

## **12.0 DRAINAGE**

The Project shall include all Work for the modification of existing drainage facilities, construction of new drainage facilities, construction of Permanent Best Management Practices (BMP) and construction of new bridges required to accommodate design flows for the ultimate US 6 and I-25 highway configuration, meet Project design criteria, and comply with the terms and conditions of the CDOT Municipal Separate Storm Sewer System (MS4) Permit.

The drainage facilities constructed for the project shall be designed to accommodate the drainage system needed for the ultimate US 6 and I-25 highway configuration with a minimal amount of future drainage system reconstruction.

The Project *Master Plan Hydrology and Hydraulics Report*, *Master Plan Water Quality Report and Preliminary Bridge Hydraulics Report* are included in the Reference Documents. The Contractor shall utilize the Project Master Plan Hydrology and Hydraulics Report, Master Plan Water Quality Report and Preliminary Bridge Hydraulics Report as the basis for the storm drainage system water quality facilities along the corridor.

The Contractor shall design and construct a complete storm drainage system to intercept and remove surface runoff from the highway and local streets, maintain surface, channel, and conduit flow through the Right-of-Way (ROW), and convey South Platte River peak discharges through the new bridge. The Contractor shall also design and construct the storm drainage facilities to limit drainage-related hazards within and outside the ROW, while minimizing future operation and maintenance costs, public inconvenience, flood damages, and water quality impacts during construction.

The materials included in the Reference Documents provide information regarding drainage concepts and permanent water quality features.

All existing cross drains, storm drains, and drainage appurtenances to be abandoned shall be removed or plugged and filled with flow-fill in accordance with CDOT *Standard Specifications*, Section 202. All existing cross drains, storm drains, and/or drainage appurtenances to be included and/or utilized with the proposed drainage design shall; meet all Project hydraulic design capacity requirements and shall be lined and/or lengthened to meet an equivalent new design life, or; shall be removed and replaced with new material. The Weir Gulch box culvert (Barnum Lake Outfall) shall be replaced with a structure that will maintain the design detention storage and release rates from Barnum Lake.

All drainage facilities of the Project shall be constructed to meet Project design criteria. Where the hydraulic capacity or existing condition of drainage facilities are inadequate, existing facilities shall be replaced.

The Contractor shall obtain approval from affected Local, State and Federal Agencies for any proposed on-Site drainage improvements that are connected to existing storm drains, upstream or downstream of the Project. Approval shall be obtained from the CCD and UDFCD for improvements to the Weir Gulch box culvert (Barnum Lake Outfall).

The Contractor shall design drainage facilities to be compatible with existing or proposed drainage systems on adjacent properties, and shall maintain existing drainage patterns. If the Contractor proposes that existing drainage patterns must be changed, the Contractor shall design a solution that does not adversely impact property owners outside the ROW; shall obtain

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approval from CDOT prior to construction; and shall secure all other necessary approvals, permits, and easements.

**12.0.1 Standards**

The Contractor shall design and construct the drainage systems in accordance with the requirements of the standards listed in Table 12.0-1. Where standards conflict, the more stringent shall apply.

<b>Table 12.0-1 STANDARDS FOR DRAINAGE</b>	
<b>Author or Agency</b>	<b>Title</b>
CDOT	<i>Standard Specifications for Road and Bridge Construction</i>
CDOT	<i>Standard Plans, M &amp; S Standards</i>
CDOT	<i>Drainage Design Manual</i>
CDOT	<i>Bridge Design Manual, Section 16 – Hydraulics and Drainage</i>
CCD	<i>Storm Drainage Design &amp; Technical Criteria</i>
CCD	<i>Standard Details</i>
UDFCD	<i>Urban Storm Drainage Criteria Manual, Volumes I, II, and III</i>

**12.0.2 Design Guidelines**

The Contractor shall design and construct the drainage systems in accordance with the requirements of the guidelines listed in Table 12.0-2.

<b>TABLE 12.0-2 DESIGN GUIDELINES FOR DRAINAGE</b>	
<b>Author or Agency</b>	<b>Title</b>
AASHTO	<i>A Policy on Geometric Design of Highways and Streets</i>
FHWA	<i>Hydraulic Design of Energy Dissipaters for Culverts and Channels, HEC-14</i>
FHWA	<i>Evaluating Scour At Bridges, HEC-18</i>
FHWA	<i>Stream Stability at Highway Structures, HEC-20</i>
FHWA	<i>Urban Drainage Design Manual, HEC-22</i>
FHWA	<i>Drainage of Highway Pavements, HEC-12</i>
FHWA	<i>Bridge Scour and Stream Instability Countermeasures, HEC-23</i>
FHWA	<i>Design of Roadside Channels with Flexible Linings, HEC-15</i>
FHWA	<i>Design of Riprap Revetment, HEC-11</i>
FHWA	<i>Design of Roadside Channels with Flexible Linings, HEC-15</i>
FHWA	<i>Hydraulic Design of Improved Inlets for Culverts, HEC-13</i>
FHWA	<i>Design of Bridge Deck Drainage, HEC-21</i>
FHWA	<i>Hydraulic Design of Highway Culverts, HDS-5</i>

<b>TABLE 12.0-2 DESIGN GUIDELINES FOR DRAINAGE</b>	
<b>Author or Agency</b>	<b>Title</b>
CDOT	<i>Erosion Control and Stormwater Quality Guide</i>
CDOT	<i>Water Quality Guidance for Consultants</i>

## **12.1 Administrative Requirements**

### **12.1.1 Coordination with Other Agencies and Disciplines**

The Contractor shall coordinate all drainage related issues with affected regulatory agencies where appropriate. The Contractor shall include CDOT in all contacts with appropriate regulatory agencies.

Approval shall be obtained from the CCD and UDFCD for improvements to the Weir Gulch box culvert (Barnum Lake Outfall).

### **12.1.2 Permits**

The Contractor shall be cognizant of and adhere to the requirements of the various environmental and stormwater permits that are necessary for construction and operation of the Project. The Contractor shall follow the requirements of the latest CDOT Stormwater Management Plan (SWMP) template and appropriate specifications. The Contractor shall be responsible for complying with CDOT’s MS4 Permit and Stormwater Consent Order #SC-081023-1 (Consent Order). The Contractor shall be required to obtain all permits, unless otherwise indicated. The listing herein is not all-inclusive and it shall be the responsibility of the Contractor to determine all of the permits required to perform the Work. Because CDOT is the landowner, CDOT is partially liable for any Contractor negligence. Fines may be incurred upon the Project for permit non-compliance by CDOT or other regulatory agencies. Any non-compliance fines will be passed onto the Contractor. The Contractor shall refer to Section 5 for additional requirements. If conflicts exist between requirements of Section 5 and Section 12, the more stringent shall apply.

#### **12.1.2.1 Colorado Discharge Permit System, Stormwater Construction Permit (CDPS-SCP)**

Implementation of the permit requirements (i.e., SWMP, SWMP Site Map, and SPCC Plan) shall be a first construction item. Construction cannot begin until these items have been accepted by CDOT. CDOT will review the Contractor’s stormwater management activities throughout the duration of the Project for verification of compliance with the CDPS-SCP, CDOT’s construction section of the MS4 Permit, and Consent Order. The Contractor shall comply with CDOT *Standard Specifications*, Sections 101, 107 and 208.

The Contractor shall obtain a CDPS-SCP from the Colorado Department of Public Health and Environment (CDPHE) for construction of the Project prior to Work commencing. The CDPS-SCP shall be in the Contractor’s name. The Contractor shall adhere to all requirements of the CDPS-SCP and the Construction Section of CDOT’s MS4 Permit and the Consent Order. Most, but not all, non-compliance issues and necessary Best Management Practices (BMP)

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maintenance will be noted during Consent Order Monthly Inspections by CDOT, Regional Erosion Control Advisory Team (RECAT) inspections, in the 1176 inspection forms by the Erosion Control Supervisor (ECS), or in the daily stormwater log, as required by the Consent Order. The Contractor shall prevent the discharge of any sediment or pollutants into any storm drains or receiving waters during the life of the CDPS-SCP.

**12.1.2.1.1 Storm Water Management Plan (SWMP)**

The SWMP work shall include the CDOT SWMP template and a SWMP Site Map that documents the detailed erosion/sediment control BMPs and their locations. The Contractor shall submit a SWMP and SWMP Site Map for Acceptance by CDOT. The Contractor shall submit a SWMP and SWMP Site Map for Acceptance by the Local Agency for work outside CDOT ROW. The Contractor shall fill out the current CDOT SWMP template, including BMP narratives. The SWMP shall clearly describe the relationship between the phases of construction and the implementation and maintenance of the stormwater management controls. Any major modifications (i.e., change modification orders or minor changes revisions) to the CDOT SWMP template shall be submitted to CDOT for Acceptance. The Contractor shall revise the SWMP Site Map as necessary based on actual construction activities throughout the duration of the CDPS-SCP. All BMPs shall be listed on the SWMP Site Map per the requirements of the CDPS-SCP.

All documents pertaining to the CDPS-SCP shall be kept on-site in the CDOT Stormwater Management Plan (SWMP) Notebook (provided by CDOT) to maintain compliance with the SCP. Upon permit inactivation, the SWMP Notebook shall be turned over to CDOT and become the property of CDOT Project files.

**12.1.2.1.2 Best Management Practices (BMPs)**

The Contractor shall install and maintain the construction BMPs for the Project in accordance with the CDOT *Erosion Control and Stormwater Quality Guide* and Sections 101, 107, and 208 of the *Standard Specifications*. Construction BMPs for the Project shall include, but are not limited to, those listed in the *Standard Specifications*, as well as, preservation of existing vegetation, surface roughening, tackifier or soil binder, soil retention blankets, temporary clean water diversions, storm drain and basins, protection of trees, hazardous waste and spill containment and saw water disposal, stabilized construction entrances, and pavement sweeping of the affected Project areas. The Contractor shall add a BMP narrative to the SWMP on how it is being used, and shall supply the manufacturer details to be placed in the SWMP Notebook. The Contractor shall have a complete supply of all necessary construction BMP Materials on Site at all times in preparation for construction water quality control emergencies.

Where permanent seeding operations are not feasible because of seasonal constraints (e.g., summer and winter months), the Contractor shall have mulch and mulch tackifier applied to disturbed areas to prevent erosion.

The Contractor shall use erosion control blankets on slopes steeper than 4H:1V, newly seeded slopes to control erosion, and to promote the establishment of vegetation.

Slopes shall be roughened at the end of each day. Concrete washout shall be contained.

Non-structural BMPs may include litter and debris control, street sweeping, and landscaping and vegetative practices.

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**12.1.2.1.3 Spill Prevention Control and Countermeasures Plan (SPCC Plan)**

The Contractor shall prepare a SPCC Plan for Acceptance by CDOT and submitted 21 Days prior to NTP2. Plan will be in accordance with *Standard Specifications Section 208*. The SPCC shall establish operating procedures for handling pollutants and preventing spills. Pollutant sources include, but are not limited to, exposed and stored soils, paints, solvents, fertilizers or chemicals, vehicle tracking, management of contaminated soils, loading and unloading operations, outdoor storage activities, vehicle/equipment maintenance and fueling, significant dust or particulate generating processes, on-Site waste management practices, concrete truck/equipment washing, dedicated asphalt and concrete batch plants, and non-industrial waste sources that may be significant such as trash and portable toilets.

**12.1.2.1.4 Drainage**

The Contractor shall be responsible for temporary drainage of the Project area during construction of the Project. The Contractor shall keep all existing storm drainage systems used for temporary drainage of the Project in operating condition during construction. Prior to the start of construction, the Contractor shall locate and clean all existing storm drainage systems in accordance with Section 202 of CDOT *Standard Specifications*. Throughout the duration of the permit, the Contractor shall continually protect inlets from sediment and pollutants and, if needed, shall remove any material deposited in the systems as a result of the Contractor's activities. All inlets shall be identified on the SWMP Site Map and shall follow the requirements of Section 208 of CDOT *Standard Specifications*.

**12.1.2.1.5 Erosion Control Supervisor**

The Contractor shall assign to the Project an employee or subcontractor to serve in the capacity of the Erosion Control Supervisor (ECS). The ECS shall be a person other than the Superintendent and shall be a person dedicated solely to erosion/sediment control. The ECS shall be experienced in all aspects of construction and have satisfactorily completed an ECS training program authorized by CDOT. Certification that this requirement has been met shall be submitted to CDOT at NTP1. A list of authorized ECS training programs will be provided by CDOT upon request by the Contractor.

The Contractor's ECS responsibilities shall follow the duties as laid out in *Standard Specifications*, Section 208, in addition to the following:

1. Direct the removal of sediment, trash, and debris from the construction BMPs and other drainage facilities within the affected areas of the Project.
2. Prepare a written report documenting that BMPs are adequate for the Site conditions of the Project and are in good working condition after inspections requiring documentation. The reports shall be kept with the SWMP inspection documentation and submitted to the CDOT Region Water Quality Manager. The appropriate form for this report will be supplied by CDOT. The inspections shall be made during the progress of the Work, during Work suspensions, and for the duration of the CDPS-SCP. During Project Work stoppages, inspections shall take place at least once every 30 Days, and within 48 hours after each event that causes surface runoff. After construction is complete, inspections shall take place at least once every 30 Days until the permit can be closed.
3. When Work is occurring in a Local Agency's jurisdiction, conduct inspections according to the required intervals of the Local Agency.

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4. Implement the necessary actions to reduce anticipated or presently existing water quality or erosion problems resulting from construction Activities. The criteria for this action shall be based on water quality data derived from any inspections and monitoring operations or by any anticipated conditions (e.g., predicted storms) that could lead to unsuitable water quality situations.

**12.1.2.1.6 Inspections**

During the Project, multiple inspections by CDOT and the Contractor and their ECS will be occurring. Inspections shall be on the appropriate CDOT Forms and shall follow the requirements in *Standard Specifications*, Section 208. Prior to work commencing, a pre-construction conference shall be held with the CDOT's Region Water Quality personnel. In addition, when the first phase of BMPs has been installed, the Contractor shall notify CDOT's Region Water Quality personnel to come out and inspect the BMPs for proper installation. Work shall not begin until the BMP installation inspection has occurred. CDOT's Region Water Quality personnel will be inspecting the Site on a monthly basis, as well as during the surprise Regional Erosion Control Assessment Team inspections. The Region Water Quality personnel may inspect the Project at any time and document any non-compliance issues that need to be resolved immediately by the Contractor. Fines may be assessed to the Contractor with the potential of Project shut downs, depending on the severity of the non-compliance. Prior to Final Acceptance of the Project construction, CDOT's Region Water Quality personnel shall be notified to perform a final walkthrough inspection. Any items identified for maintenance, replacement, or removal shall be done immediately or liquidated damages may be incurred upon the Contractor.

Based on the Consent Order, the Project Superintendent or ECS shall perform daily inspections of all BMPs to observe, record, and determine the effectiveness of all BMPs and to order their maintenance if needed. The results of the daily inspections shall be recorded in a daily stormwater log, which will be provided by CDOT. The Contractor shall cooperate with Local Agencies that may perform their own stormwater inspections on this Project.

**12.1.2.1.7 Colorado Discharge Permit System, Stormwater Construction Permit Closure**

The Contractor shall be responsible for all stormwater permit requirements until the Project has achieved final stabilization (see Book 2, Section 17, Landscaping) and the CDPS-SCP permit can be closed. This includes the maintenance of all BMPs, maintenance of all seeded/landscaped areas, and removal of all BMPs once all erosion potential has been eliminated.

**12.1.2.2 Municipal Separate Storm Sewer System (MS4) Permit**

CDOT has obtained an MS4 Permit for the storm drain systems that it owns and maintains (included in Book 3). The Contractor shall be responsible for complying with the terms and conditions of the CDOT MS4 Permit that pertain to the Project. As part of the MS4 Permit, the Contractor shall follow the requirements set forth in the New Development Re-Development portion to comply with water quality standards. The Contractor shall install BMPs for the Project in accordance with the CDOT *Erosion Control and Stormwater Quality Guide* and the Urban Drainage and Flood Control District (UDFCD) *Urban Storm Drainage Criteria Manual*. Runoff

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from all impervious areas within CDOT ROW within the Project limits shall be captured and conveyed to a BMP.

Offset Areas shall be allowed for complying with CDOT's MS4 permit and are the basis for the Master Plan Water Quality. Offset areas are defined as non-project impervious areas treated by permanent stormwater BMPs to offset project impervious areas 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.

The Plans included in the Reference Documents, the Project *Master Plan Hydrology and Hydraulics Report*, *Master Plan Water Quality Report* and *Preliminary Bridge Hydraulics Report* provide information regarding drainage concepts, and the location of permanent water quality features that were determined to be feasible to implement BMPs for the Project. The conclusions, recommendations, and design included in these documents shall be used as a starting point to develop and design a more detailed permanent stormwater quality improvement plan. The recommendations included in the reports describe the type and location of BMPs that shall be implemented. Based on the assessment, it is practical to intercept and provide stormwater quality treatment for the locations shown. In areas outside of CDOT ROW, property will be acquired by CDOT to facilitate permanent water quality for the Ultimate Configuration.

The Contractor shall immediately notify CDOT and the Local Agency of any suspected illicit or improper connections or discharges into any storm drain system that are discovered during design or construction of the Project. The Contractor shall contact the CDOT Illicit Discharge Hotline at 303-512-4426. CDOT and the Local Agencies will be responsible for investigation of the suspected illicit connection and implementing corrective action. The Contractor shall not maintain, reconnect, or otherwise allow discharge of improperly disposed materials into the storm drain system within the limits of the flows leaving the Project.

**12.1.2.3 Construction Dewatering Permit (CDW)**

Contractor shall obtain a Construction Dewatering permit prior to discharging groundwater to the surface or back to the ground. Contractor shall be responsible for all sampling, monitoring, treatment and Discharge Monitoring Reports required by the CDW.

**12.1.2.4 U.S. Army Corps of Engineers (USACE) Section 404 Permit**

Contractor shall obtain 404 permits for all work in the South Platte River.

**12.2 Design Requirements**

**12.2.1 Drainage Design Software**

The following software (most recent versions) shall be used in performing drainage design calculations.

1. CUHP/EPA-SWMM

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2. USACE, HEC-RAS
3. FHWA, HY-8
4. In Roads Storm and Sanitary
5. UD-Detention
6. UD-Inlet
7. UD-Rational

**12.2.2 Data Collection**

The Contractor shall identify all drainage-related issues utilizing available data, including but not limited to, requirements imposed by local, state, and federal government regulations, and official documents concerning the Project. Drainage related issues include, but are not limited to, areas with historically inadequate drainage (as evidenced by recorded flooding or citizen complaints), environmentally sensitive areas, and known drainage-related maintenance problems.

The Contractor shall obtain all relevant storm drainage improvement plans, drainage planning studies, and drainage reports for the Project area from all Local Agencies, UDFCD, and CDOT.

The Contractor shall obtain existing and projected future land uses from all Local Agencies and shall design facilities to be compatible with drainage systems, existing or proposed, on adjacent properties.

The Contractor shall perform detailed mapping and surveys as required to verify locations of existing drainage features necessary for the proposed drainage design. The Contractor shall verify or identify boundaries, flow patterns, and land uses of drainage basins based on field observations.

The Contractor shall resolve all conflicts between Utilities and proposed drainage improvements in accordance with Book 2, Section 7, Utility Relocations.

**12.2.3 Surface Hydrology**

The Contractor shall perform hydrologic analyses for all on-Site drainage basins, and for all off-Site drainage areas immediately adjacent to the Project Site that contribute runoff to the Project Site, or are impacted by project improvements or Ultimate Configuration. The analysis shall be based on projected future land uses and the Ultimate Configuration.

The hydrologic analyses shall identify all impacts to any existing storm drainage system.

**12.2.3.1 Design Frequencies**

For all CDOT-owned facilities, the design frequency shall comply with Table 7.2, Table of Design Frequencies in the CDOT *Drainage Design Manual* except the for design frequency of minor system storm drains on US 6 and I-25, which shall be the 10-year design frequency.

The design frequency for all other roadways in the Project area shall comply with the affected Local Agency's criteria or as stated in the Project *Master Plan Hydrology and Hydraulics Report* and *Master Plan Water Quality Report*.



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**12.2.3.2 Precipitation**

The Contractor shall design all drainage elements using the one-hour rainfall depths and equations contained in Section 5.0 of the City and County of Denver Storm Drainage Design & Technical Criteria.

**12.2.3.3 Hydrologic Methods**

The Contractor shall perform the necessary hydrologic analyses using the following methods:

1. Areas less than 90 acres shall be evaluated using the Rational Method. The minimum time of concentration shall be 5 minutes. For all areas within the CCD, the maximum time of concentration to the first design point shall be 10 minutes, according to the CCD Storm Drainage Design & Technical Criteria Manual, Table 6.2.

The hydrologic analyses shall be based on fully developed and Ultimate Configuration for all drainage basins.

**12.2.4 Hydraulic Structures**

**12.2.4.1 Roadways**

Roadway component geometric configurations shall be designed to provide adequate drainage and minimize hydroplaning and icing problems. Cross slopes shall be in accordance with the requirements of Book 2, Section 13, Roadways.

**12.2.4.1.1 Roadway Profile**

Longitudinal grades shall be in accordance with the requirements of the Book 2, Section 13, Roadways. Where minimum profile grades cannot be obtained in sag vertical curves, flanking inlets shall be constructed in the curb and gutter, or adjacent to the solid barrier guardrail, as required in the CDOT *Drainage Design Manual*.

**12.2.4.1.2 Allowable Flow Spreads and Depths**

The Contractor shall design all roadway storm drain systems including gutters, inlets, inlet spacing, catch basins, laterals, and trunk lines using the design criteria given in Table 12.2-1.

For all roadways within CCD right of way, the contractor shall use the design criteria given in the CCD Storm Drainage Design & Technical Criteria Manual, Tables 7.1, 7.2, and 7.4.

<b>Table 12.2-1 ROADWAY STORM DRAIN DESIGN STORM AND SPREAD CRITERIA</b>			
<b>Road Classification</b>		<b>Design Frequency</b>	<b>Design Spread</b>
Interstate		10-year	Shoulder + 3 ft
		100-year	Shoulder + 4 ft
Arterials	< 45 mph	10-year	Shoulder + 3 ft
	< 45 mph	100-year	Shoulder + 4 ft
	> 45 mph	10-year	Shoulder
	>45 mph	100-year	Shoulder + 4 ft

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	Sag Point	50-year	Shoulder + 3 ft
	Sag Point	100-year	Shoulder + 4 ft
Collector	< 45 mph	10-year	½ Driving Lane
	> 45 mph	10-year	Shoulder
	Sag Point	10-year	1/2 Driving Lane
Local Streets	Low ADT	5-year	1/2 Driving Lane
	High ADT	10-year	1/2 Driving Lane
	Sag Point	10-year	1/2 Driving Lane

**12.2.4.1.3 Edge Treatment**

In areas where the roadway pavement discharges runoff to Type 7 guardrail or curb, inlets shall be used to collect flow from the curb section, and the drains shall be piped to the bottom of the slope. Rundowns shall not be used to convey concentrated flows to the bottom of slopes. Erosion protection shall be constructed at the outfalls. See Section 12.2.4.5 below for more information.

**12.2.4.1.4 Roadside Ditches and Open Channels**

For roadside ditches along all existing and proposed roadways, the water surface profile shall have a minimum of one foot of freeboard for the 10-year return frequency peak discharge and shall not exceed edge of pavement for the 100-year return frequency peak discharge.

All open channels within the Project shall be designed to capture and convey the 100-year return frequency. Capacity shall be determined using Manning’s Equation.

All ditches and open channels with a grade exceeding 2 percent shall be constructed with a turf reinforcement mat or other means.

Flexible channel linings shall be designed in accordance with FHWA *HEC-15, Design of Roadside Channels with Flexible Linings*. Riprap channel lining shall be designed in accordance with FHWA *HEC-11, Design of Riprap Revetment*.

The geometric layout shall be in accordance with the AASHTO *Roadside Design Guide*, and shall consider hydraulics, safety, maintenance, long-term permanent erosion control, landscaping, and aesthetics.

All abandoned concrete diversion structures in roadside ditches and open channels shall be removed unless otherwise directed by CDOT.

**12.2.4.2 Cross Drains**

Cross drains shall be defined as pipes or culverts that convey water from one side of the road to the other, with headwall/wingwalls or flared end sections on both upstream and downstream ends of the cross drain. All cross drains shall be designed for the 100-year return frequency peak discharge for fully developed conditions. All cross drains shall be designed to accommodate the Ultimate Configuration. Hydraulic design of cross drains shall be based on the procedures included in FHWA *HDS No. 5, Hydraulic Design of Highway Culverts*. Hydraulic design data shall be listed on the final Design Plans for each cross drain, including drainage area, peak discharges, allowable headwater elevation, and design headwater elevation.

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The minimum allowable pipe size for cross drains shall be 36 inches. End sections, or headwalls with beveled edges and wingwalls, shall be provided for all cross drains regardless of size. To reduce sizes, improved inlets may be utilized. Improved inlets shall be designed based on FHWA HEC-13, *Hydraulic Design of Improved Inlets for Culverts*.

Allowable headwater elevation for the 100-year return frequency peak discharge shall be designed as described in Chapter 9.2.2 of the CDOT *Drainage Design Manual*.

The use of sag pipes or inverted siphons shall not be allowed.

In some locations, the existing cross drainage may be via porous, open-graded, free draining fill, rather than cross drains. The Contractor shall provide cross drains in these locations.

Discharge systems shall be designed to prevent scour of existing channels and embankments at the design flow rates.

The Contractor shall design cross drains for each crossing in Table 12.2-3, using analysis based on the results of a hydraulic computer model.

The Contractor shall provide cross drains for the locations in Table 12.2-3, or as required by analysis.

<b>Table 12.2-3 CROSS DRAIN LOCATIONS</b>	
<b>Location</b>	<b>Action</b>
9011+00, 9011L to 9011C	Install
11022+00, 9016R to 7022L	Install

Cross drains shall be continuous through the ROW. Bends or turns will not be permitted. Pipes connected to manholes or inlets placed in line with a cross drain will be referred to as a storm drain and shall follow the requirements for storm drains.

**12.2.4.3 Storm Drains**

Storm drains shall be defined as a network of pipes that connects inlets, manholes, and other drainage features to an outfall. Storm drain systems that convey flows generated from the US 6 and I-25 roadway shall be designed for the 10-year return frequency discharge for Ultimate Configuration. Storm drain systems draining sumps on US 6 and I-25 shall be designed for the 100-year return frequency for the Ultimate Configuration. The storm drain system shall be designed to not worsen the existing conditions for properties outside the ROW. Ponding will not be permitted within the Site, except at specifically designed water quality facilities. The storm drain system generally consists of a trunkline, laterals, inlets, and manholes.

Hydraulic analyses and plans for storm drains that are connected to existing storm drain systems upstream or downstream of the Site must be coordinated with affected Local Agencies. The hydraulic analyses shall identify impacts to the existing storm drain systems caused by the connections and proposed combined peak-design discharges for the overall systems.

The minimum allowable pipe diameter for storm drain systems is shown in Table 12.2-4.

<b>Table 12.2-4</b>	
<b>MINIMUM ALLOWABLE PIPE DIAMETER</b>	
<b>Application</b>	<b>Minimum Diameter (inches)</b>
Side Drain	18
Median Drain	18
Storm Drain Trunk Line	18
Connections:	
– Median drain to cross drain	18
– Curb inlet to trunk line	18

The use of sag pipes or inverted siphons will not be allowed.

Storm drains shall not decrease in size in the downstream direction. From upstream to downstream, pipe diameters shall remain constant or increase. All bends and turns shall occur within a manhole or inlet.

#### **12.2.4.3.1 Hydraulic Design of Storm Drains**

Storm drain design shall be performed using hydraulic gradient analysis to account for all friction and minor losses. Friction losses shall be calculated using Manning’s Equation. Minor losses at junctions, manholes, bends, and other appurtenances shall be calculated based on design procedures in the FHWA *HEC-22, Urban Drainage Design Manual*.

Storm drains under US 6 and I-25 shall be designed with the hydraulic grade line (HGL) at or below the crown of pipe for the 10-year return frequency peak discharge. The HGL shall be 1 foot below pavement and inlet grates where the pipe is sized to convey the 100-year discharge. Local Agency criteria shall be followed for storm drain system design outside of CDOT ROW. The hydraulic gradient shall be plotted for all storm drains in each storm drain profile.

The flow velocity of storm drains shall not be less than 3 feet per second for the 10-year return frequency peak discharge and shall not be greater than 22 feet per second for the major storm discharge (100-year).

#### **12.2.4.3.2 Storm Drain Alignment, Profile, and Size**

Storm drain alignments shall be straight between structures.

Profiles of all storm drains shall be straight grades between structures.

The Contractor shall comply with Local Agency criteria for storm drains outside CDOT ROW.

#### **12.2.4.3.3 Inlets**

Inlets are required at locations needed to collect runoff within the design controls specified in this Section 12. In addition, there are a number of locations where inlets may be necessary with little regard to contributing drainage area. These locations should be marked on the plans prior to any computations regarding discharge, water spread, inlet capacity, or bypass. Examples of such locations are as follows:

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1. Sag points in the gutter grade
2. Upstream of median breaks, entrance/exit ramp gores, pedestrian ramps, cross walks, and street intersections
3. Immediately upstream and downstream of bridges
4. Immediately upstream of cross slope reversals
5. On side streets at intersections
6. At the end of channels in cut sections
7. Behind retaining walls, curbs, shoulders or sidewalks to drain low areas
8. Where necessary to collect snow melt

Inlets shall not be located in a path where pedestrians are likely to walk.

CDOT *M&S Standard Plans* inlets shall be used within CDOT ROW. Type C and Type D inlets shall not be allowed within the roadway pavement limits unless used in conjunction with embankment protectors. Inlets shall be designed for HS-20 or interstate alternate live loading.

Bicycle-safe grates are required for inlets with grates on Federal Boulevard. Pedestrian-safe grates shall be used in pedestrian areas.

Concrete aprons shall be installed on all area inlets per the CDOT *M&S Standard Plans*.

City and County of Denver Standard Details for No 14 inlets shall be used for all inlets located in City and County of Denver streets.

Inlet hydraulic efficiency and spacing shall be determined based on design procedures in the FHWA *HEC-22, Urban Drainage Design Manual*. 100 percent of the bypass flow shall be added to the next downstream inlet.

For a continuous storm drain system, maximum inlet spacing shall be designed based on allowable flow spread or the manhole spacing criteria, whichever is less.

The sag vertical curve or sump area on a roadway requires inlets at the lowest point and flanking inlets on each side of the lowest inlet to provide relief from debris clogging. All sumps shall be designed in accordance with the criteria in Table 12.2.1. The flanking inlets shall be located such that the design criteria for ponding are met, even if the sump inlet is completely clogged.

Inlets are required 10 feet upstream the point where the street cross slope begins to super-elevate toward the opposite side to prevent cross street flow.

Trench drains will not be allowed in the traveled way or transverse to traffic flow on US 6 and I-25.

The use of scuppers or drainage slots in roadway barriers as a drainage element will not be allowed. Curb cuts shall not be allowed for bridge deck drains.

Valley gutters across connecting streets will not be allowed. Drainage runoff shall be intercepted upstream from connecting streets for subsurface conveyance. Drainage shall be intercepted before concentrated flows cross lanes of traffic.

Access holes such as inlets, catch basins, and manholes shall not be located in travel lanes of US 6 mainline.

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A clogging factor of 50 percent shall be used for sizing single-unit inlet grates. A clogging factor of 10 percent shall be used for sizing single-unit curb opening inlets. For multiple-unit inlets, the clogging factor may be reduced as recommended in The UDFCD *Urban Storm Drainage Criteria Manual, Volume I*, Chapter 6, Section 3.

**12.2.4.3.4 Manholes and Junction Structures**

Manholes shall be incorporated into the storm drain system to provide access for inspection, cleaning, and other maintenance activities. Manholes shall be constructed at all junctions, changes in pipe size, drops, and grade changes. Manholes shall be provided at any change in horizontal alignment greater than 2 degrees. Manholes shall not be located in travel lanes of the US 6 and I-25 mainline.

A lateral that is less than half the size (inside diameter) of the trunkline and no more than 75 feet long may be connected to the trunkline with a prefabricated pipe wye or tee connection. Larger laterals shall be connected to the trunkline with a manhole.

The spacing of manholes shall be in accordance with the criteria identified in the CDOT *Drainage Design Manual*. The spacing of manholes outside of CDOT ROW shall be in accordance with Local Agency criteria. For storm drain diameters 60-inch or greater, manholes shall be located considering Site conditions that provide for staging of large-scale maintenance activities.

Manhole and junction structure floors shall be shaped to fit the pipe inverts.

**12.2.4.4 Drain Outfalls**

Storm drain outfalls shall be designed such that the outlet elevation is as close as possible to the receiving drainageway flowline to prevent erosion. Outfalls shall be oriented in a downstream direction. Permanent erosion protection shall be provided at all outfalls and along the drainage flowlines where needed. Energy dissipaters shall be designed in accordance with the FHWA *HEC-14 Hydraulic Design of Energy Dissipaters for Culverts and Channels*, or UDFCD *Urban Storm Drainage Criteria Manual* Low Tailwater basins.

Outfalls shall be designed to minimize all existing habitat disturbances during construction. Outfalls to the South Platter River shall be submitted to UDFCD for approval of maintenance eligibility prior to construction.

Grouted boulder rundowns must extend down to bedrock or to five (5) feet below the future bottom of channel in the receiving water, whichever is less.

The effects of tailwater in the receiving drainageway on the hydraulics of the outfall shall be evaluated. The design frequency of the tailwater of the receiving drainageway shall be based on the comparison of design discharge frequencies for coincidental occurrence included in the FHWA *HEC-22, Urban Drainage Design Manual*.

**12.2.4.5 Scour and Erosion Control**

Existing scour, rill or channel erosion issues within the Project limits shall be addressed by the Contractor.

Analyze all bridges and open-bottom cross drains for scour, and design appropriate protection/mitigation per *HEC-18, Evaluating Scour at Bridges, Fourth Edition*, and *HEC-23*,

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*Bridge Scour and Stream Instability Countermeasures Experience, Selection, and Design Guidance Third Edition.*

Analyze all channel changes, realignments and crossings for erosion and scour potential and design appropriate protection or mitigation per *HEC-20, Stream Stability at Highway Structures, Third Edition.*

The following minimum criteria apply to riprap layer thickness:

1. Thickness shall not be less than the spherical diameter of the D100 stone or less than 2.0 times the spherical diameter of the D50 stone, whichever results in the greater thickness.
2. Thickness shall not be less than 12 inches for practical placement.
3. The thickness determined by either Criteria 1 or 2 (above) shall be increased by 50 percent where the riprap is placed underwater to provide for uncertainties associated with this type of placement.
4. Oversized stones shall not be used.

Geotextile (Erosion Control Class 1) shall be used under all riprap per CDOT *M & S Standards.*

#### **12.2.4.6 Sub-Drainage Systems**

Sub-drainage systems (e.g., underdrains) shall be designed in accordance with the CDOT *Drainage Design Manual.* Sub-drainage systems may be discharged to the stormwater system in compliance with regulations for groundwater discharge and control of water quality.

Groundwater is expected to be encountered during construction of this Project. If groundwater is daylighted to the ground surface via storm drains (point source), a Subterranean Permit from CDPHE will be required. Upon completion of the Project, the permit will be transferred to CDOT. The Contractor shall be responsible for obtaining the permit. Refer to subsurface analysis in Book 2, Section 10, Geotechnical, Roadway Pavements, and Structure Foundations.

Underdrains exist in certain locations. The Contractor shall preserve the capacities and functionality of all existing groundwater drains encountered during construction, or replace drains if impacted by construction. Geotechnical investigations conducted on US 6 and I-25 are provided in the Reference Documents.

No known wells or springs have been identified within the Project limits. If the Contractor encounters wells or springs within the project limits, the Contractor shall protect the flow quantity, water quality, access, and availability of the wells and springs during and after construction.

#### **12.2.4.7 Permanent Best Management Practices**

The Contractor shall design BMPs at the locations shown in the Reference Documents limit impacts to downstream facilities. BMPs shall be designed for the 0.6-inch one-hour rainfall depth. See the Project *Master Plan Drainage and Water Quality Report* for design parameters.

In locations noted in Table 12.2-5, Water Quality Ponds shall be designed to provide for the full WQCV.

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Sizing and location of BMPs shall accommodate the Ultimate Configuration. The Contactor shall utilize and construct all predefined pond locations for permanent water quality as part of this Project.

The required impervious area to be treated under CDOT's current permit consists of all impervious areas within each water quality basin within the project limits. The required impervious area to be treated will only extend up to the limits of disturbance.

Table 12.2-5 lists the BMPs by location.

<b>Table 12.2-5 BMP LOCATIONS</b>			
<b>No.</b>	<b>US 6 D-B Design Point</b>	<b>Station</b>	<b>BMP</b>
1	10	2000+00	US 6 Water Quality Pond (Extended Detention Basin)
2	106	11012+00	6 <sup>th</sup> Avenue Interchange Water Quality Pond (Extended Detention Basin)

All Water Quality Pond BMPs as listed in Table 12.2-5 shall be Extended Detention Basins (EDB) with a pre-sedimentation concrete forebay (minimum dimension of 12 feet by 12 feet with a concrete access ramp) with energy dissipation at the pipe outlet, 6-foot minimum wide concrete trickle channel with 6" mountable curb, concrete micropool (minimum dimension of 12 feet by 12 feet), and outlet structure with trash rack and water quality orifice plate. Concrete trickle channels to convey nuisance flows shall be provided from inflow locations to the primary low-level outlet, for all BMPs. Minimum grades for concrete trickle channels shall not be less than 0.4 percent. Minimum grades in the vegetated bottom of the basin shall be 3% toward the trickle channel or toward the micropool. The outlet structure used at all pond locations shall be flush with the side slope. All design calculations, geometry, and details shall conform to UDFCD's *Urban Storm Drainage Criteria Manual, Volume 3* and shall be provided to CDOT for Acceptance.

All weather vehicle maintenance access shall be provided to the forebay and outlet structures. Access surface shall be concrete below the pond design water surface elevation, and shall be constructed with 12" base course in all other areas. The access road shall have a turnaround at the end. The concrete access shall be at a maximum 4:1 slope to the micropool.

In locations where Water Quality is called out in Table 12.2-5, alternate BMPs as defined in CDOT's *Erosion Control and Stormwater Quality Guide, Chapter 6*, may be used with Acceptance from CDOT.

The elevation of the emergency spillway or overflow structure shall be at the elevation of the routed 100-year water surface. The emergency spillway or overflow structure shall have the capacity to convey the routed 100-year peak discharge. Embankments shall provide a minimum of one foot of freeboard above the routed 100-year water surface elevation through the emergency spillway.

The Contractor shall identify all base flows tributary to the ponds and provide means for these flows to circumvent the EDB. Ground water seepage, off-Site, landscape irrigation, or other type of flow shall not pass through the forebay, trickle channel, or micropool.



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The low-level outlet shall include a debris rack with a total opening area at least twice the area of the low-level outlet.

Extended detention basin slopes and bottom shall be protected against erosion from inflows and circulation within the basin. Slopes of earth embankments for extended detention facilities steeper than 4:1 will not be allowed. Slopes in detention facilities shall be planted with a seed mix approved by CDOT.

Existing unintended detention storage volume at the entrance to existing cross drains or storm drain systems shall not be considered to reduce peak discharges downstream.

Groundwater elevations shall be determined by the Contractor at all EDB locations and submitted to CDOT for Review. If groundwater is encountered, measures shall be taken (e.g., perimeter underdrain system or impermeable liner) to prevent groundwater seepage or a base flow into the pond.

Final design of all BMPs shall be approved by CDOT.

**12.2.4.8 Bridges and Deck Drainage**

Deck-drainage systems are required for highway bridges when maximum allowable flow spread for the design storm is exceeded and to limit flow across expansion joints to less than 1 cubic foot per second for the 10-year return frequency peak discharge. Stormwater flowing toward the bridge shall be intercepted prior to the approach slab. Stormwater flowing away from the bridge shall be intercepted prior to leaving the approach slab. This stormwater shall be directed to an on-site drainage system and conveyed to a BMP. Bridge deck drainage systems shall be designed in accordance with the FHWA HEC-21 Bridge-Deck Drainage Systems.

All bridge-deck drain inlets shall be grated. Deck drains on bridges shall be installed 1/2-inch lower than the surrounding deck to reduce the snag potential of the grate from snow plow blades. The bridge-deck drainage system shall be compatible with structural reinforcement, components, and aesthetics of the bridge. Outfalls shall be positioned to avoid corrosion of structural members, and splash on vehicular traffic and pedestrian areas below the bridge. Adequate erosion protection shall be provided for all deck drains piped to the bottom of the slope. Downspouts for bridge drains shall be a minimum 10-inch diameter galvanized steel pipe. See Book 2, Sections 15.2.3.4 to 12, for more information on Bridge Deck Drainage.

**12.2.4.9 Stormwater Pumping Stations**

The use of stormwater pumping stations shall be allowed only in the I-25 / US 6 interchange. Pumps shall be sized to drain all stored runoff in eight (8) hours.

Groundwater elevations shall be determined by the Contractor at all pond locations and submitted to CDOT for Review. If groundwater is encountered, measures shall be taken (e.g., perimeter underdrain system, groundwater cutoff walls or impermeable liner) to prevent groundwater seepage or a base flow into the pond that would reduce the volume of the pond intended for WQCV or temporary storage.

**12.2.5 Floodplains**

The Contractor shall coordinate all impacts to FEMA-regulated floodplains and changes to bridges and cross drains located in FEMA-regulated floodplains with CDOT, FEMA, UDFCD,

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and the local city or county floodplain administrator. The Contractor shall comply with local floodplain development permits and other National Flood Insurance Program requirements. As required by FEMA or local floodplain administrators, the Contractor shall develop hydraulic models of the waterways and crossing structures to demonstrate hydraulic performance of new structures and existing structures. The Contractor shall apply for and obtain Conditional Letters of Map Revision (CLOMR) and Letters of Map Revision (LOMR) as required. The Contractor shall be responsible for all FEMA and other Agency fees. Obtain floodplain development permits as required by the Local Agencies.

CLOMR and LOMR submittals are required for the following locations:

1. South Platte River

## **12.2.6 Area Specific Drainage Requirements and/or Information**

### **12.2.6.1 Platte River**

The Contractor shall remove and replace existing US 6 bridge structure crossing the Platte River. *Major Drainageway Planning, South Platte River, Chatfield Dam to Baseline Road, Phase B*, prepared by Wright Water Engineers, dated November 1985 shows the South Platte River being lowered in the future. Design of the bridge over the river shall accommodate the future river lowering.

The effective model from the LOMR for the Zuni and Sun Valley Reach Channel Improvements along the South Platte River shall be used for the hydraulic and floodplain analysis. Although LOMR information is included in the reference documents, the contractor shall contact UDFCD to obtain the effective LOMR model and related documents to ensure that he has the current information.

Piers for the bridge shall not be located in the center of the South Platte River channel.

The existing trail under the bridge shall be reconstructed with an elevation above the 10 year flood elevation in the river or a minimum 10-foot vertical clearance.

Bridge construction shall be coordinated with UDFCD project where the UDFCD project work falls within this project's limits.

### **12.2.6.2 Weir Gulch Culvert (Barnum Lake Outfall)**

The existing double box culvert under US 6 shall be replaced. Construction activities shall be confined to the US 6 right-of-way. Measures shall be taken to prevent draining Barnum Lake. The design detention water surface elevations and design detention discharges from Barnum Lake shall be maintained.

### **Barnum Lake Outlet Pipe**

If the outlet pipe from the northeast corner of Barnum Lake is impacted by highway, storm drain or water quality pipes for the Ultimate Condition or the interim constructed condition, the pipe shall be relocated in a manner approved by City and County of Denver.

#### **12.2.6.3 Low Points at US 6 Stations 2193+00, 2693+00, 2994+00, 4004+00, 5000+00, 5997+00**

The Low Points identified above are designed to convey the 100-year discharge between Bryant Street and Federal Boulevard to the South Platte River. The Contractor's Design, if different, shall convey the 100-year discharge from the sumps located between Bryant Street and Federal Boulevard to the South Platte River.

Surface flows outside of US 6 and I-25 right-of-ways shall not exceed pre-Project conditions.

#### **12.2.6.4 Low Point at I-25 Station 11018+50**

The Contractor shall convey the 100-year discharge from the sump located on I-25 north of US 6 to the South Platte River.

#### **12.2.6.5 I-25 3<sup>rd</sup> Avenue Basin**

BMPs located at Design point 105 (Ramp "C") shall be designed to include 0.87 acre-feet of water quality capture volume from the I-25 3<sup>rd</sup> Avenue basin, as identified in the Water Resources Report for the Valley Highway EIS.

#### **12.2.6.6 Flow from area west of Weir Gulch**

100-year flows from US 6 and tributary areas west of Weir Gulch shall be intercepted and discharged into Weir Gulch in order to reduce the flow at the sump points on US 6 between Federal and Bryant and reduce the outfall size from the US 6 sump points to the South Platte River. Water quality flows from US 6 and tributary areas west of Weir Gulch shall be diverted and conveyed in a water quality storm drain to the US 6 Water Quality Pond.

### **12.3 Construction Requirements**

Drainage facilities shall be constructed in accordance with the CDOT *Standard Specifications*, *Standard Plans*, and *M & S Standards*. Within City and County of Denver right of way, drainage facilities and all CCD Type 14 and 16 inlets shall be constructed in accordance with CCD standards.

Drainage facilities shall be designed to accommodate the construction phasing of the Project.

The Contractor shall survey BMPs according to Section 6.1.3 of the CDOT *Survey Manual* to confirm the design volume had been provided during construction and documented in the As-Built Plans. This work shall be prior to Final Acceptance. The Contractor shall map for inclusion into CDOT's GIS system, all new and existing (remaining) outfalls.

### **12.3.1 Pipe Material Selection Policy**

The Contractor shall comply with the CDOT *Design Bulletin Pipe Material Selection Policy* which is included in Book 3. The most current version as signed by the CDOT Chief Engineer at the time of the Request for Proposals (RFP) shall be utilized.

Clarifications of the CDOT Pipe Material Selection Policy are as follows:

1. Trial installations are not allowed on this Project.
2. Contractor shall be required to sample soil and water.
3. “Project Manager” implies “Contractor.”
4. Contractor shall provide a Sampling Schedule for Pipe Selection for CDOT Review.
5. Pipe material selection shall be submitted to CDOT for Acceptance as part of the Drainage Reports.
6. Aluminum alloy pipe shall not be used.

### **12.3.2 Project Special Provisions**

Subsection 603.07(a) shall include the following:

Joints for all circular reinforced pipe shall be made with confined rubber gaskets. Concrete collars shall be required at all nonstandard joints (not tongue and groove or bell and spigot), and at all connections to existing pipe.

Subsection 624.03 shall include the following:

Joint systems irrigation systems, cross drains, and storm drains shall be watertight. Testing of joints shall be performed by the Contractor in accordance with approved methods. Should any section of irrigation system, cross drains, and/or storm drains fail to meet the test requirements, it shall be corrected at the Contractor’s expense.

## **12.4 Deliverables**

### **12.4.1 Master Plan Drainage and Water Quality Report**

The *Master Plan Hydrology and Hydraulics Report* and *Master Plan Water Quality Report* is included in the Reference Documents.

#### **1.2.4.1.1 Drainage Reports**

Interim Drainage Reports shall be prepared by the Contractor and submitted for review prior to issuance of Released for Construction documents that include the subject drainage facilities.

A Final Drainage Report, incorporating addenda to previously submitted Interim Drainage Reports, shall be prepared by the Contractor and submitted for Acceptance.

Interim Drainage Reports and Final Drainage Report shall demonstrate that the drainage facility design conforms to the intent of drainage design for the Ultimate Configuration presented in the Master Plan Hydrology and Hydraulics Report and Master Plan Water Quality Report. Where modifications to the drainage design for the Ultimate Configuration is needed, the Interim Drainage Reports and Final Drainage Report shall identify the modifications and demonstrate

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that the modifications will conform to the Master Plan Hydrology and Hydraulics Report and Master Plan Water Quality Report.

The interim and final drainage reports shall follow the documentation procedure in chapter 4 of the CDOT *Drainage Design Manual*.

The drainage reports shall include the following:

1. Basic design data, design assumptions, hydrologic and hydraulic methodologies, assumptions, model inputs and outputs, detailed calculations, computations, and computer printouts, relevant design criteria, circumstances influencing design, discussion of all drainage issues and drainage facilities, appropriate maps, figures, and plans,
2. Rationale for sizing and selection of all drainage elements, including catch basins, storm drain systems, cross drains, ditches, swales, BMPs, extended detention facilities, and pipe materials selection.
3. Hydraulic data sheets with a summary of hydraulic design information for each Storm Drain and Cross Drain.
4. A delineation of contributing basins, existing drainage patterns for both highway and cross-drainage flows, drainage parameters, extended detention basin sizing, discharge characteristics, and other information necessary for the design of the drainage system. All drainage reports shall include documentation of any tributary flows from areas outside of each construction segment as defined by the Contractor.
5. Documentation that the proposed runoff will be controlled and treated in accordance with Book 2 Section 12 and all drainage and water quality permits.
6. Documentation of existing drainage discharge rates, outfall locations and pond release rates.
7. Documentation of the impact of proposed drainage designs on existing drainage facilities.
8. Documentation of compatibility with the Ultimate Configuration.
9. Calculations, analysis, and all related information used in developing conclusions and recommendations for BMPs in accordance with CDOT New Development Redevelopment (NDRD) requirements.
10. Maintenance Exhibit, showing entities (CDOT, CCD, and/or UDFCD) responsible for maintenance of various portions of the project area.

In addition to the documentation procedure in Chapter 4 of the CDOT *Drainage Design Manual*, the Contractor shall closely follow the report outline below. The section and subsection headings shall be maintained at a minimum. If a section or subsection is not used, the reason it is not applicable to the Project shall be specified. New sections or additional subsections shall be added as necessary to fully document the drainage design.

**Drainage Report Outline**

- 1 INTRODUCTION
  - 1.1 Location of Improvements
  - 1.2 Description of Improvements

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- 1.3 Discussion of Drainage Investigation
- 2 CROSS DRAINAGE, DRAINAGEWAY, AND IRRIGATION DITCH CROSSINGS
  - 2.1 Location and General Discussion
  - 2.2 Hydrology and Design Flow Development
    - 2.2.1 Information Sources
  - 2.3 Agency Coordination (i.e. UDFCD, local agencies)
  - 2.4 Description of Structural Design (i.e. for non-CDOT standard CBCs)
  - 2.5 Hydraulic Design
  - 2.6 Irrigation Ditch Crossings
  - 2.7 Drainageways and Floodplains
  - 2.8 Scour Analysis
  - 2.9 Bank Stabilization
- 3 ROADWAY DRAINAGE SYSTEMS
  - 3.1 General Discussion
  - 3.2 Design Coordination
    - 3.2.1 Adjacent Segments
    - 3.2.2 Agency Coordination
  - 3.3 Drainage Basin Delineations & Characterization
    - 3.3.1 Existing Basins
    - 3.3.2 Proposed Basins
  - 3.4 Hydrology and Design Flow Development
  - 3.5 Pavement, Median and Roadside Drainage
    - 3.5.1 Inlet/Catch Basin Spacing Design
    - 3.5.2 Storm Drain Design
    - 3.5.3 Roadside Ditch and Channel Design
    - 3.5.4 Erosion Control Design
- 4 PERMANENT BEST MANAGEMENT PRACTICES
  - 4.1 Assumptions and Methodologies
    - 4.1.1 Allowable Release Rate Discussion
  - 4.2 Hydrology and Hydraulics
    - 4.2.1 Storage and Outlet Design Documentation
  - 4.3 Adherence to the CDOT MS4 Permit and NDRD requirements
- 5 APPENDICES
  - 5.1 Hydrologic Analysis
    - 5.1.1 On-Site Hydrology
    - 5.1.2 Off-Site Hydrology
    - 5.1.3 Precipitation Data
    - 5.1.4 Soil Survey
    - 5.1.5 Land Use

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- 5.1.6 FEMA Maps
- 5.2 Hydraulic Analysis
  - 5.2.1 Spread width, Inlet and Storm Drain Calculations
  - 5.2.2 Roadside Ditch and Channel Calculations
  - 5.2.3 Hydraulic Grade Line Calculations
  - 5.2.4 Drain Outfalls, Scour and Erosion Control Calculations
  - 5.2.5 Sub-Drainage Systems
- 5.3 Permanent Best Management Practices
  - 5.3.1 Extended Detention Basin Calculations
  - 5.3.2 Stage Storage Calculations
  - 5.3.3 Trickle Channel Calculations
  - 5.3.4 Water Quality Structure Calculations
- 5.4 Basin Maps
  - 5.4.1 Existing and Proposed On Site Basin Maps
  - 5.4.2 Off Site Basin Maps (full size 22" x 34" sheets)
- 5.5 Maintenance Exhibit

The Contractor shall submit 3 hard copies of all Interim Drainage Reports and 3 hard copies of the Final Drainage Report. All drainage reports shall be signed and sealed by a Colorado Licensed Professional Engineer.

The Contractor shall submit one electronic copy of all signed and sealed drainage reports in PDF format.

All drainage reports shall include electronic copies of all computer analysis input and output files in the native file format.

#### **12.4.4 Water Quality Report**

The purpose of the Water Quality Report is to document permanent water quality design decisions for compliance with the CDPHE. All decisions shall adhere to the NDRD program as part of CDOT's overall MS4 permit.

Interim Water Quality Reports shall be prepared by the Contractor and submitted for review prior to issuance of Release for Construction documents that include the subject drainage facilities.

A Final Water Quality Report, incorporating addenda to previously reviewed reports, shall be prepared by the Contractor and submitted for Acceptance. No Addenda to the Final Water Quality Report will be allowed.

The Water Quality Reports shall reference the applicable drainage report for all technical aspects and design calculations.

The Contractor shall submit 3 hard copies of all Interim Water Quality Reports and 3 hard copies of the Final Water Quality Report. All Water Quality Reports shall be signed and sealed by a Colorado Licensed Professional Engineer.

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The Contractor shall submit one electronic copy of all signed and sealed Water Quality Reports in PDF format.

The Water Quality Reports shall closely follow the report outline and requirements as listed in the *Region 6 Permanent Water Quality Documentation, CDOT, dated April 19, 2011*.

The Water Quality Report Outline as listed in the above mentioned document shall be maintained at a minimum. If a section or subsection is not used the reason it is not applicable to the Project shall be specified. New sections or additional subsections shall be added as necessary to fully document the design.

## **12.5 Deliverables**

### **12.5.1 Drainage Design Deliverables**

The Contractor shall prepare plans for all drainage related facilities for the Project in a format that follows the documentation procedure in chapter 4 of the *CDOT Drainage Design Manual*, and the *CDOT CADD Manual* and *CDOT Drafting Manual*.

The Contractor shall submit all applicable plans with each Drainage Report.

All deliverables shall follow the Quality Management Plan for the Project as described in Book 2, Section 2, Project Management.

The Contractor shall include the following for all drainage plan deliverables:

#### PLAN VIEW

1. Provide the location of all existing and proposed storm drains. Provide a label for each proposed storm drain location. The Contractor shall establish a labeling system that is specific to each proposed storm drain system and provide a table to summarize all pertinent information. The table shall include at a minimum the Drain Line and Sheet Number where the profile can be found.
2. Provide the location of all existing and proposed inlets, manholes, end sections, and outlet protection. Provide a label for each proposed inlet, manhole, end section, outlet structure and outlet protection. Include a table that summarizes all pertinent information. The table shall include, at a minimum, the Label ID, Station & Offset, Item, Length, Pay Depth, and Notes.
3. Provide all existing and proposed grading.
4. Provide all Utility locations.
5. Provide location of ROW lines.

#### PROFILES

1. Provide profiles for all proposed storm drains. Include the Label ID from plan view sheets, station and offset, invert elevations, rim elevations, structure depth, slopes, sizes, material, utility crossings, existing and proposed finished grade lines, the design flow for the 10-year and 100-year event, and the calculated HGL for the 10-year and 100-year event.
2. Provide profiles for all proposed cross drains. Include the Label ID from plan view sheets, station and offset, invert elevations, slopes, sizes, material, utility crossings, and



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existing and proposed finished grade lines. Provide the drainage area of contributing basin, 100-year discharge, and headwater elevation on all applicable profile sheets for cross drains.

**DRAINAGE DETAILS**

1. Include details for all non-standard CDOT items.

**BMP DETAILS FOR EDB**

1. Provide each EDB in plan view. Provide existing and proposed contours that define limits of overall facility. Include access roads, overflow location or structure, forebay, trickle channel, micropool, and outlet structure. Include all locations of Utilities and property lines. Include point labels to define location and elevations within the facility.
2. Provide a table summarizing each point label. The table shall include at a minimum the Point Label, Station & Offset, Northing, Easting, Elevation and Notes.
3. Provide a cross section of the EDB from where flows enter the pond to the outlet structure. Label elevations for the WQCV. Include slopes and elevations of all features.
4. Provide a geometry plan of the EDB from where flows enter the pond to the outlet structure. Include access roads.
5. Provide specific details for the forebay, trickle channel, micropool, and outlet structure.

**12.5.2 As-Built Documents**

Clearly label and locate all items of Work with station, offset, and elevation information based on surveys of what was actually built in the field. Provide summaries of all As-Built drains with the following hydraulic information, at a minimum: pipe/culvert size, invert elevations, slope, 10-year flow (Q10), 100-year design flow (Q100), and HGL.

Provide certification for the EDB as-built volumes, water surface elevations and orifice plates stamped by a Colorado Professional Engineer.

**12.5.3 Deliverable Table**

At a minimum, the Contractor shall submit the following to CDOT and all applicable review agencies for Review, Approval, and/or Acceptance. The Contractor shall identify and coordinate all required approvals by CDOT and outside agencies.

<b>Deliverable</b>	<b>CDOT review, Acceptance or Approval</b>	<b>Schedule</b>
Interim Drainage Reports	review	Prior to Released for Construction Documents
Interim Water Quality Report	review	Prior to Released for Construction Documents
Interim Bridge Hydraulics Report	review	Prior to Released for Construction Documents
Final Drainage Report	Acceptance	Prior to issuance of Released for Construction Documents

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<b>Deliverable</b>	<b>CDOT review, Acceptance or Approval</b>	<b>Schedule</b>
Final Water Quality Report	Acceptance	Prior to issuance of Released for Construction Documents
Final Bridge Hydraulics Report	Acceptance	Prior to issuance of Released for Construction Documents
FEMA Approved CLOMR	Acceptance	Prior to issuance of Released for Construction Documents
FEMA Approved LOMR	Acceptance	After project is constructed (will need design services after construction)
Sampling Schedule for Pipe Selection	Review	Prior to NTP2
Groundwater Elevations at Pond Locations	Review	Prior to NTP2
Weir Gulch Box Culvert Replacement Design and phasing plan	Acceptance	Prior to issuance of Released for Construction Documents
SWMP Site Map	Acceptance	Prior to RFC.
Spill Prevention Control and Countermeasure Plan	Acceptance	21 Days prior to the NTP2
SWMP Plan(s)	Acceptance	Prior to RFC
EDB Certification	Acceptance	Prior to final project acceptance
Drainage Plans, Profiles, and Details	Acceptance	Prior to RFC