage Deficiencies:
The floodplain that was determined in the 1979 ***Flood Hazard Area Delineation Harvard Gulch, West Harvard Gulch & Dry Gulch*** by Gingery Associates, Inc., for the Urban Drainage and Flood Control District 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 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.

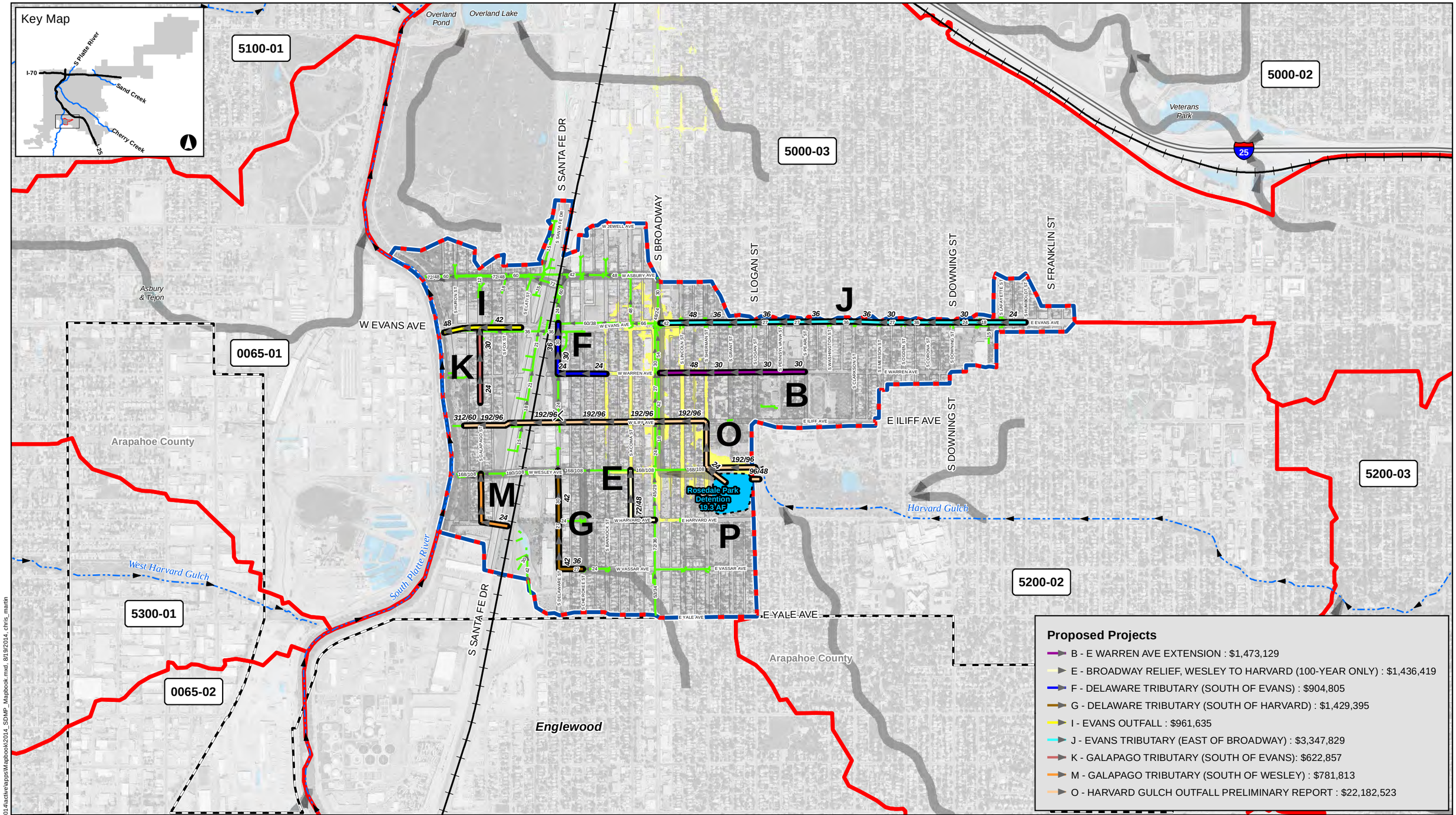
Proposed Capital Improvements:
Drainage system improvements were developed using the City's level of service criteria to address identified capacity deficiencies. For the initial storm drain system, a 2- or 5-year event level of service criteria was used to size facilities for residential or commercial/industrial 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.

For the major drainageway downstream of Logan Street, proposed improvements were designed to provide 100-year frequency storm event level of service as part of the 2005 Master Plan including an open channel alternative. The sizes of the improvements for the major drainageway were not reanalyzed as part of the 2009 Master Plan update. The May 2010 ***Harvard Gulch Outfall Alternatives Analysis and Feasibility Study Preliminary Engineering Report***, by Matrix Design Group for the City and County of Denver, evaluated alternatives for the outfall from S. Logan Street to the South Platte River. This analysis evaluated conveyance, detention, and open channel alternatives from the 2005 and 2009 ***Storm Drainage Master Plans***. This study was not finalized. Instead, a Major Drainageway Plan and Flood Hazard Area Delineation update has been requested through UDFCD's Planning Studies program. This study is currently anticipated for funding in 2015.

It was determined as part of the 2005 ***Storm Master Plan*** and the May 2010 ***Harvard Gulch Outfall Alternatives Analysis and Feasibility Study Preliminary Engineering Report*** 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 recommendations of this Master Plan update include conveyance system improvements as well as detention at a single site, Rosedale Park located between E. Wesley E. Harvard Avenues and S. Sherman and S. Logan Streets.

It was determined that opportunities for detention in the Harvard Gulch basin were limited to Rosedale Park. Other sites were considered too small. Working with the City's Parks and Recreation planners, a sculpted basin design is proposed for Rosedale Park that could provide up to 19.3 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 16' x 8' RCBC in Iliff Avenue.

<u>Project E: Broadway Relief, Wesley to Harvard (100-Year Only)</u>
A new storm drain system was constructed in South Broadway from Yale Avenue to Wesley Avenue in conjunction with the South Broadway street reconstruction project. Plans for construction of this drain were prepared by Muller Engineering at the same time as the 2009 ***Storm Drainage Master Plan***, which anticipated a future 100-year storm drain outfall in Harvard Avenue to the South Platte River. Therefore, the portion of the storm drain in S Broadway from Yale Avenue to Harvard Avenue was designed to covey the 100-year storm and the portion in S. Broadway from Harvard Avenue to Wesley Avenue was designed to carry the 5-year storm in anticipation of this future storm drain in Harvard Avenue. Notes on the construction plans at S. Broadway and Harvard Avenue state that: "This configuration involves the addition of a new storm drain outfall at the intersection of Broadway and Harvard." The subsequent May 2010 ***Harvard Gulch Outfall Alternatives Analysis and Feasibility Study Preliminary Engineering Report*** by Matrix Design Group found that the proposed outfall in W. Harvard Avenue was not viable due to depth and other considerations and that Iliff Avenue would be a better alignment. Therefore, Project E is identified in this updated ***Storm Drainage Master Plan*** as a 100-year option to ensure that the drain from Yale Avenue to Wesley Avenue provides a consistent level of flood protection to the S. Broadway corridor.



Basin 5200-01
Harvard Gulch Lower Basin

Denver Storm Drainage Master Plan

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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). Porter Hospital and the University of Denver are located within the Middle Basin. 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.

The S. Gaylord Street Outfall – South of Harvard Gulch project, designed by the City and County of Denver in December of 2009, was constructed in 2011 and consists of a storm drain network to convey 2-year flows in S. Gaylord Street from E. Cornell Avenue to Harvard Gulch.

Drainage Deficiencies:

The floodplain delineated in the 1979 ***Flood Hazard Area Delineation Harvard Gulch, West Harvard Gulch & Dry Gulch*** by Gingery Associates, Inc., for the Urban Drainage and Flood Control District, 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 in Denver 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 along 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.

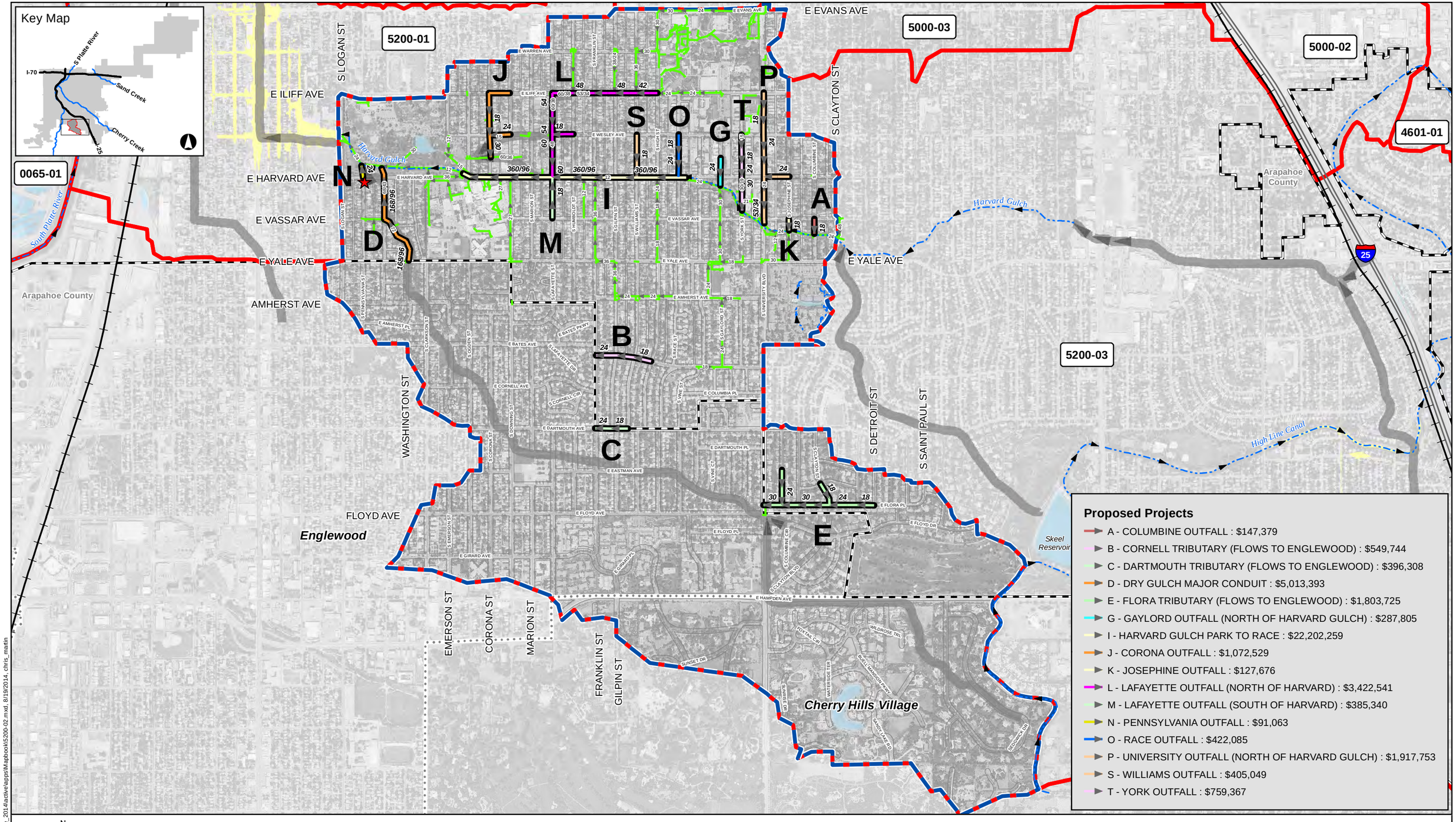
Proposed Capital Improvements:

Drainage improvements in this basin are primarily recommended to achieve the performance objectives as described in Denver's Drainage Criteria; 2-year and 5-year systems for residential and commercial areas respectively with streets carrying the excess runoff in larger storm events. However, for the major drainageway channel, proposed improvements should be designed to provide 100-year frequency storm event level of service to reduce or eliminate the regulatory floodplain through the area. A Major Drainageway Plan and Flood Hazard Area Delineation update has been requested in the UDFCD's Planning Studies program. This study is currently anticipated for funding in in 2015.

Harvard Gulch was included in the October 2009 ***Gulch Master Plan***, by Matrix Design Group for the City and County of Denver Department of Parks and Recreation.

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 closed conduit upstream of Harvard Gulch Park from Ogden Street to Downing Street and the concrete channel from Downing Street to Race Street with a double 15'x 8' RCBC.



Basin 5200-02
Harvard Gulch Middle Basin

Denver Storm Drainage Master Plan

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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.

Blueprint Denver has identified 168 acres as "Areas of Change". These are centered in commercial areas bounded by E. Iliff Avenue, S. Colorado Boulevard, I-25, and along S. Colorado Boulevard from E. Iliff Avenue south past E. Amherst Avenue. There is no industrial land use in the upper basin.

The south and east portions of the basin is traversed by the High Line Canal which intercepts some initial storm flows from basin headwater tributaries in the existing condition. However, Section 3.3.4.1 of the City and County of Denver's ***Storm Drainage Design and Technical Criteria Manual*** states 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 High Line Canal to the downstream storm drain network.

Storm drain pipes to convey the 2-year flow in Iliff Avenue from S. Birch Street to S. Colorado Boulevard were constructed in 2012 as part of City and County of Denver's General Storm – Phase I project.

Drainage Deficiencies:

The floodplain delineated in the 1979 ***Flood Hazard Area Delineation Harvard Gulch, West Harvard Gulch & Dry Gulch*** by Gingery Associates, Inc., for the Urban Drainage and Flood Control District, 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-inch to 42-inch 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.

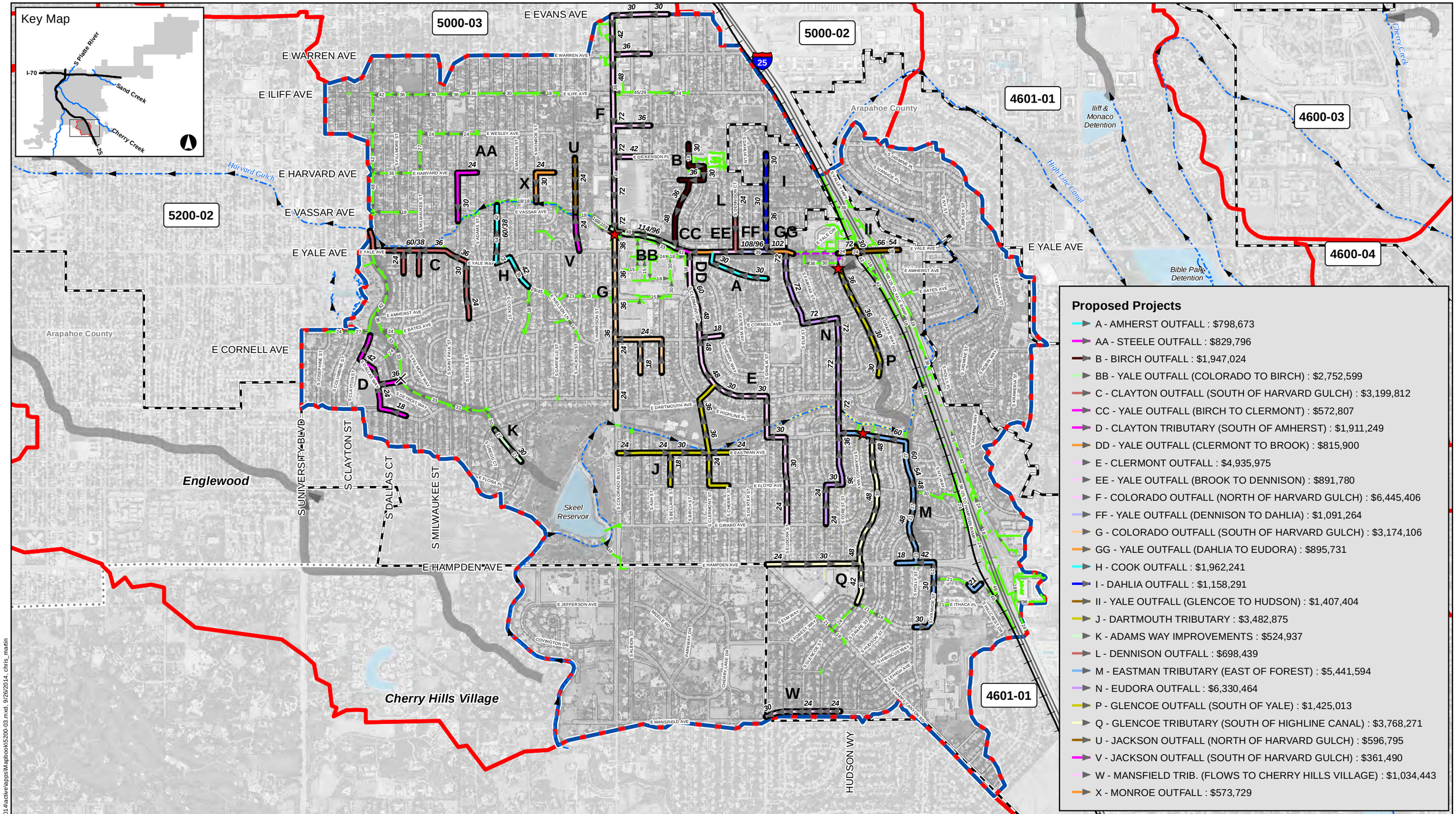
Potential Inundation Areas:

The City and County of Denver completed the 5273 E. Eastman Potential Ponding Area analysis in May 2012 to determine the extents in the area. A Potential Inundation Area was identified in S. Glencoe Street.

Proposed Capital Improvements:

Drainage improvements in this basin are primarily recommended to achieve the performance objectives as described in Denver's Drainage Criteria; 2-year and 5-year systems for residential and commercial areas respectively with streets carrying the excess runoff in larger storm events. 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 to S. 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 High Line 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 High Line Canal.
- The City and County of Denver is in the process of designing the East Yale Avenue Storm Phase I storm drain improvements, which includes concrete box pipe in S. Glencoe Street from S. Grape Way to East Yale Avenue and in E. Yale Avenue from S. Glencoe Street to S. Eudora Street to mitigate repetitive flooding in the sump in S. Glencoe Street, south of E. Yale Avenue.



Basin 5200-03
Harvard Gulch Upper Basin

Denver Storm Drainage Master Plan

Basin 5300-01 (West Harvard Gulch)

Existing System Description:

The West Harvard Gulch Collection System 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 5,536 feet to 5,250 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:

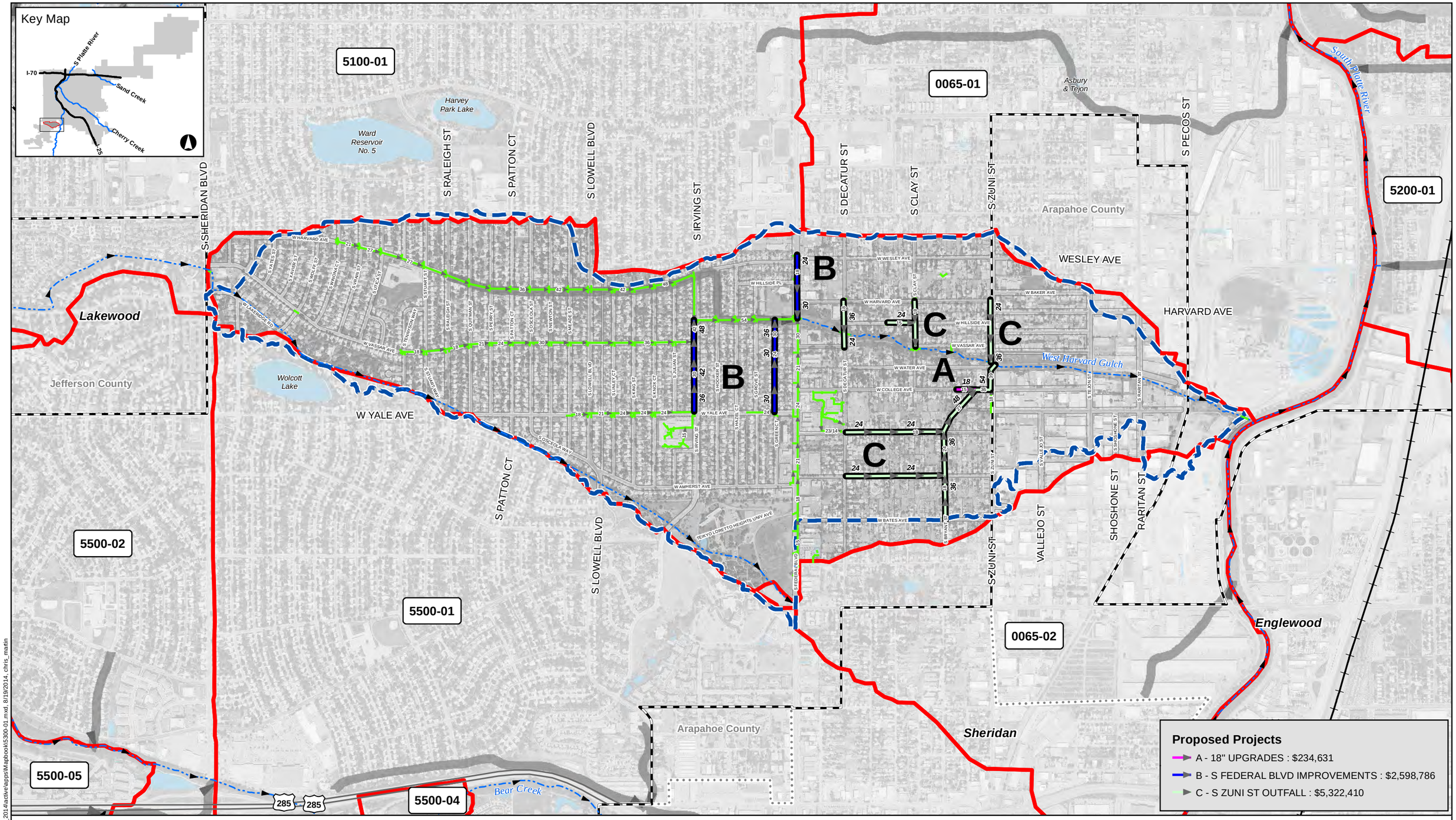
Basins 10 and 30 totaling 54 acres drains to an existing 21-inch storm drain that exceeds the 2-year flow capacity of 30 cfs. A relatively flat residential/commercial area along Yale and Amherst Avenues currently has no storm drain facilities. The existing 42-inch storm drain in Irving Street does not have the 2-year flow capacity of 88 cfs. The existing storm drains 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 drain size criteria.

Project B: S. Federal Blvd. Improvements
An existing storm drain system within South Green Court is undersized for the 2-year storm. A 30-inch to 36-inch, 2-year capacity storm drain is proposed to convey storm flows to West Harvard Gulch. Upsizing the storm drains shown on the plan within Federal Boulevard will increase capacity to the 5-year storm. Upsizing the storm drains in Irving Street will increase capacity to the 2-year storm.

Project C: S. Zuni Street Outfall
Upsizing the storm drains 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 drain 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.


Key Map
S Platte River
I-70
Sand Creek
Cherry Creek
I-25
5100-01
0065-01
5200-01
5500-01
5500-02
5500-04
5500-05
0065-02
Harvey Park Lake
Ward Reservoir No. 5
Wolcott Lake
Asbury & Tejon
South Platte River
West Harvard Gulch
Bear Creek
Lakewood
Jefferson County
Arapahoe County
Englewood
Sheridan
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
VALLEJO ST
SHOSHONE ST
RARITAN ST
WESLEY AVE
HARVARD AVE
W HARVARD AVE
W YALE AVE
W AMHERST AVE
W HILLSIDE PL
W HILLSIDE AVE
W VASSAR AVE
W WATER AVE
W COLLEGE AVE
W WESLEY AVE
W BAKER AVE
W BATES AVE
W LAKERIDGE RD
S OSCEOLA WAY
TEIKYO LORETTO HEIGHTS UNIV AVE
S FEDERAL BLVD
A
B
C
Proposed Projects
A - 18" UPGRADES : $234,631
B - S FEDERAL BLVD IMPROVEMENTS : $2,598,786
C - S ZUNI ST OUTFALL : $5,322,410
N
0 600 1,200
Feet
1 inch equals 1,200 feet
For Detailed Hydrology See Technical Appendix and Work Map
Legend
Collection System Boundary
Topographic Basin Boundary
Thalweg
Proposed Storm Pipe
UDFCD Study Recommendations
Proposed Pipe Disconnect
Existing Storm Pipe
Designed Storm Improvement
Existing Surface Flow
Significant Flooding Location
Proposed Detention Basin
Existing Basin
Potential Inundation Area
Planned Transit Line
Existing Transit Line
City and County Boundary
Other Municipalities
Other Counties
Basin 5300-01
West Harvard Gulch
Denver Storm Drainage Master Plan
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Basin 5401-01 (Greenwood Gulch)

Existing System Description:

This collection system 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.

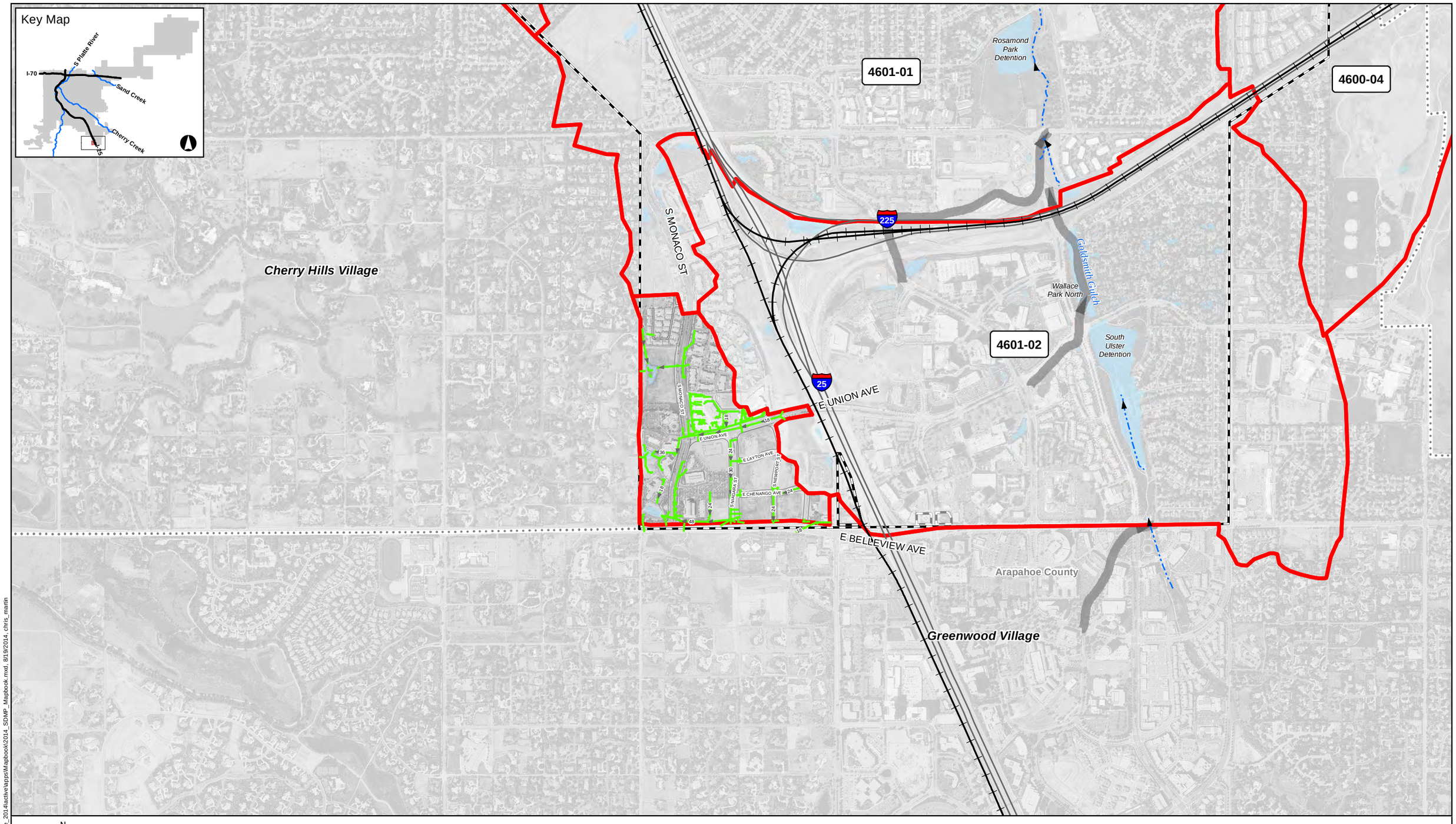
There are major existing storm drain trunk systems in Monaco Street that convey flows from the east to three separate detention basins on the western edge of the basin. The storm drain system branches up Belleview Avenue and Union Avenue. Approximately half of the basin is currently undeveloped and development plans are underway. The former Mountain View Golf property is currently being developed as part of the Belleview Station Transit Oriented Development project. The golf course is being developed into very high-density residential, commercial and retail parcels.

Drainage Deficiencies:

The storm drain system in Monaco Street appears adequate for conveying flows to the existing detention basins. There appear to be no significant drainage problems with the systems.

Proposed Capital Improvements:

There are no required improvements for this basin.



N

0 600 1,200

Feet

1 inch equals 1,200 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Topographic Basin Boundary
- Thalweg
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
- Significant Flooding Location
- Proposed Detention Basin
- Existing Basin
- Potential Inundation Area
- Planned Transit Line
- Existing Transit Line
- City and County Boundary
- Other Municipalities
- Other Counties

Basin 5401-01
Greenwood Gulch

Denver Storm Drainage Master Plan

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Basin 5500-01 (Bear Creek - Fort Logan)

Existing System Description:

This collection system 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:

- The Utica Street Storm Drain (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 drain systems. The roadways are relatively steep allowing for good stormwater conveyance, but nuisance flows traveling long distances could pose a problem.

Proposed Capital Improvements:

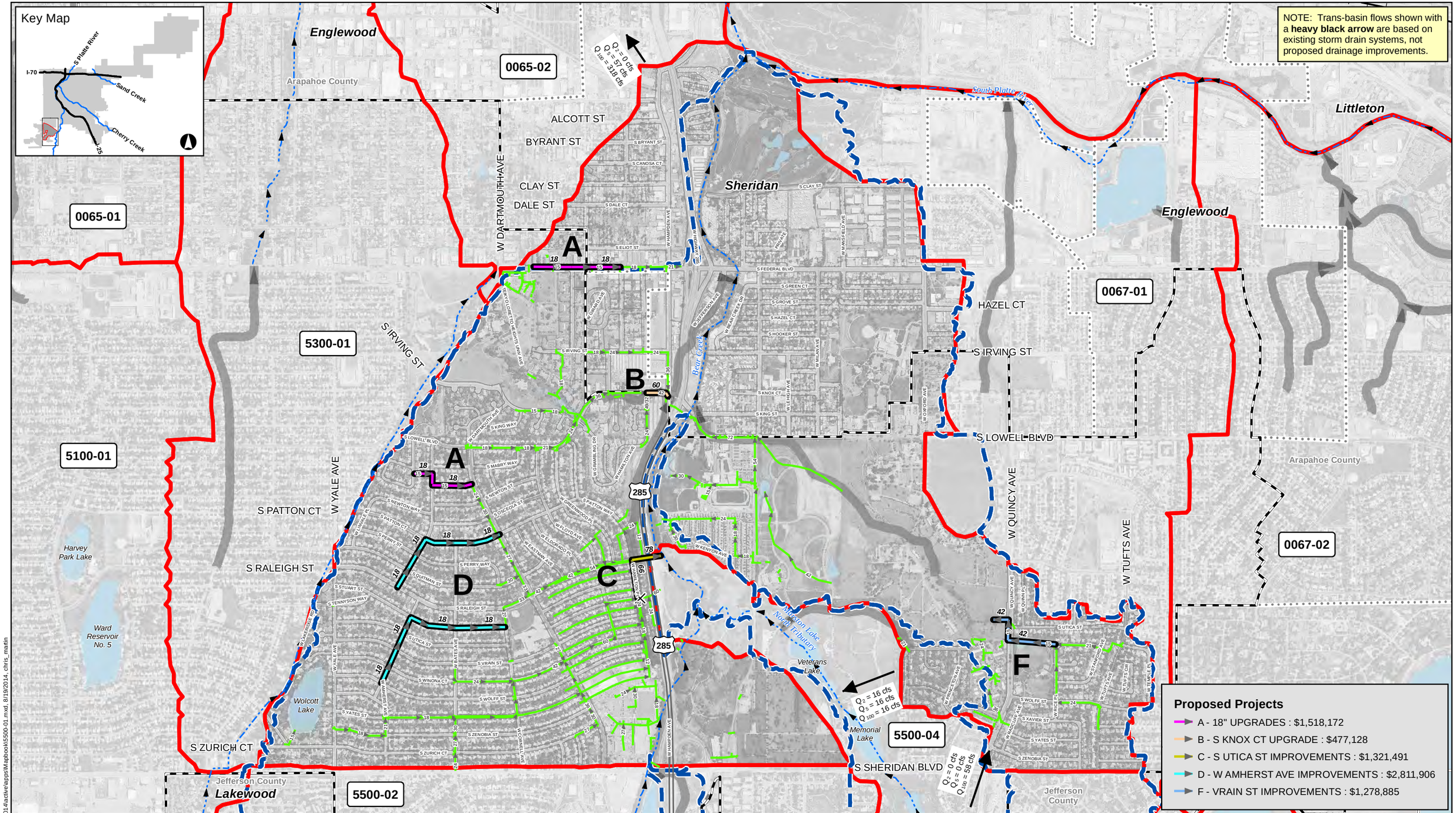
Project A: 18-Inch Upgrades
This project upsizes various pipes to the City's 18-inch minimum diameter is proposed to meet current drainage criteria.

Project B: S. Knox Court Upgrade
The existing 42-inch diameter storm drain in S. Knox Court is proposed to be upgraded to 60-inch diameter from W. Hamilton Avenue to W. Hampden Avenue.

Project C: S. Utica St. Improvements
A 66-inch storm drain is proposed along W. Hamilton Place to collect the excess flow that cannot be conveyed by the existing 60-inch storm drain crossing of Hampton Avenue at Utica Street. An 84-inch storm drain is proposed to replace the existing 54-inch storm drain at Raleigh Street and Hampton Avenue to accept the increased flow which is diverted from Utica Street through the proposed 66-inch storm drain. The proposed system will provide a 5-year level of service.

Project D: W. Amherst Avenue Improvements
Small 18-inch laterals are proposed along Amherst Avenue, Stuart Street, and Patton Court 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-inch system to convey the 2-year event to Ft. Logan Cemetery.



Basin 5500-01
Fort Logan

Denver Storm Drainage Master Plan

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Basin 5500-02 (Upper Bear Creek)

Existing System Description:

This collection system 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, multifamily 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.

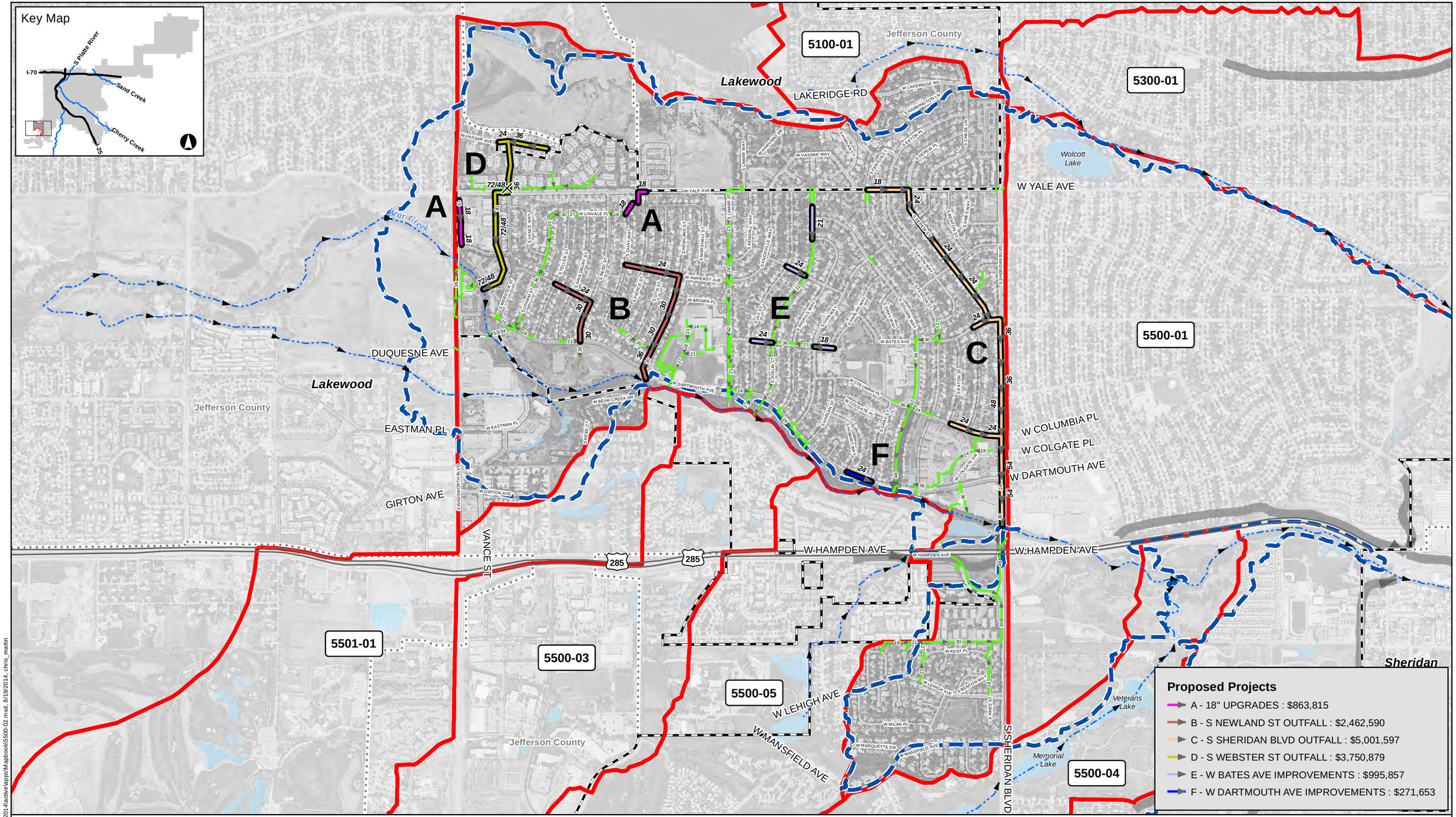
Project B: S. Newland Street Outfall
A 24-inch to 36-inch system is proposed in Newland Street to convey nuisance flows through residential areas.

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 drain in Webster Street should be upsized and extended from a 30-inch system to a 6-foot x 4-foot RCBC. The proposed storm drain 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
A minor 1 block lateral extension is proposed along Dartmouth Avenue from S. Gray Street to S. Hobart Way to address localized street flows in residential areas.



Basin 5500-02
Upper Bear Creek

Denver Storm Drainage Master Plan

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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 382 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. These discharges are shown as trans-basin flows into and back out of the collection system basin as determined by the July 1999 ***Academy Park Tributary to Bear Creek Outfall Systems Planning Study*** by Kiowa Engineering for the UDFCD. 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:

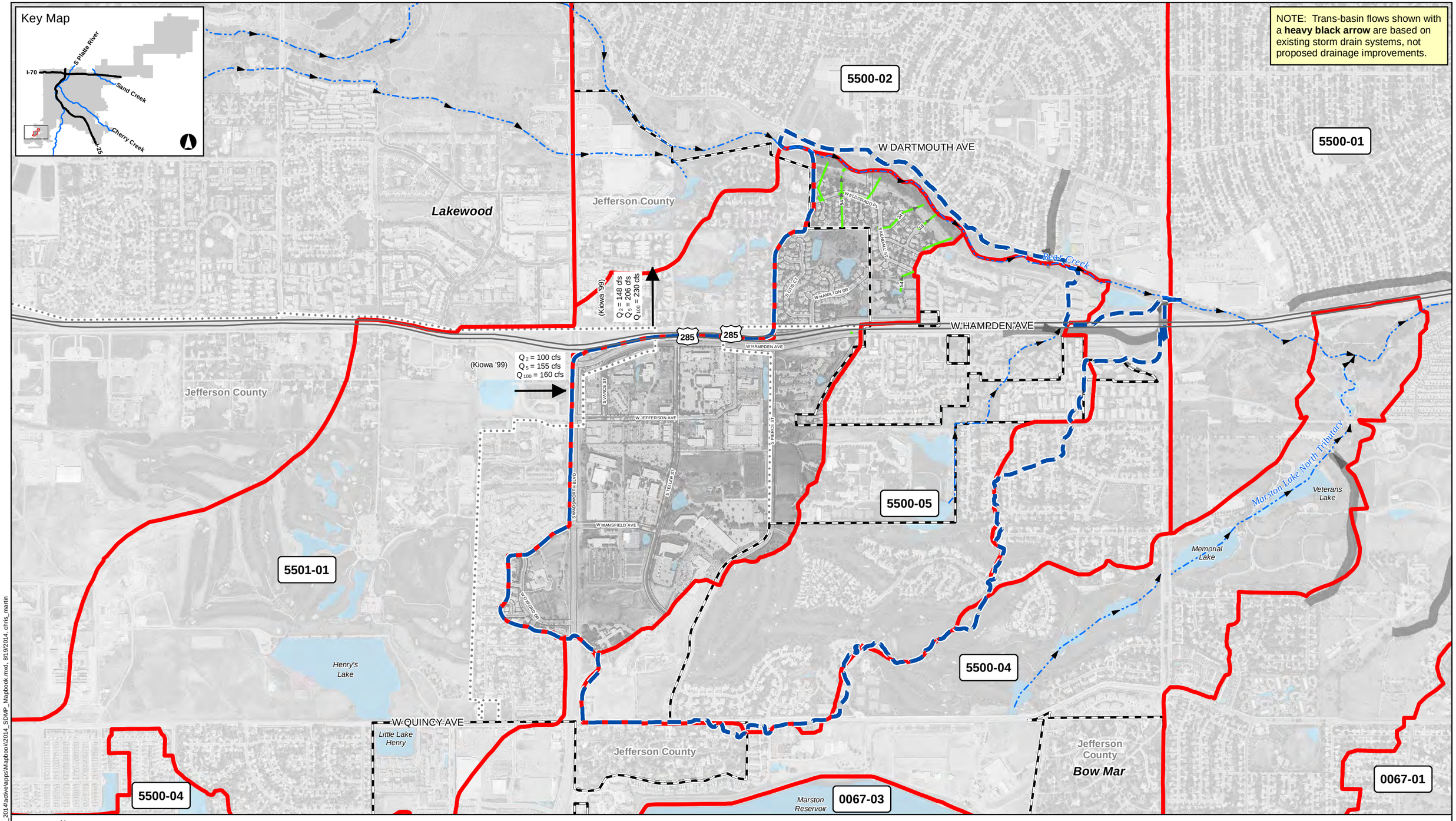
The watershed has three defined outfalls. The first outfall system drains the areas enclosed by Wadsworth Boulevard, Teller Street, Hampden Avenue, and Mansfield Street, and outfalls to the Henry's Lake Drainageway just before it is conveyed under Hampden Avenue. The second outfall in the watershed drains 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 and County 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.



N

0 600 1,200

Feet

1 inch equals 1,200 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

- Collection System Boundary
- Topographic Basin Boundary
- Thalweg
- Proposed Storm Pipe
- UDFCD Study Recommendations
- Proposed Pipe Disconnect
- Existing Storm Pipe
- Designed Storm Improvement
- Existing Surface Flow
- Significant Flooding Location
- Proposed Detention Basin
- Existing Basin
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- Other Municipalities
- Other Counties

Basin 5500-03
Academy Park

Denver Storm Drainage Master Plan

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Basin 5500-04 (Bear Creek – Marston Lake North)

Major Drainageway Plan:

Marston Lake North Drainageway – Major Drainageway Plan (MDP) was completed by Olsson Associates for the UDFCD in 2012. This plan primarily addressed improvements to the main channel of the Marston Lake North Drainageway but also proposed updated storm drainage improvements in the vicinity of the proposed Glenbrook Detention Basin (see Project B below), and other recommendations for disconnecting storm water discharges to the Bowles Lateral Irrigation Ditch that traverses the drainage basin.

Existing System Description:

This collection system basin drains to Bear Creek via the Marston Lake North Channel and is generally bound by W. Hampden Avenue on the north, W. Kenyon Avenue on the east, W. Belleview Avenue on the south, and S. Nelson Street, in Jefferson County, on the west. The majority of the basin is located in Denver with the western edges lying in Jefferson County. The Bowles Lateral crosses the basin from the northwest corner to the southeast corner, eventually flowing into Bowles Reservoir No. 1. Several storm drains 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 drain system that discharges into Lakes Lake. Lakes Lake is in the northern portion of the basin within Stanford and Balsam Park. The Marston Lake North Channel originates at S. Kipling Street in Jefferson County, north of W. Stanford Avenue, enters Denver near S. Garrison Street, and flows east to a detention basin on the east side of S. Wadsworth Boulevard, then runs along the north side of Marston Reservoir, eventually discharging into Bear Creek. Multiple storm drains 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.

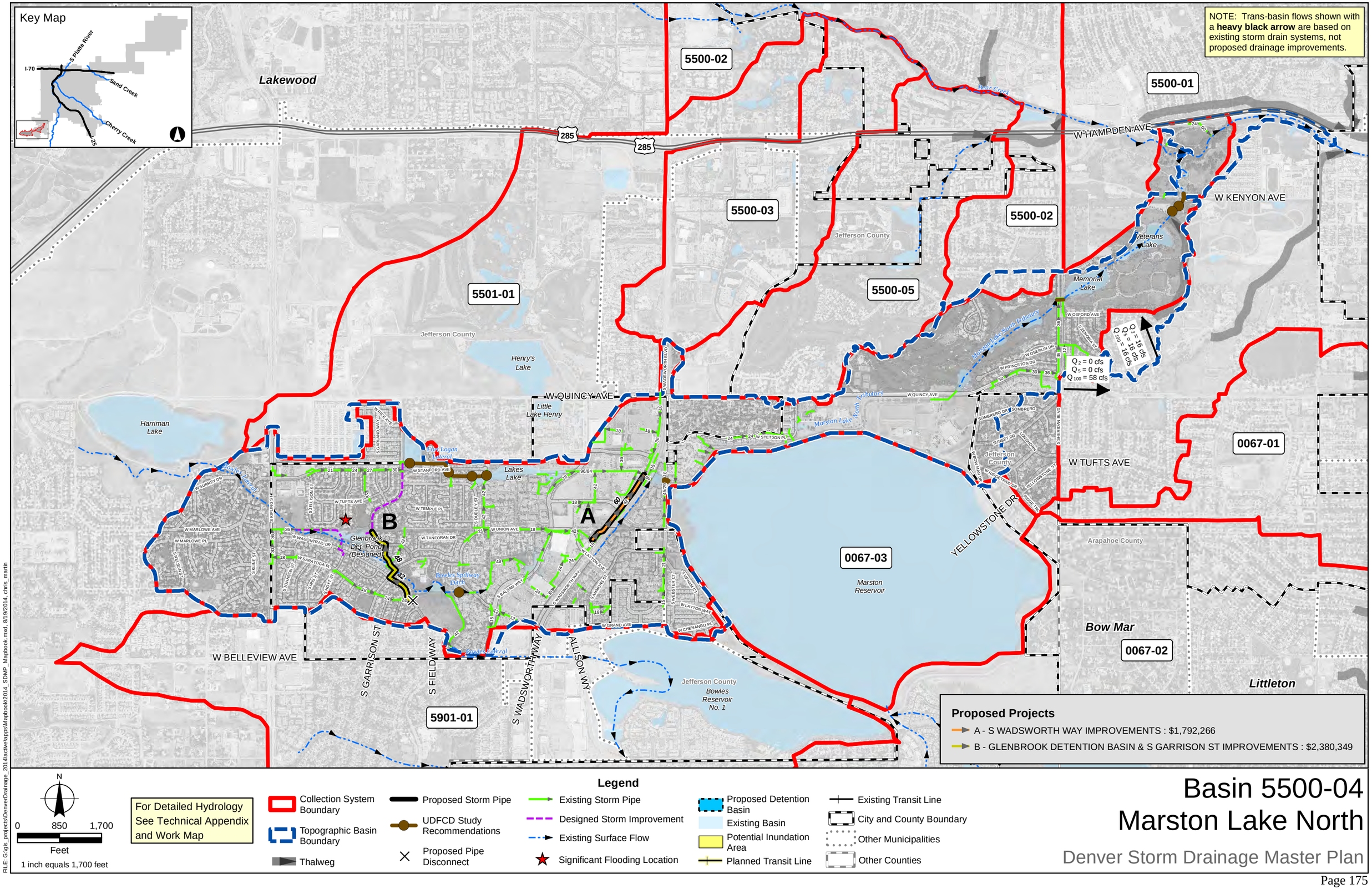
Drainage Deficiencies:

- 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 drain system independent of the Bowles Lateral.
- The 36-inch storm drain system draining Design Point 138, leading to the Glenbrook Detention Basin, is undersized.
- The 42-inch storm pipe along the west side of S. Wadsworth Way, between W. Layton Avenue (DP 117) and the Marston Lake North Drainageway (DP 117) has the capacity to convey approximately 90 cfs, while the 2-year and 5-year flows are 97 cfs and 143 cfs, respectively.
- On April 11, 2005, the property at 4693 S. Hoyt Street was flooded when the stormwater detention basin 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
This project increases the size and/or capacity of the storm system in Wadsworth from Union Avenue to the Marston Lake North Channel.

Project B: Glenbrook Detention Basin & S. Garrison Street Improvements
Improve drainage from S. Kipling Street to the Glenbrook Detention Basin, and disconnect the Glenbrook Detention Basin outflow from the Bowles Lateral Ditch with a new storm drain outlet in S. Garrison Street, from the Glenbrook Detention Basin to the Marston Lake North Drainageway. Also, as noted in the facing map, extend the 30-inch pipe that currently discharges into the Bowles Lateral Ditch near Field Way and Wagontrail Drive west to the new storm drain system in S. Garrison Street to disconnect from the Bowles Lateral Ditch. Upsize the existing 1.5 ac-ft detention basin in Wagon Trail Park with a new 6.7 ac-ft natural areas detention and water quality basin. A 48-inch outlet RCP is to be built from the new detention basin, north in Garrison Street to an existing manhole in Stanford Avenue. The existing 36-inch RCP between the existing manhole in Stanford Avenue and the Marston Lake North Drainageway is to be upsized to 48-inch RCP / 5-foot x 3-foot RCBC / 6-foot x 3-foot RCBC, and the existing outfall to Marston Lake North Drainageway to be re-built as required.



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0 850 1,700

Feet

1 inch equals 1,700 feet

For Detailed Hydrology See Technical Appendix and Work Map

Legend

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- Other Counties

Basin 5500-04
Marston Lake North

Denver Storm Drainage Master Plan

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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 collection system basin covers an area of approximately 451 acres (0.71 square miles). Land use consists of single family residential, multifamily residential, commercial, school, and Pinehurst Country Club and golf course.

The existing major drainage system consists of storm drains 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 drain 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 drain along Fenton Street, and a 24-inch pipe draining a portion of the Tall Pines apartment complex.

The recommendations of the 1999 ***Pinehurst Tributary to Bear Creek Outfall Systems Planning Study*** (OSP), prepared by Kiowa Engineering for the UDFCD, have 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 drain 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.

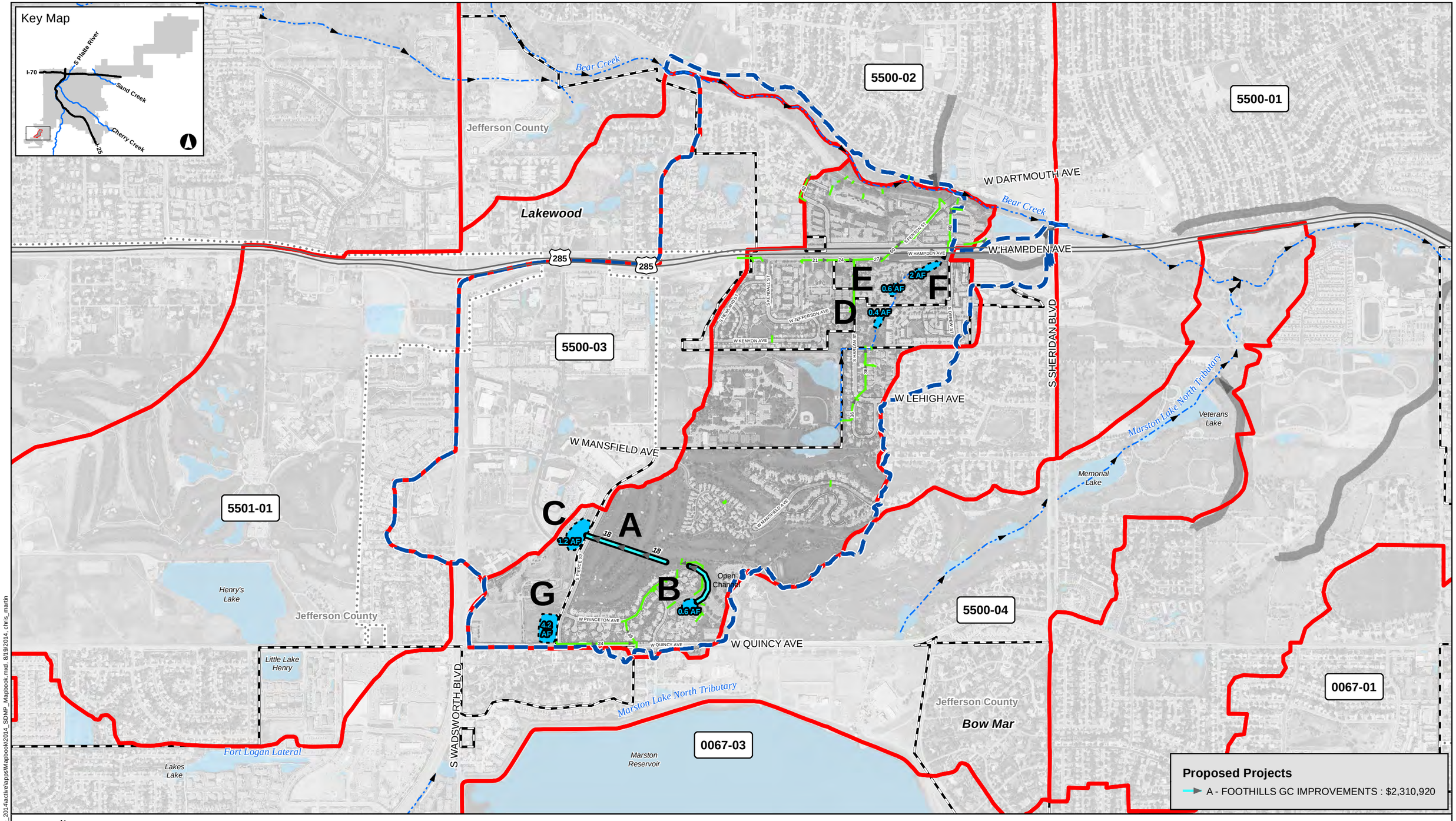
Proposed Capital Improvements:

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 basin was constructed at the northeast corner of the property, and an additional storm drain has been installed west of Harlan Street. Other minor improvements were made to local drainage systems in the area. Other improvements recommended in the 1999 Pinehurst Tributary OSP have been incorporated herein:

<u>Projects A, B, C, and G: Foothills GC Improvements and Pierce Way Detention</u>
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 basins 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.

<u>Projects D, E, and F: S. Harlan St Detention</u>
Small on-line detention basins are proposed along the Pinehurst Tributary south of Hampden Avenue. The basins were proposed in the 1999 OSP study and will attenuate peak flows to the Hampden Avenue crossing and the existing 48-inch outfall to Bear Creek.



Basin 5500-05
Pinehurst Tributary

Denver Storm Drainage Master Plan

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Basin 5501-01 (Henry's Lake)

Existing System Description:

Henry's Lake Collection System 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 1.36 square miles (868 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).

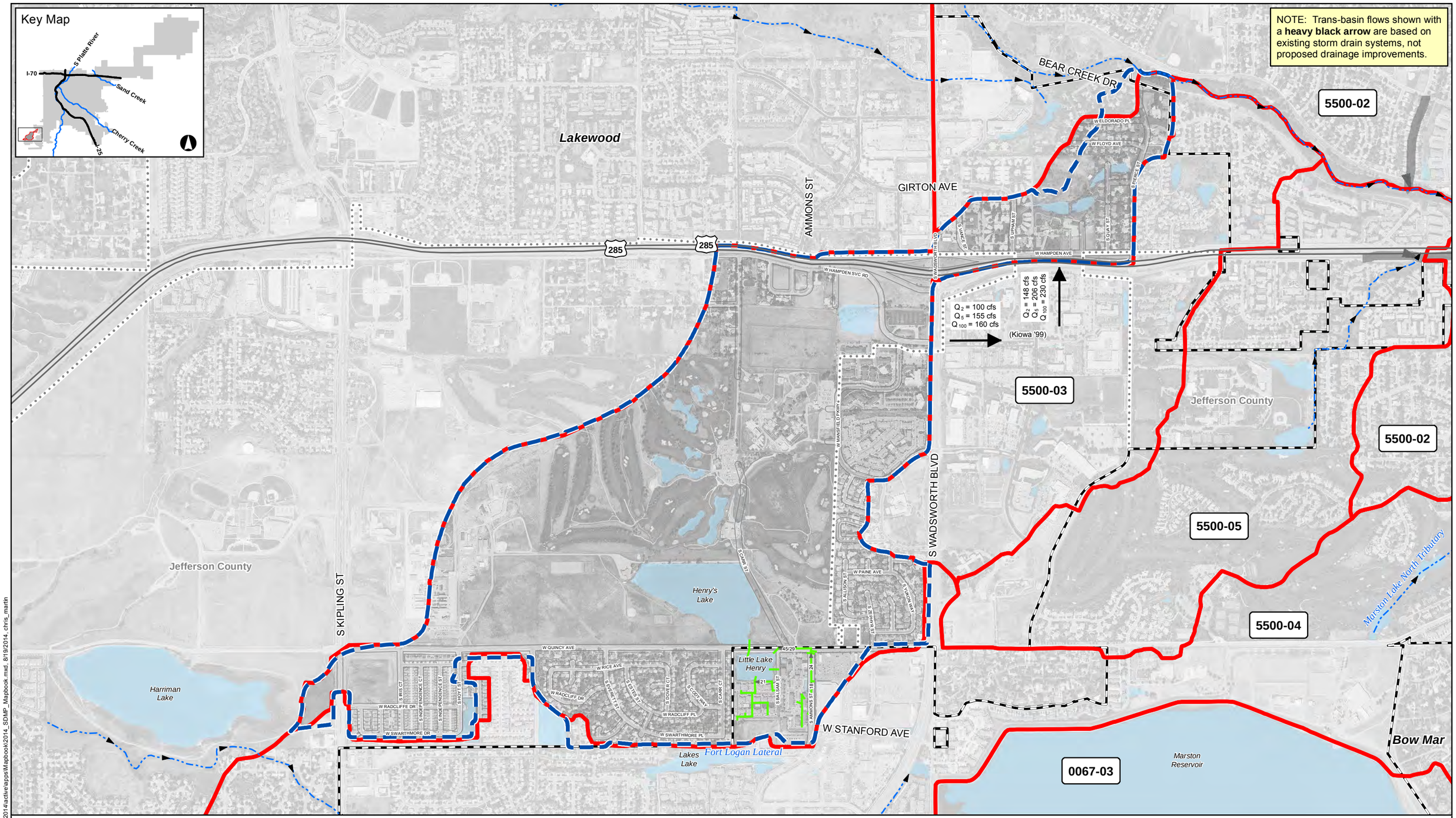
Drainage Deficiencies:

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. These discharges are shown as trans-basin flows out of and back into the basin as determined by the July 1999 ***Academy Park Tributary to Bear Creek Outfall Systems Planning Study***, by Kiowa Engineering for the UDFCD. 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-inch x 48-inch Horizontal Elliptical Reinforced Concrete Pipe (HERCP) culvert beneath Hampden Avenue. The 72-inch x 44-inch CMP beneath Wadsworth Boulevard discharges into an open top concrete vault ("bubbler"). Exiting from the vault is a smaller 48-inch RCP storm drain. 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 and County of Denver reach.



N

0 600 1,200

Feet

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Basin 5501-01
Henry's Lake

Denver Storm Drainage Master Plan

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Basin 5901-01 (Coon Creek)

Existing System Description:

This collection system 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 drain systems in the roadways. Basins 60, 61 and 64 drain to Grant B Reservoir, Basins 62 and 63 drains to Bowles Reservoir No. 1, and Basins 70, 71 and 72 drain to Grant C Reservoir.

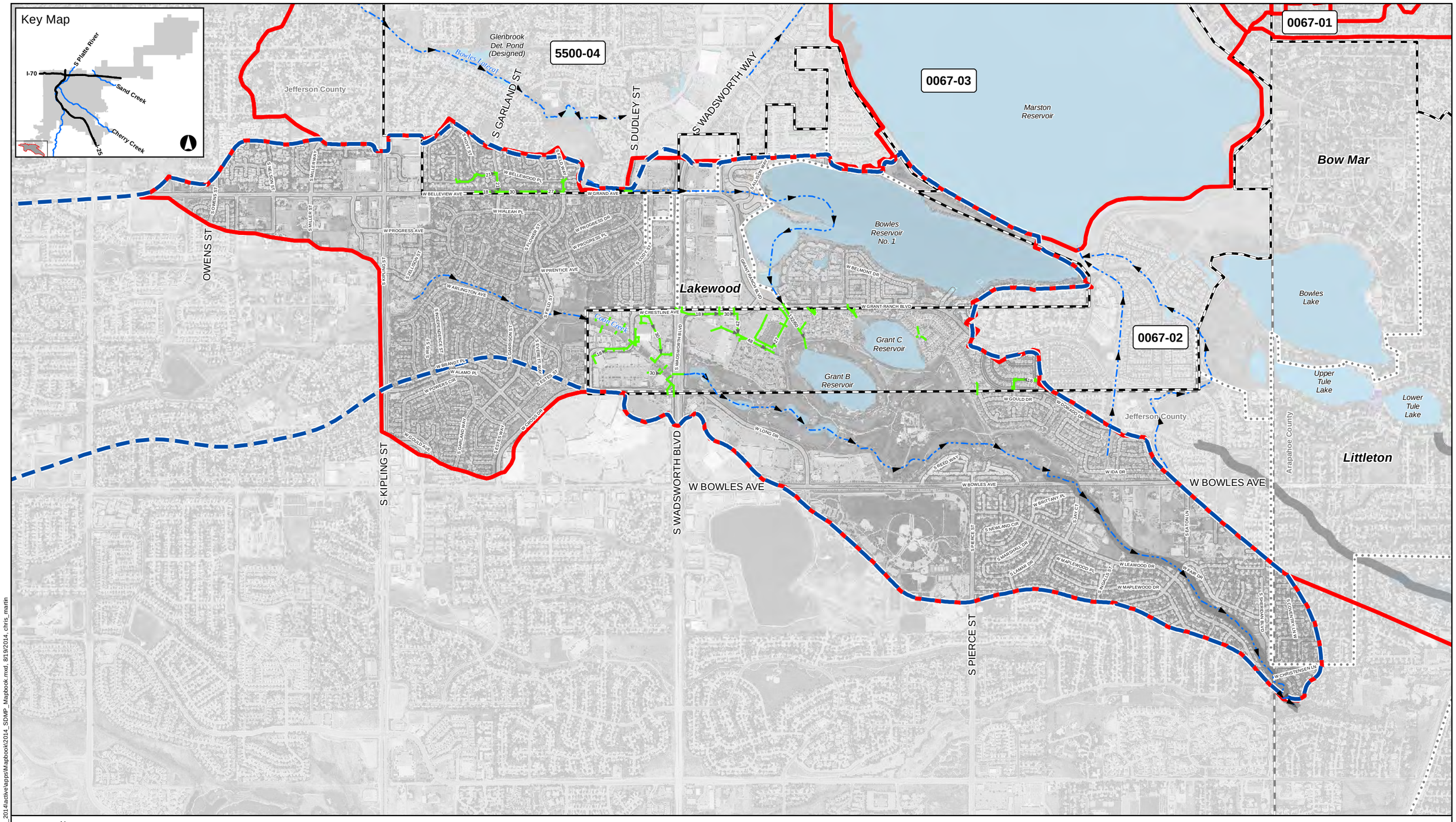
Since only a small portion of the basin is in Denver, there are few Denver-owned public outfalls. Between Estes Street and Wadsworth Boulevard there are several outfalls into Coon Creek. From the north, there are a 12-inch outfall, an 18-inch outfall, a 24-inch outfall, and a 36-inch outfall; from the south, there are two 18-inch outfalls, and two 30-inch outfalls. There are several pipe networks within the City and County 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 within the City and County of Denver. The ***Dutch Creek, Coon Creek, Lilley Gulch and Three Lakes Tributary Major Drainageway Plan and Flood Hazard Area Delineation, Phase B***, prepared by PBS&J for the UDFCD in 2008, did not identify any needed improvements for the portion of Coon Creek within Denver (Reach 12).

Proposed Capital Improvements:

There are no required improvements for this basin within the City and County of Denver.



N

0 800 1,600

Feet

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Basin 5901-01
Coon Creek

Denver Storm Drainage Master Plan

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