

Book 2 – Technical Requirements Drainage

Section 12 - Drainage

I-25 North Design Build

PE: IM C040-029 (17354)

Construction: 025A-016 (18842)

September 17, August 20, 2012

12.0 DRAINAGE

The Project shall include all Work for the modification of existing drainage facilities, construction of new drainage facilities, and construction of Permanent Stormwater Quality Facilities (PSQF) to accommodate the design flows, meet Project design criteria, and comply with the terms and conditions of the CDOT Municipal Separate Storm Sewer System Permit. All storm drainage improvements for the Basic Configuration areas shall be designed to conform to the ~~ultimate lane configuration~~ Ultimate Configuration both horizontally and vertically except for future minor modifications to inlets and inlet connecting pipes.

There is a Project Hydrology Report included in the Project Documents and Permanent Stormwater Quality Report included in the Reference Documents. These materials provide information regarding peak flows to be used in the design of cross culverts and permanent water quality and detention facilities.

The Contractor shall design and construct a complete storm drainage system to intercept and remove surface runoff from the Highway and maintain surface, channel, and conduit flow through the CDOT Right-of-Way (ROW) or Easement to accommodate the ~~ultimate configuration~~ Ultimate Configuration. The Contractor shall utilize the peak flows contained in the Hydrology Report as the basis to complete hydraulic design of all I-25 cross drainage facilities. The Permanent Stormwater Quality Report ~~shall be utilized as the basis~~ has been provided as a starting point foundation for the Contractor's water quality and detention design along the corridor. The Contractor shall also design and construct the storm drainage facilities to limit drainage related hazards within and outside the ROW and Easement, while minimizing future operation and maintenance costs, public inconvenience, flood damages, and water quality impacts during construction.

The Reference Documents on <http://www.coloradodot.info/projects/I25NorthCOSDB> identify which concrete box culverts to be replaced. All existing pipe culverts impacted by the construction of the basic configuration shall be replaced and shall have adequate hydraulic capacity. Refer to Section 15 – Structures for identifying which concrete box culverts are to be replaced.

All existing cross drains, storm drains, and drainage appurtenances to be abandoned shall be removed. However, existing cross drains, storm drains, and drainage appurtenances to be abandoned may be plugged and filled with flow-fill in accordance with CDOT Standard Specifications, Section 202 if Accepted by CDOT. All concrete box culverts shall be removed if abandoned.

The Contractor shall completely clean all CDOT-maintained existing drainage features not replaced or abandoned within the CDOT ROW or Easement used to convey runoff into or out of the new I-25 cross drainage structures.

All drainage facilities of the Project shall be constructed to meet Project design criteria. The Contractor shall obtain approval from affected Agencies for any proposed drainage improvements that are connected to existing storm drains, upstream or downstream of the Project. Where the hydraulic capacity of storm drains upstream or downstream of the project are inadequate, the drainage facilities of the Project shall be designed to meet the Project

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design criteria, and storm drain flow restriction devices that can be removed in the future when improvements to the existing off-site drainage facilities are made by others, shall be constructed to limit discharges to existing conditions.

The Contractor shall design drainage facilities compatible with existing or proposed drainage systems on adjacent properties, and shall preserve existing drainage patterns wherever possible. If existing drainage patterns must be changed due to design of the Project, the Contractor shall design and construct a solution that does not adversely impact property owners outside the CDOT ROW or Easement. Where drainage patterns are changed from existing, the Contractor shall secure all other necessary approvals, permits, and additional easements.

Standards

The Contractor shall design and construct the drainage systems in accordance with the requirements of the standards listed in Table 1.

TABLE 1 STANDARDS FOR DRAINAGE	
Author or Agency	Title
CDOT	Standard Special Provisions
CDOT	Standard Specifications for Road and Bridge Construction
CDOT	Standard Plans, M & S Standards
CDOT	Drainage Design Manual
UDFCD	Urban Storm Drainage Criteria Manual, Volumes I, II, and III

Design Guidelines

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

TABLE 12.0-2 DESIGN GUIDELINES FOR DRAINAGE	
Author or Agency	Title
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>

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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>
CDOT	<i>Erosion Control and Storm water Quality Guide</i>
CDOT	<i>Water Quality Guidance for Consultants</i>

Administrative Requirements

Coordination with Other Agencies and Disciplines

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

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 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-081 023-1 (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 COOT is the landowner, COOT 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.

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

See Book 2, Section 5.

National Pollutant Discharge Elimination System General Construction Permit (NPDES-GCP)

See Book 2, Section 5.

Municipal Separate Storm Sewer (MS4) Permit

CDOT has obtained an MS4 Permit for the storm drain systems that it owns and maintains. 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 PSQFs 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.

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Runoff from all I-25 impervious areas, for the Project ~~ultimate lane configuration~~ Ultimate Configuration shall be captured and conveyed to a PSQF. Runoff from off-site areas, outside CDOT ROW or Easement, shall be kept separate from the on-site pavement runoff and shall not be introduced into a Project PSQF.

The Permanent Water Quality Report included in the Reference Documents provides information regarding the conceptual location of permanent detention and stormwater quality facilities for which implementation is deemed feasible. The findings included in this document shall be used as a starting point to develop and design a more detailed PSQF and detention plan. The recommendations included in the report also describe the type of PSQF to be implemented.

See Book 2, Section 5 for additional MS4 permit information.

Construction Dewatering Permit

See Book 2, Section 5.

USACE Section 404 Permit

See Book 2, Section 5.

Floodplain Development Permit and FEMA Map Amendment

Portions of the Work on this Project are within ~~any~~ FEMA floodplains. For FEMA floodplains within the City of Colorado Springs or El Paso County, the Contractor shall obtain a Floodplain Development Permit from the City of Colorado Springs/El Paso County Floodplain Administrator responsible for any Work in FEMA floodplains within the Project limits. As required by the Work and if required as part of the Floodplain Development Permit, the Contractor shall obtain Conditional Letters of Map Revision (CLOMR) from FEMA. Upon completion of construction in the floodplains the Contractor shall obtain Letters of Map Revision (LOMR) from FEMA, to revise the FEMA Flood Insurance Rate Maps (FIRM), as required by the Work.

All proposed Work within the FEMA floodplains shall be in compliance with the City of Colorado Springs/El Paso County and FEMA floodplain management regulations. The Contractor shall complete all hydraulic analyses required to identify impacts to the floodplains caused by the proposed construction of the Project. Although the cross culverts and bridges are to be designed in accordance with the peak flows in the Hydrology Report, the Contractor's hydraulic analysis for CLOMRs, LOMRs, and floodplain development permits should reflect the FEMA effective flows. The Contractor's hydraulic analyses of the existing floodplains shall also reflect any changes in the channel conditions that have taken place since the original FEMA floodplain delineation, and any channel changes related to floodplain improvements by other parties that are currently under construction. The Contractor shall provide all additional mapping and surveying required to detail these channel changes.

Although portions of the Work on this Project are within USAFA boundaries and do not require FEMA CLOMRs and LOMRs applications to FEMA, all proposed work on this Project along or across the major drainageways within the USAFA shall be in compliance with the FEMA floodplain management regulations. The Contractor shall complete all hydraulic analyses required to identify impacts to the floodplains caused by the proposed construction of the

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Project. There shall be a zero rise in the 100-year water surface elevation at the CDOT easement boundary. The Contractor shall provide to CDOT a Certification letter backed by calculations, sealed and stamped by a Professional Engineer that the requirements within the CDOT easement boundaries satisfy the No Rise criteria described herein. No Floodplain Development Permit is required from the City of Colorado Springs / El Paso County Floodplain Administrator for work in regulated floodplains within the USAFA boundaries.

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For Work within a FEMA Designated Floodplain Identified as Zone A

Refer to the FEMA 265 The Zone A Manual / April 1995 document provided in the Reference Documents at <http://www.coloradodot.info/projects/125NorthCOSDB> for managing floodplains in Zone A.

For No Rise, the Contractor will need to demonstrate with calculations that the Base Flood Elevation is not exceeded. To obtain a Floodplain Development Permit, the Contractor will submit the No Rise Certification Letter backed by calculations, stamped and sealed by a Professional Engineer that the water surface elevation does not change within the Right of Way limits. If the construction results in changes design and calculations exceeding the existing Base Flood Elevation, then a CLOMR / LOMR is required.

The Contractor shall provide all information and technical data and shall also prepare the necessary reports required to obtain CDOT Approval, Floodplain Development Permits, No Rise Certification Letter, CLOMRs, and LOMRs.

Floodplain Administrator Contact:

Keith Curtis PE, LEED® AP, CFM
Floodplain Administrator
Pikes Peak Regional Building Department
2880 International Circle
Colorado Springs, CO 80910
Fax: (719) 799-2698
Cell: (719)-200-8871

Design Requirements

Drainage Design Software

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

1. SCS (NRCS), TR-20
2. USACE, HEC-HMS
3. USACE, HEC-RAS
4. FHWA, HY-8
5. FHWA, Hydrain
6. InRoads Storm and Sanitary, V8i
7. Haestad Methods, StormCAD
8. UD-Detention
9. UD-Sewer
10. UD-Inlet
11. UD-Rational

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All software used must be capable of creating summary tables for both all individual input values and all individual output values (including all hydraulic losses).

Other proprietary drainage design software and spreadsheets may be used if it is certified by the software developer that it meets the design requirements herein, and with prior Approval by CDOT. No software or spreadsheets created by design consultants may be used.

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, such as the Environmental Assessment. 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, drainage maintenance problems, and areas known to contain hazardous waste.

The Contractor shall obtain existing storm drainage improvement plans, drainage planning studies, and drainage reports for the Project area from the City of Colorado Springs/El Paso County, USAFA, and CDOT.

The Contractor shall obtain existing and projected future land uses from the City of Colorado Springs/El Paso County and USAFA, 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 actual field locations of existing drainage improvements and for final design of proposed drainage improvements. 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 Section 7 - Utilities.

Surface Hydrology

CDOT has completed the hydrologic analysis and determined corresponding peak flows for off-site drainage basins tributary to I-25 existing cross drainage facilities within the project limits. These existing cross drainage facilities convey off-site runoff under I-25 and they include pipe culverts, concrete box culverts, and two bridges (northbound and southbound) at Black Squirrel Creek. The Hydrology Report, included in the Project Documents, describes peak flows to be used by the contractor to complete the hydraulic design and sizing of the project cross drainage facilities. The Contractor shall perform revised hydrologic analyses for any locations where changes in off-site drainage patterns are proposed as a result of the design of the Project.

The Contractor shall perform the hydrologic analyses for all on-site drainage basins, and for all off-site drainage areas immediately adjacent to the Project that contribute non-concentrated runoff, that is not concentrated, directly to the on-site drainage basins, based on projected future land uses. The peak flow determined from this analysis will be used to complete the hydraulic design of all non I-25 cross drainage facilities including: pavement and area inlets, storm sewers, roadside ditches, side drains, and permanent stormwater quality facilities. The

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on-site hydrologic analyses shall also identify impacts to the existing storm drainage systems caused by the connections and proposed combined peak design discharges for the overall systems.

Design Frequencies

The design frequency for Project drainage facilities shall comply with the requirements for the various hydraulic structures included herein. Should a hydraulic structure design frequency not be identified herein, Table 7.2 (Table of Design Frequencies) in CDOT's Drainage Design Manual shall be used to identify the appropriate design frequency.

Precipitation

Precipitation data for on-site drainage analysis shall be obtained from the National Oceanic and Atmospheric Administration NOAA Atlas, Precipitation-Frequency Atlas of the Western United States, Volume III – Colorado, 1973. For rainfall duration of less than one hour, rainfall intensity shall be obtained from Rainfall Intensity Curves included in the City of Colorado Springs/El Paso County Drainage Criteria Manual.

Hydrologic Methods

The Contractor shall perform the necessary hydrologic analyses using the following methods contained in the City of Colorado Springs/El Paso County criteria:

Areas greater than 100 acres: Shall be evaluated using the SCS (NRCS) Hydrograph Procedure with the standard SCS (NRCS) 24-Hour Type IIA Cumulative Rainfall Distribution.

Areas less than 100 acres: Shall be evaluated using the Rational Method.

The hydrologic analyses shall be based on fully developed conditions for the drainage basins.

Hydraulic Structures

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 Section 13 - Roadway.

Roadway Profile

Longitudinal grades shall be in accordance with the requirements of Section 13 - Roadway. Where minimum profile grades cannot be obtained in sag vertical curves, flanking inlets shall be constructed in the curb and gutter or adjacent to solid barrier guardrail, as necessary to prevent ponding in flatter areas along the Roadway edges and in accordance with CDOT's Drainage Design Manual.

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Allowable Flow Spreads and Depths

The allowable flow spreads for I-25 mainline shall be limited to the width of the shoulder for the 10-year peak discharge, and shall not encroach more than 4 feet into the outside travel lane for the 100-year peak discharge.

Edge Treatment at Fill Slopes

In areas where the roadway pavement discharges runoff to a fill slope that is steeper than three horizontal to one vertical, a drainage barrier, Guardrail Type 3 with CDOT Type 6 curb or Guardrail Type 7 shall be used to collect flow from the roadway and convey it to inlets or embankment protectors, to prevent erosion of the embankment.

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 to prevent erosion. 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 MSHTO Roadside Design Guide, and shall consider hydraulics, safety, maintenance, long-term permanent erosion control, landscaping, and aesthetics. All abandoned concrete diversion structures and abandoned drainage structures in roadside ditches and open channels shall be removed unless otherwise directed by COOT.

Cross Culverts

Cross culverts shall be defined as pipes or culverts that convey water from one side of I-25 to the other. All cross culverts shall be designed for the 100-year return frequency peak discharge for fully developed ultimate conditions with no inundation of the I-25 paved shoulder. All cross culverts shall be designed to accommodate the Ultimate Configuration.

Hydraulic design of cross culverts 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 culvert, including drainage area, peak discharges, allowable headwater elevation, and design headwater elevation.

The minimum allowable pipe size for cross culverts shall be 36 inches. End sections, or headwalls with beveled edges and wingwalls, shall be provided for all cross culverts drains regardless of size. For concrete box culverts, concrete aprons with a toe-wall shall be installed at the box culvert outlet. 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.

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Allowable headwater elevation for the 100-year return frequency peak discharge shall be designed as described in Chapter 9.2.2 of the COOT Drainage Design Manual. In addition, allowable headwater elevation shall be limited by the minimum of the following:

1. Non-damaging to upstream or adjacent property (maximum 18 inch ponding depth at structures with no inundation of structures).
2. Below edge of roadway shoulder elevation.
3. Headwater/Depth ratio requirements shall be as shown in the CDOT Drainage Design Manual.
4. Overflow to another drainage basin.

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

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

Storm Drains

Storm drains shall be defined as a network of pipes that connect inlets, manholes and other drainage features to an outfall. Cross drains connected to the storm drainage system are considered part of the system. Runoff from within the limits of the Project and stormwater draining onto the Project shall be collected and conveyed in a storm drain system designed for the design frequencies included herein. The storm drain system shall be designed to not worsen the existing conditions for properties outside the CDOT ROW or Easement. Ponding will not be permitted within the Project, except at specifically designed stormwater detention & PSQF facilities.

Hydraulic analysis and plans for storm drains that are connected to existing storm drain systems upstream or downstream of the Project must be coordinated with affected local agencies. The hydraulic analyses shall identify the 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 3. The contractor shall not decrease storm drain size in the downstream direction. All bends and turns shall occur within a manhole or inlet.

Application	Minimum Diameter (inches)
Side Drain	18
Median Drain	18
Storm Drain Trunk Line	18
Connections:	18
Median Drain to Cross Drain	18

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Curb Inlet to Trunk Line	18
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Hydraulic Design of Storm Drains

Storm drain system 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 shall be designed with the hydraulic gradient below the top of pavement and inlet grates for the 100-year return frequency peak discharge. The pipe full flow capacity shall not be exceeded during the 10-year event. The hydraulic gradient for both the 10-year and 100-year event 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 or more than 22 feet per second for the 100-year return frequency peak discharge.

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 minimum pipe size for storm drains crossing under I-25 mainline shall be 24-inch diameter. The minimum pipe size for storm drain trunk line under open areas of the Project or within the pavement shoulder shall be 18-inch diameter.

Inlets

Inlets are required at locations needed to collect runoff within the design criteria specified in this Section. 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:

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

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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 on I-25. 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.

Inlet hydraulic efficiency and spacing shall be determined based on design procedures in the FHWA HEC-22, Urban Drainage Design Manual. 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 low point of sag vertical curve inlets shall be designed for the 100-year return frequency peak discharge and runoff shall not encroach into the travel lanes of I-25. At sump locations on I-25, flanking inlets shall be constructed on each side of the sump to provide relief should the sump inlet clog. The flanking inlets shall be located so 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 highway cross slope begins to superelevate toward the opposite side to prevent pavement cross flow.

Slotted drains or trench drains will not be allowed in the traveled way or transverse to traffic flow on I-25.

The use of scuppers or drainage slots in roadway barriers as a drainage element will not be allowed.

Access holes for inlets, catch basins, and manholes shall not be located in travel lanes of I-25 mainline.

Inlets shall be designed using the clogging factors included in CDOT Drainage Design Manual.

Manholes, Junction Structures, and Prefabricated Bends

Manholes and junction structures shall be incorporated into the storm sewer system to provide access for inspection, cleaning, and other maintenance. Manholes shall be constructed at all junctions, drops, and grade changes. Manholes shall be provided at any change in alignment greater than 2 degrees. Manholes shall not be located in any paved section of I-25 mainline including travel lanes in the ~~ultimate configuration~~ Ultimate Configuration.

A lateral that is less than half the size 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.

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The spacing of manholes shall be in accordance with the CDOT Drainage Design Manual criteria. For storm sewer sizes larger than 60-inch diameter, manholes shall be located considering site conditions that provide for staging of larger scale maintenance activities.

Manhole and junction structure floors shall be shaped to fit the pipe inverts to minimize hydraulic losses within the structure.

Manholes, junction structures, and vaults in roadside areas shall be designed to extend a maximum of 2-inches above the finished grade all around the structure.

Culvert, and Storm Drain, & Permanent Runoff Control Facility -Outfalls

Culvert and storm drain outfalls shall be designed to prevent erosion and so that the outlet elevation is as close as possible to the receiving drainageway flowline, also to prevent erosion. Outfalls shall be oriented in a downstream direction. Permanent erosion protection shall be provided at all outfalls. Energy dissipaters shall be designed in accordance with the FHWA HEC-14, Hydraulic Design of Energy Dissipators for Culverts and Channels, or UDFCD Urban Storm Drainage Criteria Manual Low Tailwater Basins. Broken back cross drains may be considered as a means to reduce scour potential or in combination with the above mentioned energy dissipaters. Outfalls shall be designed to minimize all existing habitat disturbances during construction.

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

Discharges from existing permanent runoff runoff control facilities must be safely conveyed into an existing downstream stable drainageway. Discharges from the facilities in an uncontrolled manner thereby causing erosion shall be avoided.

Scour and Erosion Potential

- 1) Existing scour or ditch/channel erosion issues within the Project ROW or Easement shall be addressed by the Contractor. Channel erosion repair is required, but is not limited to, the following locations: Repair channel invert and bank erosion and displaced riprap at southbound milepost 155.03 between 2-12'x10' CBC outlet and CDOT easement/ROW boundary.
- 2) Repair channel invert and bank erosion at southbound milepost 154.29 between 48" culvert outlet and CDOT easement/ROW boundary.
- 3) The contractor shall protect slopes that are susceptible to rill erosion.

Analyze all bridges and open-bottom cross drains for scour, and design appropriate protection/mitigation per HEC-18, Evaluating Scour at Bridges and HEC-23, Bridge Scour and Stream Instability Countermeasures Experience, Selection, and Design Guidance Second Edition.

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Analyze all ditches/channel changes, realignments and crossings for erosion and scour potential and design appropriate protection or mitigation per HEC-20, Stream Stability at Highway Structures and per other pertinent Design Guidelines shown in Table 2.

When riprap is used to control erosion, the following criteria apply to the 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. Oversized stones shall not be used.

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

All effort should be made to minimize exposed riprap and to consider visibility during design and placement.

Sub-Drainage Systems

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

Permanent Stormwater Quality Facilities

The conceptual permanent stormwater quality facilities included in the Permanent Stormwater Quality Report provide a conceptual plan that the Contractor may consider to address permanent stormwater quality requirements for the Project. Should the Contractor choose to use recommendations included in the conceptual plan, all needed refinements to the plan will be identified by the Contractor and implemented to ensure compliance with Project design criteria and also CDOT's MS4 Permit.

Extended detention basin (EDB) design shall be based on capturing 100 percent of the Water Quality Capture Volume (WQCV) and releasing it at the appropriate rate. The WQCV for each of the EDBs shall be calculated using the equations in Urban Drainage and Flood Control District (UDFCD) Urban Storm Drainage Criteria Manual Volume 3, for the entire impervious area within the CDOT ROW or Easement that is tributary to the individual EDBs.

EDBs treating runoff from impervious areas tributary to drainageways on USAFA land shall be designed in accordance with UDFCD Urban Storm Drainage Criteria Manual guidelines for Full Spectrum Detention. These basins shall provide the Excess Urban Runoff Volume for any post-project pavement beyond the existing pavement area.

Runoff from areas outside the CDOT ROW or Easement shall not be conveyed into the EDBs. The minimum allowable total tributary area shall be 2 impervious acres. The outlet structure for each EDB shall be a reinforced concrete structure with a covered micropool, an orifice plate, and trash rack/debris screen. The orifice plate shall be designed using the equations in UDFCD

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Urban Storm Drainage Criteria Manual Volume 3. Every effort shall be made to embed the outlet structure into the EDB embankment grading. [Required EDB maintenance and operation appurtenances and their design requirements are described in Volume 3.](#)

For small tributary areas (2.0 acre or less) or where EDBs are not feasible due to space limitations, proprietary stormwater vaults may be installed. Proprietary stormwater vaults shall achieve 80% TSS removal in accordance with manufacture reported pollutant removal efficiency and they shall be designed using the design procedures and equations of the manufacturers of the vaults.

PSQFs other than EDBs and stormwater vaults will not be Accepted by CDOT as viable PSQFs.

Stormwater Detention Facilities

To adhere to USAFA requirements, extended detention basins treating runoff from impervious areas tributary to drainageways on USAFA land shall be designed in accordance with UDFCD Urban Storm Drainage Criteria Manual guidelines for Full Spectrum Detention. Detention volume shall be provided for any post-project pavement beyond the existing pavement area. The post-construction runoff peak flow for the 100-year event shall be detained so as to not exceed that of the pre-construction condition.

Bridges

Bridges over drainageways shall be designed in accordance with the CDOT Drainage Design Manual and the CDOT Bridge Design Manual. Scour analyses shall be [completed for all existing and proposed bridges](#) based on the procedures in the FHWA HEC-18, Scour at Bridges, and HEC-20, Stream Stability at Highways. Scour countermeasures shall be designed in accordance with the FHWA HEC-23, Design of Countermeasures.

[The Black Squirrel Creek bridges, H-17-J \(NB\) and H-17-L \(SB\), shall be replaced or widened. If replaced, the Contractor shall a construct a replacement bridge that is at least as long as the existing bridge. A concrete box culvert \(CBC\) shall not be used. The replacement bridge shall not reduce the current bridge waterway opening and the hydraulic capacity shall be maintained. For all peak discharge return frequencies analyzed, the replacement bridge structure shall not result in inferior hydraulic performance in comparison to the existing structure.](#)

Bridge Deck Drainage

Bridge deck drainage systems are required for Highway Bridges when flow spread limits due to the design storm are exceeded, and to limit flow across expansion joints to less than 0.5 cubic foot per second for the 10-year return frequency peak discharge. Gutter flow at both ends of bridges shall be intercepted. 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 appropriate outfall. Bridge

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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. The bridge deck drainage system shall be compatible with the 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 constructed at all outfalls. Downspouts for bridge drains shall be minimum 10-inch diameter galvanized steel pipe, and shall meet the requirements of ASTM A53, Grade B, and Standard Weight Schedule 40. Downspout pipe shall be hot dipped galvanized after fabrication. Galvanizing shall meet the requirements of AASHTO M111. Metal used in the manufacture of castings shall meet the requirements of ASTM A48, Class 35B. Cleanouts shall be provided for downspout systems.

Stormwater Pumping Stations

The use of stormwater pumping stations shall not be permitted.

Construction Requirements

Drainage facilities shall be constructed in accordance with the CDOT Standard Specifications, and the CDOT Standard Plans – M & S Standards. Drainage facilities shall be designed to accommodate construction phasing of the Project. The Contractor shall provide design details for each phase of construction.

Project Special Provisions

~~The following specifications modify and take precedence over the Standard Specifications~~

~~Culverts and Sowers~~

~~Section 603 of the Standard Specifications is hereby revised for this Project as follows:~~

~~Subsection 603.02 shall include the following:~~

~~Reinforced concrete pipe shall be used for all pipe culverts and storm cowers on this Project. Existing reinforced concrete pipe that meets Project design criteria may be left in place and utilized in drainage systems.~~

~~Subsection 603.07(a) shall include the following:~~

~~Joints for all circular reinforced concrete pipe shall be made with profile 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.~~

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Deliverables

Drainage Reports

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Interim Drainage Reports shall be prepared by the Contractor and submitted for Acceptance prior to Release for Construction documents that include the subject drainage facilities. A Final Drainage Report, incorporating addenda to previously Accepted Interim Drainage Reports, shall be prepared by the Contractor and submitted for Approval prior to Final Acceptance. No Addenda to the Final Drainage Report will be allowed. 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, PSQFs, 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, inflow hydrographs for detention basins, detention basin sizing, discharge characteristics, discharge hydrographs for detention basins, detention times, 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 PSQFs in accordance with CDOT New Development Redevelopment (NDRD) requirements.

In addition to the documentation procedure in Chapter 4 of the CDOT Drainage Design Manual, the Contractor shall closely follow the report outline below [for the Interim and Final Drainage Reports](#). The section and subsection headings shall be maintained at a minimum. If a section

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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
 - 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 Spacing Design
 - 3.5.2. Storm Drain Design
 - 3.5.3. Roadside Ditch and Channel Design
 - 3.5.4. Erosion Control Design

4. PERMANENT STORMWATER QUALITY FACILITIES
 - 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

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- 5.1.3. Precipitation Data
- 5.1.4. Soil Survey
- 5.1.5. Land Use
- 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 Stormwater Quality Facilities
 - 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)

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.

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 Acceptance prior Release for Construction documents that include the subject drainage facilities.

A Final Water Quality Report, incorporating addenda to previously Accepted reports, shall be prepared by the Contractor and submitted for Approval prior to Final 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 Water Quality Reports shall include the following:

1. All assumptions, circumstances influencing design, and design criteria-related decisions shall be documented.
2. Design decisions shall be documented and shall be based on sound engineering principles.

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3. All related references including maps, figures, and plans shall be provided in the appendix.
4. All Water Quality Reports and maps shall include documentation of any tributary flows from areas outside of each defined construction segment.
5. An exhibit showing the Project in relation to the MS4 boundary area.

The Contractor shall prepare an NDRD Exhibit to be included with all Water Quality Reports. The NDRD Exhibit shall include the following:

1. A delineation of each basin with a colored, solid-filled, hatch pattern. Each basin shall be tributary to a specific PSQF. Provide different colors for each PSQF basin. These basins shall incorporate the sub-basins found in the Drainage Reports.
2. A label for each water quality basin. Include the typical basin designation circle label. Include within the circle the water quality basin ID, the basin area, and the impervious area with that basin. Provide a legend to describe the basin designation label.
3. A label for the proposed PSQFs serving each basin. The Contractor shall ensure that the location of the PSQF matches the proposed locations found in the construction drawings.
4. Flow direction arrows.
5. A delineation of disturbed areas for the Project.
6. A table with six column headings. The column headings shall be; Basin Color, Basin ID, Type of PSQF used to Treat Area, Required Impervious Area to be Treated, Actual Impervious Area Treated, and Comments. At the bottom of the table sum the columns for Required Impervious Area to be Treated and the Actual Impervious Area Treated.
7. If the actual impervious area treated is less than required impervious area to be treated, provide a note on the NDRD exhibit describing why we could not capture and treat the required impervious area for the Project.

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.

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

The Interim and Final Water Quality Reports shall closely follow the report outline below.

The Water Quality Report Outline as shown below 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.

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New sections or additional subsections shall be added as necessary to fully document the design.

Water Quality Report Outline

1. TABLE OF CONTENTS
2. INTRODUCTION
 - Vicinity Map. Site location, stationing, state highway number, name of receiving waters, location of existing and proposed outfalls, geographic reference (county, nearest town), and jurisdictional MS4 boundary areas.
3. DISCUSSION OF CDOT MS4 / NDRD REQUIREMENTS
 - Discussion of how proposed PSQFs satisfy CDOT's MS4 requirements
 - Site map showing locations of PSQFs
 - Relationship of PSQFs to Major Drainageway and Outfall Systems Plans
 - Detailed description, design criteria, and references to specifications and technical details of PSQFs as documented in the applicable Drainage Reports.
 - Detailed descriptions, design criteria, and locations of stream stabilization measures to be implemented.
 - Design Objectives
 - Treatment Options
 - Expected Pollutant Removal Rates
 - Existing Water Quality features that will be abandoned, reconfigured, or incorporated into a new design.
 - Right of Way needs and/or concerns
 - Recommended Design
 - Maintenance and Operation requirements, inspection protocols, and maintenance schedule

The following topics shall be addressed in detail:

- a) Description of project and land disturbance in acres.
 - b) What area (in acres) is required to be treated, what area (in acres) of treatment is provided, what area (in acres) is not treated, and what area (in acres) is treated in addition to what is required. Include this information in the report and as a note on the NDRD Exhibit.
 - c) Detailed description, design criteria, justifications (why an area is not treated), decision making process (why a permanent BMP was chosen over another), location of permanent BMPs to be implemented, and analysis as to how permanent BMPs (combination or individual) satisfy the current CDOT NDRD requirements.
 - d) Provide the certification number for CDPS Construction Stormwater permit for the Project.
4. MAINTENANCE AND OPERATION
 - Narrative description of the facility

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Example: Extended detention pond with a single cell outlet structure with an orifice plate which is designed for a 40-hour drain time. Three inlets drain into the basin which has a concrete lined forebay with grouted riprap berm. The forebay is designed to drain within 5 minutes and keep out large floatable/debris.

- Narrative description of maintenance access to the facility
Example: maintenance access off of I-25 southbound before guardrail or take ramp from Southbound I-25 to Westbound Speer. Parking is from the shoulder.
- Narrative description of what maintenance work will need to be done to ensure continued effectiveness of the facility.
Example:
 - Mowing basin to keep vegetation controlled so water can continue to flow unhindered. Remove vegetation from facility to keep from re-clogging grates and orifice plate.
 - Clean trash rack/grates of debris and dispose of off of PSQF site
 - Clear orifice plate holes so water can continue to flow
 - Remove sediment from basin when reaches lowest orifice hole or blocking forebay outlet pipe. Can use hand shovels, bob cats/skid steers. Remove sediment off of PSQF site to keep from re-polluting the pond.
 - Re-seed as necessary to keep area stable of erosion
 - Add additional erosion control items to keep area stable.
 - Tighten/replace trash rack bolts and screens as necessary to keep structure in working order.
- Documentation of commitments from responsible agency (such as Intergovernmental Agreements, Memoranda of Understanding, etc.) or Owner to maintain the PSQF's shall be required and included with the Final Water Quality Report

5. APPENDIX

Project in relation to MS4 boundary area Exhibit.
NDRD Exhibit

Additional 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 drains. Provide a label for each proposed 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

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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, 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 10 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 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.

PSQF DETAILS

1. Provide 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 from where flows enter the pond to the outlet structure. Label elevations for the WQCV, 10-year, and 100-year events. Include slopes and elevations of all features.
4. Provide a geometry plan 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, capacity, velocity, roughness coefficient, and HGL.

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12.5.3 Deliverable Table

At a minimum, the Contractor shall submit the following to CDOT for Review, Approval, and/or Acceptance:

Deliverable	Review, Acceptance or Approval	Schedule
Interim Drainage Reports	Acceptance	Prior to Released for Construction Documents
Interim Water Quality Report	Acceptance	Prior to Released for Construction Documents
Final Drainage Report	Approval	Prior to issuance of Released for Construction Documents
Final Water Quality Report	Approval	Prior to issuance of Released for Construction Documents
CLOMR	Acceptance	Prior to issuance of Released for Construction Documents
LOMR	Acceptance	After project is constructed (will need design services after construction)
Sampling Schedule for Pipe Selection	Review	Prior to NTP

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Project Special Provisions

The following specifications modify and take precedence over the Standard Specifications

Culverts and Sewers

Section 603 of the Standard Specifications is hereby revised for this Project as follows:

Subsection 603.02 shall include the following:

Reinforced concrete pipe shall be used for all pipe culverts and storm sewers on this Project. Existing reinforced concrete pipe that meets Project design criteria may be left in place and utilized in drainage systems.

Subsection 603.07(a) shall include the following:

Joints for all circular reinforced concrete pipe shall be made with profile 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.