US 6 Bridges Design Build Project

BR 0061-083

Sub Account Number 18838 (CN)

Water Quality Report

Prepared for:
Colorado Department of Transportation
Federal Highway Administration

Prepared by:

Olson Associates

December 2012

Water Quality and Hydraulics

Appropriate measures to minimize environmental harm from the Project have been identified. Mitigation measures for water resources in the FEIS and 2007 ROD were reviewed and carried forward if applicable, and mitigation measures were added for any resources with additional impacts. A summary of all mitigation measures for Phase 1 (including the US 6/Federal Boulevard interchange) as presented in the 2007 ROD, Phase 5 as presented in the FEIS, and the six new project elements are shown in Table 1 below. These mitigation measures are consistent with both the CDOT Mitigation Tracking Form in Appendix C and Book 2 Section 5 of the Project contract documents.

Table 1: Summary of Impacts and Mitigation

Resource	FEIS and 2007 ROD		US 6 Bridges Design Build Project: What Has Changed	US 6 Bridges Design Build Project	
	Impacts of Preferred Alternative	Mitigation		Impacts of Project	Mitigation
Water Quality and Water Resources	Short-term increase in sediment from construction. Increase in impervious drainage area. Consolidation of stormwater runoff with fewer outfalls to the South Platte River. Improved quality of stormwater discharge due to construction of water quality ponds and best management practice (BMP) stormwater facilities.	Use construction BMPs to reduce temporary impacts. On-site project area runoff will be controlled through water quality ponds or other BMPs to settle and improve water quality runoff releasing to the South Platte River. Reduction of the overall number of outfalls into the South Platte River and installation of energy dissipaters, such as riprap, at outfalls to reduce erosion potential. Use pump stations to remove runoff at underpasses on grade separations and use water quality ponds to settle sediment and improve water quality releasing into the South Platte River.	The 2012 Reevaluation and preliminary design identified the need for water quality ponds.	Improvement to water quality and stormwater management due to new ponds.	Identify hazardous spill containment structure locations and recommend BMPs based on their potential effectiveness in reducing hazardous waste discharge to the South Platte River. Comply with CDOT Standard Specification 207 and 208. Implement appropriate temporary BMPs for erosion and sediment control according to the CDOT Erosion Control and Stormwater Quality Guide (CDOT, 2002), and develop a stormwater management plan (SWMP), which includes water quality monitoring by the Contractor to ensure effectiveness of temporary construction BMPs. Provide for permanent stabilization consistent with CDOT's MS4 permit through revegetation and permanent erosion controls measures. Use storm sewer system, pump stations, or other approved methods to remove runoff at underpasses on grade separations and use water quality ponds or other approved water quality BMPs to settle sediment and improve water quality prior to releasing the runoff into the South Platte River. Reduce the overall number of outfalls into the South Platte River in compliance with CDOT's MS4 permit.

Resource	FEIS and 2007 ROD		US 6 Bridges Design Build Project: What Has Changed	US 6 Bridges Design Build Project	
	Impacts of Preferred Alternative	Mitigation		Impacts of Project	Mitigation
					Install energy dissipaters, such as riprap, or other equitable allowable BMPs, at outfalls to reduce erosion potential in accordance with Section 208 of the 2011 Standard Specification for Road and Bridge Construction. The 2012 Reevaluation and preliminary design identified the need for water quality ponds. Construct ponds or other equitable allowable permanent BMPS, for erosion and sediment control according the CDOT Erosion Control and Stormwater Quality Guide (CDOT, 2002).
Floodplains	Temporary impacts during replacement of SB Santa Fe Drive and Alameda Avenue bridges over the South Platte River. Encroachment into floodplain from SB I-25 off ramp to Santa Fe Drive.	Design bridges to minimize the impact on floodplains of piers, abutments, and roadways, to the extent practicable. Restore bridge construction areas. Install storm sewer improvements to reduce flooding on I-25 under Alameda Avenue. Provide adequate floodplain width in areas of floodplain encroachment for overall "no rise" in floodplain.	Reconstruction of SB I-25 to EB US6 ramp, which is in the 100-year floodplain, is a new project element.	Potential floodplain impacts due to the replacement of the South Platte River Bridge and the reconstruction of the I-25/US 6 interchange	Design bridges to minimize the impact on floodplains from piers, abutments, and roadways, to the extent practicable. Restore construction areas to the pre-construction conditions in accordance with Book 2 Section 5.1.6. Vegetation Provide adequate floodplain width in areas of floodplain encroachment for overall "no rise" in floodplain. Contractor shall ensure that there is no rise in floodplain elevation due to construction of the Project. If there is a rise in floodplain elevation, future coordination with the Denver Area Urban Drainage and Flood Control District will be required.

Master Plan
Water Quality Report

US 6 Bridges Design Build Project
BR 0061-083
Sub Account No. 18838 (CN)
Denver, Colorado

Prepared for
Colorado Department of Transportation

Prepared by
Olsson Associates
4690 Table Mountain Drive, Suite 200
Golden, CO 80403
Phone: (303) 237-2072
Contact: David Krickbaum, PE

August 22, 2012

Olsson Associates Project No. 011-2359

OLSSON ASSOCIATES

Master Plan Water Quality Report
US 6 Bridges Design Build Project
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1.0 INTRODUCTION

This Water Quality Report presents the water quality concepts, design calculations, permanent stormwater best management practices (BMPs) for planned bridge and highway improvements of US 6 from Knox Court to the Burlington Northern Santa Fe (BNSF) Railroad bridge to be constructed as a design build project. This report is prepared in accordance with the Colorado Department of Transportation (CDOT) *Drainage Design Manual (DDM)*, the City and County of Denver (CCD) *Storm Drainage Design & Technical Criteria Manual (SDDTCM)*, the Urban Drainage Flood Control District (UDFCD) *Urban Storm Drainage Criteria Manual (USDCM)*, and standard engineering practices.

1.1 Location of Improvements

The overall project area, shown in Figure 1, is located in the south halves of Sections 4 and 5 and the north halves of Sections 8 and 9, Township 4 South, Range 68 West of the Sixth Principal Meridian in the City and County of Denver, Colorado. The project will include highway improvements along US 6 from Knox Court to the BNSF Bridge east of Interstate 25 (I-25); along I-25 from approximately 700 feet north of the US 6 interchange to 1300 feet south of the interchange; along Federal Boulevard from 5th Avenue to 7th Avenue; along 5th Avenue from Federal Boulevard to Decatur Street; and reconstruction of Barnum Park East.

The receiving water for the project is the South Platte River.

1.2 Description of Improvements

The planned highway improvements consist of replacing the bridges at Federal Boulevard, Bryant Street, the South Platte River, I-25, and the BNSF Railroad, and associated highway and ramp improvements. Barnum Park East, located at the southeast corner of the Federal Boulevard/US 6 Interchange, will also be reconstructed with the project.

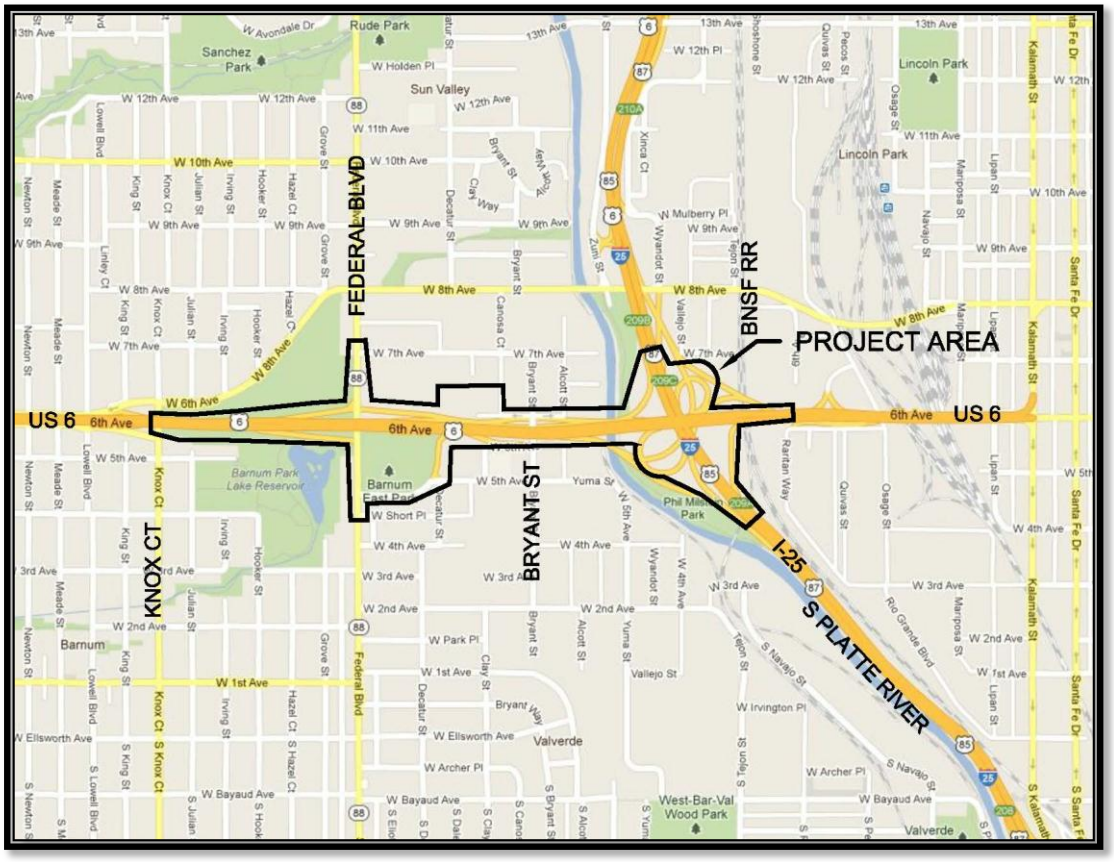


Figure 1: Vicinity Map

2.0 WATER QUALITY REQUIREMENTS

2.1 Adherence to the CDOT MS4 Permit and NDRD Requirements

CDOT's MS4 permit and New Development and Redevelopment (NDRD) Stormwater Management Program require that BMPs be provided for significant highway redevelopment construction that will disturb more than 1 acre.

NDRD requires that development and redevelopment projects provide 100% water quality capture volume or BMPs to remove 80% of the total suspended solids.

2.2 Assumptions and Methodologies

"Offset area" is defined as non-project impervious area treated by permanent stormwater BMPs to offset project impervious area in a highly constrained area that cannot be treated. "Highly constrained" is defined as an area where water quality treatment cannot be provided due to public safety concerns, maintenance crew safety concerns, stormwater pumping requirements, utility conflicts, elevation constraints, space constraints, or other factors which limit the ability to install and maintain BMPs.

3.0 WATER QUALITY DESIGN

3.1 Design Coordination

3.1.1 Adjacent Segments

The EIS delineated a basin on I-25 to the south of this project, designated the "3rd Avenue Basin," located on I-25 between the I-25 Bridge over the BNSF railroad and the I-25 & Alameda project. It proposed that the water quality flows from the 3rd Avenue basin be conveyed to the 6th Avenue Interchange Water Quality Pond. The 3rd Avenue basin will be constructed by others. However, the 6th Avenue Interchange Water Quality Pond, constructed with this project, will need to be sized to provide water quality capture volume for the 3rd Avenue basin.

3.1.2 Agency Coordination

Design approvals will be required from CDOT and CCD.

3.2 Hydrology and Design Flow Development

The Rational Method model was used to estimate the peak runoff rates for the water quality storm. This method is defined as:

$Q = CIA$

where: Q = Peak discharge in cubic feet per second (cfs)

C = Runoff coefficient

I = Rainfall intensity in inches per hour

A = Drainage area in acres

A Water Quality storm event with a one-hour point rainfall value of 0.6 inches was used for design, which is consistent with UDFCD and CCD criteria, instead of 0.5-inches in the CDOT criteria.

The time of concentration is required to select the appropriate rainfall intensity. The time of concentration was calculated using equations from Section 2.4 of the Runoff chapter of the USDCM. The resultant time found using these equations is compared to the time of concentration for urbanized basins, which is also calculated using an equation from Section 2.4. The lesser of the two times is used to determine the rainfall intensity, with a minimum allowable time of concentration equal to five minutes. Runoff coefficients were determined using the percent imperviousness, NRCS hydrologic soil group, and Table RO-3 from the USDCM. Equation 5.1 from the SDDTCM was used to determine the rainfall intensities for each sub-basin. Manning's equation for full pipe flow was used to calculate pipe flow velocities and travel times. Figure 7.2 from the DDM was used to calculate overland flow travel times for the 100-year storm event.

3.3 Description of Water Quality Basins

The project area is divided into fifteen water quality basins, labeled WQ-1 through WQ-15.

At Knox Court, the west extent of the project, runoff from non-project area flows east into the project area. WQ-1 includes both non-project and project area, consisting of all the tributary area upstream of the proposed water quality diversions near the Weir Gulch culvert under US 6 (see Section 3.4.2 for further discussion of the water quality diversions). This water quality basin is comprised of 2.29 acres of project impervious area and 31.83 acres of non-project impervious area.

Basin WQ-2 includes an area on US 6 between Knox Court and Federal Boulevard which discharges to Weir Gulch. This basin includes 2.68 acres of project impervious area and 0 acres of non-project impervious area.

Basin WQ-3 includes the project area drained by the US 6 – Federal to Bryant storm drain system. This basin includes US 6 from the Weir Gulch culvert under US 6 to Bryant Street, Federal Boulevard from West 5th Avenue to West 7th Avenue, W 5th Avenue from Federal to North Decatur Street, and Barnum Park East. WQ-3 includes 23.84 acres of project impervious area and 4.67 acres of non-project impervious area.

Basin WQ-4 is 0.34 acres of the eastbound collector/distributor ramp to Bryant Street. This basin is lower in elevation than the US 6 Water Quality Pond; therefore runoff from this area is not intercepted by the storm drain system and flows east.

The embankment of the US 6 Water Quality Pond is a grassy slope on the downstream side of the pond. This basin, WQ-5, contains 0.41 acres of pervious area and 0 acres of impervious area. No treatment is needed.

At the north extent of the project area on Federal Boulevard is 0.17 acres of impervious project area and 0 acres of non-project impervious area. Runoff from this area, WQ-6, flows north of the proposed inlets.

Basin WQ-7, which includes 0.48 acres of impervious project area and 0 acres of non-project impervious area, drains south to and is treated by the existing Barnum Lake Constructed Wetland Pond constructed with the Federal Boulevard Improvement Project: Alameda to 6th Avenue.

Basin WQ-8 includes the westbound US 6 frontage road, on the north side of US 6 between the US 6 Water Quality Pond and Alcott Street. This area is 0.73 acres of project impervious area and 0 acres of non-project impervious area. As it is lower in elevation than the storm drain system to US 6 Water Quality Pond, runoff flows east beyond the project limits.

US 6 between Bryant Street and the east abutment of the I-25 collector/distributor tunnel drains to the South Platte River. This basin, WQ-9, is comprised of 6.34 acres of project impervious area and 0 acres of non-project impervious area.

Basin WQ-10 includes the eastbound US 6 to southbound I-25 ramp, from Bryant Street to the South Platte River. This basin contains 1.13 acres of impervious project area and 0 acres of non-project impervious area.

I-25 between 8th Avenue and US 6, Ramps "A,' "B," and "C," and a portion of US 6 at the bridge over I-25 are included in Basin WQ-11. This basin contains 9.23 acres of project impervious area and 1.04 acres of non-project impervious area.

Basin WQ-12 consists of Ramp "D," US 6 between the BNSF bridge and the I-25 collector/distributor tunnel, a portion of I-25 between US 6 and the BNSF bridge to the south, and the area under the flyover ramp between Ramp "C" and I-25. This water quality basin consists of 5.66 acres of project impervious area and 1.01 acres of non-project impervious area.

Basin WQ-13 consists of 1.98 acres of project impervious area and 0 acres of non-project impervious area on US 6 from the BNSF bridge to the east extent of the project.

The embankment of the north and east sides of Ramp "B" is a grassy slope. This basin, WQ-14, contains 0.80 acres of pervious area and 0 acres of impervious area. No treatment is needed.

The embankment on the west and south sides of Ramp "C" is a grassy slope. This basin, WQ-15, contains 0.37 acres of pervious area and 0 acres of impervious area. No treatment is needed.

See Appendix B for the Water Quality Concept Plan.

3.4 Permanent Stormwater Best Management Practices

The US 6 Water Quality Pond and the 6th Avenue Interchange Water Quality Pond are proposed extended detention basins (EDB) that will be used to provide water quality for the project area. Locations for the water quality ponds are shown in Figure 2 below.

Due to site constraints, EDB and underground vaults are the only viable water quality treatment options. Vaults were not considered due to safety concerns to maintenance crews and the public. Infiltration basins, infiltration trenches, and filtering basins were not considered due to high groundwater levels. Wet ponds and constructed stormwater wetlands are not a viable option due to the lack of a constant source of flow.

Extended detention basins have an expected pollutant removal rate of 55-75% TSS removal, as stated in Table 4.7 of the New Development and Redevelopment Stormwater Management Program Manual, CDOT, February 2004.

There are no existing water quality features within the project area.

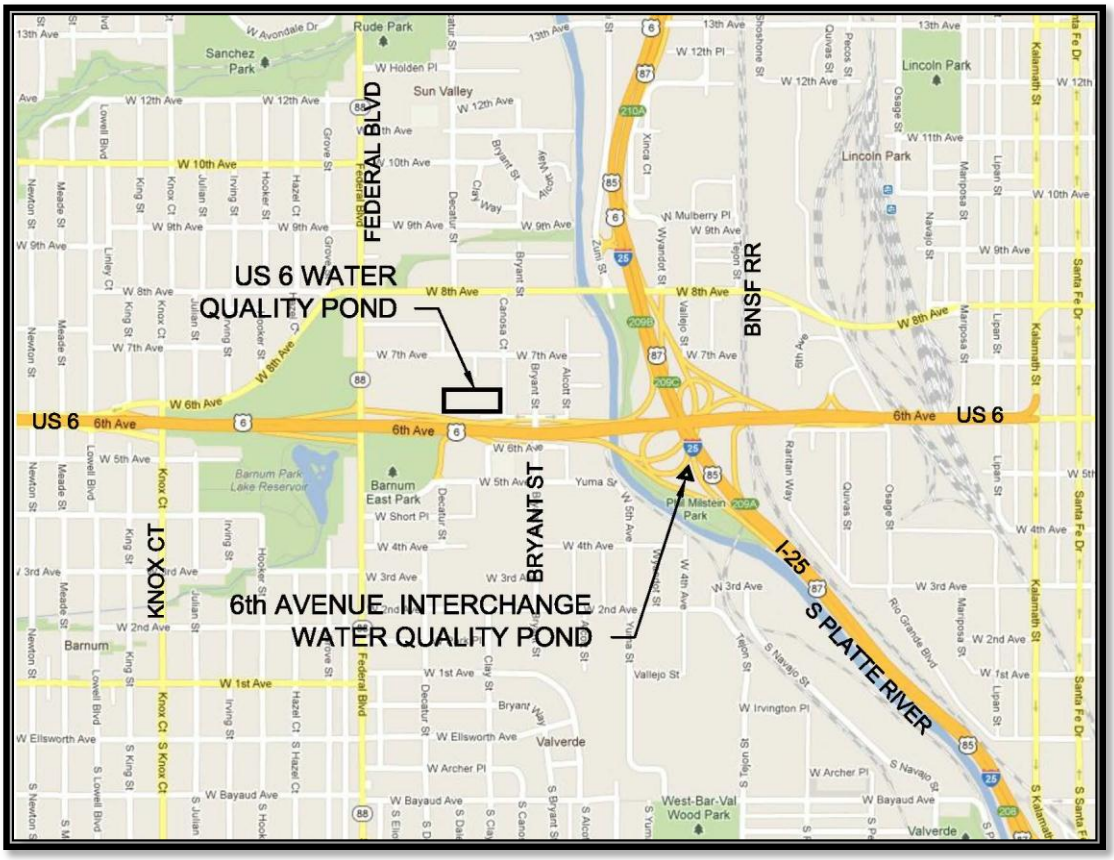


Figure 2: Locations of BMPs

3.4.1 Water Quality Treatment

Water quality treatment for Basins WQ-1 and WQ-3 will be provided by the US 6 Water Quality Pond. Basin WQ-12 will be treated by the 6th Avenue Interchange Water Quality Pond. See Sections 3.4.2 and 3.4.3 for further discussion of these ponds.

Basins WQ-5, WQ-14, and WQ-15 are vegetated slopes with 0 acres of impervious area. No treatment is needed.

Basin WQ-11 includes area which cannot drain to the South Platte River via a gravity drainage system. High flows in the South Platte River are influenced by releases from Chatfield Reservoir. Releases from the reservoir and resulting high water surface elevations on the river can occur at any time; therefore an outfall from I-25 to the river that is set too low could result in a clear day flooding of I-25 and could prevent water quality discharges to the river. A series of interconnected ponds and a pump station are proposed to drain stormwater from the US 6 and I-25 interchange. Since pumping is required, this basin is considered to be highly constrained and water quality treatment is not provided. Refer to the US 6 Bridges Design Build Project Master Plan Hydrology and Hydraulics Report for further discussion of this storm drain and pumping system.

Basin WQ-2 includes a portion of the storm drain systems in US 6 between Knox Court and Federal Boulevard which discharge to Weir Gulch. Within the boundaries of this area, the inverts of the storm drains are below the crown elevation of the Weir Gulch culvert. When the culvert is running full, water will backflow into the storm system. The water quality diversions have been placed uphill at elevations higher than the crown of Weir Gulch. Below this elevation, stormwater drains directly to Weir Gulch and is not treated. If the diversions are placed closer to the outfall to Weir Gulch in order to treat additional area, culvert flows will backflow into the storm drain system, into the diversions, and into the US 6 Water Quality Pond. WQ-2 is not treated.

The storm drain system in US 6 is at a minimum 0.5% slope to the US 6 Water Quality Pond from the eastbound collector/distributor ramp to Bryant Street. Basin WQ-4 represents the area from which runoff cannot be collected, as the elevations of the ramp are lower than this storm drain system. There is no room for an EDB. Maintenance of an underground BMP installed in the traffic lanes would create a hazardous condition for the public and maintenance crews. WQ-4 is not treated.

Basin WQ-6 represents an area at the northern extents of the project on Federal Boulevard near 7th Avenue. The pavement within this basin will be overlaid, but this overlay area extends farther north (downstream) than the terminus of the planned curb replacement on Federal Boulevard. Inlets cannot be installed beyond the curb replacement boundaries. Therefore, runoff from this area cannot be intercepted by the storm drain system and flows off-site to the north. This area is not treated.

Basin WQ-7 is treated by the existing Barnum Lake Constructed Wetland Pond constructed with the Federal Boulevard Improvement Project: Alameda to 6th Avenue.

Basin WQ-8 is not treated because the elevations are lower than the storm drain system which diverts water quality flows to the US 6 Water Quality Pond. There is no room for an EDB. Maintenance of an underground BMP installed in the traffic lanes would create a hazardous condition for the public and maintenance crews.

Basin WQ-9 drains to the South Platte River. A water quality diversion pipe from this system cannot drain to either of the proposed EDBs at a minimum slope. There is no room for an EDB. Maintenance of an underground BMP installed in the traffic lanes would create a hazardous condition for the public and maintenance crews. This area is not treated.

Basin WQ-10 is the ramp from eastbound US 6 to southbound I-25 and is considered highly constrained. There is no room for an EDB. Maintenance of an underground BMP would create a hazardous condition for the public and maintenance crews. This area drains to the South Platte River and is not treated.

Runoff from basin WQ-13 flows to the east project limits on US 6 and is not treated. The highway is elevated in this area. Construction of an EDB or underground BMP is not possible on the steep slopes. Maintenance of an underground BMP installed in the traffic lanes would create a hazardous condition for the public and maintenance crews.

The untreated project impervious areas will be offset by the treated non-project areas using the "offset areas" principle. The total acres of impervious area required to be treated are 73.17 acres. The total acres of treatment provided are 86.97 acres. The total area not treated is 23.71

acres. The total acres of impervious area treated in addition to what is required are 37.51 acres, which is a greater area than the area not treated.

3.4.2 US 6 Water Quality Pond

The US 6 Water Quality Pond will treat project and non-project impervious area from the west end of the project area and will be used to provide "offset area" for portions of the project which are highly constrained and are unable to be treated. Approximately 57 acres of non-project area (from Vrain Street to Knox Court) will flow east onto the project area. Water quality flows will be diverted from WQ-1 to WQ-3 at four locations: Manholes 411R, 308R, 107C, and 111C1. The water quality flows will enter the US 6 – Federal to Bryant storm drain system, will then be diverted from the storm drain system at Manhole 6000C, and will outlet to the US 6 Water Quality Pond on the north side of the highway. Refer to the US 6 Bridges Design Build Project Master Plan Hydrology and Hydraulics Report for basin maps and storm drain system schematics.

The US 6 Water Quality Pond will be constructed on CDOT owned property, adjacent to and on the north side of US 6 and west of Canosa Court. This pond will have a total volume of at least 2.45 acre-feet, which is the required WQCV for WQ-1 (1.33 acre-feet) and WQ-3 (1.12 acre-feet). The embankment should have 3:1 side slopes and the pond bottom should be graded at a 2% slope to the outlet. The outlet invert is at elevation 5203.00. An outlet structure with a water quality plate should be designed to release water quality flows in 40 hours. The water quality pond will outlet to the US 6 – Federal to Bryant Storm Drain System outfall, which outfalls to the South Platte River. During large storm events, it is possible for water to backflow from the outfall into the US 6 Water Quality Pond. The outlet structure will need an overflow weir in order to release larger flows. An emergency spillway will be graded in on the east embankment of the pond. The embankment will tie to the US 6 retaining wall on the south side of the pond, and will have at least 1 foot of freeboard. The storm drain outfall into the pond is located on the south side of the pond, and will require a grouted boulder rundown into a forebay in order to dissipate energy. A trickle channel will convey flows at a 0.5% slope to the outlet structure.

Refer to the *Final Drainage Report for Federal Boulevard/US 6 Interchange Improvements* by Olsson Associates for discussion of existing drainage patterns of Federal Boulevard and 5th Avenue. Refer to the US 6 Bridges Design Build Project Master Plan Hydrology and Hydraulics Report for discussion of the storm drain system design.

See Appendix B for the Water Quality Concept Plan.

3.4.3 6th Avenue Interchange Water Quality Pond

The 6th Avenue Interchange Water Quality Pond will be constructed in CDOT right-of-way, on the south side of Ramp "C," adjacent to I-25. This pond will provide WQCV for the 3rd Avenue basin on I-25 to the south and WQ-12, for a total WQCV required of 1.01 acre-feet at elevation 5207.76. The 3rd Avenue basin will have a water quality outfall in the southeast corner of the pond which will be constructed in the future by others. The outlet invert is at elevation 5201.23. An outlet structure should be designed to release water quality flows in 40 hours and will need an overflow weir for the minor and major storm event flows. The water quality pond will outlet to the South Platte River. An emergency spillway will be graded in at the southwest corner of the pond adjacent to Ramp "C," at elevation 5207.76.

See Appendix B for the Water Quality Concept Plan.

3.4.4 Right of Way Concerns

The proposed BMPs are located in CDOT right of way or property owned by CDOT.

4.0 MAINTENANCE AND OPERATION

4.1.1 US 6 Water Quality Pond

The US 6 Water Quality Pond can be access from Canosa Court. The retaining wall on the north side of the highway will prevent maintenance personnel from accessing the pond from the highway.

The pond outlet works will need routine maintenance to clear the trash rack and orifice plate of debris. The pond bottom and trickle channel should be scraped and regraded as needed to remove sediment build-up. A minor amount of continuous maintenance will be necessary to keep vegetation established and not overgrown.

4.1.2 6th Avenue Interchange Water Quality Pond

The 6th Avenue Interchange Water Quality Pond can be accessed from Ramp “C,” the southbound I-25 to eastbound US 6 ramp.

The pond outlet works will need routine maintenance to clear the trash rack and orifice plate of debris. The pond bottom and trickle channel should be scraped and regraded as needed to remove sediment build-up. A minor amount of continuous maintenance will be necessary to keep vegetation established and not overgrown.

Appendix A

Water Quality Pond Stage Storage and Calculations

WQ Pond Contribution - WEST US 6 BASINS (WQ1)

Basin	Area (Ac)	%I	A*%I
WB6-7	0.42	100.00	41.9
WB6-8	0.66	100.00	65.7
EB6-5	0.74	86.57	63.7
EB6-6	0.68	84.75	57.6
OS-11	4.57	29.56	135.1
OS-12	3.28	27.22	89.2
OS-13	0.54	89.56	48.4
OS-14	1.16	24.18	28.0
OS-15	0.47	0.00	0.0
OS-16	0.78	0.00	0.0
OS-17	0.53	100.00	53.0
OS-18	0.87	0.00	0.0
OS-20	12.65	60.25	762.2
OS-21	1.87	63.10	118.0
OS-22	2.95	60.45	178.3
OS-23	2.47	52.09	128.7
OS-24	0.37	100.00	37.0
OS-25	0.61	100.00	61.0
OS-26	9.87	53.06	523.7
OS-27	5.04	100.00	504.0
OS-28	4.67	58.70	274.1
OS-29	2.11	62.77	132.4
OS-30	1.76	62.23	109.5
	59.05	57.77	3412

WQ Pond Contribution - US 6 POND (WQ3)

Basin	Area (Ac)	%I	A*%I
SW1	0.73	100.00	73.2
SW2	0.61	56.18	34.3
SE1	0.84	97.63	82.4
SE2	1.41	100.00	140.7
P1	2.25	0.00	0.0
WB1	2.49	100.00	248.9
WB2	0.70	100.00	70.4
WB3	1.03	100.00	102.8
WB3A	0.07	100.00	6.8
WB4	1.05	100.00	104.7
WB5	0.65	100.00	65.4
WB5A	0.07	100.00	6.9
WB6-5	0.28	100.00	28.2
EB1	0.47	100.00	47.2
EB2	1.60	100.00	159.6
CD1	3.31	100.00	331.2
CD2	1.13	100.00	112.6
CD3	0.69	100.00	69.5
CD4	0.45	100.00	45.5
FR	0.69	100.00	68.8
NF1	0.23	100.00	22.7
NF2	0.29	96.51	27.6
NF3	0.36	75.62	26.9
NF4	0.40	65.62	26.3
NF5	0.25	100.00	24.7
NF6	1.11	85.73	95.5
NF7	0.54	97.95	52.7
NF8	1.02	90.56	92.1
NF9	0.32	98.76	31.9
NE	1.41	99.15	140.3
BPE1	1.83	73.10	133.8
BPE2	6.83	12.09	82.5
5TH1	1.12	69.64	78.0
5TH2	0.96	57.17	54.6
5TH3	0.47	37.07	17.6
5TH4	1.49	28.27	42.2
5TH5	1.32	28.27	37.4
5TH6	0.24	65.22	15.8
5TH7	0.10	100.00	9.9
OS-10	0.49	82.69	40.1
WEST BASINS	59.05	57.77	3411.7
	100.35	62.41	6263

Water Quality Capture Volume

Volume Formula per UDFCD (Volume 3)

$V_{WQCV}=(WQCV/12)*A*1.2$

$WQCV = 1.0*(0.91*I^3-1.19*I^2+0.78*I)$

Where: V_{WQCV} = storage volume

WQCV = watershed inches of runoff (Figure EDB-2) = 0.24 in

A = tributary area (acres)

1.2 Factor = Multiplier of 1.2 to account for the additional 20% of required storage for sediment accumulation

V_{WQCV}= 2.45 ac-ft

= 106,881 ft^3

WQ Pond Contribution - WQ12 & 3rd Avenue Basin - 6th Avenue Interchange Water Quality Pond

Basin	Area (Ac)	%I	A*%I	
WB6-1a	0.52	100.00	51.5	
WB6-2a	0.15	100.00	15.3	
EB6-1a	0.46	100.00	46.5	
VHE4	2.66	37.96	101.1	
VHE5	1.84	66.75	123.1	
VHE7	0.97	100.00	97.0	
VHW7	1.39	100.00	138.6	
VHW6	2.86	15.66	44.8	
RG-1	0.61	100.00	60.8	(Flyover Ramp)
3RD	17.19	100.00	1719.0	
	28.66	83.67	2398	

Water Quality Capture Volume

Volume Formula per UDFCD (Volume 3)

$V_{WQCV}=(WQCV/12)*A*1.2$

$WQCV = 1.0*(0.91*I^3-1.19*I^2+0.78*I)$

Where: V_{WQCV} = storage volume

WQCV = watershed inches of runoff (Figure EDB-2) = 0.35 in

A = tributary area (acres)

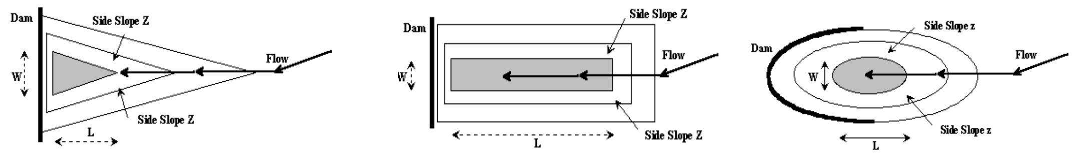
1.2 Factor = Multiplier of 1.2 to account for the additional 20% of required storage for sediment accumulation

V_{WQCV}= 1.01 ac-ft

= 44,014 ft^3

STAGE-STORAGE SIZING FOR POLYGONAL, ELLIPTICAL, OR IRREGULAR PONDS

Project: US 6 BRIDGES
Basin ID: US 6 Water Quality Pond



Design Information (Input):

Width of Pond Bottom, W =		ft
Length of Pond Bottom, L =		ft
Dam Side-slope (H:V), Z_d =		ft/ft

Check Pond Shape

Right Triangle		OR…
Isosceles Triangle		OR…
Rectangle		OR…
Circle / Ellipse		OR…
Irregular	X	(Use Overide values in cells G32:G52)

Stage-Storage Relationship:

	MINOR	MAJOR	
Storage Requirement from Sheet 'Modified FAA':			acre-ft.
Storage Requirement from Sheet 'Hydrograph':			acre-ft.
Storage Requirement from Sheet 'Full-Spectrum':			acre-ft.

Labels for WQCV, Minor, & Major Storage Stages (input)	Stage ft (input)	Side Slope (H:V) ft/ft Below El. (input)	Pond Width at Stage ft (output)	Pond Length at Stage ft (output)	Surface Area at Stage ft^2 (output)	Surface Area at Stage ft^2 User Overide	Volume Below Stage ft^3 (output)	Surface Area at Stage acres (output)	Volume Below Stage acre-ft (output)	Target Volumes for WQCV, Minor, & Major Storage Volumes (for goal seek)
	5203.00					0	0	0.000	0.000	
	5203.50		0.00	0.00		610	152	0.014	0.004	
	5204.00		0.00	0.00		3,666	1,221	0.084	0.028	
	5204.50		0.00	0.00		11,507	5,015	0.264	0.115	
	5205.00		0.00	0.00		18,318	12,471	0.421	0.286	
	5205.50		0.00	0.00		22,737	22,734	0.522	0.522	
	5206.00		0.00	0.00		26,783	35,114	0.615	0.806	
	5206.50		0.00	0.00		30,782	49,506	0.707	1.136	
	5207.00		0.00	0.00		34,819	65,906	0.799	1.513	
	5207.50		0.00	0.00		38,814	84,314	0.891	1.936	
	5208.00		0.00	0.00		42,575	104,662	0.977	2.403	
WQCV	5208.05		0.00	0.00		42,928	106,799	0.985	2.452	
	5208.50		0.00	0.00		46,106	126,832	1.058	2.912	
	5209.00		0.00	0.00		49,686	150,780	1.141	3.461	
							#N/A		#N/A	
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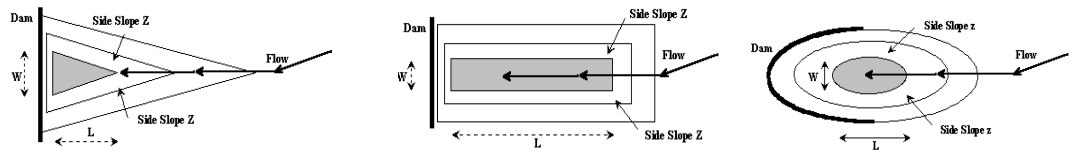
STAGE-STORAGE SIZING FOR POLYGONAL, ELLIPTICAL, OR IRREGULAR PONDS

Project: US 6 BRIDGES
Basin ID: 6th Avenue Interchange Water Quality Pond



Design Information (Input):

Width of Pond Bottom, W =		ft
Length of Pond Bottom, L =		ft
Dam Side-slope (H:V), Z_d =		ft/ft

Check Pond Shape

Right Triangle		OR…
Isosceles Triangle		OR…
Rectangle		OR…
Circle / Ellipse		OR…
Irregular	X	(Use Overide values in cells G32:G52)

Stage-Storage Relationship:

	MINOR	MAJOR	
Storage Requirement from Sheet 'Modified FAA':			acre-ft.
Storage Requirement from Sheet 'Hydrograph':			acre-ft.
Storage Requirement from Sheet 'Full-Spectrum':			acre-ft.

Labels for WQCV, Minor, & Major Storage Stages (input)	Stage ft (input)	Side Slope (H:V) ft/ft Below El.	Pond Width at Stage ft (output)	Pond Length at Stage ft (output)	Surface Area at Stage ft^2 (output)	Surface Area at Stage ft^2 User Overide	Volume Below Stage ft^3 (output)	Surface Area at Stage acres (output)	Volume Below Stage acre-ft (output)	Target Volumes for WQCV, Minor, & Major Storage Volumes (for goal seek)
	5201.23	(input)				0	0	0.000	0.000	
	5201.50		0.00	0.00		339	46	0.008	0.001	
	5202.00		0.00	0.00		1,272	449	0.029	0.010	
	5202.50		0.00	0.00		3,581	1,662	0.082	0.038	
	5203.00		0.00	0.00		5,245	3,869	0.120	0.089	
	5203.50		0.00	0.00		6,293	6,753	0.144	0.155	
	5204.00		0.00	0.00		6,811	10,029	0.156	0.230	
	5204.50		0.00	0.00		7,350	13,570	0.169	0.312	
	5205.00		0.00	0.00		7,910	17,385	0.182	0.399	
	5205.50		0.00	0.00		8,491	21,485	0.195	0.493	
	5206.00		0.00	0.00		9,094	25,881	0.209	0.594	
	5206.50		0.00	0.00		9,718	30,584	0.223	0.702	
	5207.00		0.00	0.00		10,363	35,604	0.238	0.817	
	5207.50		0.00	0.00		11,030	40,953	0.253	0.940	
WQCV	5207.76		0.00	0.00		11,388	43,867	0.261	1.007	1.005 AF
	5208.00		0.00	0.00		11,718	46,640	0.269	1.071	
	5208.50		0.00	0.00		12,427	52,676	0.285	1.209	
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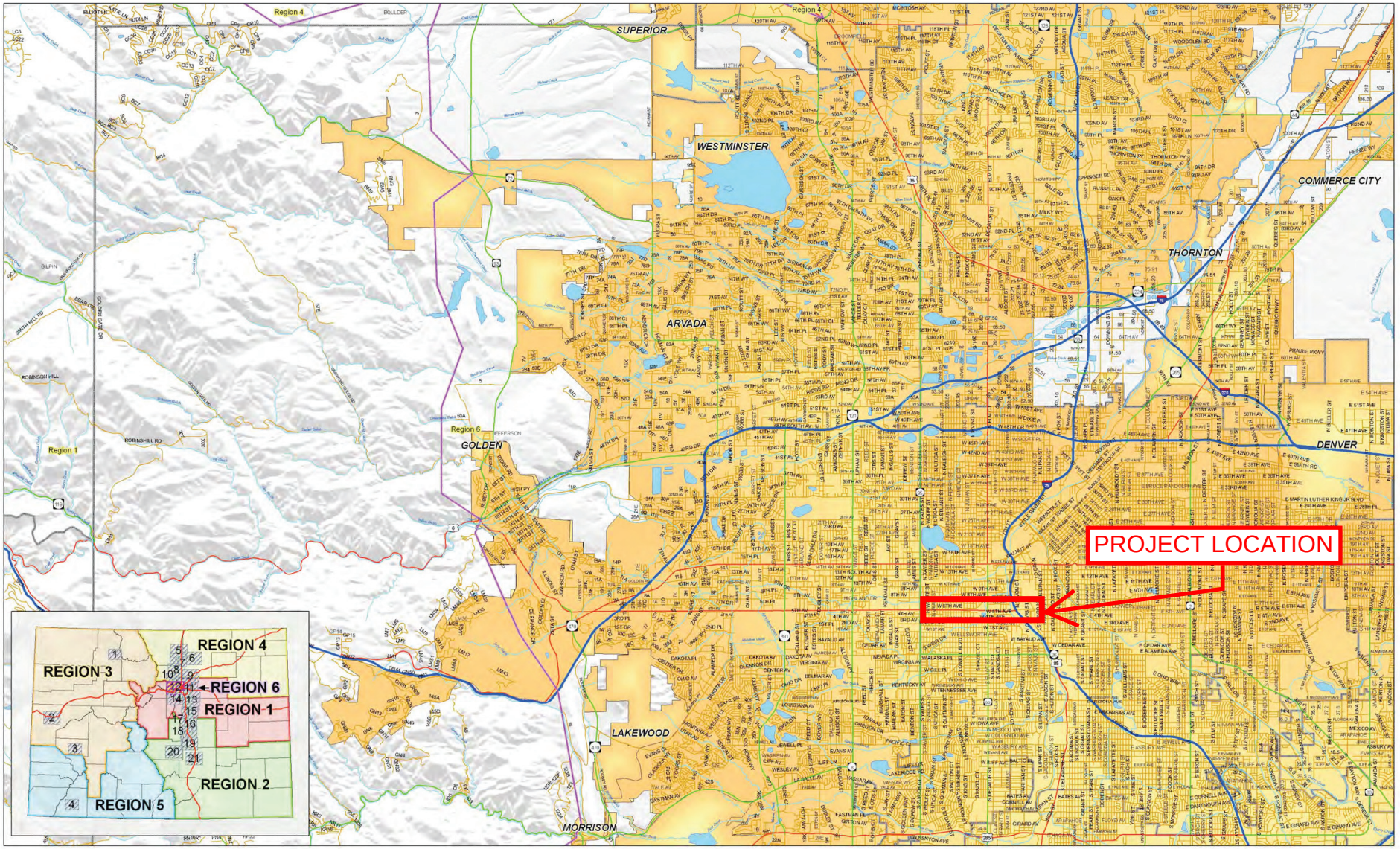
CDOT MS4 Permit Coverage Area, Map 12



Legend

- Rivers and Streams
- Interstate
- U.S. Hwy
- State Hwy
- Local Roads
- CDOT Regions
- Lakes
- County Boundary
- CDOT MS4 Coverage Area (after March 10, 2008)

0 2 4 8 Miles

N

Phase I & II MS4 permit coverage areas as of November 2007.

Information sources:
urban area boundaries - 2000 census from CDOT GIS Section.
jurisdictional boundaries from CDOT GIS Section Data Management Unit as of 12/31/2006.
Cherry Creek Basin used to delimit MS4 area from FHU.

Appendix B

Water Quality Concept Plan

N

1" = 100'

0' 50' 100' 200'

SCALE IN FEET

LEGEND	
	EXISTING STORM DRAIN
	ULTIMATE STORM DRAIN CONFIGURATION

*BMP = BEST MANAGEMENT PRACTICE
CWP = CONSTRUCTED WETLAND POND
EDB = EXTENDED DETENTION BASIN
NR = NOT REQUIRED
OA = OFFSET AREA
RIS = REMOVAL OF IMPERVIOUS SURFACE(S)
STC = STORMCEPTOR

NOTES:
INSTALL FISH STAMPS ON ALL NEW INLETS.

BASIN ID
AREA
IMPERVIOUS AREA

PERMANENT WATER QUALITY BMPS

BASIN COLOR	BASIN ID	TYPE OF PERMANENT BMP*	REQUIRED IMPERVIOUS AREA TO BE TREATED (AC)	ACTUAL IMPERVIOUS AREA TREATED (AC)	COMMENTS
	WQ-1	EDB	2.29	34.12	US 6 WATER QUALITY POND
TOTAL - ALL WQ BASINS			73.17	86.97	

REQUIRED IMPERVIOUS ARE TO BE TREATED = 73.17 AC
ACTUAL IMPERVIOUS AREA TREATED = 86.97 AC
AREA NOT TREATED = 23.71 AC
AREA TREATED IN ADDITION TO REQUIRED = 37.51 AC

WQ-1
59.1 34.1

US 6

US 6

VRAIN ST

UTICA ST

TENNYSON ST

STUART ST

RALEIGH ST

QUITMAN ST

PERRY ST

OSCEOLA ST

NEWTON ST

MEADE ST

W 5TH AVENUE

W 5TH AVENUE

MATCHLINE SEE FIGURE 4

Computer File Information		Index of Revisions			
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Last Modification Date: 08/22/2012	Initials: MEO	R-X			
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Drawing File Name: 112359_US 6 BRIDGES WQ PLAN.DWG		R-X			
Acad Ver. 2011	Scale: 1:100 Units: FEET	R-X			

Colorado Department of Transportation
DOT DEPARTMENT OF TRANSPORTATION
8833 South Wadsworth Court
Littleton, CO 80128
Phone: 303-972-9112 FAX: 303-972-9114
Region 6 TG

As Constructed
No Revisions:
Revised:
Void:

WATER QUALITY PLAN

Designer: M. ORLOFF
Detailer: M. ORLOFF
Sheet Subset: WATER QUALITY
Subset Sheet:: 3 of 6

Project No./Code Number
18192
Sheet Number 3

LEGEND	
	EXISTING STORM DRAIN
	ULTIMATE STORM DRAIN CONFIGURATION

*BMP = BEST MANAGEMENT PRACTICE
CWP = CONSTRUCTED WETLAND POND
EDB = EXTENDED DETENTION BASIN
NR = NOT REQUIRED
OA = OFFSET AREA
RIS = REMOVAL OF IMPERVIOUS SURFACE(S)
STC = STORMCEPTOR

NOTES:
INSTALL FISH STAMPS ON ALL NEW INLETS.

BASIN ID
AREA
IMPERVIOUS AREA

PERMANENT WATER QUALITY BMPS					
BASIN COLOR	BASIN ID	TYPE OF PERMANENT BMP*	REQUIRED IMPERVIOUS AREA TO BE TREATED (AC)	ACTUAL IMPERVIOUS AREA TREATED (AC)	COMMENTS
	WQ-2	OA	2.68	0.00	HIGHLY CONSTRAINED
TOTAL - ALL WQ BASINS			73.17	86.97	

REQUIRED IMPERVIOUS ARE TO BE TREATED = 73.17 AC
ACTUAL IMPERVIOUS AREA TREATED = 86.97 AC
AREA NOT TREATED = 23.71 AC
AREA TREATED IN ADDITION TO REQUIRED = 37.51 AC

W 8TH AVE
W 6TH AVE
US 6
W 5TH AVE
LOWELL BLVD
KING ST
KNOX CT
JULIAN ST
WEIR GULCH
BARNUM LAKE
WATER QUALITY DIVERSION TO US 6 WATER QUALITY POND
WATER QUALITY DIVERSION TO US 6 WATER QUALITY POND
WQ-1 59.1 34.1
WQ-2 4.28 2.68
MATCHLINE SEE FIGURE 3
MATCHLINE SEE FIGURE 5
N
1" = 100'
0' 50' 100' 200'
SCALE IN FEET

Computer File Information			Index of Revisions			
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Last Modification Date: 08/22/2012	Initials: MEO	R-X				
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Drawing File Name: 112359_US 6 BRIDGES WQ PLAN.DWG		R-X				
Acad Ver. 2011	Scale: 1:100 Units: FEET	R-X				

Colorado Department of Transportation
DOT
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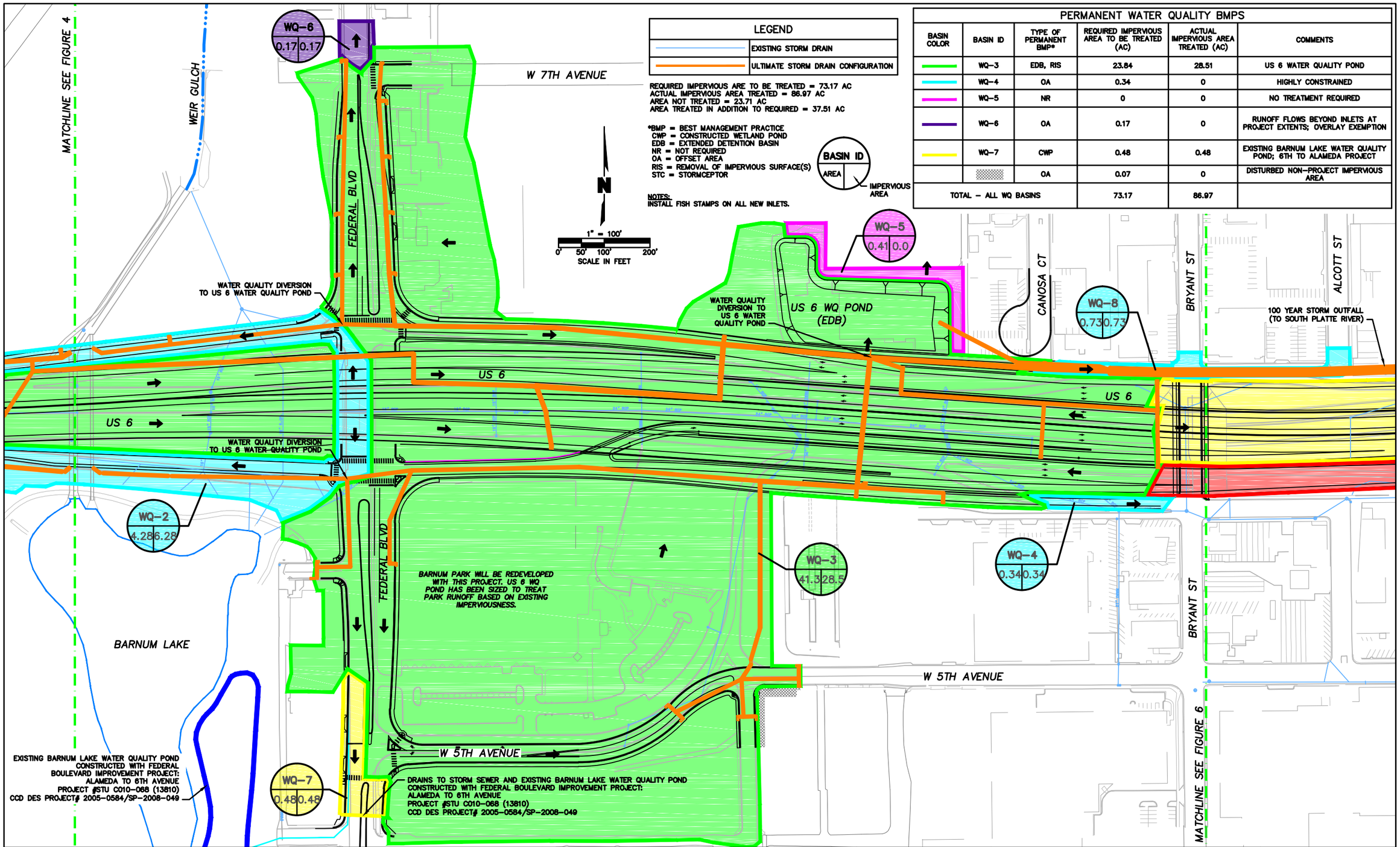
Littleton, CO 80128
Phone: 303-972-9112 FAX: 303-972-9114
Region 6 TG

As Constructed
No Revisions:
Revised:
Void:

WATER QUALITY PLAN

Designer: M. ORLOFF
Detailer: M. ORLOFF
Sheet Subset: WATER QUALITY
Subset Sheet:: 4 of 6

Project No./Code
Number
18192
Sheet Number 4



LEGEND	
	EXISTING STORM DRAIN
	ULTIMATE STORM DRAIN CONFIGURATION

REQUIRED IMPERVIOUS ARE TO BE TREATED = 73.17 AC
ACTUAL IMPERVIOUS AREA TREATED = 86.97 AC
AREA NOT TREATED = 23.71 AC
AREA TREATED IN ADDITION TO REQUIRED = 37.51 AC

*BMP = BEST MANAGEMENT PRACTICE
CWP = CONSTRUCTED WETLAND POND
EDB = EXTENDED DETENTION BASIN
NR = NOT REQUIRED
OA = OFFSET AREA
RIS = REMOVAL OF IMPERVIOUS SURFACE(S)
STC = STORMCEPTOR

NOTES:
INSTALL FISH STAMPS ON ALL NEW INLETS.

BASIN ID / AREA — IMPERVIOUS AREA

PERMANENT WATER QUALITY BMPS

BASIN COLOR	BASIN ID	TYPE OF PERMANENT BMP*	REQUIRED IMPERVIOUS AREA TO BE TREATED (AC)	ACTUAL IMPERVIOUS AREA TREATED (AC)	COMMENTS
	WQ-3	EDB, RIS	23.84	28.51	US 6 WATER QUALITY POND
	WQ-4	OA	0.34	0	HIGHLY CONSTRAINED
	WQ-5	NR	0	0	NO TREATMENT REQUIRED
	WQ-6	OA	0.17	0	RUNOFF FLOWS BEYOND INLETS AT PROJECT EXTENTS; OVERLAY EXEMPTION
	WQ-7	CWP	0.48	0.48	EXISTING BARNUM LAKE WATER QUALITY POND; 6TH TO ALAMEDA PROJECT
		OA	0.07	0	DISTURBED NON-PROJECT IMPERVIOUS AREA
TOTAL - ALL WQ BASINS			73.17	86.97	

Computer File Information	
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Last Modification Date: 08/22/2012	Initials: MEO
Full Path: F:\PROJECTS\011-2359_WTRS\PRELIMINARY_PLANS	
Drawing File Name: 112359_US 6 BRIDGES WQ PLAN.DWG	
Acad Ver. 2011	Scale: 1:100 Units: FEET

Index of Revisions		
R-X		
R-X		
R-X		
R-X		
R-X		

Colorado Department of Transportation
CDOT DEPARTMENT OF TRANSPORTATION
8833 South Wadsworth Court
Littleton, CO 80128
Phone: 303-972-9112 FAX: 303-972-9114
Region 6 TG

As Constructed
No Revisions:
Revised:
Void:

WATER QUALITY PLAN

Designer: M. ORLOFF
Detailer: M. ORLOFF
Sheet Subset: WATER QUALITY
Subset Sheet:: 5 of 6

Project No./Code Number: 18192
Sheet Number 5

PERMANENT WATER QUALITY BMPS

BASIN COLOR	BASIN ID	TYPE OF PERMANENT BMP*	REQUIRED IMPERVIOUS AREA TO BE TREATED (AC)	ACTUAL IMPERVIOUS AREA TREATED (AC)	COMMENTS
	WQ-8	OA	0.73	0	HIGHLY CONSTRAINED
	WQ-9	OA	6.34	0	HIGHLY CONSTRAINED
	WQ-10	OA	1.13	0	HIGHLY CONSTRAINED
	WQ-11	OA	10.26	0	HIGHLY CONSTRAINED
	WQ-12	EDB	5.66	6.67	6TH AVENUE INTERCHANGE WQ POND
	WQ-13	OA	1.98	0	HIGHLY CONSTRAINED
	WQ-14	NR	0	0	NO TREATMENT REQUIRED
	WQ-15	NR	0	0	NO TREATMENT REQUIRED
	I-25 3RD AVE	EDB	17.19	17.19	6TH AVENUE INTERCHANGE WQ POND
TOTAL – ALL WQ BASINS			73.17	86.97	

REQUIRED IMPERVIOUS ARE TO BE TREATED = 73.17 AC
ACTUAL IMPERVIOUS AREA TREATED = 86.97 AC
AREA NOT TREATED = 23.71 AC
AREA TREATED IN ADDITION TO REQUIRED = 37.51 AC

W 7TH AVENUE
PLANNED 7TH AVENUE OUTFALL (DENVER STORM DRAINAGE MASTER PLAN BASIN 0063-01)
RAMP "A" POND
RAMP "B" POND
STORED POND PUMP STATION SIZED TO DRAIN STORED VOLUME IN 8 HOURS WITH DISCHARGE TO RIVER WITH RUNDOWN
100 YEAR STORM OUTFALL (TO SOUTH PLATTE RIVER)
100 YEAR STORM OUTFALL (TO SOUTH PLATTE RIVER)
BRYANT ST
ALCOTT ST
US 6
W 5TH AVENUE
YUMA ST
6TH AVENUE INTERCHANGE WQ POND (EDB)
SOUTH PLATTE RIVER
VALLEY HIGHWAY (I-25)
BNSF RAILROAD
RARITAN WAY
WATER QUALITY PIPE FROM I-25 3RD AVENUE BASIN
WATER QUALITY FLOW FROM 3RD AVENUE BASIN
MATCHLINE SEE SHEET 2

WQ-8 0.73 | 0.73
WQ-9 6.34 | 6.34
WQ-10 1.13 | 1.13
WQ-11 20.8 | 10.3
WQ-12 11.4 | 6.67
WQ-13 11.4 | 6.67
WQ-14 0.80 | 0.0
WQ-15 0.37 | 0.0

N
1" = 100'
0' 50' 100' 200'
SCALE IN FEET

LEGEND
EXISTING STORM DRAIN
ULTIMATE STORM DRAIN CONFIGURATION

*BMP = BEST MANAGEMENT PRACTICE
CWP = CONSTRUCTED WETLAND POND
EDB = EXTENDED DETENTION BASIN
NR = NOT REQUIRED
OA = OFFSET AREA
RIS = REMOVAL OF IMPERVIOUS SURFACE(S)
STC = STORMCEPTOR

NOTES:
INSTALL FISH STAMPS ON ALL NEW INLETS.

BASIN ID
AREA
IMPERVIOUS AREA

Computer File Information			Index of Revisions			Colorado Department of Transportation	As Constructed	WATER QUALITY PLAN	Project No./Code
Creation Date: 12/12/2011 Initials: MEO	R-X					8833 South Wadsworth Court Littleton, CO 80128 Phone: 303-972-9112 FAX: 303-972-9114	No Revisions:		Number
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Drawing File Name: 112359_US 6 BRIDGES WQ PLAN.DWG	R-X							Sheet Subset: WATER QUALITY	Subset Sheet:: 6 of 6
Acad Ver. 2011 Scale: 1:100 Units: FEET	R-X					Region 6 TG			Sheet Number 6

Preliminary Bridge Hydraulics Report

US6 Bridges Design Build Project
BR 0061-083
Sub Account Number 18838 (CN)
Denver, Colorado

Prepared for
Colorado Department of Transportation

Prepared by
Olsson Associates
4690 Table Mountain Drive, Suite 200
Golden, CO 80403
Phone: (303) 237-2072
Contact: David Krickbaum, PE

July 6, 2012

Olsson Associates Project No. 011-2359

OLSSON ASSOCIATES

Preliminary Bridge Hydraulics Report
US6 Bridges Design Build Project
BR 0061-083
Sub Account Number 18838 (CN)

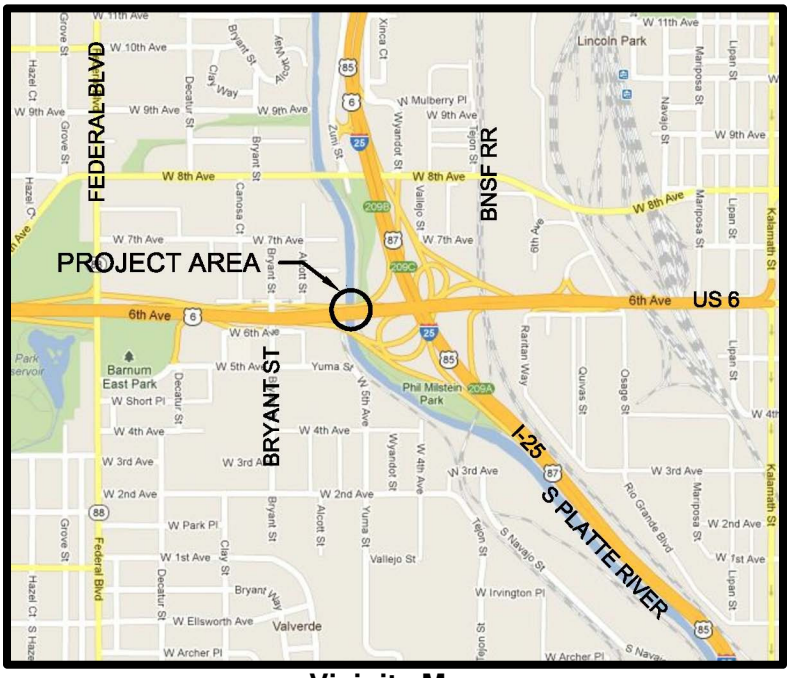
Table of Contents

Appendix

Preliminary Bridge Hydraulics Report
US6 Bridges Design Build Project
BR 0061-083
Sub Account Number 18838 (CN)

1.0 Introduction

The purpose of this report is to identify the minimum requirements for a new bridge on US6 over the South Platte River and to evaluate the resulting floodplain impacts. The bridge is located in Section 8 Township 4 South Range 68 West in the City and County of Denver, Colorado. The project location is shown in the Vicinity Map.



Vicinity Map

2.0 Hydrology

2.1 Previous Studies

A Flood Hazard Area Delineation (FHAD) was prepared for the South Platter River from Sand Creek to Oxford by Wright Water Engineers in September 1985. A Major Drainageway Plan (MDP) was prepared for the river from Chatfield Dam to Baseline Road by Wright Water Engineers in November 1985.

Urban Drainage and Flood Control District (UDFCD) and City and County of Denver (CCD) have constructed the Zuni and Sun Valley Reach Channel Improvements project, from approximately 100 feet upstream of Spear Boulevard to approximately 360 feet downstream of 3rd Avenue. A conditional Letter of Map Revision (CLOMR) was completed by Matrix Design Group in April 2009 and approved for this work. The CLOMR was assigned Case No. 09-08-0632R. A Letter of Map Revision (LOMR) has been submitted for review. These improvements reduce the 100-base flood elevations (BFEs) and flood plain extents on the South Platte River

through the subject project area. The HEC-RAS model from the approved CLOMR was used for the preliminary hydraulic analysis of the new US6 bridge.

2.2 Peak Discharges

Peak discharges at the US6 bridge were obtained from the approved CLOMR model and are presented in Table 1.

Table 1 – Peak Discharge at US6 Bridge (cfs)

River Station	10-Year	50-Year	100-Year	500-year
11014 (Downstream of US6)	7,550	15,000	19,200	31,500
11204 (Upstream of US6)	6,400	12,700	16,500	31,500

3.0 Existing Structure

The original existing structures appear to have been constructed around 1955, based on as-built plans. The structure ID Numbers are F-16-EE and F-16-EF for the north and south structures, respectively. The structures appear to have been widened about 1967.

Photo 1 – Existing US6 bridges over the South Platte River

4.0 Design Discussion

4.1 Freeboard Criteria

The freeboard requirement was obtained from Chapter 8 of the Urban Drainage and Flood Control District's (UDFCD) Urban Storm Drainage Criteria Manual. The City and County of Denver's Storm Drainage Design and Technical Criteria Manual refers to the UDFCD manual for bridge criteria. The manual states that the distance between the design flow water surface

and the bottom of the bridge deck should be a minimum of three feet for the 100-year flood on larger streams or rivers where large floating debris is likely.

4.2 Hydraulic Analysis and Recommended Design

The HEC-RAS model from the Zuni to Sun Valley Reach Channel Improvements CLOMR submittal was used for analysis. HEC-RAS model version 3.1.3 was used for both the CLOMR analysis and the bridge analysis for this study.

The 100-year discharge at the location of the bridge is 16,500 cfs. The average velocity through the existing bridge was 9.0 fps. The lowest low chord elevation on the existing bridge was 5204.73, which occurred on the downstream side. The 100-year water surface elevation upstream of the bridge, at cross section 11204 in the HEC-RAS model, was 5207.42, 2.69 feet higher than the low chord.

It was desired that the new bridge opening length should be at least as wide as the floodway downstream of the bridge, which is approximately 156 feet. To achieve 2 horizontal to 1 vertical side slopes (2:1) to the bridge abutments, the lower portion of the South Platte River channel was left intact in the model cross sections. Above the lower flow portion of the channel bottom, the 2:1 slope started and continued to the locations where the abutments might intersect the slopes. The abutments were set so that some vertical distance was available between the low chord and the bank. The vertical distances were 1.5 feet and 2.8 feet. These locations defined the overall length of the bridge opening. If the minimum vertical distance must be greater, the abutments can be moved in, reducing the bridge opening length. Two piers of 4-foot diameter were set to indicate a 3-span bridge. The piers are 67-68 feet apart.

The resulting overall opening was 202.9 feet long. The average velocity through the bridge was 7.2 fps, less than for existing conditions. The water surface elevation at cross section 11204 was 5206.69. The resulting required bridge low chord would be 5209.69. For this level of analysis, the low chord was set at 5210.0. The bridge opening can be reduced if warranted by additional input on the bridge design parameters. If it does decrease, the low chord elevation of the bridge might need to increase. If a 1- or 2-span bridge were used, the low chord could potentially be slightly lowered. Upstream and downstream cross sections of the bridge opening are included in the Appendix.

An existing 44-inch diameter brick sanitary line is located west of the bridge. The center line of the sanitary line is approximately 31.7 feet away from the proposed west bridge abutment.

4.3 Design Considerations for Potential Future Projects

The 1985 MDP shows the South Platte River channel bottom being lowered by approximately 4 feet in the area of the bridge. The bridge design must take into account the future lowering of the South Platte River. The hydraulic analysis in this report is based on the existing channel bottom elevation.

5.0 Scour Analysis

A preliminary analysis was prepared to evaluate the scour potential at the US6 bridge opening needed to convey the 100-year South Platte River flow and meet freeboard requirements.

Soil boring information near the bridge was provided by RockSol Consulting Group, Inc. The borings indicated the soils are generally sand over sandstone bedrock. Soil boring 10 was located south of the existing bridge in the South Platte River channel. Sandstone bedrock was encountered at a depth of 14 feet. Soil boring 11 was located in the channel north of the bridge. Sandstone bedrock was encountered at a depth of 8 feet.

The HEC-RAS model from the approved CLOMR for the South Platte River Zuni to Sun Valley reach was used as the basis of the bridge analysis. A 3-span bridge and a single-span bridge were evaluated.

Input parameters of d_{50} = 1.0 mm and d_{95} = 2.0 mm were used in the analyses. For the 3-span bridge with two piers, the piers were assumed to have rounded noses. For the 3-span bridge, the left abutment scour depth was predicted to be 12.8 feet, and the channel/pier scour depth was predicted to be 10.9 feet at the right bank during the 100-year event. For the single span bridge, the maximum scour depth was predicted to be 8.3 feet at the left abutment during the 100-year event. Scour calculations are included in the appendix.

Foundations used in the bridge design should be constructed below the anticipated scour depth. Riprap protection should be used at the abutments and piers. Riprap size and dimensions of protection should be determined as the design progresses.

6.0 Floodplain Analysis

The South Platte River in the project area is channelized. The existing US6 bridge low chord is below the 100-year water surface elevation. Although the bridge is not overtopped, it causes a rise in the 100-year water surface elevation upstream of US6. Upstream of US6, the west bank is not adequate to contain the 100-year discharges. As a result, extensive flooding occurs on the low-lying west side of the South Platte River from Vallejo Street to 6th Avenue, affecting many warehouses, retail stores, and small fabricating shops. In places, the floodplain in this area is more than 1,500 feet wide. The effective Flood Insurance Rate Map (FIRM) is included in the Appendix.

The South Platte River Zuni to Sun Valley reach CLOMR was prepared for improvements along the river downstream of 8th Avenue. Those improvements reduce the 100-year floodplain in the vicinity of this project.

In the proposed preliminary alternative, the South Platte River bridge low chord will be a minimum of 3 feet above the 100-year water surface elevation to meet UDFCD and CCD freeboard requirements, allowing the 100-year flood to pass underneath. Without the obstruction of the bridge, the upstream water surface elevation will be lowered by 0.5 foot to 0.7 foot and the floodplain will be reduced. However, shallow flooding will still exist on the west side of the river, due to the low bank elevations upstream of US6. HEC-RAS output for the original CLOMR model and the 3-span bridge are included in the appendix. The floodplain map showing the effective FEMA floodplain, CLOMR floodplain and US6 bridge replacement floodplain is shown in Figure 1.

7.0 Agency Coordination

Approvals from UDFCD, CCD, Federal Emergency Management Agency (FEMA) and the U.S. Army Corps of Engineers will be needed for the US6 bridge construction over the South Platte River.

8.0 References

Urban Drainage and Flood Control District. April 2008. *Urban Storm Drainage Criteria Manual Vol. 2, Chapter 8: Hydraulic Structures*.

U.S. Army Corps of Engineers Hydrologic Engineering Center. May 2005. Hydrologic Engineering Center River Analysis System (HEC-RAS) Version 3.1.3.

Wright Water Engineers, Inc. November 1985. *Major Drainageway Plan: South Platte River Chatfield Dam to Baseline Road, Phase B – Volume 1: Preliminary Engineering Design*.

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

Appendix

Bridge Upstream and Downstream Cross Sections

100-year Scour Calculations – 3-span Bridge

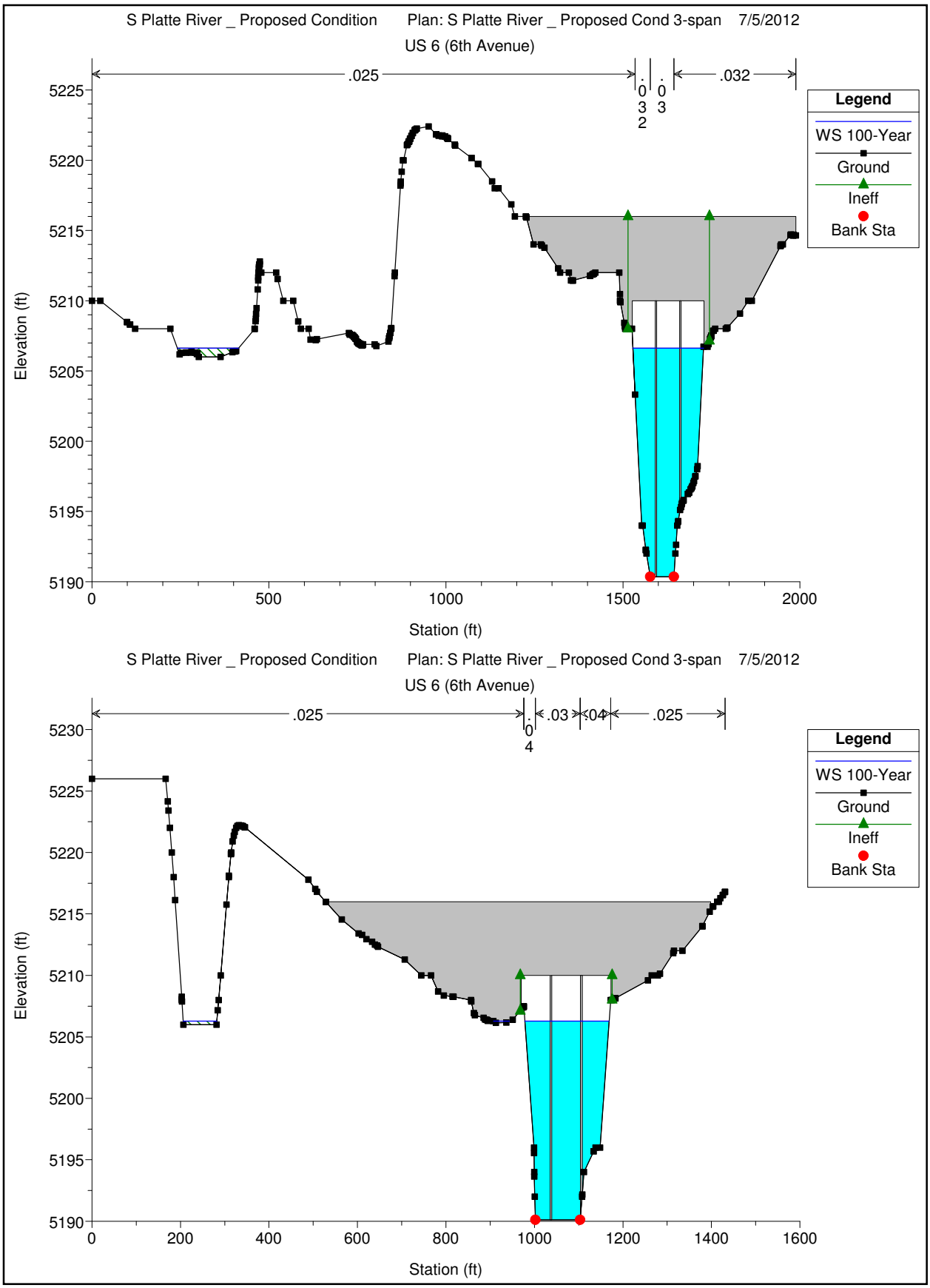
100-year Scour Calculations – Single Span Bridge

FIRM Panel

CLOMR Model HEC-RAS Output

3-span Bridge Model HEC-RAS Output

Figure 1 – 100-Year Floodplains


S Platte River _ Proposed Condition
Plan: S Platte River _ Proposed Cond 3-span
7/5/2012
US 6 (6th Avenue)
.025
.032
.032
.03
Legend
WS 100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
5225
5220
5215
5210
5205
5200
5195
5190
0
500
1000
1500
2000
S Platte River _ Proposed Condition
Plan: S Platte River _ Proposed Cond 3-span
7/5/2012
US 6 (6th Avenue)
.025
.03
.04
.025
Legend
WS 100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
5230
5225
5220
5215
5210
5205
5200
5195
5190
0
200
400
600
800
1000
1200
1400
1600

3-span bridge 100-year scour

Contraction Scour

		Left	Channel	Right
Input Data				
	Average Depth (ft):	4.98	16.66	8.09
	Approach Velocity (ft/s):	2.54	7.00	3.81
	Br Average Depth (ft):	10.24	16.28	9.55
	BR Opening Flow (cfs):	3777.04	8302.19	4420.77
	BR Top WD (ft):	48.92	63.07	79.55
	Grain Size D50 (mm):	1	1	1
	Approach Flow (cfs):	671.54	9916.52	5911.94
	Approach Top WD (ft):	53.05	85.03	191.94
	K1 Coefficient:	0.640	0.640	0.640
Results				
	Scour Depth Ys (ft):	12.80	1.04	1.53
	Critical Velocity (ft/s):	2.17	2.66	2.36
	Equation:	Live	Live	Live

Pier Scour

All piers have the same scour depth

Input Data

Pier Shape:	Round nose
Pier Width (ft):	4.00
Grain Size D50 (mm):	1.00000
Depth Upstream (ft):	16.34
Velocity Upstream (ft/s):	8.35
K1 Nose Shape:	1.00
Pier Angle:	0.00
Pier Length (ft):	172.58
K2 Angle Coef:	1.00
K3 Bed Cond Coef:	1.10
Grain Size D90 (mm):	2.00000
K4 Armouring Coef:	1.00

Results

Scour Depth Ys (ft):	9.32
Froude #:	0.36
Equation:	CSU equation

Combined Scour Depths

Pier Scour + Contraction Scour (ft):

Channel:	10.37
Right Bank:	10.86

Single-span bridge 100-year scour

Contraction Scour

		Left	Channel	Right
Input Data				
	Average Depth (ft):	4.82	16.50	7.93
	Approach Velocity (ft/s):	2.57	7.12	3.85
	Br Average Depth (ft):	10.16	16.15	9.55
	BR Opening Flow (cfs):	2960.16	9185.78	4354.06
	BR Top WD (ft):	48.68	67.07	83.30
	Grain Size D50 (mm):	1.00	1.00	1.00
	Approach Flow (cfs):	657.30	9989.59	5853.11
	Approach Top WD (ft):	53.05	85.03	191.94
	K1 Coefficient:	0.640	0.640	0.640
Results				
	Scour Depth Ys (ft):	8.33	1.72	0.95
	Critical Velocity (ft/s):	2.16	2.66	2.35
	Equation:	Live	Live	Live

Combined Scour Depths

ON THIS PANEL
SHIP 3 SOUTH,
NSHIP 4 SOUTH,

5

4

8

9

0,2% ANNUAL CHANCE
FLOOD DISCHARGE
CONTAINED IN CULVERT

1% ANNUAL CHANCE
FLOOD DISCHARGE
CONTAINED IN CULVERT

ZONE X
ZONE AE

W 9TH AVE
W BARBERRY PL
W BARBERRY PL
W 8TH AVE
W SEVERN PL
W 7TH AVE
W 6TH AVE FRONTAGE RD
W 5TH PL
W 5TH AVE
W SHORT PL
W 4TH AVE
W 3RD AVE
W 2ND AVE
W PARK PL
W 10TH AVE
W MULBERRY PL
W 9TH AVE
W 8TH AVE
W 7TH AVE
W 6TH AVE

N GROVE ST
N DECATUR ST
N DALE CT
N CANOSA CT
N BRYANT ST
N ALCOTT ST
N YUMA ST
N WYANDOT ST
N VALLEJO ST
N UMATILLA ST
N TEJON ST
N RARITAN WAY
N QUIVAS ST
N OSAGE ST
N SEMINOLE RD
CLAY ST
FEDERAL BLVD

RAILROAD
South Platte River
LIMIT OF FLOODWAY
Pedestrain Bridge
Culvert
Weir
Gulch
Retaining Wall
Footbridge
3rd Avenue Bridge

5201
5203
5204
5205
5206
5207
5208
5210
5211
5212
5213
5214
5218
5221
5241
5242

KK1396
KK1397

87
25

B
C
D
E
F
G
H
I
J
K
L
P
Q
BF
BG
BH
BI
BJ
BK
BL
BM
BN
BO
BP
BQ
BR
BS

MAP SCALE 1" = 500'

250 0 500 1000 FEET

NFIP

PANEL 0182G

FIRM

FLOOD INSURANCE RATE MAP

CITY AND COUNTY OF
DENVER,
COLORADO

PANEL 182 OF 300

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
DENVER, CITY AND COUNTY OF	080046	0182	G

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
0800460182G

MAP REVISED:
NOVEMBER 17, 2005

Federal Emergency Management Agency

NATIONAL FLOOD INSURANCE PROGRAM

CLOMR model HEC-RAS output

HEC-RAS Plan: S Platte Riv River: S_Platte_Prp Reach: 01 Profile: 100-Year

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
01	13420	100-Year	16500.00	5201.34	5212.04	5208.92	5213.86	0.002326	10.87	1553.75	1116.50	0.59
01	13196	100-Year	16500.00	5201.14	5210.32	5209.38	5213.01	0.005283	13.29	1278.60	626.62	0.81
01	13064	100-Year	16500.00	5194.50	5210.83	5204.12	5211.94	0.001117	9.13	2243.73	1110.61	0.40
01	12997		Bridge									
01	12930	100-Year	16500.00	5193.22	5208.65	5204.44	5210.31	0.002101	11.64	1927.69	236.91	0.53
01	12427	100-Year	16500.00	5192.20	5208.15	5202.23	5209.43	0.000980	9.83	2088.34	531.27	0.43
01	11658	100-Year	16500.00	5190.90	5207.87	5199.78	5208.70	0.000612	8.09	2561.74	374.57	0.35
01	11372	100-Year	16500.00	5190.55	5207.90	5200.78	5208.36	0.000386	6.52	3460.77	800.99	0.28
01	11288		Bridge									
01	11204	100-Year	16500.00	5190.35	5207.42	5200.38	5208.15	0.000576	7.88	2505.87	584.05	0.34
01	11110		Bridge									
01	11014	100-Year	19200.00	5190.12	5206.15	5200.01	5207.52	0.001005	9.98	2218.22	238.76	0.44
01	10431	100-Year	19200.00	5189.41	5204.82	5200.15	5206.67	0.001482	12.65	1995.24	860.08	0.57
01	9926	100-Year	19200.00	5188.81	5203.49		5205.78	0.001963	12.67	1693.75	157.76	0.60
01	9898	100-Year	19200.00	5188.77	5203.51	5199.21	5205.65	0.001743	12.43	1825.28	162.63	0.57
01	9893		Bridge									
01	9887	100-Year	19200.00	5188.74	5203.30		5205.54	0.001854	12.71	1786.49	163.48	0.59
01	9849	100-Year	19200.00	5188.67	5202.98		5205.38	0.005542	13.04	1587.69	141.33	0.61
01	9749	100-Year	19200.00	5188.48	5202.42		5204.83	0.005517	12.78	1553.87	160.66	0.60
01	9713	100-Year	19200.00	5188.41	5202.28		5204.64	0.003672	13.00	1606.96	159.01	0.61
01	9687	100-Year	19200.00	5188.24	5202.29		5204.49	0.001908	12.60	1708.10	157.51	0.59
01	9637	100-Year	19200.00	5187.53	5202.40	5197.26	5204.03	0.000904	10.81	2064.60	165.59	0.49
01	9611		Bridge									
01	9584	100-Year	19200.00	5187.19	5201.73	5196.76	5203.29	0.000881	10.51	2052.91	162.50	0.49
01	9517	100-Year	19200.00	5186.76	5201.71		5203.20	0.000834	10.42	2131.42	182.25	0.47
01	9377	100-Year	19200.00	5186.58	5201.02		5203.01	0.001152	11.96	1884.83	174.41	0.55
01	9100	100-Year	19200.00	5186.22	5200.02		5202.50	0.002549	13.49	1591.10	165.77	0.64
01	9000	100-Year	19200.00	5186.09	5200.00	5196.14	5202.09	0.001252	12.17	1857.90	820.85	0.57
01	8910	100-Year	19200.00	5185.97	5199.86	5196.00	5201.97	0.001268	12.23	1861.56	228.35	0.58
01	8852	100-Year	19200.00	5185.90	5199.79	5195.90	5201.90	0.001261	12.20	1874.27	201.45	0.58
01	8599	100-Year	19200.00	5185.57	5199.61		5201.54	0.001145	11.71	1964.20	204.65	0.55
01	8199	100-Year	19200.00	5185.05	5199.23		5201.07	0.001090	11.49	2010.13	240.51	0.54
01	7951	100-Year	19200.00	5184.73	5198.92		5200.79	0.001101	11.56	1975.74	200.02	0.54
01	7649	100-Year	19200.00	5184.34	5197.86		5200.34	0.001563	13.33	1723.47	161.30	0.64
01	7611	100-Year	19200.00	5184.28	5197.79		5200.28	0.001565	13.34	1721.15	161.18	0.64
01	7551	100-Year	19200.00	5184.21	5197.71		5200.18	0.001555	13.29	1726.72	161.70	0.64
01	7344	100-Year	19200.00	5183.94	5197.74		5199.76	0.001229	11.99	1897.15	179.02	0.57
01	7184	100-Year	19200.00	5183.73	5198.18		5199.37	0.000656	9.03	2367.83	208.18	0.42

HEC-RAS Plan: S Platte Riv River: S_Platte_Prp Reach: 01 Profile: 100-Year (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
01	7129	100-Year	19200.00	5182.24	5198.27		5199.29	0.000496	8.42	2600.23	207.36	0.37
01	7049	100-Year	19200.00	5182.13	5198.15	5190.91	5199.24	0.000525	8.66	2450.92	202.89	0.38
01	6956	100-Year	19200.00	5181.98	5198.00	5191.02	5199.18	0.000567	8.99	2344.94	181.84	0.40
01	6899	100-Year	19200.00	5181.89	5198.03		5199.06	0.000477	8.29	2409.42	158.13	0.36
01	6876	100-Year	19200.00	5181.85	5198.02	5190.45	5199.05	0.000466	8.20	2377.86	153.83	0.36
01	6851		Bridge									
01	6817	100-Year	19200.00	5181.77	5197.83	5190.53	5198.90	0.000493	8.40	2325.71	169.65	0.37
01	6764	100-Year	19200.00	5181.67	5197.48		5198.79	0.000620	9.32	2108.02	142.05	0.41
01	6646	100-Year	19200.00	5181.49	5195.94		5198.56	0.001370	13.05	1497.92	129.71	0.60
01	6545	100-Year	19200.00	5181.33	5196.00	5191.63	5198.09	0.001123	11.94	1748.21	148.00	0.55
01	6381	100-Year	19200.00	5181.07	5196.05		5197.46	0.000755	9.92	2181.56	185.87	0.45
01	6341	100-Year	19200.00	5181.02	5196.04	5190.85	5197.41	0.000746	9.88	2213.19	193.85	0.45
01	6321		Bridge									
01	6302	100-Year	19200.00	5180.96	5195.97	5191.15	5197.37	0.000787	10.14	2233.59	293.24	0.46
01	6270	100-Year	19200.00	5177.56	5196.14	5187.84	5197.16	0.000429	8.64	2689.00	551.16	0.35
01	6169	100-Year	19200.00	5177.26	5195.75	5189.42	5197.08	0.000654	9.93	2392.68	273.26	0.43
01	5999	100-Year	19200.00	5176.97	5195.54	5189.57	5196.95	0.000701	10.34	2256.62	287.97	0.44
01	5849	100-Year	19300.00	5176.72	5194.01		5196.68	0.001422	14.08	1687.02	165.00	0.62
01	5799	100-Year	19300.00	5176.63	5193.91	5190.38	5196.60	0.001398	13.93	1643.58	135.96	0.62
01	5734		Bridge									
01	5709	100-Year	19300.00	5176.16	5193.50		5196.13	0.001354	13.73	1665.69	141.91	0.61
01	5649	100-Year	19300.00	5175.96	5193.45		5196.02	0.001291	13.47	1727.18	146.44	0.59
01	5559	100-Year	19300.00	5175.86	5193.34	5190.07	5195.87	0.001697	13.87	1696.54	148.80	0.61
01	5509		Bridge									
01	5401	100-Year	19300.00	5175.69	5193.13		5195.28	0.001099	12.37	1873.55	172.06	0.55
01	5310	100-Year	19300.00	5175.59	5192.87		5195.14	0.001172	12.70	1799.27	155.49	0.56
01	4655	100-Year	19300.00	5174.87	5191.13	5187.93	5194.16	0.001653	14.43	1589.39	163.48	0.66
01	4573	100-Year	19300.00	5174.78	5190.89	5187.95	5194.00	0.001727	14.66	1486.88	127.58	0.68
01	4554		Bridge									
01	4523	100-Year	19300.00	5174.73	5189.87		5193.69	0.002965	16.47	1319.63	123.96	0.78
01	4430	100-Year	19300.00	5174.62	5189.75	5187.92	5193.29	0.002757	15.81	1474.97	152.30	0.75
01	4327		Bridge									
01	4226	100-Year	19300.00	5174.40	5189.25		5192.58	0.003135	15.53	1425.19	153.48	0.75
01	4135	100-Year	19300.00	5173.86	5189.14		5192.07	0.003608	14.59	1491.54	173.80	0.69
01	3985	100-Year	19300.00	5173.76	5189.15		5191.00	0.000948	11.28	2123.33	215.39	0.54
01	3213	100-Year	19400.00	5173.22	5188.44		5190.22	0.001016	11.64	2291.26	259.33	0.53
01	2200	100-Year	19400.00	5172.51	5187.92		5189.07	0.000888	10.97	2653.95	299.95	0.49
01	1650	100-Year	19400.00	5172.12	5187.50		5188.60	0.000807	10.44	2742.56	313.29	0.47

HEC-RAS Plan: S Platte Riv River: S_Platte_Prp Reach: 01 Profile: 100-Year (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
01	863	100-Year	19400.00	5171.57	5186.94		5188.00	0.000699	9.71	2846.69	335.49	0.44
01	164	100-Year	19400.00	5171.08	5186.74	5180.27	5187.53	0.000451	7.90	3190.13	1459.79	0.35
01	45	100-Year	19400.00	5171.00	5185.95	5180.58	5187.40	0.000822	10.34	2335.09	1262.71	0.47

3-span bridge HEC-RAS output

HEC-RAS Plan: 3-span River: S_Platte_Prp Reach: 01 Profile: 100-Year

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
01	13420	100-Year	16500.00	5201.34	5212.99	5208.92	5213.54	0.000856	6.98	3576.55	1297.01	0.36
01	13196	100-Year	16500.00	5201.14	5209.65	5209.38	5212.86	0.007010	14.48	1166.70	164.47	0.92
01	13064	100-Year	16500.00	5194.50	5210.33	5204.12	5211.53	0.001257	9.49	2154.68	1039.89	0.42
01	12997		Bridge									
01	12930	100-Year	16500.00	5193.22	5208.14	5204.44	5209.95	0.002399	12.15	1838.03	234.52	0.57
01	12427	100-Year	16500.00	5192.20	5207.54	5202.23	5208.96	0.001137	10.31	1972.80	388.22	0.46
01	11658	100-Year	16500.00	5190.90	5207.20	5199.78	5208.12	0.000714	8.50	2423.97	361.72	0.37
01	11372	100-Year	16500.00	5190.55	5207.21	5200.78	5207.75	0.000469	7.00	3234.04	782.37	0.30
01	11288		Bridge									
01	11204	100-Year	16500.00	5190.35	5206.69	5200.32	5207.51	0.000685	8.35	2410.21	375.46	0.36
01	11110		Bridge									
01	11014	100-Year	19200.00	5190.12	5206.32		5207.53	0.000903	9.53	2419.50	318.11	0.42
01	10431	100-Year	19200.00	5189.41	5204.82	5200.15	5206.67	0.001482	12.65	1995.24	860.08	0.57
01	9926	100-Year	19200.00	5188.81	5203.49		5205.78	0.001963	12.67	1693.75	157.76	0.60
01	9898	100-Year	19200.00	5188.77	5203.51	5199.21	5205.65	0.001743	12.43	1825.28	162.63	0.57
01	9893		Bridge									
01	9887	100-Year	19200.00	5188.74	5203.30		5205.54	0.001854	12.71	1786.49	163.48	0.59
01	9849	100-Year	19200.00	5188.67	5202.98		5205.38	0.005542	13.04	1587.69	141.33	0.61
01	9749	100-Year	19200.00	5188.48	5202.42		5204.83	0.005517	12.78	1553.87	160.66	0.60
01	9713	100-Year	19200.00	5188.41	5202.28		5204.64	0.003672	13.00	1606.96	159.01	0.61
01	9687	100-Year	19200.00	5188.24	5202.29		5204.49	0.001908	12.60	1708.10	157.51	0.59
01	9637	100-Year	19200.00	5187.53	5202.40	5197.26	5204.03	0.000904	10.81	2064.60	165.59	0.49
01	9611		Bridge									
01	9584	100-Year	19200.00	5187.19	5201.73	5196.76	5203.29	0.000881	10.51	2052.91	162.50	0.49
01	9517	100-Year	19200.00	5186.76	5201.71		5203.20	0.000834	10.42	2131.42	182.25	0.47
01	9377	100-Year	19200.00	5186.58	5201.02		5203.01	0.001152	11.96	1884.83	174.41	0.55
01	9100	100-Year	19200.00	5186.22	5200.02		5202.50	0.002549	13.49	1591.10	165.77	0.64
01	9000	100-Year	19200.00	5186.09	5200.00	5196.14	5202.09	0.001252	12.17	1857.90	820.85	0.57
01	8910	100-Year	19200.00	5185.97	5199.86	5196.00	5201.97	0.001268	12.23	1861.56	228.35	0.58
01	8852	100-Year	19200.00	5185.90	5199.79	5195.90	5201.90	0.001261	12.20	1874.27	201.45	0.58
01	8599	100-Year	19200.00	5185.57	5199.61		5201.54	0.001145	11.71	1964.20	204.65	0.55
01	8199	100-Year	19200.00	5185.05	5199.23		5201.07	0.001090	11.49	2010.13	240.51	0.54
01	7951	100-Year	19200.00	5184.73	5198.92		5200.79	0.001101	11.56	1975.74	200.02	0.54
01	7649	100-Year	19200.00	5184.34	5197.86		5200.34	0.001563	13.33	1723.47	161.30	0.64
01	7611	100-Year	19200.00	5184.28	5197.79		5200.28	0.001565	13.34	1721.15	161.18	0.64
01	7551	100-Year	19200.00	5184.21	5197.71		5200.18	0.001555	13.29	1726.72	161.70	0.64
01	7344	100-Year	19200.00	5183.94	5197.74		5199.76	0.001229	11.99	1897.15	179.02	0.57
01	7184	100-Year	19200.00	5183.73	5198.18		5199.37	0.000656	9.03	2367.83	208.18	0.42

HEC-RAS Plan: 3-span River: S_Platte_Prp Reach: 01 Profile: 100-Year (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
01	7129	100-Year	19200.00	5182.24	5198.27		5199.29	0.000496	8.42	2600.23	207.36	0.37
01	7049	100-Year	19200.00	5182.13	5198.15	5190.91	5199.24	0.000525	8.66	2450.92	202.89	0.38
01	6956	100-Year	19200.00	5181.98	5198.00	5191.02	5199.18	0.000567	8.99	2344.94	181.84	0.40
01	6899	100-Year	19200.00	5181.89	5198.03		5199.06	0.000477	8.29	2409.42	158.13	0.36
01	6876	100-Year	19200.00	5181.85	5198.02	5190.45	5199.05	0.000466	8.20	2377.86	153.83	0.36
01	6851		Bridge									
01	6817	100-Year	19200.00	5181.77	5197.83	5190.53	5198.90	0.000493	8.40	2325.71	169.65	0.37
01	6764	100-Year	19200.00	5181.67	5197.48		5198.79	0.000620	9.32	2108.02	142.05	0.41
01	6646	100-Year	19200.00	5181.49	5195.94		5198.56	0.001370	13.05	1497.92	129.71	0.60
01	6545	100-Year	19200.00	5181.33	5196.00	5191.63	5198.09	0.001123	11.94	1748.21	148.00	0.55
01	6381	100-Year	19200.00	5181.07	5196.05		5197.46	0.000755	9.92	2181.56	185.87	0.45
01	6341	100-Year	19200.00	5181.02	5196.04	5190.85	5197.41	0.000746	9.88	2213.19	193.85	0.45
01	6321		Bridge									
01	6302	100-Year	19200.00	5180.96	5195.97	5191.15	5197.37	0.000787	10.14	2233.59	293.24	0.46
01	6270	100-Year	19200.00	5177.56	5196.14	5187.84	5197.16	0.000429	8.64	2689.00	551.16	0.35
01	6169	100-Year	19200.00	5177.26	5195.75	5189.42	5197.08	0.000654	9.93	2392.68	273.26	0.43
01	5999	100-Year	19200.00	5176.97	5195.54	5189.57	5196.95	0.000701	10.34	2256.62	287.97	0.44
01	5849	100-Year	19300.00	5176.72	5194.01		5196.68	0.001422	14.08	1687.02	165.00	0.62
01	5799	100-Year	19300.00	5176.63	5193.91	5190.38	5196.60	0.001398	13.93	1643.58	135.96	0.62
01	5734		Bridge									
01	5709	100-Year	19300.00	5176.16	5193.50		5196.13	0.001354	13.73	1665.69	141.91	0.61
01	5649	100-Year	19300.00	5175.96	5193.45		5196.02	0.001291	13.47	1727.18	146.44	0.59
01	5559	100-Year	19300.00	5175.86	5193.34	5190.07	5195.87	0.001697	13.87	1696.54	148.80	0.61
01	5509		Bridge									
01	5401	100-Year	19300.00	5175.69	5193.13		5195.28	0.001099	12.37	1873.55	172.06	0.55
01	5310	100-Year	19300.00	5175.59	5192.87		5195.14	0.001172	12.70	1799.27	155.49	0.56
01	4655	100-Year	19300.00	5174.87	5191.13	5187.93	5194.16	0.001653	14.43	1589.39	163.48	0.66
01	4573	100-Year	19300.00	5174.78	5190.89	5187.95	5194.00	0.001727	14.66	1486.88	127.58	0.68
01	4554		Bridge									
01	4523	100-Year	19300.00	5174.73	5189.87		5193.69	0.002965	16.47	1319.63	123.96	0.78
01	4430	100-Year	19300.00	5174.62	5189.75	5187.92	5193.29	0.002757	15.81	1474.97	152.30	0.75
01	4327		Bridge									
01	4226	100-Year	19300.00	5174.40	5189.25		5192.58	0.003135	15.53	1425.19	153.48	0.75
01	4135	100-Year	19300.00	5173.86	5189.14		5192.07	0.003608	14.59	1491.54	173.80	0.69
01	3985	100-Year	19300.00	5173.76	5189.15		5191.00	0.000948	11.28	2123.33	215.39	0.54
01	3213	100-Year	19400.00	5173.22	5188.44		5190.22	0.001016	11.64	2291.26	259.33	0.53
01	2200	100-Year	19400.00	5172.51	5187.92		5189.07	0.000888	10.97	2653.95	299.95	0.49
01	1650	100-Year	19400.00	5172.12	5187.50		5188.60	0.000807	10.44	2742.56	313.29	0.47

HEC-RAS Plan: 3-span River: S_Platte_Prp Reach: 01 Profile: 100-Year (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
01	863	100-Year	19400.00	5171.57	5186.94		5188.00	0.000699	9.71	2846.69	335.49	0.44
01	164	100-Year	19400.00	5171.08	5186.74	5180.27	5187.53	0.000451	7.90	3190.13	1459.79	0.35
01	45	100-Year	19400.00	5171.00	5185.95	5180.58	5187.40	0.000822	10.34	2335.09	1262.71	0.47

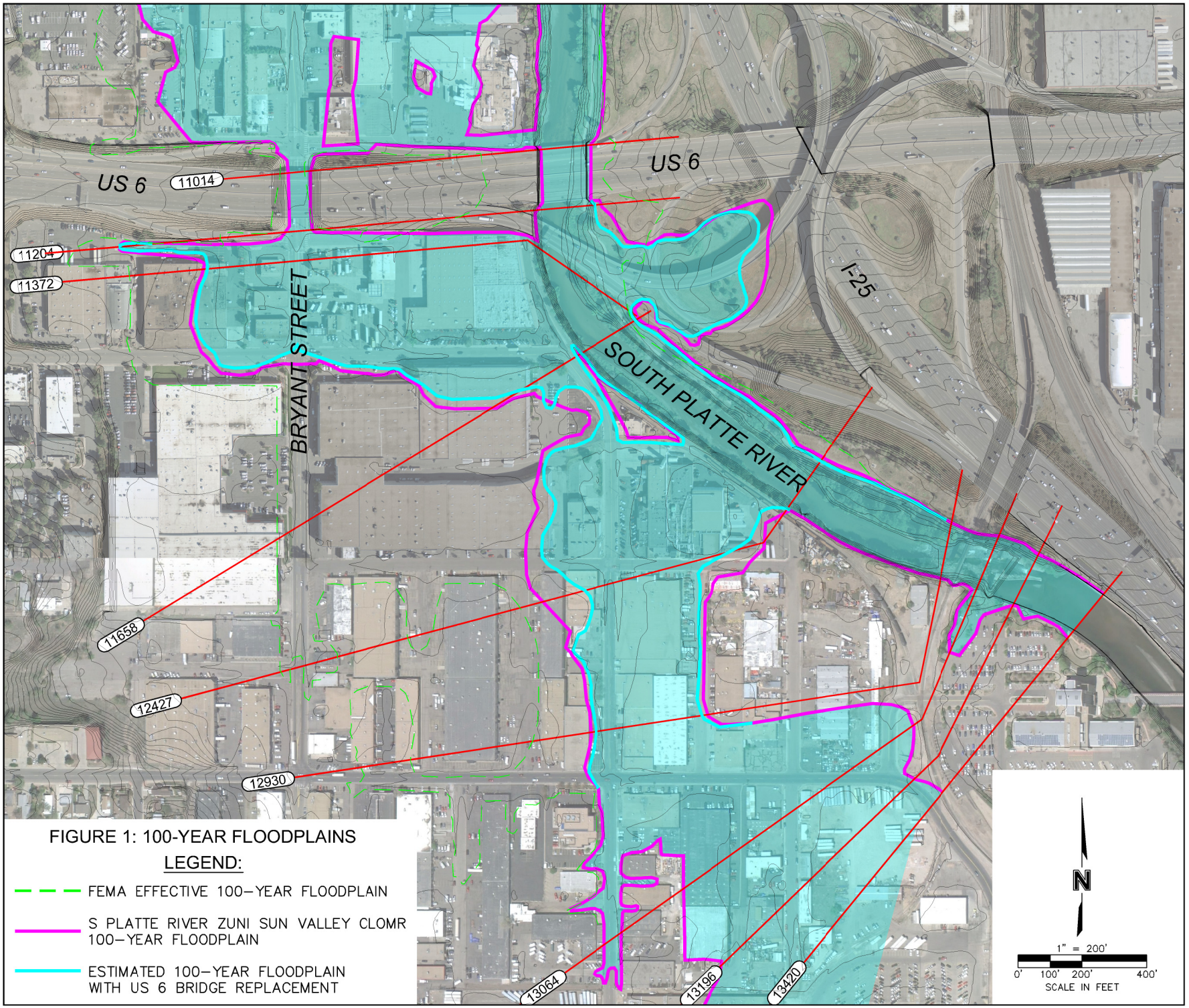


FIGURE 1: 100-YEAR FLOODPLAINS

LEGEND:

- FEMA EFFECTIVE 100–YEAR FLOODPLAIN
- S PLATTE RIVER ZUNI SUN VALLEY CLOMR 100–YEAR FLOODPLAIN
- ESTIMATED 100–YEAR FLOODPLAIN WITH US 6 BRIDGE REPLACEMENT