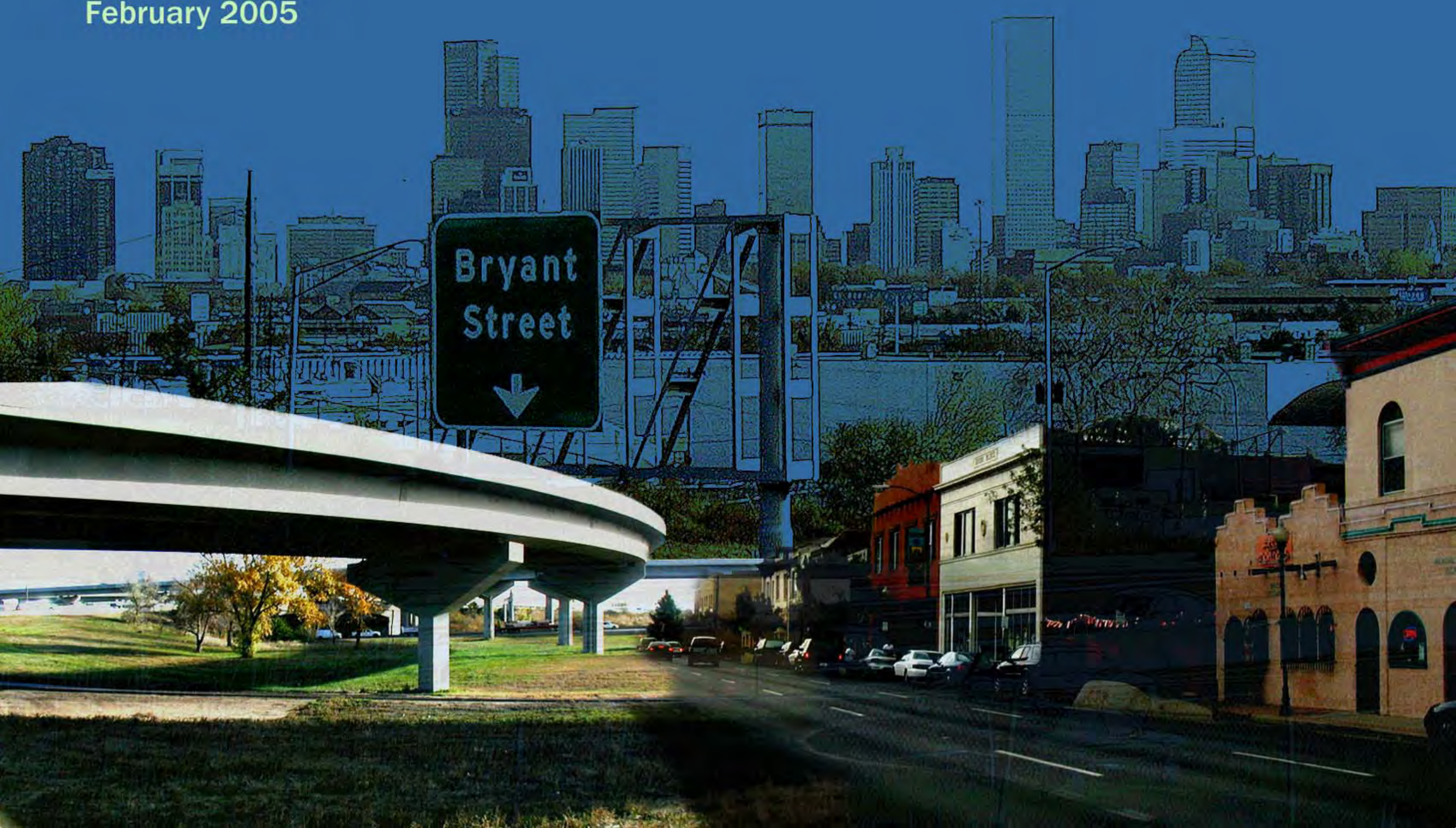
Water Resources Report

Prepared for:
Colorado Department of Transportation
Federal Highway Administration

Prepared by:
Felsburg Holt & Ullevig
Muller Engineering

February 2005



WATER RESOURCES REPORT FOR THE VALLEY HIGHWAY EIS DENVER, COLORADO

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Colorado Department of Transportation

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February 28, 2005

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LIST OF ABBREVIATED TERMS

A	AASHTO	American Association of State Highway and Transportation Officials
	AC FT	acre foot
B	BMPs	best management practices
C	CCD	City and County of Denver
	CDOT	Colorado Department of Transportation
	CDPHE	Colorado Department of Public Health and Environment
	cfs	cubic feet per second
	CML	Consolidated Main Line railroad
	CUHP	Colorado Urban Management Model
D	DEIS	Draft Environmental Impact Statement
	DS	dry swale
E	EB	eastbound
	EDB	extended detention basin
	EIS	Environmental Impact Statement
F	FEMA	Federal Emergency Management Agency
	FHAD	Flood Hazard Area Delineation
	FHWA	Federal Highway Association
	FIS	Flood Insurance Study
	FO	fiber optic
G	GIS	geographical information system
I	I-25	Interstate 25
	in	inches
	Inlet/MH	inlet and/or man hole box
M	MS4	Municipal Separate Storm Sewer Systems
N	NB	northbound
	NPDES	National Pollutant Discharge Elimination System
O	OH-E	overhead electric
	OH-T	overhead telecommunications
P	PED	planning, engineering and design
	PS	pump station vault and pumps

LIST OF ABBREVIATED TERMS

R	R.R.	railroad
	ROW	right-of-way
S	SAN	sanitary
	SB	southbound
	SH 85	State Highway 85
	SPUI	single point urban interchange
	STM	storm sewer
	SW	shallow wetland basin
T	T-REX	Transportation Expansion Project
	TSS	total suspended soils
U	UD	urban drainage
	UDFCD	Urban Drainage and Flood Control District
	UDSWMM	urban drainage storm water management model
	UG-E	underground electric
	UG-T	underground telecommunications
	US 6	6th Avenue
V	VERT.	vertical
W	WB	westbound
	WL	water line
	WQ	water quality
	WQVC	water quality capture volume
	WSE	water surface elevation
X	Xcel	Xcel Energy
Y	YR	year

1.0 INTRODUCTION

1.1 Valley Highway Corridor Project Overview

This project would involve reconstruction and reconfiguration of the Valley Highway (I-25) Corridor between Logan Street and US 6 (6^{th} Avenue) in the City and County of Denver (CCD) and elements of US 6 from I-25 to Federal Boulevard (see **Figure 1-1**), hereafter referred to as the "project corridor". In addition to reconstruction of the I-25 mainline, the Broadway/Lincoln Avenue, Santa Fe Drive, and Alameda Avenue interchanges would be improved in the corridor and grade separation of Santa Fe Drive and Kalamath Street with the Consolidated Main Line railroad and Alameda have been considered.

This water resources technical report provides supporting documentation for the draft environmental impact statement (DEIS) being prepared for CDOT regarding the Valley Highway project corridor. The water resources technical report consists of existing and proposed hydrology and hydraulics for drainage basins in and near the project corridor. It defines current drainage deficiencies and recommends methods for improvements. Discussion includes on-site drainage system changes for each of the system alternatives as well as the incorporation of Best Management Practices (BMPs). The report also discusses impacts and mitigation (if required) to the South Platte River. Work must be coordinated with Denver's Stormwater Drainage Master Plan and sanitary master plan to ensure service continuity.

1.2 Purpose and Need

The ***purpose*** of the Valley Highway Project is to:

- Provide lane continuity and balance on I-25 from Logan Street to US 6, linking with sections of I-25 to the north and south
- Optimize highway system operations while recognizing the constraints on highway expansion identified through the regional transportation planning process
- Improve connectivity between transportation modes
- Improve pedestrian / bicycle mobility across the project corridor
- Increase safety along and across the corridor for motorists, pedestrians, and bicyclists
- Correct roadway deficiencies along I-25 and US 6 to meet current design standards to provide a safer, more efficient, and more reliable transportation system
- Increase safety and reduce congestion and delays related to the at-grade crossing of Santa Fe Drive / Kalamath Street and the Consolidated Main Line

The ***need*** for the project arose primarily out of a number of identified roadway deficiencies that result in unsafe conditions. The age, condition, and geometric design of the roadway compromise the safety of the traveling public and require improvements to meet current design and safety standards.

Valley Highway, 02-069, 02/16/2005

Study Area

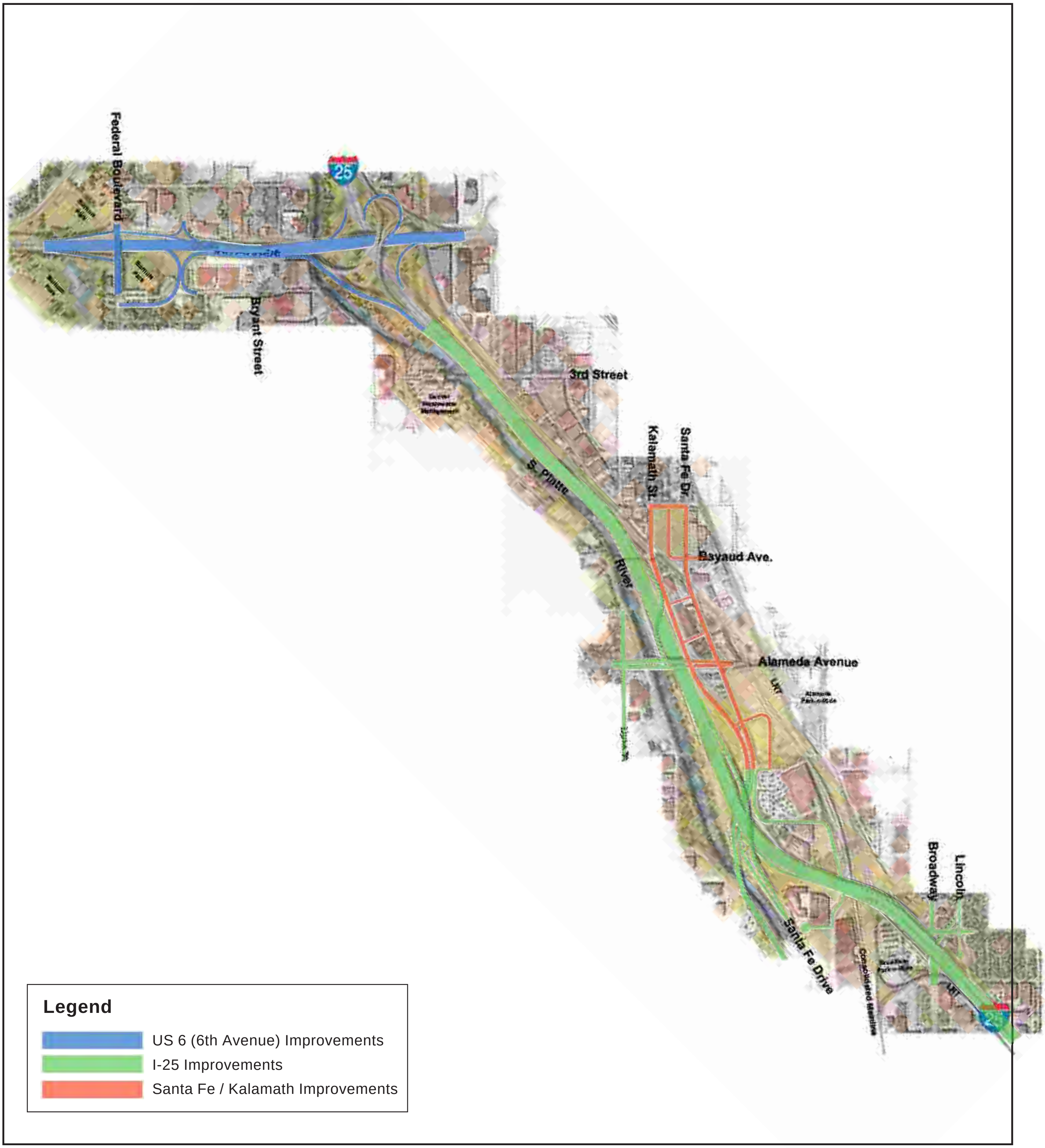
Figure 1-1

1.3 System Alternatives

The "No Action" Alternative and three additional system alternatives are being considered for the project corridor, which provide a reasonable range of alternatives that meet the purpose and need of the project. **Figures 1-2, 1-3,** and **1-4** show the three System Alternatives. Some highlights of the alternatives are as follows:

- No Action Alternative
  - Includes planned improvements as part of the Broadway Viaduct project only
- System Alternative 1 – Minimize Project Footprint
  - Provides four continuous lanes (each way) throughout the corridor on I-25
  - Includes the North Decatur Extension Alternative in the US 6 area
  - Provides grade-separation of Santa Fe and Kalamath with the Consolidated Main Line and Bayaud and maintains the existing alignment
  - Includes a West Side Half Urban interchange at Alameda
  - Includes a Half Single Point Urban Interchange (SPUI) with directorial ramps at Santa Fe
  - Provides a Modified Diamond Interchange at Broadway
- System Alternative 2 – Maximize Operational and Performance Safety
  - Provides four continuous lanes (each way) throughout corridor on I-25
  - Includes a Diamond at Federal with west side access ramps to Bryant
  - Provides grade-separation of Santa Fe and Kalamath with the Consolidated Main Line railroad and Bayaud and maintains the existing alignment
  - Provides a grade separation of Santa Fe and Kalamath with Alameda and a SPUI at Alameda with Alameda underneath
  - Includes a Full SPUI at Santa Fe with directional ramps
  - Provides a Directional Interchange with a tunnel at Broadway
- System Alternative 3 – Maximize Facilitation of Local Objectives
  - Provides four continuous lanes (each way) throughout corridor on I-25
  - Includes a SPUI at Federal
  - Provides grade-separation of Santa Fe and Kalamath with the Consolidated Railroad and Bayaud with a consolidated Santa Fe and Kalamath
  - Provides a grade separation of Santa Fe and Kalamath with Alameda and a SPUI at Alameda with Alameda over the top
  - Includes a Full SPUI at Santa Fe
  - Provides a Tight Diamond Interchange at Broadway

Work must minimize sanitary sewer disruption and coordinate with Denver's sanitary master plan and the METRO Wastewater District master plans.



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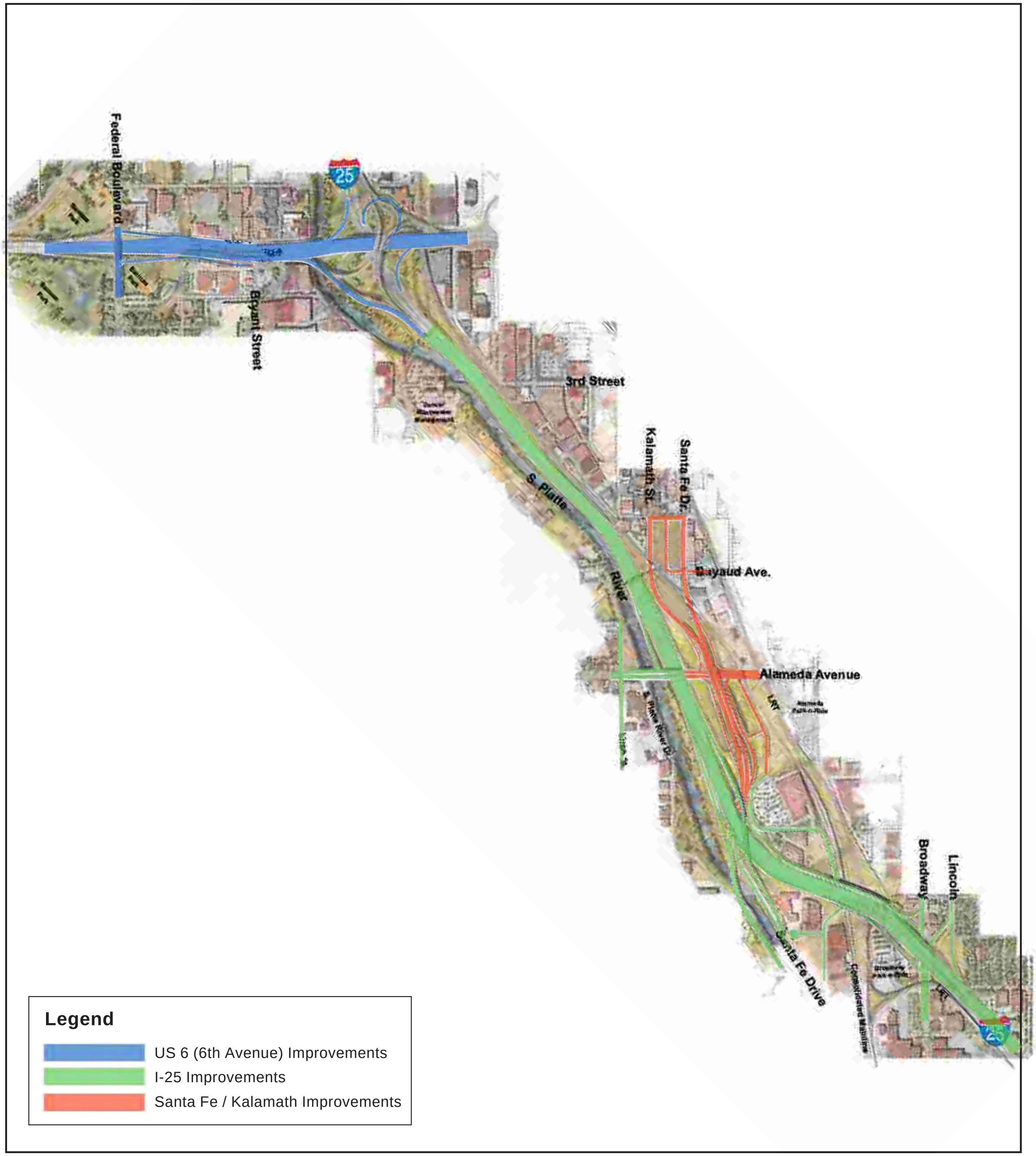
System Alternative 1
Maximize Use of Existing Right-of-Way

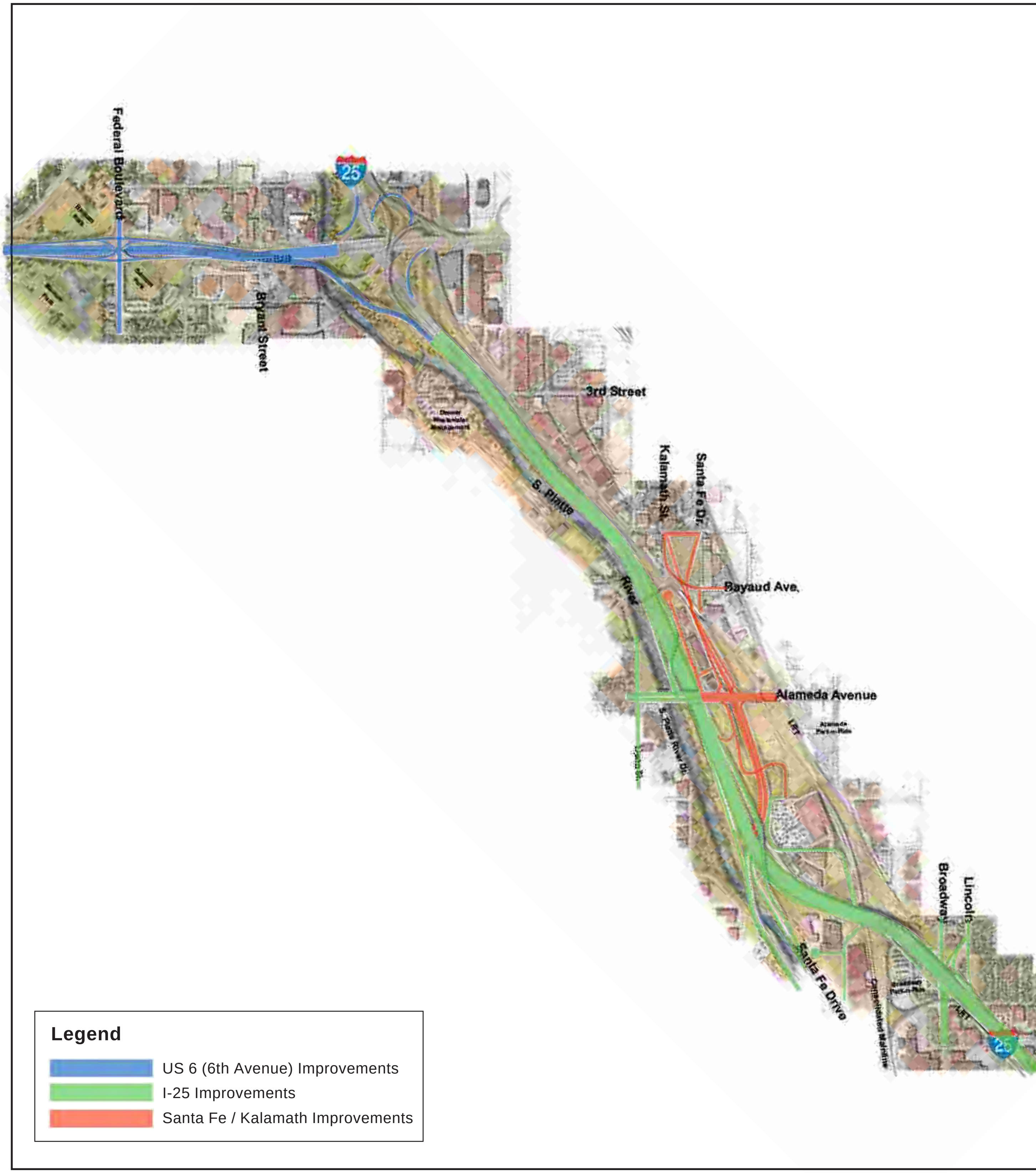


North

System Alternative 2
Maximize Operational Performance / Safety

Valley Highway Logan to 6th Ave. Environmental Impact Statement (EIS)

Figure 1-3



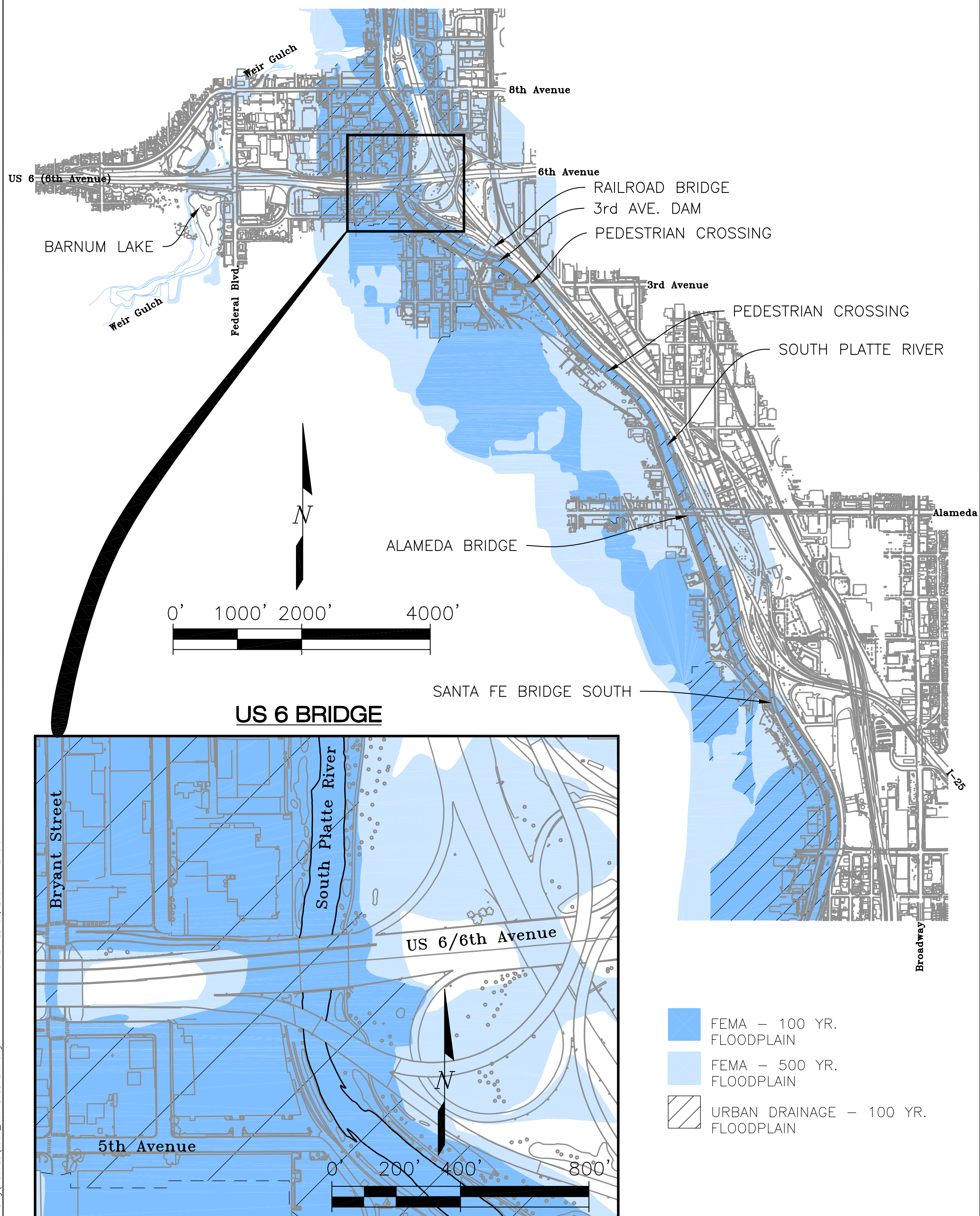
North

System Alternative 3
Maximize Facilitation of Local Objectives

1.4 Previous Studies and Reports

Floodplain and stormwater drainage studies have been completed for much of the project area. The Federal Emergency Management Agency (FEMA) identified 100- and 500-year floodplains for the South Platte River, including those within the project corridor in 1990. More floodplain information is discussed in FEMA's Flood Insurance Study (FIS) Volumes 1 and 2, last updated in 1990. Urban Drainage and Flood Control District (UDFCD), in agreement with several city and county agencies, published a Flood Hazard Area Delineation (FHAD) and a Major Drainageway Planning study for the South Platte River in 1985, which encompass the project corridor. In addition, UDFCD published a Major Drainageway Planning study for Weir Gulch, a small tributary to the South Platte River in 1988. This tributary flows under 6th Avenue, near Federal Boulevard prior to its confluence with the South Platte River. These floodplains can be seen in **Figure 1-5**, a digital schematic of FEMA FIRM community panel numbers 080046 0013C and 0014C last updated in 1990, and UDFCD FHAD.

More detailed hydrology and hydraulic studies have been completed as well. The City and County of Denver has recently completed the *Storm Drainage Master Plan Phase I Final*, (Matrix 2003) for the metro area, which encompasses the project corridor and contains the framework for future city storm sewer projects. Several storm drainage improvements are proposed in or near the project corridor. Denver's master plan and subsequent drainage improvements should be considered with each phase of final design for the Valley Highway project. Off-site drainage information and peak discharge calculations for the Valley Highway project are based on the information provided in the *Storm Drainage Master Plan* and the *Draft Floodplain and Drainage Assessment* written by Muller Engineering Company in January 2000. The Reference section of this report contains a list of all of the previous studies and reports used for this report and **Appendix E** contains several sheets from these studies. In addition, **Appendix E** contains a list of the existing reports and studies for the drainage basins impacted by this project, as provided by the City and County of Denver.



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Valley Highway - Logan to 6th Ave.
Environmental Impact Statement (EIS)

FIGURE
1-5

2.0 DRAINAGE SYSTEM HISTORY

2.1 Environmental Setting

The Valley Highway project corridor is situated in the southern portion of the Denver Metro Area along the South Platte River. The drainage basin near the project corridor is almost entirely developed with industrial, commercial, and residential uses. It has undergone a change of land use over the last decade. The industrial properties to the west of older established neighborhoods have been converted to shopping centers, restaurants, and commercial facilities to provide employment, retail shopping, and some recreational activities to the adjacent area.

The climate, soils, and weather vary greatly over the approximately 4,000 square mile watershed that extends from the Continental Divide in the Rocky Mountain Range to the high plains and foothills of eastern Colorado (FHAD 1985). The mountainous regions are subject to great snowfalls and flooding caused by sudden melting of snow followed by large spring storms, whereas the plains areas, including the project corridor, are more subject to frequent summer thunderstorms resulting in flash flooding.

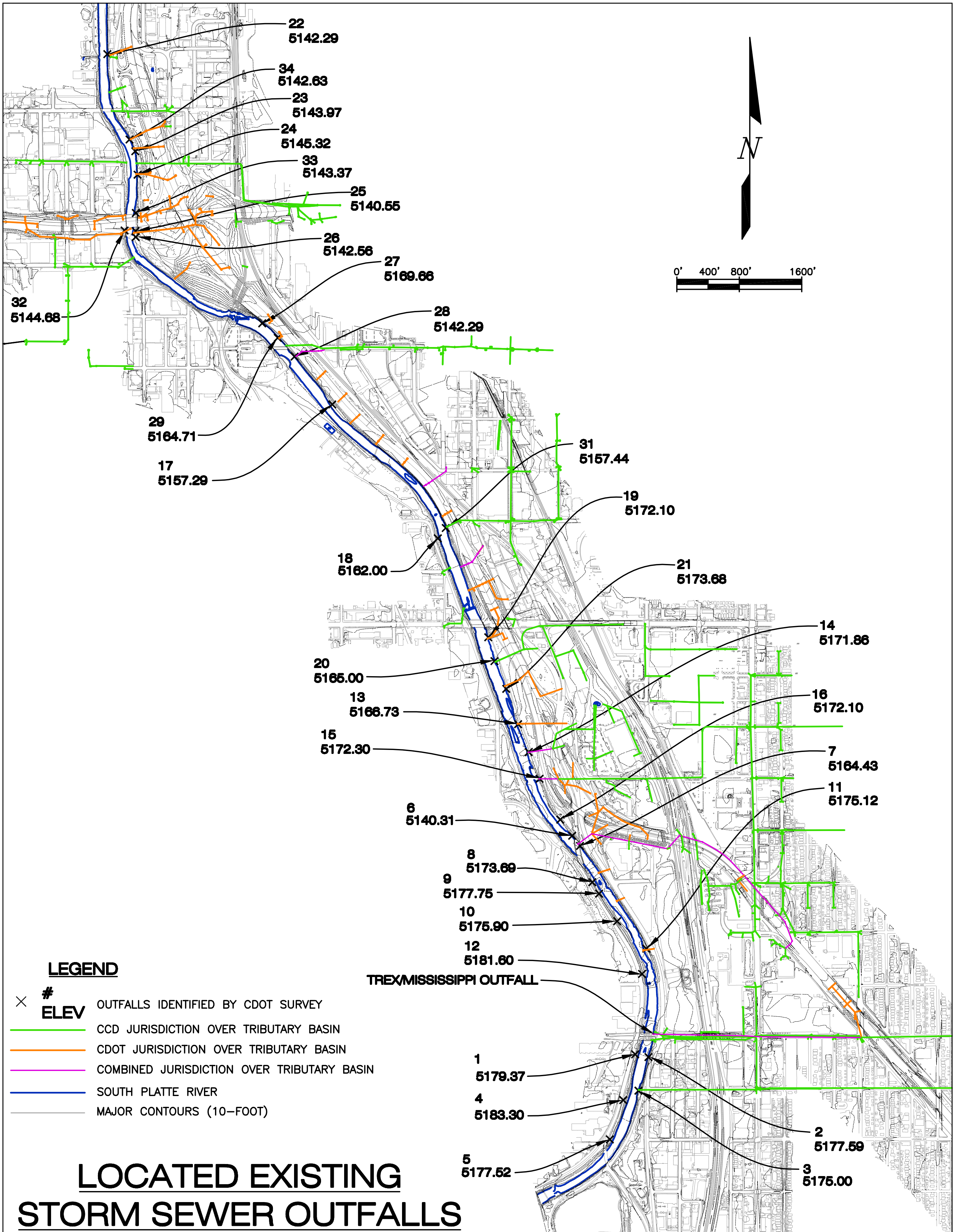
Located just east of the Rocky Mountain Range and far from any moisture source, Denver has a mild and arid climate. It receives an average of 15.2 inches of precipitation per year with most occurring in spring and summer (NOAA 2000). The mean daily maximum temperature ranges from 43.4 degrees in January to 87.4 degrees in July, while the mean minimum varies from 16.0 degrees in January to 58.3 degrees in July (FEMA 1990). The Colorado Climate Center describes the Denver region as having dry winters with an occasional wind-blown snowstorm and very cold temperatures alternated with some surprisingly warm days. It says that springtime brings winds and highly changeable weather, an occasional blizzard, and occasional gentle soaking rains or wet snows. Low-humidity, yet hot days and comfortable nights and the ever-present threat of big thunderstorms should be expected in summer. Fall in Denver is usually dry and comfortable in temperature (http://ccc.atmos.colostate.edu/climateofcolorado.php).

A Soil Conservation Survey (SCS) has not been performed for the city of Denver and the project corridor because it is all heavily urbanized. According to the Flood Insurance Study (FIS) for the City and County of Denver, the soils in Denver are generally deep, well-drained, clayey soils that are neutral or mildly alkaline (FEMA 1990). Additionally, the FIS states that there are substantial sand and gravel deposits along the South Platte River (FEMA 1990).

Stormwater runoff through the project corridor and tributary drainage basins flows overland, in storm sewers, and by open channel to the South Platte River. Runoff east of I-25 flows from east to west and is intercepted by numerous storm sewer systems and conveyed to the river. Runoff from west of I-25 and the South Platte River flows from west to east, but also towards the river. **Figure 2-1** shows the location of all known existing outfalls along the river, as surveyed by CDOT. **Table 2-1** provides a description of each outfall (CDOT 2002). A more complete table is contained in Appendix A. Land west of Federal Boulevard is tributary to Weir Gulch, as depicted on **Figure 1-5**, where it is conveyed to the South Platte River north of 8th Avenue.

Table 2-1 Located Existing Outfalls

Number on Map	Project Significance	Size	Material	Watershed Land Uses	Date(s) Flow Observed
1		12"	Concrete	Industrial, Commercial	8/1/2002
2		15"	Brick	Highway	None
3		15"	Green PVC	Highway	None
4		12"	Concrete	Industrial, Commercial	None
5				Highway	None
6		15"	Concrete	Highway	None
7	**CCD - 42" Outfall**	42"	Concrete	Highway, Commercial	10/21/2002
8		15"	Concrete	Industrial	None
9		18"	Concrete	Highway	None
10		30"	Concrete	Industrial, Commercial	None
11				Highway	None
12		15"	Concrete	Industrial, Commercial	None
13		24"	Concrete	Highway, Industrial, Commercial	None
14		24"	Concrete	Highway	6/28/2002
15	**Next to CCD - Virginia Outfall**	54"	Concrete	Highway, Commercial	6/28/2002, 10/21/2002
16		15"	Concrete	Highway	None
17		18"	Concrete	Highway	None
18		15"	CMP	Commercial/ park	None
19	**I-25 - Alameda Pump Station Outfall**	24"	Concrete	Highway	6/28/2002
20	**CCD - Alameda Outfall**	30"	Concrete	Highway	None
21		24"	Concrete	Highway	None
22	**CDOT flow only**	36"?	Concrete	Highway	None
23	**CDOT flow only**	18"	Concrete	Highway	None
24	**CDOT flow only**	18"	Concrete	Highway	None
25	**I-25 - 6th Avenue Outfall**	24"	Concrete	Highway	6/28/2002
26		24"	Concrete	Highway	None
27	**CDOT flow only**	12"	Concrete	Industrial/ Highway	None
28	**Next to CCD - 3rd Avenue Outfall**	24"	Concrete	Industrial/ Highway	10/21/2002
29	**CDOT flow only**	12"	Concrete	Highway	None
30	**Outfall is not located on map because provided location data is incorrect. Outfall is thought to be the old Mississippi Outfall.**	66"	Concrete	Industrial, commercial	8/1/2002
31	**CCD - Bayaud Outfall**	36"	Concrete	Highway/ industrial/ commercial	None
32	**Major US 6 and CCD Outfall**	42"	Concrete	Highway	6/28/2002, 10/10/2002
33		18"W x 24"H	Concrete	Highway	None
34		24"	Concrete	Highway	None



LOCATED EXISTING STORM SEWER OUTFALLS

Valley Highway - Logan to 6th Ave.
Environmental Impact Statement (EIS)

FIGURE 2-1

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2.2 Significant Flood Events

2.2.1 Basin Information

The South Platte River watershed, including the project corridor has a long history of flooding. The river basin has flooded from large snowmelts in the mountains, storms covering large areas with continuous rainfall, as well as localized storms with high rainfall intensities. The majority of flooding in the project corridor is caused by summer thunderstorms that drop great amounts of rain in short time intervals causing flash floods where the runoff exceeds the capacity of storm sewers and drainage channels.

2.2.2 Channel Description

The South Platte River in the project corridor is mostly channelized, but some obstructions exist. The 3rd Avenue and 6th Avenue bridges cause the 100-year water surface elevation of the river to increase. “The 6th Avenue Bridge is overtopped by the 100-year flood, resulting in almost a 2-foot rise in the 100-year flood elevation. When combined with the low left [west] bank upstream of the bridge, extensive flooding occurs on the left bank from Vallejo Street to the 6th Avenue Bridge. The area flooded includes warehouses, retail stores, and small fabricating shops” (Wright 1985). Depth of flooding is generally less than 2 feet but may extend as much as 2,400 feet wide (Wright 1985/Flood Hazard Area Delineation (FHAD) 1985). Currently, the Santa Fe (south) and the Alameda Bridges do not effect the water surface elevation of the river. Refer to **Figure 1-5** for the 100- and 500-year floodplain boundaries for the South Platte River.

No substantial flooding occurs within the project corridor along Weir Gulch. “Channel improvements along Weir Gulch have been constructed from West Alameda Avenue to the confluence with the South Platte. Improvements include the re-grading of Barnum Lake and the construction of an additional outlet culvert under West 6th Avenue (U.S. Highway 6), designed to reduce the extent of 100- and 500-year flooding below Barnum Lake” (Federal Emergency Management Agency (FEMA) 1990). The floodplain in this location can be seen on **Figure 1-5**.

2.2.3 Significant Flood Events in Denver Metro Area

There is a great detail of information available regarding the flooding history of the South Platte River and its tributaries; however, due to the size of the drainage basin, the available information is not specific to localized areas of flooding. The following is a representative sample of the flooding history on the South Platte River including a range of flooding causes and results.

May-June 1844 – "The earliest flood for which circumstantial evidence is available occurred in 1844, at which time the bottomlands in the vicinity of Denver were covered in water from bluff to bluff" (Matrix Design Group, Inc. (Matrix) 2003).

May 21, 1914 – "A severe thunderstorm produced heavy rainfall of 0.83 inches in 15 minutes. Flooding caused considerable damage to bottom lands in eastern and southern parts of Denver" (Matrix 2003).

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" (Matrix 2003).

June 16, 1965 – The largest and most damaging natural disaster in the history of Denver occurred June 16 and 17, 1965, when a cloudburst dumped 15 inches of water on tributary basins near Larkspur. Beginning in Castle Rock, a twenty-foot high wall of water worked its way to southwest Denver where an estimated 154,000 cfs dumped into the South Platte River at its confluence with Plum Creek and a measured discharge of 40,300 cfs flowed at the stream gage near the 19th Street bridge in Denver. By the morning of June 17, the South Platte River "had grown to a mile-and-a-half wide in places. It had destroyed or seriously damaged all but three of the bridges that spanned it in Denver." In addition, numerous neighborhoods and businesses were completely destroyed (Adamson 1996). Flooding occurred throughout the South Platte River Basin with estimated damages of $500 million, of which $300 million occurred in the Denver area" (FEMA 1990). "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" (Matrix 2003).

July 7, 1967 – "A storm of cloudburst proportion caused damage from flooding in southwest and south Denver. Unofficial reports indicated rainfall of 2.00 inches in 30 minutes and more than 3.00 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" (Matrix 2003).

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 an interstate highway, 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" (Matrix 2003).

Historical information on flooding is scarce for Weir Gulch. Reported instances of flooding included basement damage and some channel and bridge damage (FEMA 1990).

2.3 US 6 and I-25 Drainage

In addition to the significant flood events in the Denver area, there is a history of minor flooding. The underpasses of Logan Street and Evans Avenue are part of the T-REX project area, which is located outside of the Valley Highway Project limits; these have flooded so many times that they are often referred to, by some, as "Lake Logan" and "Lake Evans." In fact, whenever a heavy rainstorm is expected in the Denver area, the two lakes are also expected. According to Dave Haley with CDOT maintenance, the underpass of Alameda Avenue, which is in this project corridor, is also a flooding concern and often floods when Logan and Evans do. He stated that he or other maintenance crew members are required to address flooding at Alameda approximately 12 times per year and often need to push debris away with plows to improve inlet interception and remove runoff from the under-crossing. Mr. Haley observed that flooding is generally not due to a clogged storm sewer system, but a lack of capacity for the system to accommodate large amounts of water. Historically, the clogged inlets are the main cause for flooding. He also stated that the matter is worse when a power failure occurs and the pump at Alameda, which pumps runoff into the South Platte River, cannot operate. The following is a representative list of street flooding occurrences.

July 30, 1998 – Denver streets flooded. Zodiac boats were needed for rescues at "Lake Logan" and a kayaker was rescued from the South Platte River at Santa Fe (Matrix 2003).

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' once again stopped traffic. The Harvard Gulch at Jackson Street rain gage measured the heaviest rainfall of 0.67 inches in five minutes and 2.48 inches in an hour. Additional reports of flash flooding were noted in Centennial and Englewood" (Matrix 2003).

July 23, 2001 – Denver International Airport (DIA) received 1.42 inches of rain, while areas east Denver received 0.50 to 1.50 inches of rain during a summer thunderstorm. Power was lost in places throughout the city and motorists encountered street flooding including the intersection of Alameda Avenue and Santa Fe Drive (Gutierrez 2001).

September 13, 2002 – Stormwater rose too quickly for cars to escape being flooded at the I-25/Logan Street underpass resulting in CDOT closing I-25 from Santa Fe to Hampden Avenue for over three hours between 3:30 and 6:30 p.m. A number of motorists were rescued from their vehicles, but after being submerged, most vehicles were useless. This slow moving storm dropped about 1 inch of rain throughout the corridor (Farer 2002). Storm sewer improvements as part of the Transportation Expansion Project (T-REX) construction project should vastly improve this historic drainage problem by October 2003.

April 23, 2003 – An afternoon rainstorm left a 2-foot deep, 20-foot long "Lake Evans" slowing traffic to a crawl. Flooding also occurred on I-25 at Alameda and near the Tech Center at Belleview. CDOT brought in pumps to remove the runoff (Piper 2003).

June 18, 2003 – As much as an inch of rain in less than one hour fell over the I-25 corridor jamming traffic in both directions at Evans as vehicles ploughed through muddy construction water covering the highway (Farer 2003).

July 19, 2003 – Roughly two inches of rain fell in about two hours causing flooding on I-25 and the 11-hour closure of the highway between Santa Fe and Hampden Avenue. CDOT crews used pumps to remove the 2.5-foot deep pond of water at Evans (Backus 2003).

There are some serious existing drainage concerns for I-25. As previously mentioned, the project corridor has been subject to both major and minor flooding events. T-REX is located just south of the project corridor and contains the often-flooded underpasses of Logan Street and Evans Avenue. Flooding problems in that stretch of highway should be addressed with the completion of the T-REX project. The project corridor experiences heavy flooding at the underpass of Alameda and receives offsite runoff from the City and County of Denver (CCD). This area, I-25 under Alameda, is located at a lower elevation than the South Platte River, requiring a pump for storm water discharge. The Valley Highway intercepts the historic drainage path from the east causing CCD runoff to combine with the highway runoff to make flooding locations worse. In some cases, CCD runoff combines with I-25 runoff to cause flooding from 4 inches of sheet flow in some places to as much as 16 feet of ponding in others. Overall, the highway system is slightly undersized, but the most substantial flooding occurs with the combined runoff of CCD and highway flows.

3.0 DESIGN CRITERIA

Design of the storm drainage sewer system, structures, and water quality features will be in accordance with FHWA, CDOT, AASHTO, City and County of Denver (CCD), Urban Drainage and Flood Control District (UDFCD), and FEMA criteria. Design will follow CDOT Drainage Design Manual, deferring to UDFCD Drainage Criteria Manual Volumes 1-3 where necessary. Any storm drainage system that incorporates CCD land or runoff will also comply with CCD Storm Drainage Design and Technical Criteria. Cross drainage systems will be designed for the 100-year storm while also following CCD requirements for the 2-5 year storms. The major design storm for CDOT storm drains is the 100-year storm and the minor design storm is the 5-year event. **Tables 3-1** and **3-2** contain some of the specific design criteria for this project. Because the South Platte River is in the "Tier 1, Maximum Design Criteria" category of receiving water bodies, 100% of the water quality capture volume or 80% Total Suspended Soils (TSS) removal is required for runoff from the entire CDOT right-of-way, as stated in CDOT's Municipal Separate Storm Sewer Systems (MS4) Permit as part of the "New Development and Redevelopment Program" (CDOT 2003). All design relating to the South Platte River and influencing the FEMA floodplain shall follow FEMA regulations.

Table 3-1 Allowable Roadway Encroachments

Source	Roadway Type	Storm Event	Allowable Ponding Depth	Allowable Spread Width
CDOT	Interstate	Minor	--	Shoulder
CDOT	Arterial	Minor	--	Shoulder + 4 feet
CDOT	Collector	Minor	--	1/2 Driving Lane or Shoulder + 4 feet
CDOT	Interstate	Major	6" at crown, 18" at panline	Shoulder + 4 feet
CDOT	Other Roadways	Major	Minimum depth, street closing prohibited	--
CCD	Arterial	Minor	No curb overtopping	Must leave one 10-foot lane free of water per side
CCD	Local/Collector	Minor	No curb overtopping	Must leave one 10-foot lane free of water
CCD	Arterial	Major	6" at crown, 12" at panline	--
CCD	Local/Collector	Major	12" at flowline	--
UDFCD	Freeway	Minor	--	Shoulder
UDFCD	Arterial	Minor	No curb overtopping	Two lane widths leaving at least one free per side
UDFCD	Collector	Minor	No curb overtopping	Must leave one lane free of water
UDFCD	Arterial/Freeway	Major	0" at crown, 12" at flowline	--
UDFCD	Local/Collector	Major	18" at flowline	--

Table 3-2 Allowable Culvert Ponding Depths

Source	Type	Storm Event	Allowable Headwater to Depth Ratio
CDOT	< 36" structures	Major	2
CDOT	36" to 60" structures	Major	1.7
CDOT	60" to 84" structures	Major	1.5
CDOT	84" to 120" structures	Major	1.2
CDOT	> 120" structures	Major	1
CCD	Culverts	Major	1.5

Note: Tables 3-1 and 3-2 are for reference only. Final design should be based on CDOT, UDFCD, and CCD criteria manuals, not these tables.

4.0 HYDROLOGIC AND HYDRAULIC MODELING

Several computer software tools were used for hydrologic and hydraulic modeling, each of which is an accepted method by CCD, CDOT, UDFCD, and FEMA. The Colorado Urban Hydrograph Procedure (CUHP) computer program and the Urban Drainage Storm Water Management Model (UDSWMM) programs were used to model the upstream, offsite basins in the project corridor and to calculate runoff quantities for larger tributary basins for area not previously defined in other reports. The UDFCD spreadsheet for the Rational Method was used for basins less than 90 acres, which includes all onsite basins. Basins were delineated, using aerial photo-based contour maps for onsite basins, and various related drainage studies for off-site basins. Runoff quantities were calculated to show the severity of flooding by onsite and offsite sources and to design storm sewer improvements for both onsite and offsite runoff for all of the system alternatives. Additional UDFCD spreadsheets were used for calculating allowable spread width and inlet interception ratios. The computer programs *FlowMaster* and *CulvertMaster* were also used for hydraulic modeling.

4.1 Colorado Urban Hydrograph Procedure (CUHP) Hydrologic Model

Guidance for additional input parameters was taken from Urban Drainage and Flood Control District (UDFCD) Drainage Criteria Manual Volume 1 and the CDOT Drainage Design Manual; however, rainfall amounts used in the CUHP input were obtained from the City and County of Denver Storm Drainage Design and Technical Criteria. According to CCD storm drainage design and technical criteria, the City and County of Denver is located within one rainfall zone with the following one-hour point rainfall depths (in inches).

2-year	5-year	10-year	50-year	100-year
0.95	1.34	1.55	2.25	2.57

The minimum time of concentration used for this urban setting was 5 minutes as recommended by UDFCD. A Soil Conservation Survey has not been performed for the project area so the detailed soil information is unknown. According to Ground Engineering, a hydrologic soil group B is the worst case for soil types along the South Platte River. In addition, Ground Engineering mentioned that the soil falls into group C further away from the river. More specifically, the soil probably changes groups where the topography changes rapidly, parallel to the river. Therefore, hydrologic soil group B was used for most on-site basin calculations. Group C was used when existing data and calculations from other reports used it and when it seemed reasonable due to the distance from the river and location relative to a rapid change in topography. Hydrologic soil group C is more conservative than B so if there was doubt as to which to use, group C was selected. A probable soil type boundary is shown on **Figure 5-1**, later in this report and the soil classification used, is listed in **Tables 5-1** and **7-1** as well as in Appendices A and C. The soil group was used for each of the basins as a variable to calculate infiltration and decay rates. Because the offsite basins are fully developed, with no plans for major changes nor any anticipated increase in imperviousness, no future conditions were added to the models except for the changes within the project corridor. The modeling for this EIS is preliminary and should be re-examined and adjusted for more detail with final design.

4.2 Urban Drainage Stormwater Management Model Routing

Basins leading to the major outfalls were subdivided into sub-basins reflecting tributaries to flooding locations, drainage structures, and highway sub-basins. These sub-basins were routed using Urban Drainage Storm Water Management Model (UDSWMM) to compare peak flow rates. For smaller basins, calculated flow rates were added directly to simplify analysis. Therefore, the peak flow rates in this study are preliminary and should be re-examined with final design.

4.3 Urban Drainage Storm Drainage Spreadsheets

Urban Drainage and Flood Control District (UDFCD) has design spreadsheets available on their website at http://www.udfcd.org/download.htm. These spreadsheets are based upon equations from and are discussed in their Drainage Criteria Manuals (see **Appendix A**). Variables and input methods are described in these manuals as well.

5.0 EXISTING DRAINAGE SYSTEM

Drainage basins have been delineated for the project corridor and tributary areas. There are four general areas with similar drainage patterns and outfall systems. Basin nomenclature is broken up into two parts that are described as follows. The first part, “US 6,” “CCD,” and “I-25” designates the general area tributary to the basin. The “CCD” indicates offsite runoff from the City and County of Denver. The remainder of the basin name represents the general location of the basin outfall. For example, I-25 – 3rd Avenue Basin consists of runoff from I-25 which outfalls near 3rd Avenue. **Figure 5-1** shows the offsite basins while **Figures 5-2** to **5-5** show the onsite basins according to their general area. Calculations for basin flow rates are provided in **Appendix A**. **Table 5-1** is a summary of the key data for the existing basins while **Table 5-2** summarizes flooding problems highlighted in this report.

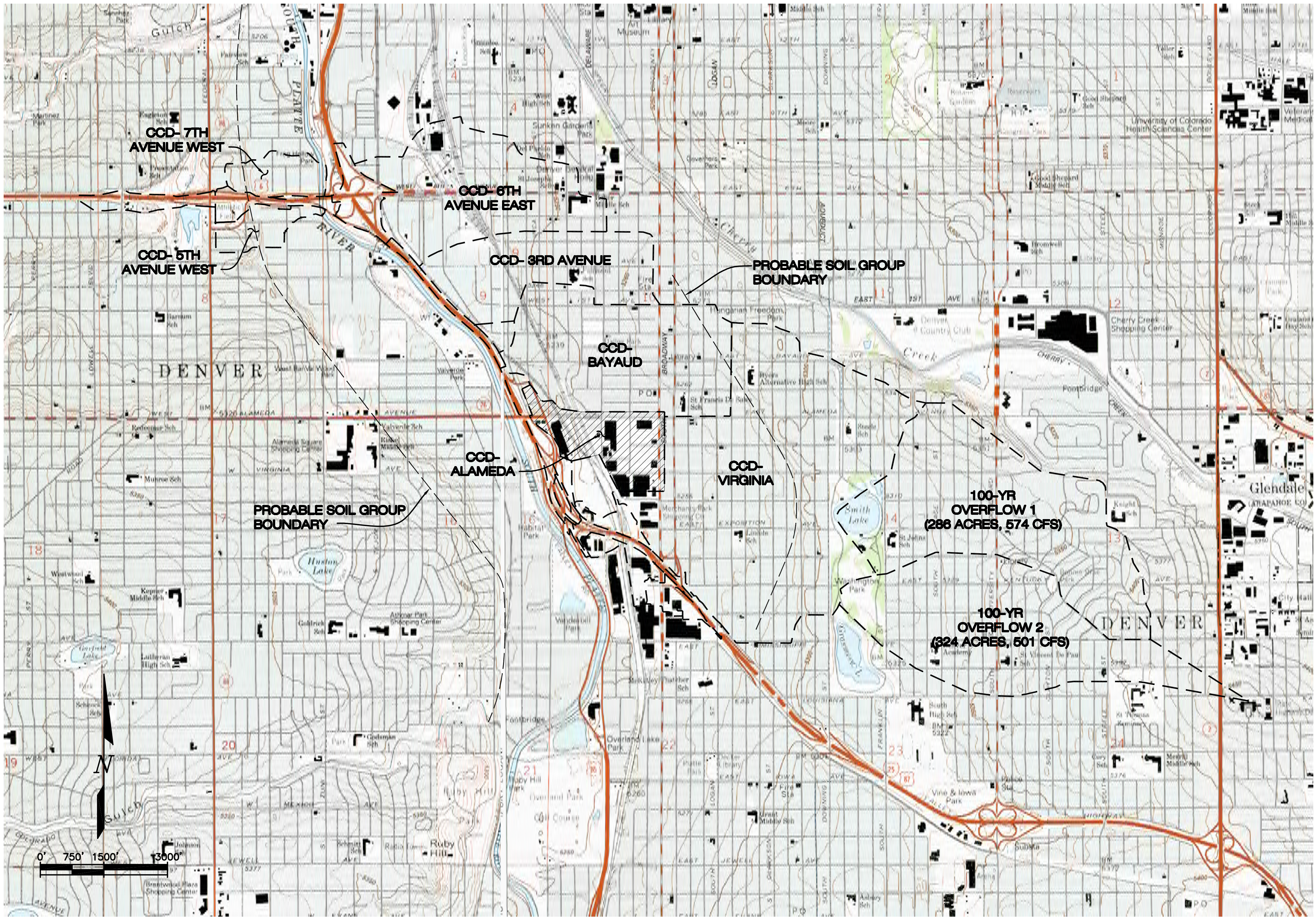
Table 5-1 Existing Basin Information

Basin Name	Soil Type	Area (acres)	Imperviousness	100-Year Flow Rate (cfs)
US 6 – West	C	26	64%	81
US 6 – East	C	17	50%	55
US 6 – South Platte River	B	7.8	90%	47
CCD – 7th Avenue West	C	47	75%	NOT CALCULATED
CCD – 5th Avenue West	C	39	75%	NOT CALCULATED
I-25 – 6th Avenue Interchange	B	36	43%	100
I-25 – 3rd Avenue	B	13	100%	59
CCD – 6th Avenue East	C	263	80%	840
CCD – 3rd Avenue	C	187	62%	570
I-25 – Alameda	B	25	94%	126
I-25 – Low Point	B	2.6	100%	18
SH 85	B	13	90%	51
CCD – Virginia	C	726 (plus 610 acres in 100-year)	48%	2560 (includes extra acres)
CCD – Alameda	C	99	80%	400
CCD – Bayaud	C	310	55%	950
CCD – Ellsworth	C	9.3	65%	70
I-25 – T-REX	B	5.4	100%	22
I-25 – Broadway	B	14	82%	56
CCD – 42” Outfall	B	49	86%	200

Note: Values not calculated were deemed not relevant to the project area.

Table 5-2 Existing Major Flooding Areas

Location	Basin(s) Contributing To Flooding	Flooding Extent On I-25	Affected Structures/Land Use
I-25 near 3rd Avenue	CCD – 3rd Avenue	5 inches of ponding	CCD roads, railroad tracks, four (+/-) building foundations
I-25 near Ellsworth	CCD – Ellsworth	4 inches of sheet flow	CCD roads, railroad tracks
I-25 near Bayaud	CCD – Bayaud	9 inches of sheet flow	CCD roads, railroad tracks, several building foundations
I-25 under Alameda	I-25 and CCD - Alameda	Up to 16 feet of ponding possible	CCD roads, railroad tracks, three (+/-) building foundations



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OFF-SITE BASINS

FIGURE 5-1

5.1 US 6 Area

Figure 5-2 shows the US 6 Area, which is subdivided into four sub-basins consisting of approximately 143 acres of roadway, grassy ROW, parks, residential, and light industrial uses. This drainage area is defined by the highpoint west of Federal Boulevard to the east edge of the South Platte River, the tributary areas, and nearby drainage. Runoff from basins west of Federal Boulevard flow from west to east and is intercepted by Weir Gulch, located west of Federal Boulevard. Runoff east of Federal Boulevard also flows to the east and is collected in storm sewer systems that convey it to the South Platte River.

This area is near two floodplains, Weir Gulch and the South Platte River. An inline detention facility, Barnum Lake, located south of US 6, releases runoff under US 6 to prohibit flooding on the highway. The floodplain is close to the EB US 6 to Federal Boulevard off-ramp and should be considered in future design of ramps in this area. The US 6 Bridge over the South Platte River causes a rise in the floodplain resulting in flooding of the area south of US 6 and west of the South Platte River, as previously mentioned (Wright 1985/FHAD 1985). The 500-year floodplain overtops most of US 6 from Federal Boulevard to the South Platte River.

US 6 – West Basin is located on US 6 from the high point west of Federal Boulevard to Federal Boulevard. The existing outfall for this basin consists of a few inlets and a storm sewer system that conveys runoff to Weir Gulch. Some runoff may be routed through Barnum Lake prior to its outfall to Weir Gulch. This basin has an existing area of approximately 26 acres and is 64 percent impervious. Some offsite areas consisting of residential and industrial land uses are part of this basin. Under existing conditions, the area produces approximately 81 cfs of runoff in the 100-year storm event.

US 6 – East Basin is located east of the US 6 – West Basin, from Federal Boulevard to the high point near the Bryant Street overcrossing. It is comprised of 17 acres of highway, parks, and residential land uses for a combined imperviousness of 50 percent. The 55 cfs of runoff (Q_{100}) from this basin is combined with that for the CCD – 5th Avenue West Basin and flows to the South Platte River.

US 6 – South Platte River Basin is comprised of 7.8 acres of US highway and infields and is 90 percent impervious. The basin is located on US 6 from the high point near Bryant to a point near the east side of the South Platte River. The natural low point of this basin is along the bank of the South Platte River, near the bridge. There are a few inlets near the west bank of the South Platte River that convey a portion of the basin's 47 cfs (Q_{100}) in a storm sewer system and outfall to the river. A small portion of runoff from the eastbound lanes will flow to the storm sewer system for CCD – 5th Avenue West Basin. The remaining portions of runoff from this basin are conveyed to the east bank of the South Platte River by storm sewers and culverts in the I-25 corridor.

CCD – 5th Avenue West Basin is located south of US 6 from Federal Boulevard to the South Platte River. It consists of 39 acres of parks, residential, and light industrial areas. A storm sewer system parallels US 6 from Federal Boulevard and Decatur Street where it then follows the alignment of the off-ramp, crosses Bryant Street and continues to the river. This storm sewer system serves both this basin and the US 6 – East Basin and outfalls into the South Platte River near the US 6 Bridge. A small portion of the US 6 – South Platte River Basin also contributes to this outfall.

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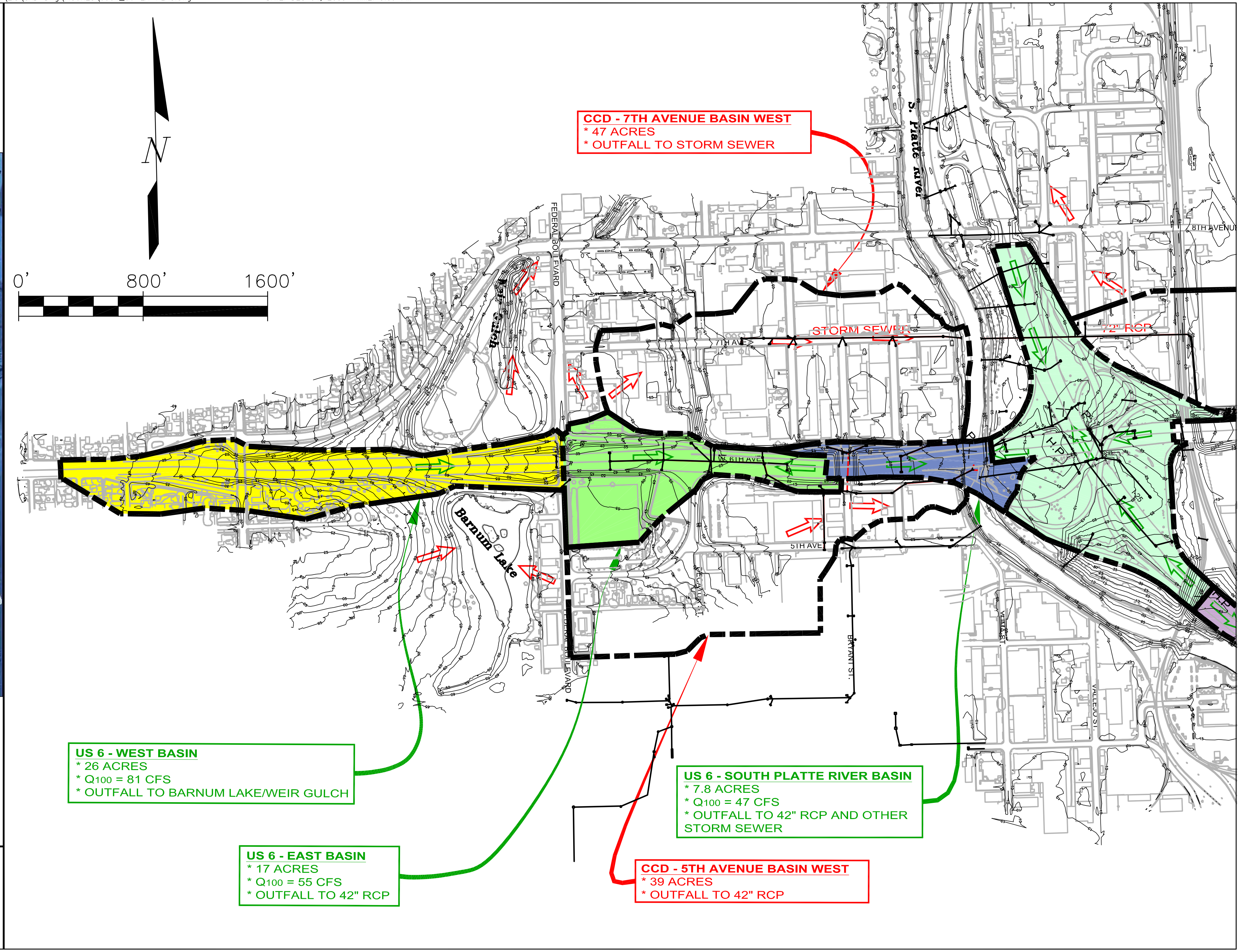

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FIGURE
5-2

The last basin in this area is the CCD – 7th Avenue West Basin, which is located north of US 6 from approximately 250 feet east of Federal Boulevard to the South Platte River. This 47-acre basin consists of mostly residential and light industrial uses. Runoff from this basin is conveyed through a storm sewer system located along 7th Avenue that outfalls in the South Platte River.

5.2 I-25 – 6th Avenue Interchange Area

The I-25 – 6th Avenue Interchange Area consists of runoff from the I-25 and 6th Avenue Interchange, I-25 – 3rd Avenue Basin, and some CCD runoff east of I-25. This area is depicted in **Figure 5-3**, and described below as shown from right to left on the figure. There are no reports of existing flooding problems on I-25. The 500-year floodplain encompasses all of the interchange infields and I-25 under US 6. It also includes large portions of the CCD – 6th Avenue East Basin between I-25 and Quivas Street and the railroad tracks. The 100-year floodplain covers a small portion of the EB US 6 to SB I-25 on-ramp.

CCD – 3rd Avenue Basin consists of basins 8 and 10 from the *Draft Floodplain and Drainage Assessment* written by Muller Engineering Company in January 2000 (Muller 2000). According to that report, the 570 cfs runoff from the 187-acre basins 8 and 10 exceeds the capacity of the existing 60” RCP, which can only convey approximately 180 cfs to the South Platte River. Forty-five cubic feet of runoff per second from the CCD – Ellsworth Basin, to the south, flows along the railroad tracks and as the slopes and cross sections change along its path, runoff flows over the tracks to I-25 leaving approximately 10 cfs to flow to the ponding area of the CCD – 3rd Avenue Basin located between 3rd Avenue and I-25. Further study of this area, shows that approximately 140 cfs flows from the basin onto the highway and the remaining 260 cfs flows north to the CCD – 6th Avenue East Basin. The 140 cfs that flows onto the interstate yields approximately 5 inches of ponding at the low point on I-25. See **Appendix A** for existing hydraulic calculations.

I-25 – 3rd Avenue Basin consists of 13 acres of interstate with an imperviousness of 100 percent. Runoff from this basin, Q_{100} = 59 cfs, is collected in several inlets along the roadway and in a sump on the interstate near 3rd Avenue where it is conveyed to the South Platte River. The flooding of the CCD basins to the east and south (with outfalls at Bayaud Avenue, Ellsworth Avenue, and 3rd Avenue) add to the runoff from I-25 in this basin to increase flooding at the sump of I-25 near 3rd Avenue (Muller 2000).

CCD – 6th Avenue East Basin is located north of the CCD – 3rd Avenue Basin and east of the I-25 – 6th Avenue Interchange Basin. It extends north to include 8th Avenue and east to Delaware Street. This basin consists of 263 acres of residential and industrial areas and has a 100-year flow rate of 840 cfs and approximately 300 cfs can be conveyed in the existing 72” RCP to the South Platte River. The excess basin runoff combines with the 260 cfs from the CCD – 3rd Avenue Basin and floods the area. Due to the elevation of the railroad tracks impeding flow, some flooding occurs between I-25 and the tracks, south of US 6, and some occurs north of US 6, near 7th Avenue. The grading for the US 6 ramps east of I-25 impedes runoff from flowing from the south of US 6, between I-25 and the tracks north to 7th Avenue. This offsite basin does not appear to cause any flooding to US 6 or I-25.

I-25 – 6th Avenue Interchange Basin consists of 36 acres of I-25 and infields with an estimated imperviousness of 43 percent. Runoff from this basin, Q_{100} = 100 cfs, is collected in several inlets and conveyed by different storm sewer systems to the South Platte River. There are no reported flooding issues in this area.

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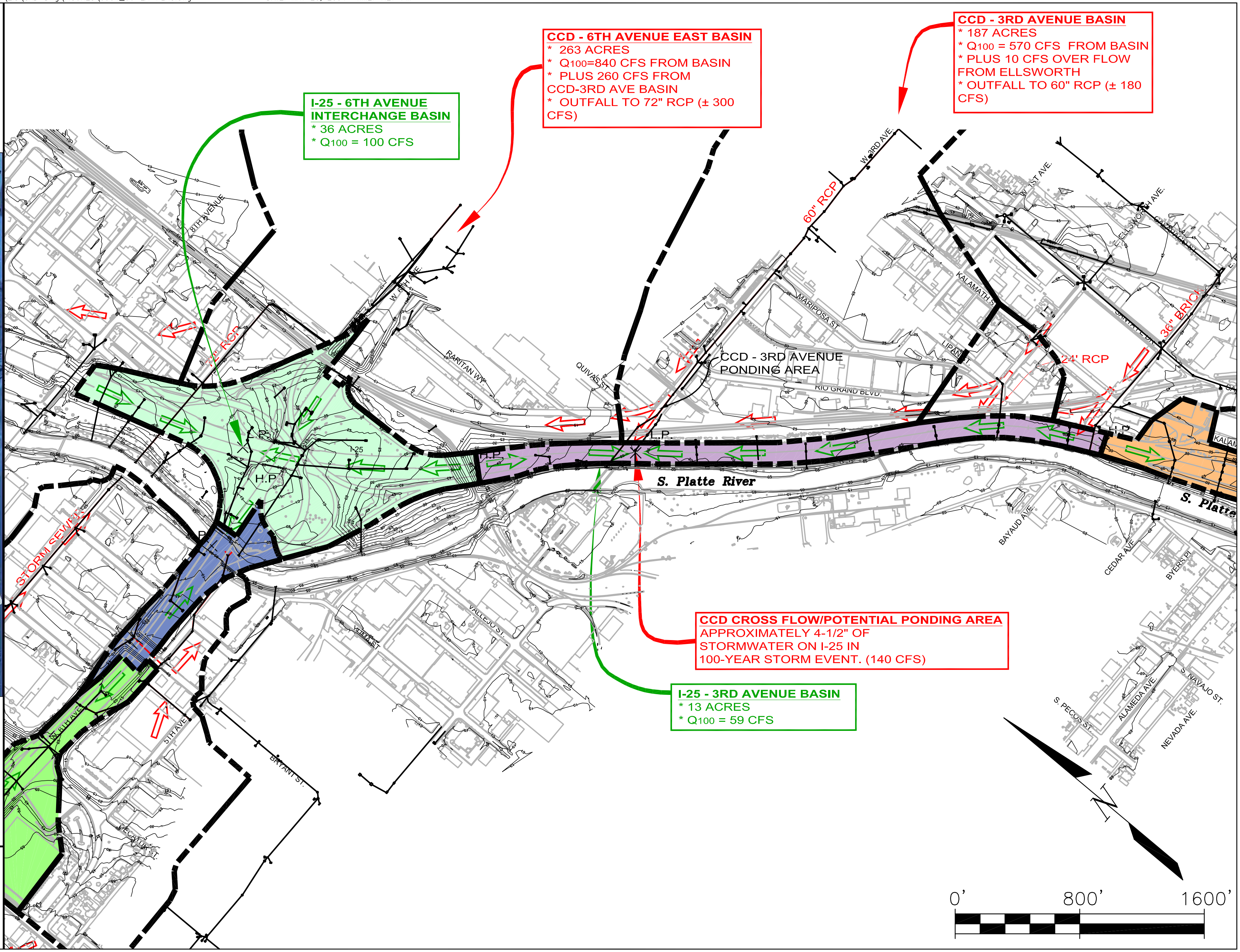

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FIGURE
5-3

5.3 Alameda Area

This outfall area consists of several basins, most of which are offsite and produce severe flooding on the interstate. The onsite areas consist of some runoff from SH 85 (Santa Fe/Kalamath) and a basin on I-25. The I-25 Alameda Area is shown on **Figure 5-4**. The "Master Drainageway Planning: South Platte River" by Wright Water Engineers, dated November 1985 recommends two planned improvements to the area between I-25 and the South Platte River. The first is to lay back the existing riverbank at a 3H:1V slope and the second is to construct a trail atop the east bank, parallel to the river. Currently, there are no plans to implement this portion of the master plan, however, CCD and Urban Drainage should be consulted at final design to verify this. This outfall area has portions of land inside the 500-year floodplain for the South Platte River, but no area is within the 100-year floodplain. The 100-year floodplain is, however, very close to I-25 and may be impacted by future construction. The Alameda Avenue and SH 85 bridges cross the river, but there is no evidence of them influencing the floodplain elevations in the area.

5.3.1 City and County of Denver (CCD) Basins

CCD – Virginia Basin consists of basins 1, 2, 3, 4, and 7 from the Muller 2000 report. Additionally, in the 100-year storm event, runoff from CCD – Overflow Basins 1 and 2 add approximately 1,075 cfs to the runoff from CCD – Virginia Basin. Runoff from all of these basins collect at the intersection of Broadway and Virginia where flooding of the intersection occurs several times per year (Muller 2000). After exceeding the existing 66" brick storm sewer capacity of 212 cfs, the remaining runoff, Q_{100} = 1,777 cfs, enters the CCD – Alameda Basin as it flows through the Broadway Marketplace to the intersection of Santa Fe and Alameda Avenue. Then it combines with additional runoff from basin 11 of the Muller 2000 study for a peak flow of 2,087 cfs in the 100-year storm. Runoff floods the intersection and commercial parking lots several times per year, according to local business owners (Muller 2000). Currently, the runoff flows from Santa Fe and Alameda Avenue, across Kalamath Street to a small grassy basin, the Kalamath Ponding Area, where it ponds and flows to I-25 and SH 85. Approximately 1,136 cfs flows to the sump on I-25 and 264 cfs flows to SH 85 in the 100-year storm. The remaining runoff collects in curb and gutter and the localized ponding areas until it is conveyed by storm sewers to the South Platte River. The City and County of Denver is aware of the flooding problems at these locations and has addressed them in the Denver Storm Drainage Master Plan Phase I Final (Matrix 2003); however, there is no set schedule for plan implementation. CCD is planning to improve the storm sewer system at Alameda and Santa Fe to reduce the flooding at this intersection through a project to be completed in 2004. However, that project will only address the 5-year runoff. CCD – Virginia Basin also includes basin 13 of the Muller 2000 report. Runoff off from this portion of the basin also flows to the 66" storm sewer; however, in the 100-year storm event, over flow from this area, approximately 200 cfs, will flow to the SH 85 Ponding Area as described below. This flow rate has already been subtracted from the total basin flow rates described above.

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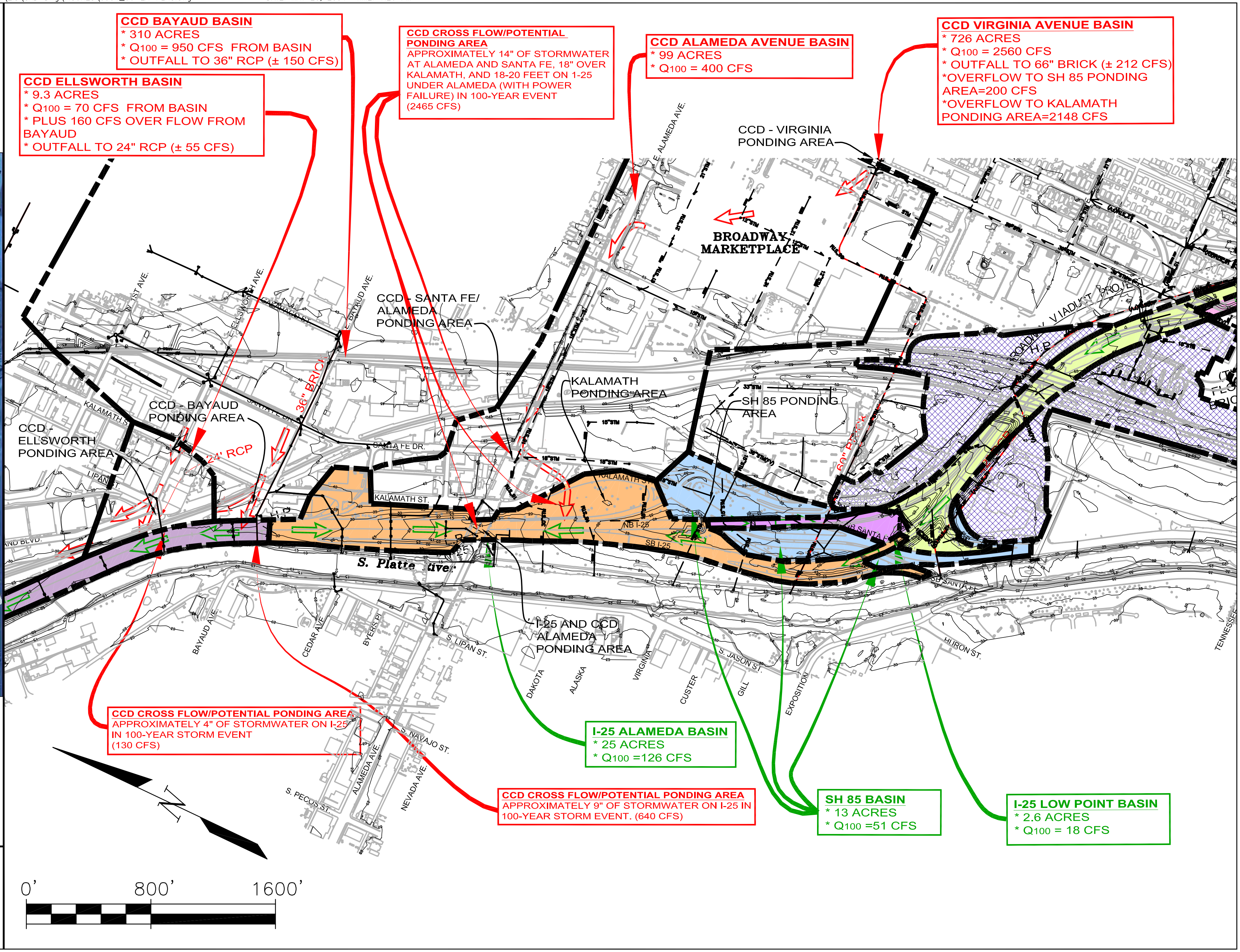

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FIGURE
5-4

CCD – Bayaud Basin is comprised of basins 5, 6, and 9 from the Muller 2000 report. According to the report, the 100-year flow rate from this 310-acre basin is 950 cfs, but the existing capacity of the 36" brick storm sewer is only 150 cfs. The remaining 800 cfs flows towards the interstate with approximately 160 cfs flowing north towards the CCD – Ellsworth Basin at the first set of railroad tracks. This leaves 640 cfs to flow onto I-25 resulting in approximately 9" of sheet flow across the interstate in the 100-year storm. Appendix A contains weir calculations for existing basins.

CCD – Ellsworth Basin is basin 12 from the Muller 2000 report. It consists of 9.3 acres and results in 70 cfs of runoff in the 100-year storm (Muller 2000). The existing 24" RCP has the capacity of approximately 55 cfs, leaving 15 cfs excess runoff to combine with the 160 cfs from the CCD – Bayaud Avenue Basin. This 175 cfs flows towards the interstate and ponds at the railroad tracks where approximately 130 cfs flows over I-25 resulting in 4" of sheet flow and the remaining 45 cfs flows north to the CCD - 3rd Avenue Basin.

5.3.2 SH 85 and I-25 Basins

SH 85 Basin consists of 13 acres of land along SH 85 as it crosses under I-25. It is comprised of state highway, ramps and related infields and has an imperviousness of approximately 90%. Runoff from this basin, Q_{100} = 51 cfs, is conveyed through various storm sewers to the South Platte River and excess runoff ponds at the SH 85 Ponding Area as shown on **Figure 5-4**. As previously mentioned, approximately 200 cfs from the CCD – Virginia Basin and 264 cfs overflow from the Kalamath Ponding Area collects in the SH 85 Ponding Area along with excess runoff from the CCD – 42" Outfall Basin which is approximately 100 cfs in the 100-year storm event. As the SH 85 Ponding Area fills to a depth of 1.0 foot, runoff will flow across SH 85 and to the South Platte River, however, based on flow rates, this seems unlikely because the amount of flow required for this to occur dramatically exceeds the 100-year flow from the tributary basin. See **Appendix A** for weir calculations for this area.

I-25 – Low Point Basin consists of 2.6 acres of interstate located on the NB lanes of I-25 between the I-25 - Broadway Basin and the I-25 - Alameda Basin. Currently, runoff from this basin, Q_{100} = 18 cfs, is conveyed to the South Platte River through a storm sewer under I-25. Runoff from this area in excess of the existing storm sewer capacity flows to the SH 85 Ponding Area.

I-25 – Alameda Basin, consists of approximately 25 acres of interstate and ROW grading with an imperviousness of 90 percent. Approximately 126 cfs flows through this basin in the 100-year storm and collects on I-25, under Alameda Avenue. The runoff from the CCD – Alameda Avenue Basin (including the CCD – Virginia Basin) combines with this runoff in the I-25 sump under Alameda Avenue where it is pumped to the South Platte River at the Alameda Pump Station. The approximate elevation of I-25 under Alameda is 5208 while the base flow elevation of the South Platte River is approximately 5214. The difference in elevations requires the pump station and entails a difficult existing storm and groundwater drainage system.

A set of construction drawings, dated February 1957, shows the plans for a cofferdam and underdrain system that were installed around the sump on I-25. The plan set does not appear to mention the construction of a pump station. Another set of construction drawings, dated November 1969, shows the plans for the Alameda Pump Station, however the plan set shows adjustments to the existing pump station, not the construction of a new one. In this set of plans, the pump station consisted of three pumps with 15 horsepower vertical shaft motors and 8" discharge pipe(s). The plans called to have the pumps moved 9'-5" higher. A third set of available plans is dated September 1974. These plans show 1-6" and 2-12" submersible pumps and discharge pipes. The pumps are set approximately 17 feet below the existing I-25 sump. The pump station vault is 12' x 12' at its base and approximately 30' in height. When water ponds approximately 8 feet, the 6" pump starts and it stops at a 2-foot depth. The 6" pump is set to turn on first with the 12" pumps following as needed. Each pump has its own cast iron outlet pipe and all three outlet pipes discharge to a concrete vault which outlets through a 24" concrete pipe to a concrete rundown and to the South Platte River. This is the existing configuration according to Arvada Pump Company, who has been contracted for the maintenance of this pump station for approximately ten years.

The pumps capacity is based on the total dynamic head for the system and the pump curves of each pump. By using elevations provided by the available pump station plans, survey data, and field visits, this capacity can be approximated. The 6" pump has an approximate range of operating capacity of 2.2 to 2.6 cfs while the 12" pumps have a range of 9.4 to 12.3 cfs at maximum allowable spread width on the interstate. Therefore, the operating range of the pump station is 21.0 to 27.2 cfs. Should the pump be dysfunctional, the configuration of I-25 and Alameda allow runoff to pond up to 16 feet before it flows into gravity inlets or over the bank of the river. According to CDOT maintenance crews, power failures have resulted in severe flooding in the past, but even with the pump running, the I-25 sump under Alameda floods a dozen or so times per year.

5.4 I-25 – Broadway Area

The area described by the I-25 Broadway area consists of the remaining project corridor from the SH 85 Basin southern boundary to the I-25 underpass of Logan Street. This area is shown on **Figure 5-5**. Part of this area is the Broadway Viaduct project area. The Broadway Viaduct Project consists of removing, replacing, and realigning the existing viaduct over Broadway Boulevard, the railroad, and light rail tracks and includes re-construction of various on- and off-ramps. The project also includes the addition of light rail tracks. Construction of the SB I-25 viaduct is nearly complete and the remainder of the project will be completed as funding allows. The drainage design for this project is considered part of the existing conditions since it will be constructed prior to final design and construction of the Valley Highway Project. No part of this area is in the 100 or 500 year floodplain.

I-25 - T-REX Basin extends along I-25 from the southern Broadway Viaduct abutment, south to the underpass of Logan Street. It also includes the area on the SB I-25 lanes from the Broadway Viaduct highpoint to the south and inlet bypass flow for the NB I-25 lanes for the same area. In all, the basin consists of 5.4 acres of interstate area and produces approximately 22 cfs of runoff in the 100 year storm. CDOT has recently constructed the "T-REX Outfall," or "Mississippi Outfall" a large concrete box culvert that follows the alignment of Mississippi Avenue and outlets to the South Platte River as part of the Transportation Expansion Project (T-REX). This outlet conveys runoff from CCD and I-25 and should alleviate flooding problems in the area. Runoff from the I-25 – T-REX Basin is collected by inlets on I-25 and conveyed to the river by this T-REX/Mississippi Outfall.

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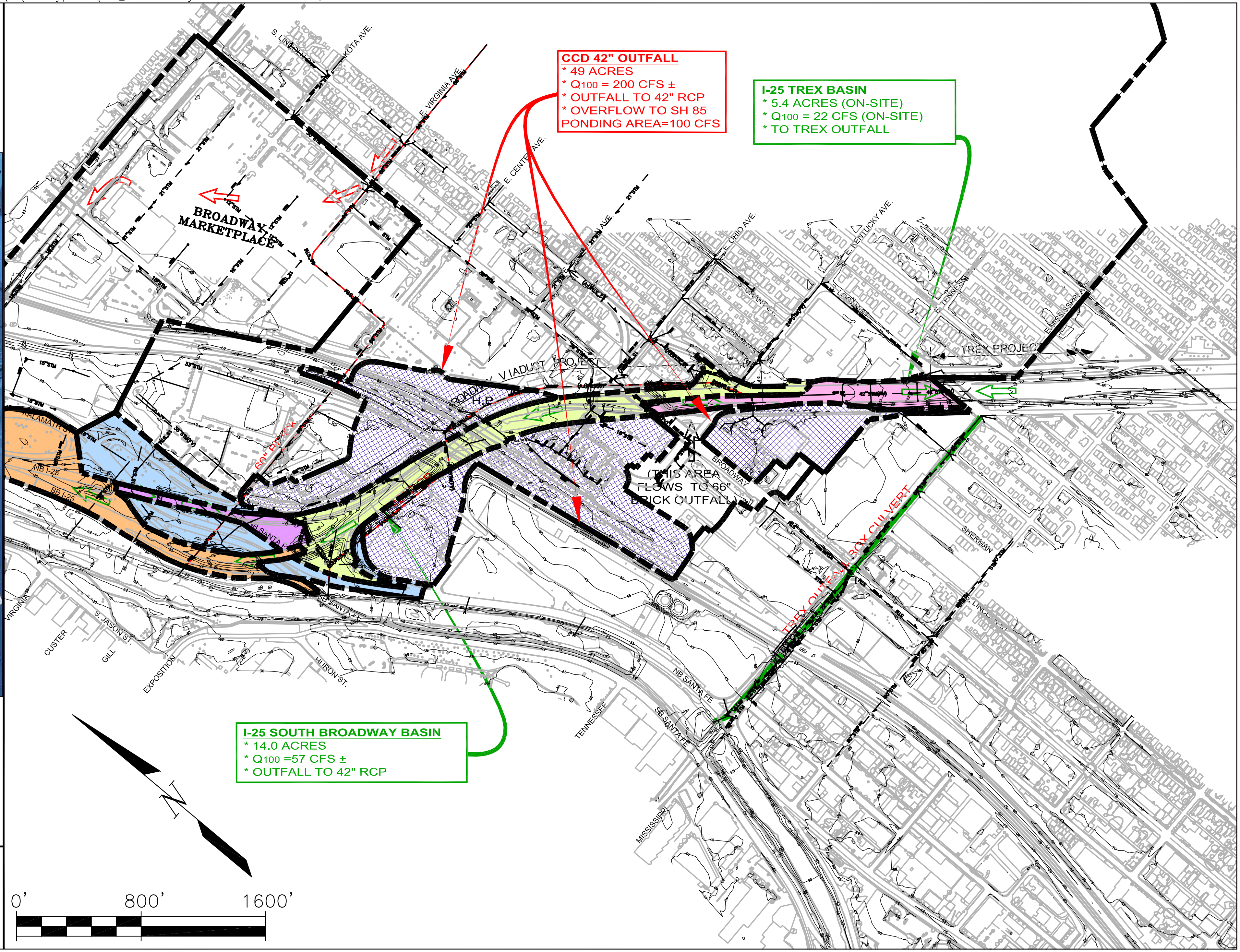

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FIGURE
5-5

I-25 – Broadway Basin consists of 14.0 acres of interstate, ROW grading, and the Broadway Viaduct. The CCD – 42" Outfall Basin consists of 49 acres of industrial areas under and near the Broadway Viaduct and includes the Broadway Light Rail station. Runoff from both of these basins flow to several storm sewers that join together in a manhole located in the infield between NB SH 85 to SB I-25 on-ramp, SH 85, and I-25. From this manhole, a 42" pipe conveys the flow to the South Platte River. The 42" RCP has an approximate capacity of 150 cfs. The runoff on the viaduct is collected by bridge drains that drop the runoff in pipes inside the viaduct piers and conveys them to type C inlets. From there, the runoff is conveyed to the 42" storm sewer outfall. Due to the elevation of the Broadway Viaduct and inlets, the resulting flooding from storms greater than the 42" capacity will be on CCD property where it will sheet flow to the South Platte River. Most of the excess runoff from the CCD – 42" Outfall Basin will flow to the SH 85 Ponding Area as previously described.

6.0 BEST MANAGEMENT PRACTICES

Best Management Practices (BMPs) are methods to improve and/or maintain existing water quality by treating stormwater to the maximum extent practical. Three main types of BMPs are structural, nonstructural, and construction. Structural BMPs remain in place and require routine maintenance to ensure their functionality. Grass buffers, water quality/sedimentation ponds, riprap outlet protection and wetland channels are examples of structural BMPs. Nonstructural BMPs are intended to reduce or eliminate the pollutants that impact stormwater runoff (UDFCD 2002). Examples of these are street sweeping and spill containment. Examples of construction BMPs would be silt fences, straw bale barriers, and temporary check dams. Construction BMPs are used to reduce erosion of disturbed soil and often remain in place until vegetation is established. Specific Structural BMPs that apply to this project will be discussed in this section.

The MS4 permit for CDOT requires that Best Management Practices (BMPs) be addressed for the on-site drainage area. The goal of this requirement is to improve and protect water quality conditions in the receiving water body. Currently, there are minimal structural BMPs, such as riprap outlet protection, being used within the project corridor for highway runoff. Two nonstructural BMPs, street sweeping and using a deicing agent instead of using sand or salt for snow and ice treatment are being used on I-25 and US 6. Upon the completion of this project, the quality of stormwater runoff from the project area and discharging into the South Platte River should be improved over the existing conditions. The “New Development and Redevelopment Program” states that 100 percent water quality capture volume (WQCV) must be provided for the project area or 80 percent Total Suspended Solids (TSS) Removal (CDOT 2003). Many different BMPs are approved for use in CDOT projects that can meet these requirements.

The majority of sediment and debris that is washed up with stormwater runoff comes from the first portion of any storm, the first flush. Consequently, structural BMPs are designed to remove the sediment and debris from the first flush and not from all runoff. The first flush is often described as less than the 2 year storm event. Therefore, in some cases, this project will use a small storm sewer pipe to route flow to the BMPs leaving excess runoff to flow directly to the river.

Although any BMP that fits the situation could be used for this project, this report recommends several different types including an Extended Detention Pond with Micropool, an Extended Detention with Shallow Wetland, and a Dry Swale. Copies of the fact sheets, which illustrate the conceptual design, from the “New Development and Redevelopment Program” are included in Appendix B. An Extended Detention Pond with Micropool consists of two stages, an upper, pre-sedimentation forebay and a lower, micropool. The upper stage should consist of a solid driving surface and serves to remove much of the larger sediment and debris in the stormwater runoff. The lower stage is the main collection place for smaller sediment by providing a pool for sediment to settle while allowing runoff to filter through an orifice plate before flowing to the river. In larger storms, an outlet structure will permit large volumes of runoff to flow to the river untreated, while the smaller storms will be held for approximately 40 hours to allow time for sediment settling. The pond also consists of a trickle channel to convey small flows from the upper to lower stages of the pond. The Extended Detention Shallow Wetland is similar to the Extended Detention Pond in that they both have two stages and a similar outlet configuration.

The difference is that instead of a trickle channel, runoff filters through a shallow constructed wetland between the upper and lower stages. Wetlands can provide added water quality enhancement through the biological uptake of pollutants. Dry Swales are open-channels, lined with grass or vegetation and filter pollutants as runoff moves through the swale. If constructed and designed properly, it can function as a stand-alone BMP but is also beneficial in series with other BMPs. All BMPs will require maintenance on a regular basis and should have adequate maintenance access. CDOT maintenance will review all final designs for BMPs to ensure the access and maintainability of such designs. In addition, all BMPs should be designed to be aesthetically pleasing for trail users, home and business owners, and vehicle occupants.

A secondary benefit of using detention pond-type BMPs is that they can aid in the collection of contaminations from spills on I-25 and US 6. While this aid is not automatic, CDOT could have maintenance crews block the pond outlets until they could remove the contaminated material, preventing spills from flowing to the river. In fact, gates could be installed onto the outlet structures to enable their blockage when spills occur. Even if contaminants filter into the ground in the ponds, it is easier to remove contaminated soil than to treat contaminated water. Shortly after or during a storm event, the ponds would contain water, which would reduce the ability to collect spills and prevent flow to the river.

There are six major outfall locations with BMPs in the project corridor that provide 100 percent of the WQCV for 94 percent of the on-site, I-25 and US 6 related, acreage and an additional 35-54 acres of off-site runoff. The Decatur, 6th Avenue Interchange, Santa Fe/Kalamath, SH 85, and Broadway Water Quality Ponds are Extended Detention Ponds. The Alameda Water Quality Pond is an Extended Detention Shallow Wetland. Dry Swales are used in combination with other BMPs near the 6th Avenue Interchange and as a stand-alone BMP north of the I-25/Alameda interchange. These ponds are discussed in detail in the next section of the report. Additional offsite area, approximately 55 acres, can be routed through CCD BMPs with the redevelopment of land near the system alternatives, not as part of this project.

Six percent of the on-site area is located in such a way that implementing a structural BMP is extremely difficult or would require subsurface structures. Subsurface structures are difficult to maintain and their use is highly discouraged by maintenance personnel. With at-grade structures, the ability to determine if facilities are operating properly or identify maintenance needs can be completed by simple surface visual observations. Subsurface structures, however, are not as easy to visually inspect to confirm proper operation and determine maintenance needs. They require confined space entry procedures, which increases maintenance costs and time. They are also easily overlooked because there are no negative visual impacts if not properly maintained. If subsurface structures are not maintained frequently, there is potential for the system to go septic of fail in their efficiencies.

The US 6 – South Platte River Basin is located along US 6 and touches the banks of the South Platte River. The basin low point is located on the bridge over the river and runoff that is collected is currently conveyed directly into the river. Approximately 3.2 acres of the basin would be routed to the 6th Avenue Interchange Water Quality Pond. The steep banks of the river, location of wetlands, and high floodplain limit access to the area and the ability to use a structural BMP. There is insufficient room for a water quality pond nor the right conditions for other at-grade BMPs. It may be possible to use a subsurface BMP in this location, but as previously mentioned, there are several negative consequences from their use.

Due to negative aspects regarding long-term maintenance, CDOT is against the use of subsurface BMPs. Additionally, in the instance of the US 6 – South Platte River Basin, any structure in this area would be a floodway encroachment and would likely impact wetlands as well. Therefore, with the small drainage basin and the negative impacts that would stem from a subsurface BMP located in this area, it is recommended that runoff continue to drain directly into the river. Wherever possible, grassed medians and buffers along the roadways will be installed to increase pervious area and assist in water quality enhancement. However, with the confined location of the highway, this will only be possible in limited areas.

Runoff from the I-25 – T-REX Basin flows to the T-REX concrete Box Culvert located in Mississippi. The T-REX Basin is within this project area, but actually drains into the T-REX system. Since the basin is considered as part of the drainage system for T-REX, and due to the close proximity of residences in this area, this project will not incorporate additional structural water quality BMPs into this area. However, the basin will have nonstructural BMPs such as street sweeping and using deicing agents.

The New Development and Redevelopment Program requires that CDOT evaluate the need to develop special requirements for projects that have the potential to discharge stormwater into identified sensitive waters. This special requirement dictates that additional stormwater BMPs must be identified and implemented beyond the 100% WQCV design criteria to improve or protect existing water quality conditions. This program was initiated by CDOT in May 2004. The additional BMPs that will be considered for this requirement on this project are as follows (CDOT), 2004c):

- Work with City and County of Denver to provide public signs requesting the public to pick up fecal material from their dogs. Dispensers for plastic bags to collect this material could also be provided. The South Platte River currently is not meeting water quality standards due to fecal coliform, and pets could be one of many sources.
- The use of deicing chemicals (magnesium chloride and other products) reduces the amount of traction sand that has been used historically. Deicing chemicals eliminate the need to add a sediment/salt mixture on to the road to improve safety conditions for the driving public. This maintenance activity reduces the amount of sediment that would enter the drainage system and ultimately enter the South Platte River. Standard operating guidance has been established for the efficient application and management of the deicing chemicals.
- Sweeping of I-25 would help reduce the amount of sediment and debris that would enter the South Platte River. This action is currently being performed in the area as part of Air Quality Regulation No. 16.
- Post-construction monitoring programs could ensure that the BMPs are operating as designed and being maintained in a timely fashion. Indicator parameters can be used to determine the post-construction effectiveness of the BMP.
- CDOT and City and County of Denver could work together to improve the South Plate River in the project are and in Denver Metropolitan Area. Possible improvements could include public education, landscape enhancements, improved riparian vegetation, and water quality monitoring programs.

A key component in the success of the CDOT Stormwater Program is maintenance. Trained CDOT Maintenance personnel will be performing several important inspection functions concerning proper BMP operation, outfall discharges and erosion protection, detention pond sediment removal. In accordance to CDPHE Regulation No. 61, sufficient equipment, financial support and manpower must be provided to the CDOT Maintenance Department to properly manage stormwater in the project area (CDPHE, 2004).

Following construction, much of the post-construction acreage will be routed through BMPs. **Table 6-1** compares the pre- and post- construction acreage where runoff flows untreated into the South Platte River. The post-construction on-site area consists of 173 acres. Of this, 162 acres, or 94%, will be routed through a BMP to enhance water quality. In addition, 30 off-site acres will be routed through the SH 85 and Broadway Water Quality Ponds and 5-24 acres will be routed through the Santa Fe/Kalamath Water Quality Pond, depending on the system alternative. These 35-54 off-site acres which equates to 20%-31% of the on-site project area, overcompensates for the 6% of on-site acres that is not routed through BMPs. **Table 6-2** summarizes the structural BMP requirements and how they will be met with this project. Two percentages are shown, “As Shown” and “At Pond Embankment.” The “As Shown” percentage represents the pond capacity to meet the project WQCV requirements. The “At Pond Embankment” percentage represents reserve capacity available should the pond be upsized. For example, the WQCV required for the US 6 Interchange area is 1.67 acre-feet. The volume of the pond shown on figures in the next section of this report would be 1.67 acre-feet (100% WQCV), but if the design were modified, it could probably have a volume of 4.2 acre-feet (251% WQCV). The increased volume of a pond could provide room for larger storms to be treated, instead of the normal two-year design storm and help to overcompensate for any on-site areas that are not routed through BMPs. In addition, the non-structural BMPs that are currently being used, such as street sweeping and deicing agents, will continue to be used over US 6 and I-25 in the project area.

With the redevelopment in the Alameda/Bayaud area, an additional 55 acres or so, will be routed through a BMP as well. As CCD develops the properties, they can implement these water quality features, as their standards require. A maintenance agreement between CCD and CDOT may be required for the BMPs with combined runoff, in this area and others. The maintenance agreements are needed to define maintenance obligations, access methods, and financial commitments for the long-term operations and maintenance of the combined systems.

Table 6-1 Pre- and Post-Construction Acreage without BMPs

Acreage Type to River without BMPs	Acres
Pre-Construction On-Site (US 6, I-25, SH 85)	160
Post-Construction On-Site (US 6, I-25, SH 85)	11.0

Table 6-2 BMP Summary

Contributing Basin and Area	Contributing Area (acres)	Required WQCV (acre-feet)	Structural BMP Type	Provided Size	% WQCV Provided	
					as shown	at pond embankment
US 6 - Decatur	43	1.08	EDB	1.08 acre-feet	100%	
US 6 - South Platte River (excluding sub-basin tributary to I-25 – 6th Avenue Interchange)	4.6	0.20	None	NA	0%	
I-25 - 6th Avenue Interchange, I-25 - 3rd Avenue, US 6 – South Platte River Sub-basin	57	1.67	EDB	1.67 as shown, up to 4.2 acre-feet at pond embankment	100%	251%
CCD – K-S, SF-S, SB-4, SB-14 (alternative dependent)	5-24 (off-site)	0.07-0.78 (CCD)	EDB	0.07-0.78 acre-feet	100%	
I-25 - Alameda SB 31	5.3	0.15	DS	230 LF of swale (if designed to UD criteria, it meets 100% WQCV)	Assume 100%	
I-25 - Alameda SB 22, SB 23	20	0.52	SW	0.98 as shown, up to 5.2 acre-feet at pond embankment*	188%	1000%
SH-85, I-25 Broadway SB 31	17	0.69	EDB	0.71 as shown, up to 2.3 acre-feet at pond embankment	103%	333%
I-25 - Broadway SB 32, SB 33, CCD - 42" Outfall	50 (including 30 off-site acres)	2.15 (including1.74 for CCD)	EDB	2.3 as shown, up to 5.1 acre-feet at pond embankment	107%	237%
I-25 - TREX	6.3	0.32	None	NA	0%	
Totals:	173 plus 35-54 off-site for CCD	5.08 plus 1.81-2.52 for CCD		6.96-7.67 as shown, up to 18.8 at pond embankments	101% (weighted percentages)	247-262%

* If this BMP were to provide volumes with depth greater than 2-3 feet, an EDB would be used instead of an SW.

BMP: Best Management Practice

DS: Dry Swale

EDB: Extended Detention Basin

SW: Shallow Wetland Basin

UD: Urban Drainage (and Flood Control District)

WQCV: Water Quality Capture Volume

7.0 DESIGN ALTERNATIVES

There are three system alternatives for the Valley Highway Project, which represent a reasonable range of alternatives. Some portions of these alternatives require the same drainage improvements for each alternative while other portions vary greatly and require completely different improvements. Although some localized drainage pattern changes from existing to proposed will occur, the overall historic drainage patterns remain the same. The drainage improvements required to meet the previously described CDOT criteria are presented below. **Table 7-1** contains a summary of future on-site basin flow rates and required water quality capture volume (WQCV). Additional basin flow information for off-site and on-site basins and sub basins is contained in Appendix C. **Table 7-2** contains a summary, by basin and system alternative, of the storm drainage improvements required to meet the CDOT and other criteria. For this project, pipe and outlet sizes have been classified into three groups small, medium, and large where small consists of pipes less than 36 inches in diameter, medium consists of pipes equal to 36 inches and up to and including 48 inches in diameter, and large consists of pipes greater than 48 inches in diameter. Regardless of which alternative is selected, final design for the project area should consult the *Storm Drainage Master Plan Phase I Final*, (Matrix 2003) for planned storm sewer improvements.

Table 7-1 Future Basin Information Summary

Basin Name	Area (Acres)	Imperviousness	2-Year Flow Rate (cfs)	5-Year Flow Rate (cfs)	100-Year Flow Rate (cfs)	WQCV (Acre-Feet)
US 6 – Decatur	43	64%	Not Calculated	Not Calculated	127	1.08
US 6 – South Platte River	7.8	43%	Not Calculated	Not Calculated	50	0.33
I-25 – 6th Avenue Interchange	37	43%	19	33	103	0.69
I –25 – 3rd Avenue	17	100%	24	35	71	0.86
I-25 – Alameda	25	70%	24	37	90	0.68
SH 85 (System 3)	11	89%	14	20	42	0.43
I-25 - Broadway	20	81%	21	31	70	0.67
I-25 - T-REX	6.3	100%	Not Calculated	Not Calculated	26	0.32

Note: Values not calculated were not deemed relevant to project planning.

Table 7-2 Summary of Estimated Required Drainage Improvements

System Alternative 1

Basin Name	# Of Structures	Linear Feet Of Pipe (Size)	# Of Outfalls (Size)	# And Type Of Graded Area[1]
US 6 – Decatur	20 Inlet/MH	2,750 (small), 2,250 (medium)	1 (small), 1 (medium)	2 WQ pond
US 6 – South Platte River	0	0	0	0
I-25 – 6th Avenue Interchange	49 Inlet/MH	2,000 (small), 500 (medium), 150 (large)	1 (small), 1 (medium), 1 (large)	750 LF swales, 1 WQ pond
I –25 – 3rd Avenue	24 Inlet/MH	5,250 (small), 1,400 (medium)	1 (medium)	0
CCD – 3rd Avenue	1 Inlet/MH	300 (medium)	1 (medium)	1 ponding area
CCD – Bayaud/ Ellsworth	43 Inlet/MH, 1 PS (small) Retaining wall	4,000 (small), 2,400 (medium), 1,600 (large), 3,800 (box)	5 (small), 2 (large)	2,750 LF swales, 1 WQ pond, 1 ponding area
I-25 – Alameda	21 Inlets/MH 1 PS (medium)	2,900 (small), 200 (medium)	4 (small), 1 (medium)	240 LF swales, 1 WQ pond
CCD – Alameda/ Virginia	Retaining wall	520 (box)	1 (large)	1 ponding area
SH 85 (includes SB-31)	25 Inlets/MH	2,100 (small)	2 (small), 1 (medium)	1 WQ pond
CCD – Broadway	Included in SH 85 or I-25 – Broadway Basin Improvements			
I-25 – Broadway	2 Inlets/MH	700 (small) 250 (medium)	2 (small), 1 (medium)	1 WQ pond
I-25 – Broadway Tunnel	N/A	N/A	N/A	N/A
I-25 - T-REX	0	0	0	0
TOTAL:	185 Inlets/MH, 1 PS (small) 1 PS (medium) Retaining wall	19,700 (small), 7,300 (medium), 1,750 (large), 3,800 (box)	15 (small), 7 (medium), 4 (large)	3,740 LF swales, 7 WQ ponds, 3 ponding areas

Table 7-2 Summary of Estimated Required Drainage Improvements *(continued)*

System Alternative 2

Basin Name	# Of Structures	Linear Feet Of Pipe (Size)	# Of Outfalls (Size)	# And Type Of Graded Area[1]
US 6 – Decatur	20 Inlet/MH	2,750 (small), 2,250 (medium)	1 (small), 1 (medium)	1 WQ pond
US 6 – South Platte River	0	0	0	0
I-25 – 6th Avenue Interchange	49 Inlet/MH	2,000 (small), 500 (medium), 150 (large)	1 (small), 1 (medium), 1 (large)	750 LF swales, 1 WQ pond
I –25 – 3rd Avenue	24 Inlet/MH	5,250 (small), 1,400 (medium)	1 (medium)	0
CCD – 3rd Avenue	1 Inlet/MH	300 (medium)	1 (medium)	1 ponding area
CCD – Bayaud/ Ellsworth	50 Inlet/MH, 1 PS (small) Retaining wall	3,200 (small), 1,900 (medium), 800 (large), 3,800 (box)	4 (small), 2 (large)	1,500 LF swales, 1 WQ pond, 1 ponding areas
CCD – Alameda/ Virginia	17 Inlet/MH Retaining wall	600 (small), 400 (medium), 520 (box)	1 (small), 1 (medium) 1 (large)	1 ponding area
I-25 – Alameda	21 Inlets/MH 1 PS (medium)	2,900 (small), 200 (medium)	4 (small), 1 (medium)	240 LF swales, 1 WQ pond
SH 85 (includes SB-31)	32 Inlets/MH	2,800 (small), 1,100 (medium)	2 (medium)	1 WQ pond
CCD – Broadway	Included in SH 85 or I-25 – Broadway Basin Improvements			
I-25 – Broadway	2 Inlets/MH	700 (small) 250 (medium)	2 (small), 1 (medium)	1 WQ pond
I-25 – Broadway Tunnel	3 Inlets/MH	200 (small)	0	0
I-25 - T-REX	0	0	0	0
TOTAL:	219 Inlets/MH, 1 PS (small) 1 PS (medium) Retaining wall	20,400 (small), 7,000 (medium), 950 (large), 4,320 (box)	13 (small), 9 (medium), 4 (large)	5,140 LF swales, 6 WQ ponds, 2 ponding areas

Table 7-2 Summary of Estimated Required Drainage Improvements *(continued)*

System Alternative 3

Basin Name	# Of Structures	Linear Feet Of Pipe (Size)	# Of Outfalls (Size)	# And Type Of Graded Area[1]
US 6 – Decatur	20 Inlet/MH	2,750 (small), 2,250 (medium)	1 (small), 1 (medium)	1 WQ pond
US 6 – South Platte River	0	0	0	0
I-25 – 6th Avenue Interchange	49 Inlet/MH	2,000 (small), 500 (medium), 150 (large)	1 (small), 1 (medium), 1 (large)	750 LF swales, 1 WQ pond
I –25 – 3rd Avenue	24 Inlet/MH	5,250 (small), 1,400 (medium)	1 (medium)	0
CCD – 3rd Avenue	1 Inlet/MH	300 (medium)	1 (medium)	1 ponding area
CCD – Bayaud/ Ellsworth	39 Inlet/MH Retaining wall	7,800 (small), 4,200 (medium), 3,800 (box)	1 (large)	5,100 LF swales, 1 ponding area
CCD – Alameda/ Virginia[2]	71 Inlet/MH, 1 PS (medium) Retaining wall	1,800 (small), 4,400 (medium), 4,500 (large), 4,800 (box)	4 (small), 1 (large)	1 WQ pond
I-25 – Alameda	21 Inlets/MH 1 PS (medium)	2,900 (small), 200 (medium)	4 (small), 1 (medium)	240 LF swales, 1 WQ pond
SH 85 (includes SB-31)	32 Inlets/MH	2,800 (small), 1,100 (medium)	2 (medium)	1 WQ pond
CCD – Broadway	Included in SH 85 or I-25 – Broadway Basin Improvements			
I-25 – Broadway	2 Inlets/MH	700 (small) 250 (medium)	2 (small), 1 (medium)	1 WQ pond
I-25 – Broadway Tunnel	N/A	N/A	N/A	N/A
I-25 T-REX	0	0	0	0
TOTAL:	259 Inlets/MH, 2 PS (medium) Retaining wall	26,000 (small), 14,300 (medium), 4,550 (large), 8,600 (box)	12 (small), 8 (medium), 3 (large)	990 LF swales, 6 WQ ponds, 1 ponding area

1 - Inlet and/or Manhole Box (Inlet/MH), Water Quality (WQ), Pump Station Vault and Pumps (PS); some inlet boxes and manholes may only need to be modified. This drainage issue is to be decided during final design.
2 - Alameda/Virginia Street improvements by CCD include approximately 20 inlet boxes, 1,000 LF (medium) and 1,000 (large) pipe that will be required for basins off Figures 7-11 and 7-12.

The South Platte River is the final outfall for most of the existing storm sewer systems and all drainage improvements. Due to the river and roadway profiles, relatively flat topography in tributary basins, and the close proximity of the river to the interstate, the outlet pipes at the river cannot always be above the 100-year or even 10-year water surface elevation (WSE) of the river. Therefore, many outfalls may require flap gates to prevent river backflow. The hydraulic grade lines of the storm sewers should be reviewed in final design to determine the need for a flap gate or similar device. In addition, outlet protection is required to reduce the flow to a non-erosive velocity. Appendix E contains a picture of an example outfall, approved by Urban Drainage and Flood Control District. UDFCD should review final design plans in the South Platte River corridor.

7.1 US 6 Area

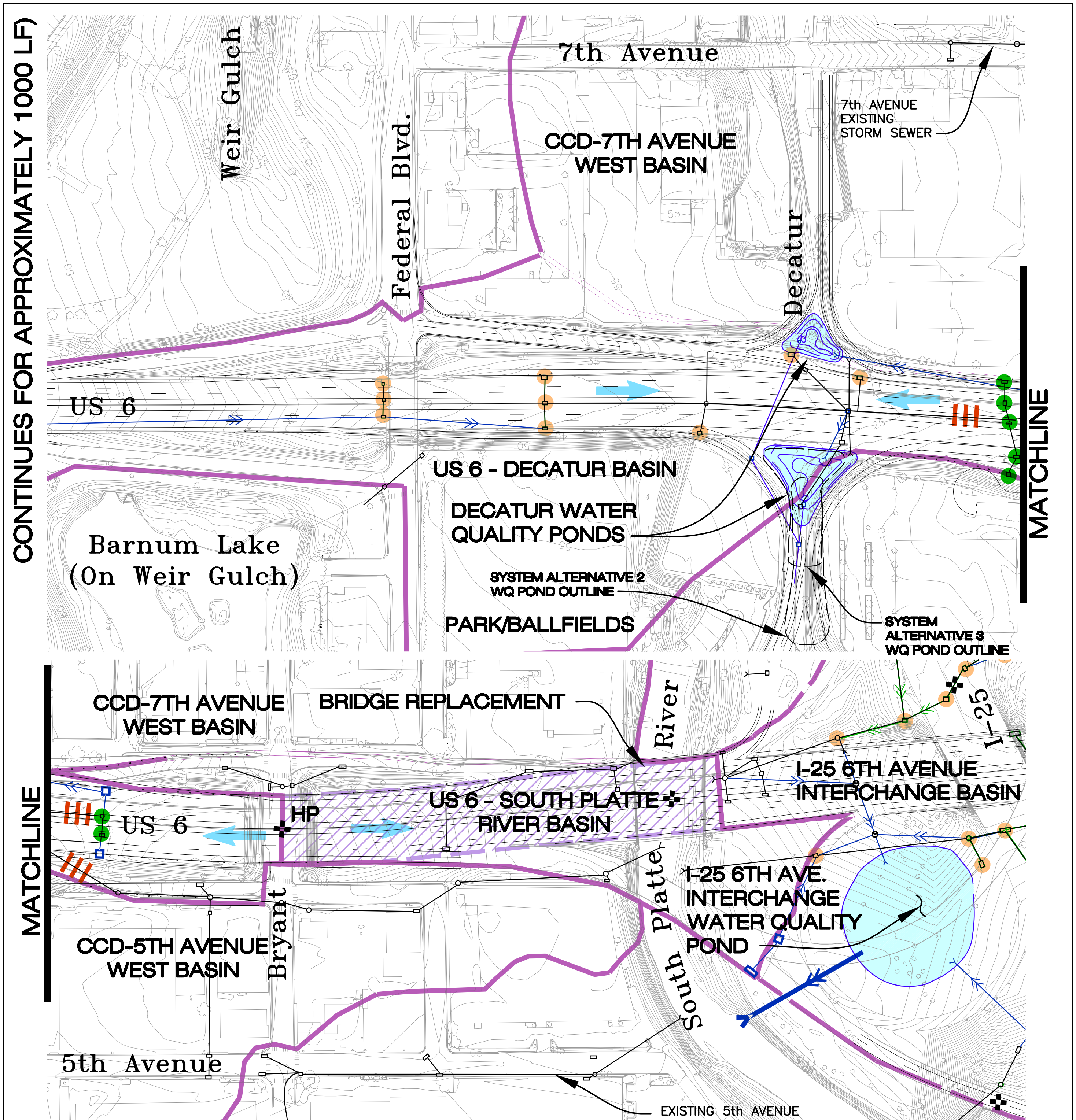
The US 6 Area consists of two drainage basins located on US 6 from the project limits on the west to the South Platte River on the east. The US 6 – Decatur Basin consists of approximately 43 acres, while the US 6 – South Platte River Basin consists of approximately 7.8 acres, both are comprised of roadway and grassy ROW. A small portion of offsite land, consisting of a park, is tributary to the US 6 – Decatur Basin. These basins are shown on **Figure 7-1A**. Additional offsite basins in this area are CCD – 5th and 7th Avenue Basins, which outfall to the South Platte River and will not be altered by CDOT through this project.

Runoff from US 6 – Decatur Basin will be collected by inlets and conveyed to an extended dry detention basin, located near Decatur Street, which will provide 100% of the required WQCV for this basin. From the Decatur Water Quality Pond, runoff will be conveyed to the South Platte River. Currently, runoff from west of Federal Boulevard flows to Weir Gulch, but with the completion of this project, it should be routed through a BMP, the Decatur Water Quality Pond, before flowing to the river. It appears that much of the existing storm sewer line west of Decatur could be modified to collect this runoff and convey runoff to the water quality pond instead of Weir Gulch. The structural integrity of the existing inlets and pipes should be reviewed before reusing them.

There are three different water quality pond configurations for this area, depending on the selected system alternative. The Decatur Water Quality Pond schematic designs for the alternatives are depicted on **Figure 7-1B**. For System Alternative 1, two smaller ponds will provide the required WQCV. The first is located north of US 6 and serves the land between Decatur and Bryant, approximately 30% of the basin. The second pond is located south of US 6 and serves the remaining portion of the basin. From the ponds, the runoff must be conveyed to the South Platte River. To reduce the total amount of pipe for this, it seems reasonable to route runoff from one pond outlet to the outlet structure of the other pond, or a nearby manhole, and then route the combined flows to the river. The water quality pond for System Alternative 2 is located south of US 6 along Decatur Street. This roadway alternative relocates the ramps from Decatur to US 6 so the pond is located on the old Decatur alignment. Some additional ROW may need to be purchased for this alternative. System Alternative 3 also relocates the on and off ramps connecting Decatur to US 6. The pond for this alternative is also located south of US 6 and along the Decatur Street alignment. It seems reasonable that the ponds for System Alternatives 2 and 3 could be used for either of the alternatives, as is or with small changes. For all of the pond alternatives, the outlets could be connected to the existing storm sewers located on 5th Avenue and/or 7th Avenue. This possibility would reduce the length of pipe required, but would involve coordination with CCD. It may be less expensive to investigate the possibility of conveying pond outlet flows to Weir Gulch, north or south of US 6 or even near 8th Avenue, to reduce the length of pipe required. Otherwise, a new storm sewer would be required to convey the flow to the river.

The **US 6 – South Platte River Basin** consists of approximately 7.8 acres with a 100-year storm runoff of 50 cfs. It is located too close to the river to provide an at-grade Best Management Practice (BMP) for water quality enhancement for the entire basin; therefore, runoff from it flows directly to the South Platte River. As shown on Figure 7-1A, the US 6 – South Platte River Sub-basin may be able to be collected and routed to the 6th Avenue Interchange Water Quality Pond. The actual area should be finalized, and maximized, during final design, but is estimated to be approximately 3.2 acres. US 6 – South Platte River Basin receives other BMPs such as street sweeping and deicing, as described in Section 6.0. The existing storm sewer system in this area may be structurally fit enough to be reused, but this should be checked prior to final design.

With the completion of the Valley Highway project, the US 6 Bridge over the South Platte River will be replaced. The design for this bridge should meet and address the requirements of FHWA's "Non-regulatory supplement regarding 23 CFR 650 A, Location and Hydraulic Design of Encroachments on Flood Plains." This policy provides guideline for interaction with FEMA and states to avoid longitudinal and significant encroachments where practicable. In addition to the bridge replacement, the river channel will be graded so upon the completion of the project, US 6 will be out of the floodplain. Design for this bridge should also include review of increased flow velocities near the bridge and piers and possible riprap or other protection required for the banks and channel in the river. Any exposed riprap above the river's ordinary high water will be required to have topsoil and seeding. Design and improvements in this area should be consistent with current and future master plans for the South Platte River. The City and County of Denver, Urban Drainage and Flood Control District, and the Army Corps of Engineers are currently finalizing the Planning, Engineering and Design (PED) Phase of the South Platte River Environmental Restoration (channel rehabilitation) project commonly referred to as the Denver County Reach which extends from approximately 100' south of the 8th Avenue Bridge to immediately downstream of Lakewood Gulch. Construction of this project could commence in 2005 pending authorization and appropriation of federal funds. This project should be reviewed to coordinate impacts to the final design of the US 6 Bridge replacement.

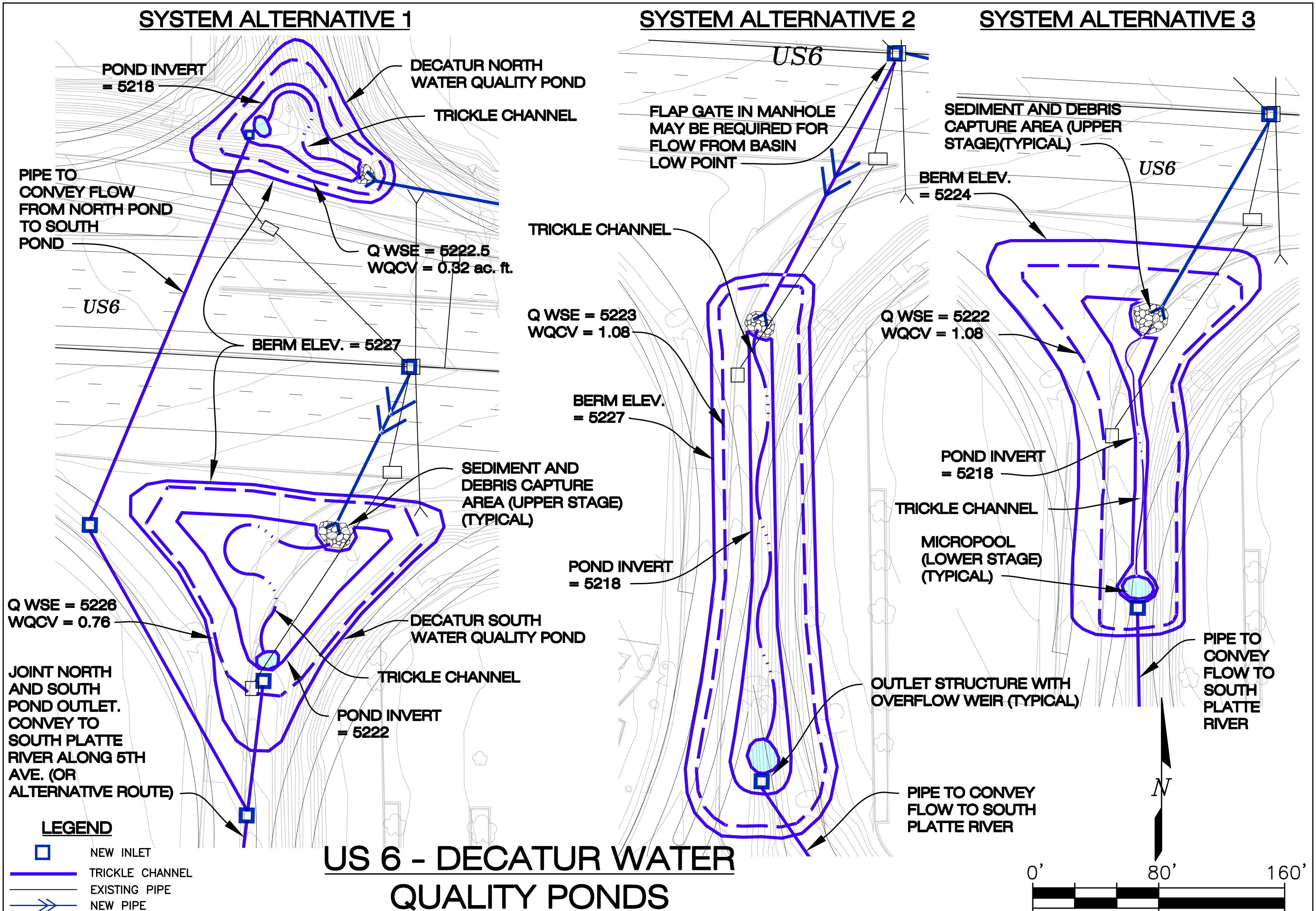


LEGEND

- A BASIN DESIGNATION
- B BASIN AREA
- C % IMPERVIOUS
- NEW INLET
- REMOVE PIPE
- REMOVE STRUCTURE
- MODIFY OR REMOVE AND REPLACE INLET/MANHOLE
- MODIFY OR REMOVE AND REPLACE EXISTING PIPE
- EXISTING PIPE
- NEW PIPE
- US 6 BASIN BOUNDARY
- US 6 SUB BASIN BOUNDARIES
- DRAINAGE FLOW ARROW
- SWALE
- US 6 – SOUTH PLATTE RIVER SUB-BASIN

US 6 - DECATUR BASIN(S)

FIGURE
7-1A



US 6 - DECATUR WATER QUALITY PONDS

Valley Highway Logan to 6th Ave. Environmental Impact Statement (EIS)

FIGURE 7-1B

NAME: P:\9904\EIS\CAD-Dwg\FIGURES\9904_06-US6-WQ1.dwg DATE: DEC 02, 2004 TIME: 8:15 AM

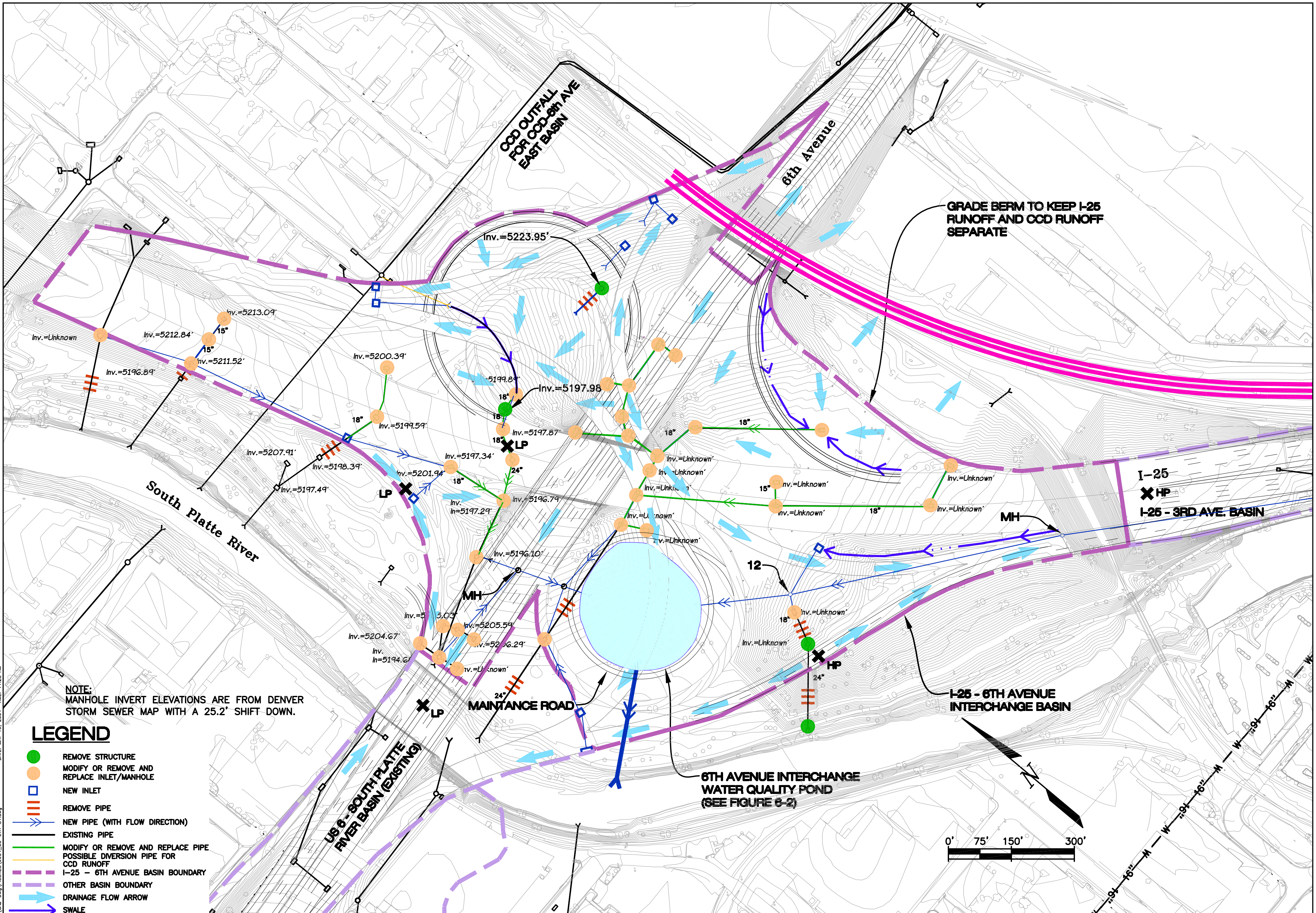
7.2 I-25 – 6th Avenue Interchange Outfall

The I-25 – 6th Avenue Interchange area consists of runoff from the I-25 – 6th Avenue Interchange Basin, I-25 – 3rd Avenue Basin, and the CCD – 3rd Avenue Basin. The CCD – 6th Avenue Basin is also in this area, however there are no existing flooding issues with that basin and no required drainage improvements. The drainage improvements for the three system alternatives for this area are the same.

7.2.1 6th Avenue Area Basins

Very few roadway changes are involved in the three system alternatives for the I-25 – 6th Avenue Interchange Basin. In fact, the only changes involve removing and relocating two ramps. However, this basin area is within the project limits and requires BMPs. The existing storm sewer system could be completely removed and replaced with one that routes minor storm runoff to the 6th Avenue Interchange Water Quality Pond and excess runoff directly to the South Platte River. However, based on existing elevations, it seems plausible that some inlets could be modified, by raising their inverts, for a new storm sewer system that could be routed to the water quality pond. Modification of inlets may reduce construction impacts to the roadway. Structural conditions should be examined with final design to determine whether the inlets can and should be modified or replaced. **Figure 7-2** depicts the storm sewer improvements to this area. Future runoff quantities were not calculated for this basin area.

The roadway improvements in the I-25 – 3rd Avenue Basin involve mostly widening the roadway and a minor profile adjustment. The new basin area consists of approximately 17 acres of roadway and is 100% impervious. The 5 and 100 year flow rates are 35 and 71 cfs, respectively. The existing storm sewer system in this area should be removed and replaced. **Figure 7-3** shows required storm sewer improvements to meet the criteria. All runoff will be collected by inlets and conveyed to the localized sump located near 3rd Avenue. From there, a storm sewer pipe, approximately 30” in diameter will convey the first flush runoff to the 6th Avenue Interchange Water Quality Pond. The first flush is approximated as equal to the 2-year storm or 24 cfs for this basin. The low point in this basin is approximately 2,100 feet south of the pond. A 30” pipe at 0.72% slope would place the downstream invert in the pond at approximately 5199.0. This elevation is consistent with the design of the pond. Runoff in excess of the 30” pipe capacity will outfall to the South Platte River through the storm sewer located near the basin low point and shown on **Figure 7-3**. This outfall will require adequate outlet protection. An inlet design spreadsheet was created for this project and was used to estimate the location and number of inlet grates along the project corridor based on allowable spread widths, inlet capacities, and street profiles. This spreadsheet is provided in Appendix C. It is assumed that vane grate inlets will be used on the interstate roadways and 1 to 5 vane grates will be located at each inlet box.



NOTE:
MANHOLE INVERT ELEVATIONS ARE FROM DENVER STORM SEWER MAP WITH A 25.2' SHIFT DOWN.

LEGEND

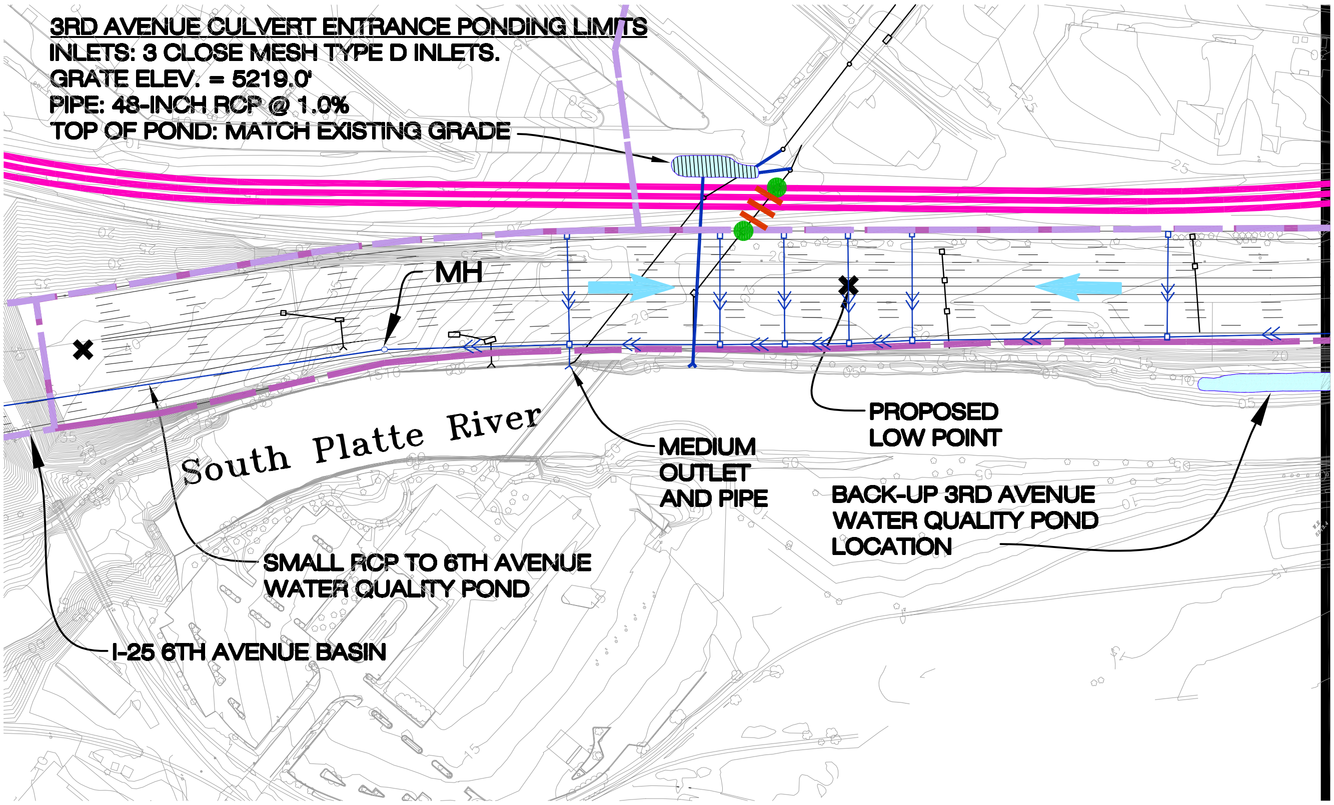
- REMOVE STRUCTURE
- MODIFY OR REMOVE AND REPLACE INLET/MANHOLE
- NEW INLET
- REMOVE PIPE
- NEW PIPE (WITH FLOW DIRECTION)
- EXISTING PIPE
- MODIFY OR REMOVE AND REPLACE PIPE
- POSSIBLE DIVERSION PIPE FOR CCD RUNOFF
- I-25 – 6TH AVENUE BASIN BOUNDARY
- OTHER BASIN BOUNDARY
- DRAINAGE FLOW ARROW
- SWALE

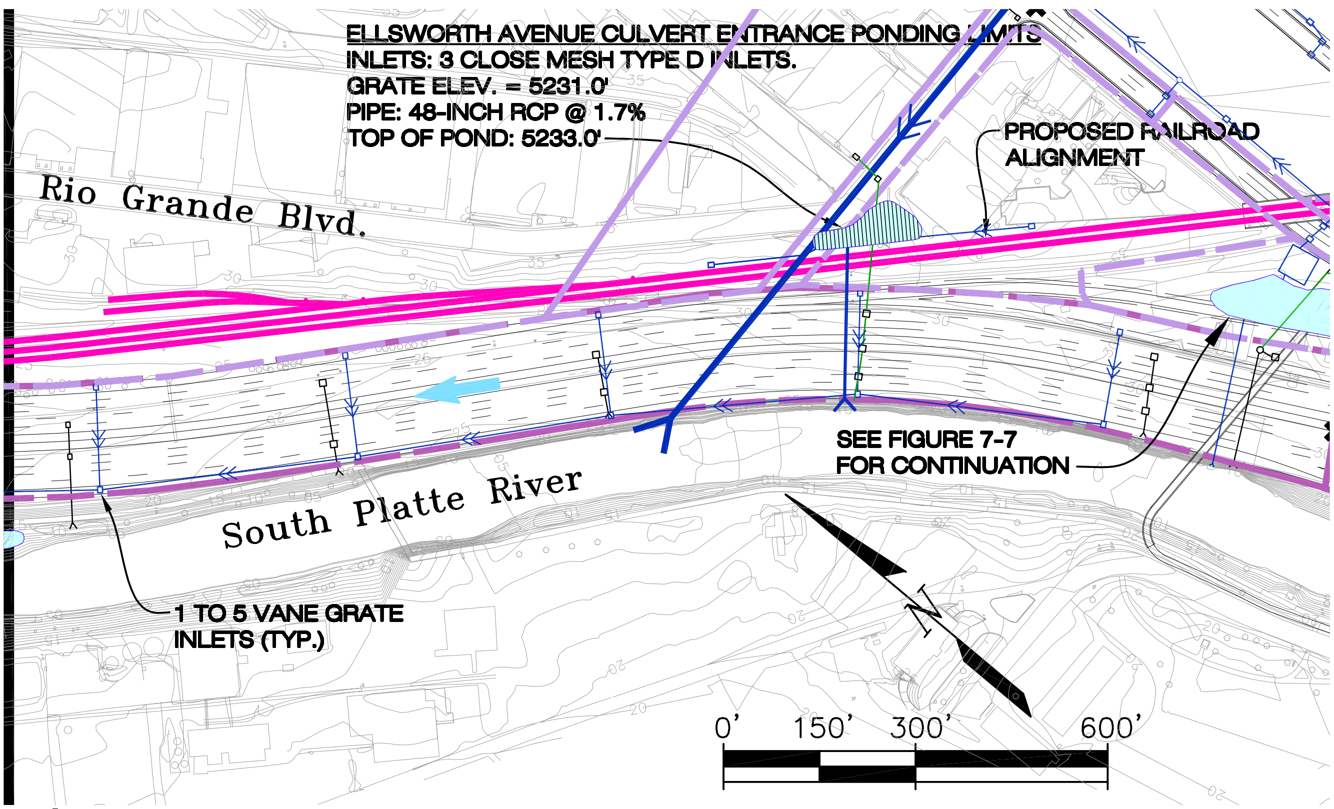
Valley Highway - Logan to 6th Ave. Environmental Impact Statement (EIS)

SYSTEM ALTERNATIVE 1,2 & 3
6TH AVENUE INTERCHANGE DRAINAGE PLAN

FIGURE 7-2

NAME: P:\9904\EIS\CAD-Dwg\FIGURES\9904_06-6TH-S1.dwg DATE: MAY 19, 2004 TIME: 11:28 AM





LEGEND

- NEW INLET
- REMOVE PIPE
- EXISTING PIPE
- NEW PIPE
- I-25 3RD AVENUE BASIN BOUNDARY
- OTHER BASIN BOUNDARY
- DRAINAGE FLOW ARROW
- SWALE
- REMOVE STRUCTURE

NOTE:
ALL EXISTING STORM SEWERS AND INLETS IN THIS BASIN SHOULD BE REMOVED WITH PROJECT CONSTRUCTION.

I-25 3RD AVENUE DRAINAGE

(SYSTEM ALTERNATIVE 1 SHOWN)

NAME: P:\9904\EIS\CAD-Dwg\FIGURES\9904_06-3RD-S1.dwg DATE: JAN 30, 2004 TIME: 10:53 AM

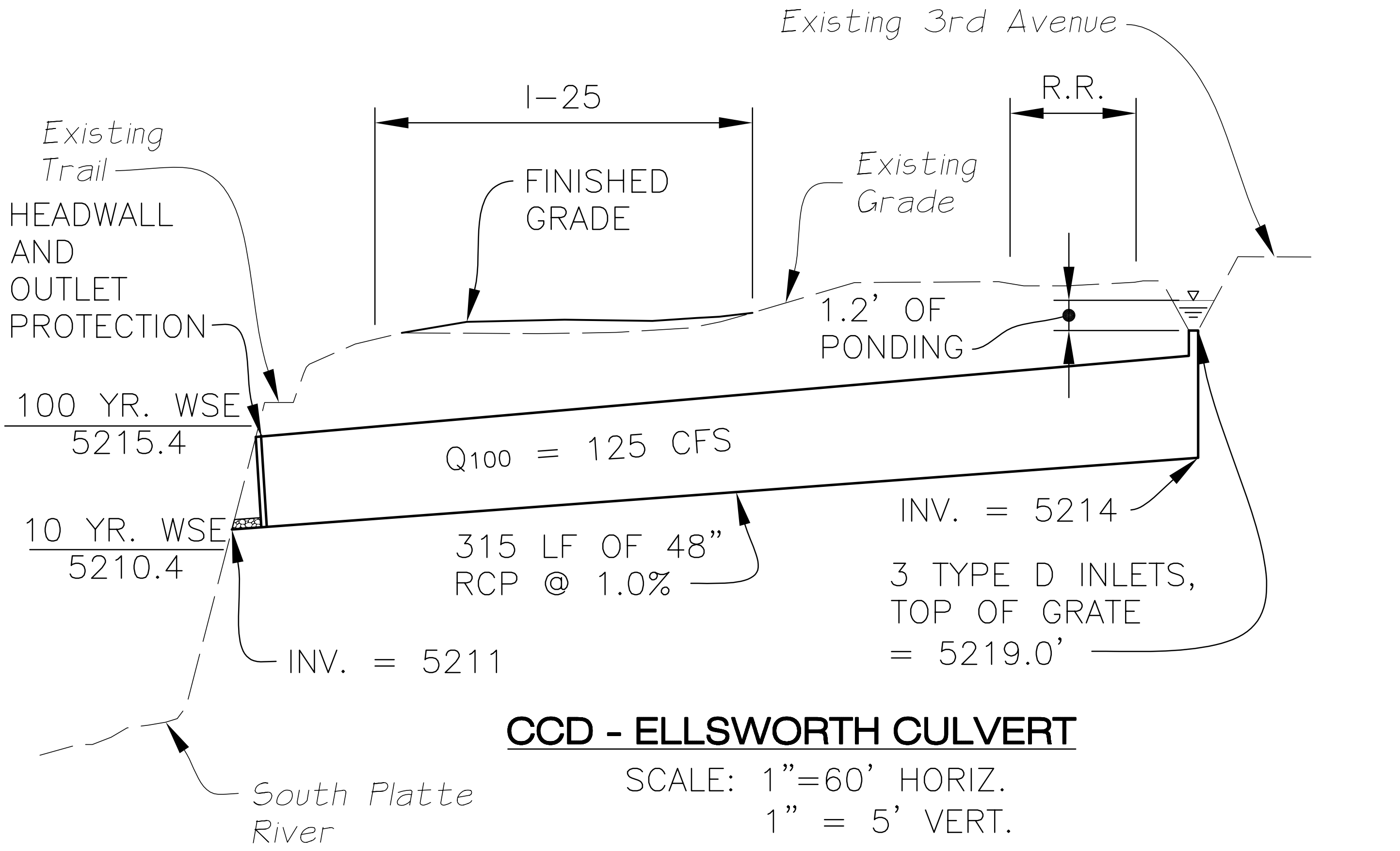
Valley Highway - Logan to 6th Ave. Environmental Impact Statement (EIS)

FIGURE
7-3

Currently, stormwater runoff from the CCD – 3rd Avenue Basin collects in the area where 3rd Avenue meets I-25 near Raritan Way and floods the local area and the interstate. A small drainage pond with three Type D inlets and a 48-inch pipe will provide drainage for the 125 cfs of runoff from this basin. The flow will be diverted to the South Platte River to meet the CDOT cross-flow runoff requirements. A close mesh grate with 50% clogging will cause approximately 1.2 feet of ponding to occur at this location. **Figure 7-4** provides a profile of a possible pond design and **Figure 7-3** shows the plan view. This ponding area could also double as a BMP for CCD with some modifications.

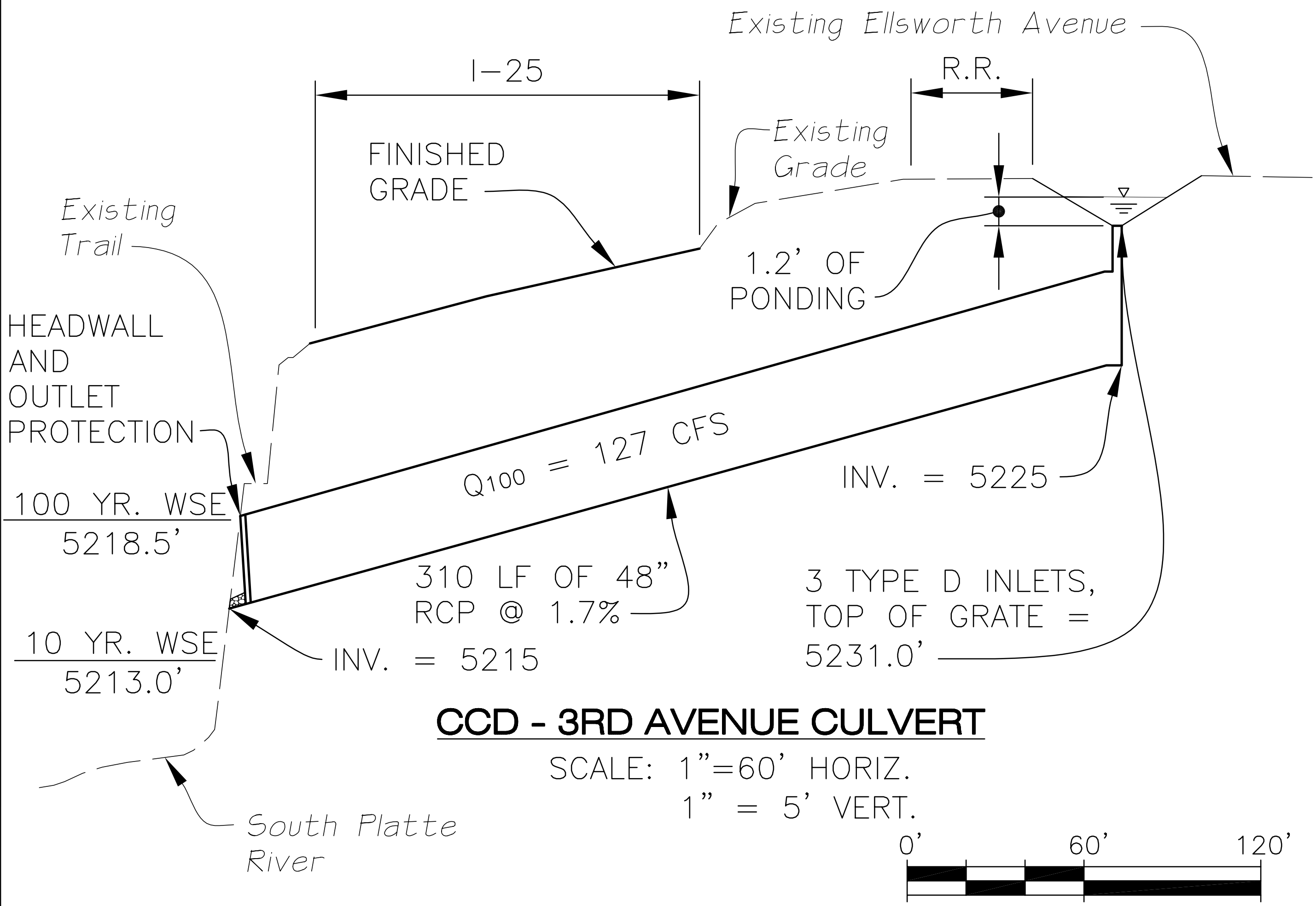
7.2.2 6th Avenue Interchange Water Quality Pond

The 6th Avenue Interchange Water Quality Pond is located in the southwest infield of the interchange. The I-25 – 6th Avenue Interchange Basin has a WQCV requirement of 0.75 acre-feet while the I-25 – 3rd Avenue Basin requires 0.86 acre-feet. The portion of the US 6 – South Platte River Basin that will be routed to this pond requires a WQCV of 0.13 acre-feet. With a pond invert of 5197.0 and a water level of 5198.3, 1.67 acre-feet of WQCV is provided. The northbound I-25 flyover runs directly above the proposed location so the pond will have to be constructed in a way that the bridge piers are not exposed. This will reduce the pond capacity slightly, but there is room for additional ponding depth to account for volume losses. A minimum of two storm sewer pipes will flow into this pond including the one from the I-25 – 3rd Avenue Basin and one from the I-25 – 6th Avenue Interchange Basin. Additional pipes may be required with final design, but each additional pipe may require another upper stage, which increases cost and maintenance and reduces pond volume. The pond overflow outlet structure and pipe must be sized to equal the maximum inflow to prevent the pond from overflowing onto the roadway. Adequate maintenance access must be provided to the water quality pond, preferably to easily access the upper and lower stages, and approved by CDOT maintenance. Access can be provided from the SB I-25 to EB US 6 ramp; however, adequate acceleration and deceleration lanes should be part of the access design. The outfall can be maintained with access from the existing South Platte River trail. A plan view showing this water quality pond is provided in **Figure 7-5** while **Figure 7-6** shows a profile view.



CCD - ELLSWORTH CULVERT

SCALE: 1"=60' HORIZ.
1" = 5' VERT.



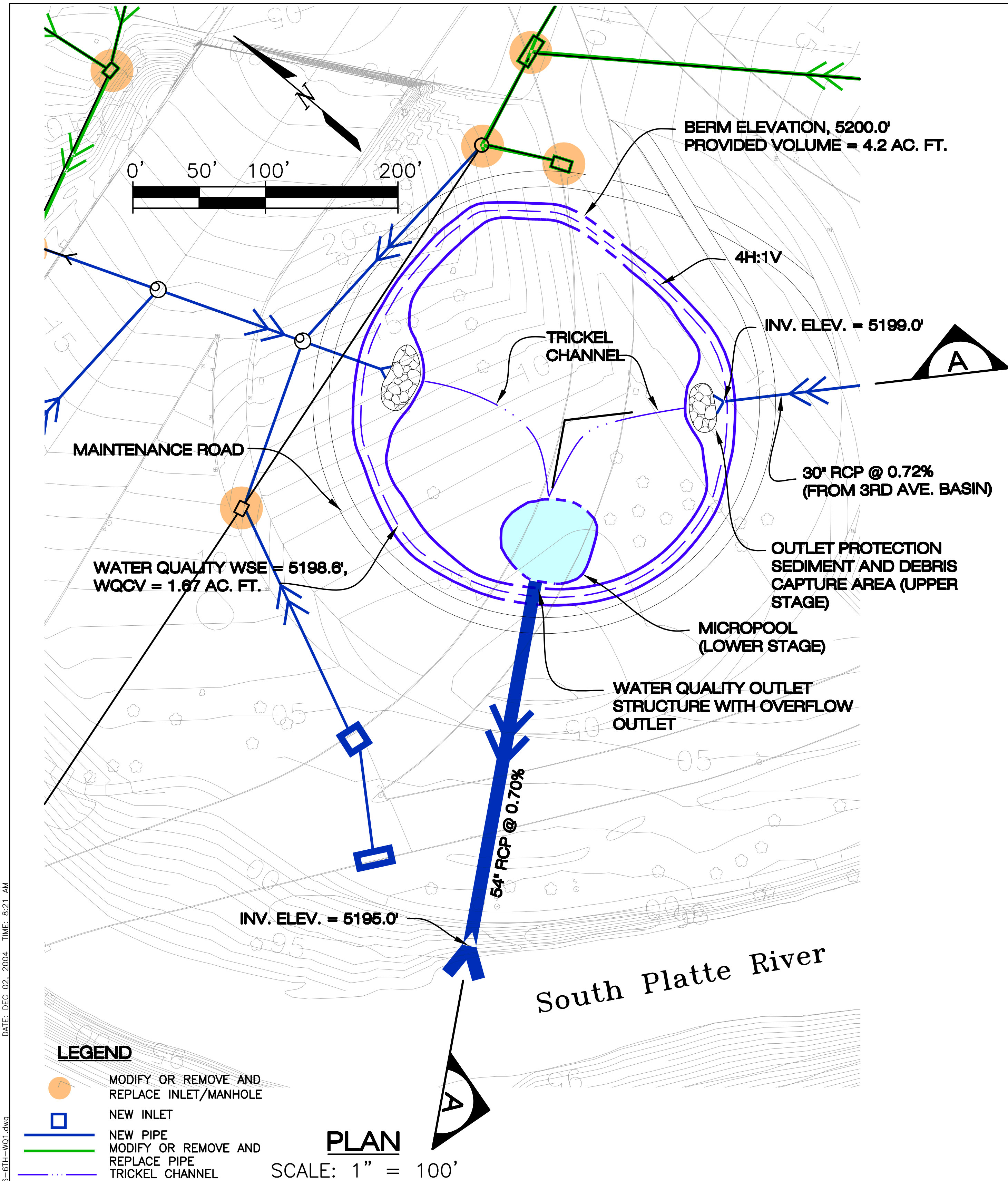
CCD - 3RD AVENUE CULVERT

SCALE: 1"=60' HORIZ.
1" = 5' VERT.

Valley Highway - Logan to 6th Ave.
Environmental Impact Statement (EIS)

FIGURE
7-4

NAME: P:\9904\EIS\CAD-Dwg\FIGURES\9904_06-3RD-WQ1.dwg DATE: JAN 28, 2004 TIME: 1:13 PM

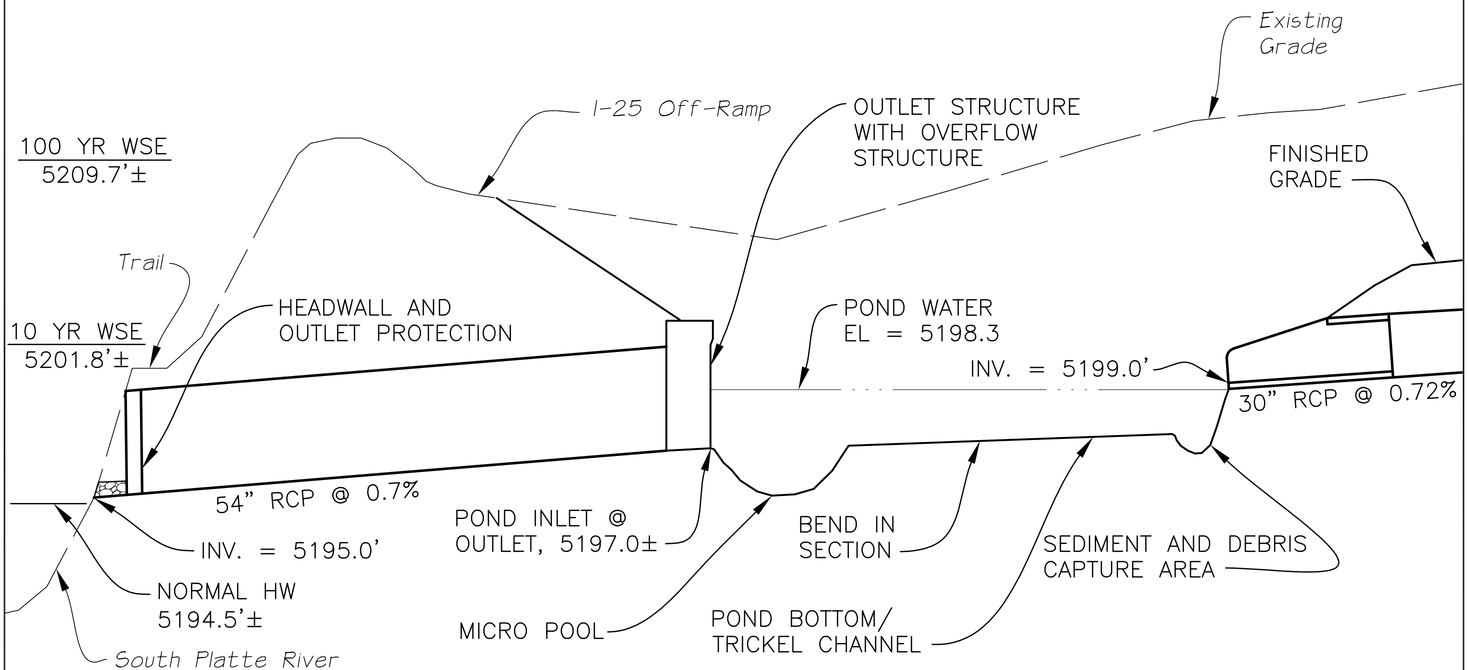


SYSTEM ALTERNATIVE 1, 2,& 3 (SYSTEM 1 SHOWN)
6th AVENUE INTERCHANGE
WATER QUALITY POND

NAME: P:\9904\EIS\CAD-Dwg\FIGURES\9904_06-6TH-WQ1.dwg DATE: DEC 02, 2004 TIME: 8:21 AM

Valley Highway - Logan to 6th Ave. Environmental Impact Statement (EIS)

FIGURE 7-5



SECTION A

SCALE: 1" = 100' HORIZ., 1" = 10' VERT.

SYSTEM ALTERNATIVE 1, 2 & 3
6th AVENUE INTERCHANGE
WATER QUALITY POND

7.3 CCD – Ellsworth, Bayaud, Alameda Basins

The CCD – Bayaud, Ellsworth, and Alameda Basins vary greatly from the existing conditions and the CCD – Bayaud and Ellsworth Basins are completely combined for the proposed project. These basins have been divided into sub-basins for more detailed analysis. Each system alternative requires a different storm sewer system layout, as described below.

As previously mentioned, all system alternatives include a grade separation of Santa Fe and Kalamath with Bayaud and the Consolidated Railroad line. For System Alternatives 2 and 3, they will also be grade separated at Alameda. System Alternative 2 shows the combined Santa Fe/Kalamath crossing over Alameda whereas in System Alternative 3, they cross under Alameda. In addition, System Alternative 2 maintains two distinct roads for Santa Fe and Kalamath with separate grade separations at Bayaud and the railroad while System Alternative 3 shows a combined grade separation. In all cases, runoff flows east to west, towards the Santa Fe and Kalamath on its path to the river, altering existing drainage paths. Without storm drainage improvements, the existing flooding from the CCD – Bayaud, Virginia, and Alameda Basins, approximately 3,500 cfs, would flood the area either on Santa Fe either near Bayaud or Alameda, or on Alameda itself, depending on the system alternative. This would create a pond in excess of 15 feet at the grade separations for the three alternatives, either under Bayaud, the railroad line, or Alameda, depending on the alternative and approximately 2 feet on Alameda in System Alternative 2, and make the road unsafe and un-drivable.

The City and County of Denver has several storm sewer improvements planned for this area as described in the Storm Drainage Master Plan Phase I Final (Matrix 2003). The improvements include a new and larger outfall pipe for Ellsworth, Bayaud, and Alameda to alleviate existing flooding problems and substandard storm sewers. Another improvement involves the construction of an 8' x 5' box culvert along Center Avenue to convey runoff from the CCD – Virginia Basin. In addition, the plan identifies a possible 100-year storm sewer improvement consisting of a triple 10' x 6' box culvert along Center Avenue. Copies of several sheets from the Master Plan are contained in Appendix D. Most of these improvements will not convey the 100-year runoff to the river, but 2 to 5 year storm events, as CCD requires.

In some instances, CCD's planned storm sewers conflict with Valley Highway EIS roadway and storm sewer improvements requiring coordination between CCD and CDOT for final design. The three system underpass alternatives alter the ability to construct the enlarged Bayaud Outfall pipe. The proposed elevation of the grade separation of Santa Fe and Kalamath at the railroad and Bayaud is approximately the same elevation as the river so it conflicts with a gravity box culvert along Bayaud. However, since the alternatives do not change the elevation of Ellsworth Avenue, theoretically, the box culvert could be located along that alignment for the entire reach of the box culvert. This would also eliminate some of the need for the improved outfall for the CCD – Ellsworth Basin. Additionally, CDOT requires 100-year cross flow to be routed through the ROW with no overflow onto the interstate. Therefore, CCD's proposed Bayaud Outfall, that would be relocated to Ellsworth with this project, is not large enough and would have to be resized to 12' x 6' concrete box culvert or a comparable size for a portion of the length, from the river to the eastern railroad tracks.

7.3.1 System Alternative 1

System Alternative 1 maintains the at-grade intersection of Santa Fe and Kalamath with Alameda keeping the CCD – Bayaud and CCD – Alameda Basins separated. The CCD – Bayaud Basin is subdivided to show how to route as much flow as possible to the Ellsworth Outfall to reduce the runoff to the sump on Santa Fe between the Consolidated Railroad and Bayaud. The plan for the CCD – Bayaud Basin for System Alternative 1 is shown on **Figure 7-7**.

Sub-basin SB-1 consists of approximately 265 acres of the existing CCD – Bayaud Basin. A swale will be located on the east side of the railroad tracks to collect and convey runoff to the Ellsworth Box Culvert. It should be sized for the runoff in excess of the existing and proposed storm sewer system up to the 100-year storm.

Similar to SB-1, runoff from SB-2, SB-3, and SB-4 will require swales, inlets and storm sewers to collect the 100-year runoff just east and north of the railroad tracks, Santa Fe, and Kalamath and convey it to the Ellsworth Box Culvert. Collecting this runoff prior to it flowing onto Santa Fe and Kalamath will reduce the tributary area to the sumps on the roadways and reduce the size and dependence on the required pump station. Runoff from SB-7 will be collected by inlets and conveyed by storm sewers to SB-4 where it will combine with runoff from SB-4 and flow to the Ellsworth Box Culvert.

Approximately 1.5 acres in Sub-basin SF-S and K-S are tributary to the sump on Santa Fe and Kalamath yielding approximately 10 cfs in the 100-year storm. The pump would convey the runoff to the Santa Fe/Kalamath Water Quality pond, which would be drained by gravity to the river. The plan for this system is shown on **Figure 7-7**. The different configurations of the Santa Fe/Kalamath Water Quality pond are shown on **Figure 7-12b**. An NPDES permit may be required for pump station discharge.

This alternative also shows a ponding area near the intersection of Ellsworth Avenue and Lipan Street where 127 cfs currently flows over the train tracks and onto I-25. With the system alternatives, this situation remains, but will be reduced to only 65 cfs flowing from SB-5 and SB-6. To prohibit this flow from encroaching I-25, a small drainage pond with three Type D inlets and a 48-inch pipe is proposed. A close mesh grate with 50% clogging will cause 1.2 feet of ponding to occur at this location. **Figure 7-7** depicts the plan view of this area while **Figure 7-4** shows the storm sewer profile. The larger size of the Ellsworth Box and the Ellsworth Ponding Area are part of the drainage plan for all system alternatives. This small drainage pond, the Ellsworth Ponding Area, can double as a water quality enhancement area by creating an outfall system that would convey the 100-year stormwater runoff safely under I-25 while reducing sediment from flowing to the river in smaller storm events. Additional BMPs can provide water quality enhancement as property takes in this area, due to roadway changes, are redeveloped.

The existing drainage patterns will be maintained in System Alternative 1 for the CCD – Virginia and CCD – Alameda Basins. **Figure 7-10** shows the plan for these basins. The Alameda graded area, located between I-25 and Kalamath, will prevent stormwater runoff from flowing onto I-25. A large concrete box culvert can convey this flow to the river. Without CCD Master Plan improvements of an 8' x 5' Center Box Culvert, this Alameda Culvert would be approximately 7' H x 45' W. The size may be reduced in final design based upon future CCD improvements. The

Alameda graded area provides room for stormwater runoff to pond and increase headwater depth to maximize the box culvert capacity. Similar to the Ellsworth Ponding Area, this area could double as a BMP for CCD.

7.3.2 System Alternative 2

In System Alternative 2, the consolidated Santa Fe/Kalamath road goes over Alameda, and then separates as it goes under Bayaud and the railroad in a sump. Some drainage patterns for this alternative match those in System Alternative 1, while others change due to the overcrossing at Alameda. **Figure 7-8** shows the drainage improvements and patterns for the Bayaud area while **Figure 7-11** depicts those for the Alameda area.

The storm sewer system improvements for the CCD – Bayaud Basin are similar to those in System Alternative 1. It includes the Ellsworth Box Culvert and ponding area as well as the improvements for Sub-basins SB-1 to SB-6. Sub-basins SF-S and K-S are different in this alternative. As seen in **Figure 7-8**, SF-S consists of approximately 1.8 acres and K-S of 1.7 acres. These basins will drain in a similar fashion as they would in System Alternative 1, but combine for a total 100-year runoff of approximately 24 cfs. They will also require a pump to remove the runoff and convey it to the Santa Fe/Kalamath Water Quality Pond. An NPDES permit may be required for pump station discharge. In addition, runoff from SB-8 would be collected and conveyed by inlets, swales, and storm sewers to SB-4 where it is conveyed to the Ellsworth Box Culvert, similar to System Alternative 1 SB-7. Runoff from System Alternative 2 SB-7 will sheet flow or be routed by inlets and storm sewer pipes to the Santa Fe/Kalamath Water Quality Pond where it will be conveyed to the South Platte River. This pond will provide adequate BMPs for SF-S, K-S, and SB-7. **Figure 7-12b** shows the plan view for this pond. Sub-basin 7-15, depicted on **Figures 7-8** and **7-11**, is comprised of approximately 4.5 acres of Santa Fe, Kalamath, and Alameda. Runoff from this basin flows by gravity to the north, but is high enough in elevation to be collected and conveyed by the existing or improved Alameda storm sewer system, which would reduce the flow to the sump and related pump system.

The storm sewer improvements in the Alameda area for System Alternative 2 are similar to those from the previous alternative. **Figure 7-11** shows a similar Alameda graded area and box culvert as in System Alternative 1. The graded areas serve the same purpose and are different only to accommodate the different road alignments.

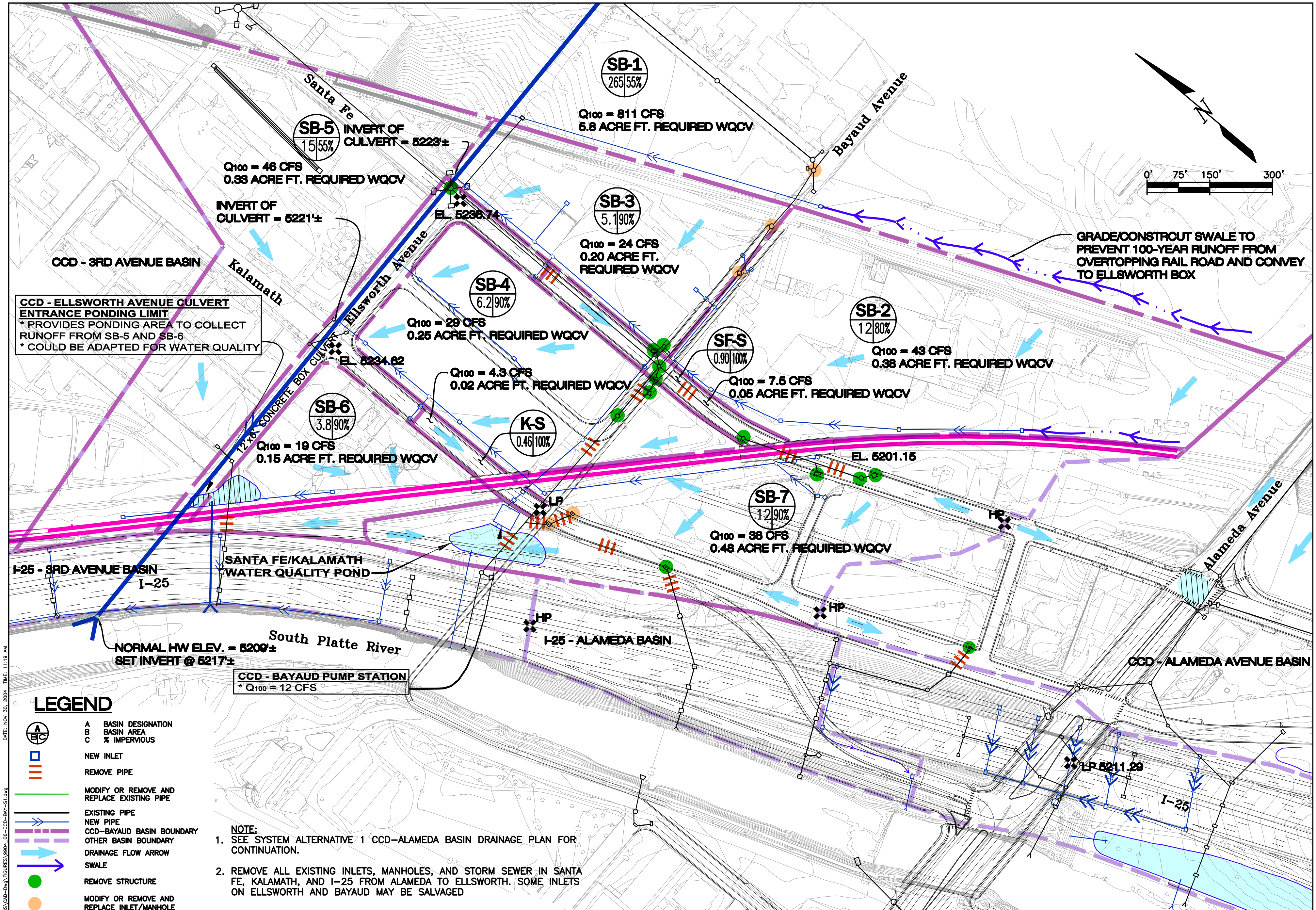
One additional difference between these two designs is that with the Santa Fe/Kalamath overcrossing, runoff will be channeled through the overcrossing opening over Alameda instead of flowing over Kalamath. The reduced flow area on Alameda causes the runoff to flow at approximately two feet deep under Santa Fe/Kalamath. This depth is not acceptable to CCD so additional inlets and storm sewer capacity would need to be added to the existing system in Alameda. The CCD Master Plan improvements for the 8’ x 5’ Center Box Culvert would reduce the runoff in this area, and thereby reduce the depth of flow. In addition, CCD has plans to enlarge the existing storm sewer system in Alameda to the 2 to 5 year storm. For these reasons, no schematic design is included on **Figure 7-11** and coordination with CCD would be required for improvements to the Alameda storm sewer system.

7.3.3 System Alternative 3

System Alternative 3 has the consolidated Santa Fe/Kalamath crossing below Alameda with a sump located just to the north side of Alameda. Due to the differences in both horizontal and vertical layout of the roadways, the drainage improvements change as well. **Figure 7-9** shows the storm sewer layout for the CCD - Bayaud Basin area and includes the Ellsworth Box Culvert and a storm sewer system to reduce flow to the sump. In this alternative, SB-1 and SB-5 are the same as the previous alternatives. Runoff from SB-2, SB-3, and SB-4 is collected and conveyed to the Ellsworth Box Culvert prior to flowing onto Santa Fe and Kalamath in a similar manner as the previous alternatives. Runoff from SB-6 would be collected and conveyed to the Ellsworth Ponding Area in such a way that no runoff in the 100-year storm event would flow onto I-25.

There are significant drainage improvement differences in the Alameda Basin area. **Figure 7-12** shows the plan for this area. Because the combined Santa Fe/Kalamath is lower than the existing ground in that area, runoff from the CCD – Virginia and Alameda Basins would flow to the sump under Alameda. Therefore, the proposed box culvert in the previous alternatives will not work for this one. The proposed drainage improvements for this alternative consist of enlarging CCD's Center Box Culvert to 16' x 8' or a comparable size to convey the 100-year runoff from the CCD – Virginia Basin to the river. In addition, it consists of increasing the capacity of the existing Alameda storm sewer system so it can convey the 100-year runoff to the river.

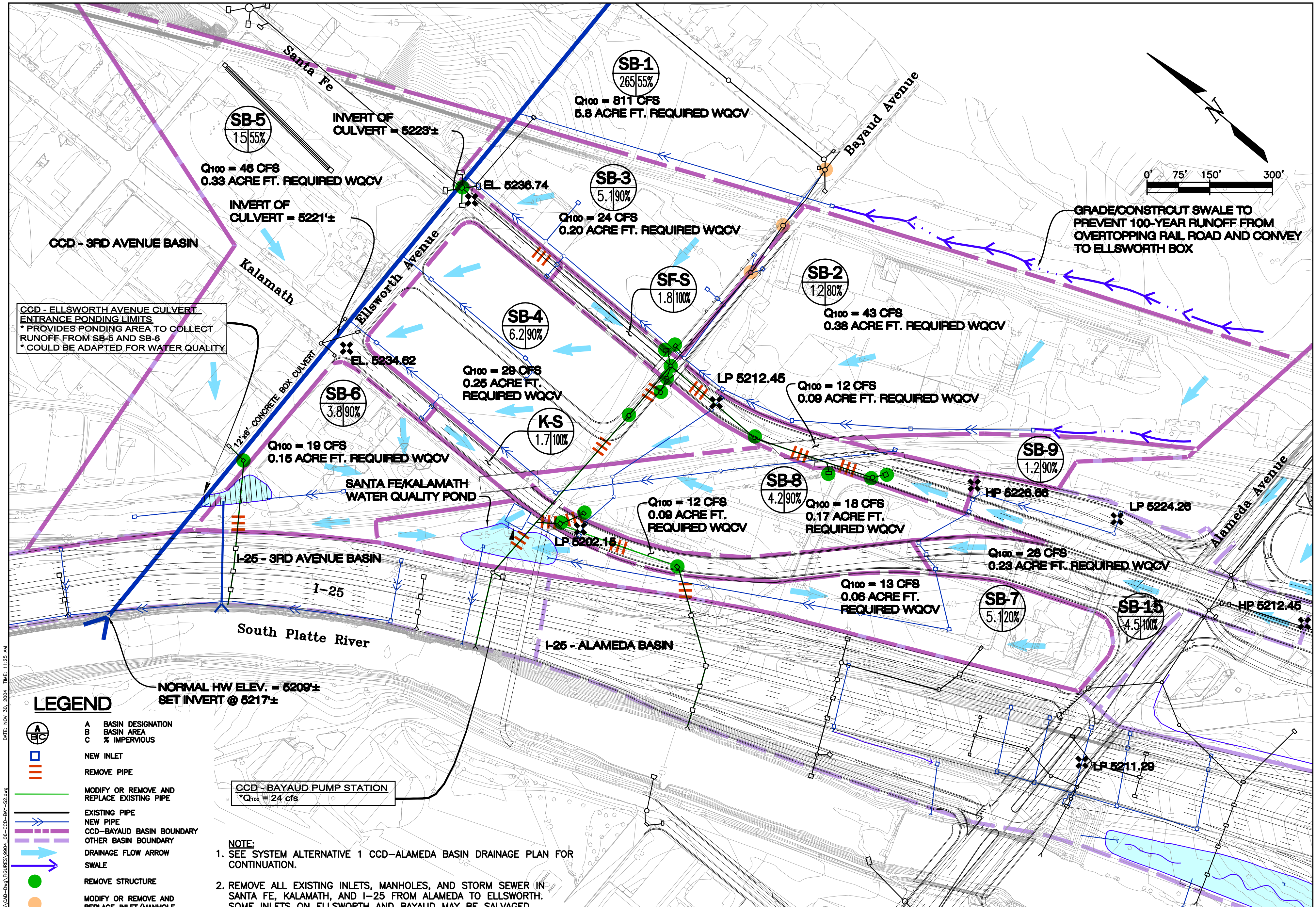
The CCD – Alameda Basin was divided into sub-basins for more detailed analysis. Runoff from sub-basins SB-11, SB-12, SB-13, and SB-14 of approximately 380 cfs in the 100 year event would be routed to an improved Alameda Avenue storm sewer system and conveyed to the river. This would require the storm sewer to be extended with inlets along Cherokee, the east side of the railroad tracks, and the east side of the proposed Santa Fe/Kalamath, as shown in **Figure 7-12**. The Alameda Avenue storm sewer would be routed along the east side of Santa Fe until it can cross under Santa Fe and I-25 to the river. Approximately 7.0 acres from the CCD – Bayaud and Alameda Basins for SF-S are tributary to the sump on Santa Fe under Alameda Avenue yielding approximately 37 cfs in the 100 year storm. A pump station would also be required for this alternative. An NPDES permit may also be required for this pump station discharge. There appears to be adequate room for a pump station and water quality pond on the south side of Alameda between I-25 and Santa Fe/Kalamath, however due to groundwater contamination potential, the pump station and water quality pond should be located in such a way as to not intersect the groundwater plume. The pump station would outfall to the Santa Fe/Kalamath Water Quality Pond with an outlet to the South Platte River. **Figure 7-12b** shows the Santa Fe/Kalamath pond in plan view.



Valley Highway Logan to 6th Ave. Environmental Impact Statement (EIS)

SYSTEM ALTERNATIVE 1
CCD - BAYAUD BASIN
DRAINAGE PLAN

FIGURE
7-7



NOTE:

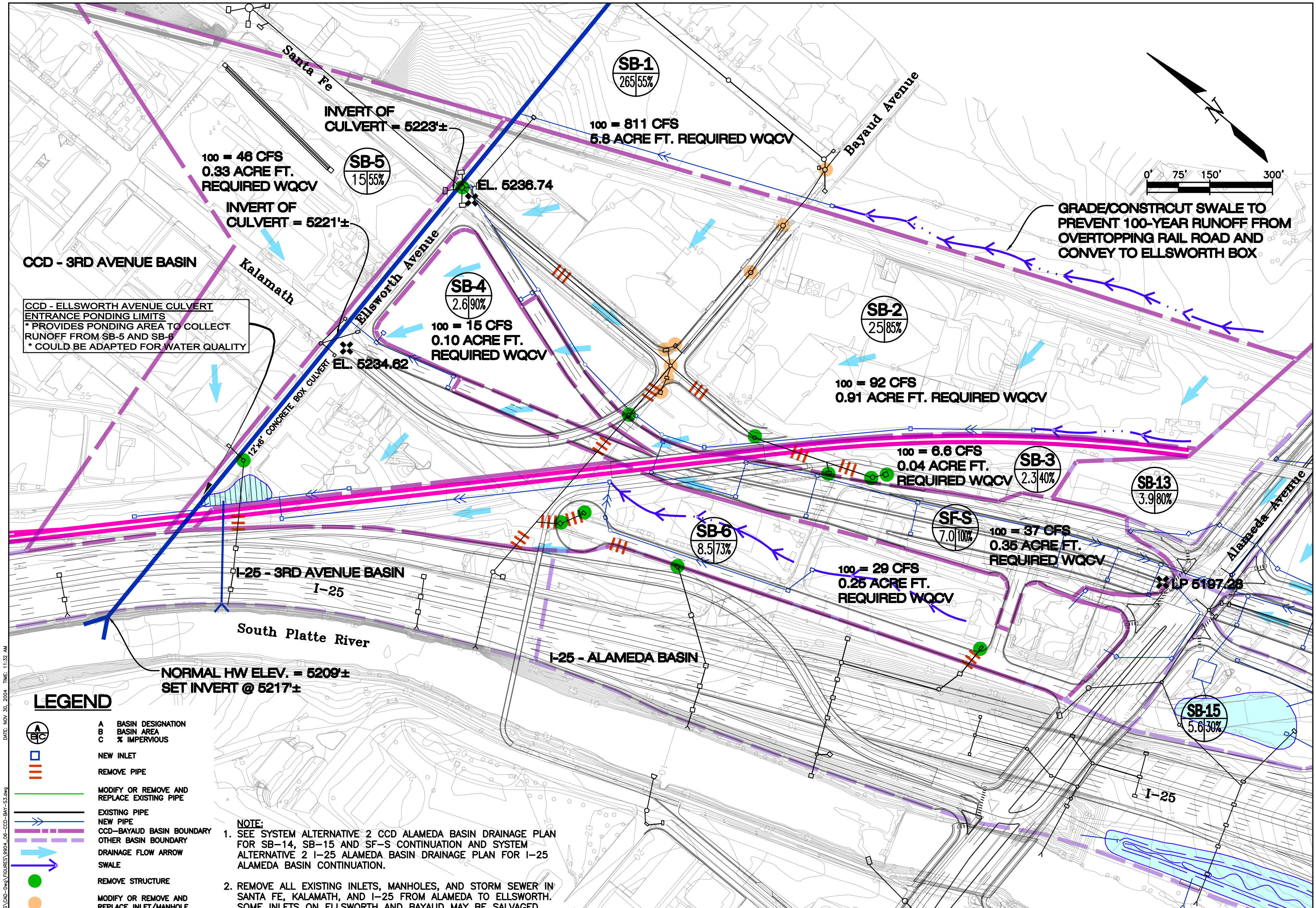
1. SEE SYSTEM ALTERNATIVE 1 CCD–ALAMEDA BASIN DRAINAGE PLAN FOR CONTINUATION.
2. REMOVE ALL EXISTING INLETS, MANHOLES, AND STORM SEWER IN SANTA FE, KALAMATH, AND I–25 FROM ALAMEDA TO ELLSWORTH. SOME INLETS ON ELLSWORTH AND BAYAUD MAY BE SALVAGED

Valley Highway Logan to 6th Ave. Environmental Impact Statement (EIS)

SYSTEM ALTERNATIVE 2
CCD - BAYAUD BASIN
DRAINAGE PLAN

FIGURE 7-8

NAME: P:\9904\EIS\CAD-Dwg\FIGURES\9904_06-CCD-BAY-S2.dwg DATE: NOV 30, 2004 TIME: 11:25 AM



NOTE:

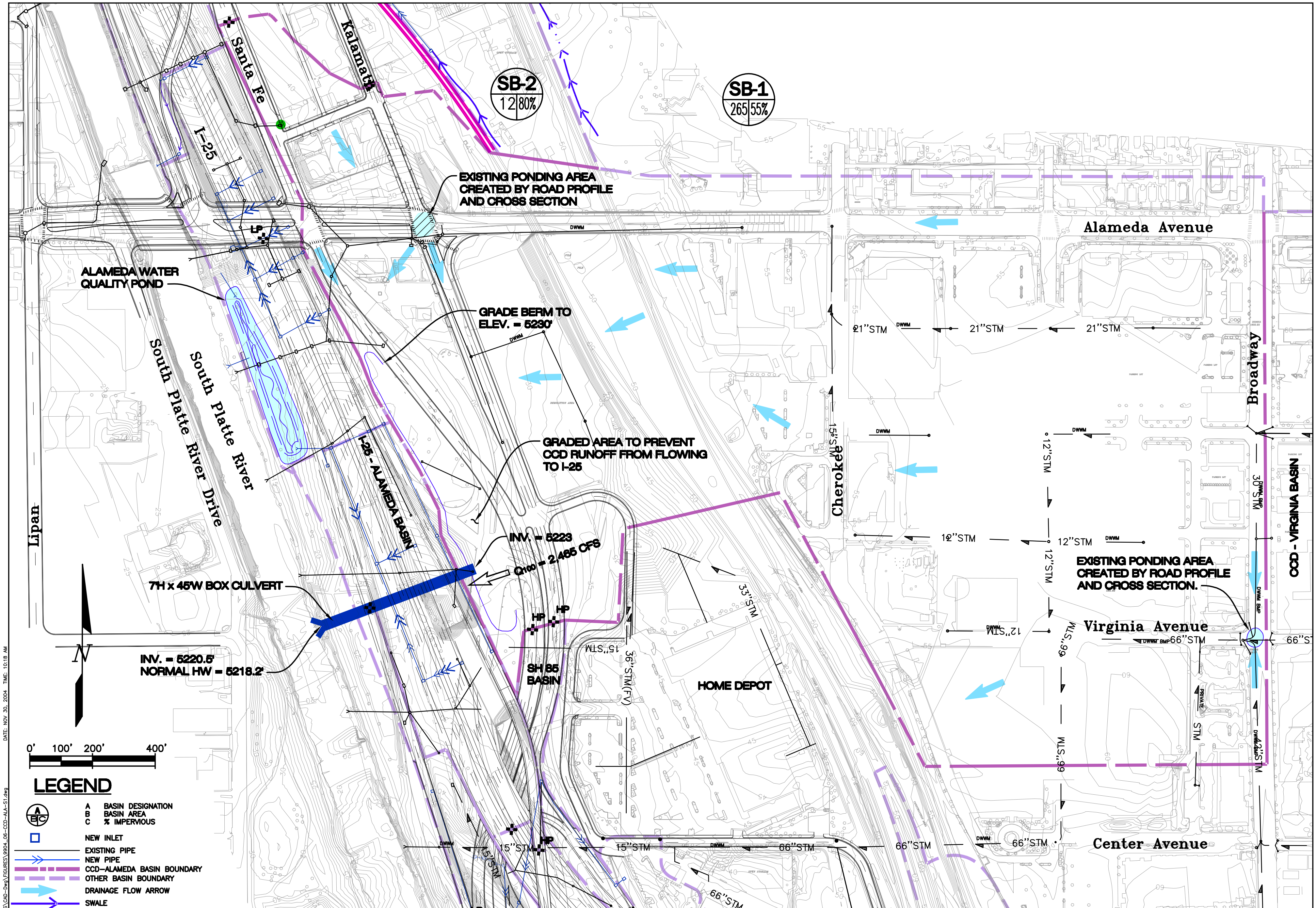
1. SEE SYSTEM ALTERNATIVE 2 CCD ALAMEDA BASIN DRAINAGE PLAN FOR SB–14, SB–15 AND SF–S CONTINUATION AND SYSTEM ALTERNATIVE 2 I–25 ALAMEDA BASIN DRAINAGE PLAN FOR I–25 ALAMEDA BASIN CONTINUATION.
2. REMOVE ALL EXISTING INLETS, MANHOLES, AND STORM SEWER IN SANTA FE, KALAMATH, AND I–25 FROM ALAMEDA TO ELLSWORTH. SOME INLETS ON ELLSWORTH AND BAYAUD MAY BE SALVAGED

Valley Highway Logan to 6th Ave. Environmental Impact Statement (EIS)

SYSTEM ALTERNATIVE 3
CCD - BAYAUD BASIN
DRAINAGE PLAN

FIGURE
7-9

NAME: P:\9904\EIS\CAD-Dwg\FIGURES\9904_06-CCD-BAY-S3.dwg DATE: NOV 30, 2004 TIME: 11:32 AM



Valley Highway Logan to 6th Ave. Environmental Impact Statement (EIS)

SYSTEM ALTERNATIVE 1
CCD - ALAMEDA BASIN
DRAINAGE PLAN

FIGURE 7-10

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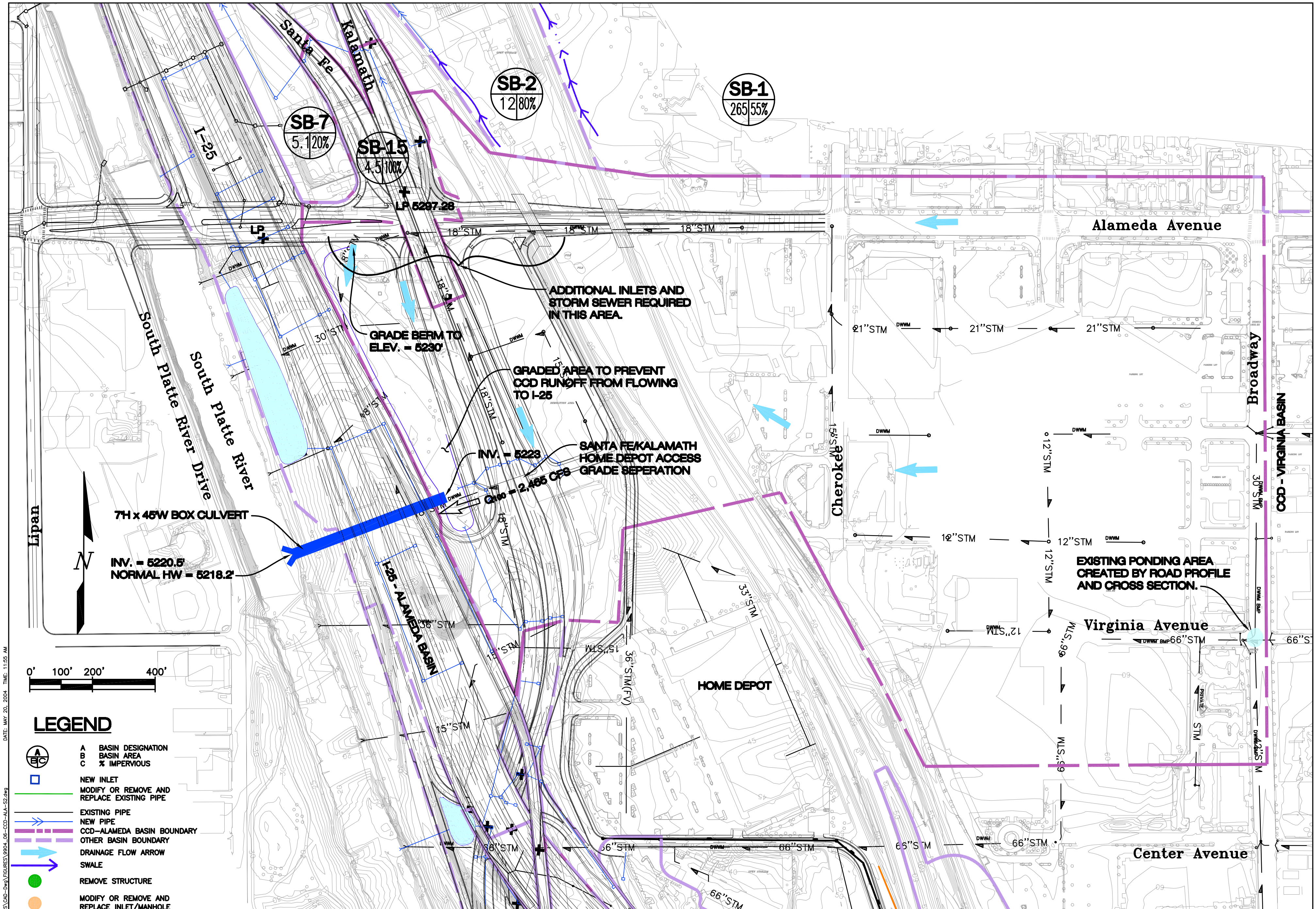
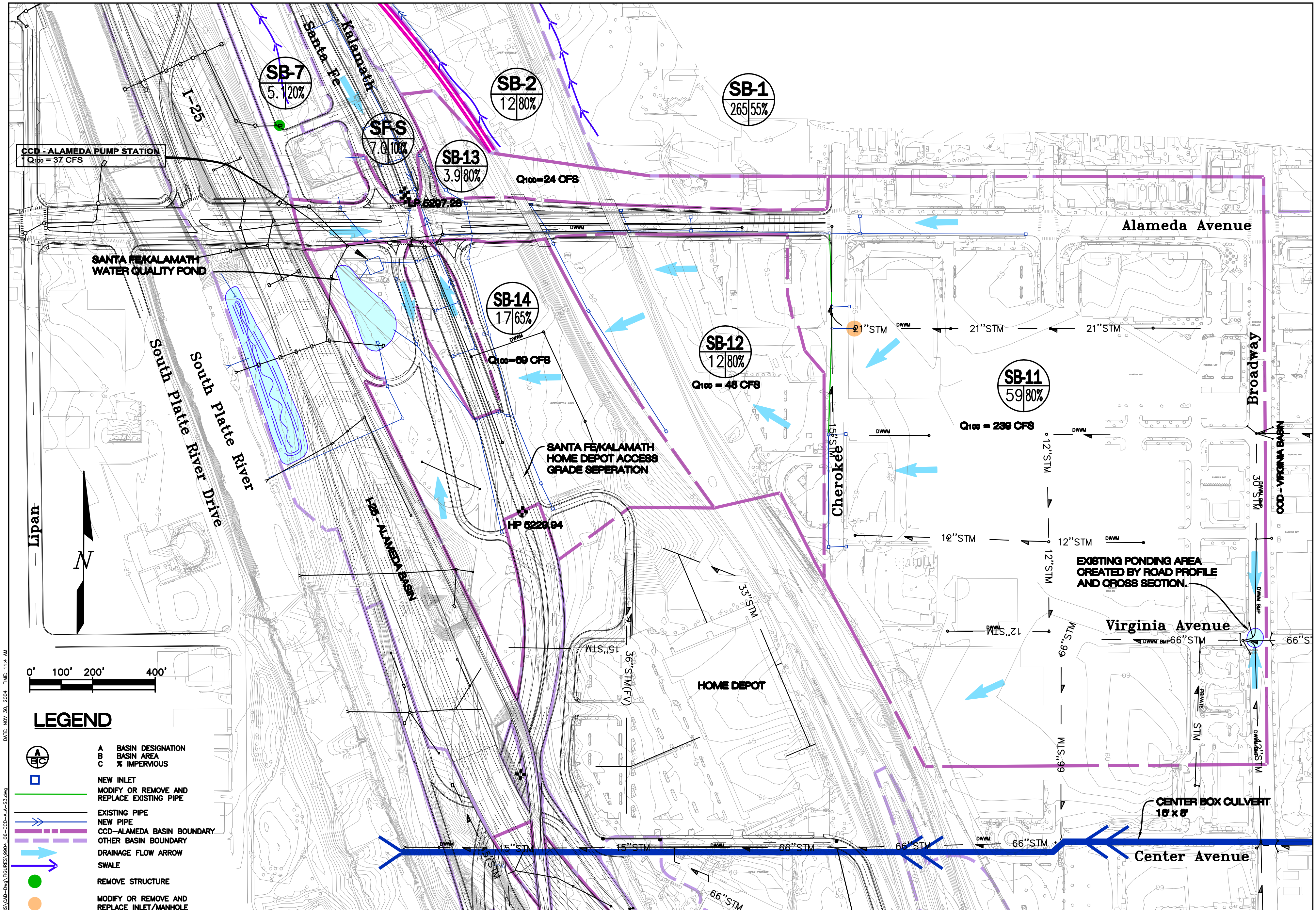


Valley Highway - Logan to 6th Ave.
Environmental Impact Statement (EIS)

SYSTEM ALTERNATIVE 2
CCD - ALAMEDA BASIN
DRAINAGE PLAN

FIGURE 7-11

NAME: P:\9904\EIS\CAD-Dwg\FIGURES\9904_06-CCD-ALA-S2.dwg DATE: MAY 20, 2004 TIME: 11:55 AM

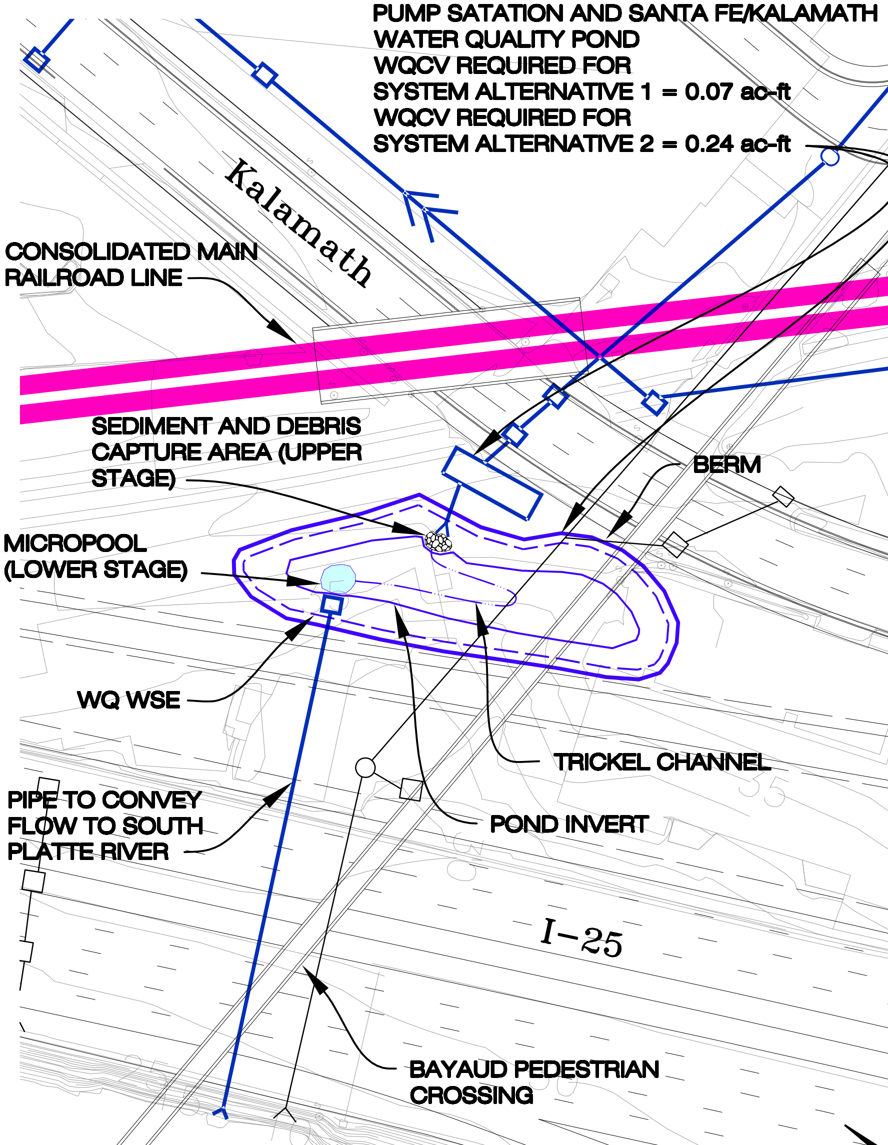


Valley Highway Logan to 6th Ave. Environmental Impact Statement (EIS)

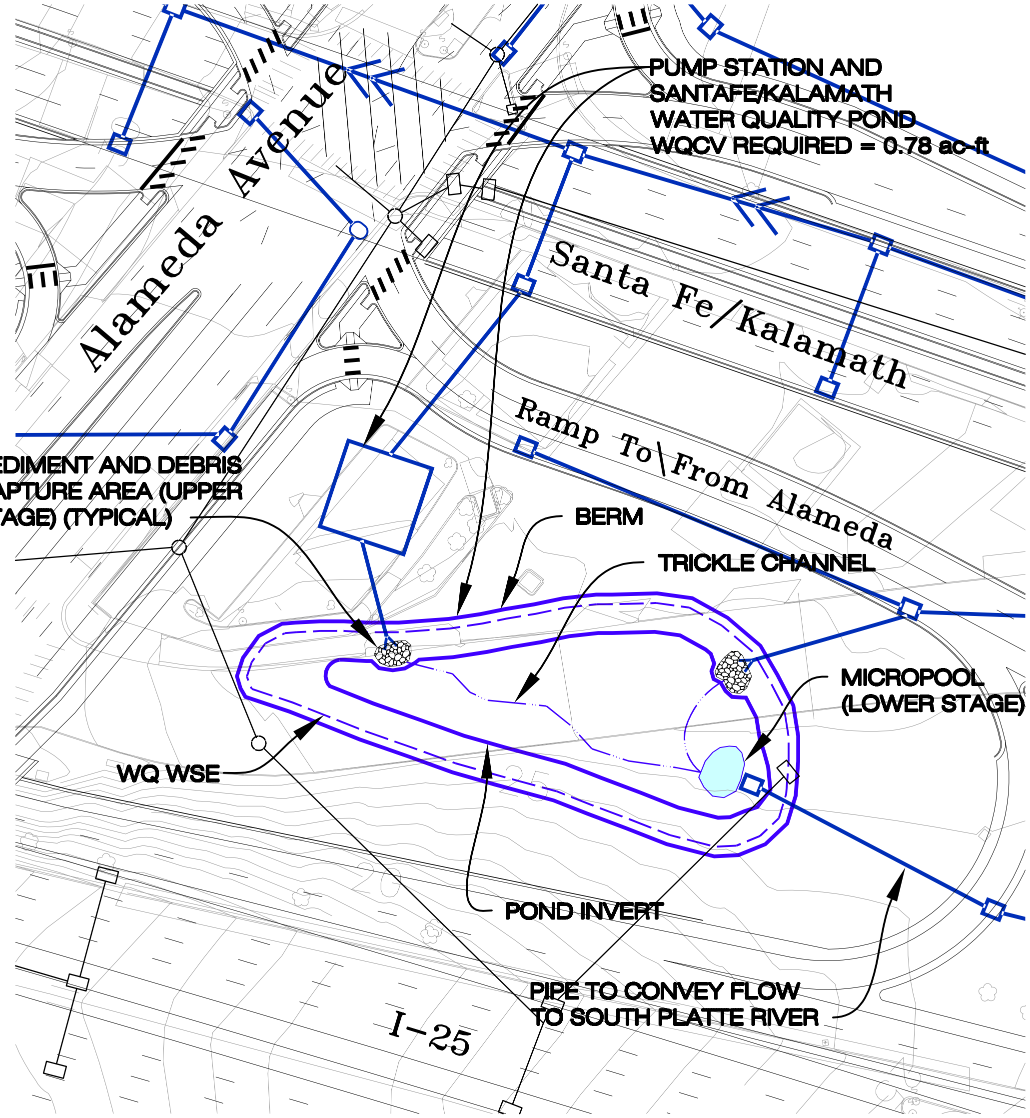
SYSTEM ALTERNATIVE 3
CCD - ALAMEDA BASIN
DRAINAGE PLAN

FIGURE
7-12

NAME: P:\9904\EIS\CAD-Dwg\FIGURES\9904_06-CCD-ALA-S3.dwg DATE: NOV 30, 2004 TIME: 11:4 AM



SYSTEM ALTERNATIVE 1 & 2
(SYSTEM ALTERNATIVE 1 SHOWN)



SYSTEM ALTERNATIVE 3

LEGEND

- NEW INLET
- TRICKLE CHANNEL
- EXISTING PIPE
- NEW PIPE

N

0' 25' 50' 100'

Valley Highway Logan to 6th Ave. Environmental Impact Statement (EIS)

SANTA FE / KALAMATH
WATER QUALITY POND

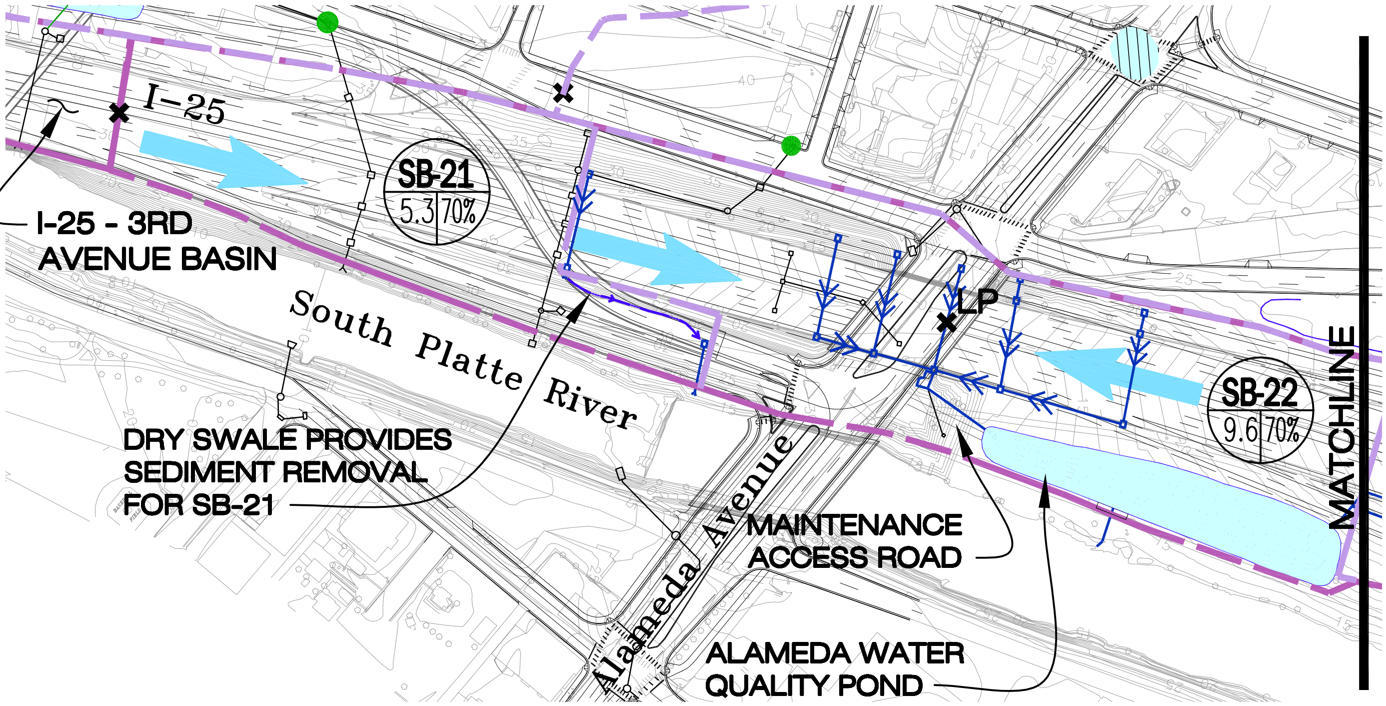
FIGURE
7-12B

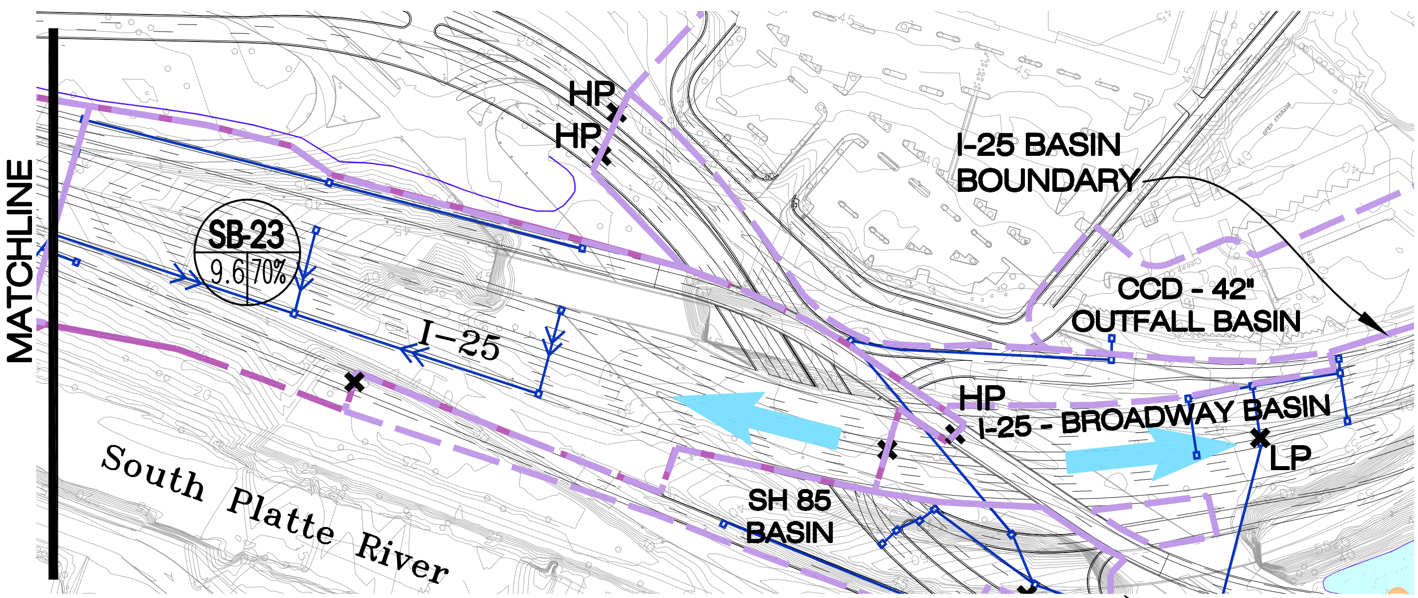
7.4 I-25 Alameda Outfall

The I-25 – Alameda Basin consists of 25 acres and is bounded by a high point near Bayaud and a high point near the limits of the Broadway Viaduct project. All system alternatives involve widening I-25 in this basin area and a small profile modification. This and the existing flooding concerns will require all existing storm sewer systems to be removed and replaced. The new storm sewer system will be designed to reduce the tributary area to the existing sump and pump station. With the new roadway profile being 2.5 feet higher at the sump, the existing pumps will have a maximum capacity of 27.5 cfs while meeting the CDOT spread width criteria. **Figure 7-13** shows the drainage improvements in this area.

The I-25 - Alameda Basin spans almost 3,400 feet from the high point on the north side to the high point on the south side and is divided into three sub-basins, SB-21, SB-22, and SB-23, depicted in **Figure 7-13**. Because of this long basin span and the low elevation of the sump under the Alameda Bridge, it is not feasible to divert all of the runoff from the north side of the bridge to the water quality pond while trying to minimize the ponding depths at the sump below the bridge. Therefore, runoff from SB-21, a 5.3-acre basin located north of Alameda, will be collected through an inlet and pipe system, and then diverted to a grass-lined dry swale. The Dry Swale, displayed in **Figure 7-13**, is approximately 230 feet long, will meet the BMP requirements, and then convey the runoff to the river. Space for the dry swale is provided in all System Alternatives with the swale terminating near the northbound on-ramp in System Alternatives 1 and 3. Sub-basin SB-23 consists of 10 acres with runoff that is collected by inlets and conveyed directly to the Alameda Water Quality Pond. The remaining runoff, approximately 25 cfs from 9.7 acres of I-25 in SB-22, will flow to the sump on I-25 under Alameda and be pumped to the water quality pond. An NPDES permit will be required for the Alameda pump station for discharge to the river. Although the planned quantity of runoff flowing to the Alameda pump station is less than the existing capacity, the pumps and station are close to 50 years old and may need to be modified or replaced. This should be decided during final design.

The required WQCV for the I-25 – Alameda Basin is 0.68 acre-feet. **Figures 7-14** and **7-15** show the plan and profile for the Alameda Water Quality Pond, which will provide the required WQCV for the basin. The volume requirements do not change for an Extended Detention Shallow Wetland or Extended Detention Pond so with final design, the type of BMP could be adjusted for current needs. Citizens expressed a desire for habitat expansion and pleasing aesthetics for the BMPs. A Shallow Wetland could meet both of these citizen desires. With a pond invert of 5221.0 and a water surface elevation of 5222.0, the provided volume is 0.72 acre-feet. There is room for expansion of the pond by expanding the pond to the south or increasing the ponding depth. With any grading work done between I-25 and the river, it is important to maintain the riverbank elevations of approximately 5228.0 to keep the floodplain in its existing location. It is also important to grade a berm between the pond and I-25 to the same or higher elevation as the berm to the river to prevent overflow runoff from re-entering the highway from the pond. An outlet structure with an overflow weir/gate is required to allow runoff in excess of the first flush volume to flow to the river. In addition, an overflow spillway is required to allow runoff to flow from the pond to the river in the 100 year storm. The schematic design depicted in **Figures 7-14** and **7-15** shows the minimum pond elevation to optimize the existing pumps and allow the discharge to be above the 10 year water surface elevation. With final design of this area, it may be more desirable to raise the pond elevation. Doing so would increase the runoff to the I-25 sump and, possibly, require additional or upsized pumps to remove the runoff from the highway.

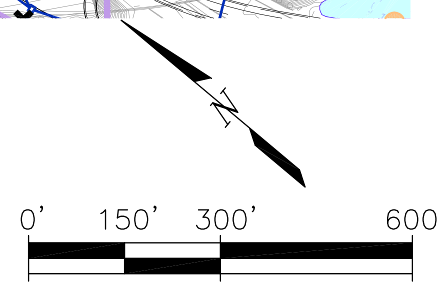




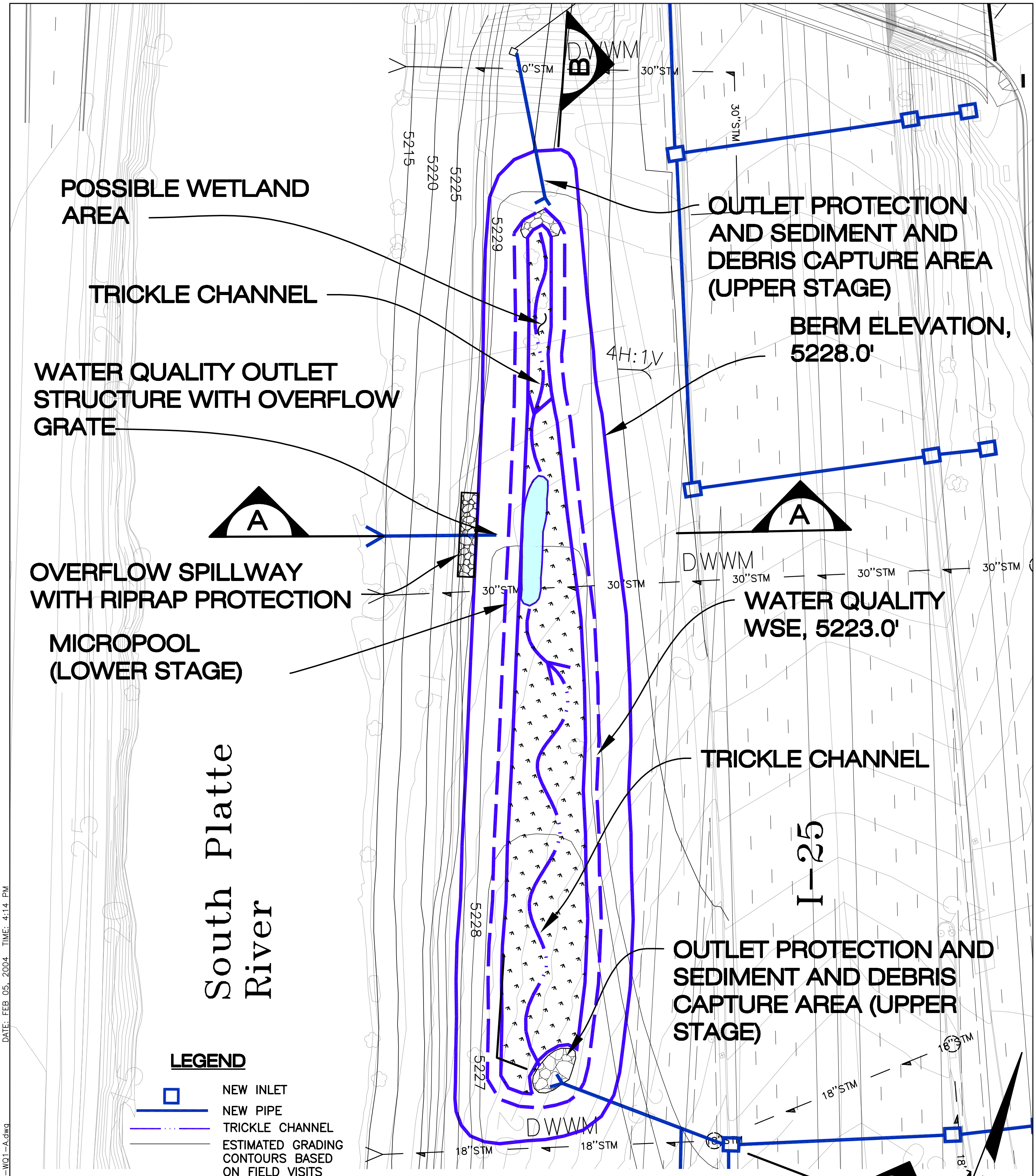
LEGEND

- A BASIN DESIGNATION
- B BASIN AREA
- C % IMPERVIOUS
- NEW INLET
- EXISTING PIPE
- NEW PIPE
- I-25 ALAMEDA BASIN BOUNDARY
- ALAMEDA SUB BASIN BOUNDARIES
- OTHER BASIN BOUNDARY
- DRAINAGE FLOW ARROW
- SWALE

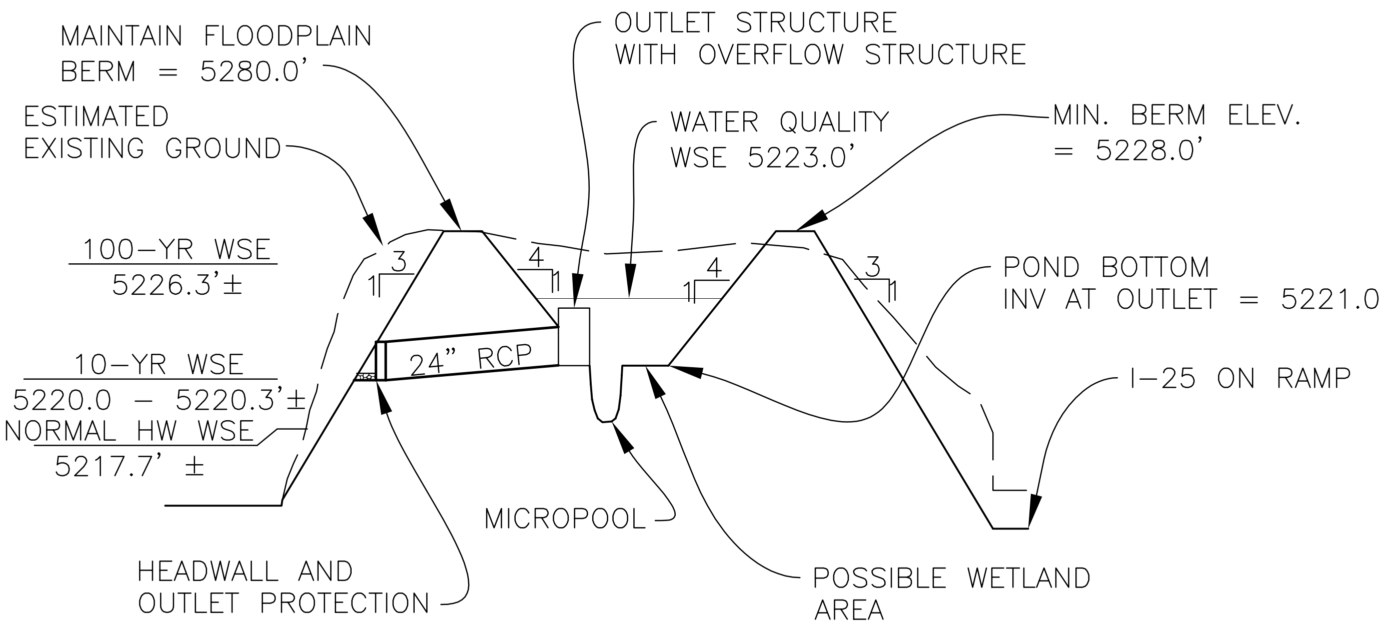
NOTE:
ALL EXISTING STORM SEWERS AND INLETS SHOULD BE REMOVED WITH PROJECT CONSTRUCTION.



SYSTEM ALTERNATIVE 1, 2,& 3 (SYSTEM 1 SHOWN)
I-25 ALAMEDA DRAINAGE PLAN

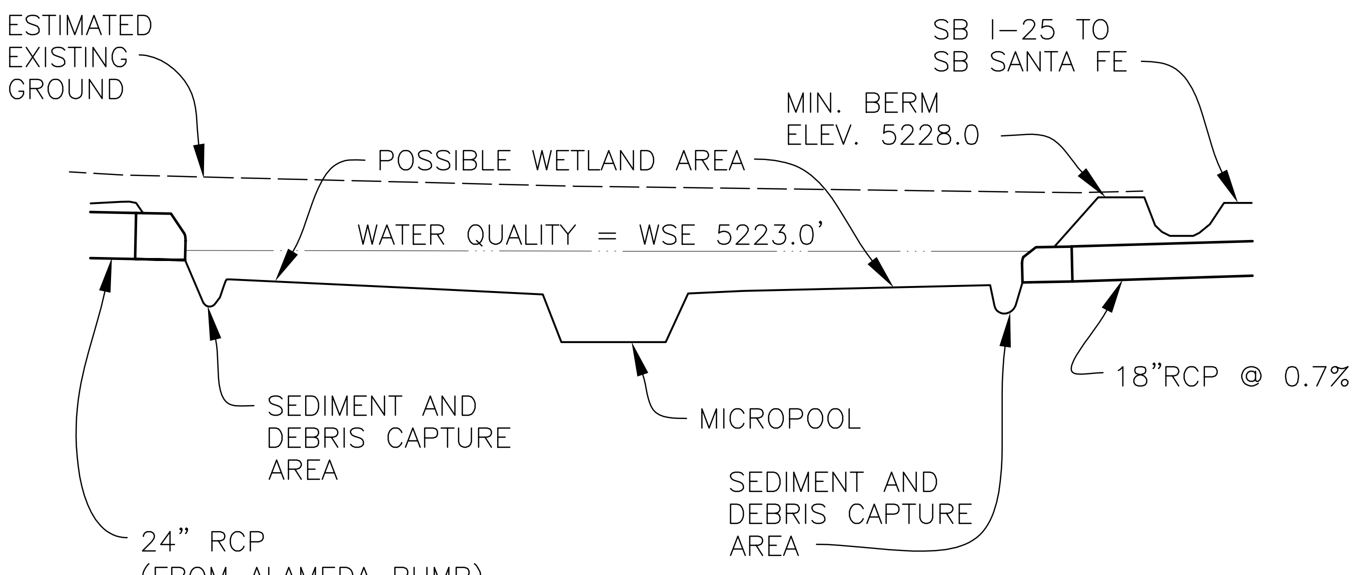


SYSTEM ALTERNATIVE 1, 2,& 3 (SYSTEM 1 SHOWN)
I-25 ALAMEDA BASIN
WATER QUALITY POND



SECTION A

SCALE: 1" = 50' HORIZ., 1" = 10' VERT.



SECTION B

SCALE: 1" = 100' HORIZ., 1" = 10' VERT.

NOTE:
EXISTING SURVEY NOT SHOWN.
SURVEY AVAILABLE AT TIME OF
REPORT WAS INACCURATE.

I-25 ALAMEDA BASIN WATER QUALITY POND

Valley Highway - Logan to 6th Ave.
Environmental Impact Statement (EIS)

FIGURE
7-15

NAME: P:\9904\EIS\CAD-Dwg\FIGURES\9904_06-ALA-WQ1.dwg DATE: MAY 20, 2004 TIME: 9:42 AM

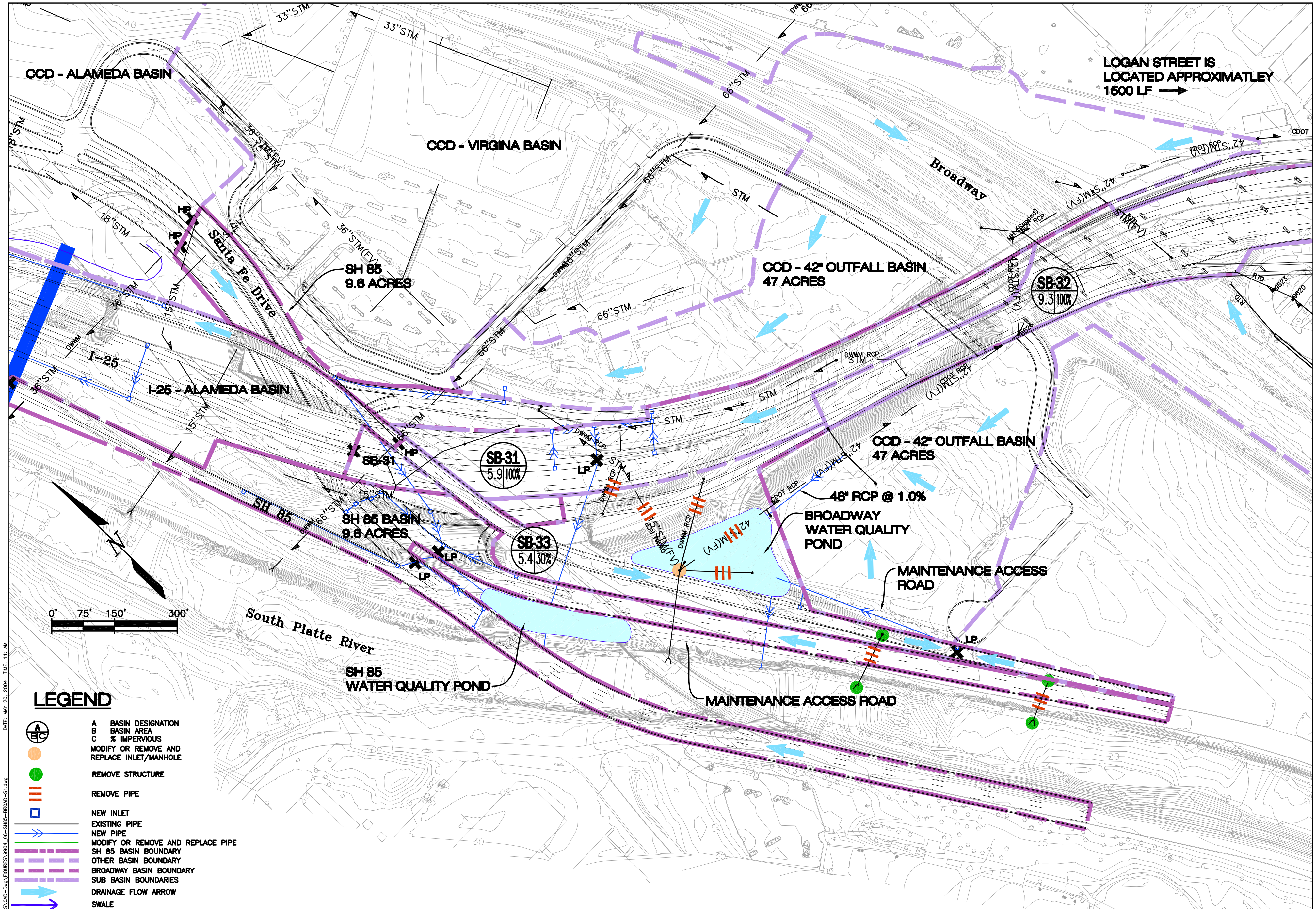
7.5 SH 85 Outfall Area

Immediately south of the I-25 Alameda Basin, SH 85 crosses beneath I-25. The exact location of the sump on SH 85 changes for the three system alternatives. A BMP is required for this basin which is to be located near the sump area. **Figure 7-16** shows the area for the SH 85 and I-25 – Broadway Basins for System Alternative 1. The basins and area for System Alternatives 2 and 3 are similar to those for System Alternative 1. **Appendix C** contains a detailed chart of the sub-basin differences in this area.

For the three system alternatives, all runoff from the SH 85 Basin will flow to the sump and be collected by inlets and conveyed through a small storm sewer system to the SH 85 Water Quality Pond. Runoff from the I-25 – Broadway Sub-basin SB-31 will also be collected and conveyed to this pond. This will reduce the required WQCV for the Broadway Water Quality Pond by approximately 11%. Several existing storm sewers that convey runoff from SB-31 to the 42" Outfall would have to be removed with a new storm sewer system installed for both SB-31 and SH 85 Basin. The stormwater runoff for this area has a similar drainage pattern, but the location of the storm sewers vary between alternatives, based upon the location of the sump on SH 85 and the SH 85 Water Quality Pond. **Figure 7-16** shows the storm sewer configuration for System Alternative 1 while **Figure 7-19** shows the configuration for the other two alternatives.

For System Alternative 1, the SH 85 Water Quality Pond is located in the open space between northbound Santa Fe and southbound Santa Fe, immediately east of the South Platte River. **Figure 7-17** shows the plan for this pond while **Figure 7-18** shows the cross-sections. This location is desired because it reduces conflicts with the existing utilities including the 66" brick storm sewer that runs beneath the Santa Fe sump area. In addition, the location avoids the planned CCD Center Box Culvert. With the low points of Santa Fe located south of the 66" storm sewer and planned box, constructing a water quality pond on the opposite side of the storm sewer would require diverting the runoff from the sump in SH 85 either over or under the 66" storm sewer and planned box. The existing elevations of the sewer and the proposed elevations of the road preclude this. At the proposed location, the pond provides 100 % of the WQCV for the SH 85 Basin without interfering with the existing and planned storm sewers. In addition, adequate volume is available for approximately 11% of the WQCV for the I-25-Broadway Basin, as discussed in the following sections of this report. As with the I-25 Alameda Water Quality Pond, it is important to maintain the FEMA floodplain berm at approximately 5229.0 and to ensure that excess runoff will flow to the river and not back to the roadways. An overflow structure and spillway is required for this pond as well.

System Alternatives 2 and 3 vary from System Alternative 1 in the configuration of the sump on SH 85 and the ramps. The sump on SH 85 for System Alternatives 2 and 3 is located north of the 66" storm sewer. For the same reasons as in System Alternative 1, the BMP must be located on the same side of the storm sewer as the sumps, or for System Alternatives 2 and 3, on the north side. **Figure 7-19** shows the location of the pond for System Alternatives 2 and 3. This pond will also provide 100% of the WQCV for SH 85 Basin and approximately 11% of the WQCV for the I-25 Broadway Basin.

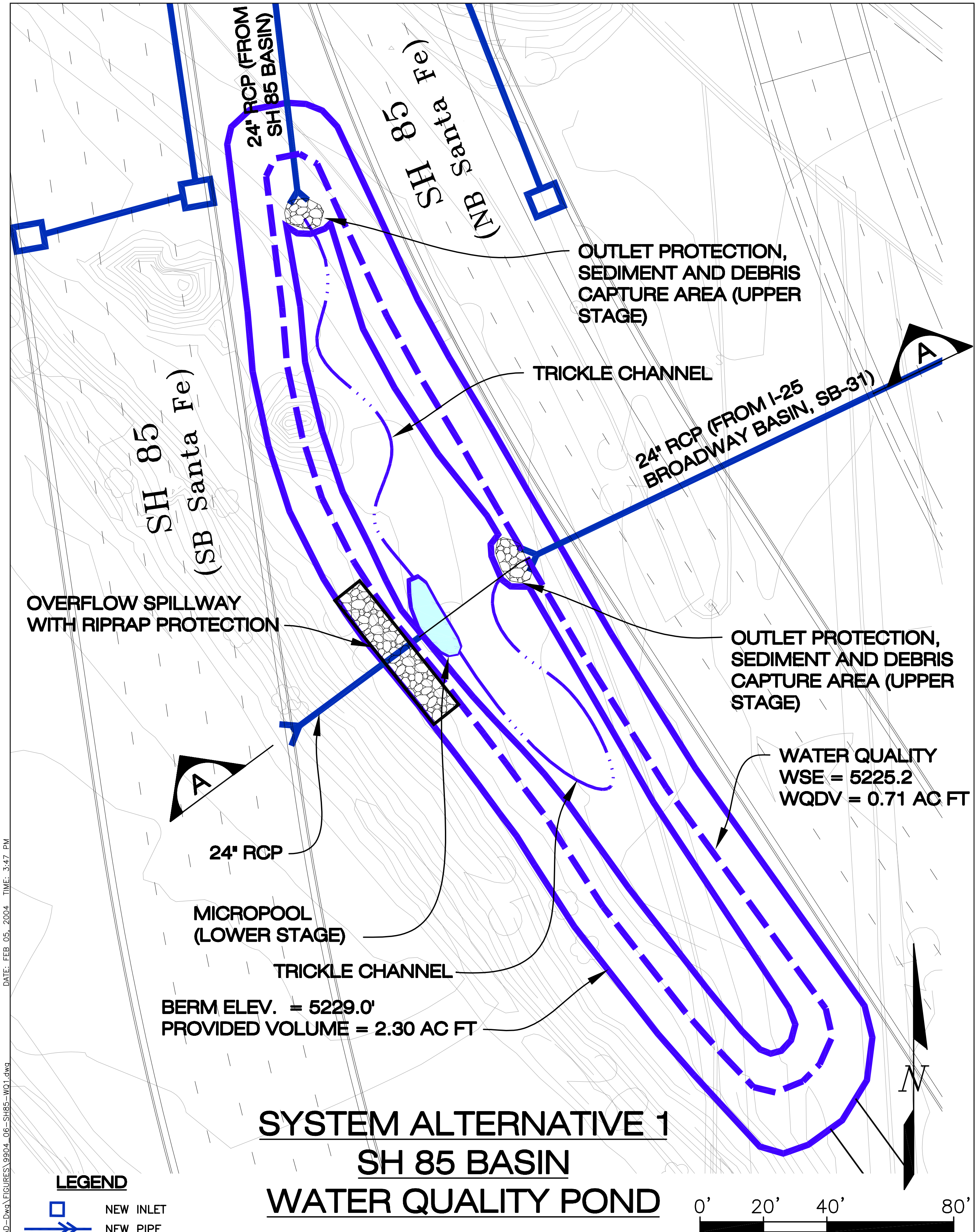


LEGEND

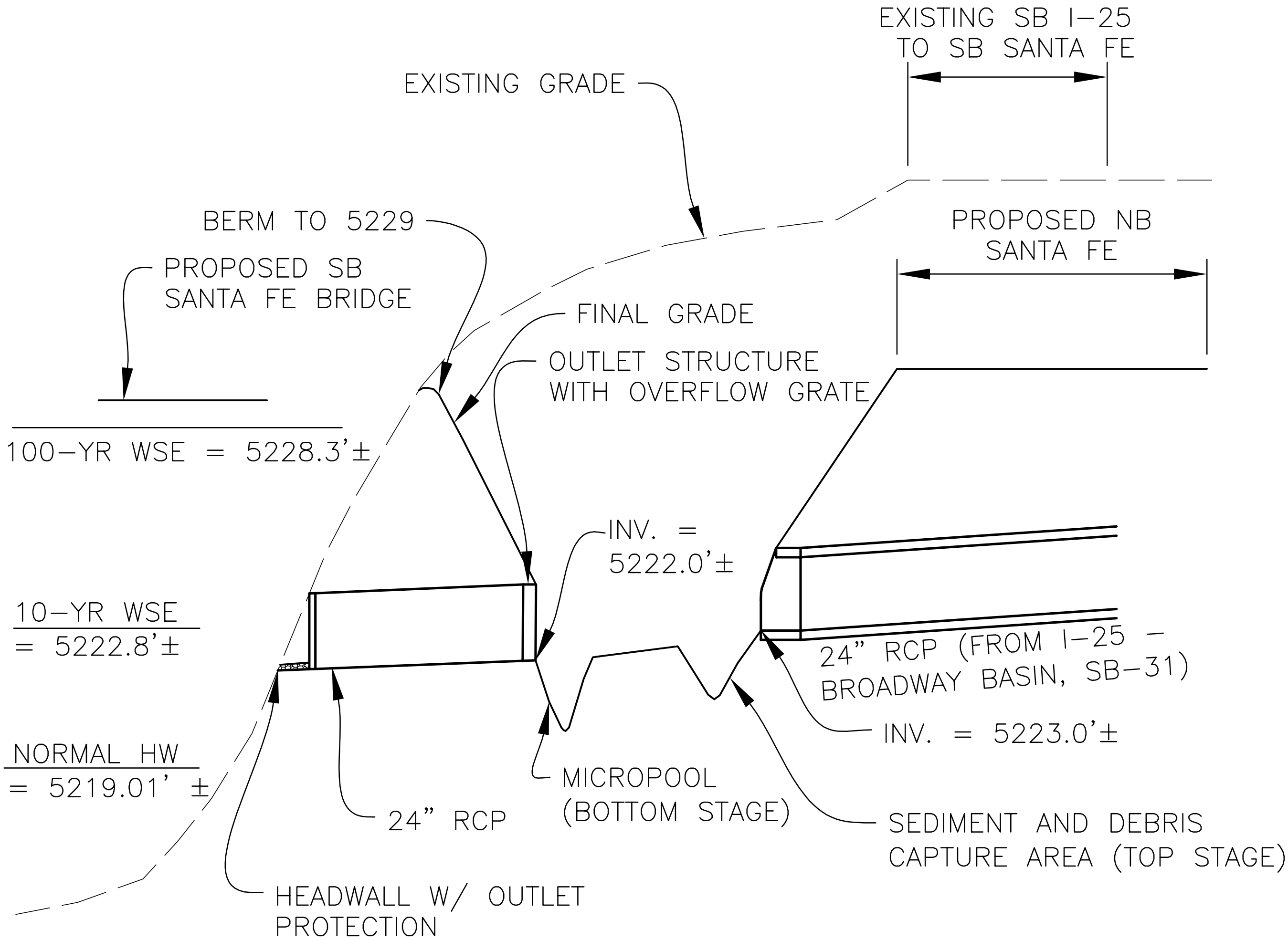
- A BASIN DESIGNATION
- B BASIN AREA
- C % IMPERVIOUS
- MODIFY OR REMOVE AND REPLACE INLET/MANHOLE
- REMOVE STRUCTURE
- REMOVE PIPE
- NEW INLET
- EXISTING PIPE
- NEW PIPE
- MODIFY OR REMOVE AND REPLACE PIPE
- SH 85 BASIN BOUNDARY
- OTHER BASIN BOUNDARY
- BROADWAY BASIN BOUNDARY
- SUB BASIN BOUNDARIES
- DRAINAGE FLOW ARROW
- SWALE

SYSTEM ALTERNATIVE 1
SH 85 & BROADWAY BASINS
DRAINAGE PLAN

FIGURE 7-16



SYSTEM ALTERNATIVE 1
SH 85 BASIN
WATER QUALITY POND



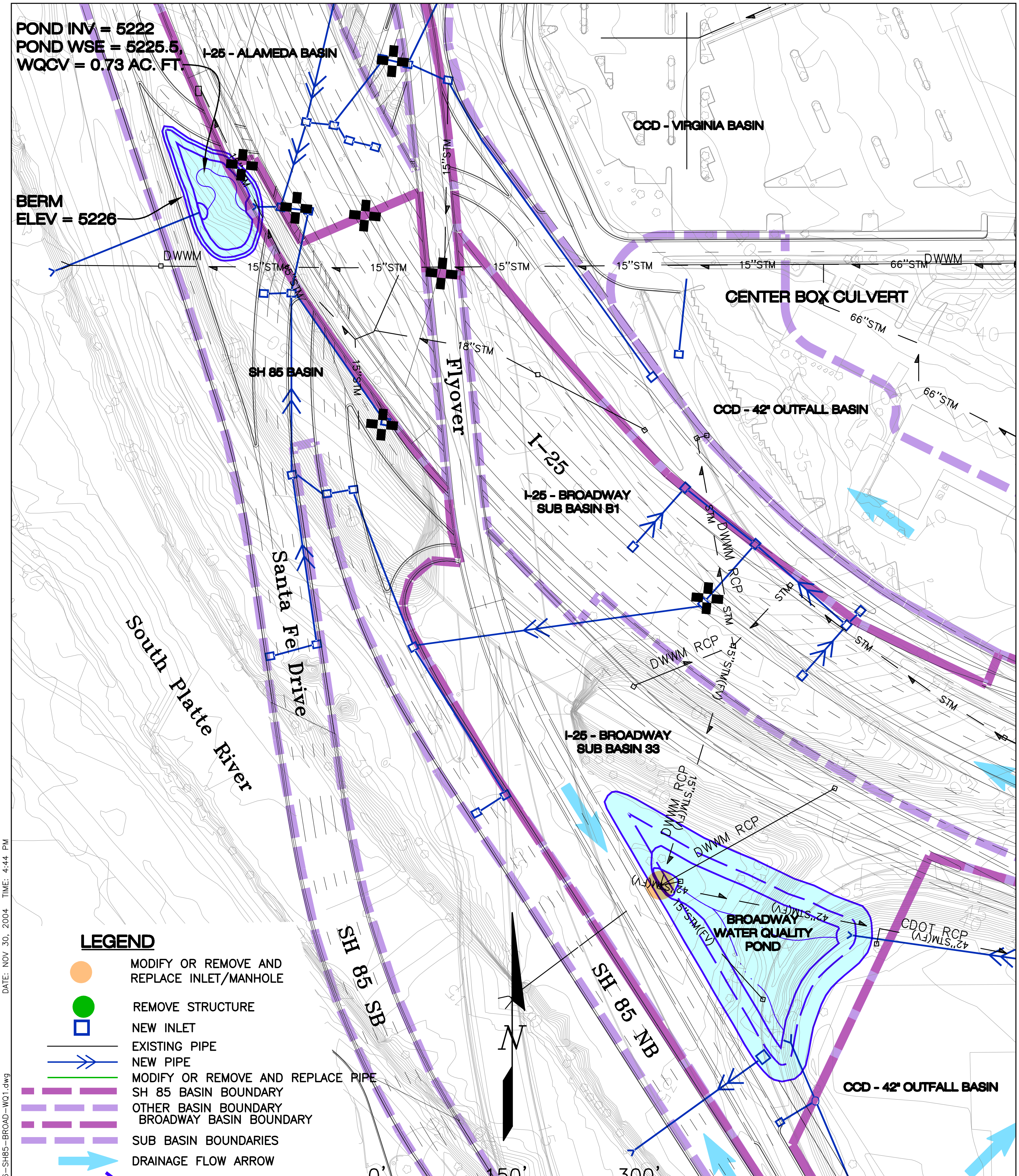
SECTION A

SCALE: 1" = 30' HORIZ., 1" = 5' VERT.

SYSTEM ALTERNATIVE 1
SH 85 BASIN
WATER QUALITY POND

Valley Highway - Logan to 6th Ave.
Environmental Impact Statement (EIS)

FIGURE
7-18



SYSTEM ALTERNATIVE 2,& 3 (SYSTEM 2 SHOWN)
SH 85 WATER QUALITY POND

Valley Highway - Logan to 6th Ave.
Environmental Impact Statement (EIS)

FIGURE
7-19

NAME: P:\9904\EIS\CAD-Dwg\FIGURES\9904_06-SH85-BROAD-WQ1.dwg DATE: NOV 30, 2004 TIME: 4:44 PM

7.6 I-25 – Broadway Area

The area described by the I-25 Broadway Outfall consists of the remaining project corridor from the I-25 Alameda and SH 85 Basins southern boundaries to the I-25 underpass of Logan Street. **Figure 7-16** depicts this area.

7.6.1 I-25 – Broadway Basin and CCD – 42" Outfall Basin

All three of the system alternatives show the removal and relocation of the NB SH 85 to SB I-25 ramp, which will provide approximately 1.0 acre of land that will be devoted to the Broadway Water Quality Pond. The existing 42" Outfall is in this area has several tributary pipes. With the smaller tributary pipes being diverted to the SH 85 Water Quality Pond, the remaining runoff in the 42" pipe can be routed through the Broadway Water Quality Pond, using the existing 42" Outfall to the South Platte River as the pond outfall. Due to the differences in the SH 85 pond location and elevations, there are some differences in the Broadway area, but they all follow the same principles. The local storm sewers tributary to the 42" Outfall, other than those serving SB-31, will remain in place.

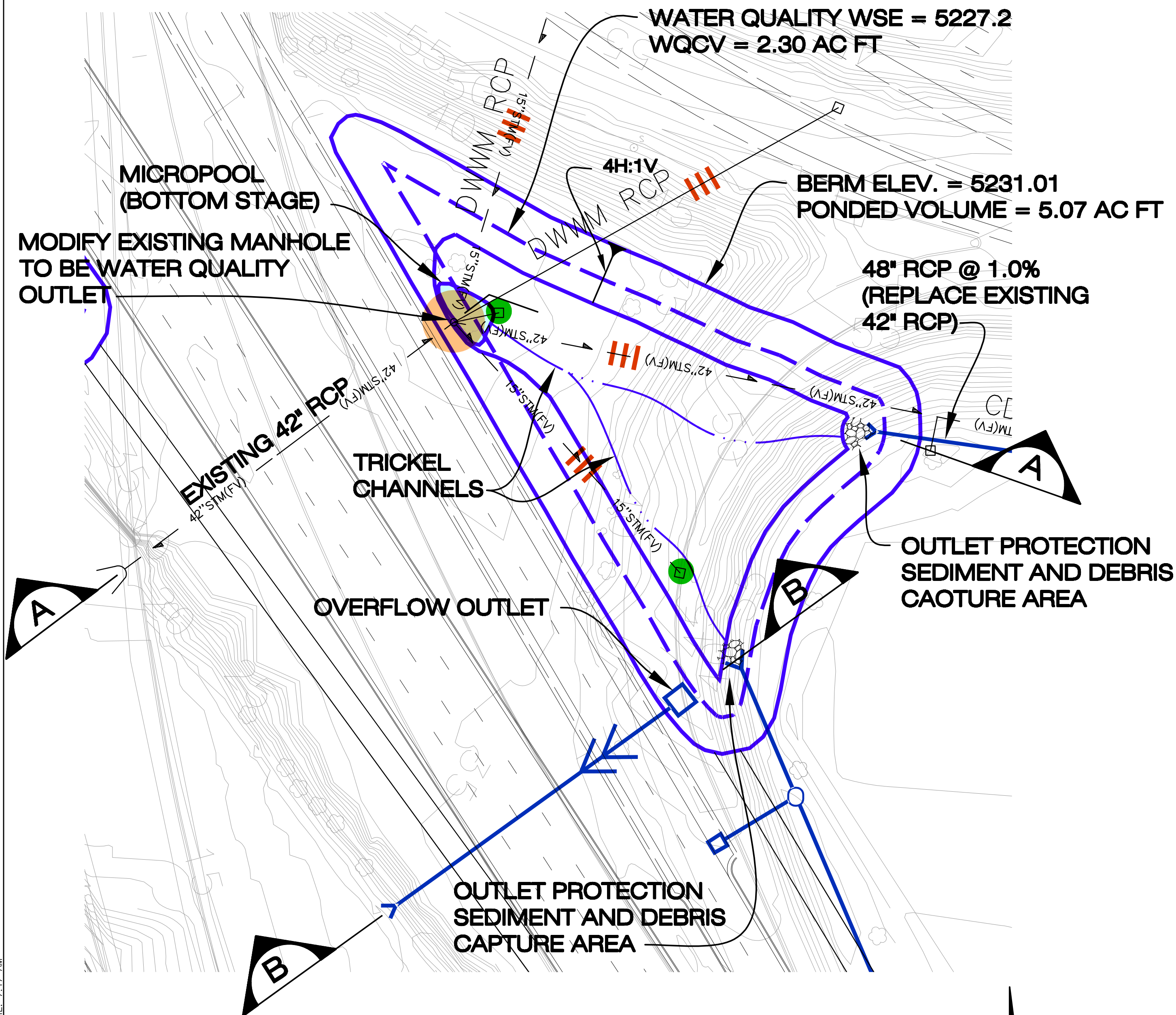
The required WQCV for the I-25 – Broadway Basin is approximately 0.67 acre-feet, which includes 0.26 acre-feet required by SB-31, shown in **Figure 7-16**. The CCD – 42" Outfall Basin requires 1.74 acre-feet of WQCV. Even though CDOT is not responsible for the WQCV for the CCD – 42" Outfall Basin, because runoff from that basin is combined with runoff from the I-25 – Broadway Basin, adequate WQCV will be provided for the entire area. If the 0.26 acre-feet (11%) of WQCV for SB-31 is provided in the SH 85 Water Quality Pond, a total of 2.15 acre-feet is required for the Broadway Water Quality Pond. Diverting the flow from SB-31 can be achieved by removing the 15" and 21" pipes that are tributary to the 42" Outfall and then constructing a new system which outfalls into the SH 85 pond, as described above and shown in **Figures 7-16** and **7-19**. In addition to removing these pipes, approximately 500 LF of the remaining 42" pipe will be removed and replaced with approximately 250 LF of 48" pipe at a 1.0% slope from the manhole located to the south of I-25 and to the east side of the Broadway Water Quality Pond. **Figure 7-16** shows this location. The existing 42" pipe is at a slope of 1.6% and terminates at the manhole in the pond at an elevation of 5219.7'. Reducing the elevation of this pipe will raise the pipe invert and allow it to outfall into the pond at an approximate elevation of 5223.6'. The 42" must be replaced with a greater diameter pipe due to the reduced capacity at a lesser slope. The pond can then be built with an invert elevation of approximately 5222.0' at the outlet. At this elevation, the pond will be above the normal high WSE of 5220.2 at the South Platte River and approximately 6 feet higher than the existing groundwater table. A plan view showing the location of the pond is provided in **Figure 7-20**. **Figure 7-21** shows a detail of the pond layout.

The existing 42" storm sewer outfall can be used as an outfall for the water quality pond. The existing upstream invert of the pipe can remain at the current elevation of 5219.7, leaving the pond invert 2.3' above the upstream invert of the outfall. The existing outfall pipe has the capacity to convey approximately 61 cfs of flow. It is estimated that approximately 123 cfs will be draining into the pond from the I-25 – Broadway and CCD – 42" Basins. To convey the additional 62 cfs of flow, an additional overflow system will be required. The southwest corner of the pond provides a good location for this system. At this location, the proposed northbound SH 85 alignment is higher allowing more vertical clearance for the pipe to run beneath the road. The pipe can be placed at a slope of 0.5% with an upstream invert elevation of 5225.8'± and an outfall elevation of 5225.0'±. The overflow elevation of the structure will be a 5230.0'±. A profile showing this design is provided in **Figure 7-21**. The combined overflow structures at the existing 42" Outfall and the new one must discharge runoff at the same (or greater) rate as it enters the pond to prevent the pond from filling and flooding local parcels.

7.6.2 Other Broadway Area Basins

No changes will be made to the I-25 T-REX Basin as the runoff for that area has been accounted for in the design of the T-REX Box Culvert in Mississippi Avenue. The runoff from the I-25 – T-REX Basin accounts for only a small percentage of the total runoff in the T-REX Box Culvert. Roadway and transit improvements in this area and the close proximity to residential areas prohibit implementation of a BMP for this basin.

For System Alternative 2, the Broadway Tunnel Basin is located along the proposed tunnel from SB Broadway to SB I-25 and consists of 1.3 acres of roadway with 6.4 cfs in the 100 year storm event. Two roadway highpoints located north and south of the tunnel create this basin with the sump located at the northern end of the tunnel. Two vane-grate inlets will collect the runoff and meet CCD and CDOT criteria where it will be conveyed to the existing 42" Outfall. **Figure 7-22** shows three options for possible connections to the existing 42" Outfall in plan view. The grate elevation of the inlet is lower than any manhole rim on the 42" Outfall from the inlet to the river. When the 42" Outfall exceeds its capacity, it is possible that stormwater could bubble out, or flood the new inlet. The installation of a flap gate would be required at the manhole connection to the 42" Outfall to reduce the potential for flooding due to backwater effects of stormwater surcharge in the 42" Outfall. There may be times when the amount of water in the 42" Outfall would restrict the outflow of stormwater from the Broadway Tunnel sump inlet. In these cases, localized flooding would occur. The maximum flooding depth before the flood ponding can spill is 18 feet.



LEGEND

☐	NEW INLET
→→	NEW PIPE
—	EXISTING PIPE
—··—	TRICKEL CHANNEL
● (orange)	MODIFY OR REMOVE AND REPLACE INLET/MANHOLE
● (green)	REMOVE STRUCTURE
III	REMOVE PIPE

BROADWAY
WATER QUALITY POND

N

0' 40' 80' 160'

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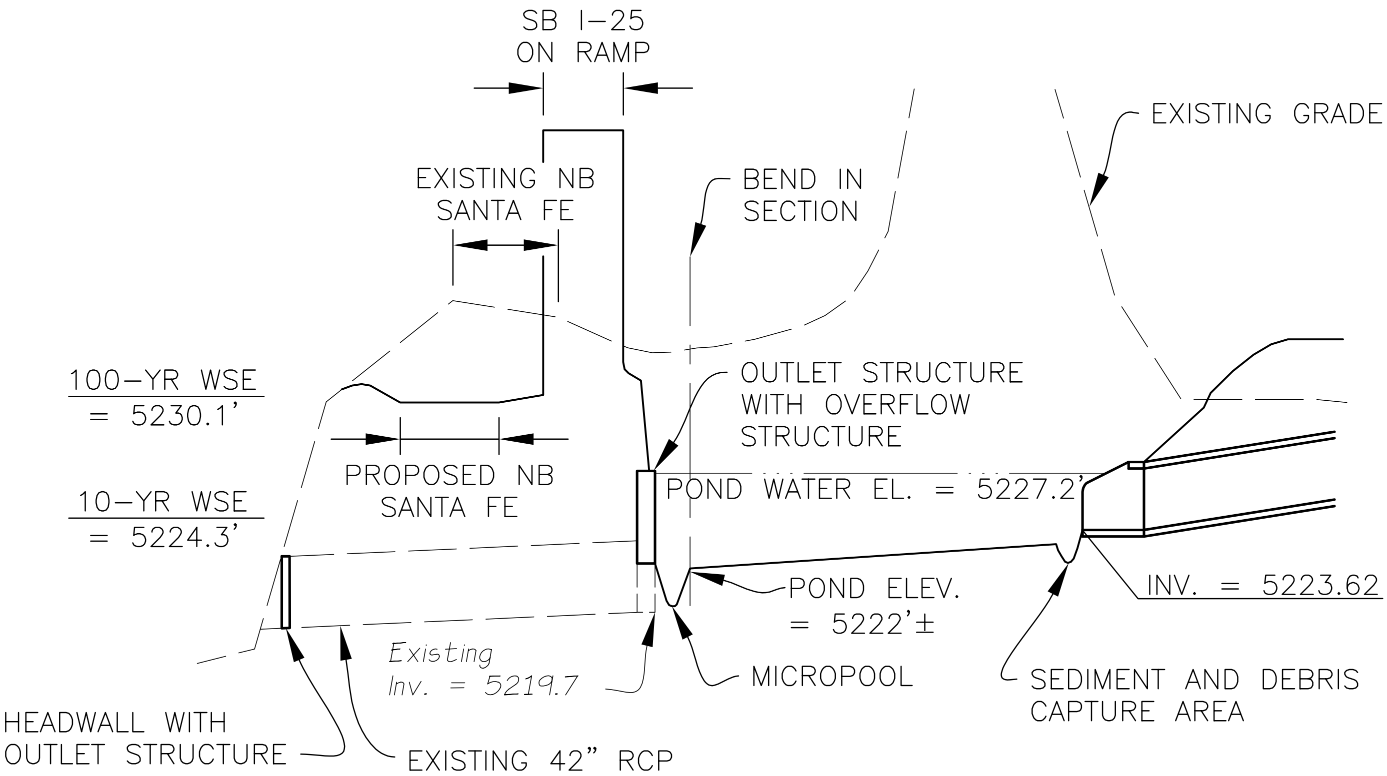
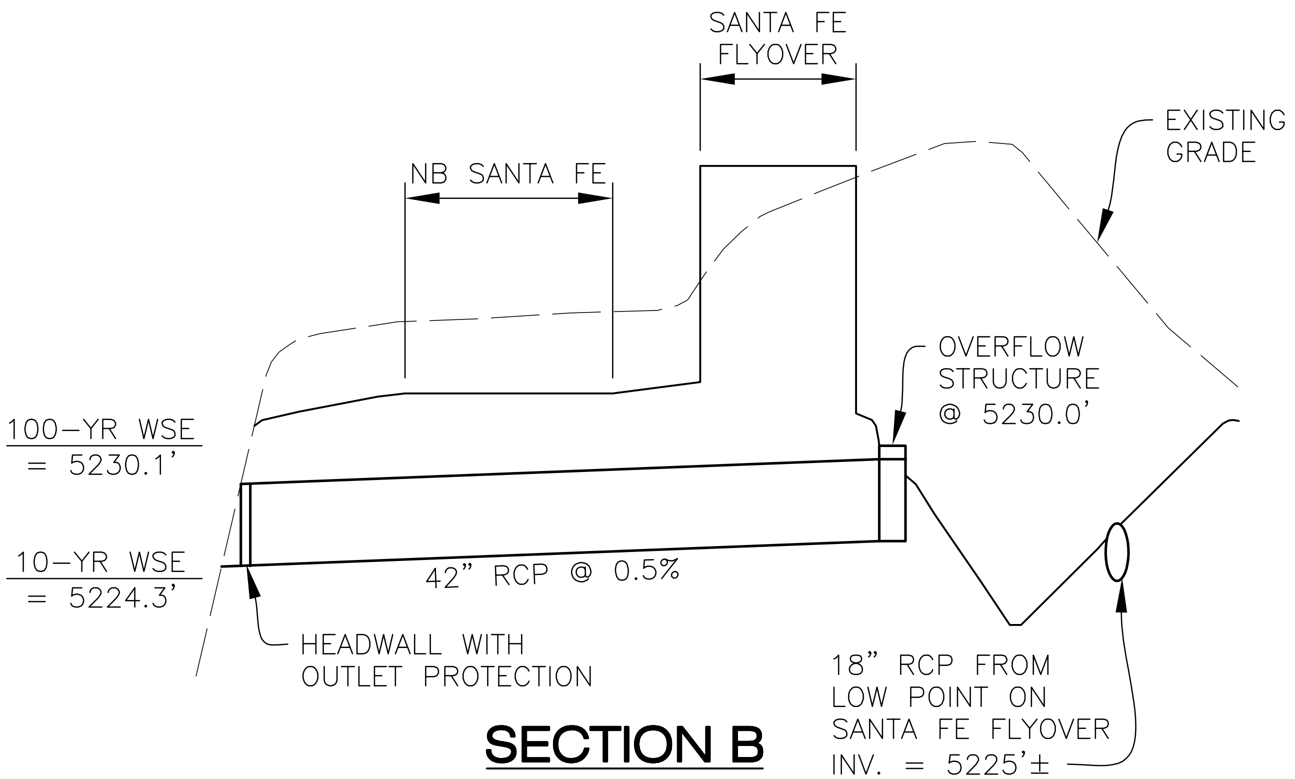
Valley Highway - Logan to 6th Ave. Environmental Impact Statement (EIS)

FIGURE
7-20



SECTION A

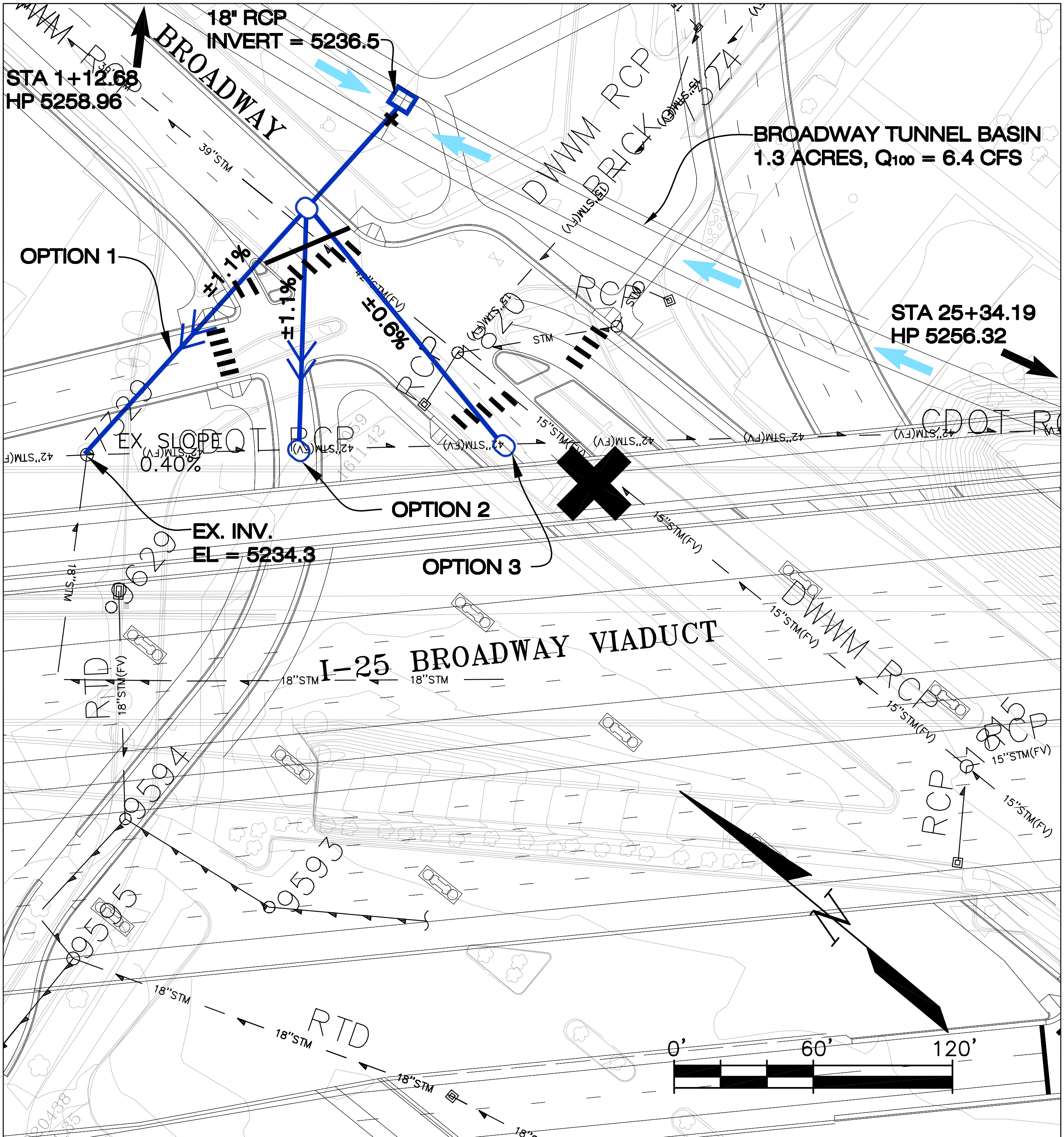
SCALE: 1" = 100' HORIZ., 1" = 10' VERT.



SECTION B

SCALE: 1" = 50' HORIZ., 1" = 10' VERT.

BROADWAY
WATER QUALITY POND



NOTE:
MANY UTILITIES EXIST IN BROADWAY THAT MAY CONFLICT WITH STORM SEWER IMPROVEMENTS.

LEGEND

- NEW INLET
- NEW PIPE
- EXISTING PIPE
- DRAINAGE FLOW ARROW

SYSTEM ALTERNATIVES 2 & 3
CCD - BROADWAY TUNNEL BASIN
DRAINAGE PLAN

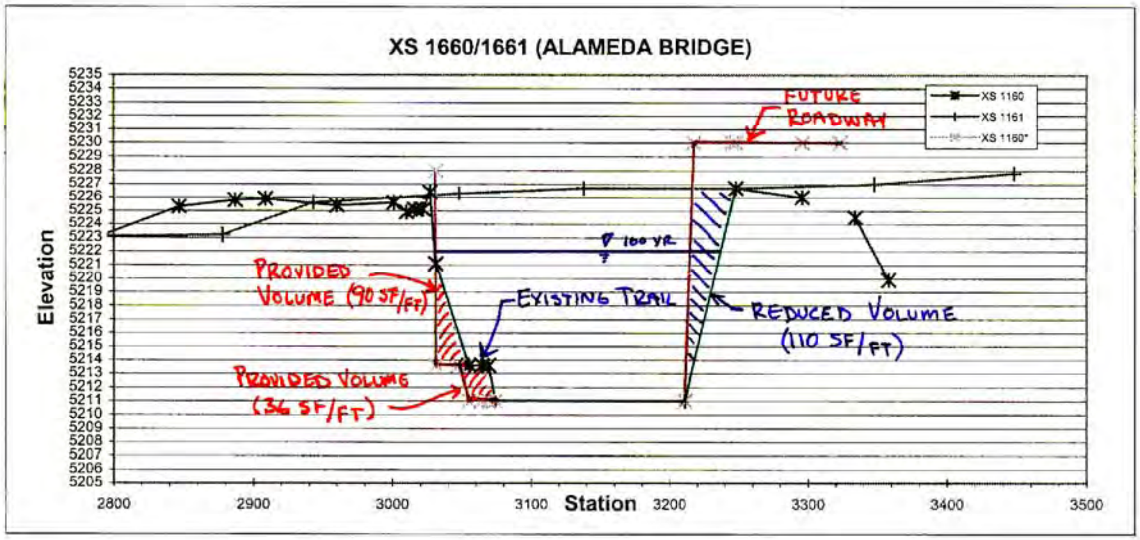
8.0 FLOODPLAIN IMPACTS

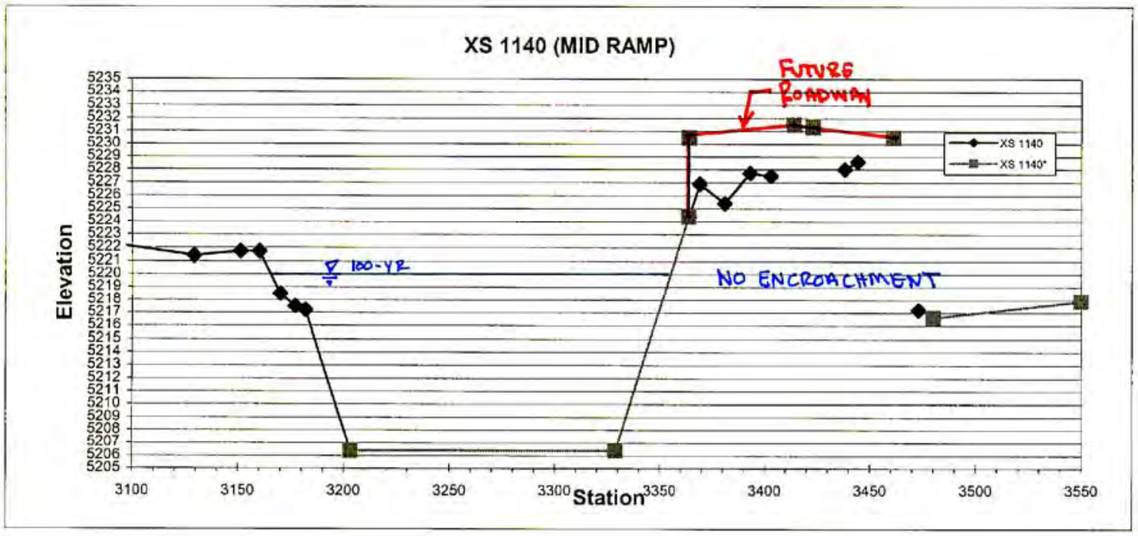
The South Platte River is an important resource for the Denver Metro Area. Not only does it provide drinking water and industry uses, but is also supports a range of warm water aquatic life and numerous recreation opportunities. The 100-year flow rate for this stretch of the river is 19,000 cubic feet per second.

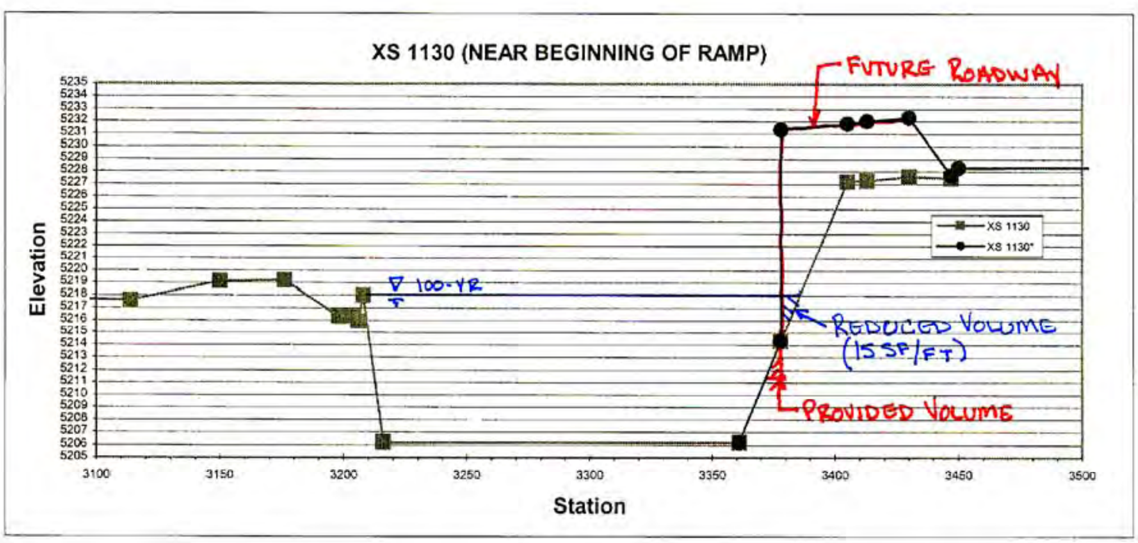
There are several impacts to the South Platte River Floodplain due to the construction of the system alternatives. The first and largest impact is the reconstruction of the US 6 Bridge. When replaced, the US 6 Bridge will provide the required freeboard above the 100-year water surface elevation of the South Platte River and will reduce the rise in the floodplain caused by the existing bridge configuration. The existing floodplain crosses over the existing bridge, but with the construction of the new bridge, this will not occur. As shown on the Major Drainageway Planning Study, there will be no negative impacts to the river corridor or floodplain if the US 6 Bridge is removed from the floodplain (Wright 1985). It is important to note that all designs occurring within the FEMA floodplain should meet requirements set forth in the FHWA "Non-regulatory supplement 23 CFR 650 A" which can be found at http://www.fhwa.dot.gov/legsregs/directives/fapg/0650asul.htm.

Additional floodplain impacts occur near Alameda Avenue and SH 85 at the bridge replacements. System Alternatives 1 and 3 have ramps and roads north of Alameda Avenue that protrude into the floodplain. The volume of conveyance area that these ramps remove from the channel is approximately 175 cubic yards, which can be cut from the channel bank so that there is no rise in the floodplain. Adequate volume can be provided on the west side of the river near the bridge and on the east side along the ramps. **Figure 8-1** shows a revised FEMA cross-section to show the project impacts. Final design should take a more detailed look at hydraulics to ensure that there is no rise since this is a floodway encroachment. Should a rise be discovered, there are several design modifications that could be made to the bridge area. The bridge could be designed to be longer, which would have less of an impact on the channel. In addition, the ramps at Alameda could also be on piers, or built in with the bridge to reduce impact to the river. The SH 85 and Alameda Bridge will be replaced with the project, but they should not negatively impact the floodplain. Similarly, SH 85 ramps on the west side of I-25 protrude into the floodplain. The ramps do not impact the main channel of the river, but only a portion of the overbank area. Therefore, it seems that additional flow capacity in the overbank can be provided in this area to account for the new ramp locations and to ensure no rise, or allowable rise in the floodplain. This should also be examined in greater detail during final design.

As previously mentioned, there are several areas where localized flooding occurs. The areas that have a ponding depth of 18 inches or more in the 100-year storm event have been identified as "Potential Ponding Areas" in the Denver *Storm Drainage Master Plan Phase I Final,* (Matrix 2003). The storm sewer improvements associated with the alternatives will not worsen these conditions, and may in fact reduce the localized flooding.







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Valley Highway - Logan to 6th Ave. Environmental Impact Statement (EIS)

FIGURE

8-1

9.0 UTILITIES

Existing utilities are rampant in the project corridor. There are underground and aboveground electric and telephone lines, fiber optic, gas, sanitary, storm sewer, and water lines. Proposed storm sewer improvements are for planning purposes only and can be moved with final design. Care should be taken to disrupt as few utilities as possible, both with final design and during construction. Because sanitary sewer lines usually flow by gravity, the greatest utility concern is the 46" sanitary sewer that runs to the east of, and parallel to I-25 and SH 85 from Mississippi to Alameda. This utility line, as well as others, crosses several improvements including the Center Box Culvert and the roadway for the grade separation of Santa Fe and Alameda. It is inadvisable to add lift stations or disrupt gravity flow in this and all other storm and sanitary sewer lines; however, it is anticipated that the 46" sanitary sewer, and many others are deep enough to avoid. Maintenance of any required pump/lift stations will involve discussions with Denver Public Works, both Engineering and Wastewater Management Divisions. A mutually agreed shared solution will be required in each instance of utility crossing between existing gravity sewers and the proposed improvements for the alternatives with this project. **Table 9-1** contains a preliminary list of potential utility conflicts. The City and County of Denver should be contacted for their GIS information regarding existing utilities prior to final design.

Table 9-1 Potential Utility Conflicts

Utility Type	System Alternative	Location Description
Underground Electric (UG-E)	1 – 3	6th Avenue Water Quality Pond
UG-E	1 – 3	I-25 – 6th Avenue Interchange storm sewers @ southwest infield and I-25
UG-E, Underground Telecommunications (UG-T)	1 – 3	I-25 – 3rd Avenue and Alameda inlets and storm sewers on west side of I-25
Gas, UG-T, Sanitary (SAN)	1 – 3	CCD – 3rd Avenue cross culvert, storm sewers, and pond area
UG-E	1 – 3	I-25 – 3rd Avenue and Alameda inlets and storm sewers on east side of I-25
Xcel, Overhead Telecommunications (OH-T), UG-T	1 – 3	CCD – Ellsworth cross culvert, storm sewers, and pond area
Sanitary, Gas, OH-T, Xcel Energy ling (Xcel), Storm sewer (STM)	1 – 3	CCD – Ellsworth Box Culvert
Waterline (WL), SAN, OH-T, UG-E, Overhead Electric (OH-E), Gas, UG-T	1 – 3	Grade separation of CML roadway, storm sewers, inlets, pump station, water quality pond
46" SAN, UG-T, UG-E, other SAN, WL	2, 3	Grade separation of Santa Fe and Alameda roadway, storm sewers, inlets, pump station, water quality pond
30" SAN, STM	1 – 3	I-25 – Alameda Water Quality Pond
UG-T, UG-E	1 – 3	I-25 – Alameda Dry Swale, outlet
STM	1, 2	CCD – Alameda Box Culvert and pond area
46" SAN, other SAN, Gas, WL, UG E, OH-T, Existing STM, Planned STM, Fiber Optic (FO)	3	CCD – Center Box Culvert
UG-FV	1	SH 85 Water Quality Pond
46" San, UG-E, UG-FV	1 – 3	Broadway Water Quality Pond

10.0 SUMMARY

The system alternatives provide a range of roadway improvements and each has corresponding storm drainage improvements, which should improve existing drainage conditions. The proposed storm drainage improvements within the project corridor provide opportunities for cooperation and coordination with CDOT and CCD. Improved storm sewer systems within the project corridor, both on CDOT roadways and in City and County of Denver right-of-way will decrease flooding on CCD streets, I-25 and US 6. Proposed inlets and culverts will reduce the identified existing storm sewer system deficiencies listed in **Table 5-2**. In addition, the proposed storm sewer system under I-25 and US 6 will improve vehicle mobility by removing runoff from the roadways according to CDOT criteria. The most significant existing system deficiency, the ponding at I-25 under Alameda, will be greatly reduced by the addition of inlets, storm sewers, and a water quality pond. The grade separations along Santa Fe and Kalamath create sump conditions that require pump stations. Pump stations require regular maintenance and more attention than gravity storm sewers. However, they are the only practical way to remove runoff from sumps at grade separations that are located below the receiving water body, as in this case. The maintenance agreements between CCD and CDOT will define responsibilities for the pump station systems at I-25/Alameda and Santa Fe/Kalamath/Alameda or CML, depending on the system alternative.

There are additional improvements to the project corridor, aside from reduced flooding. Runoff from approximately 92% of the onsite area and nearly 50 acres of offsite area will be routed through proposed Best Management Practices (BMPs), mostly in the form of water quality ponds, for water enhancement which will provide an overall improved water quality in the runoff discharging into the South Platte River. The proposed water quality ponds and grassed swale BMPs comply with CDOT's MS4 Phase I permit program for new development and redevelopment, along with the non-structural BMPs of street sweeping and using a deicing agent. With adjacent roads providing convenient access, they should be easy to maintain. They can also be aesthetically pleasing and an asset to the South Platte River corridor users. The water quality ponds have the ability to help contain contaminated spills instead of discharging directly to the South Platte River. This function is limited to localized weather conditions near the time of the spill and the response time by maintenance crews. Many existing storm sewer outfalls will be removed as part of this project, and the number of outfalls will be consolidated through the addition of the water quality ponds. New outfalls installed with this project will be aesthetically pleasing for trail and corridor users. The South Platte River floodplain will not be raised within the project corridor due to thin project. In fact, the 6th Avenue Bridge will be raised so that the floodplain will flow beneath it. This will lower water surface elevation upstream of the bridge, which may reduce localized flooding. Since the I-25 Valley Highway Project crosses a large portion of CCD drainage paths, a coordinated effort will increase CDOT's ability to incorporate the proposed improvements for this project while also accommodating future CCD drainage needs and goals. Overall, the completion of the Valley Highway project should have no negative impacts from the stormwater runoff and should improve the quality of the runoff discharging into the South Platte River. In addition, it will reduce flooding locations throughout the project corridor on both city and state roads.

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APPENDIX A EXISTING BASINS

Located Existing Outfalls
Basin Information Summary
Existing Basin Runoff Calculations
Existing Basin Weir/Flooding Calculations

Located Existing Outfalls
Physical Properties

Number on Map	Project Significance	Name	CDOT Outfall ID	Additional Location and Land Use Description	Highway	Milepost	City	Receiving	Size	Material	Type	Longitude	Latitude	Elevation (feet)	Watershed Land Uses	Date(s) Flow Observed
1		South platte R 37, spr85 209.37	85A209.37	SE of intersection between Santa Fe Dr. and Mississipi on the westside of the South Platte River (across from Carpet Exchange) along bike path. Drains S/B SH 85.	85	209	Denver	South Platte	12"	Concrete	Circular Pipe	-104.992981405	39.696037866	5179.38	Industrial, Commercial	8/1/2002
2		spr85 a209.35	8A209.35	Drains N/B SH85. South of Mississippi and SH 85 in retaining wall on east side of river. Difficult to access.	85	209	Denver	South Platte	15"	brick	circular pipe	-104.992377695	39.695940212	5177.60	highway	
3		spr85 a209.27	85A209.27	N/B SH 85, across from Denver floor and South of Mississippi. On East side of River, visible from bike trail on west side, appears to be new.	85	209	Denver	South Platte	15"	Green PVC	circular pipe	-104.992839783	39.694761435	5175.01	highway	
4		South platte R 38	85A209.26	South of intersection between Santa Fe Dr. and Mississippi on west side of South Platte River along bike path. Across from Investors Realty. Drains S/B SH 85.	85	209	Denver	South Platte	12"	Concrete	Circular Pipe	-104.9935337	39.69443204	5183.31	Industrial, Commercial	
5		spr85 a209.16	85A209.16	Along trail following S/B SH 85 and South Platte. Just north of where S/B SH 85 crosses the South Platte.	85	209	Denver	South Platte				-104.994156954	39.693052187	5177.53	highway	
6		southplatteriver08	85A209.95	I-25 and S/B Santa Fe (SH 85), Under S/B lanes of SH 85, East side of SPR, directly under bridge, toward West side of bridge. 15" Concrete pipe is inside 21"x21" opening in bridge support wall. Seems to drain highway only.	85	210	Denver	South Platte	15"	Concrete	Circular Pipe	-104.9957928	39.70374007	5170.32	Highway	
7	CCD - 42" Outfall	southplatteriver07	85A209.91	I-25 and S/B Santa Fe (SH 85), Under S/B lanes of SH 85, East side of SPR, directly under bridge, along East side of SPR and toward East side of bridge	85	210	Denver	South Platte	42"	Concrete	Circular Pipe	-104.9954385	39.70338035	5164.44	Highway, Commercial	10/21/2002
8		South platte R 33	85A209.80	Rock marked green. Outfall is south of S/B Santa Fe bridge (Hwy 85) on west side of South Platte River along bike path, across from Habitat Park. Drains S/B SH 85.	85	210	Denver	South Platte	15"	Concrete	Circular Pipe	-104.9948875	39.70210156	5173.70	Industrial	
9		spr85 a209.78	85A209.78	S/B SH 85 and South Platte, just South of SB 85 bridge over South Platte River. Outfall hidden in brush, could be difficult to locate without GPS.	85	210	Denver	South Platte	18"	Concrete	Circular Pipe	-104.994582695	39.701696857	5177.76	highway	
10		South platte R 34	85A209.76	North of intersection between Santa Fe Dr. and Mississippi on west side of South Platte River along bike path, south of Sante Fe bridge over river. Drains S/B SH 85.	85	210	Denver	South Platte	30"	Concrete	Circular Pipe	-104.9937658	39.70072421	5175.91	Industrial, Commercial	
11		spr85 a209.62	85A209.62	On west side of South Platte in retaining wall. Drains N/B SH 85, east side of South Platte. Not very accessible.	85	210	Denver	South Platte				-104.992448297	39.699754905	5175.13	highway	
12		34B, spr85 a209.55 estimated	85A209.56	North of intersection between Santa Fe Dr. and Mississippi on west side of South Platte River along bike path. Giant rip rap wash out area. Drains S/B SH 85.	85	210	Denver	South Platte	15"	Concrete	Circular Pipe	-104.9926469	39.69886607	5181.61	Industrial, Commercial	
13		southplatteriver12	25A207.42	North of SH 85 interchange with I-25, east side of South Platte River. Drains S/B and N/B I-25.	25	207	Denver	South Platte	24"	Concrete	Circular Pipe	-104.9982257	39.70767239	5166.74	Highway, Industrial, Commercial	
14		southplatteriver11	25A207.36	North of SH 85 interchange with I-25, east side of South Platte River. Drains S/B and N/B I-25.	25	207	Denver	South Platte	24"	Concrete	Circular Pipe	-104.9977523	39.70669099	5171.87	Highway	6/28/2002
15	Next to CCD - Virginia Outfall	southplatteriver10	25A207.29	~0.5 mi South of Alameda along East bank of SPR. Appears to drain S/B SH 85, but may be draining other areas as well (i.e. other side of freeway)	25	207	Denver	South Platte	54"	Concrete	Circular Pipe	-104.9972653	39.70574844	5172.31	Highway, Commercial	6/28/2002, 10/21/2002
16		southplatteriver09	25A207.18	0.1 mi North of S/B SH85 Bridge over SPR, along East side of SPR, outfall is marked green	25	207	Denver	South Platte	15"	Concrete	Circular Pipe	-104.9963305	39.70430796	5172.11	Highway	
17		SPR22 eastbank 18inFES	25A208.35	North of Alameda along bike trail, after trail crosses river just under the freeway sign.	25	208	Denver	South Platte	18"	concrete	circular pipe w/ FES	-105.006608755	39.718951776	5157.30	highway	
18		westbank spr15in1240 Bayaud	25A207.97	I-25 and South Platte, north of Alameda, West bank of River, just below bike trail. Not sure if this is CDOT owned during visit.Marked green.	25	208	Denver	South Platte	15"	CMP	circular pipe	-105.001835633	39.714225523	5162.01	commercial/ park	
19	I-25 - Alameda Pump Station Outfall	southplatteriver15	25A207.66	CDOT marked green and CDOT sign in front of outfall. Drains S/B and N/B I-25.	25	208	Denver	South Platte	24"	Concrete	Circular Pipe	-104.9995648	39.7107339	5172.11	Highway	6/28/2002
20	CCD - Alameda Outfall	southplatteriver14	25A207.59	CDOT marked green and CDOT sign in front of outfall. Drains S/B and N/B I-25.	25	208	Denver	South Platte	30"	Concrete	Circular Pipe	-104.9992875	39.70989537	5165.01	Highway	
21		southplatteriver13	25A207.51	East side of South Platte River and just south of Alameda Ave. Bridge. Drain S/B and N/B I-25. No pipe observed on 10/21/02.	25	208	Denver	South Platte	24"	Concrete	Circular Pipe	-104.9987569	39.70891695	5173.69	Highway	
22	CDOT flow only	spr north of 8th and zuni	25A209.38	South Platte River and I-225. Walk along bike path North from 8th and Zuni. Overflow is on East bank of, bike trail follows west back.	25	209	Denver	South Platte	36"?	concrete	circular pipe	-105.016763152	39.731313908	5142.30	highway	
23	CDOT flow only	SPR31	25A209.13	South along bike trail (East bank of South Platte) from 6th Ave. crossing.	25	209	Denver	South Platte	18"	conrete	circular pipe w/ lid	-105.015514107	39.727893280	5143.98	highway	
24	CDOT flow only	SPR29	25A209.08	South of W/B 6th Ave. lanes just below bike trail on E. Bank of SPR.	25	209	Denver	South Platte	18"	concrete	circular pipe	-105.015416414	39.727068369	5145.33	highway	
25	I-25 - 6th Avenue Outfall	SPR27.5	25A208.91	South Platte River and 6th Ave., just north of 6th Ave. E/B lanes, on East bank of SPR.	25	209	Denver	South Platte	24"	concrete	circular pipe w/ lid	-105.015521669	39.725086822	5140.56	highway	6/28/2002
26		SPR27.4	25A208.90	Between 6th Ave W/B and 6th to N/B I-25 off ramp from 6th Ave (elevated). On East bank of SPR.	25	209	Denver	South Platte	24"	concrete	Circular pipe	-105.015515804	39.724876262	5142.57	highway	

Located Existing Outfalls
Physical Properties

Number on Map	Project Significance	Name	CDOT Outfall ID	Additional Location and Land Use Description	Highway	Milepost	City	Receiving	Size	Material	Type	Longitude	Latitude	Elevation (feet)	Watershed Land Uses	Date(s) Flow Observed
27	CDOT flow only	SPR26 eastbank retwall	25A208.62	I-25 and South Platte, north of Alameda along bike trail. North of fancy bridge and in retaining wall. Not accessible for sampling.	25	209	Denver	South Platte	12"	concrete	circular pipe	-105.009776974	39.721819151	5169.68	industrial/ highway	
28	Next to CCD - 3rd Avenue Outfall	SPR23 24InFES eastbank	25A208.56	I-25 and South Platte, north of Alameda along bike trail. South of fancy bridge along bike trail.	25	209	Denver	South Platte	24"	concrete	circular pipe w/ FES	-105.008312251	39.720643161	5168.60	Industrial/ Highway	10/21/2002
29	CDOT flow only	SPR25 eastbank retwall	25A208.50	I-25 and South Platte, north of Alameda along bike trail. North of fancy bridge and in retaining wall. Not accessible for sampling.	25	209	Denver	South Platte	12"	concrete	circular pipe	-105.009072348	39.721305360	5164.72	highway	
30		South platte R 41	23RDVIA	SE corner of S/B SH 85 and Mississippi. Across from Carpet Exchange and west side of South Platte River.			Denver	S. Platte	66"	Concrete	Circular Pipe w/Headwall&Wingwalls	-104.9910474 *	39.76546888 *	5101.69	Industrial, Commercial	8/1/2002
31	CCD - Bayaud Outfall	DenverFastening EastBank RetWall		I-25 and South Platte, north of Alameda on east bank of river, across from 1240 W. Bayaud in retaining wall.			Denver	SPR	36"	concrete	circular pipe	-105.001471357	39.714586360	5157.45	highway/ industrial/ commercial	
32	Major US 6 and CCD Outfall	SPR27.6		South Platte River and 6th Ave., on North side of 6th Ave. E/B lanes bridge. West bank of South Platte, between 6th and I-25 off-ramp. No access from bike trail, cross 6th Ave. bridge to get to outfall.			Denver	SPR	42"	concrete	circuler pipe with lid	-105.016022797	39.725108305	5144.69	highway	6/28/2002, 10/10/2002
33		SPR28		6th Ave. and I-25 at south Platte Riv. (under E/B lanes of 6th ave.)				SPR	18"W x 24"H	concrete	box culvert	-105.015505630	39.725722152	5143.38	highway	
34		SPR31.5		South Platte River located between 6th and 8th Ave., West of N/B I-25 lanes below grassy area left of bike trail. Outfall has circular access lid cover.				SPR	24"	concrete	circular pipe with lid	-105.015772573	39.728308037	5142.64	highway	

* PROVIDED DATA APPEARS TO BE INCORRECT

BASIN INFORMATION SUMMARY

Basin ID	Sub-basin ID	Soil Type	Existing Conditions: Basin Area (acre)	100-yr Q (cfs)	CFS/ Acre	I %	WQDV	Future Conditions: Basin Area (acre)	100-yr Q (cfs)	CFS/ Acre	5-yr Q (cfs)	2-yr Q (cfs)	I %	WQDV	
US 6 - West		C	26	81	3.12	64	0.65	* Incorporated into US - 6 Decatur Basin							
US 6 - East		C	17	55	3.24	50	0.35	* Incorporated into US - 6 Decatur Basin							
US 6 - Decatur		C						43.0	127.00	2.95	49.00	21.00	64	1.08	
US 6 - South Platte River		B	7.8	47	6.03	90	0.31	7.8	50.00	6.41	23.00	16.00	92	0.33	
I-25 - 6th Avenue Interchange		B	36	100	2.78	43	0.68	37.0	103.00	2.78	33.00	19.00	43	0.69	
I-25 - 3rd Avenue		B	13	59	4.54	100	0.65	17.0	71.00	4.18	35.00	24.00	100	0.85	
I-25 - Alameda		B	25	126	5.04	94	1.09	25.0	90.00	3.60	37.00	24.00	70	0.69	
	SB-21	B						5.3	20.00	3.77	8.40	5.50	70	0.15	
	SB-22	B						9.6	39.00	4.06	16.00	11.00	70	0.26	
	SB-23	B						9.6	36.00	3.75	15.00	10.00	70	0.26	
SH 85 - SYS 1		B	13	51	3.92	90	0.52	9.6	38.00	3.96	17.00	12.00	87	0.36	
SH 85 - SYS 2		B						9.6	39.50	4.11	18.80	13.00	93	0.41	3
SH 85 - SYS 3		B						11.0	42.00	3.82	20.00	14.00	89	0.43	
I-25 - Low Point		B	2.6	18	6.92	100	0.13	* Incorporated into other basin							
I-25 - Broadway		B	14	57	4.07	82	0.48	20.0	70.00	3.50	31.00	21.00	81	0.67	
	SB-31	B						5.9	42.00	7.12	21.00	14.00	100	0.30	
	SB-32	B						9.3	58.00	6.24	28.00	20.00	100	0.47	
	SB-33	B						5.4	17.00	3.15	4.70	2.40	30	0.08	
I-25 - TREX		B	5.4	22	4.07	100	0.27	6.3	25.64	4.07			100	0.32	1
CCD - 7th Ave West		C	47		0.00	75	1.41	No Change in Basin							
CCD - 5th Ave West		C	39		0.00	75	1.17	No Change in Basin							
CCD - 6th Avenue East		B	263	840	3.19	80	8.63	No Change in Basin							
CCD - 3rd Avenue		C	187	570	3.05	62	4.54	No Change in Basin							
CCD - Ellsworth (combined with Bayaud in future)		C	9.3	70	7.53	65	0.24	265.0	810.9	3.06			55.0	5.84	
CCD - Bayaud (combined with Ellsworth in future)		C	310	950	3.06	55	6.83								
	CCD - SB-1	B						265.0	810.90	3.06			55	5.84	1
	CCD - SB-2	B						11.7	43.00	3.68	19.00	13.00	80	0.38	
	CCD - SB-3	B						5.1	24.00	4.71	12.00	8.80	90	0.20	
	CCD - SB-4	B						6.2	29.00	4.68	13.00	9.30	90	0.25	
	CCD - SB-5	B						15.0	45.97	3.06			55	0.33	1
	CCD - SB-6	B						3.8	19.00	5.00	9.00	6.20	90	0.15	
	CCD - SYS 1 - SB-7	B						11.9	38.01	3.19			90	0.48	1
	CCD - SYS 1 - SF SUMP	B						0.9	7.50	8.33	3.90	2.80	100	0.05	
	CCD - SYS 1 - K SUMP	B						0.5	4.30	9.35	2.10	1.50	100	0.02	
	CCD - SYS 2 - SB-7	B						5.1	13.00	2.55	3.00	2.20	20	0.06	
	CCD - SYS 2 - SB-8	B						4.2	18.00	4.29	9.10	6.30	90	0.17	
	CCD - SYS 2 - SB 9	B						1.2	6.10	5.08	2.80	2.00	90	0.05	3
	CCD - SYS 2 - SF SUMP	B						1.8	12.10	6.72	5.90	4.10	100	0.09	3
	CCD - SYS 2 - K SUMP	B						1.7	11.60	6.82	5.70	4.00	100	0.09	3
	CCD - SYS 3 - SB-2	B						25.0	92.00	3.06	42.00	29.00	85	0.91	
	CCD - SYS 3 - SB-3	B						2.3	6.60		2.10	1.20	40	0.04	
	CCD - SYS 3 - SB-4	B						2.6	15.00		7.10	4.90	90	0.10	
	CCD - SYS 3 - SB-6	B						8.5	29.00		12.00	8.10	73	0.25	
	CCD - SYS 3 - SF SUMP	B						7.0	37.00		16.00	13.00	100	0.35	
	CCD - SYS 1 - TOTAL	B						585.1	1832.6		59.0	41.6		13.5	
	CCD - SYS 2 - TOTAL	B						584.1	1832.0		73.8	51.9		13.4	
	CCD - SYS 3 - TOTAL	B						590.4	1847.4		79.2	56.2		13.7	
CCD - Virginia		C	726	2560	3.53	48	14.58	No Change in Basin							
CCD - Alameda (System Alternative 1)		C	99	400	4.04	80	3.25	No Change in Basin							
	CCD-SB-11	C						59.0	238.36	4.04			80	1.94	1
	CCD-SB-12	C						12.0	48.48	4.04			80	0.39	1
	CCD-SB-13	C						3.9	23.63	6.06			80	0.13	2
	CCD - SYS 2 - SB-15	C						4.5	27.27	6.06			100	0.23	2, 3
	CCD - SYS 3 - SB-14	C						17.0	68.68	4.04			65	0.43	1
CCD - 42" Outfall		B	49	200	4.08	86	1.81	30.7					86	1.13	

1) Future Conditions calculated using existing cfs/acre

2) Future Conditions calculated using existing cfs/acre * 1.5 because of small basin

3) Revised 02/02/04

Existing Basin Runoff Calculations

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: Existing US6 West Basin

I. Catchment Hydrologic Data

Catchment ID = E US6 WEST
Area = 26.00 Acres
Percent Imperviousness = 64.00 %
NRCS Soil Type = C A, B, C, or D

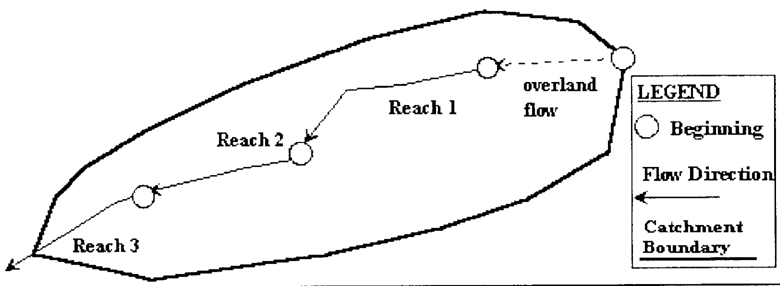
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.65
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.48
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0200	50	0.48		0.13	6.25
1	0.0030	200		20.00	1.10	3.04
2	0.0400	3,000		20.00	4.00	12.50
3						
4						
5						
Sum		3,250				

Computed Tc = 21.80
Regional Tc = 28.06

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 4.83 inch/hr	Rainfall Intensity at Tc, I = 4.19 inch/hr
Peak Flowrate, Qp = 81.46 cfs	Peak Flowrate, Qp = 70.73 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: Existing US6 East Basin

I. Catchment Hydrologic Data

Catchment ID = E US6 EAST
Area = 17.00 Acres
Percent Imperviousness = 50.00 %
NRCS Soil Type = C A, B, C, or D

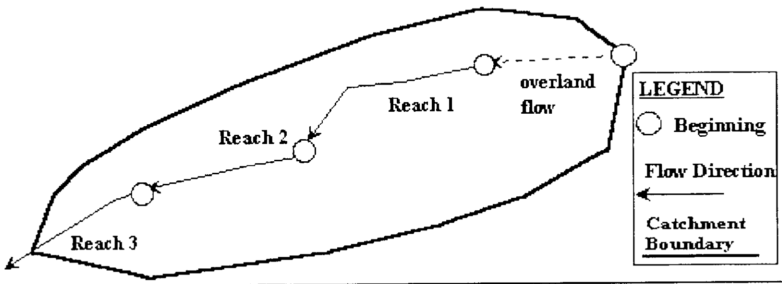
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.60
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.40
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0200	50	0.40		0.12	7.13
1	0.0100	1,300		20.00	2.00	10.83
2						
3						
4						
5						
Sum		1,350				

Computed Tc = 17.97
Regional Tc = 17.50

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 5.34 inch/hr	Rainfall Intensity at Tc, I = 5.41 inch/hr
Peak Flowrate, Qp = 54.74 cfs	Peak Flowrate, Qp = 55.47 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: Existing US6-South Platte River Basin

I. Catchment Hydrologic Data

Catchment ID = E US6-SPR
Area = 7.80 Acres
Percent Imperviousness = 90.00 %
NRCS Soil Type = B A, B, C, or D

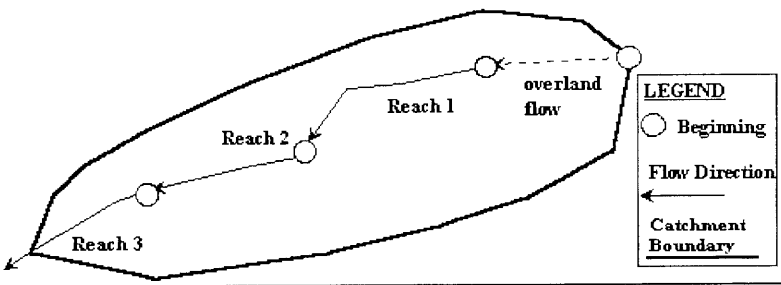
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.81
Overide Runoff Coefficient, C = ____ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.73
Overide 5-yr. Runoff Coefficient, C = ____ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0200	50	0.73		0.22	3.79
1	0.0300	900		20.00	3.46	4.33
2						
3						
4						
5						
Sum		950				

Computed Tc = 8.12
Regional Tc = 15.28

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 7.51 inch/hr	Rainfall Intensity at Tc, I = 5.78 inch/hr
Peak Flowrate, Qp = 47.46 cfs	Peak Flowrate, Qp = 36.53 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: Existing I-25 - 6th Avenue Interchange Basin

I. Catchment Hydrologic Data

Catchment ID = E I-25 - 6th Avenue
Area = 36.00 Acres
Percent Imperviousness = 43.00 %
NRCS Soil Type = B A, B, C, or D

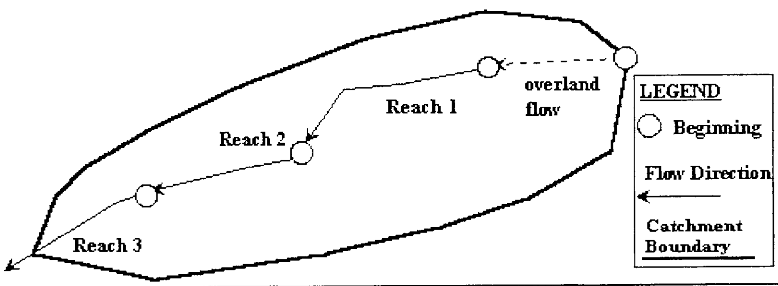
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.50
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.31
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0200	50	0.31		0.10	8.00
1	0.0222	1,580		20.00	2.98	8.85
2						
3						
4						
5						
Sum		1,630				

Computed Tc = 16.85
Regional Tc = 19.06

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 5.52 inch/hr	Rainfall Intensity at Tc, I = 5.18 inch/hr
Peak Flowrate, Qp = 99.93 cfs	Peak Flowrate, Qp = 93.92 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: Existing I-25 - 3rd Avenue Basin

I. Catchment Hydrologic Data

Catchment ID = E I-25 - 3rd Avenue
Area = 13.00 Acres
Percent Imperviousness = 100.00 %
NRCS Soil Type = B A, B, C, or D

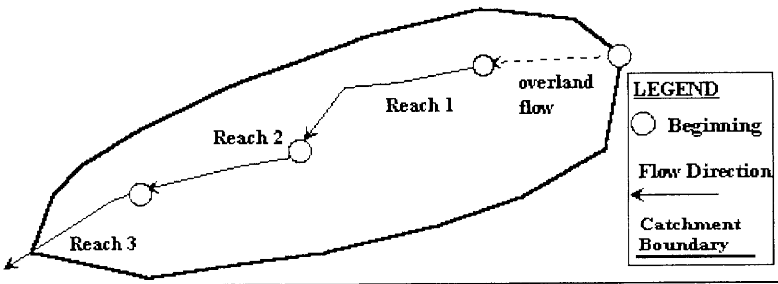
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.96
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.90
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0200	50	0.90		0.40	2.08
1	0.0044	2,250		20.00	1.33	28.13
2						
3						
4						
5						
Sum		2,300				

Computed Tc = 30.20
Regional Tc = 22.78

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 4.02 inch/hr	Rainfall Intensity at Tc, I = 4.72 inch/hr
Peak Flowrate, Qp = 49.89 cfs	Peak Flowrate, Qp = 58.57 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: Existing SH 85

I. Catchment Hydrologic Data

Catchment ID = E SH 85
Area = 13.00 Acres
Percent Imperviousness = 90.00 %
NRCS Soil Type = B A, B, C, or D

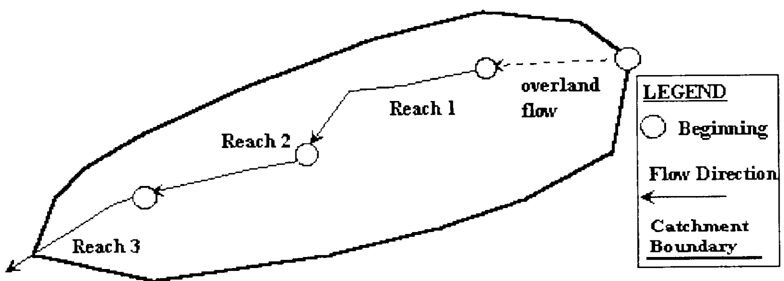
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.81
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.73
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0200	50	0.73		0.22	3.79
1	0.0040	2,100		20.00	1.26	27.67
2						
3						
4						
5						
Sum		2,150				

Computed Tc = 31.46
Regional Tc = 21.94

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 3.92 inch/hr	Rainfall Intensity at Tc, I = 4.81 inch/hr
Peak Flowrate, Qp = 41.27 cfs	Peak Flowrate, Qp = 50.65 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: Existing - I-25 - Low Point Basin

I. Catchment Hydrologic Data

Catchment ID = E I-25 Low Poing
Area = 2.60 Acres
Percent Imperviousness = 100.00 %
NRCS Soil Type = B A, B, C, or D

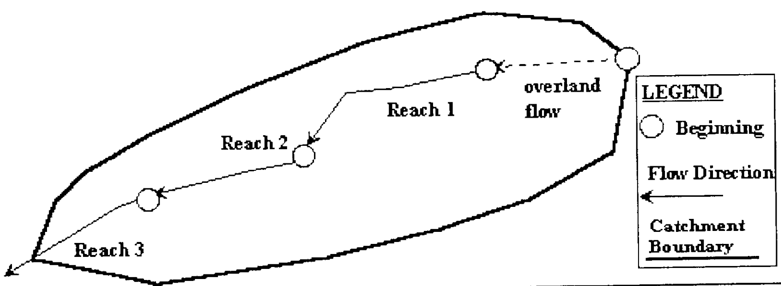
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.96
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.90
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft	C-5		fps	minutes
	input	input	output	input	output	output
Overland	0.0200	50	0.90		0.40	2.08
1	0.0150	1,060		20.00	2.45	7.21
2						
3						
4						
5						
Sum		1,110				

Computed Tc = 9.29
Regional Tc = 16.17

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 7.15 inch/hr	Rainfall Intensity at Tc, I = 5.63 inch/hr
Peak Flowrate, Qp = 17.77 cfs	Peak Flowrate, Qp = 13.98 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: Existing I-25 - Alameda Avenue Basin

I. Catchment Hydrologic Data

Catchment ID = E I-25 - Alameda
Area = 25.00 Acres
Percent Imperviousness = 90.00 %
NRCS Soil Type = B A, B, C, or D

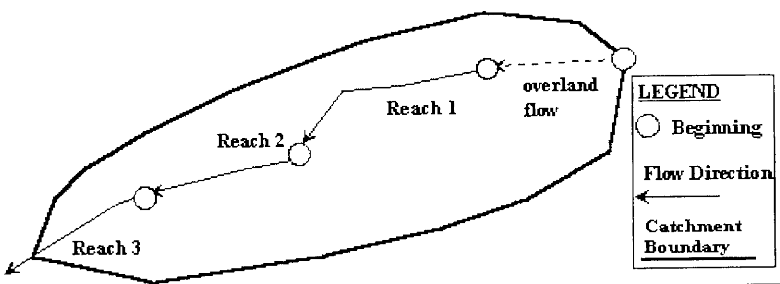
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.81
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.73
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0200	50	0.73		0.22	3.79
1	0.0350	2,053		20.00	3.74	9.14
2						
3						
4						
5						
Sum		2,103				

Computed Tc = 12.94
Regional Tc = 21.68

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 6.24 inch/hr	Rainfall Intensity at Tc, I = 4.84 inch/hr
Peak Flowrate, Qp = 126.39 cfs	Peak Flowrate, Qp = 98.04 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: Existing I-25 - TREX Basin

I. Catchment Hydrologic Data

Catchment ID = E I-25 - TREX
Area = 5.40 Acres
Percent Imperviousness = 100.00 %
NRCS Soil Type = B A, B, C, or D

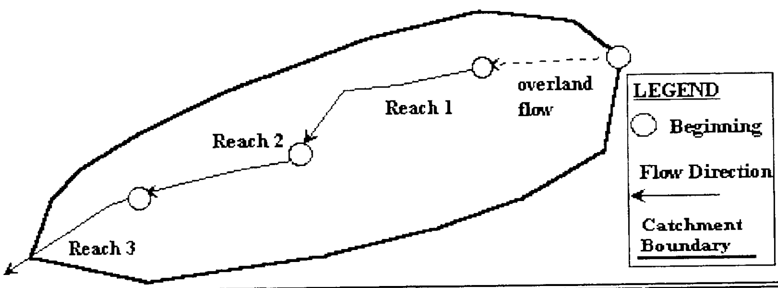
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.96
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.90
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0200	50	0.90		0.40	2.08
1	0.0050	3,000		20.00	1.41	35.36
2						
3						
4						
5						
Sum		3,050				

Computed Tc = 37.43
Regional Tc = 26.94

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 3.53 inch/hr	Rainfall Intensity at Tc, I = 4.29 inch/hr
Peak Flowrate, Qp = 18.20 cfs	Peak Flowrate, Qp = 22.15 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: Existing I-25 - Broadway Basin

I. Catchment Hydrologic Data

Catchment ID = E I-25 - Broadway
Area = 14.00 Acres
Percent Imperviousness = 82.00 %
NRCS Soil Type = B A, B, C, or D

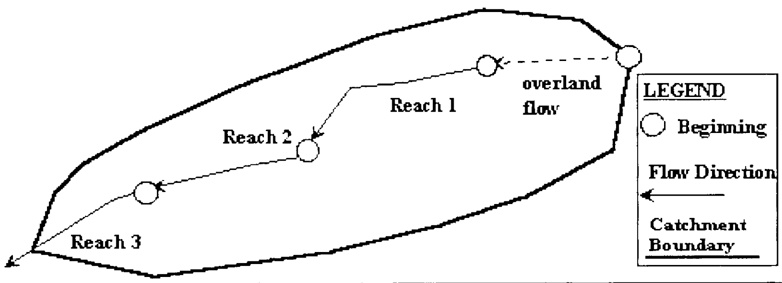
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.72
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.62
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft	C-5		fps	minutes
	input	input	output	input	output	output
Overland	0.0200	50	0.62		0.17	4.89
1	0.0240	2,116		20.00	3.10	11.38
2						
3						
4						
5						
Sum		2,166				

Computed Tc = 16.28
Regional Tc = 22.03

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 5.61 inch/hr	Rainfall Intensity at Tc, I = 4.80 inch/hr
Peak Flowrate, Qp = 56.52 cfs	Peak Flowrate, Qp = 48.37 cfs

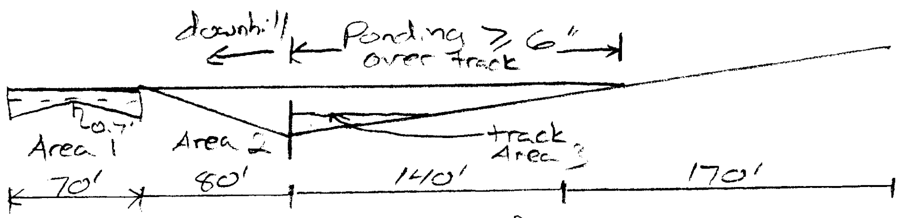
Existing Basin Weir/Flooding Calculations

Subject: Flow Depths Sheet No. ______ Of ______

Prepared By: SAW/SJE Checked By: ________ Date: Calc 6-18-03 Project No.: 9904.06

Third Avenue

XS – 2



@ 2/3 H

$Q = C L H^{3/2}$ $Q = 392$ @ tracks

Estimate Q in 1st ½ foot

$Q = (2.8)(20)(.5)^{3/2} = 20$ cfs (flow down tracks)

Estimate Q in next ½ foot

$Q = (2.8)(147)(0.5)^{3/2} = 145$ cfs

$Q = (2.8)(70)(0.5)^{3/2} = 69$ cfs

> 214 cfs

Recalculate @ 1.1 feet deep:

Area 1 = $Q = (2.8)(70)(0.6-0.2)^{3/2} = 50$ cfs → down road

Area 2 = $Q = (2.8)(2/3 \cdot 80)(1.1)^{3/2} = 172$ cfs → down tracks

Area 3 = $Q = (2.8)(2/3 \cdot 0.1)(140))(0.6)^{3/2} = 134$ cfs → over tracks

356 cfs

⇒ Proportional 51 cfs on Road

177 cfs along tracks

125 cfs over tracks

Recalculate @ 1.2 feet deep:

Area 1 = $Q = (2.8)(70)(0.7-0.2)^{3/2} = 70$

Area 2 = $Q = (2.8)(53.3)(1.2)^{3/2} = 196$

Area 3 = $Q = (2.8)(140)(0.7)^{3/2} = 183$

449

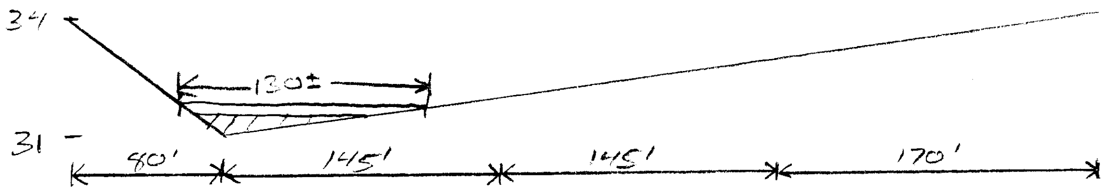
Muller Engineering Company, Inc.
DESIGN NOTES AND COMPUTATIONS

Subject: Flow Depths Sheet No. ______ Of ______

Prepared By: JAW/JJE Checked By: ________ Date: 6/18/03 Project No.: 9904.06

Ellsworth

XS #7 - @ track



$Q = 175 = CLH^{3/2}$

Q = 48cfs, down tracks

Q = 175 - 48 = 127

127 cfs, over tracks

L (@2/3H)	H	Q
39	0.8	78
48	0.5	47.5
108	0.75	197
115	1.0	322
92	0.8	183
86	0.75	156

→ trapped on east side of tracks; everything else to go over I-25.

☆ Q = 127 cfs w/ w = 130± & d = 0.3'± sheet flow over I-25.

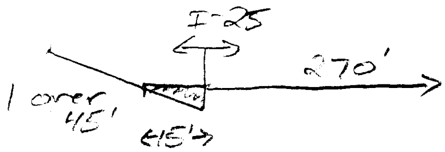
Muller Engineering Company, Inc.
DESIGN NOTES AND COMPUTATIONS

Subject: Flow Depths	Sheet No. ____ Of ____

Prepared By: JAW/JJE	Checked By: ________	Date: Calc 6-18-03	Project No.: 9704.06

Ellsworth

XS #8



$Q = CLH^{3/2}$ L @ 2/3 H

$Q = (2.8)(10)(0.5)^{3/2}$

Q = 10 cfs ← Includes 10 cfs →

D = 4-0.5
Hwy = 270'

	H	L tracks	Q tracks	Q Hwy	
8"	0.67	23	35 cfs +	53 cfs	= 88 cfs
7"	0.58	17.4	22 cfs +	17 cfs	= 39 cfs
7 1/2"	0.63	20.9	29 cfs	35 cfs	= 64 cfs
	0.59	19	24 cfs +	20.41 cfs	= 44 cfs

10 cfs will Join Third Ave Flows

Muller Engineering Company, Inc.
DESIGN NOTES AND COMPUTATIONS

Subject: I-25 @ Bayou   Sheet No. ______ Of ______

Prepared By: BCB   Checked By: ________   Date: 5/19/05   Project No.: [illegible]

XS-#4

I-25 @ Bayou X-Section

$$Q = 2.8(340)(1.0)^{1.5} = 952 \text{ cfs}$$

$$D = 1.0'$$

$$Q = 2.8(300)(.8)^{1.5} = 600 \text{ cfs}$$

USE THIS CROSS SECTION TO DET. DEPTH OF I-25 OVERTOPPING.

USE 10" DEPTH → 650 cfs

9" → 528 cfs

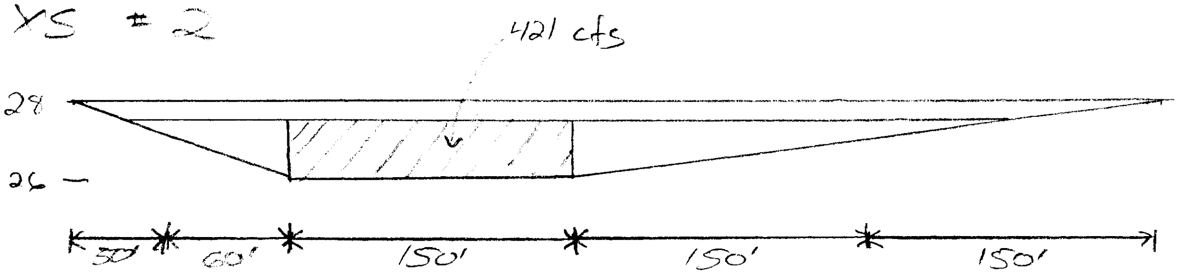
Muller Engineering Company, Inc.
DESIGN NOTES AND COMPUTATIONS

Subject: Flow Depths | Sheet No. ______ Of ______

Prepared By: JAW/JJE | Checked By: ________ | Date: ________ | Project No.: 9904.06

Alameda

XS # 2



Alameda, across Kalamath & into grassy area prior to I-25

$$Q = CLH^{3/2}$$

$L = 150 + (\frac{1}{2}H(150)) + \frac{1}{2}H(50)$

Q = 2465

Q	H	L
3358	2.0	424
2091	1.6	369
2228	1.65	375.5
2370	1.7	382
2528	1.75	390
2459	1.73	386

1.73' of Ponding
12/5/03

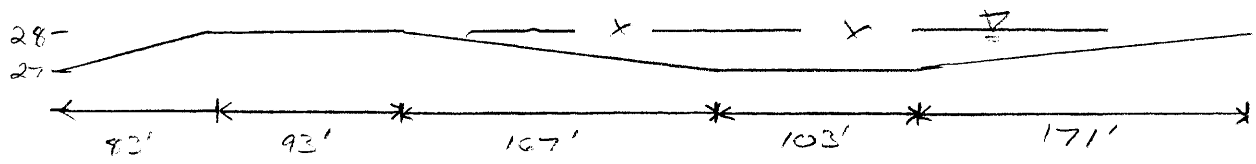
Muller Engineering Company, Inc.
DESIGN NOTES AND COMPUTATIONS

Subject: Flow Depths Sheet No. ____ Of ____

Prepared By: JAW/JJE Checked By: ____ Date: ____ Project No.: 9904.06

Santa Fe

XS #1



What Q ponds before flowing over 28?

$h = 1 \quad L = 328$ @ 2/3 H $\quad C = 2.8$

$Q = C L H^{3/2}$

$Q = (2.8)(328)(1)^{3/2}$

$Q = 918 >$ Future Q_{100}

APPENDIX B BMP FACT SHEETS

BMP Fact Sheets (from CDOT MS4 Permit New Development and Redevelopment Program)

DOT MS4 Permit
w Development and
edevelopment Program

7704.06

Rec'd 2/13/03

DOT

DEPARTMENT OF TRANSPORTATION

Submittal to the

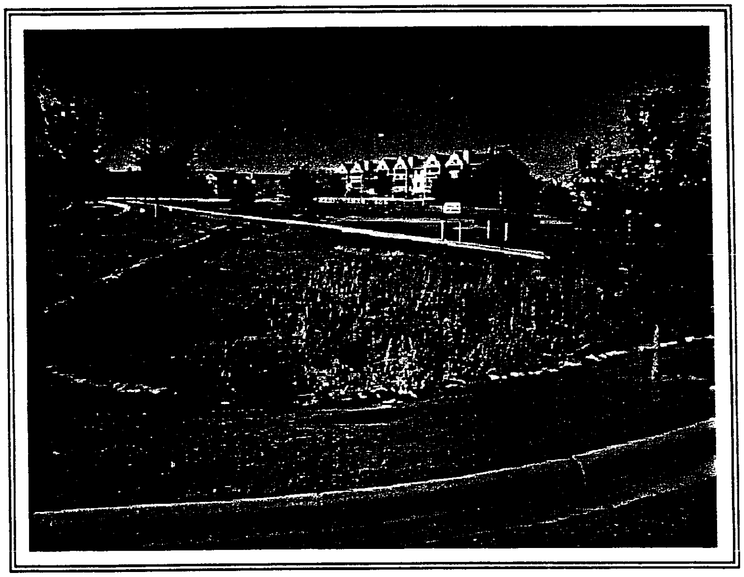
Colorado Department of Public Health and Environment

Jan 2003

Extended Detention Pond with Micropool

Description

A structural BMP used to capture and treat a specific volume of stormwater runoff. Because of a smaller outlet, the pond releases stored flows over a period of a few days and drains totally dry sometime after the storm ends. The pond is considered dry, although the formation of small wetland marshes or shallow pools in the bottom can enhance the effectiveness of the pond.



Application Guidelines

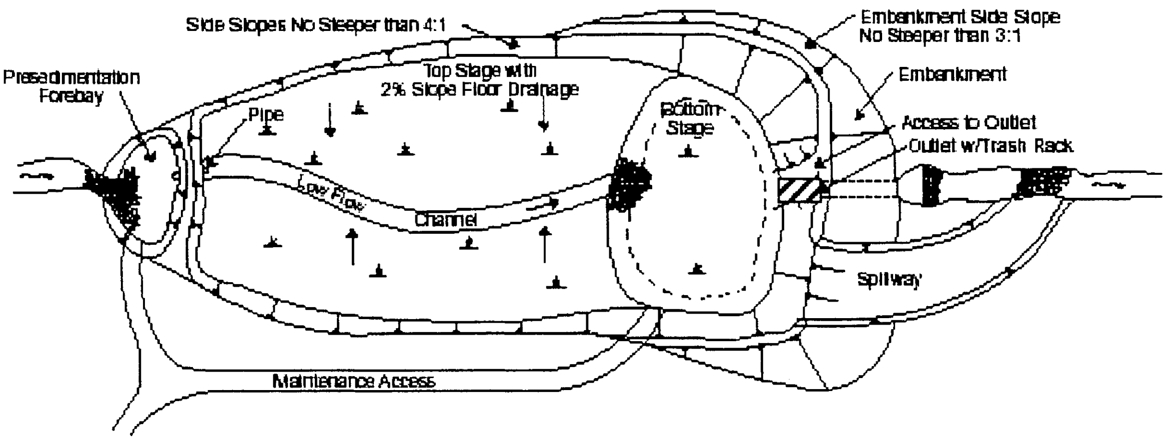
- Pond can be used to enhance stormwater quality and reduce peak discharges,
- Most applicable in residential, commercial, and industrial areas,
- If constructed early in development of a particular site, the pond becomes an effective means of trapping sediment from construction activities,
- Ponds can be retrofitted into existing flood control facilities,
- Ponds are used to improve quality of urban runoff,
- Used for regional and/or follow-up water quality treatment but are also effective as an "on-site" BMP,
- Pond also works well in conjunction with other BMP's used to control upstream and downstream sediments,
- Ponds can be effective if they are combined with BMP's that attenuate peak stormwater discharges or reduce runoff volumes. If needed, flood routing detention volume can be designed and captured by the pond, above volume used for water quality treatment,
- Pond size can be reduced if effectively combined with other BMP's,
- Pond can also be used for recreation and open space and in some cases, wildlife habitat if wetlands or shallow pools are incorporated into the design.

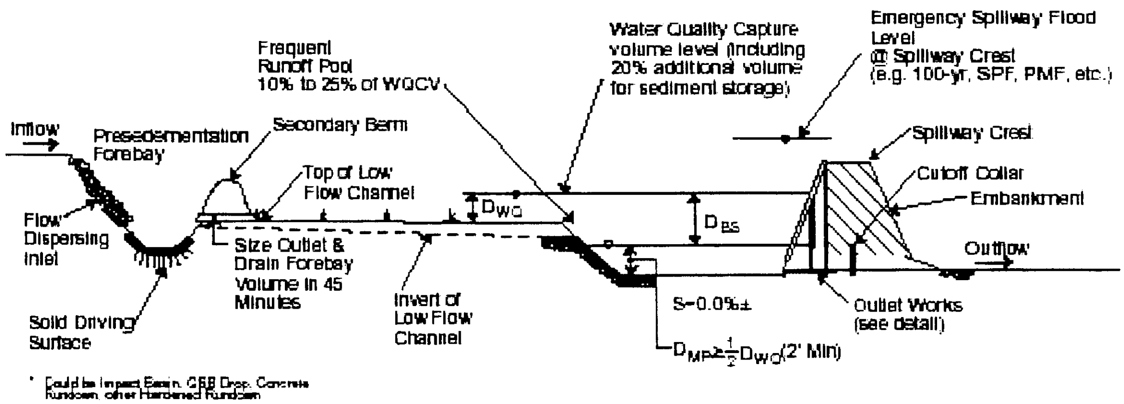
Basic Design Criteria

- If possible, pond should be incorporated into existing facility or flood control basin,
- Consider other urban uses such as recreation, open space, and/or wildlife habitat,
- Generally, minimum drain time of 40 hours is recommended to allow finer particulates found in urban stormwater runoff to settle,
- Generally, land required is approximately 0.5 to 2.0% of tributary development area,
- Account for groundwater elevations in the design and construction of the basin,
- Review State Engineer's regulatory requirements for dam embankments and storage volumes if minimum dam heights and volumes are exceeded.

Extended Detention Pond with Micropool

Reference: Denver Urban Drainage and Flood Control District, Volume 3 Criteria Manual.





SECTION
NOT TO SCALE

6TH AVE INFIELD, DECATUR

Extended Detention Shallow Wetland

Description

A structural BMP used to capture and treat a specific volume of stormwater runoff. This structure is a shallow wetland with additional detention storage provided for water quality treatment. Wetland species are added to the bottom of the pond to enhance the pollutant removal capability and a perennial base flow is required to maintain and promote wetland vegetation.

Application Guidelines

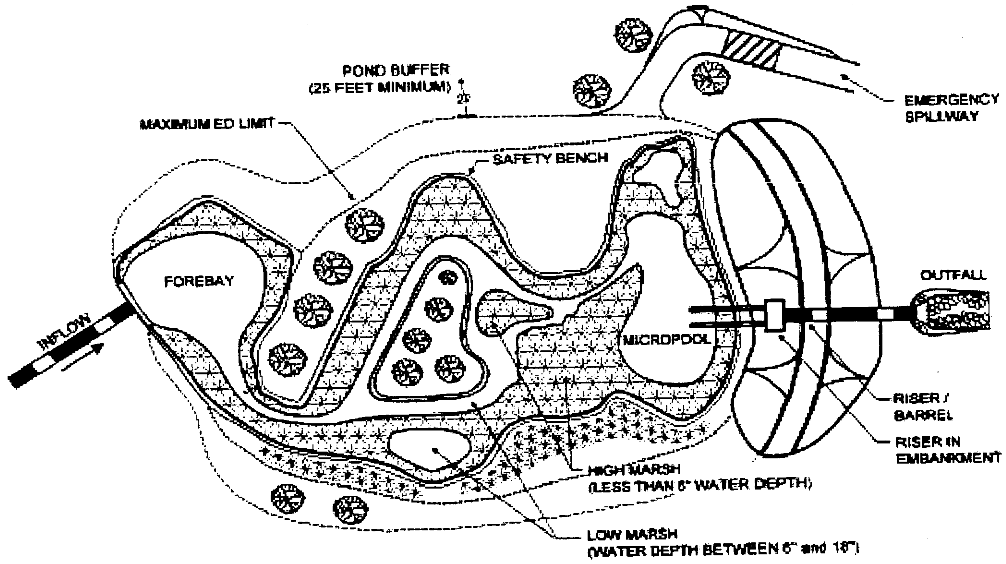
- Wetland can be used to reduce peak discharges,
- Can be used as a follow-up structural BMP or as a stand-alone facility,
- Small existing wetlands can be enlarged and incorporated into constructed wetland (requires state and federal permits),
- Requires an area sufficiently large for impounding stormwater in shallow basins,
- Wetland cells can be arranged in a series of terraces,
- If needed, flood storage can be provided above volume used for water quality treatment,
- Wetlands can provide effective follow-up treatment to on-site and other basin BMP's,
- State and Federal regulations protecting natural wetlands recognize classification of wetlands constructed for water quality treatment,
- Constructed wetlands generally not allowed on receiving waters and cannot be used to mitigate loss of natural wetlands,
- Advantage is in aesthetics and creation of wildlife habitat, disadvantage is need for continuous base flow to maintain wetland growth.

Basic Design Criteria

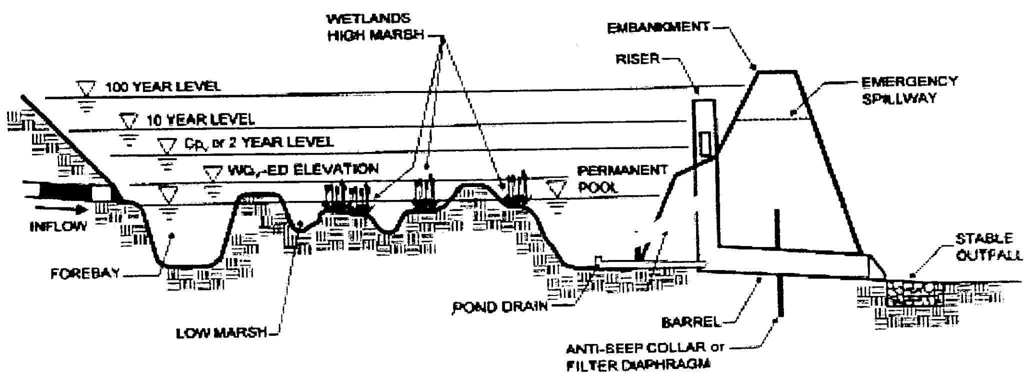
- Generally, minimum drain time of 24 hours is recommended,
- Wetlands constructed outside of the Waters of the U.S. and explicitly designed for stormwater management, are not subject to the provisions of the Clean Water Act (Sections 401 and 404). When abandoned, they may be regulated as natural wetlands,
- Perennial base flow is needed and is determined through a water budget analysis,
- Consider other urban uses such as recreation, open space, and/or wildlife habitat,
- Loamy soils are required in the wetland bottom to sustain plant growth,
- Exfiltration through pond bottom is not reliable because of low permeability soils and/or high ground water elevations,
- Review State Engineer's regulatory requirements for dam embankments and storage volumes if minimum dam heights and volumes are exceeded.

Extended Detention Shallow Wetland

Reference: Maryland Stormwater Design Manual.



PLAN VIEW



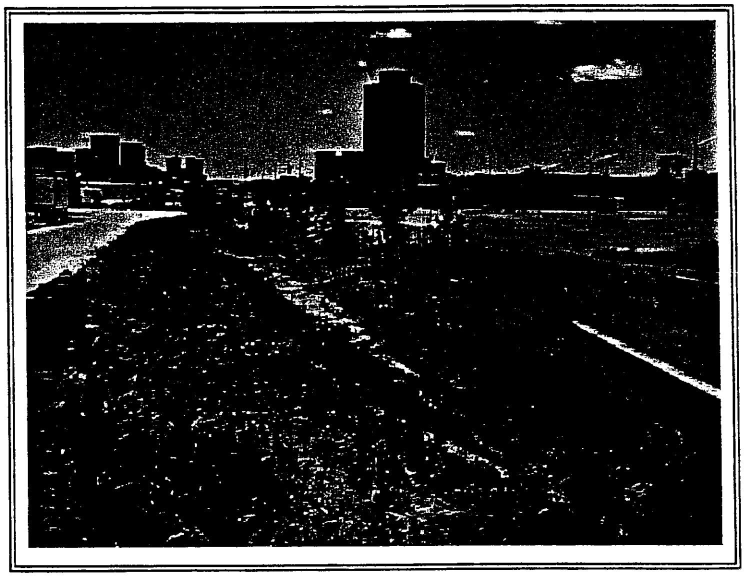
PROFILE

ALAMEDA

Dry Swale

Description

A structural BMP used to filter pollutants as stormwater runoff moves through the swale. This BMP is constructed as an open-channel drainageway with grass or other vegetation to provide conveyance and to filter pollutants. Other features such as check dams, pre-treatment forebays, gravel pads, and riprap can be used to temporarily inhibit stormwater runoff and enhance treatment.



Application Guidelines

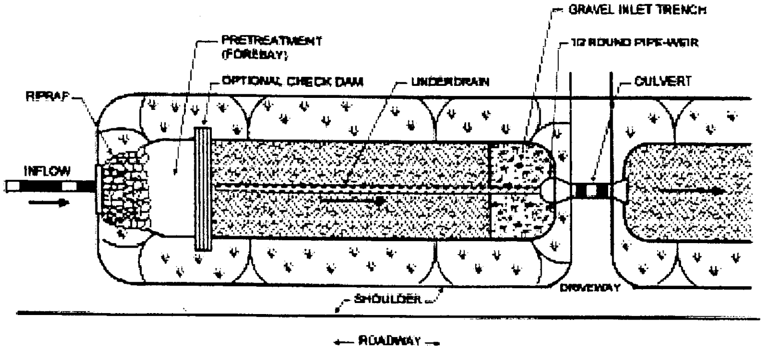
- Structure can be used to enhance stormwater quality and reduce peak runoff,
- Efficient for removing a wide variety of pollutants including suspended solids and nutrients.
- Swales work best in conjunction with other BMP's and can be used as an alternative to or enhancement of a conventional storm sewer,
- Excavated area is lined with layers of filter fabric around the permeable soil,
- Flows that infiltrate into the channel soil are conveyed by an underdrain system,
- Swales are used in low density residential areas or for very small impervious areas, generally less than 10 acres,
- Runoff sources can be overland flow from impervious areas or discharges from drainage pipes,
- Swales can be used in early post-construction when stabilizing vegetation is not established and principal consideration is preventing erosion in unvegetated channels,
- Well suited for flat or rolling terrain,
- Swale depressions can be used in place of above-ground islands in large parking lots.

Basic Design Criteria

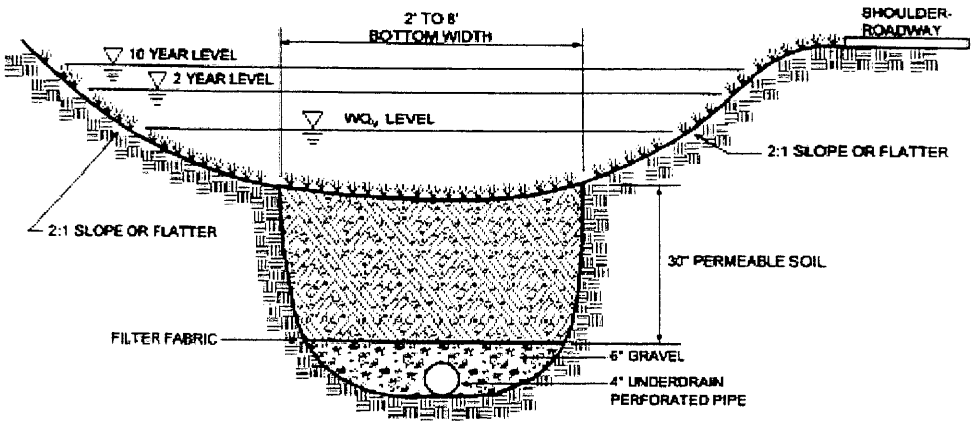
- Generally, swales are designed to temporarily store the water quality volume for a maximum of 48 hours,
- Regular inspection and maintenance is necessary to remove surface sediment, trash, debris, and leaf litter, and dead or diseased plant material. Routine mowing is required,
- A vegetative cover needs to be established as soon as possible to prevent erosion and scour. They should also be constructed early in the construction schedule before grading and paving increase runoff rates,
- The maximum ponding depth is generally no greater than 1.5 feet at the outlet,
- Longitudinal slope should be as flat as possible, to minimize velocities and enhance pollutant filtering.

Dry Swale

Reference: Denver Urban Drainage and Flood Control District, Volume 3 Criteria Manual.



PLAN VIEW



SECTION

APPENDIX C BASIN AND INLET INFORMATION

Basin Information Summary
Future Basin Runoff Calculations
Inlet Spacing Spreadsheet

BASIN INFORMATION SUMMARY

			Existing Conditions					Future Conditions							
Basin ID	Sub-basin ID	Soil Type	Basin Area (acre)	100-yr Q (cfs)	CFS/ Acre	I %	WQDV	Basin Area (acre)	100-yr Q (cfs)	CFS/ Acre	5-yr Q (cfs)	2-yr Q (cfs)	I %	WQDV	
US 6 - West		C	26	81	3.12	64	0.65	* Incorporated into US - 6 Decatur Basin							
US 6 - East		C	17	55	3.24	50	0.35	* Incorporated into US - 6 Decatur Basin							
US 6 - Decatur		C						43.0	127.00	2.95	49.00	21.00	64	1.08	
US 6 - South Platte River		B	7.8	47	6.03	90	0.31	7.8	50.00	6.41	23.00	16.00	92	0.33	
I-25 - 6th Avenue Interchange		B	36	100	2.78	43	0.68	37.0	103.00	2.78	33.00	19.00	43	0.69	
I-25 - 3rd Avenue		B	13	59	4.54	100	0.65	17.0	71.00	4.18	35.00	24.00	100	0.85	
I-25 - Alameda		B	25	126	5.04	94	1.09	25.0	90.00	3.60	37.00	24.00	70	0.69	
	SB-21	B						5.3	20.00	3.77	8.40	5.50	70	0.15	
	SB-22	B						9.6	39.00	4.06	16.00	11.00	70	0.26	
	SB-23	B						9.6	36.00	3.75	15.00	10.00	70	0.26	
SH 85 - SYS 1		B	13	51	3.92	90	0.52	9.6	38.00	3.96	17.00	12.00	87	0.36	
SH 85 - SYS 2		B						9.6	39.50	4.11	18.80	13.00	93	0.41	3
SH 85 - SYS 3		B						11.0	42.00	3.82	20.00	14.00	89	0.43	
I-25 - Low Point		B	2.6	18	6.92	100	0.13	* Incorporated into other basin							
I-25 - Broadway		B	14	57	4.07	82	0.48	20.0	70.00	3.50	31.00	21.00	81	0.67	
	SB-31	B						5.9	42.00	7.12	21.00	14.00	100	0.30	
	SB-32	B						9.3	58.00	6.24	28.00	20.00	100	0.47	
	SB-33	B						5.4	17.00	3.15	4.70	2.40	30	0.08	
I-25 - TREX		B	5.4	22	4.07	100	0.27	6.3	25.64	4.07			100	0.32	1
CCD - 7th Ave West		C	47		0.00	75	1.41	No Change in Basin							
CCD - 5th Ave West		C	39		0.00	75	1.17	No Change in Basin							
CCD - 6th Avenue East		B	263	840	3.19	80	8.63	No Change in Basin							
CCD - 3rd Avenue		C	187	570	3.05	62	4.54	No Change in Basin							
CCD - Ellsworth (combined with Bayaud in future)		C	9.3	70	7.53	65	0.24	265.0	810.9	3.06			55.0	5.84	
CCD - Bayaud (combined with Ellsworth in future)		C	310	950	3.06	55	6.83								
	CCD - SB-1	B						265.0	810.90	3.06			55	5.84	1
	CCD - SB-2	B						11.7	43.00	3.68	19.00	13.00	80	0.38	
	CCD - SB-3	B						5.1	24.00	4.71	12.00	8.80	90	0.20	
	CCD - SB-4	B						6.2	29.00	4.68	13.00	9.30	90	0.25	
	CCD - SB-5	B						15.0	45.97	3.06			55	0.33	1
	CCD - SB-6	B						3.8	19.00	5.00	9.00	6.20	90	0.15	
	CCD - SYS 1 - SB-7	B						11.9	38.01	3.19			90	0.48	1
	CCD - SYS 1 - SF SUMP	B						0.9	7.50	8.33	3.90	2.80	100	0.05	
	CCD - SYS 1 - K SUMP	B						0.5	4.30	9.35	2.10	1.50	100	0.02	
	CCD - SYS 2 - SB-7	B						5.1	13.00	2.55	3.00	2.20	20	0.06	
	CCD - SYS 2 - SB-8	B						4.2	18.00	4.29	9.10	6.30	90	0.17	
	CCD - SYS 2 - SB 9	B						1.2	6.10	5.08	2.80	2.00	90	0.05	3
	CCD - SYS 2 - SF SUMP	B						1.8	12.10	6.72	5.90	4.10	100	0.09	3
	CCD - SYS 2 - K SUMP	B						1.7	11.60	6.82	5.70	4.00	100	0.09	3
	CCD - SYS 3 - SB-2	B						25.0	92.00	3.06	42.00	29.00	85	0.91	
	CCD - SYS 3 - SB-3	B						2.3	6.60		2.10	1.20	40	0.04	
	CCD - SYS 3 - SB-4	B						2.6	15.00		7.10	4.90	90	0.10	
	CCD - SYS 3 - SB-6	B						8.5	29.00		12.00	8.10	73	0.25	
	CCD - SYS 3 - SF SUMP	B						7.0	37.00		16.00	13.00	100	0.35	
	CCD - SYS 1 - TOTAL	B						585.1	1832.6		59.0	41.6		13.5	
	CCD - SYS 2 - TOTAL	B						584.1	1832.0		73.8	51.9		13.4	
	CCD - SYS 3 - TOTAL	B						590.4	1847.4		79.2	56.2		13.7	
CCD - Virginia		C	726	2560	3.53	48	14.58	No Change in Basin							
CCD - Alameda (System Alternative 1)		C	99	400	4.04	80	3.25	No Change in Basin							
	CCD-SB-11	C						59.0	238.36	4.04			80	1.94	1
	CCD-SB-12	C						12.0	48.48	4.04			80	0.39	1
	CCD-SB-13	C						3.9	23.63	6.06			80	0.13	2
	CCD - SYS 2 - SB-15	C						4.5	27.27	6.06			100	0.23	2, 3
	CCD - SYS 3 - SB-14	C						17.0	68.68	4.04			65	0.43	1
CCD - 42" Outfall		B	49	200	4.08	86	1.81	30.7					86	1.13	

1) Future Conditions calculated using existing cfs/acre

2) Future Conditions calculated using existing cfs/acre * 1.5 because of small basin

3) Revised 02/02/04

Future Basin Runoff Calculations

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: US6 Decatur Basin

I. Catchment Hydrologic Data

Catchment ID = US6 DECATUR
Area = 43.00 Acres
Percent Imperviousness = 64.00 %
NRCS Soil Type = C A, B, C, or D

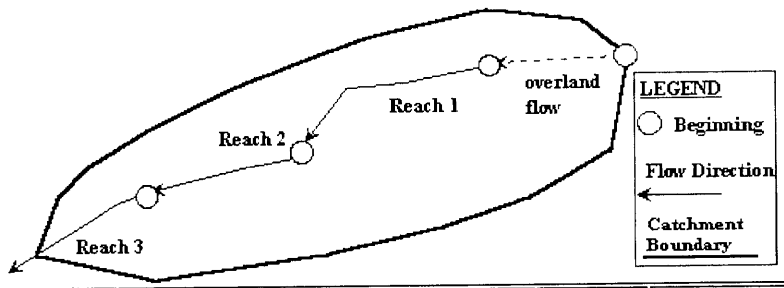
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr =	100 years	(input return period for design storm)
C1 =	28.50	(input the value of C1)
C2=	10.00	(input the value of C2)
C3=	0.786	(input the value of C3)
P1=	2.57 inches	(input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.65
Overide Runoff Coefficient, C = ________ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.48
Overide 5-yr. Runoff Coefficient, C = ________ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft	C-5		fps	minutes
	input	input	output	input	output	output
Overland	0.0200	50	0.48		0.13	6.25
1	0.0030	200		20.00	1.10	3.04
2	0.0400	3,000		20.00	4.00	12.50
3	0.0100	300		20.00	2.00	2.50
4						
5						
Sum		3,550				

Computed Tc = 24.30
Regional Tc = 29.72

IV.

Peak Runoff Prediction using Computed Tc	**ediction using Regional Tc**
Rainfall Intensity at Tc, I = 4.55 inch/hr	Rainfall Intensity at Tc, I = 4.05 inch/hr
Peak Flowrate, Qp = 126.94 cfs	Peak Flowrate, Qp = 113.10 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: US6-South Platte River Basin

I. Catchment Hydrologic Data

Catchment ID = US6-SPR
Area = 7.80 Acres
Percent Imperviousness = 92.00 %
NRCS Soil Type = B A, B, C, or D

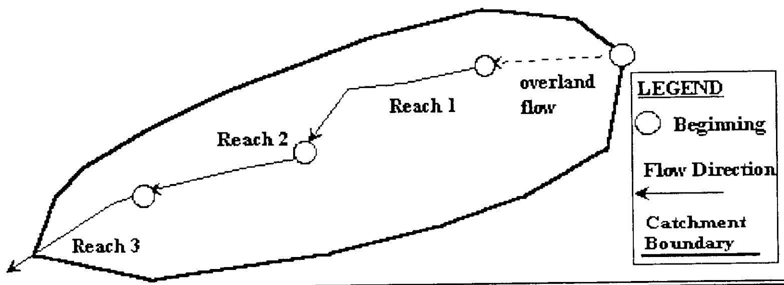
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.84
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.76
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0200	50	0.76		0.24	3.48
1	0.0300	900		20.00	3.46	4.33
2						
3						
4						
5						
Sum		950				

Computed Tc = 7.81
Regional Tc = 15.28

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 7.62 inch/hr	Rainfall Intensity at Tc, I = 5.78 inch/hr
Peak Flowrate, Qp = 49.65 cfs	Peak Flowrate, Qp = 37.71 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: I-25 - 6th Avenue Interchange Basin

I. Catchment Hydrologic Data

Catchment ID = I-25 - 6th Avenue
Area = 37.00 Acres
Percent Imperviousness = 43.00 %
NRCS Soil Type = B A, B, C, or D

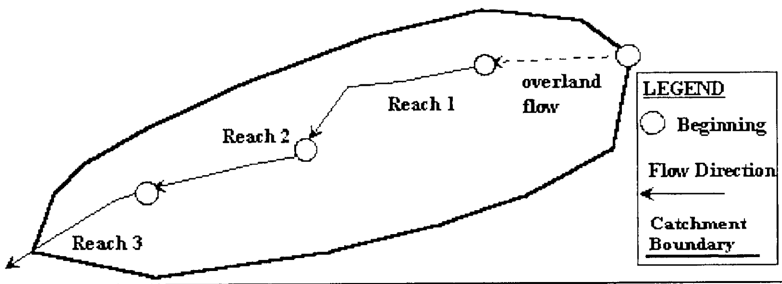
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.50
Overide Runoff Coefficient, C = (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.31
Overide 5-yr. Runoff Coefficient, C = (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0200	50	0.31		0.10	8.00
1	0.0222	1,580		20.00	2.98	8.85
2						
3						
4						
5						
Sum		1,630				

Computed Tc = 16.85
Regional Tc = 19.06

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 5.52 inch/hr	Rainfall Intensity at Tc, I = 5.18 inch/hr
Peak Flowrate, Qp = 102.71 cfs	Peak Flowrate, Qp = 96.53 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: I-25 - 3rd Avenue Basin

I. Catchment Hydrologic Data

Catchment ID = I-25 - 3rd Avenue
Area = 17.00 Acres
Percent Imperviousness = 100.00 %
NRCS Soil Type = B A, B, C, or D

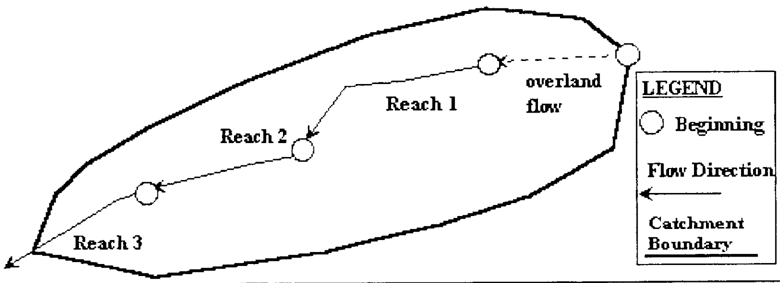
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.96
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.90
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0200	88	0.90		0.53	2.76
1	0.0050	2,800		20.00	1.41	33.00
2						
3						
4						
5						
Sum		2,888				

Computed Tc = 35.75
Regional Tc = 26.04

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 3.63 inch/hr	Rainfall Intensity at Tc, I = 4.38 inch/hr
Peak Flowrate, Qp = 58.93 cfs	Peak Flowrate, Qp = 71.09 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: CCD - Bayaud Basin - System Alternatives 1 and 2 - Sub-Basin 2

I. Catchment Hydrologic Data

Catchment ID = SB-2 (SA 1, 2)
Area = 11.70 Acres
Percent Imperviousness = 80.00 %
NRCS Soil Type = B A, B, C, or D

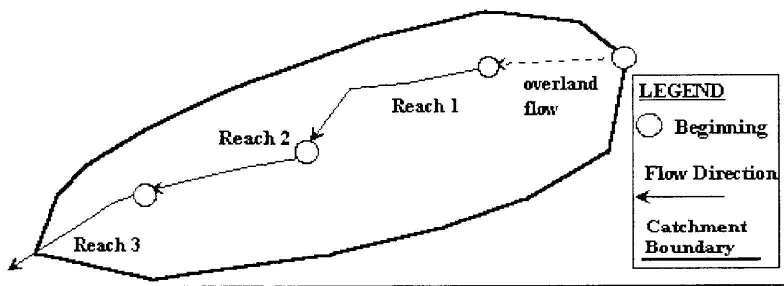
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.70
Overide Runoff Coefficient, C = (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.59
Overide 5-yr. Runoff Coefficient, C = (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0133	300	0.59		0.35	14.38
1	0.0075	600		20.00	1.73	5.77
2	0.0033	300		20.00	1.15	4.33
3	0.0067	300		20.00	1.63	3.06
4						
5						
Sum		1,500				

Computed Tc = 27.55
Regional Tc = 18.33

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 4.24 inch/hr	Rainfall Intensity at Tc, I = 5.29 inch/hr
Peak Flowrate, Qp = 34.72 cfs	Peak Flowrate, Qp = 43.32 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: CCD - Bayaud Basin - System Alternatives 1 and 2 - Sub-Basin 3

I. Catchment Hydrologic Data

Catchment ID = SB-3 (SA 1,2)
Area = 5.10 Acres
Percent Imperviousness = 90.00 %
NRCS Soil Type = B A, B, C, or D

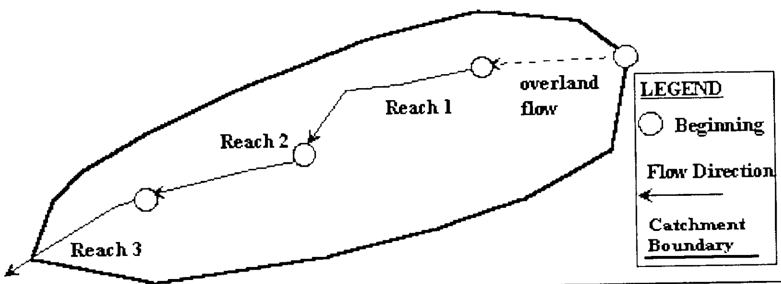
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.81
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.73
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0150	300	0.73		0.49	10.21
1	0.0150	100		20.00	2.45	0.68
2	0.0033	600		20.00	1.15	8.66
3						
4						
5						
Sum		1,000				

Computed Tc = 19.55
Regional Tc = 15.56

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 5.12 inch/hr	Rainfall Intensity at Tc, I = 5.73 inch/hr
Peak Flowrate, Qp = 21.13 cfs	Peak Flowrate, Qp = 23.68 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: CCD - Bayaud Basin - System Alternatives 1 and 2 - Sub-Basin 4

I. Catchment Hydrologic Data

Catchment ID = SB-4 (SA 1,2)
Area = 6.20 Acres
Percent Imperviousness = 90.00 %
NRCS Soil Type = B A, B, C, or D

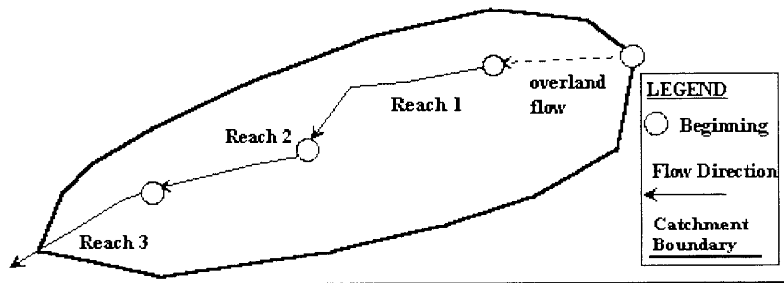
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.81
Overide Runoff Coefficient, C = (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.73
Overide 5-yr. Runoff Coefficient, C = (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0068	300	0.73		0.38	13.24
1	0.0068	250		20.00	1.65	2.52
2	0.0044	450		20.00	1.33	5.63
3						
4						
5						
Sum		1,000				

Computed Tc = 21.39
Regional Tc = 15.56

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 4.88 inch/hr	Rainfall Intensity at Tc, I = 5.73 inch/hr
Peak Flowrate, Qp = 24.49 cfs	Peak Flowrate, Qp = 28.79 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: CCD - Bayaud Basin - System Alternative 1 and 2 - Sub-Basin 6

I. Catchment Hydrologic Data

Catchment ID = SB-6 (SA 1,2)
Area = 3.80 Acres
Percent Imperviousness = 90.00 %
NRCS Soil Type = B A, B, C, or D

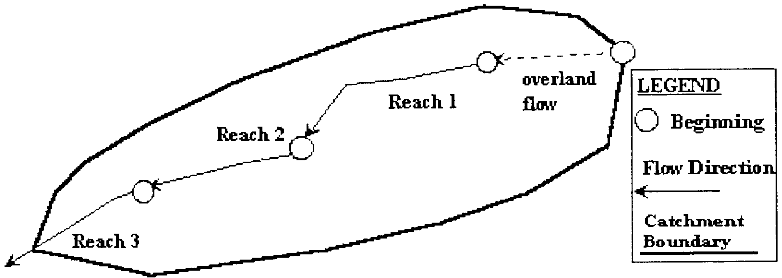
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.81
Overide Runoff Coefficient, C = ________ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.73
Overide 5-yr. Runoff Coefficient, C = ________ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0060	300	0.73		0.36	13.82
1	0.0060	200		20.00	1.55	2.15
2						
3						
4						
5						
Sum		500				

Computed Tc = 15.97
Regional Tc = 12.78

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 5.66 inch/hr	Rainfall Intensity at Tc, I = 6.28 inch/hr
Peak Flowrate, Qp = 17.43 cfs	Peak Flowrate, Qp = 19.32 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: CCD - Bayaud Basin - System Alternative 1 - Santa Fe Sump Sub-Basin

I. Catchment Hydrologic Data

Catchment ID = SA-1 - SF Sump
Area = 0.90 Acres
Percent Imperviousness = 100.00 %
NRCS Soil Type = B A, B, C, or D

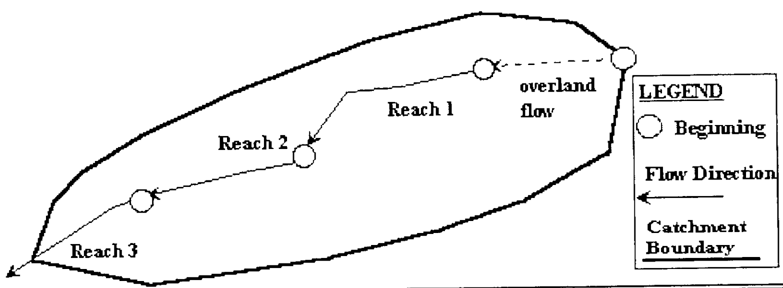
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.90
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.90
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Conveyance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0200	25	0.90		0.28	1.47
1	0.0340	500		20.00	3.69	2.26
2						
3						
4						
5						
Sum		525				

Computed Tc = 3.73
Regional Tc = 12.92

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 9.35 inch/hr	Rainfall Intensity at Tc, I = 6.25 inch/hr
Peak Flowrate, Qp = 7.53 cfs	Peak Flowrate, Qp = 5.04 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: CCD - Bayaud Basin - System Alternative 1 - Kalamath Sump Sub-Basin

I. Catchment Hydrologic Data

Catchment ID = SA-1 - K Sump
Area = 0.46 Acres
Percent Imperviousness = 100.00 %
NRCS Soil Type = B A, B, C, or D

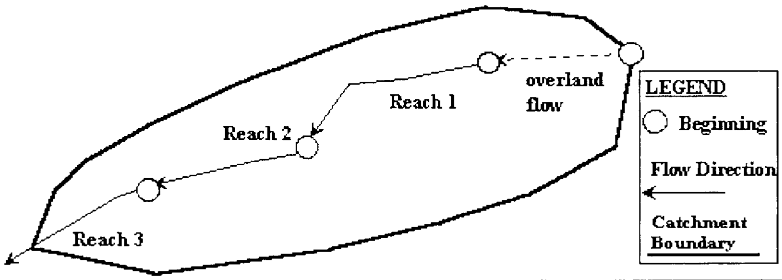
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.96
Overide Runoff Coefficient, C = (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.90
Overide 5-yr. Runoff Coefficient, C = (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0200	25	0.90		0.28	1.47
1	0.0429	350		20.00	4.14	1.41
2						
3						
4						
5						
Sum		375				

Computed Tc = 2.88
Regional Tc = 12.08

IV.

Peak Runoff Prediction using Computed Tc		ediction using Regional Tc	
Rainfall Intensity at Tc, I =	9.83 inch/hr	Rainfall Intensity at Tc, I =	6.43 inch/hr
Peak Flowrate, Qp =	4.32 cfs	Peak Flowrate, Qp =	2.83 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: CCD - Bayaud Basin - System Alternative 2 - Sub-Basin 7

I. Catchment Hydrologic Data

Catchment ID = SA-2 - SB-7
Area = 5.10 Acres
Percent Imperviousness = 20.00 %
NRCS Soil Type = B A, B, C, or D

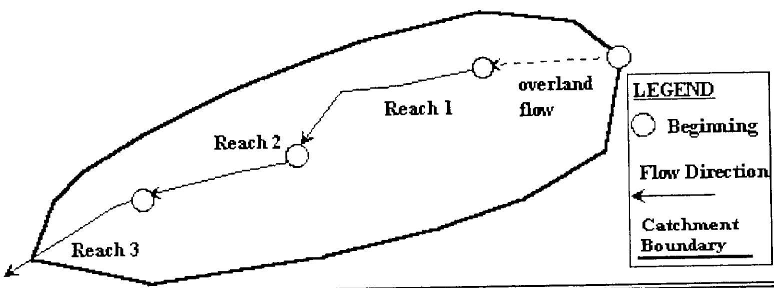
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.44
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.20
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0067	300	0.20		0.15	32.28
1	0.0067	600		20.00	1.63	6.12
2				20.00		
3				20.00		
4						
5						
Sum		900				

Computed Tc = 38.40
Regional Tc = 15.00

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 3.47 inch/hr	Rainfall Intensity at Tc, I = 5.83 inch/hr
Peak Flowrate, Qp = 7.81 cfs	Peak Flowrate, Qp = 13.12 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: CCD - Bayaud Basin - System Alternative 2 - Sub-Basin 8

I. Catchment Hydrologic Data

Catchment ID = SA-2 - SB-8
Area = 4.20 Acres
Percent Imperviousness = 90.00 %
NRCS Soil Type = B A, B, C, or D

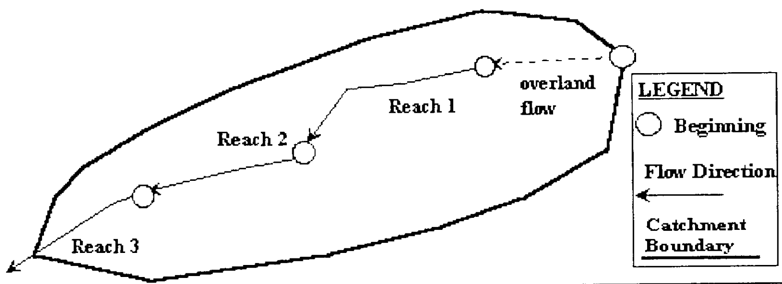
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.73
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.73
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft	C-5		fps	minutes
	input	input	output	input	output	output
Overland	0.0060	300	0.73		0.36	13.82
1	0.0060	700		20.00	1.55	7.53
2				20.00		
3				20.00		
4						
5						
Sum		1,000				

Computed Tc = 21.35
Regional Tc = 15.56

IV.

Peak Runoff Prediction using Computed Tc	**ediction using Regional Tc**
Rainfall Intensity at Tc, I = 4.88 inch/hr	Rainfall Intensity at Tc, I = 5.73 inch/hr
Peak Flowrate, Qp = 14.91 cfs	Peak Flowrate, Qp = 17.50 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: CCD - Bayaud Basin - System Alternatives 2 - Sub-Basin 9

I. Catchment Hydrologic Data

Catchment ID = SB-9 (SA 2)
Area = 1.20 Acres
Percent Imperviousness = 90.00 %
NRCS Soil Type = B A, B, C, or D

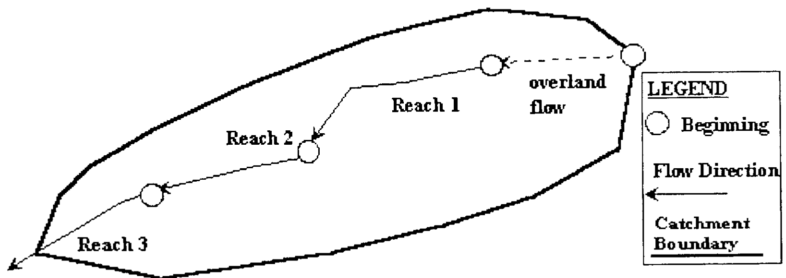
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.81
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.73
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft	C-5		fps	minutes
	input	input	output	input	output	output
Overland	0.0133	300	0.73		0.47	10.62
1	0.0075	240		20.00	1.73	2.31
2						
3						
4						
5						
Sum		540				

Computed Tc = 12.92
Regional Tc = 13.00

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 6.25 inch/hr	Rainfall Intensity at Tc, I = 6.23 inch/hr
Peak Flowrate, Qp = 6.07 cfs	Peak Flowrate, Qp = 6.05 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: ЭCD - Bayaud/Alameda Basin - System Alternative 2 - Santa Fe Sump Sub-Basi

I. Catchment Hydrologic Data

Catchment ID = SA-2 - SF Sump
Area = 1.80 Acres
Percent Imperviousness = 100.00 %
NRCS Soil Type = B A, B, C, or D

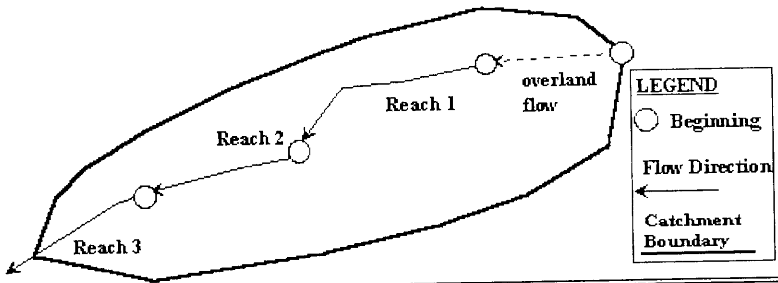
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.96
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.90
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0200	25	0.90		0.28	1.47
1	0.0125	400		20.00	2.24	2.98
2	0.0350	300		20.00	3.74	1.34
3	0.0400	600		20.00	4.00	2.50
4	0.0125	200		20.00	2.24	1.49
5						
Sum		1,525				

Computed Tc = 9.78
Regional Tc = 18.47

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 7.01 inch/hr	Rainfall Intensity at Tc, I = 5.27 inch/hr
Peak Flowrate, Qp = 12.06 cfs	Peak Flowrate, Qp = 9.06 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: CCD - Bayaud Basin - System Alternative 2 - Kalamath Sump Sub-Basin

I. Catchment Hydrologic Data

Catchment ID = SA-2 - K Sump
Area = 1.70 Acres
Percent Imperviousness = 100.00 %
NRCS Soil Type = B A, B, C, or D

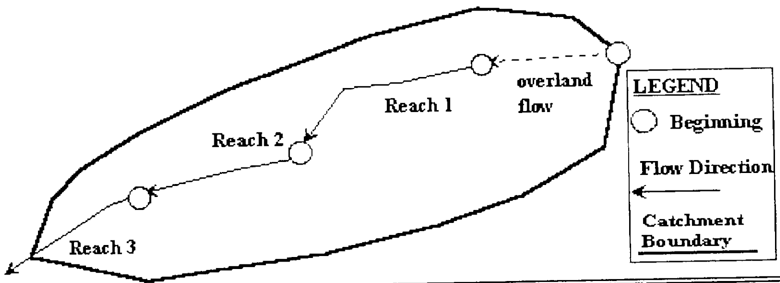
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.96
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.90
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Conveyance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0200	25	0.90		0.28	1.47
1	0.0100	500		20.00	2.00	4.17
2	0.0428	900		20.00	4.14	3.63
3						
4						
5						
Sum		1,425				

Computed Tc = 9.26
Regional Tc = 17.92

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 7.16 inch/hr	Rainfall Intensity at Tc, I = 5.35 inch/hr
Peak Flowrate, Qp = 11.63 cfs	Peak Flowrate, Qp = 8.69 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: CCD - Bayaud Basin - System Alternatives 3 - Sub-Basin 2

I. Catchment Hydrologic Data

Catchment ID = SB-2 (SA 3)
Area = 25.40 Acres
Percent Imperviousness = 85.00 %
NRCS Soil Type = B A, B, C, or D

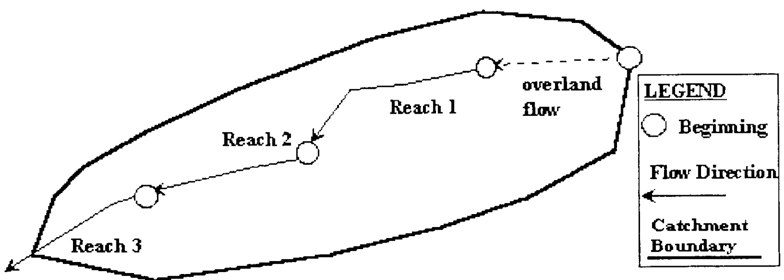
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.75
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.66
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0133	300	0.66		0.40	12.62
1	0.0075	600		20.00	1.73	5.77
2	0.0050	600		20.00	1.41	7.07
3	0.0033	600		20.00	1.15	8.66
4						
5						
Sum		2,100				

Computed Tc = 34.12
Regional Tc = 21.67

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 3.73 inch/hr	Rainfall Intensity at Tc, I = 4.85 inch/hr
Peak Flowrate, Qp = 71.20 cfs	Peak Flowrate, Qp = 92.41 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: CCD - Bayaud Basin - System Alternative 3 - Sub-Basin 3

I. Catchment Hydrologic Data

Catchment ID = SB-3 (SA 3)
Area = 2.30 Acres
Percent Imperviousness = 40.00 %
NRCS Soil Type = B A, B, C, or D

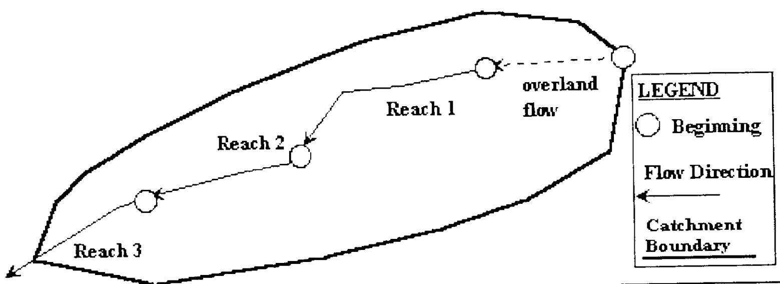
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.50
Overide Runoff Coefficient, C = ____ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.30
Overide 5-yr. Runoff Coefficient, C = ____ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0056	100	0.30		0.09	17.55
1	0.0056	800		20.00	1.50	8.91
2						
3						
4						
5						
Sum		900				

Computed Tc = 26.46
Regional Tc = 15.00

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 4.34 inch/hr	Rainfall Intensity at Tc, I = 5.83 inch/hr
Peak Flowrate, Qp = 4.94 cfs	Peak Flowrate, Qp = 6.64 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: CCD - Bayaud Basin - System Alternative 3 - Sub-Basin 4

I. Catchment Hydrologic Data

Catchment ID = SB-4 (SA 3)
Area = 2.60 Acres
Percent Imperviousness = 90.00 %
NRCS Soil Type = B A, B, C, or D

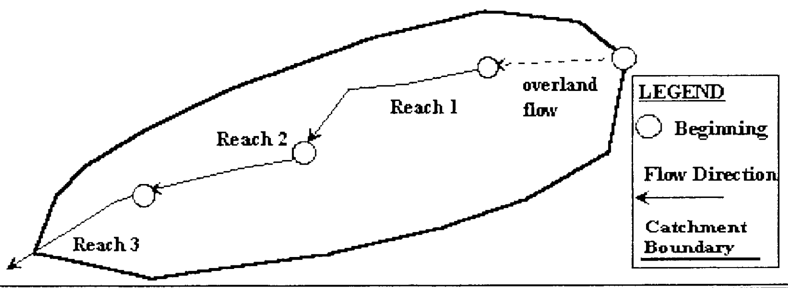
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr =	100 years	(input return period for design storm)
C1 =	28.50	(input the value of C1)
C2=	10.00	(input the value of C2)
C3=	0.786	(input the value of C3)
P1=	2.57 inches	(input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.81
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.73
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0091	50	0.73		0.17	4.92
1	0.0091	500		20.00	1.91	4.37
2						
3						
4						
5						
Sum		550			Computed Tc =	9.28
					Regional Tc =	13.06

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 7.16 inch/hr	Rainfall Intensity at Tc, I = 6.22 inch/hr
Peak Flowrate, Qp = 15.06 cfs	Peak Flowrate, Qp = 13.09 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: CCD - Bayaud Basin - System Alternative 3 - Sub-Basin 6

I. Catchment Hydrologic Data

Catchment ID = SB-6 (SA 3)
Area = 8.50 Acres
Percent Imperviousness = 73.00 %
NRCS Soil Type = B A, B, C, or D

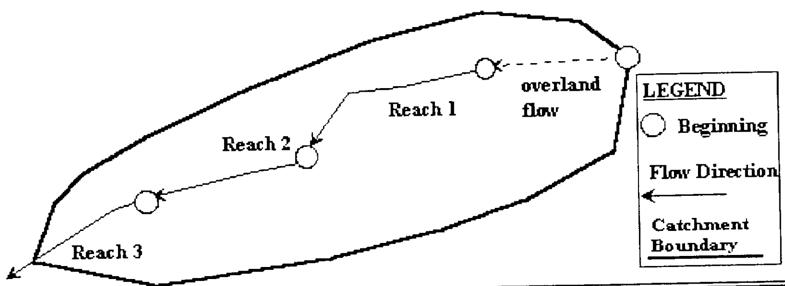
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.64
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.52
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0200	50	0.52		0.14	5.89
1	0.0021	1,400		20.00	0.93	25.20
2						
3						
4						
5						
Sum		1,450				

Computed Tc = 31.10
Regional Tc = 18.06

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 3.95 inch/hr	Rainfall Intensity at Tc, I = 5.33 inch/hr
Peak Flowrate, Qp = 21.53 cfs	Peak Flowrate, Qp = 29.07 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: CCD - Bayaud/Alameda Basin - Sys Alt 3 - Santa Fe Sump Sub-Basin

I. Catchment Hydrologic Data

Catchment ID = SA-3 - SF Sump
Area = 7.00 Acres
Percent Imperviousness = 100.00 %
NRCS Soil Type = B A, B, C, or D

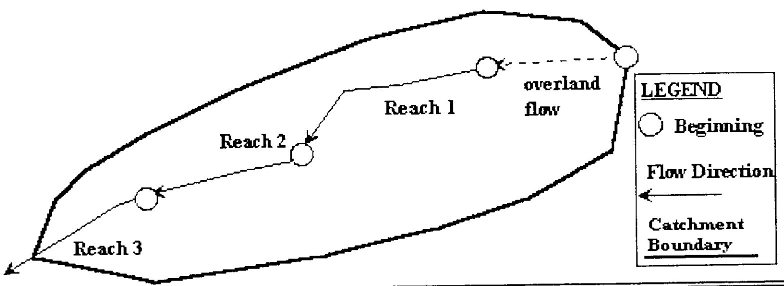
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.96
Overide Runoff Coefficient, C = ____ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.90
Overide 5-yr. Runoff Coefficient, C = ____ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0200	50	0.90		0.40	2.08
1	0.0111	1,800		20.00	2.11	14.23
2						
3						
4						
5						
Sum		1,850				

Computed Tc = 16.31
Regional Tc = 20.28

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 5.61 inch/hr	Rainfall Intensity at Tc, I = 5.02 inch/hr
Peak Flowrate, Qp = 37.49 cfs	Peak Flowrate, Qp = 33.57 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: I-25 - Alameda Avenue Basin

I. Catchment Hydrologic Data

Catchment ID = I-25 - Alameda
Area = 25.00 Acres
Percent Imperviousness = 70.00 %
NRCS Soil Type = B A, B, C, or D

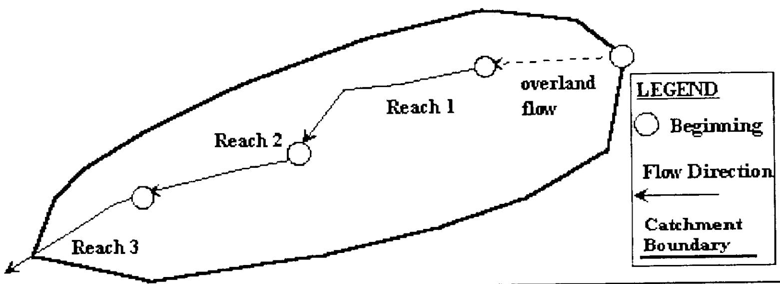
II. Rainfall Information   I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.62
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.49
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0200	50	0.49		0.13	6.18
1	0.0350	2,000		20.00	3.74	8.91
2						
3						
4						
5						
Sum		2,050				

Computed Tc = 15.09
Regional Tc = 21.39

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 5.82 inch/hr	Rainfall Intensity at Tc, I = 4.88 inch/hr
Peak Flowrate, Qp = 90.27 cfs	Peak Flowrate, Qp = 75.69 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: I-25 - Alameda Avenue Sub-Basin 21

I. Catchment Hydrologic Data

Catchment ID = I-25 - Alameda - SB 21
Area = 5.30 Acres
Percent Imperviousness = 70.00 %
NRCS Soil Type = B A, B, C, or D

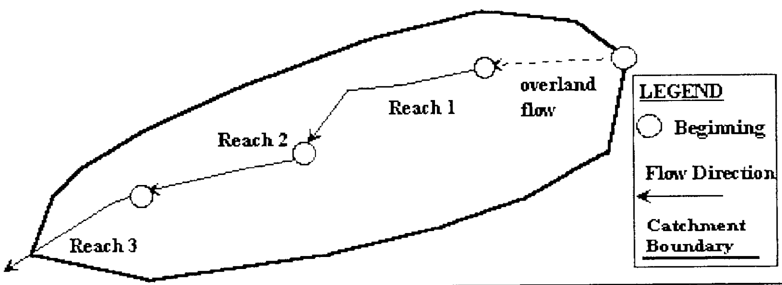
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.62
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.49
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0200	88	0.49		0.18	8.20
1	0.0139	718		20.00	2.36	5.07
2						
3						
4						
5						
Sum		806				

Computed Tc = 13.27
Regional Tc = 14.48

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 6.17 inch/hr	Rainfall Intensity at Tc, I = 5.93 inch/hr
Peak Flowrate, Qp = 20.30 cfs	Peak Flowrate, Qp = 19.51 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: I-25 - Alameda Avenue Sub-Basin 22

I. Catchment Hydrologic Data

Catchment ID = I-25 - Alameda - SB 22
Area = 9.60 Acres
Percent Imperviousness = 70.00 %
NRCS Soil Type = B A, B, C, or D

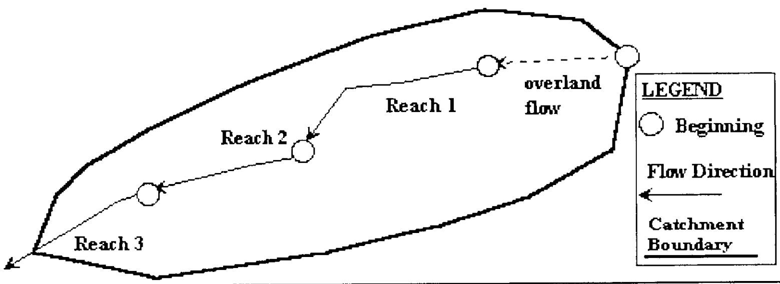
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.62
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.49
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0200	88	0.49		0.18	8.20
1	0.0350	700		20.00	3.74	3.12
2						
3						
4						
5						
Sum		788				

Computed Tc = 11.32
Regional Tc = 14.38

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 6.61 inch/hr	Rainfall Intensity at Tc, I = 5.95 inch/hr
Peak Flowrate, Qp = 39.40 cfs	Peak Flowrate, Qp = 35.46 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: I-25 - Alameda Avenue Sub-Basin 23

I. Catchment Hydrologic Data

Catchment ID = I-25 - Alameda - SB 23
Area = 9.60 Acres
Percent Imperviousness = 70.00 %
NRCS Soil Type = B A, B, C, or D

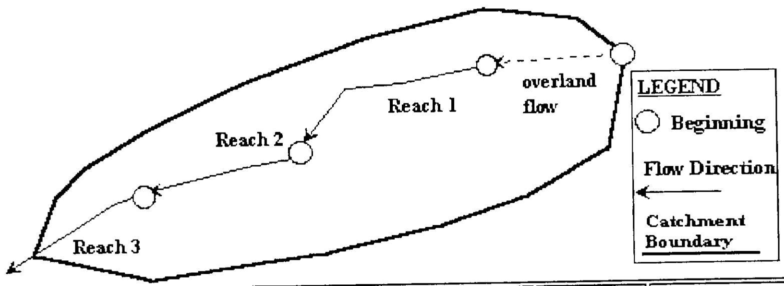
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.62
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.49
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0200	88	0.49		0.18	8.20
1	0.0350	1,350		20.00	3.74	6.01
2						
3						
4						
5						
Sum		1,438				

Computed Tc = 14.21
Regional Tc = 17.99

IV.

Peak Runoff Prediction using Computed Tc	**ediction using Regional Tc**
Rainfall Intensity at Tc, I = 5.98 inch/hr	Rainfall Intensity at Tc, I = 5.34 inch/hr
Peak Flowrate, Qp = 35.65 cfs	Peak Flowrate, Qp = 31.81 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: SH 85 - System Alternative 1

I. Catchment Hydrologic Data

Catchment ID = SH 85
Area = 9.60 Acres
Percent Imperviousness = 87.00 %
NRCS Soil Type = B A, B, C, or D

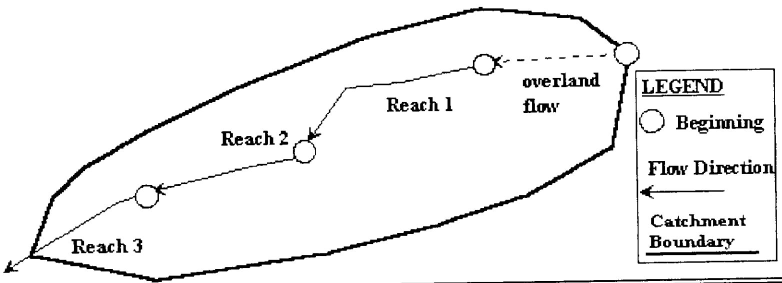
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.77
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.68
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft	C-5		fps	minutes
	input	input	output	input	output	output
Overland	0.0200	50	0.68		0.20	4.23
1	0.0057	1,750		20.00	1.51	19.29
2						
3						
4						
5						
Sum		1,800				

Computed Tc = 23.52
Regional Tc = 20.00

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 4.63 inch/hr	Rainfall Intensity at Tc, I = 5.06 inch/hr
Peak Flowrate, Qp = 34.40 cfs	Peak Flowrate, Qp = 37.54 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: SH 85 - System Alternative 2

I. Catchment Hydrologic Data

Catchment ID = SH 85
Area = 9.60 Acres
Percent Imperviousness = 93.00 %
NRCS Soil Type = B A, B, C, or D

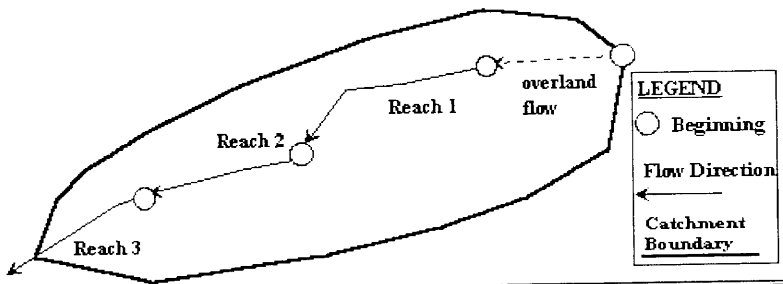
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.85
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.77
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0200	50	0.77		0.25	3.32
1	0.0049	2,050		20.00	1.40	24.46
2						
3						
4						
5						
Sum		2,100				

Computed Tc = 27.78
Regional Tc = 21.67

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 4.22 inch/hr	Rainfall Intensity at Tc, I = 4.85 inch/hr
Peak Flowrate, Qp = 34.39 cfs	Peak Flowrate, Qp = 39.51 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: SH 85 - System Alternative 3

I. Catchment Hydrologic Data

Catchment ID = SH 85
Area = 11.00 Acres
Percent Imperviousness = 89.00 %
NRCS Soil Type = B A, B, C, or D

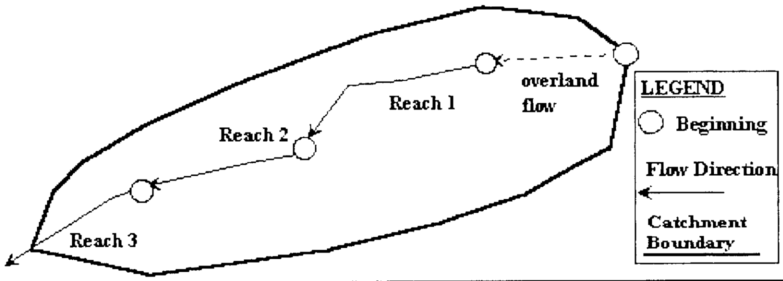
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.80
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.71
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft	C-5		fps	minutes
	input	input	output	input	output	output
Overland	0.0200	50	0.71		0.21	3.94
1	0.0049	2,050		20.00	1.40	24.46
2						
3						
4						
5						
Sum		2,100				

Computed Tc = 28.40
Regional Tc = 21.67

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 4.16 inch/hr	Rainfall Intensity at Tc, I = 4.85 inch/hr
Peak Flowrate, Qp = 36.52 cfs	Peak Flowrate, Qp = 42.49 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: I-25 - Broadway Basin

I. Catchment Hydrologic Data

Catchment ID = I-25 - Broadway
Area = 20.00 Acres
Percent Imperviousness = 81.00 %
NRCS Soil Type = B A, B, C, or D

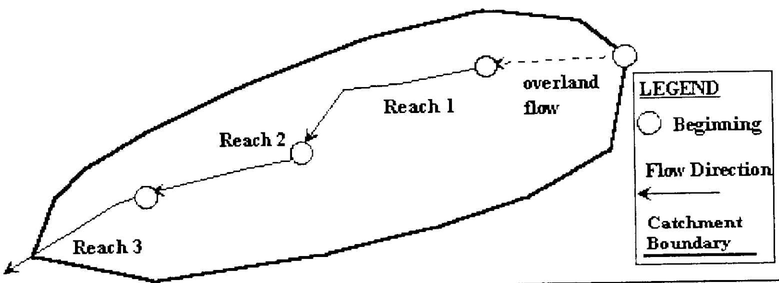
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.71
Overide Runoff Coefficient, C = ________ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.61
Overide 5-yr. Runoff Coefficient, C = ________ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft	C-5		fps	minutes
	input	input	output	input	output	output
Overland	0.0200	96	0.61		0.23	6.95
1	0.0300	2,900		20.00	3.46	13.95
2						
3						
4						
5						
Sum		2,996				

Computed Tc = 20.90
Regional Tc = 26.64

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 4.94 inch/hr	Rainfall Intensity at Tc, I = 4.32 inch/hr
Peak Flowrate, Qp = 70.11 cfs	Peak Flowrate, Qp = 61.32 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: I-25 - Broadway Sub-Basin 31

I. Catchment Hydrologic Data

Catchment ID = I-25 - Broadway SB-31
Area = 5.90 Acres
Percent Imperviousness = 100.00 %
NRCS Soil Type = B A, B, C, or D

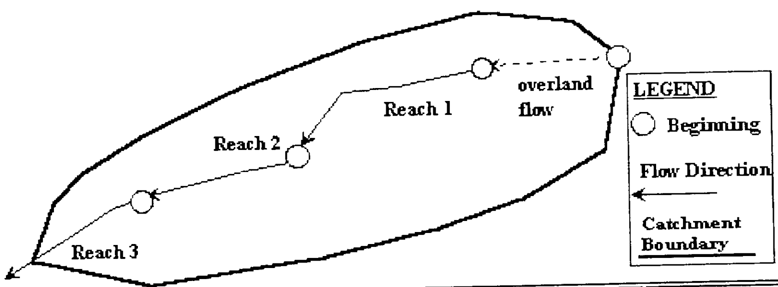
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.96
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.90
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Conveyance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0200	96	0.90		0.56	2.88
1	0.0300	1,100		20.00	3.46	5.29
2						
3						
4						
5						
Sum		1,196				

Computed Tc = 8.17
Regional Tc = 16.64

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 7.50 inch/hr	Rainfall Intensity at Tc, I = 5.55 inch/hr
Peak Flowrate, Qp = 42.27 cfs	Peak Flowrate, Qp = 31.28 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: I-25 - Broadway Sub-Basin 32

I. Catchment Hydrologic Data

Catchment ID = I-25 - Broadway SB-32
Area = 9.30 Acres
Percent Imperviousness = 100.00 %
NRCS Soil Type = B A, B, C, or D

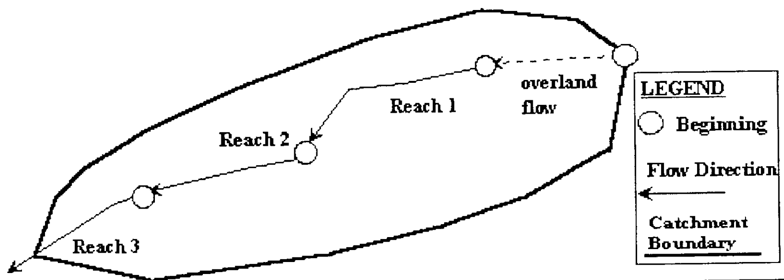
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.96
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.90
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0200	96	0.90		0.56	2.88
1	0.0300	1,800		20.00	3.46	8.66
2						
3						
4						
5						
Sum		1,896				

Computed Tc = 11.54
Regional Tc = 20.53

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 6.56 inch/hr	Rainfall Intensity at Tc, I = 4.99 inch/hr
Peak Flowrate, Qp = 58.29 cfs	Peak Flowrate, Qp = 44.31 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: I-25 - Broadway Sub-Basin 33

I. Catchment Hydrologic Data

Catchment ID = I-25 - Broadway SB-33
Area = 5.40 Acres
Percent Imperviousness = 30.00 %
NRCS Soil Type = B A, B, C, or D

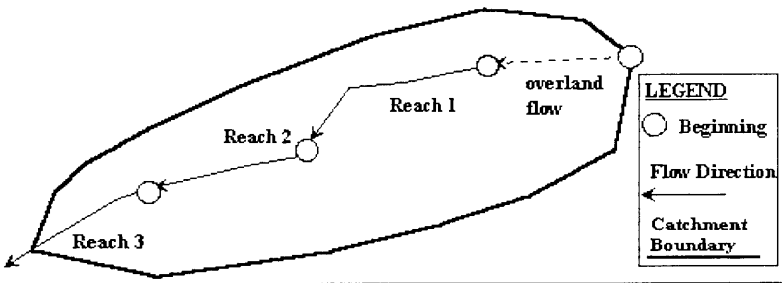
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.47
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.25
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0200	50	0.25		0.10	8.65
1	0.0300	400		20.00	3.46	1.92
2	0.3300	150		20.00	11.49	0.22
3						
4						
5						
Sum		600			Computed Tc =	10.79
					Regional Tc =	13.33

IV.

Peak Runoff Prediction using Computed Tc	ediction using Regional Tc
Rainfall Intensity at Tc, I = 6.74 inch/hr	Rainfall Intensity at Tc, I = 6.16 inch/hr
Peak Flowrate, Qp = 17.10 cfs	Peak Flowrate, Qp = 15.61 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Valley Highway EIS
Catchment ID: I-25 - Broadway Tunnel Basin

I. Catchment Hydrologic Data

Catchment ID = I-25 Broadway Tunnel
Area = 1.30 Acres
Percent Imperviousness = 100.00 %
NRCS Soil Type = B A, B, C, or D

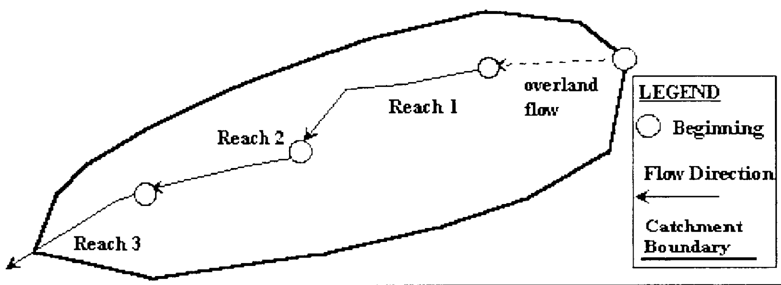
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.50 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.96
Overide Runoff Coefficient, C = ______ (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.90
Overide 5-yr. Runoff Coefficient, C = ______ (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Convey-ance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
	input	input	output	input	output	output
Overland	0.0200	50	0.90		0.40	2.08
1	0.0400	300		20.00	4.00	1.25
2	0.0200	200		20.00	2.83	1.18
3	0.0040	1,300		20.00	1.26	17.13
4						
5						
Sum		1,850				

Computed Tc = 21.63
Regional Tc = 20.28

IV.

Peak Runoff Prediction using Computed Tc	**ediction using Regional Tc**
Rainfall Intensity at Tc, I = 4.85 inch/hr	Rainfall Intensity at Tc, I = 5.02 inch/hr
Peak Flowrate, Qp = 6.02 cfs	Peak Flowrate, Qp = 6.23 cfs

Inlet Spacing Spreadsheet

Valley Highway EIS

Gutter Flow Rates and Approximate Inlet Spacing

9/24/2003

Design Frequency =	Minor	
Inlet Type	C	
Allowable Spread =	**12 ft**	(Shoulder Width)
Cross Slope, S_x	0.02 (ft/ft)	
Grate Width =	2 ft	
Grate Length =	3 ft	

		One Vane Grate			Two Vane Grates			Three Vane Grates			Four Vane Grates			Five Vane Grates		
Long. Slope, S_L (ft/ft)	Allowable Flow, $Q_{(allow)}$ (cfs)	Qin (cfs)	Qb (cfs)	Capture %	Qin (cfs)	Qb (cfs)	Capture %	Qin (cfs)	Qb (cfs)	Capture %	Qin (cfs)	Qb (cfs)	Capture %	Qin (cfs)	Qb (cfs)	Capture %
0.001	1.52	0.80	0.72	52.80	1.30	0.22	85.80	1.40	0.12	92.40	1.50	0.02	99.00	1.50	0.02	99.00
0.002	2.14	1.20	0.94	56.00	1.60	0.54	74.67	1.90	0.24	88.67	2.00	0.14	93.34	2.10	0.04	98.01
0.003	2.62	1.20	1.42	45.73	1.80	0.82	68.59	2.20	0.42	83.83	2.40	0.22	91.45	2.50	0.12	95.27
0.004	3.03	1.70	1.33	56.10	1.80	1.23	59.40	2.10	0.93	69.30	2.40	0.63	79.20	2.60	0.43	85.80
0.005	3.39	1.40	1.99	41.32	2.10	1.29	61.99	2.70	0.69	79.70	3.00	0.39	88.55	3.20	0.19	94.45
0.006	3.71	1.60	2.11	43.11	2.20	1.51	59.28	2.90	0.81	78.14	3.30	0.41	88.92	3.40	0.31	91.61
0.008	4.29	1.80	2.49	42.00	2.40	1.89	56.00	3.20	1.09	74.67	3.60	0.69	84.01	3.90	0.39	91.01
0.010	4.79	2.00	2.79	41.74	2.60	2.19	54.27	3.40	1.39	70.96	4.00	0.79	83.49	4.30	0.49	89.75
0.015	5.87	2.40	3.47	40.90	2.90	2.97	49.42	3.80	2.07	64.76	4.60	1.27	78.39	5.00	0.87	85.21
0.020	6.78	2.70	4.08	39.85	3.20	3.58	47.23	4.10	2.68	60.51	5.00	1.78	73.79	5.60	1.18	82.65
0.025	7.58	3.00	4.58	39.60	3.50	4.08	46.20	4.40	3.18	58.08	5.40	2.18	71.28	6.10	1.48	80.52
0.030	8.30	3.10	5.20	37.36	3.70	4.60	44.59	4.70	3.60	56.64	5.70	2.60	68.69	6.50	1.80	78.33
0.035	8.96	3.20	5.76	35.70	4.00	4.96	44.63	4.90	4.06	54.67	5.90	3.06	65.82	6.80	2.16	75.86
0.040	9.58	3.20	6.38	33.39	4.20	5.38	43.83	5.10	4.48	53.22	6.20	3.38	64.70	7.10	2.48	74.09
0.045	10.16	3.30	6.86	32.47	4.40	5.76	43.29	5.30	4.86	52.15	6.40	3.76	62.97	7.30	2.86	71.82
0.050	10.71	3.30	7.41	30.80	4.60	6.11	42.94	5.50	5.21	51.34	6.60	4.11	61.60	7.60	3.11	70.94
0.055	11.24	3.30	7.94	29.37	4.80	6.44	42.72	5.60	5.64	49.84	6.80	4.44	60.52	7.80	3.44	69.42
0.060	11.74	3.40	8.34	28.97	4.90	6.84	41.75	5.80	5.94	49.42	6.90	4.84	58.79	8.00	3.74	68.17

Design Frequency =	Major	
Inlet Type	C	
Allowable Spread =	**16 ft**	(Shoulder Width+4 feet)
Cross Slope, S_x	0.02 (ft/ft)	
Grate Width =	2 ft	
Grate Length =	3 ft	

		One Vane Grate			Two Vane Grates			Three Vane Grates			Four Vane Grates			Five Vane Grates		
Long. Slope, S_L (ft/ft)	Flow Rate, $Q_{(allow)}$ (cfs)	Qin (cfs)	Qb (cfs)	Capture %	Qin (cfs)	Qb (cfs)	Capture %	Qin (cfs)	Qb (cfs)	Capture %	Qin (cfs)	Qb (cfs)	Capture %	Qin (cfs)	Qb (cfs)	Capture %
0.001	3.26	1.4	1.86	42.91	2.40	0.86	73.55	2.90	0.36	88.88	3.20	0.06	98.07	3.20	0.06	98.07
0.002	4.61	1.70	2.91	36.84	3.00	1.61	65.01	3.90	0.71	84.52	4.20	0.41	91.02	4.40	0.21	95.35
0.003	5.65	2.00	3.65	35.39	3.30	2.35	58.39	4.40	1.25	77.85	5.00	0.65	88.47	5.30	0.35	93.78
0.004	6.53	2.70	3.83	41.37	3.20	3.33	49.03	3.80	2.73	58.23	4.50	2.03	68.96	5.10	1.43	78.15
0.005	7.30	2.40	4.90	32.89	3.70	3.60	50.71	5.20	2.10	71.27	6.10	1.20	83.60	6.60	0.70	90.46
0.006	7.99	2.60	5.39	32.53	3.90	4.09	48.79	5.50	2.49	68.81	6.50	1.49	81.32	7.10	0.89	88.83
0.008	9.23	3.00	6.23	32.51	4.20	5.03	45.51	5.90	3.33	63.93	7.20	2.03	78.01	8.00	1.23	86.68
0.010	10.32	3.30	7.02	31.98	4.40	5.92	42.64	6.20	4.12	60.09	7.70	2.62	74.62	8.70	1.62	84.31
0.015	12.64	4.00	8.64	31.65	5.00	7.64	39.56	6.90	5.74	54.60	8.70	3.94	68.84	10.00	2.64	79.13
0.020	14.59	4.30	10.29	29.47	5.50	9.09	37.69	7.40	7.19	50.71	9.40	5.19	64.42	10.90	3.69	74.70
0.025	16.31	4.50	11.81	27.58	5.90	10.41	36.16	7.80	8.51	47.81	9.90	6.41	60.68	11.70	4.61	71.71
0.030	17.87	4.60	13.27	25.74	6.30	11.57	35.25	8.10	9.77	45.32	10.30	7.57	57.63	12.30	5.57	68.82
0.035	19.30	4.60	14.70	23.83	6.70	12.60	34.71	8.50	10.80	44.03	10.70	8.60	55.43	12.80	6.50	66.31
0.040	20.64	4.70	15.94	22.77	7.00	13.64	33.92	8.80	11.84	42.64	11.10	9.54	53.79	13.30	7.34	64.45
0.045	21.89	4.60	17.29	21.02	7.10	14.79	32.44	9.10	12.79	41.57	11.40	10.49	52.08	13.70	8.19	62.59
0.050	23.07	4.60	18.47	19.94	7.10	15.97	30.77	9.40	13.67	40.74	11.70	11.37	50.71	14.00	9.07	60.68
0.055	24.20	4.50	19.70	18.60	7.10	17.10	29.34	9.70	14.50	40.08	11.90	12.30	49.18	14.40	9.80	59.51
0.060	25.27	4.50	20.77	17.80	7.10	18.17	28.09	10.00	15.27	39.56	13.30	11.97	52.62	14.90	10.37	58.95

APPENDIX D DENVER STORM DRAINAGE MASTER PLAN

City and County of Denver Storm Drainage Master Plan – Phase I Final (selected sheets)

CITY & COUNTY OF DENVER
STORM DRAINAGE MASTER PLAN

PHASE I FINAL

December 2, 2003

Basin 0063-01 (Central Platte Valley)

Existing System Description:
This basin consists of a majority of the Central Platte Valley area of downtown Denver. This basin consists of 1,342 acres (2.10 square miles) and includes older neighborhood residential in the upper reaches east of the railroad tracks and Sante Fe, and commercial in the lower reaches. All drainage from this basin will outfall into the South Platte River. Intercepted stormwater is discharged via at least 32 storm drainage outfalls, which are comprised mainly of local storm drains from I-25 and adjacent properties. Some of the existing larger outfalls include:

- Bayaud Avenue outfall is 36-inch (54-inch upstream) with 351 tributary acres
- 3rd Avenue outfall is 54-inch with 104 tributary acres
- 6th Avenue outfall is 72-inch with 273 tributary acres
- 13th Avenue outfall is 42-inch with 119 tributary acres
- Colfax Avenue outfall is 36-inch with 53 tributary acres
- Elitch outfall is 48-inch with 44 tributary acres

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

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

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

Proposed Capital Improvements:
Difficulties in constructing additional or replacement storm drains are the crossing of the railroad and I-25. ***Blueprint Denver*** shows the majority of the basin (commercial areas) subject to change. Only the residential neighborhood east of the railroad tracks between Alameda and 8th Avenue is shown as an "Areas of Stability", a relatively small area of the overall basin.

Project A: West 13th Avenue Outfall 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 relatively new 72-inch storm drain in 6th Avenue must be upsized to an 90-inch pipe to provide a minimum 5-year level of service. An existing constriction occurs where a 60-inch pipe with 0.61% slope connects downstream to a 42-inch and 48-inch pipe at 0.61%. This intermediate reach of pipe between Quivas and Tejon should be replaced with a larger pipe (78-inch for 5-year capacity).

Project C: West Bayaud Avenue The existing system has less than a 1-year event capacity (Design Point 1516 with 351 tributary acres). The Bayaud Avenue outfall consisting of a 54-inch pipe is proposed for replacement with an 84-inch pipe for a 5-year system. (Alternatively, a 100-year system to serve the sump at Galapago & Bayaud would require a 120-inch pipe outfall.) At Galapago, the proposed pipe jogs over to Ellsworth Avenue to preserve the existing trunk system upstream. Since flooding is known to occur in Broadway, the proposed storm system extends to Lincoln 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.

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 will replace the existing 60-inch outfall in 3rd Avenue to achieve a 5-year level of service.

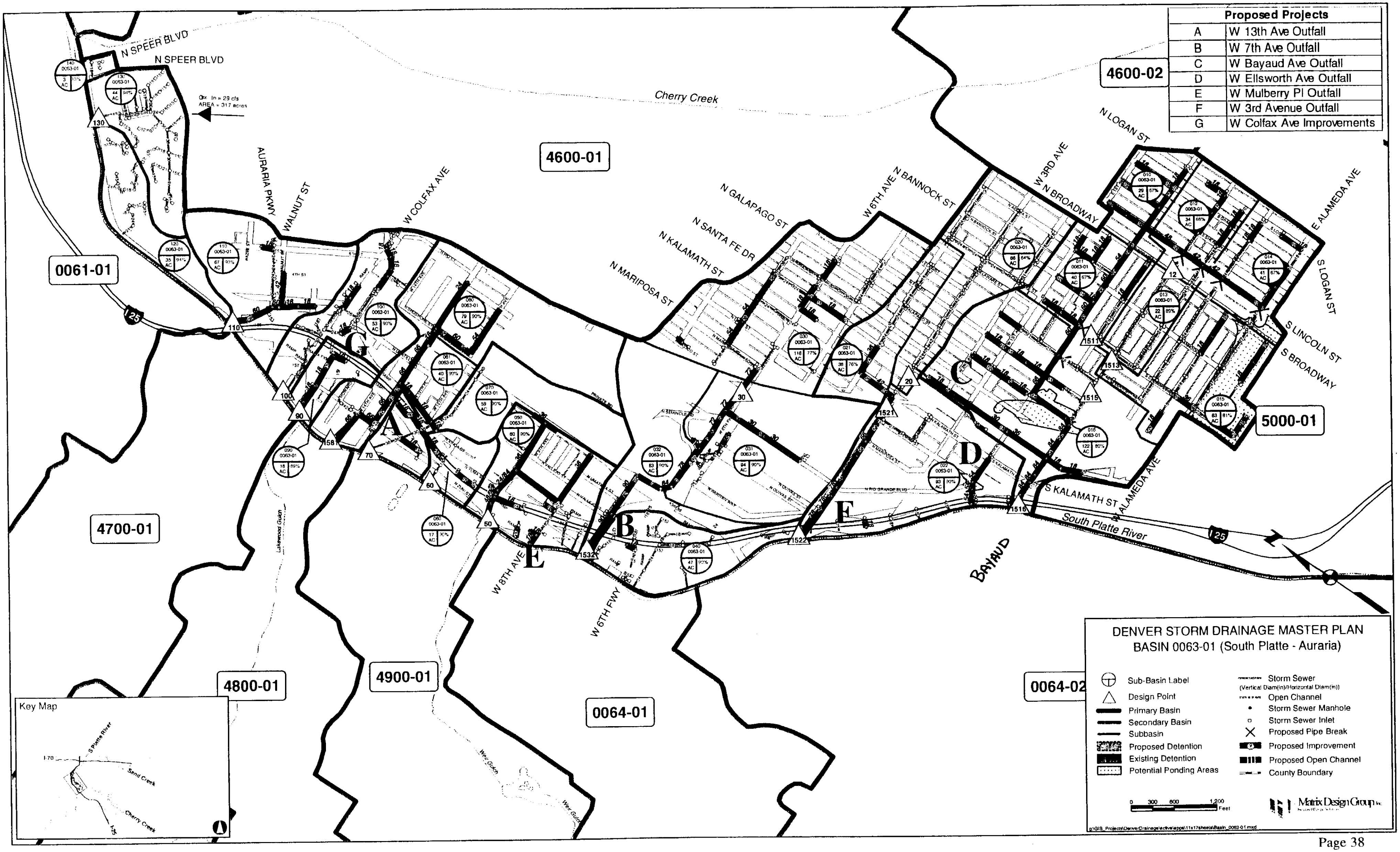
Project G: West Colfax Avenue Improvements 18-inch upgrades and replacement of an existing 36-inch pipe with a new 60-inch pipe is proposed in this general area.

Hydrology:

BASIN 0063-01

Design Point	Design Point	Contributing Basins	Tributary Area	Peak Discharge*		
Minor Event Model	Overland Flow Model	Minor Event Model	Minor Event Model (acres)	2-Year (cfs)	5-Year (cfs)	100-Year (cfs)
12		12	34	38	62	148
20		20	66	47	78	192
30		30	116	160	246	546
50		50	60	98	142	292
60		60	17	27	39	81
70		70	59	75	109	229
90		90	16	24	35	74
100		100	53	70	102	214
110		110	67	106	154	317
130	1070	130	44	74	106	**176**
1511		10,11	69	66	106	263
1513		10-13	125	115	190	477
1515		10-15	229	207	333	820
1516		10-16	351	276	431	1111
1521		20,21	104	89	143	338
1522		20-22	197	192	276	581
1532		30-32	273	299	391	922
1581		80,81	119	122	179	411

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


Proposed Projects
A W 13th Ave Outfall
B W 7th Ave Outfall
C W Bayaud Ave Outfall
D W Ellsworth Ave Outfall
E W Mulberry Pl Outfall
F W 3rd Avenue Outfall
G W Colfax Ave Improvements
DENVER STORM DRAINAGE MASTER PLAN
BASIN 0063-01 (South Platte - Auraria)
Sub-Basin Label
Design Point
Primary Basin
Secondary Basin
Subbasin
Proposed Detention
Existing Detention
Potential Ponding Areas
Storm Sewer
(Vertical Diam(in)/Horizontal Diam(in))
Open Channel
Storm Sewer Manhole
Storm Sewer Inlet
Proposed Pipe Break
Proposed Improvement
Proposed Open Channel
County Boundary
Matrix Design Group
Key Map
4600-01
4600-02
5000-01
0061-01
4700-01
4800-01
4900-01
0064-01
0064-02
Cherry Creek
South Platte River
N SPEER BLVD
AURARIA PKWY
WALNUT ST
W COLFAX AVE
N GALAPAGO ST
N SANTA FE DR
N KALAMATH ST
N MARIPOSA ST
W 6TH AVE
N BANNOCK ST
W 3RD AVE
N BROADWAY
N LOGAN ST
E ALAMEDA AVE
S LOGAN ST
S LINCOLN ST
S BROADWAY
ALAMEDA AVE
S KALAMATH ST
BAYAUD
W 8TH AVE
W 6TH FWY

Basin 0064-01 (1st & Federal)

Existing System Description:
This basin is tributary to Weir Gulch and the South Platte River by topography and pipe network. In general, this basin is located south of Weir Gulch. This basin consists of 610 acres (0.95 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 in 8 storm drainage outfalls, which is comprised of two to Weir Gulch and 6 directly to the South Platte River. The outfalls include:

Weir Gulch
- Irving Street outfall is 38"x60" with 208 tributary acres
- Grove Street outfall is 42-inch with 78 tributary acres

South Platte River
- Yuma Street outfall is 24-inch for local drainage
- 5th Avenue outfall is 42-inch with 177 tributary acres
- 6th Avenue 42-inch outfall for 72 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 of the existing inlets is unknown at this time.

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

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

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

Proposed Capital Improvements:
Proposed South Platte River channel improvements 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 from the 100-year event and even includes 500-year capacity culverts.

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 the 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 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 Bayaud Avenue A 24-inch lateral in Bayaud previously identified in the 1989 Master Plan is shown again in this master plan for construction.

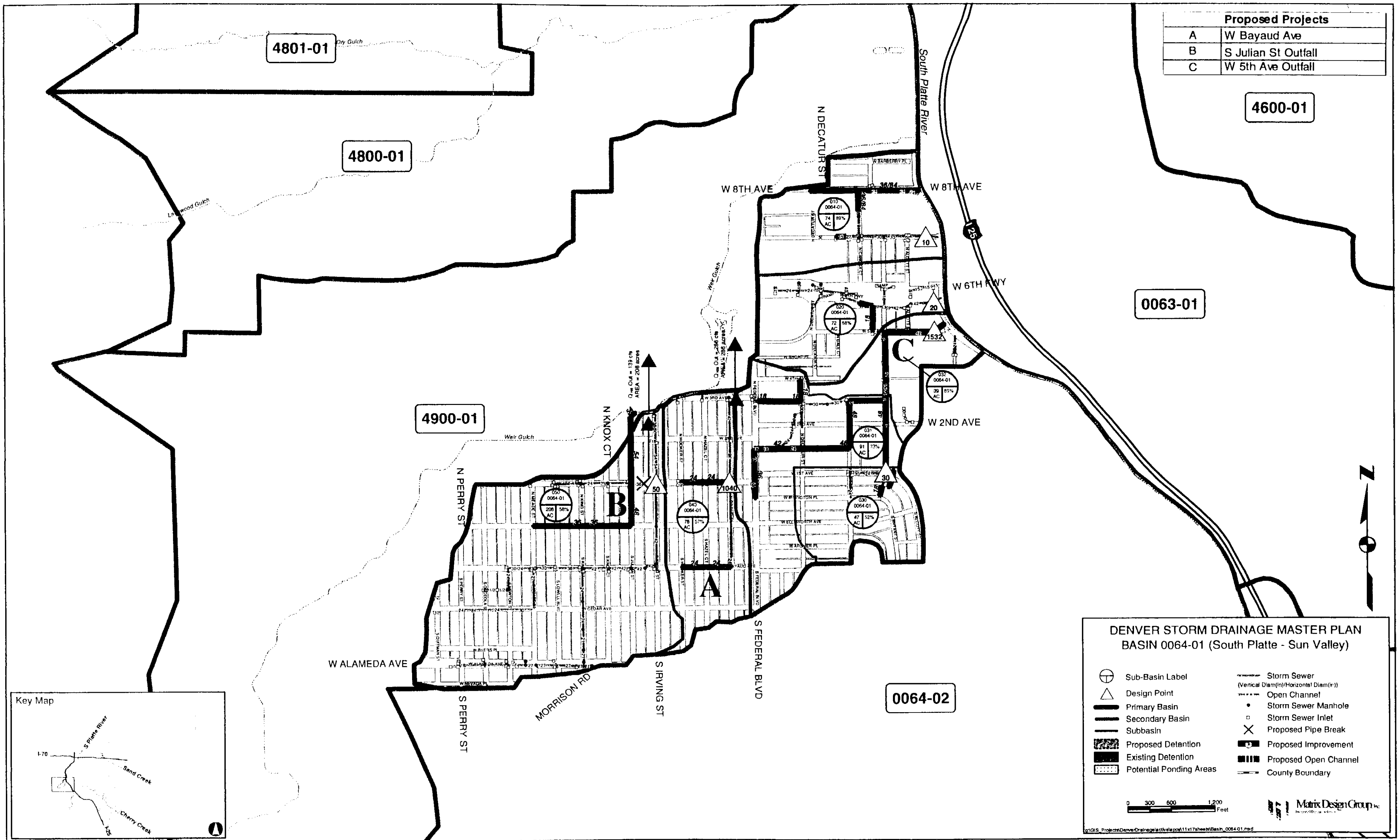
Project B: South Julian Street Outfall A new 54-inch outfall is proposed in Julian Street to meet current criteria. This proposed pipe will also remove some flow to a currently undersized outfall in Irving Street.

Project C: West 5th Avenue Outfall A new 72-inch outfall is proposed in 5th Avenue to better serve properties in the current South Platte River floodplain. A new 48-inch outfall is also proposed in 8th Avenue. 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.

Hydrology:

BASIN 0064-01

Design Point	Contributing Basins	Tributary Area	Peak Discharge		
		(acres)	2-Year (cfs)	5-Year (cfs)	100-Year (cfs)
10	10	74	102	149	311
20	20	72	69	112	265
30	30	47	41	75	195
50	50	208	209	361	915
1032	30,31,32,40,50	463	162	373	1403
1040	40,50	286	121	327	1048



Proposed Projects
A W Bayaud Ave
B S Julian St Outfall
C W 5th Ave Outfall
4801-01
4800-01
4900-01
4600-01
0063-01
0064-02
Dry Gulch
Lakewood Gulch
Weir Gulch
South Platte River
N DECATUR ST
W 8TH AVE
W 6TH PKWY
W 2ND AVE
N KNOX CT
N PERRY ST
W ALAMEDA AVE
S PERRY ST
MORRISON RD
S IRVING ST
S FEDERAL BLVD
I-25
A
B
C
Key Map
S Platte River
Sand Creek
Cherry Creek
I-70
I-25
DENVER STORM DRAINAGE MASTER PLAN
BASIN 0064-01 (South Platte - Sun Valley)
Sub-Basin Label
Design Point
Primary Basin
Secondary Basin
Subbasin
Proposed Detention
Existing Detention
Potential Ponding Areas
Storm Sewer
Open Channel
Storm Sewer Manhole
Storm Sewer Inlet
Proposed Pipe Break
Proposed Improvement
Proposed Open Channel
County Boundary
0 300 600 1,200 Feet
Matrix Design Group

Basin 5000-01 (I-25 Basin)

Existing System Description:
This basin consists of 802.55 acres (1.25 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 subject to change. The residential neighborhood is shown as an "Areas of Stability". All drainage from this basin outfalls to the South Platte River. Intercepted stormwater is discharged in at least 13 storm drainage outfalls, which are comprised of the following:

- 54-inch with 602 tributary acres, or 75% of basin 5000-01
- 36-inch for the I-25 & Sante Fe intersection
- 30-inch for the Sante Fe & Alameda intersection
- 30-inch for the Alameda & I-25 intersection
- 2-24-inch for local I-25 drainage
- 2-18-inch for local I-25 drainage
- 5-15-inch for local I-25 drainage

The storm drain infrastructure consists of a detailed network of laterals in most streets. A grid pattern of laterals is collected in Pennsylvania and Broadway streets. The inlets are old sandstone/granite catch basins with limited capacity due to design and numerous asphalt overlays throughout the years. As improvements and handicap ramps are installed in the neighborhood, these inlets are being replaced with current standard inlets. Many of these old inlets must be replaced to improve collection efficiency. Drainage from the I-25 basin is constrained by the elevation of the South Platte River and I-25, which generally reduces capacity and creates sump or surcharge conditions during major storm events.

Drainage Deficiencies:
The existing drainage system has capacity to convey an approximately 1-year storm event to the South Platte River. Rainfall runoff in excess of the storm drain capacity has a history of ponding in the sump and flat areas. Major drainage problems have been experienced in the sump on Alameda at the Sante Fe intersection. Ponding also occurs on the flat commercial areas by backing up water behind the railroad and I-25.

The basin delineation is based upon the storm drain network, which contravenes the site topography. Land east of the 5000-01 basin drains to Cherry Creek during minor storm events, and enters this basin in major events when the storm drain pipes are overwhelmed with runoff or plugged. In a major event, two additional areas drain into this basin: 384 acres from 4600-02, and 324 acres from 5000-02. This split flow contribution exacerbates the flooding experienced in the lower basin.

Proposed Capital Improvements:
The existing lakes at Washington Park could be reconfigured to act as "peaking" facilities by detaining stormwater only in major events when the pipe capacity is exceeded.

This basin requires improvements primarily to the outfall since the lateral network is currently extensive in this basin. Storm pipes through the commercial areas should have 5-year capacity, whereas the lateral network through the residential areas should have at least a 2-year capacity.

Project A: 18" Upgrades Existing 12- and 15-inch pipes along Dakota and Virginia Streets are proposed to be replaced with 18-inch pipes to meeting current drainage criteria and reduce maintenance.

Project B: Alameda Avenue Outfall The existing system should be re-used to the extent possible. Rather than replacing existing large pipe, a new parallel pipe to intercept a portion of the existing storm drains is most effective. An 8'x5' box culvert along the Center Street projected alignment from the South Platte to Pennsylvania will improve drainage conveyance. This alignment was selected as the most efficient route; however, Center Street west of Broadway is not City-owned and therefore a drainage easement will be required. Alternatively, a different alignment could be selected. Regardless of alignment, a new crossing under the railroad tracks and I-25 is necessary. This new outfall should be considered during the next phase of TREX construction for the I-25 crossing.

Project C: Dakota Avenue Improvements Existing small storm drains will be replaced with 18-inch pipe to meet current drainage criteria as the minimum pipe size on collector drains.

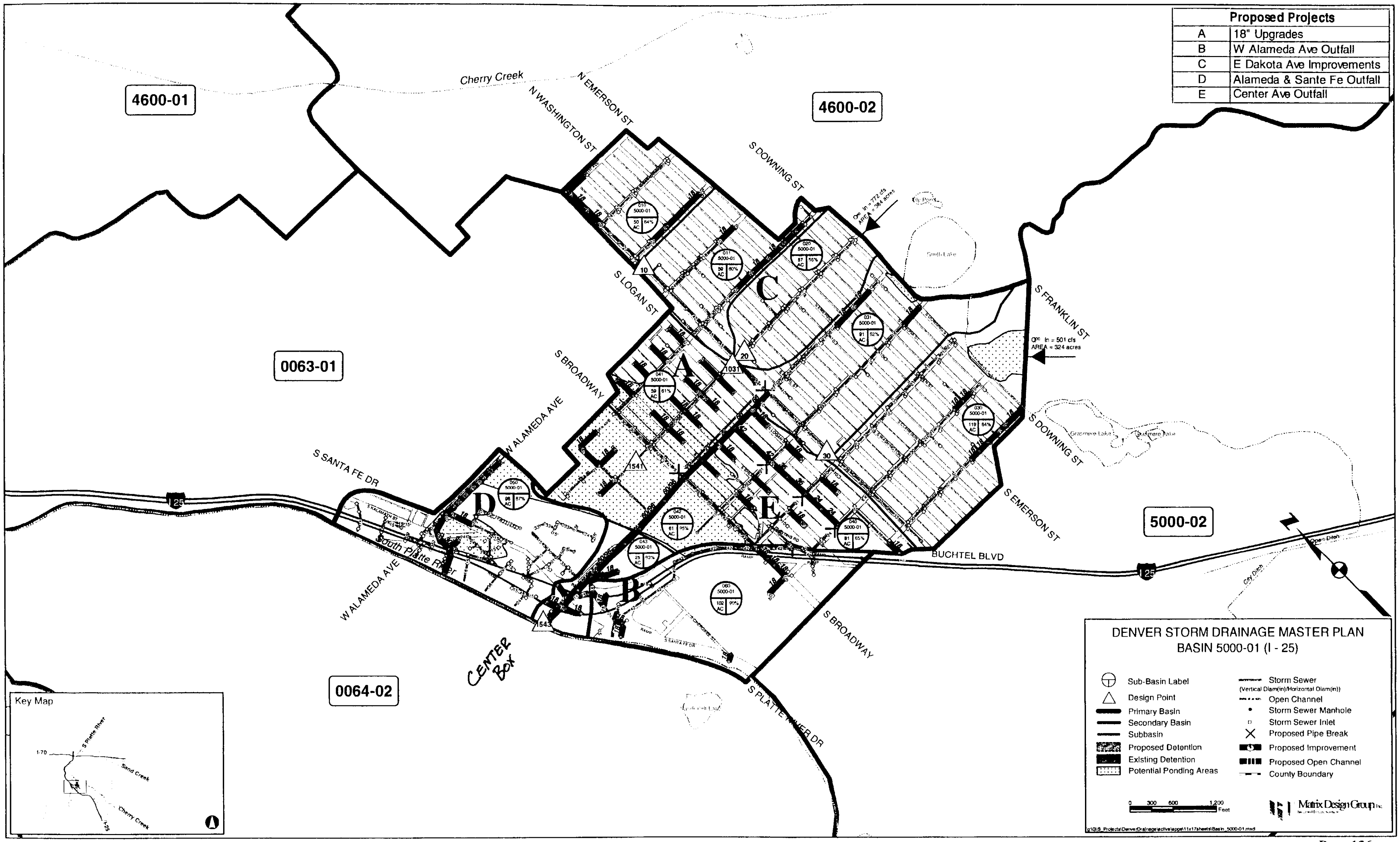
Project D: Alameda & Sante Fe Outfall The sump at Alameda and Santa Fe is a chronic flood problem area and will require construction of an enlarged outfall to the Platte River across I-25. Currently, the storm drain at the point of the sump is 18-inch, which should be upsized to a 30-inch pipe.

Project E: Center Avenue Outfall Existing small storm drains are proposed to be replaced with 18-inch pipes to meeting current drainage criteria and reduce maintenance. Also, a new collector drain in Grant Street is proposed that ties into the proposed Center Avenue outfall. This new collector will reduce historic flooding in Broadway by capturing sheet flow runoff. Grant Street was selected as the preferred alignment for the collector since it has the fewest existing utilities. Construction in Broadway is discouraged to avoid disruption to arterial traffic flow and existing utilities.

Hydrology:
BASIN 5000-01

Design Point	Design Point	Contributing Basins	Tributary Area	Peak Discharge*		
Minor Event Model	Overland Flow Model	Minor Event Model	Minor Event Model (acres)	2-Year (cfs)	5-Year (cfs)	100-Year (cfs)
10	NA	10	50	56	93	**NA**
20	NA	20	57	45	80	**NA**
30	NA	30	119	131	218	**NA**
1031	1530	10-31	376	311	528	**2029**
1541	NA	10-41	516	378	650	**NA**
1543	120	10-43	602	387	654	**2558**

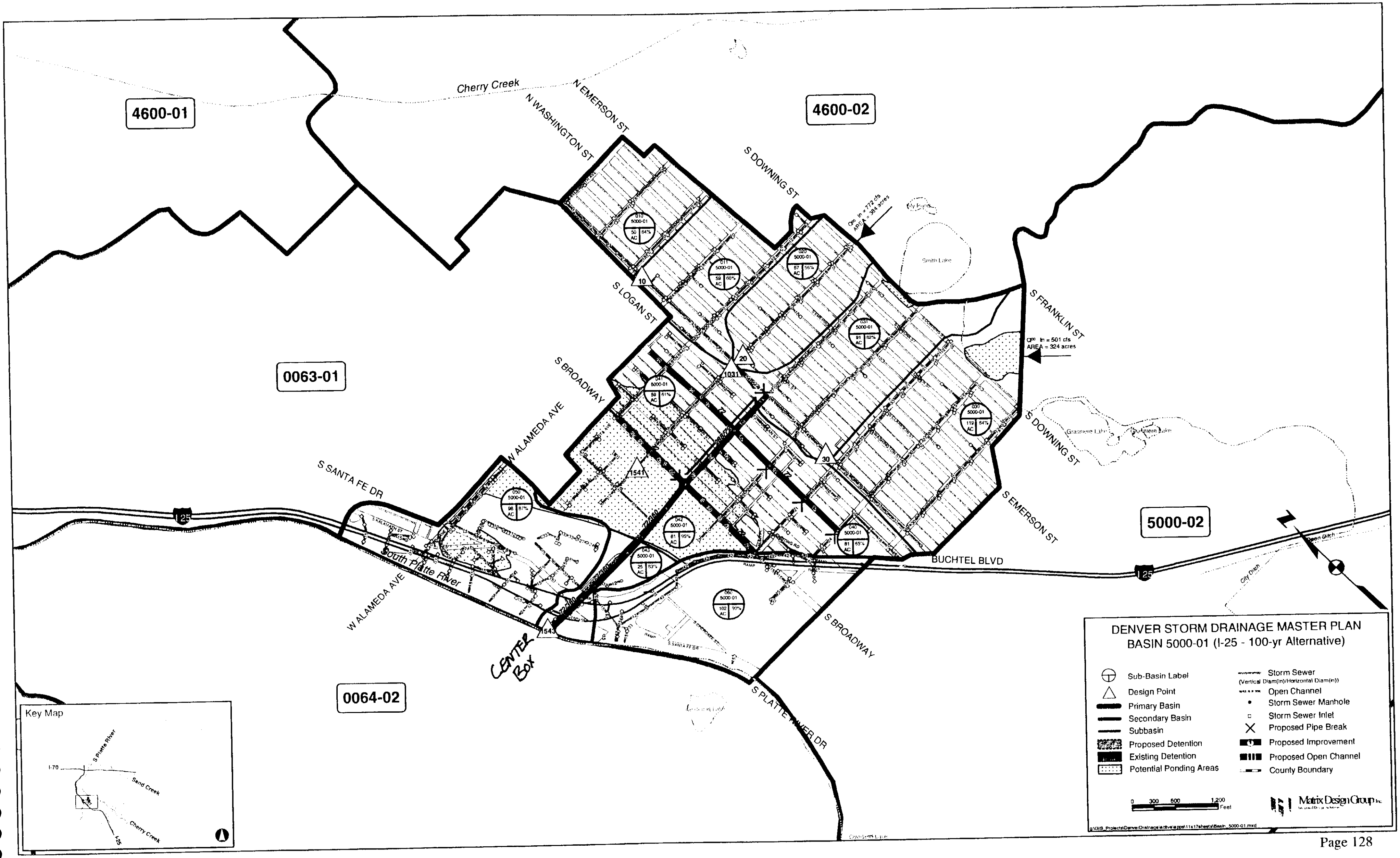
* 100-year discharge in **bold** represents analysis based on "overland" drainage paths determined from topography. Other events (2-year, 5-year, and remaining 100-year) are analyzed based on existing pipe network flow paths. Since several pipe networks do not follow overland drainage paths, this differing approach in modeling could create significant differences in peak flow distribution between storm events.


Proposed Projects
A 18" Upgrades
B W Alameda Ave Outfall
C E Dakota Ave Improvements
D Alameda & Sante Fe Outfall
E Center Ave Outfall
4600-01
4600-02
0063-01
0064-02
5000-02
Cherry Creek
N EMERSON ST
N WASHINGTON ST
S DOWNING ST
S LOGAN ST
S BROADWAY
S FRANKLIN ST
S EMERSON ST
W ALAMEDA AVE
S SANTA FE DR
South Platte River
BUCHTEL BLVD
S PLATTE RIVER DR
CENTER Box
DENVER STORM DRAINAGE MASTER PLAN
BASIN 5000-01 (I - 25)
Sub-Basin Label
Design Point
Primary Basin
Secondary Basin
Subbasin
Proposed Detention
Existing Detention
Potential Ponding Areas
Storm Sewer
Open Channel
Storm Sewer Manhole
Storm Sewer Inlet
Proposed Pipe Break
Proposed Improvement
Proposed Open Channel
County Boundary
Matrix Design Group
Key Map

Basin 5000-01 (I-25 Basin)
(Alternative 100-Year System)

Alternative 100-Year System to Reduce the Potential Ponding:
Ponding is predicted in the retail plaza and RTD Park-N-Ride area near Broadway and Alameda. During a 100-year storm, runoff beyond the capacity of the pipe network is imported into the basin, estimated to be 772 cfs from 384 acres. The combined effect from runoff in the 5000-01 basin and off-site flow from basin 4600-02 results in a 100-year flow of 2,558 cfs at the outfall. A 100-year drainage system must cross under I-25 and the railroad tracks; therefore, a box culvert system would be more appropriate than an open channel system. A triple 10'x6' box culvert constructed from the outfall in the South Platte to Broadway (2,720 lf) would convey the 100-year flow. In addition, new laterals and inlets would be required to capture the 100-year runoff (see Alternative 100-Year map on the facing page).

The approximate increase in cost to raise the level of service from a 5-year system to a 100-year system and eliminate the potential ponding in the basin is $24.1M (high cost due to jack & bore pipe under the railroad and I-25 to reach the South Platte River). The cost of the 5-year system is estimated to be $8.8M. The total cost of the 100-year system is roughly $32.9M. However, physical damage estimates are at least $4.3M from a 5-year storm event, and $9.4M from a 100-year storm event (based upon FEMA flood depth verses damage tables), which do not include indirect costs and opportunity costs.

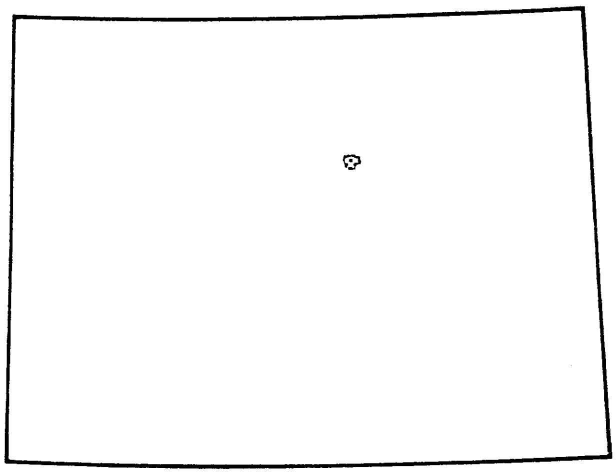

DENVER STORM DRAINAGE MASTER PLAN
BASIN 5000-01 (I-25 - 100-yr Alternative)
Sub-Basin Label
Design Point
Primary Basin
Secondary Basin
Subbasin
Proposed Detention
Existing Detention
Potential Ponding Areas
Storm Sewer
(Vertical Diam(in)/Horizontal Diam(in))
Open Channel
Storm Sewer Manhole
Storm Sewer Inlet
Proposed Pipe Break
Proposed Improvement
Proposed Open Channel
County Boundary
0 300 600 1,200 Feet
Matrix Design Group
4600-01
4600-02
0063-01
0064-02
5000-02
Cherry Creek
N EMERSON ST
N WASHINGTON ST
S DOWNING ST
S LOGAN ST
S FRANKLIN ST
S BROADWAY
W ALAMEDA AVE
S SANTA FE DR
S EMERSON ST
BUCHTEL BLVD
S PLATTE RIVER DR
South Platte River
CENTER Box
Key Map
I-70
S Platte River
Sand Creek
Cherry Creek
I-25

APPENDIX E FLOOD AND DRAINAGE WAY INFORMATION

Flood Insurance Study (selected sheets)
Flood Hazard Area Delineation – South Platte River (selected sheets)
Major Drainageway Planning – South Platte River – Phase B – Volume 1 (selected sheets)
Major Drainageway Planning – South Platte River – Phase B – Volume 2 (selected sheets)
Preliminary Design Report for the Upper Central Platte Valley (selected sheets)
I-25 Broadway/Santa Fe/Alameda Draft Floodplain and Drainage Assessment (selected sheets)
Existing Report List (of impacted basins) as provided by City and County of Denver
Picture of Sample Outlet Structure

FLOOD INSURANCE STUDY

CITY AND COUNTY OF DENVER, COLORADO

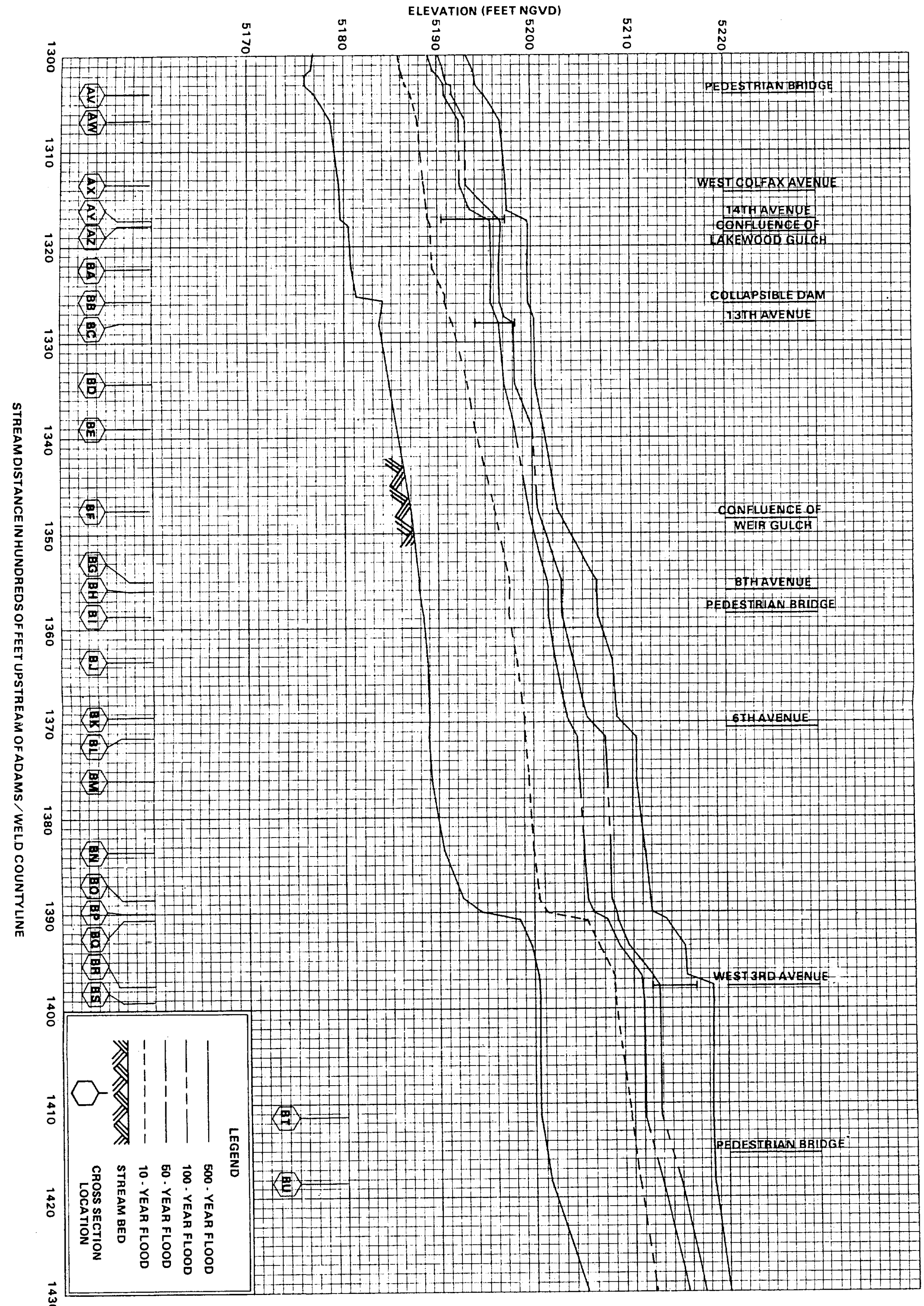


VOLUME 2 OF 2

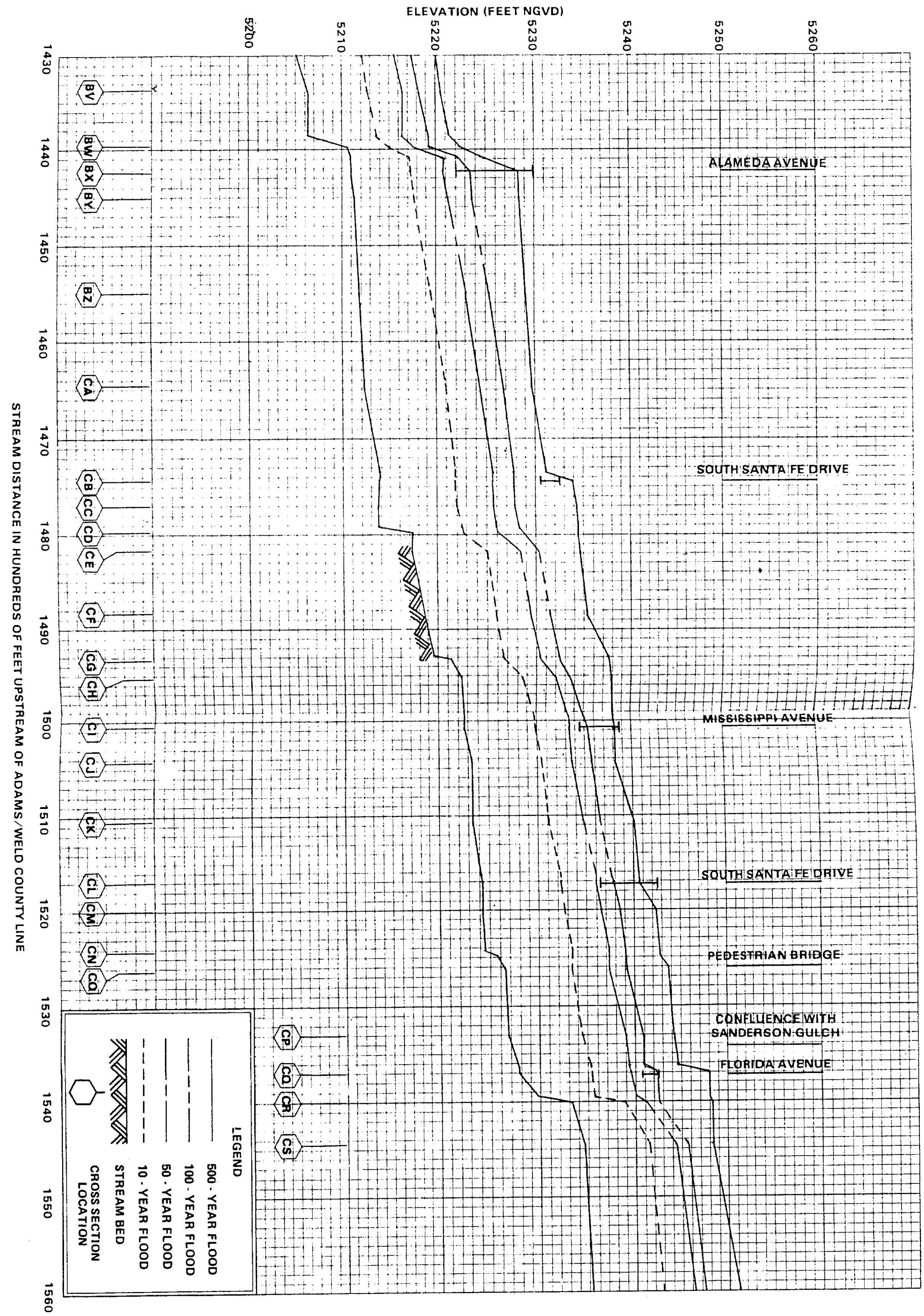
REVISED:SEPTEMBER 28, 1990

Federal Emergency Management Agency

COMMUNITY NUMBER - 080046



86P	FEDERAL EMERGENCY MANAGEMENT AGENCY CITY AND COUNTY OF DENVER, CO	**FLOOD PROFILES** SOUTH PLATTE RIVER



FEDERAL EMERGENCY MANAGEMENT AGENCY CITY AND COUNTY OF DENVER, CO	**FLOOD PROFILES** SOUTH PLATTE RIVER

FLOOD HAZARD AREA DELINEATION

SOUTH PLATTE RIVER

DENVER METROPOLITAN AREA

SAND CREEK TO OXFORD AVE.

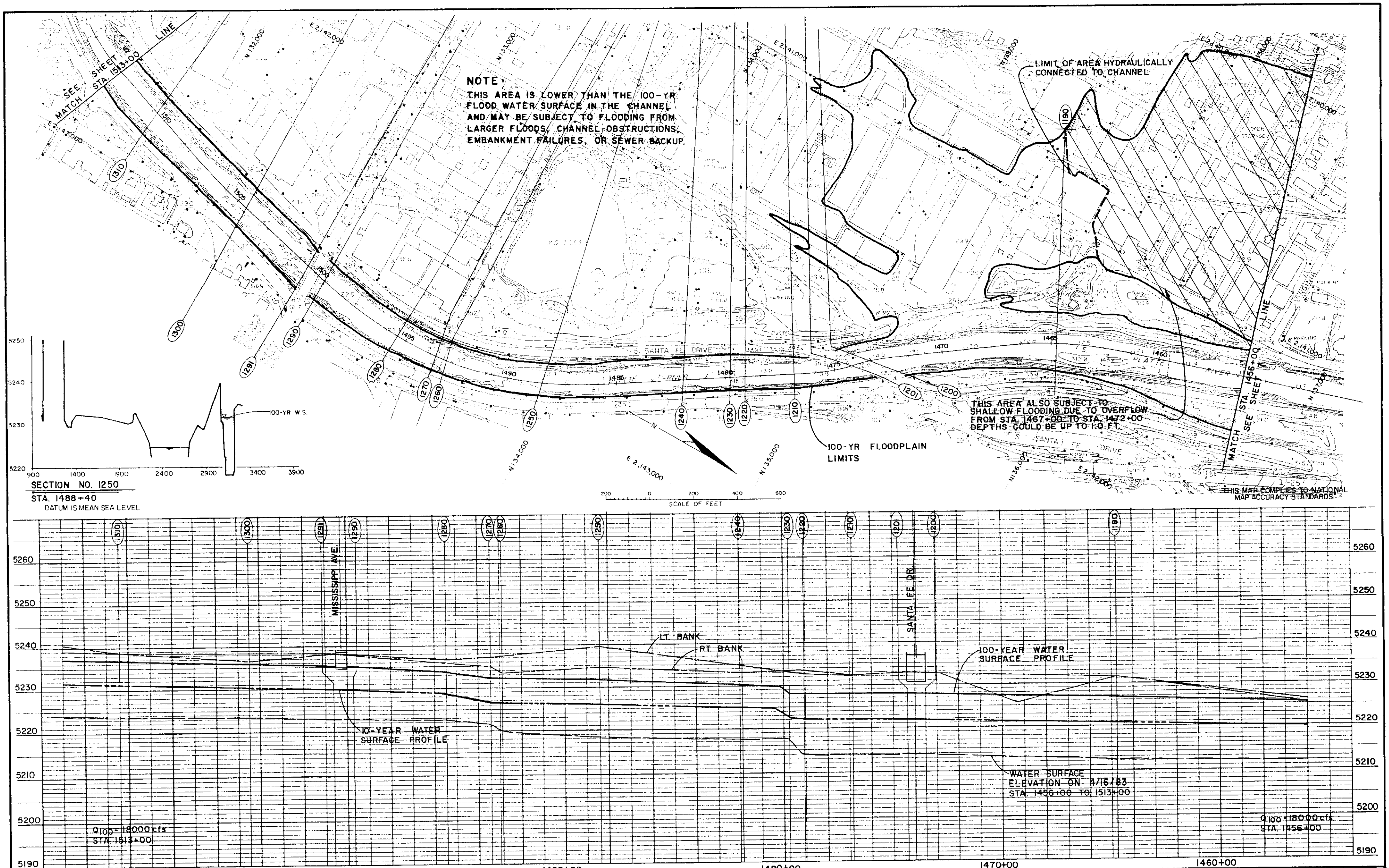
PREPARED FOR

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

PREPARED BY

WRIGHT WATER ENGINEERS, INC.

SEPTEMBER 1985



GROUND CONTROL SURVEY, AERIAL PHOTOGRAPHY APRIL 16, 1983
TOPOGRAPHIC MAPPING BY Delta Aerial Surveys, Inc. 2345 SO. FEDERAL BLVD. SUITE 195 DENVER, COLORADO 80219 (303) 934-5500
CONTOUR INTERVAL: 2 FEET

WRIGHT WATER ENGINEERS, INC.
CONSULTING ENGINEERS
2490 W. 26th Ave, Suite 55A
Denver, Colorado 80211
(303) 480-1700

DESIGNED WCC DATE 11/84
DRAWN DATE 11/84
CHECKED MWA DATE 11/84
REVISED DATE

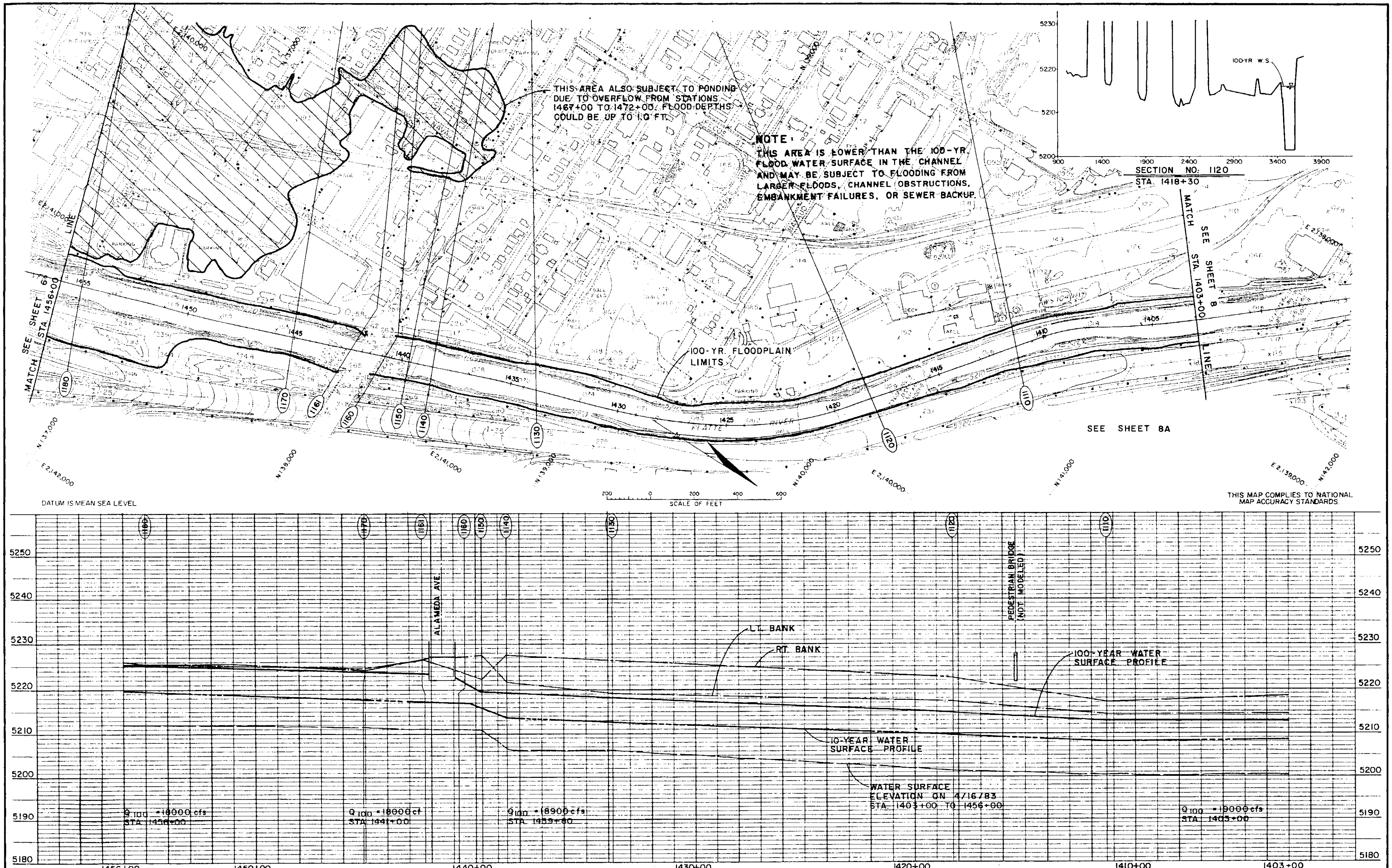
URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

FLOOD HAZARD AREA DELINEATION

SOUTH PLATTE RIVER

PLAN AND PROFILE
STA. 1456+00 TO STA. 1513+00

SHEET 6 OF 25



GROUND CONTROL SURVEY, AERIAL PHOTOGRAPHY APRIL 16, 1983, TOPOGRAPHIC MAPPING BY Delta Aerial Surveys, Inc., 2345 SO. FEDERAL BLVD. SUITE 195, DENVER, COLORADO 80219, (303) 934-5500. CONTOUR INTERVAL: 2 FEET

WRIGHT WATER ENGINEERS, INC.
CONSULTING ENGINEERS
2490 W 26th Ave, Suite 55 A
Denver, Colorado 80211
(303) 480-1700

DESIGNED	WCC	DATE	11/84
DRAWN	DLM	DATE	1/84
CHECKED	[illegible]	DATE	3/85
REVISED		DATE	

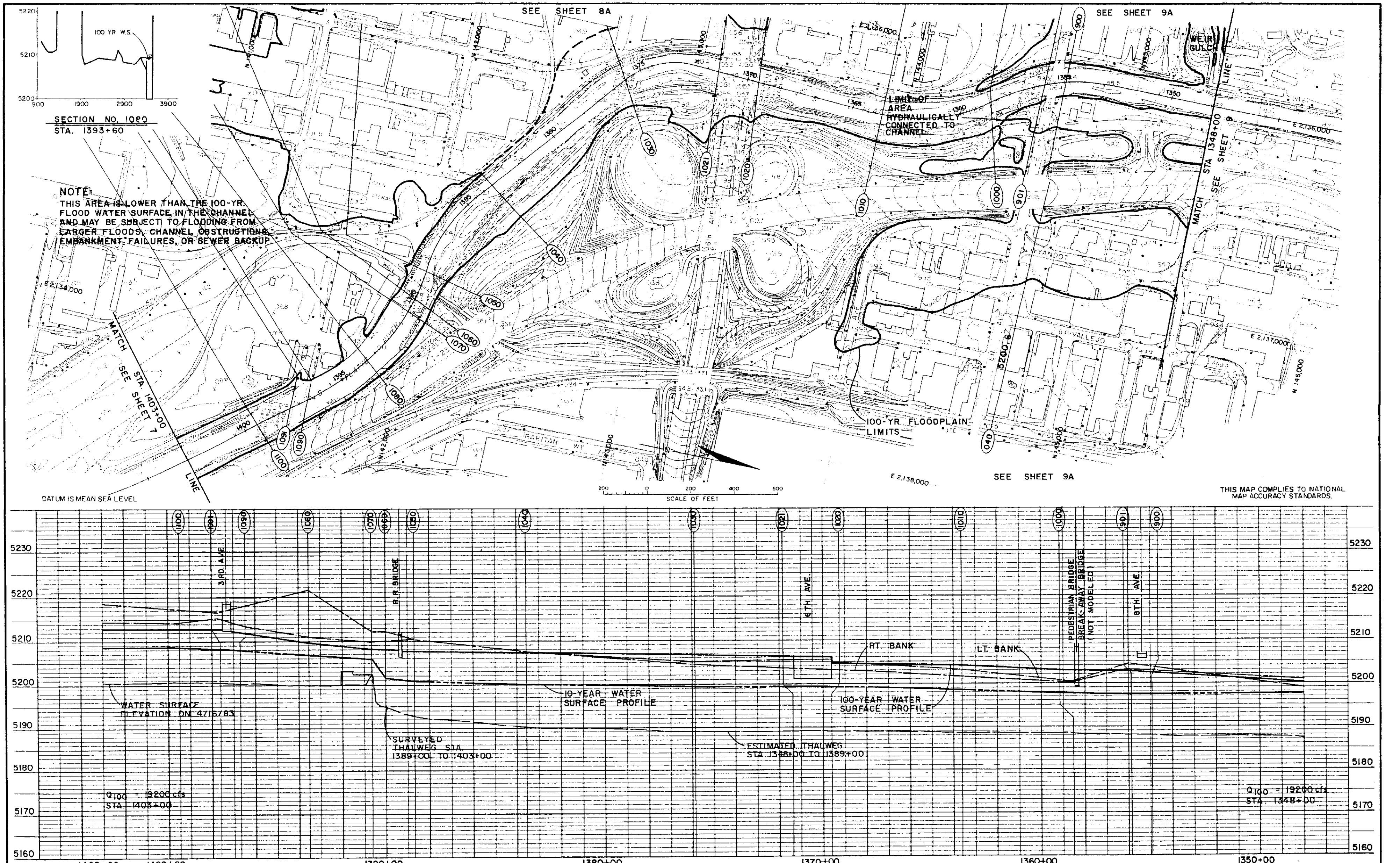
URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

FLOOD HAZARD AREA DELINEATION

SOUTH PLATTE RIVER

PLAN AND PROFILE
STA. 1403+00 TO STA. 1456+00

SHEET 7 OF 25



GROUND CONTROL SURVEY,
AERIAL PHOTOGRAPHY APRIL 16, 1983
TOPOGRAPHIC MAPPING BY
CONTOUR INTERVAL: 2 FEET

Delta Aerial Surveys, Inc.
2345 SO FEDERAL BLVD SUITE 195
DENVER, COLORADO 80219
(303) 934-5500

WRIGHT WATER ENGINEERS, INC.
CONSULTING ENGINEERS
2490 W 26th Ave, Suite 55A
Denver, Colorado 80211
(303) 480-1700

DESIGNED	[illegible]	DATE	1/84
DRAWN	[illegible]	DATE	1/84
CHECKED	[illegible]	DATE	11/84
REVISED		DATE	

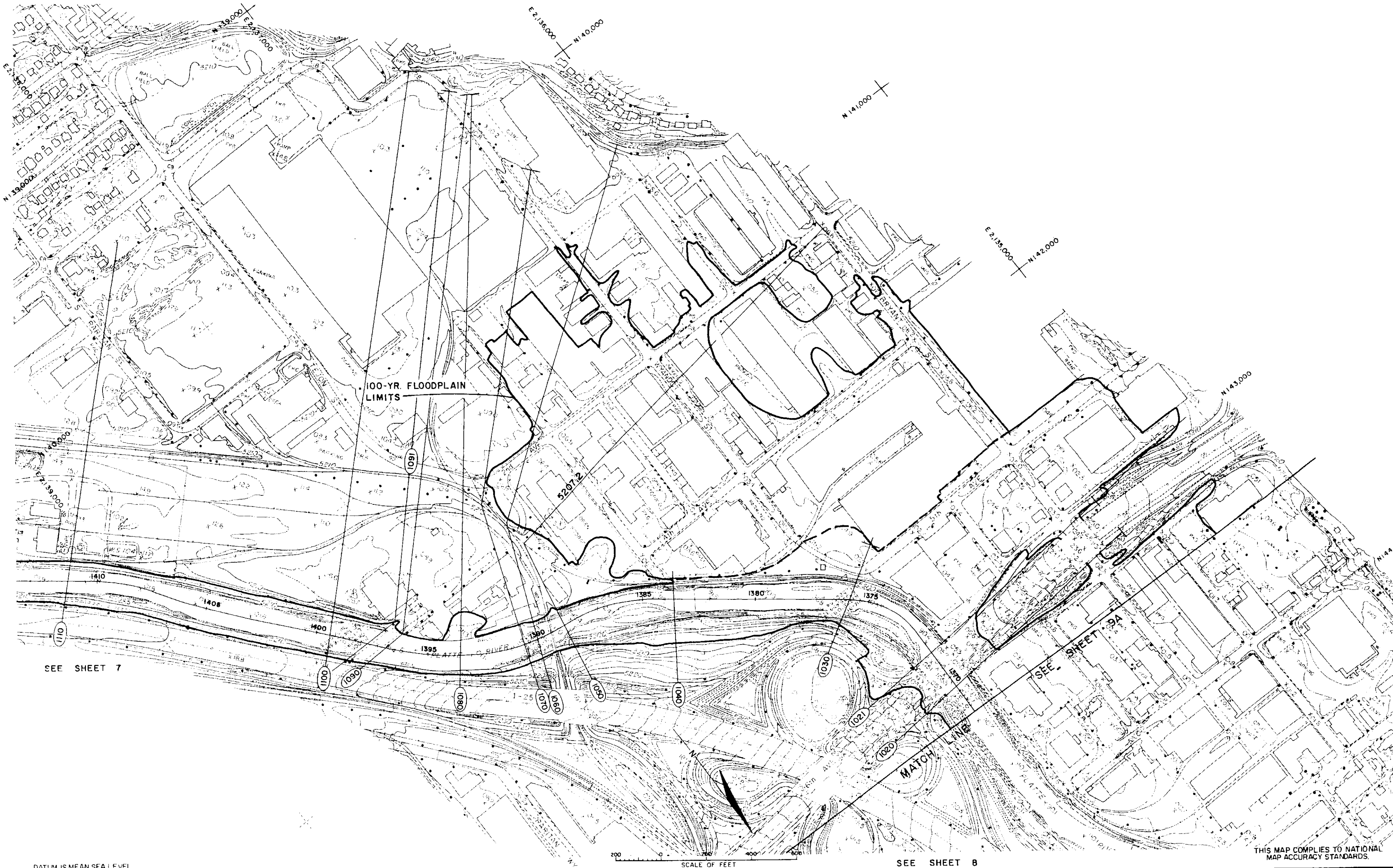
URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

FLOOD HAZARD AREA DELINEATION

SOUTH PLATTE RIVER

PLAN AND PROFILE
STA. 1348+00 TO STA. 1403+00

SHEET 8 OF 25



GROUND CONTROL SURVEY, AERIAL PHOTOGRAPHY APRIL 16, 1983 TOPOGRAPHIC MAPPING BY CONTOUR INTERVAL: 2 FEET	Delta Aerial Surveys, Inc. 2345 SO FEDERAL BLVD SUITE 195 DENVER COLORADO 80219 (303) 934-5500	WRIGHT WATER ENGINEERS, INC. CONSULTING ENGINEERS 2490 W. 26th Ave, Suite 55 A Denver, Colorado 80211 (303) 480-1700	DESIGNED W.CC DATE 1/84 DRAWN DATE 1/84 CHECKED DATE REVISED DATE	URBAN DRAINAGE AND FLOOD CONTROL DISTRICT FLOOD HAZARD AREA DELINEATION	SOUTH PLATTE RIVER	PLAN FOR PROFILE SEE SHEETS 7 & 8
						SHEET 8A OF 25

MAJOR DRAINAGEWAY PLANNING

SOUTH PLATTE RIVER

CHATFIELD DAM TO BASELINE ROAD

See back of repo for August '88 revi

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

PHASE B - VOLUME I

PRELIMINARY ENGINEERING DESIGN

PROJECT SPONSORS

- ADAMS COUNTY
- ARAPAHOE COUNTY
- DOUGLAS COUNTY
- JEFFERSON COUNTY
- CITY AND COUNTY OF DENVER
- TOWN OF COLUMBINE VALLEY
- CITY OF BRIGHTON
- COMMERCE CITY
- CITY OF ENGLEWOOD
- CITY OF LITTLETON
- CITY OF SHERIDAN
- CITY OF THORNTON
- GREENWAY FOUNDATION

PROJECT ADVISORS

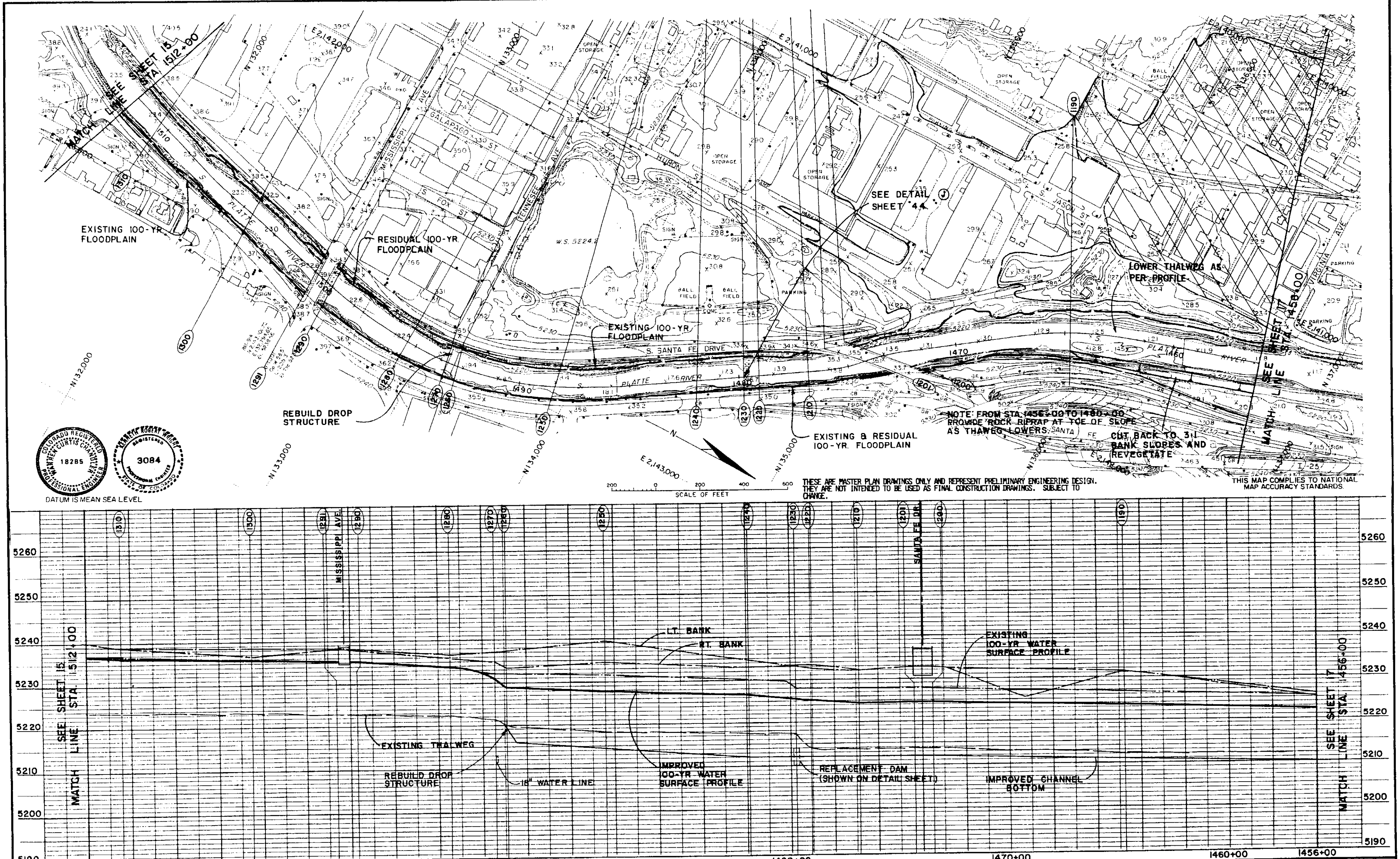
- DENVER REGIONAL COUNCIL OF GOVERNMENTS
- COLORADO WATER CONSERVATION BOARD
- SOUTH SUBURBAN PARKS AND RECREATION DISTRICT
- COLORADO DIVISION OF WILDLIFE
- U.S. ARMY CORPS OF ENGINEERS
- COLORADO DIVISION OF PARKS AND OUTDOOR RECREATION

WRIGHT WATER ENGINEERS, INC.

URBAN ENVIRONMENTS, LTD.

DENTON HARPER MARSHALL, INC.

NOVEMBER 1985



GROUND CONTROL SURVEY,
AERIAL PHOTOGRAPHY APRIL 16, 1983
TOPOGRAPHIC MAPPING BY
CONTOUR INTERVAL: 2 FEET

Delta Aerial Surveys, Inc.
2345 SO. FEDERAL BLVD. SUITE 195
DENVER, COLORADO 80219
(303) 934-5500

WRIGHT WATER ENGINEERS, INC.
2490 W. 26th Ave., Suite 55-A
Denver, Colorado 80211 (303) 480-1700
URBAN ENVIRONMENTS, LTD.
DENTON HARPER MARSHALL, INC.

DESIGNED DATE 5/85
DRAWN DATE 5/85
CHECKED DATE 5/85
REVISED DATE

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

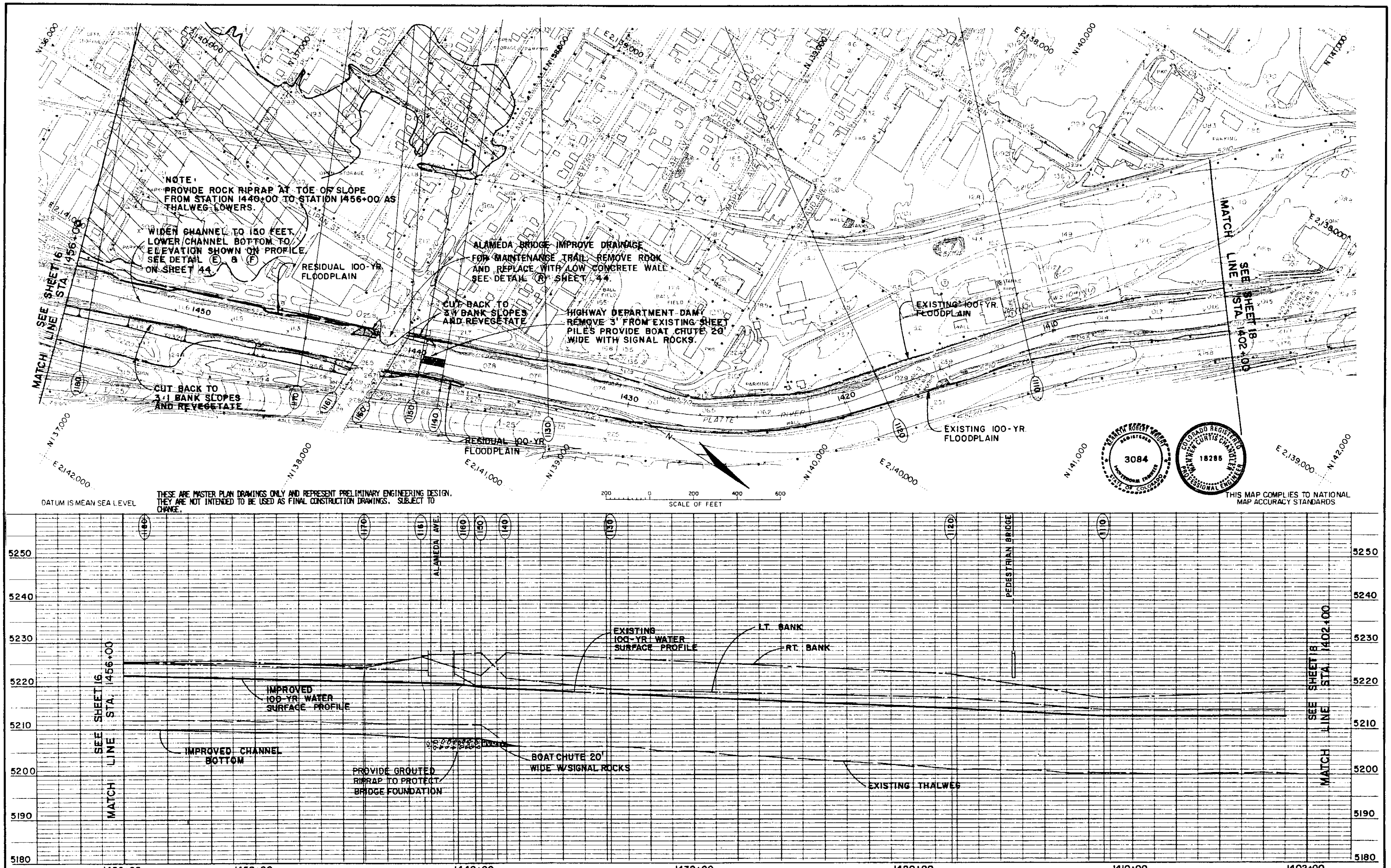
PHASE B PLAN

MAJOR DRAINAGEWAY PLANNING

SOUTH PLATTE RIVER

PLAN AND PROFILE
STA. 1456+00 TO STA. 1512+00

SHEET 16 OF 45



GROUND CONTROL SURVEY, AERIAL PHOTOGRAPHY APRIL 16, 1983, TOPOGRAPHIC MAPPING BY Delta Aerial Surveys, Inc. 2345 SO FEDERAL BLVD SUITE 195 DENVER COLORADO 80219 (303) 934-5500. CONTOUR INTERVAL: 2 FEET

WRIGHT WATER ENGINEERS, INC. 2490 W 26th Ave., Suite 55-A Denver, Colorado 80211 (303) 480-1700
URBAN ENVIRONMENTS, LTD.
DENTON HARPER MARSHALL, INC.

DESIGNED WCC, RRG DATE 5/85
DRAWN PCM, RDK DATE 5/85
CHECKED BCK, RRG DATE 5/85
REVISED ____ DATE ____

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

PHASE B PLAN

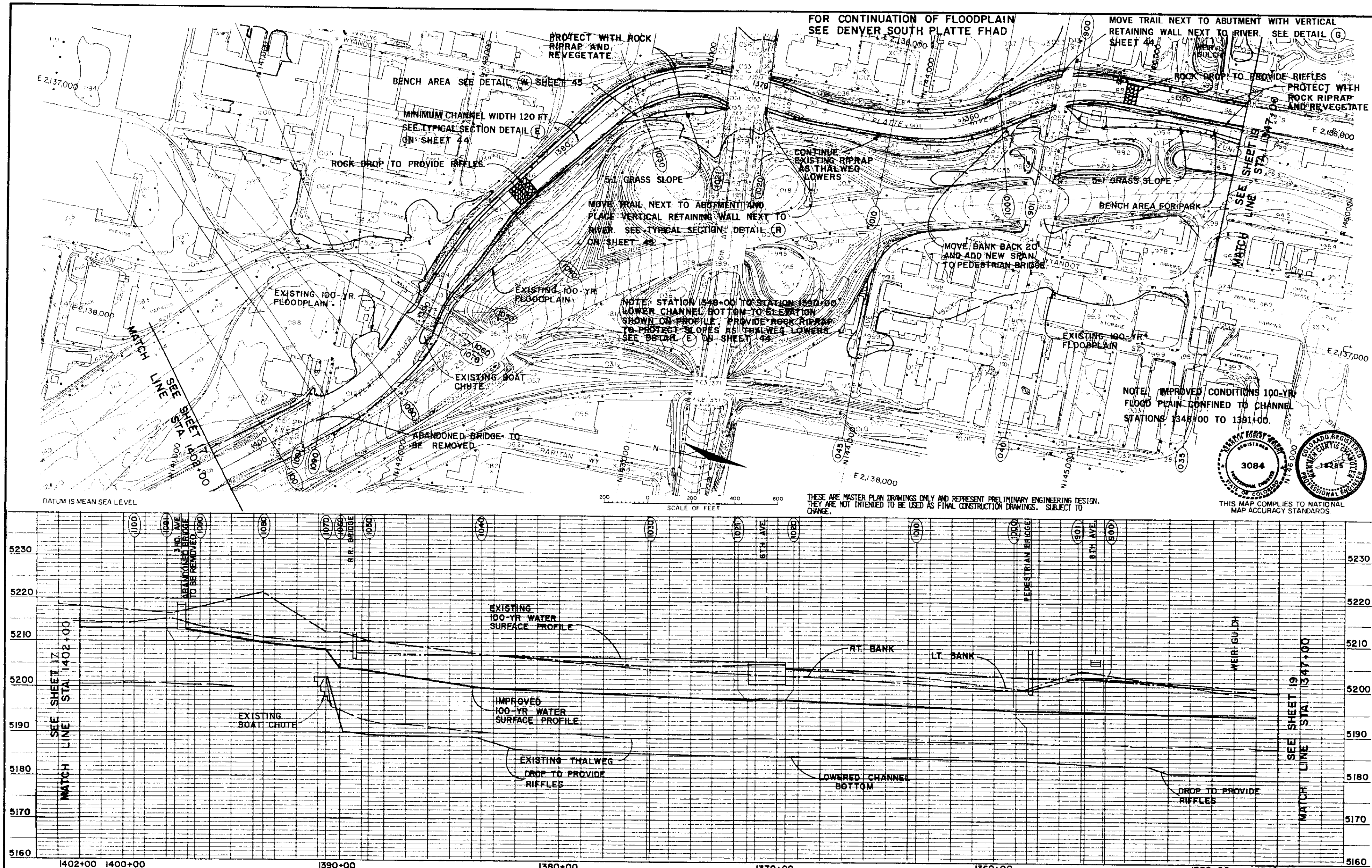
MAJOR DRAINAGEWAY PLANNING

SOUTH PLATTE RIVER

PLAN AND PROFILE

STA. 1402+00 TO STA. 1456+00

SHEET 17 OF 45



GROUND CONTROL SURVEY,
AERIAL PHOTOGRAPHY APRIL 16, 1983
TOPOGRAPHIC MAPPING BY Delta Aerial Surveys, Inc. 2345 SO FEDERAL BLVD. SUITE 195 DENVER COLORADO 80219 (303) 934-5500
CONTOUR INTERVAL: 2 FEET

WRIGHT WATER ENGINEERS, INC.
2490 W 26th Ave., Suite 55-A
Denver, Colorado 80211 (303) 480-1700
URBAN ENVIRONMENTS, LTD.
DENTON HARPER MARSHALL, INC.

DESIGNED ___ DATE 5/85
DRAWN ___ DATE 5/85
CHECKED ___ DATE 5/85
REVISED ___ DATE ___

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

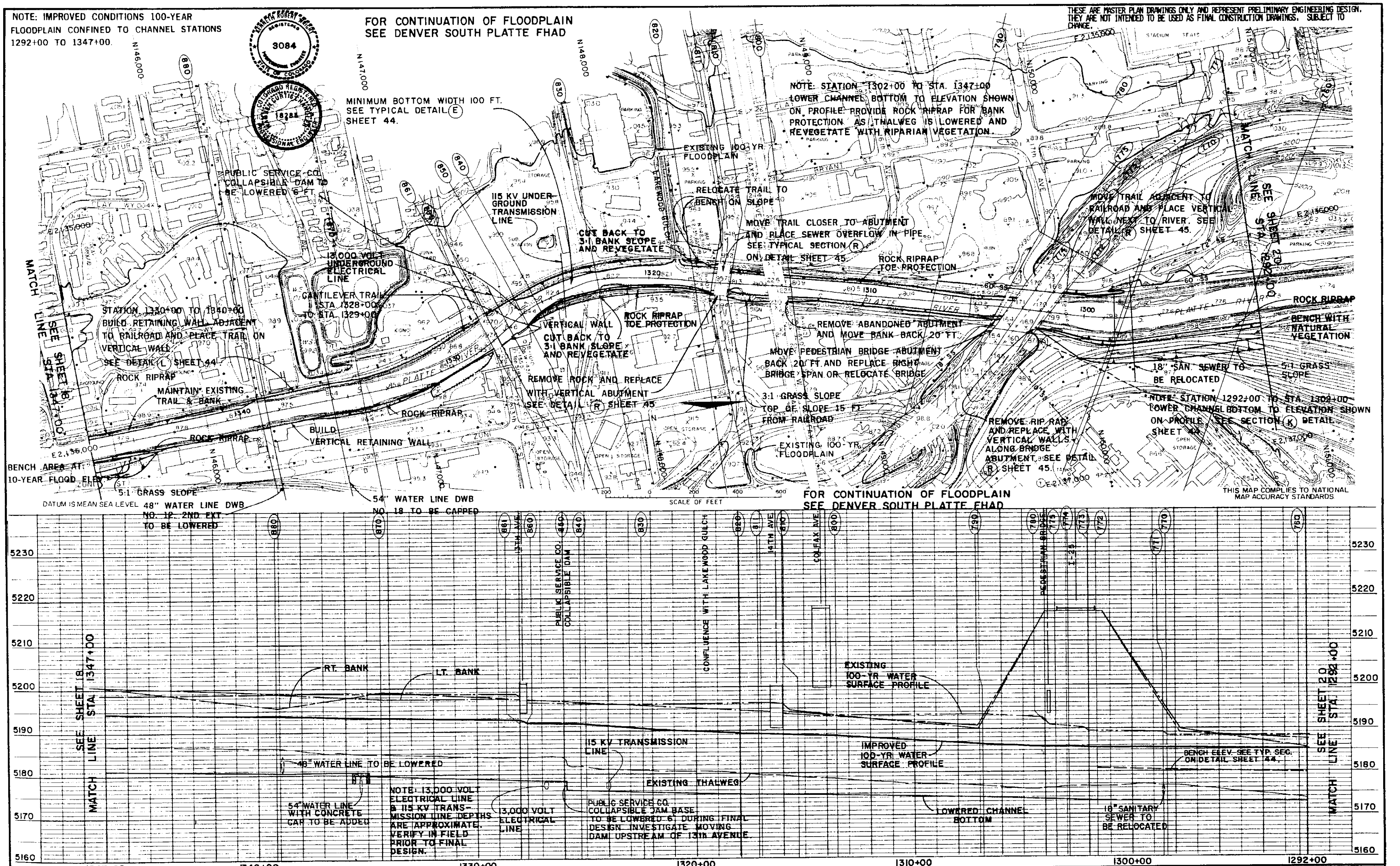
PHASE B PLAN

MAJOR DRAINAGEWAY PLANNING

SOUTH PLATTE RIVER

PLAN AND PROFILE

STA. 1347+00 TO STA. 1402+00



GROUND CONTROL SURVEY, AERIAL PHOTOGRAPHY APRIL 16, 1983
TOPOGRAPHIC MAPPING BY Delta Aerial Surveys, Inc. 2345 SO. FEDERAL BLVD. SUITE 195 DENVER, COLORADO 80219 (303) 934-5500
CONTOUR INTERVAL: 2 FEET

WRIGHT WATER ENGINEERS, INC. 2490 W. 26th Ave., Suite 55-A. Denver, Colorado 80211 (303) 480-1700
URBAN ENVIRONMENTS, LTD.
DENTON HARPER MARSHALL, INC.

DESIGNED WCC, WAG DATE 5/85
DRAWN PRM, CDA DATE 5/85
CHECKED WCC, DKW DATE 5/85
REVISED ____ DATE ____

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

PHASE B PLAN

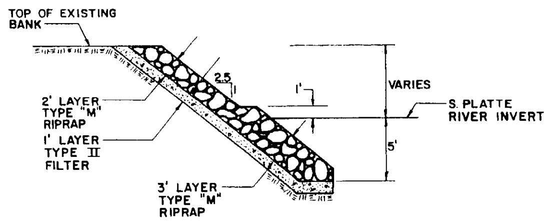
MAJOR DRAINAGEWAY PLANNING

SOUTH PLATTE RIVER

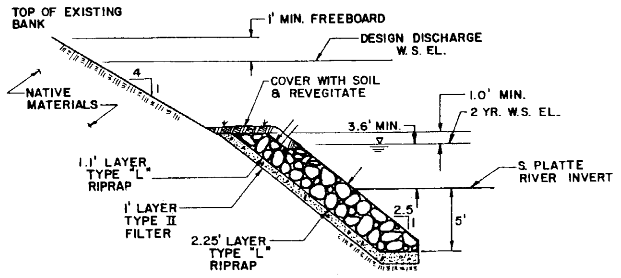
PLAN AND PROFILE

STA 1292+00 TO STA. 1347+00

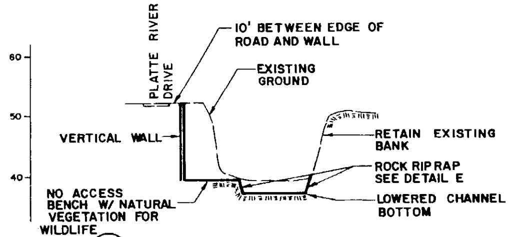
SHEET 19 OF 45



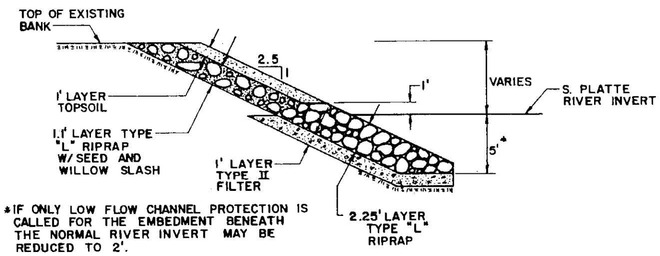
A REACH I — RIPRAP SLOPE PROTECTION DETAIL
1" = 5'



D TYPICAL RIPRAP SLOPE PROTECTION DETAIL
1" = 5'

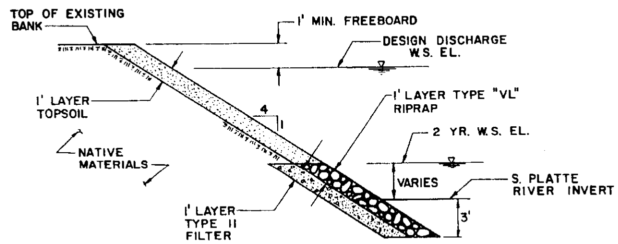


H TYPICAL SECTION STA. 1570+00
1" = 100' HORIZ. 1" = 10' VERT.

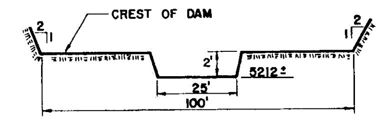


*IF ONLY LOW FLOW CHANNEL PROTECTION IS CALLED FOR THE EMBEDMENT BENEATH THE NORMAL RIVER INVERT MAY BE REDUCED TO 2'.

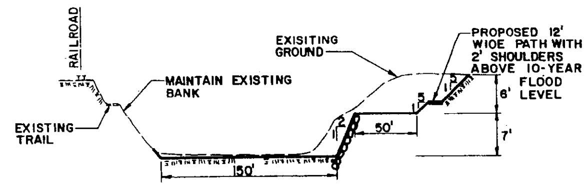
B REACH I — RIPRAP W/VEGETATION SLOPE PROTECTION DETAIL
1" = 5'



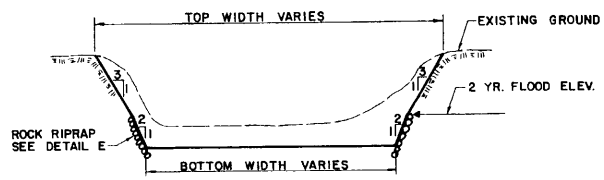
E TYPICAL CHANNEL WIDENING
1" = 5'



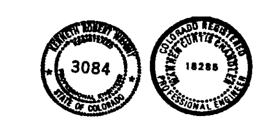
J DAM AT STA. 1479+00

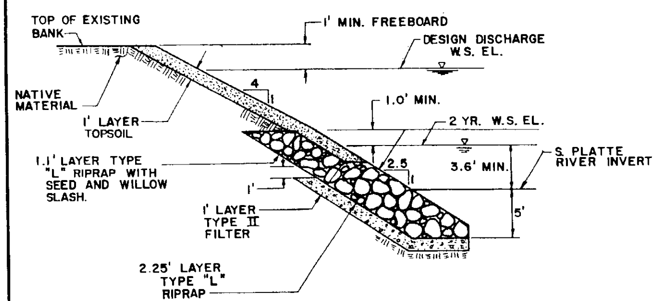


K SPEER BLVD. TO I-25
1" = 50' HORIZ. 1" = 10' VERT.

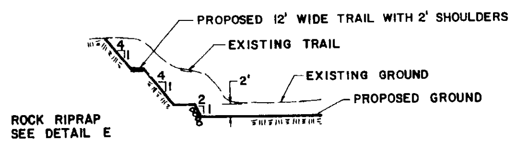


F TYPICAL CHANNEL DEEPENING
1" = 50' HORIZ. 1" = 10' VERT.

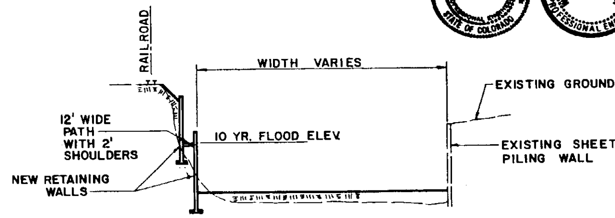




C TYPICAL RIPRAP WITH VEGETATION SLOPE PROTECTION DETAIL
1" = 5'



G TYPICAL SECTION AT STA. 1355+00 TO STA. 1358+00
1" = 50' HORIZ. 1" = 10' VERT.



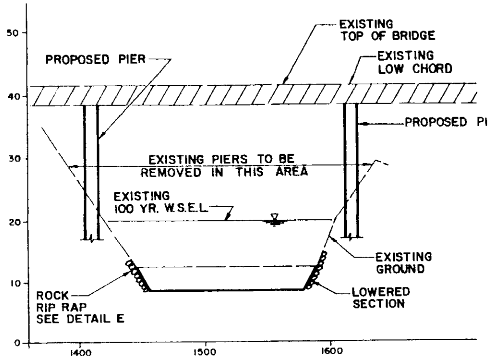
L TYPICAL SECTION UPSTREAM OF 13th AVE.
1" = 50' HORIZ. 1" = 10' VERT.

THESE ARE MASTER PLAN DRAWINGS ONLY AND REPRESENT PRELIMINARY ENGINEERING DESIGN. THEY ARE NOT INTENDED TO BE USED AS FINAL CONSTRUCTION DRAWINGS. SUBJECT TO CHANGE.

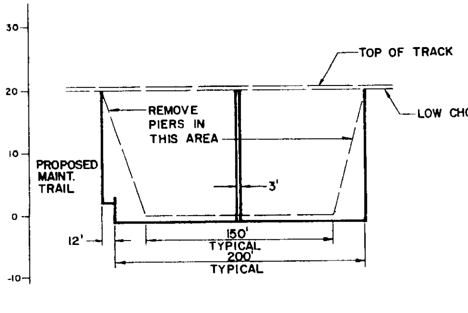
0 1 2 3
ORIGINAL SCALE IN INCHES

WRIGHT WATER ENGINEERS, INC. 2490 W. 26th Ave., Suite 55-A Denver, Colorado 80211 (303) 480-1700 URBAN ENVIRONMENTS, LTD. DENTON HARPER MARSHALL, INC.	DESIGNED WCC, MAG DATE 5/85 DRAWN MCM DATE 5/85 CHECKED WCC, MAG DATE 5/85 REVISED ____ DATE ____	URBAN DRAINAGE AND FLOOD CONTROL DISTRICT PHASE B PLAN	MAJOR DRAINAGEWAY PLANNING SOUTH PLATTE RIVER.	TYPICAL DETAILS	SHEET 44 OF 45

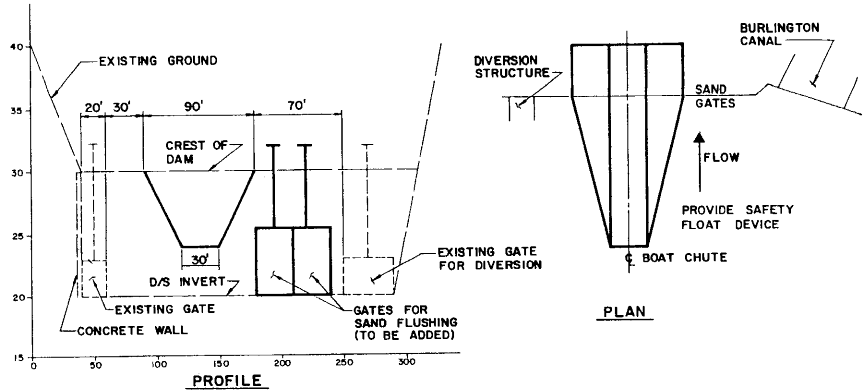
THESE ARE MASTER PLAN DRAWINGS ONLY AND REPRESENT PRELIMINARY ENGINEERING DESIGN. THEY ARE NOT INTENDED TO BE USED AS FINAL CONSTRUCTION DRAWINGS. SUBJECT TO CHANGE.



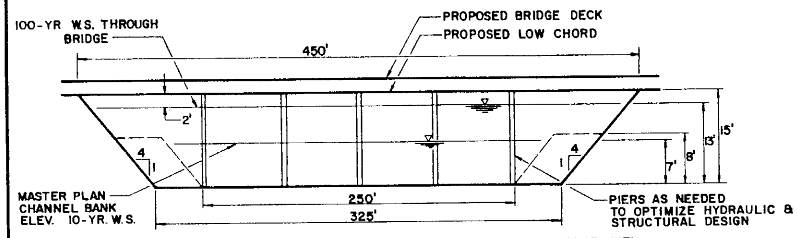
(M) RAILROAD BRIDGE NORTH OF YORK STREET
1" = 50' HORIZ 1" = 10' VERT.



(Q) TYPICAL RAILROAD BRIDGE IMPROVEMENT
STA. 1108+50 TO STA. 1067+00
1" = 50' HORIZ. 1" = 10' VERT.

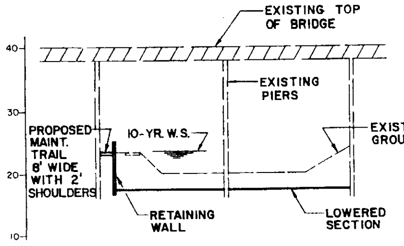


(S) BURLINGTON DAM BOAT CHUTE
1" = 10' HORIZ. 1" = 5' VERT.

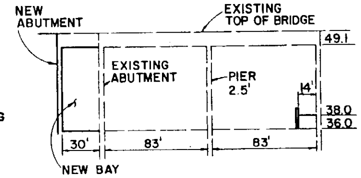


PROVIDE TRAIL IN ACCORDANCE WITH REQUIREMENTS IN VOLUME II.

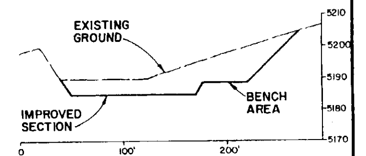
(N) TYPICAL ADAMS COUNTY BRIDGE DETAIL
1" = 50' HORIZ. 1" = 10' VERT.



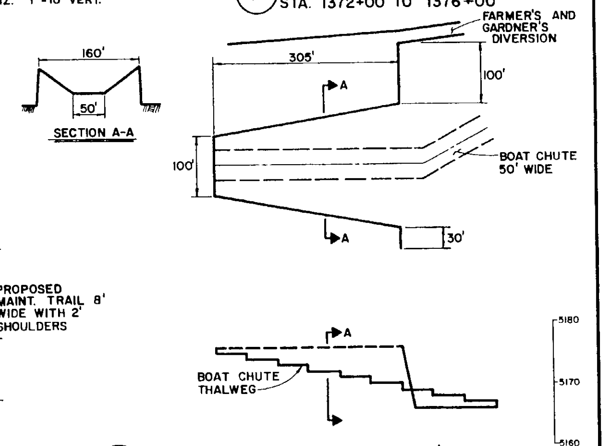
(R) TYPICAL BRIDGE MODIFICATION WITH TRAIL RELOCATION AND CHANNEL LOWERING



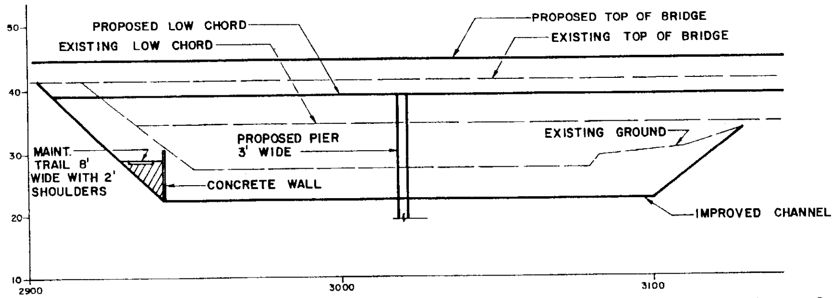
(T) EVANS AVE. BRIDGE
1" = 50' HORIZ. 1" = 10' VERT.



(W) BENCH AREA U/S OF SIXTH AVE.
STA. 1372+00 TO 1376+00

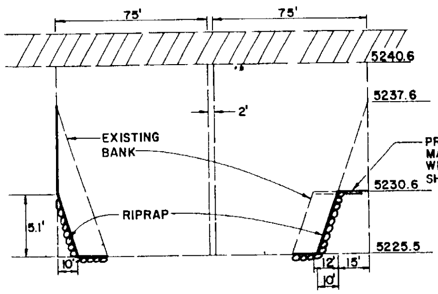


(V) RELOCATED FARMER'S AND GARDNER'S DIVERSION DAM STA. 1262+00 1" = 100'



(P) FRANKLIN STREET BRIDGE
1" = 20' HORIZ. 1" = 10' VERT.

0 1 2 3
ORIGINAL SCALE IN INCHES



(U) FLORIDA AVE. BRIDGE
1" = 30' HORIZ. 1" = 5' VERT.

WRIGHT WATER ENGINEERS, INC. 2490 W. 26th Ave., Suite 55-A Denver, Colorado 80211 (303) 480-1700 URBAN ENVIRONMENTS, LTD. DENTON HARPER MARSHALL, INC.	DESIGNED WCC, MWG DATE 5/85 DRAWN PC M DATE 5/85 CHECKED WCC, MWG DATE 5/85 REVISED ____ DATE ____	URBAN DRAINAGE AND FLOOD CONTROL DISTRICT PHASE B PLAN	MAJOR DRAINAGEWAY PLANNING SOUTH PLATTE RIVER	TYPICAL DETAILS

MAJOR DRAINAGEWAY PLANNING

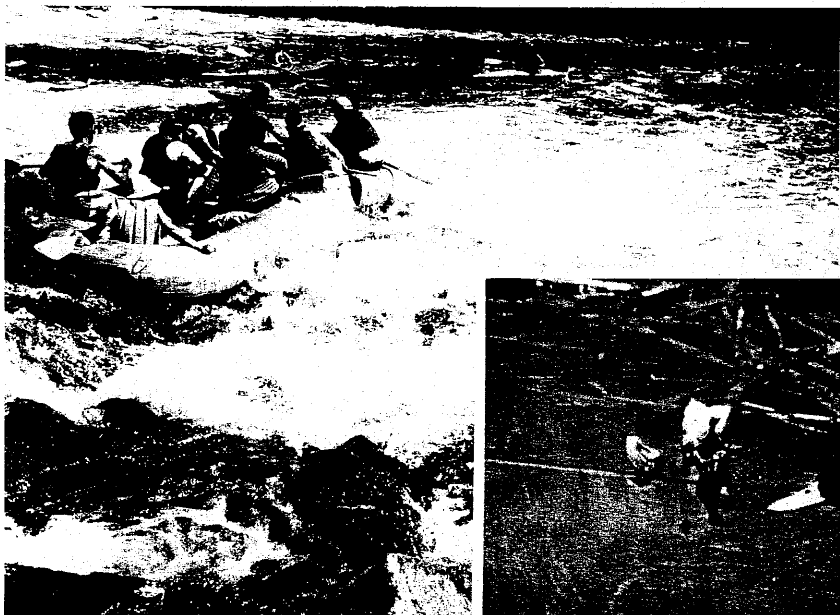
SOUTH PLATTE RIVER

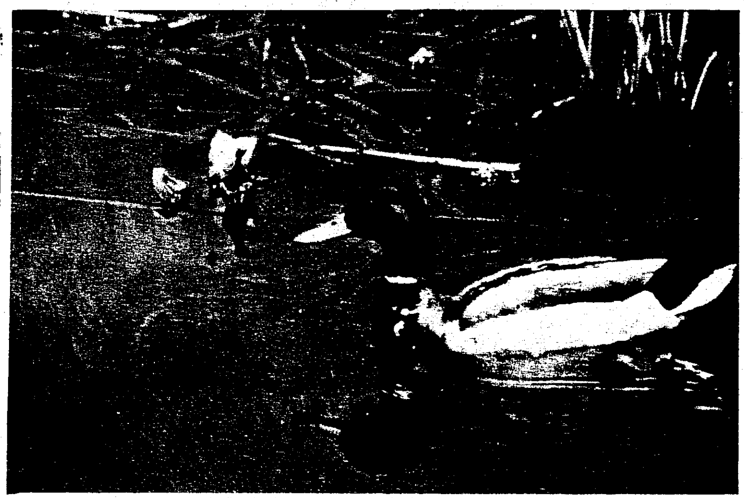
CHATFIELD DAM TO BASELINE ROAD

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

PHASE B - VOLUME II

RECREATION PLAN





PROJECT SPONSORS

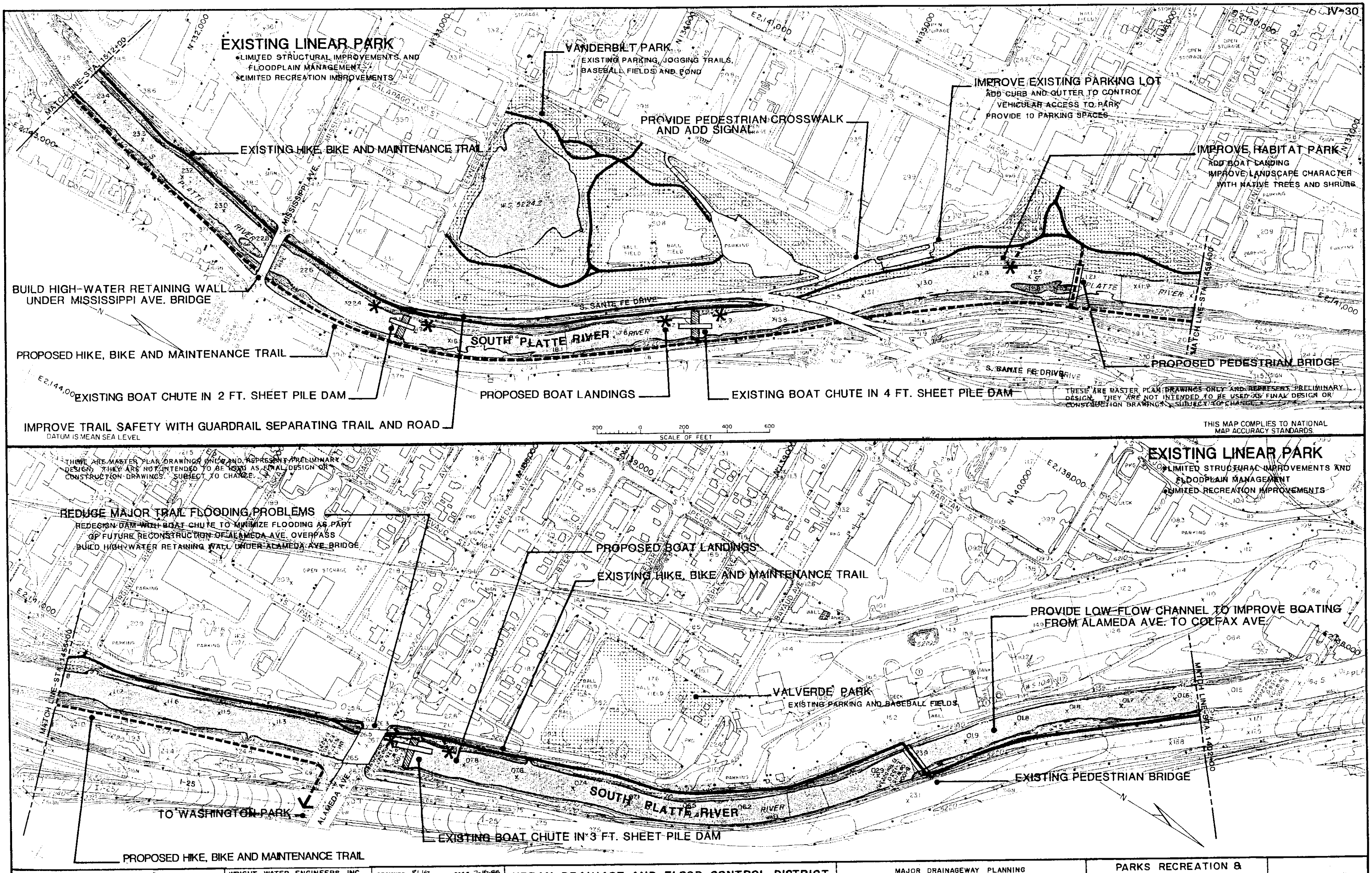
- ADAMS COUNTY
- ARAPAHOE COUNTY
- DOUGLAS COUNTY
- JEFFERSON COUNTY
- CITY AND COUNTY OF DENVER
- TOWN OF COLUMBINE VALLEY
- CITY OF BRIGHTON
- COMMERCE CITY
- CITY OF ENGLEWOOD
- CITY OF LITTLETON
- CITY OF SHERIDAN
- CITY OF THORNTON
- GREENWAY FOUNDATION

PROJECT ADVISORS

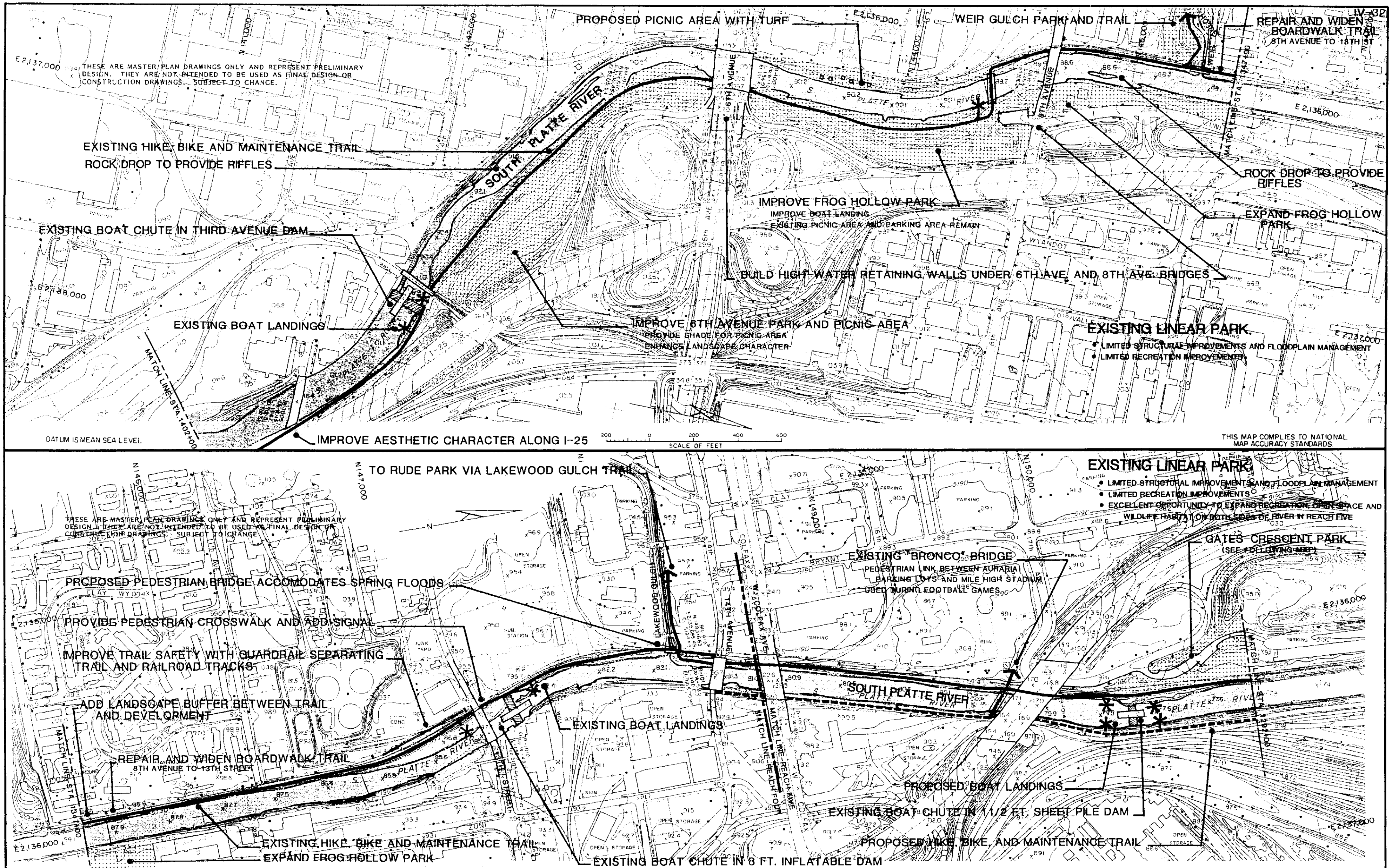
- DENVER REGIONAL COUNCIL OF GOVERNMENTS
- COLORADO WATER CONSERVATION BOARD
- SOUTH SUBURBAN PARKS AND RECREATION DISTRICT
- COLORADO DIVISION OF WILDLIFE
- U.S. ARMY CORPS OF ENGINEERS
- COLORADO DIVISION OF PARKS AND OUTDOOR RECREATION

WRIGHT WATER ENGINEERS, INC.
URBAN ENVIRONMENTS, LTD.
DENTON HARPER MARSHALL, INC.

NOVEMBER 1985



GROUND CONTROL SURVEY, AERIAL PHOTOGRAPHY APRIL 16, 1983 TOPOGRAPHIC MAPPING BY Delta Aerial Surveys, Inc. 2345 SO FEDERAL BLVD SUITE 195 DENVER COLORADO 80219 (303) 934-5500 CONTOUR INTERVAL: 2 FEET	WRIGHT WATER ENGINEERS, INC. 2490 W 26th Ave., Suite 55-A Denver, Colorado 80211 (303) 480-1700 URBAN ENVIRONMENTS, LTD. DENTON HARPER MARSHALL, INC.	DESIGNED RLW DATE 7-15-85 DRAWN PRM DATE 8-14-85 CHECKED RLW DATE 9-9-85 REVISED RLB/PRM DATE 11-6-85	URBAN DRAINAGE AND FLOOD CONTROL DISTRICT PHASE B PLAN	MAJOR DRAINAGEWAY PLANNING SOUTH PLATTE RIVER	PARKS RECREATION & OPEN SPACE PLAN STA. 1402+00 TO STA. 1512+00	SHEET 10 OF 23



GROUND CONTROL SURVEY, AERIAL PHOTOGRAPHY APRIL 16, 1983
TOPOGRAPHIC MAPPING BY Delta Aerial Surveys, Inc. 2345 SO FEDERAL BLVD SUITE 195 DENVER COLORADO 80219 (303) 934-5500
CONTOUR INTERVAL: 2 FEET

WRIGHT WATER ENGINEERS, INC. 2490 W. 26th Ave., Suite 55-A Denver, Colorado 80211 (303) 480-1700
URBAN ENVIRONMENTS, LTD.
DENTON HARPER MARSHALL, INC.

DESIGNED	RLG	DATE	7-15-85
DRAWN	PRM	DATE	8-14-85
CHECKED	RLG	DATE	9-9-85
REVISED	RLB/PRM	DATE	11-6-85

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

PHASE B PLAN

MAJOR DRAINAGEWAY PLANNING

SOUTH PLATTE RIVER

PARKS RECREATION & OPEN SPACE PLAN
STA. 1292+00 TO STA. 1402+00

SHEET 11 OF 23

Preliminary Design Report for the
Upper Central Platte Valley
South Platte River Restoration

Prepared for:
Urban Drainage and Flood Control District
City and County of Denver

Prepared by:
McLaughlin Water Engineers, Ltd.

December 1998

Phase 1:

Colfax Reach (Lakewood Gulch to I-25)

Implementation of the project in this reach will result in a substantial reduction in flood hazard and improvements in fish and wildlife habitat. The project could further be broken down into several components:

- Repair west bank below existing hiker/biker maintenance trail.
- Excavate east bank, provide toe lining, and create wildlife corridor.
- Shape the low flow channel and create meanders.
- Construct hiker/biker maintenance trail.
- Replace Bronco Bridge.
- Replace 14th Avenue bridge.

Total estimated cost for this reach is $3 million.

Colfax Viaduct, Looking Downstream from 14th Avenue

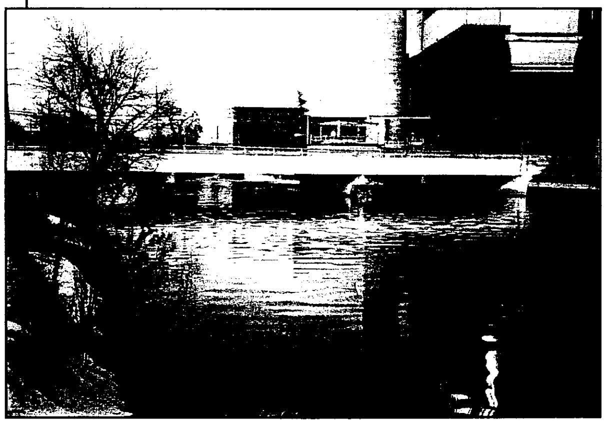
Phase 2:

Zuni Reach (11th Avenue to Lakewood Gulch).

Implementation of the project in this reach will provide the greatest flood hazard reduction benefits. Estimated costs include providing temporary diversion facilities for Zuni Power Plant and constructing the closed loop cooling system. This project could be further separated into several components including:

- Build components of closed loop cooling system in Public Service Company Zuni Power Plant outside of river.
- Remove dam and construct infiltration gallery, while providing temporary source of water supply for cooling purposes to Public Service Company.
- Excavate west bank, construct new hiker/biker maintenance trail and take out existing elevated trail.
- Shape low flow channel and create meanders.
- Create wildlife corridor on east bank.
- Construct hiker/biker maintenance trail.

Total estimated cost for this reach is $12 million.



13th Avenue and Zuni Power Plant, Pool Behind Dam

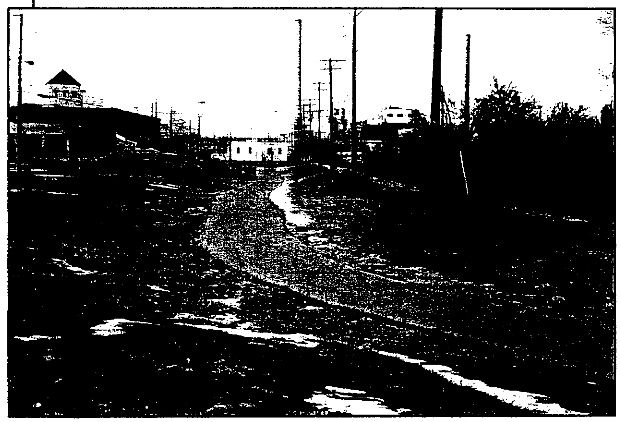
Phase 3:

Sun Valley Reach (8th Avenue to 11th Avenue)

Implementation of the project in this reach will provide improved access to the river for the Sun Valley Community Center and neighborhood. Components in this reach include:

- Lower the 48-inch water line.
- Widen the channel on the west side.
- Develop improvements at Weir Gulch Park.
- Create wildlife corridor on east bank.
- Shape low flow channel and create meanders.
- Construct hiker/biker maintenance trail.

Total estimated cost for this reach is $4 million.



West Bank Near Weir Gulch, Sun Valley Community Center

INTRODUCTION AND PURPOSE

Overview

In 1994, Mayor Wellington E. Webb formed the South Platte River Working Group to explore opportunities for restoring and enhancing the 10.5 mile corridor of the Platte River that runs through Denver. In 1995, Mayor Webb endorsed the written recommendations of the Working Group, entitled *A Vision for the South Platte River*. The goals and objectives of Denver's South Platte River project were derived from those recommendations and include assurance of water flow and quality levels needed to support recreational and environmental needs along the river, improvements for riparian and aquatic habitat, flood damage reduction, creation of additional parks, added focus on environmental education, and an increase in community awareness of the South Platte River as a resource.

The Upper Central Platte Valley Reach is a key component of Denver's 10.5 miles of the South Platte River. It extends for approximately 1 mile west of downtown Denver, from 8th Avenue to I-25 through residential, commercial, and industrial areas (Figure 1). This reach of the South Platte River has been subject to flood damage, channelization, and destruction of fish and wildlife habitat. Residential and industrial areas in this reach are still threatened by flooding. Flood waters spill from this reach of the channel and flow northeast; this overbank flow surrounds the Elitch Gardens and Pepsi Center area. Completion of the flood damage reduction measures proposed for the Upper Central Platte Valley Reach will not only benefit this reach, but will also reduce flood damage in the reach of the South Platte immediately downstream.

The Public Service Company's Zuni Power Plant dominates this reach of the river with its diversion dam for cooling water (Figures 2 and 3). This dam is the sole remaining obstacle to boating the entire 10.5 mile reach of the South Platte River through Denver. Water backup from this dam has replaced the South Platte River with a reservoir for one-half mile upstream through the Denver Metropolitan area. Riverbanks in this reach are steep, making access difficult and impairing wildlife habitat. Much of the vegetation is non-native and in a degraded condition.

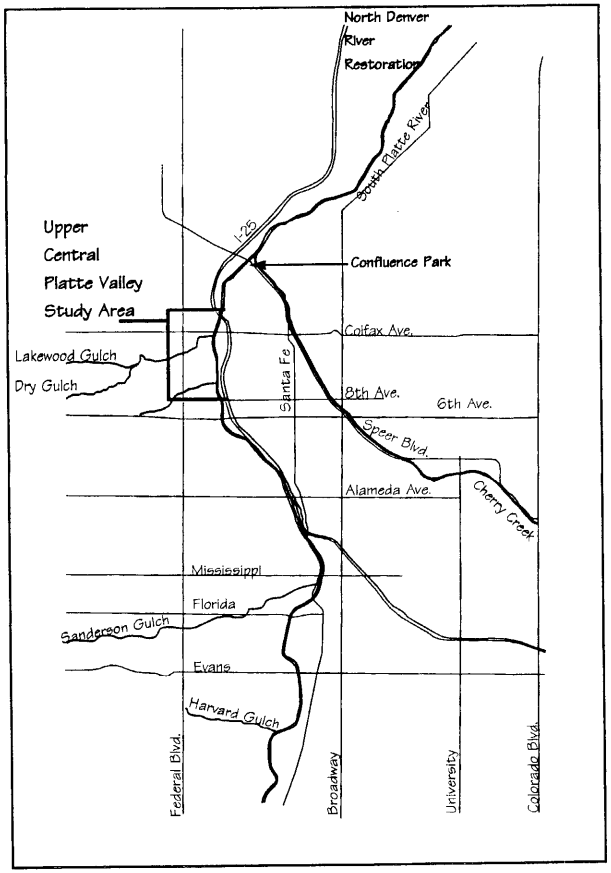


Figure 1: Location Map

In order to implement the goals of the Mayor's South Platte River Commission, a Task Force for the Upper Central Platte Valley Reach, led by the Urban Drainage and Flood Control District, has been formed and has developed a detailed plan for restoration of the South Platte River in the Upper Central Valley Reach. The Task Force has representatives from recreation, fish and wildlife, water and neighborhood interests and also includes the Public Service Company, Denver Housing Authority, U.S. Army Corp of Engineers, and the Division of Wildlife. Task Force members are listed inside the front cover, before the Table of Contents.

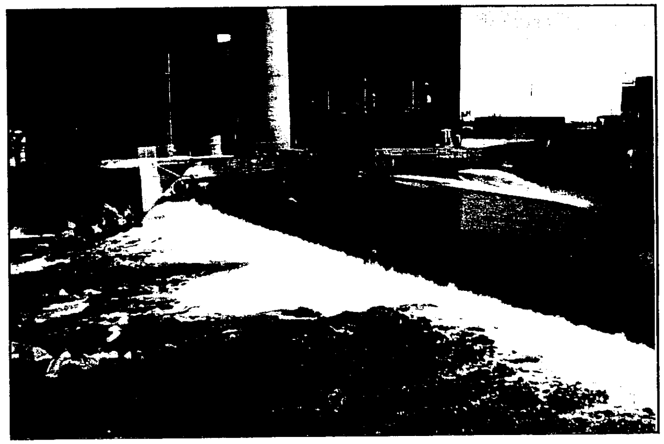
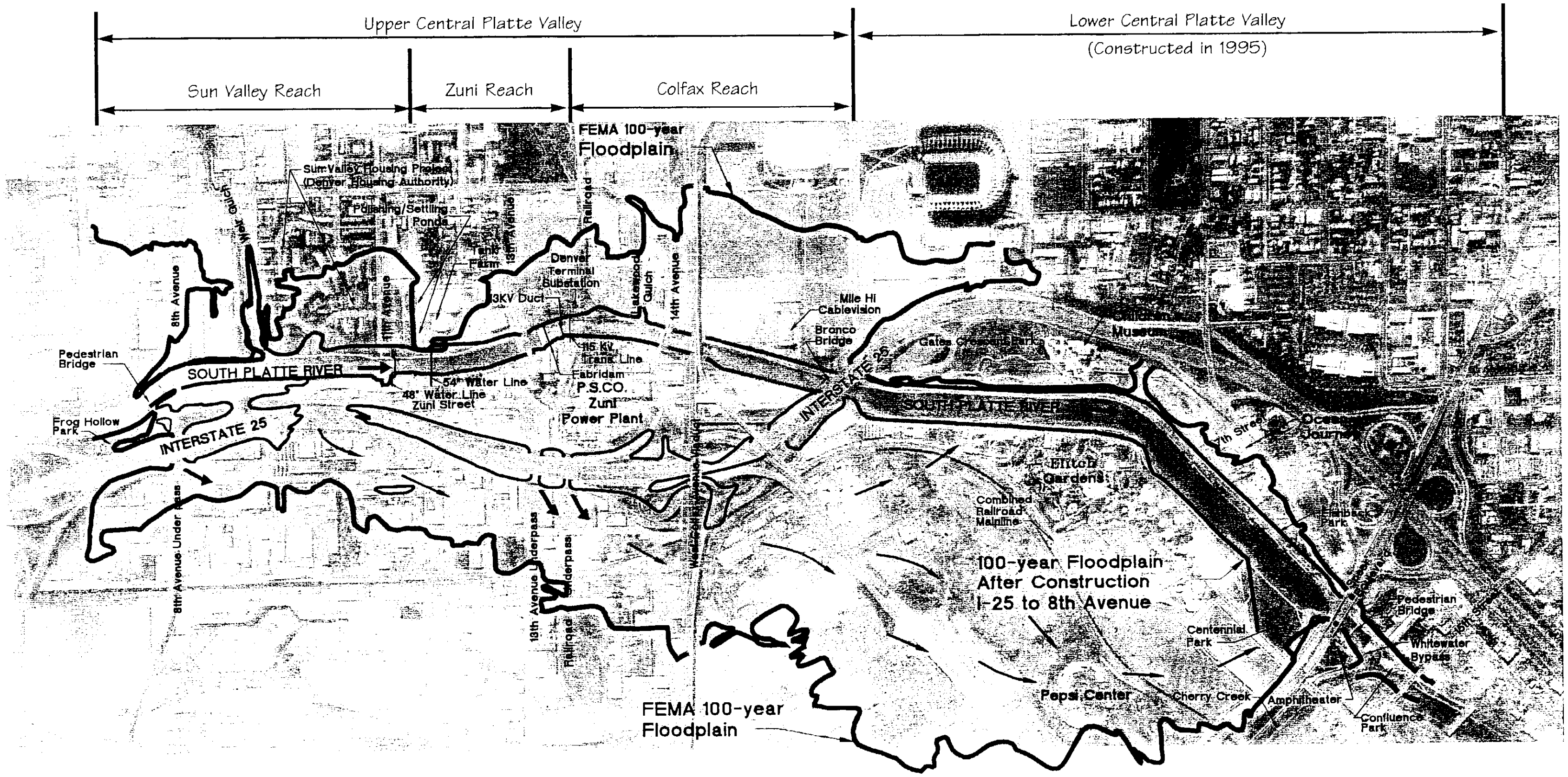


Figure 2: Zuni Power Plant/Diversion Dam

The major goals of the plan developed by this Task Force include:

- **Flood Damage Reduction.** Flood damage will be reduced for residents and businesses in the one-mile Central Platte River Valley by widening and lowering the river channel, replacing the Bronco Bridge, and replacing the 14th Avenue bridge. Also overbank flows will be reduced downstream, in the areas adjacent to Elitch Gardens and the Pepsi Center.

- **Elimination of Dam.** By removing the Zuni Power Plant dam and providing a closed loop cooling system to the power plant, fish habitat, adjacent wetland habitat and boating opportunities will be restored and improved.



LEGEND

- The designated FEMA 100 year floodplain indicates the limits of the 100-year floodplain prior to construction of the flood damage reduction progject for the I-25 to Confluence Park reach.
- 100-year floodplain after construction of the Upper Central South Platte River Valley Restoration Project.

Figure 3: Floodplain Map

These reaches are shown in Figure 3 of Part 1 - Preliminary Design Report and plan and profile drawings are presented in Drawings 2 through 5 in Part 2 - Technical Report.

Sun Valley Reach (8th Avenue to 11th Avenue)

Flood Damage Reduction. Flood damage reduction components for the Sun Valley Reach are presented in Sheets 2 and 3. These drawings include the following project components for flood damage reduction:

- Removing the Fabridam in the Zuni Reach will help confine 100-year flood flows to the channel in the Sun Valley Reach by eliminating the backwater from the dam, which presently extends into this reach.
- A flow transition drop will occur at the 8th Avenue bridge from the existing gradient upstream to a 0.0013 foot gradient downstream of 8th Avenue to the 54-inch water line. This sloping drop will be lined with riprap and boulders.
- The stream bottom in this reach will be lowered by approximately 2 feet beginning at 8th Avenue, to 0 feet at the 54-inch water line, to approximately 3 feet at the Fabridam downstream from 13th Avenue in the Zuni Reach.
- Both the east and west banks will be toelined with riprap.
- Grade east bank slope below current water line and plant shrubs and ground cover.
- The infiltration gallery will be constructed in this reach starting at a point approximately 50 feet upstream from the 54-inch water line and running upstream for approximately 400 feet. The infiltration gallery will be connected to the PSC's Zuni plant by a collector pipeline of sufficient capacity. Water will be either pumped from a wet well collection facility, located on the east bank near the 54-inch water line, to the Zuni Power Plant cooling facilities, or if possible, flow by gravity. A final decision on gravity flow versus pumping will be made after PSC determines the design and elevation of the inlet facilities for the replacement water at the Zuni Power Plant.
- The west bank will be widened in the vicinity of the Sun Valley neighborhood and community center and will be terraced and made less steep than existing conditions in order to provide more access to the river, while adding additional conveyance through this reach. The top of the bank for the project will be graded to blend with existing topography at the community center.
- The mouth of Weir Gulch will be widened and the concrete walls will be removed.
- Two major sanitary sewers that parallel the sewer along the west bank will be protected in place.

After construction of the project as shown in Sheets 2 through 5 herein, over bank flows from floods equivalent to, or less than the 100-year frequency storm, will no longer escape from the channel near 8th Avenue to the east.

Boatability. Boatability throughout this reach will be significantly improved because of elimination of the Fabridam in the Zuni Reach. A low flow channel will be constructed that will concentrate the flow to improve boating.

Fish and Wildlife Habitat. Through this reach, the proposed project will include a low flow channel approximately 1.5 feet deep and 50 feet wide for boating and to improve fish and wildlife habitat. The slope of the channel through this reach will be approximately .0013. Sheet 11 provides details for the low flow channel structures designed to improve fish habitat. The east bank through the Sun Valley Reach will be developed as a wildlife corridor and appropriate native tree and shrub species will be planted to provide food and cover for wildlife.

Recreation. A major recreational improvement will be constructed in this reach by opening Weir Gulch and improving the park with an amphitheater as requested by nearby residents. The existing 10-foot hiker/biker maintenance trail will be removed and a new 10-foot concrete trail will be constructed along the west bank throughout this reach due to west bank excavation.

Utilities. The 16-inch Denver Water Department line presently hanging on the 8th Avenue bridge will be relocated approximately 20 feet downstream of the 8th Avenue bridge and buried approximately 4-5 feet deep in the channel in order to increase conveyance of flows through this reach. The 48-inch water line at the intersection of 11th Avenue with the South Platte will be lowered approximately 7 feet in order to improve flow conveyance in the channel and avoid the infiltration gallery.

Metro Wastewater Reclamation District owns two sanitary sewers, 48-inch and 72-inch, that parallel the river along the west banks between Weir Gulch and 13th Avenue. The 72-inch sewer line is 65 feet west of the station line and will not be affected by the widening. The 48-inch sewer line is 25 feet west of the station line and will be protected as the excavation will encroach toward the sewer line. Location of the trail and buried rock bank protection will serve to protect the sewer line after improvements.

Zuni Reach (11th Avenue to upstream of Lakewood Gulch)

Flood Damage Reduction. The following project components will be implemented in this reach to provide flood damage reduction:

- Existing overbank flooding at 13th Avenue and at the railroad underpass will be eliminated by removal of the Fabridam and channel widening and lowering.
- 100-year flows will be confined to the stream channel throughout this reach.
- Upstream of 13th Avenue the channel will be widened on the west bank by an average of approximately 50 feet. This will widen the channel back to the PSC polishing pond without affecting the

I-25 Broadway/Santa Fe/Alameda
Draft Floodplain and Drainage Assessment
Existing Conditions
January 10, 2000
Revised April 7, 2000

Prepared For:

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Prepared By:

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Irongate 4, Suite 100
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Lakewood, Colorado 80226
Project No. 9904.01

Peak flows were estimated using the Colorado Urban Hydrograph procedure as specified by the Urban Drainage and Flood Control District. The drainage area was originally subdivided into four sub-basins for which peak flows were determined. Sub-basin S1, which includes the area to the east of Smith Lake will flow into Smith Lake and will be discussed in detail in a later section of this report. The other three sub-basins were then further subdivided into 12 sub-basins. CUHP parameters for eleven of these sub-basins can be seen in Table 2. Subasin 12 was too small for CUHP and was calculated using the rational method. The peak flows for these basins were then routed using SWMM to gain a clearer understanding of the peak flows that will occur during the various storm events. The peak flows from each basin are summarized in Table 3 of this report. The CUHP and the SWMM output can be found in the Appendix. As the analysis proceeds toward final design, the pervious and impervious parameters may change as a more detailed study is completed.

Table 2: Colorado Urban Hydrograph Parameters

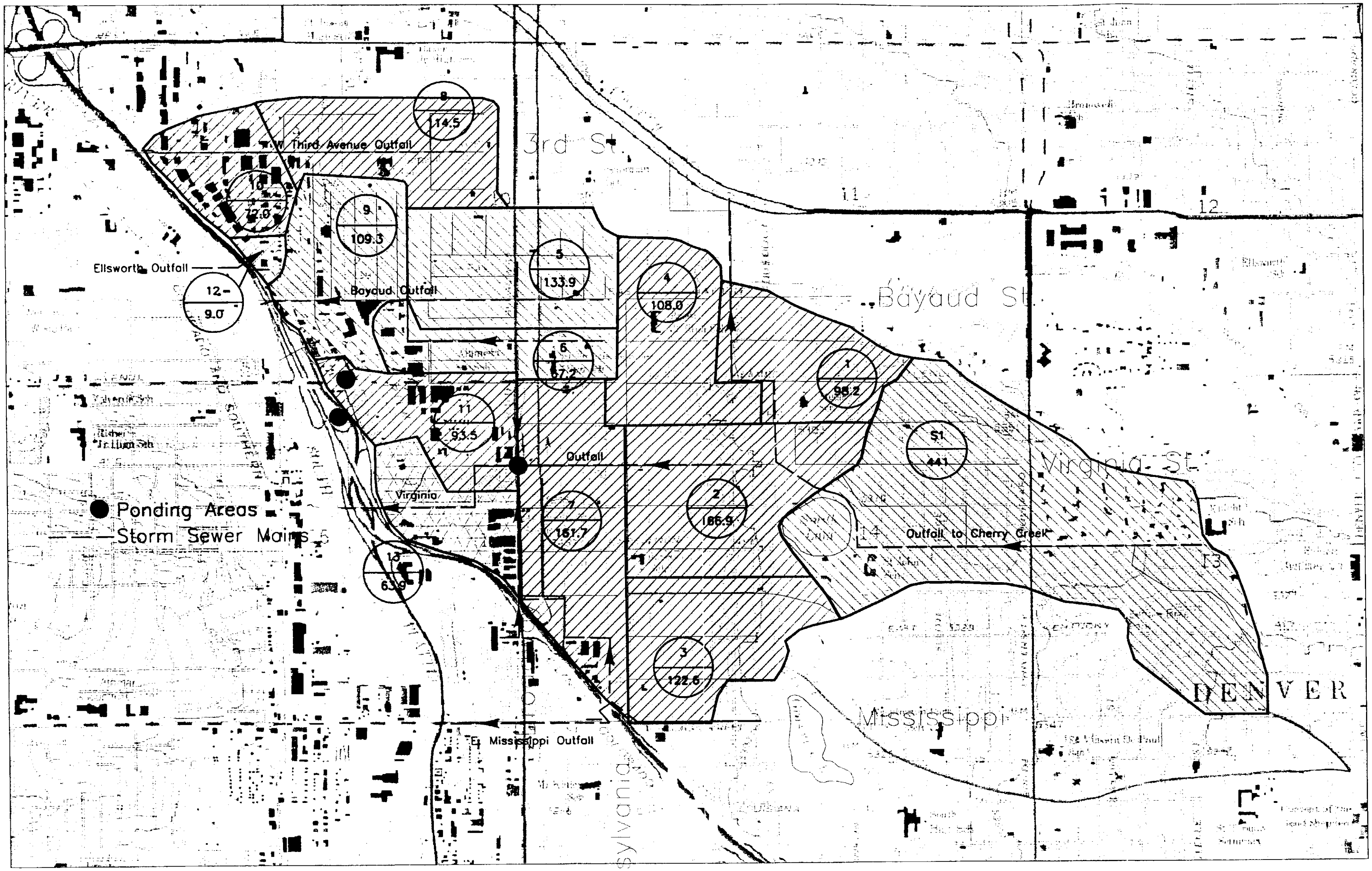
Sub-Basin	Basin Area (mi^2)	Basin Length (mi)	Centroidal Length (mi)	Percent Impervious (%)	Weighted Slope (ft/ft)	Time of Concentration (min)	Max Depression Storage (Pervious)	Max Depression Storage (Impervious)	Initial Infiltration Rate (in/in)	Final Infiltration Rate (in/in)	Horton's Decay Coefficient
1	0.15	0.59	0.3	47	0.011		0.35	0.3	3	0.5	0.0018
2	0.26	0.78	0.49	47	0.007		0.35	0.3	3	0.5	0.0018
3	0.19	0.72	0.36	47	0.008		0.35	0.3	3	0.5	0.0018
4	0.17	0.67	0.27	50	0.01		0.35	0.3	3	0.5	0.0018
5	0.21	0.76	0.36	50	0.005		0.35	0.3	3	0.5	0.0018
6	0.11	0.85	0.45	50	0.002	35.9	0.35	0.3	3	0.5	0.0018
7	0.25	0.93	0.19	50	0.004		0.35	0.3	3	0.5	0.0018
8	0.18	0.76	0.32	50	0.006		0.35	0.3	3	0.5	0.0018
9	0.17	0.68	0.24	65	0.004		0.35	0.3	3	0.5	0.0018
10	0.11	0.55	0.23	80	0.005	34.1	0.35	0.3	3	0.5	0.0018
11	0.15	0.7	0.41	80	0.009	34.2	0.35	0.3	3	0.5	0.0018

% Imperviousness for the basins was estimated using Table 3-1 _Recommended Runoff Coefficients and Percent Impervious_ Multi-Unit detached from the UD&FCDCM. The density of the Units/acre for the residential areas to the east of I-25 was estimated to be approximately 9.7 units/Acre. Extrapolating from Figure 2-1 Residential Housing Density vs. Impervious Area confirms that the % Imperviousness should be 50%.

Basin Area, Basin Length and **Centroidal Lengths** were calculated from Autocadd Drawing File 9904-basin.dwg. **Weighted Slope** was calculated using Equation 4-5 from the UD&FCDCM with data obtained from USGS mapping and data obtained from aerial photography.

Horton's Equation parameters were based on Hydrologic soils Group C and the values in Table 2-2, _Recommended Horton's Equation Parameters_. An SCS soils report has not been published for Denver County.

Pervious and Impervious Depression Retention was estimated using Table 2-1 _Typical Depression Retention for Various Land Covers_. The maximum value of 0.3 was used for the Impervious Retention due to the large amount of retention from high street crowns and very mild slopes in the subject area.



Location of Outfall	Description	Q_{cap}
W Third Avenue Outfall	60" RCP	140 cfs
Ellsworth Outfall	24" RCP	58 cfs
Bayaud Outfall	36" Brick	146 cfs
Virginia Outfall	66" Brick	212 cfs
Basin 13 Outfall	Multiple RCPs	400 cfs
E. Mississippi Outfall	69" RCP	479 cfs

REVISIONS

NO	DATE	BY	CHK'D	DESCRIPTION

MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
IRONGATE 4, SUITE 100
777 S. WADSWORTH BLVD.
LAKEWOOD, COLORADO 80226
(303) 988-4939

I-25/BROADWAY

FIGURE 1

DRAINAGE BASINS

DESIGNED		DATE	1/10/2000
DRAWN	DLK	FILE	9904-BASIN
CHECKED	MSD	PROJ. NO.	9904
SCALE	NTS	SHEET	1 OF 1

Table 3: Peak Flows

Basin	Peak Flow (cfs)				Cfs per Acre			
	5	10	50	100	5	10	50	100
1	117	158	291	339	1.2	1.6	3.0	3.5
2	157	217	399	472	1.6	2.2	4.1	4.8
3	132	178	321	383	1.3	1.8	3.3	3.9
4	140	188	343	398	1.4	1.9	3.5	4.1
5	144	196	353	417	1.5	2.0	3.6	4.2
6	61	81	148	178	0.6	0.8	1.5	1.8
7	190	253	447	535	1.9	2.6	4.6	5.4
8	130	174	311	371	1.3	1.8	3.2	3.8
9	165	212	370	423	1.7	2.2	3.8	4.3
10	89	112	189	219	0.9	1.1	1.9	2.2
11	166	211	353	400	1.7	2.1	3.6	4.1
				Ave:	1.4	1.8	3.3	3.8

Smith Lake and Washington Park

Drainage from Sub-basin S1, located to the east and southeast of Smith Lake will flow into Smith Lake. The hydrograph from this basin minus the capacity of the storm sewer running along Marion Pkwy was routed into Smith Lake. The volume in Smith Lake available for storm storage was conservatively estimated to be 47 acre-feet. This is based on the area of the perimeter of Smith Lake and the outlet elevations as taken from mapping obtained from the Denver Department of Parks and Recreation. The estimated time needed for Smith Lake to overflow was 60 minutes. Assuming a 1.2% constant slope and a travel velocity of 2.19 ft/sec along the 4300 foot length from Marion Pkwy to Broadway, the total time needed for water to flow from basin S1 to Broadway and Virginia was calculated to be approximately 90 minutes. The flow from basin 3 to Virginia and Broadway at 90 minutes is about 900 cfs. Therefore, the weir flow from Smith Lake of approximately 350 cfs would not create a peak flow rate greater than the peak flow from the lower basins and will therefore not be considered in the design.

Interstate 25 is affected by drainage from the east flowing toward the South Platte River. Storm sewers accept smaller flows, but larger flows run overland and affect I-25 in large, infrequent storms. Flow enters I-25 at the following locations.

Broadway Market Place

Runoff from Sub-Basins 1, 2, 3, 4 and 7 will reach a sump at Virginia & Broadway where flooding will occur. Interviews with business owners at this intersection have indicated that drainage problems occur at this intersection on a yearly basis. After the water has accumulated to the necessary volume it will flow across the Broadway Marketplace to the Northwest and exit into W. Alameda Ave. It will then flow west down W. Alameda Ave under the Light Rail to a small sump at W. Alameda Ave and Santa Fe. Interviews with business owners at this intersection have indicated that drainage problems also occur at this intersection on a yearly basis. The water will then flow southwest across the Denny's parking lot to a small detention basin on the west side of Kalamath St. When the detention basin capacity is reached the water will flow onto I-25 and into the sump under W. Alameda Ave (Figure 2). It will then be pumped into the South Platte River. For the 100-year storm event the runoff at Broadway and Virginia is expected to be approximately 1,989 cfs. Approximately 212 cfs will be routed through a 66" brick storm sewer that runs from Broadway and Virginia under the Broadway Marketplace to the South Platte River. Therefore the runoff that can be expected from Sub-Basins 1, 2, 3, 4 and 7 for the 100-year storm event is

1989
- 212 to pipe
1777

Existing outfall along South Platte River near Invesco Field at Mile High.