

## **12.0 DRAINAGE**

This Section 12 includes the requirements for the drainage Work for the US 550/160 Connection South Design Build Project (Project). This Work shall be completed in accordance with the Contract Documents.

The National Environmental Policy Act (NEPA) approval documents and Draft Master Drainage Design Report (DMDDR) are included in the Reference Documents. These documents provide information regarding stormwater quality treatment, on Site and off Site drainage basins, design flows, and a conceptual layout of the proposed drainage for informational purposes.

For the overall system capacity, drainage will fully accommodate the Basic Configuration and AREs that are incorporated into the Project representing the ultimate build-out of US 550. Basic Configuration improvements shall be designed and constructed to limit reconstruction of future improvements. The Project consists of the Basic Configuration and the AREs as identified in Book 2, Section 1.

The Contractor shall design and construct a complete drainage system to intercept and remove surface runoff from the Project; maintain surface, channel, and conduit flow through the ROW; and convey flows crossing US 550 and US 160 under Bridges and through cross drains. The drainage system shall be designed and constructed to manage subsurface flows to avoid saturation of Subgrade Materials that support the Roadway and its associated Structures. Since the project lies outside of CDOT's Municipal Separate Storm Sewer System (MS4) boundary, permanent water quality (PWQ) control measures (CM) are not required. The Contractor shall design and construct the 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.

Where applicable, the Contractor shall evaluate all existing cross drains, storm drains, and drainage facilities to remain within the Project for condition and performance, and shall provide recommendations on adequacy to CDOT for Acceptance. All drainage facilities shall be clean prior to Final Acceptance.

The Contractor shall design drainage facilities to be compatible with existing drainage systems on adjacent properties and shall preserve existing drainage patterns or discharges. Wherever possible, the Contractor shall design drainage facilities to be compatible with proposed drainage systems on adjacent properties. All existing and proposed drainage facilities shall be designed and constructed to be commensurate with Colorado Drainage Law documented in the Urban Drainage and Flood Control District (UDFCD) *Urban Storm Drainage Criteria Manual*. The Contractor shall obtain approval from affected Local Agencies for any proposed on Site drainage improvements that connect to or impacts existing storm drains upstream or downstream of the Project. If existing drainage patterns or discharges must be changed or they increase above pre-project peak flow rates due to the design of the Project, the Contractor shall design and construct a solution that does not adversely impact CDOT or property owners outside the CDOT ROW or Easement areas. Where drainage patterns or discharges are changed from existing, the Contractor shall secure necessary approvals, permits, and additional Easements from Local Agencies and affected Stakeholders.

### **12.1 Administrative Requirements**

#### **12.1.1. Standards**

The Contractor shall design and construct the Project in accordance with the requirements of the standards in the documents listed in Table 12-1 and those referenced in Book 3. The Contractor shall use the latest adopted edition at the time of the Proposal Due Date.

**Table 12-1 Standards for Drainage**

Author or Agency	Title
CDOT	<i>Standard Specifications for Road and Bridge Construction (CDOT Standard Specifications)</i>
CDOT	<i>Standard Plans, M&amp;S Standards</i>
CDOT	<i>Drainage Design Manual (DDM)</i>
CDOT	<i>Erosion Control and Stormwater Quality Guide</i>
CDOT	<i>Design Bulletin Pipe Material Selection Policy</i>
CDOT	<i>Bridge Design Manual, Section 16—Hydraulics and Drainage</i>
Urban Drainage and Flood Control District (UDFCD)	<i>Urban Storm Drainage Criteria Manual, Volumes I, II, and III (USDCM)</i>
Federal Emergency Management Agency (FEMA)	<i>National Flood Insurance Program Regulations (44 Code of Federal Regulations [CFR] Parts 59-80)</i>
La Plata County	<i>La Plata County Code, Chapter 74: Development Standards and Specifications</i>

### 12.1.2. Design Guidelines

Where the above standards do not address a certain design criterion or element, the design guidelines listed in Table 12-2 shall be used.

**Table 12-2 Design Guidelines for Drainage**

Author or Agency	Title
American Association of State Highway and Transportation Officials (AASHTO)	<i>A Policy on Geometric Design of Highways and Streets</i>
Federal Highway Administration (FHWA)	<i>Hydraulic Design Series (HDS) No. 4, Introduction to Highway Hydraulics</i>
FHWA	<i>HDS No. 5, Hydraulic Design of Highway Culverts</i>
FHWA	<i>Hydraulic Engineering Circular (HEC) No. 12, Drainage of Highway Pavements</i>
FHWA	<i>HEC-14, Design of Energy Dissipators for Culverts and Channels</i>
FHWA	<i>HEC-15, Design of Roadside Channels with Flexible Linings</i>
FHWA	<i>HEC-18, Evaluating Scour at Bridges</i>
FHWA	<i>HEC-20, Stream Stability at Highway Structures</i>
FHWA	<i>HEC-21, Design of Bridge Deck Drainage</i>
FHWA	<i>HEC-22, Urban Drainage Design Manual</i>
FHWA	<i>HEC-23, Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance-Third Edition</i>

### 12.1.3. Coordination with Other Agencies and Disciplines

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

The implementation of the conceptual drainage plan, as described in the NEPA approval documents and DMDDR, is dependent upon Agreements between CDOT and third parties. The Agreements between the

third parties and CDOT are anticipated to be completed prior to the execution of the Contract. The Agreements will identify existing and proposed drainage facilities that currently receive runoff from the Project or off Site basins and that will receive runoff from Project improvements or Off-Site basins (see Book 2, Section 6). All proposed designs and construction shall fully comply with the terms of these agreements.

#### **12.1.4. Permits**

The Contractor shall comply with the requirements of all Permits that are necessary for installation and operation of the Work. The Contractor shall adhere to the following Permit requirements. The Contractor shall refer to Book 2, Section 5, for additional requirements. If conflicts exist between requirements of Book 2, Section 5, and this Section 12, the more stringent requirement shall apply.

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

Refer to Book 2, Section 5.

###### **12.1.4.1.1 Stormwater Management Plan (SWMP)**

Refer to Book 2, Section 5.

###### **12.1.4.1.2 Control Measures**

Refer to Book 2, Section 5.

###### **12.1.4.1.3 Temporary Drainage**

The Contractor shall be responsible for design, maintenance, and construction of temporary drainage for the Project at all times during construction. Temporary drainage shall maintain the conveyance of water or irrigation necessary to avoid damage to the Highway, the ROW, or to private property. The minimum size for temporary storm drains and cross drains shall be 12 inches. The minimum size of temporary underdrains shall be 4 inches. The Contractor shall be responsible for the final selection of pipe size and Material type for temporary drainage features. Temporary drainage shall be designed to avoid hydroplaning and icing for each phase or stage of construction. Temporary drainage features shall comply with Project clear zone requirements and shall not present hazards to the traveling public.

The Contractor shall keep all existing storm drainage systems used for temporary drainage on the Project in operating condition during construction. Prior to the start of construction, the Contractor shall locate and clean all existing drainage systems in accordance with Section 202 of CDOT *Standard Specifications* as required to maintain temporary drainage to support the Contactor's design.

The Contractor shall track all temporary drainage that is installed on the Project. It shall include location and type of pipe and connection to existing fixtures, and if required, a resolution for abandonment or removal after the permanent drainage is in place.

The Contractor shall continuously maintain temporary drainage features until removal or abandonment. Throughout the duration of the Project, the Contractor shall continually protect existing, temporary and/or new permanent inlets from sediment and pollutants and, if needed, shall remove any material deposited in the systems. All existing, temporary, and new permanent inlets and outlets shall be identified on the SWMP Site map and shall follow the requirements of Section 208 of CDOT *Standard Specifications*. All temporary drainage features shall be removed when they are no longer required unless abandonment is Approved by CDOT. The proposed method and materials for abandonment of any temporary drainage feature shall be submitted to CDOT for Approval prior to implementation.

12.1.4.1.4 Erosion Control Measures

Refer to Book 2, Section 5.

12.1.4.1.5 Site Inspections

Refer to Book 2, Section 5.

**12.1.4.2 Municipal Separate Storm Sewer System**

Refer to Book 2, Section 5.

**12.1.4.3 Construction Dewatering Permit**

Refer to Book 2, Section 5.

**12.1.4.4 U.S. Army Corps of Engineers Section 404 Permit**

Refer to Book 2, Section 5.

**12.1.4.5 Other Regulations and Requirements**

12.1.4.5.1 Floodplain Regulations

It is not anticipated there will be floodplain impacts on the Project. In the event there is, the Contractor shall comply with all Local, State, and Federal Requirements associated with potential impacts to regulated floodplains. Regulated floodplains include the most recent flood hazard areas delineated on FEMA Flood Insurance Rate Maps (FIRM) (or Digital FIRMs [DFIRM]) or shown by more recent studies, local or regional master plans, or local floodplain maps.

12.1.4.5.2 Senate Bill 15-212 Requirements

Senate Bill 212, Colorado Revised Statutes (C.R.S.) 37-92-602 (8) (SB 212), contains requirements regarding the design of new stormwater detention and infiltration facilities and notifications regarding the intention to operate new stormwater detention and infiltration facilities. On behalf of CDOT and Local Agencies that will own and maintain new facilities, the Contractor shall provide the required information for the notifications and shall disseminate notifications for facilities owned by CDOT, as required by the statute.

The Contractor shall design stormwater detention and infiltration facilities to meet Project goals and requirements and in accordance with the requirements of SB 15-212. Where standards conflict with SB 15-212 requirements, the more stringent requirements shall apply.

12.1.4.5.3 Senate Bill 40 Requirements

Refer to Book 2, Section 5, for additional requirements.

**12.2 Design Requirements**

**12.2.1. Submittals**

All submittals shall be prepared, Reviewed, and submitted in accordance with the requirements set forth in Book 2, Section 3.

### **12.2.2. Drainage Design Software**

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

1. FHWA, HY-8
2. FHWA, Hydraulic Toolbox
3. Bentley, InRoads Storm and Sanitary
4. Bentley, FlowMaster
5. Bentley, CulvertMaster
6. Bentley, StormCAD
7. UDFCD, UD-Detention
8. UDFCD, UD-Culvert
9. UDFCD, UD-Inlet
10. UDFCD, UD-Rational
11. UDFCD, UD-BMP
12. UDFCD, CRS 37-92602(8) Compliance Design Data Workbook
13. Environmental Systems Research Institute (ESRI), Arc-Geographic Information System (GIS)
14. US Army Corps of Engineers, HEC-HMS
15. EPA Stormwater Management Model (SWMM)
16. NRCS, Rock Chute Method

All software used must be capable of creating summary tables for all individual input values and all individual output values (including all hydraulic losses) and summary tables of the accumulated results of the analyses at key locations in the system.

No software or spreadsheets created by the Contractor may be used without Acceptance by CDOT. The Contractor shall demonstrate the proposed alternative provides analyses and results more adequately than the aforementioned software. Alternative software shall also provide results of comparable accuracy and reliability prior to CDOT Acceptance. CDOT is under no obligation to consider alternatives to Accepted software and spreadsheets.

### **12.2.3. Permanent and Interim Drainage**

The Contractor shall provide drainage design for all Work within the Project limits in accordance with Book 2, Section 1, Basic Configuration and any Additional Requested Elements (ARE). If stockpiles are placed within CDOT ROW per Book 2, Section 13, and the Earthwork Management Plan (EMP), the Contractor shall develop an interim drainage design meeting Technical Criteria and shall be included with the appropriate drainage submittals.

### **12.2.4. Data Collection**

The Contractor shall identify all drainage related issues using available data, including, but not limited to, requirements imposed by Local, State, and Federal Regulations and official documents concerning the Project.

The Contractor shall obtain all relevant storm drainage improvement plans, drainage planning studies, and drainage reports for the Project area from CDOT, FEMA, and all Local Agencies, including La Plata County, City of Durango, and appropriate ditch companies. The DMDDR includes documentation that relates to drainage adjacent to the Project. CDOT makes no representation as to accuracy, completeness, or adequacy of these documents.

The Contractor shall obtain any existing and known projected future land uses from all Local Agencies, as necessary, to 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 further verify or identify boundaries, flow patterns, and land uses of drainage basins based on field observations.

### **12.2.5. Surface Hydrology**

The Contractor shall perform hydrologic analyses for all on Site drainage basins and for all local off Site drainage areas immediately adjacent to the Project that contribute runoff to on Site drainage basins. Local, on Site drainage basins shall include those that manage runoff generated from the Project improvements. Local, off Site drainage basins shall include those contributing flow onto the Project where flow rates are not quantified by published documents. The analyses shall be based on known projected future land uses.

The Contractor shall perform hydrologic analyses for any locations where published design flow rates are not available or where changes in off Site drainage patterns or increased discharges are proposed as a result of the design of the Project.

#### **12.2.5.1 Design Frequencies**

For all CDOT owned facilities, the design storm frequency shall comply with *Table 7.2, Table of Design Frequencies*, in the CDOT *Drainage Design Manual (DDM)* for rural areas.

The design storm frequency for all cross drains shall be the 50-year design storm event.

The design storm frequency for all other Roadways affected by the Project shall comply with the affected Local Agency's criteria.

#### **12.2.5.2 Precipitation**

Precipitation data for all drainage analyses shall be obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14, *Precipitation Frequency Atlas of the Western United States, Volume III, Colorado*.

#### **12.2.5.3 Hydrologic Methods**

The Contractor shall perform all necessary hydrologic analyses required to evaluate and satisfactorily comply with all Project design standards and criteria, except as provided by previously published documents as described in this Section 12. 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 as described in the UDFCD *USDCM*. The minimum time of concentration shall be 10 minutes.
2. Areas greater than 90 acres shall be evaluated using methods described in the CDOT *DDM*.

## **12.2.6. Hydraulic Structures**

### **12.2.6.1 Roadways**

Roadway component geometric configurations shall be designed to provide adequate drainage and minimize hydroplaning and icing. Superelevation transitions shall be designed to eliminate 0.0% cross slopes on Bridge decks or on profile crest and sag curves where grades flatter than 0.5% occur.

Cross slopes shall be in accordance with the requirements of Book 2, Section 13.

#### **12.2.6.1.1 Roadway Profile**

Longitudinal grades shall be in accordance with the requirements of Book 2, Section 13. Where there is curb and gutter or Guardrail Type 9 Single Sloped Barrier and the minimum profile grades cannot be maintained, flanking inlets shall be constructed, as required in the CDOT *DDM*.

#### **12.2.6.1.2 Allowable Flow Spreads**

The Contractor shall design all Roadway and ramp storm drain systems including gutters, inlets, inlet spacing, catch basins, laterals, and trunk lines, using Section 13.02 of the CDOT *DDM*.

All other Roadways outside of CDOT ROW shall comply with the Local Agency's criteria.

#### **12.2.6.1.3 Edge Treatment**

In areas where the Roadway pavement discharges runoff to Guardrail Type 9 Single Sloped Barrier or Type 3 W Beam Guardrail with curb, inlets, Type 3 Embankment Protectors or Type 5 Embankment Protectors shall be used to manage flow from the curb section, down the Roadway embankment and protect the embankment from erosion. Erosion protection shall be constructed at the outfalls.

#### **12.2.6.1.4 Roadside Ditches, Open Channels, and Slope Protection**

For Roadside ditches along all existing and proposed Roadways, the design water surface profile shall have a minimum of 1 foot of freeboard, measured from the bottom of the Base Course to the water surface elevation, for the 10-year storm frequency peak discharge and shall not exceed edge of pavement for the 100-year storm frequency peak discharge. The Contractor is not responsible for analyzing or improving existing Roadside ditches that are not impacted or improved as part of this Project.

For infill sections and median ditches, the water surface profile elevation shall not exceed the edge of pavement for the 100-year storm frequency peak discharge.

All open channels within the Project shall be designed to capture and convey the 50-year design flow and designed in accordance with Chapter 8 of the CDOT *DDM*. Capacity shall be determined using Manning's Equation or backwater analysis at culverts, inlets, and other hydraulic Structures.

All proposed Roadside ditches, swales, or other areas of concentrated flow shall be evaluated to determine the channel hydraulic shear stresses for 10-year design flows. Where hydraulic shear stresses are found to exceed the maximum allowable shear stresses, a Turf Reinforcement Mat (TRM) or riprap armoring shall be designed and placed to protect against the design shear stresses in the proposed ditch or channel facility. The maximum permissible shear stresses for a TRM Class 3 (CDOT *Standard Special Provision 216*) must meet or exceed the criteria identified in the CDOT *Erosion Control and Stormwater Quality Guide* or FHWA *Design of Roadside Channels with Flexible Linings*, HEC-15. Where slopes exceed the maximum allowable gradient of 5 percent or where the maximum allowable shear stress of

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3.1 pounds per square foot is exceeded, embedded riprap armoring or other permanent erosion control treatment shall be designed and placed to protect against the design shear stresses in the proposed ditch/ channel facility.

Flexible channel linings shall be designed in accordance with FHWA *Design of Roadside Channels with Flexible Linings, HEC-15*. Riprap channel lining shall be designed in accordance with FHWA *Bridge Scour and Stream Instability Countermeasures, HEC-23, or the USDCM*.

All abandoned concrete diversion Structures in Roadside ditches and open channels shall be removed and disposed of off Site.

### **12.2.6.2 Cross Drains**

Cross drains shall be defined as pipes or culverts that convey water from one side of the Highway to the other. All cross drains shall be designed for the 50-year frequency peak discharge for the Project with no inundation of the Highway paved Shoulders or adjacent properties and no inadvertent detention or retention.

Hydraulic design of cross drains shall be based on the procedures included in FHWA HDS-5, *Hydraulic Design of Highway Culverts*. Hydraulic design data shall be listed on the final design and RFC Documents for each cross drain, including drainage area, peak discharges, allowable headwater elevation, and design headwater elevation.

The minimum allowable pipe size for cross drains shall be 36 inches in diameter. Flared end sections with toe walls or headwalls with beveled edges and wingwalls shall be provided for all cross drain pipe ends, regardless of size. Concrete aprons with a toe wall shall be installed at the ends of box culverts with the necessary scour protection. To reduce culvert sizes, improved inlets may be used. Improved inlets shall be designed based on FHWA HDS-5, *Hydraulic Design of Highway Culverts*.

All cross drain pipe Material shall comply with Section 624 – Drainage Pipe in the CDOT *Standard Specifications*.

Allowable headwater elevation for the 50-year frequency peak discharge shall be designed as described in Chapter 9.2.2 of the CDOT *DDM*. In addition, allowable headwater elevation shall be limited by the minimum of the following:

- Non-damaging to upstream or adjacent property.
- Below outside edge of Roadway Shoulder elevation.
- Headwater to depth ratio requirements shall be as shown in the CDOT *DDM*, Table 9.3.
- No overflow to another drainage basin is allowed.

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

Small mammal crossing pipes shall not be used for stormwater conveyance. Refer to Book 2, Section 5, for additional requirements.

Cross drains shall be continuous and straight. Bends or turns will not be permitted.

Cross drains that are connected directly to off Site existing drainage systems shall have a manhole constructed inside and adjacent to CDOT ROW, to join the CDOT cross drain to the existing drainage system. Manholes shall be constructed of the appropriate size and type, according to the CDOT *DDM*.

All stormwater runoff, either from off Site or on Site areas, shall drain freely to an existing cross drainage or storm drain system.

### **12.2.6.3 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 and side drains connected to the storm drainage system are considered part of the storm drain system for the purpose of determining the hydraulic performance of storm drains. Runoff generated from within the limits of the Project and/or draining onto the Project from off Site areas shall be collected and conveyed in a drainage system designed for the design frequencies included herein. The drainage system shall be designed to not worsen the existing conditions for properties outside the CDOT ROW or Easement. Ponding shall not be permitted within the Project, except at specifically designed stormwater detention and PWQ CM facilities.

Hydraulic analyses 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 Contractor shall obtain acceptance of the proposed design by Local Agencies affected by connections to their storm drain systems and for runoff leaving the Project.

The minimum allowable pipe diameter for storm drain systems shall be 18 inches.

All storm drain pipe Material shall comply with Section 624 – Drainage Pipe in the CDOT *Standard Specifications*.

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.

#### **12.2.6.3.1 Hydraulic Design of Storm Drains**

Storm drain system design shall be performed using hydraulic gradient analysis to account for all friction losses 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 FHWA HEC-22, *Urban Drainage Design Manual*.

Storm drains under the Highway shall be designed with the Hydraulic Grade Line (HGL) at or below the crown of pipe for the 10-year frequency peak discharge. The Energy Grade Line (EGL) shall be at or below of the surface of pavement and inlet grates where the pipe is required to convey the 100-year frequency peak discharge. Local Agency criteria shall be followed for storm drain system design outside of CDOT ROW. The hydraulic and energy gradient for the minor (10-year) and major (100-year) design peak discharges 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 frequency peak discharge and shall not be greater than 22 feet per second for the 100-year frequency peak discharge. This minimum storm drain flow velocity requirement may be waived, at CDOT's sole discretion, in locations where tailwater controls the flow and no alternative solution is evident.

#### **12.2.6.3.2 Storm Drain Alignment and Profile**

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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.

12.2.6.3.3 Inlets

Inlets are required at locations to collect runoff within the design controls specified in this Section 12. In addition, there are locations where inlets may be necessary with little regard to contributing drainage area. These locations shall be designated on the plans prior to computations regarding discharge, water spread, inlet capacity, or bypass. Examples of such locations can be found in Chapter 13.4.2 of the CDOT *DDM*:

1. CDOT *M&S Standard Plans* inlets shall be used on all CDOT Roadways.
2. The following criteria apply to inlets:
  - A. Type C and Type D inlets shall not be allowed within the Roadway pavement limits unless used in conjunction with embankment protectors.
  - B. Vane grate inlets shall be used in the Shoulders of the Highway and shall not extend into adjacent travel lanes.
  - C. Close mesh grates shall be used for Type C and D inlets near pedestrian areas; concrete aprons shall be installed on Type C and D inlets.
  - D. Type 13 or Type C inlets shall be used in conjunction with valley pans.
  - E. Pursuant to the CDOT Design Guide, placement of drainage inlet grates should be avoided within a bicycle facility regardless of whether that facility is a bike lane, shoulder, or shared lane. If this is not possible, drainage inlet grates should be replaced with bicycle-safe grates that maintain the required hydraulic capacity for the inlet. A bicycle-safe grate should have, at a minimum, bars perpendicular to the travel direction at a 4 inch center-to-center spacing.
3. Inlet hydraulic efficiency and spacing shall be determined based on design procedures in FHWA *HEC-22, Urban Drainage Design Manual*; 100 percent of the bypass flow shall be added to the next downstream inlet.
4. 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.
5. The sag vertical curve or sump area on a Roadway requires an inlet at the lowest point and flanking inlets on each side of the lowest inlet to provide relief from debris clogging. Inlets shall be located such that the design criteria for spread are maintained.
6. Inlets are required 10 feet upstream from the point where the street cross slope begins to super-elevate toward the opposite side to minimize cross street flow. Bypass flow across the Highway shall be limited to 0.1 cubic foot per second (cfs) or less for the 10-year design frequency. Sump inlets shall not be placed at the zero point of the superelevation transition.
7. Trench drains will not be allowed in the traveled way or transverse to traffic flow on the Highway.
8. Inlets and inlet aprons shall not be located in the travel lanes of the Highway or CDOT Roadways.
9. 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 *USDCM, Volume I*, Chapter 7, Section 3.

#### 12.2.6.3.4 Maintenance Access Structures

Maintenance access Structures shall be incorporated into the storm drain system to provide access for inspection, cleaning, and other maintenance activities. Maintenance access shall be constructed at all junctions, changes in pipe size, drops, and grade changes. Maintenance access shall be provided at any change in horizontal alignment greater than 2 degrees. Maintenance access shall not be located in travel lanes of the Highway or travel lanes of Highway ramps. Inlets should be used for maintenance access where permitted by pipe sizes according to the CDOT *DDM*.

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 maintenance access Structure.

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

Maintenance access and junction Structure floors shall be shaped to fit the pipe inverts to minimize hydraulic losses within the Structure.

Maintenance access Structures, 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.

#### 12.2.6.4 Water Quality Control Measures

If PWQ is implemented, the Contractor is to design, construct, and locate all ponds, low impact development (LIDs), and water quality vaults.

#### 12.2.6.5 Off Site Drainage Systems

The Contractor shall assess the impacts of the increase in peak flows on the downstream system and provide as part of the drainage report to CDOT for Review and Acceptance. The report shall provide information regarding the source and amount of flows discharged off Site and the characteristics of the off Site system receiving the increase in peak flow. The report shall include options for mitigating the increase in peak flows to the off Site system. The report also shall include a record of communications with the owner of the off Site system and their stated position regarding the proposed design to address potential impacts due to the increase in peak flows.

The Contractor shall take immediate temporary action to mitigate potential impacts due to the increased peak flows while awaiting Acceptance for proposal to provide permanent mitigation of potential impacts.

The Contractor shall mitigate the increase in anticipated peak flow rates, if necessary, based on the Local Agency direction and as Approved by CDOT.

#### 12.2.6.6 Bridge Deck Drainage

All deck drainage should be carried to the ends of the Bridge. Drains at the end of the Bridge should have sufficient inlet capacity to carry all of the minor drainage. A curb roll is required from the Bridge ends to the end of the guardrail. At the end of this curb roll, an inlet and pipe (preferred design) or well depressed

rundown with a transition from the curb roll is required to convey the drainage down the fill slope. Additionally, storm drains shall be provided at the ends of the Bridge to minimize flow onto the Bridge. Combination curb opening and grated inlets should be used. No intermediate deck drainage is allowed.

See Book 2, Section 15, for more information on Bridge deck drainage.

#### **12.2.6.7 Stormwater Pumping Stations**

The use of stormwater pumping stations shall not be permitted.

#### **12.2.6.8 Drain Outfalls**

Cross Drain and storm drain outfalls shall be designed such that the outlet elevation matches the receiving drainageway flowline. Outfalls shall be oriented in a downstream direction and designed to minimize existing habitat disturbances during construction.

Permanent erosion protection shall be provided at all outfalls and along the drainage flowlines where needed. Energy dissipaters shall be designed in accordance with FHWA *HDS-5, Hydraulic Design of Highway Culverts*, or UDFCD *USDCM, Design of Low Tailwater Riprap Basins for Storm Sewer Pipe Outlets*.

All drain outfalls require either a headwall or flared end section regardless of pipe size. All drain outfalls with a pipe diameter (or an equivalent diameter) of 36 inches or larger shall require toe walls. End sections or headwalls shall be used for drains 48 inches and smaller. A headwall shall be used for any drain 54 inches and larger. Saddle headwalls shall not be used. Concrete pipe joint fasteners for end sections shall be installed so that a minimum of 15 linear feet of the outlet end of the pipe are mechanically locked together.

The effect 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 FHWA *HEC-22, Urban Drainage Design Manual*.

Grouted boulder rundowns must extend down to bedrock or to at least 2 feet below the ultimate scour depth in the channel in the receiving water, whichever is less.

#### **12.2.7. Scour and Erosion Control**

Scour, rill, or channel erosion, slope failures, and areas with poor vegetative cover within the Project limits caused by the Work shall be identified and corrected by the Contractor.

Bridges over drainageways shall be designed in accordance with the CDOT *DDM* 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, Evaluating Scour at Bridges*, and *HEC-20, Stream Stability at Highway Structures*. Scour countermeasures shall be designed in accordance with the FHWA *HEC-23, Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance-Third Edition*.

Outlet protection for culverts shall be designed in accordance with the standards of the *USDCM*, Chapter 9, Section 3 or FHWA *HDS-5, Hydraulic Design of Highway Culverts* or UDFCD *USDCM Design of Low Tailwater Riprap Basins for Storm Sewer Pipe Outlets*.

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 the criteria above, shall be increased by 50 percent where the riprap is placed underwater to provide for uncertainties associated with this type of placement.
4. Stones greater than the D100 spherical diameter shall not be used.
5. Minimum D50 shall not be less than 9 inches.
6. Geotextile (Drainage) (Class 1) shall be used under all riprap per CDOT M&S Standards.

### **12.2.8. Subsurface Drainage Systems**

Where needed, subsurface drainage systems (e.g., underdrains, edge drains) shall be designed in accordance with the CDOT *DDM*. Subsurface drainage systems shall not be discharged to the stormwater systems, with the exception of open channel conveyances.

Groundwater may be encountered during construction of this Project. If groundwater is day-lighted to the ground surface via storm drains (point source), a Subterranean Permit from CDPHE shall be required. Upon completion of the Project, the permit shall be transferred to CDOT. The Contractor shall be responsible for obtaining the permit. Refer to Book 2, Section 5.

If underdrains are found to 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 for the Project are provided in the Reference Documents.

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.

### **12.2.9. Irrigation Facilities**

All irrigation ditches, canals, and laterals crossing the Project shall be protected and preserved in place, or reconstructed as needed to accommodate the Project, and the Contractor shall ensure all facilities are maintained so that normal ditch operations are uninterrupted. The Contractor shall coordinate with the appropriate owners to identify and mitigate any potential disturbance to the irrigation facilities or operations. All irrigation facilities impacted by the Project shall be cleaned prior to Final Acceptance.

The Contractor shall limit stormwater discharges to irrigation ditches to be equal to or less than pre-Project discharges.

See Table 12-3 for a summary of irrigation facilities potentially affected by the Project. For additional information on coordination with the Mason Lateral irrigation, see Book 2, Section 6.

**Table 12-3 Irrigation Summary Table**

Location	Irrigation Type	Irrigation Ditch Name	Irrigation Owner	Relocation by
Station 817+68	18" RCP Lateral	Private	Orris	Contractor
Station 827+90	To be determined	Private	Thurston	To be determined
Station 828+50	To be determined	Private	Thurston	To be determined
Station 836+50	To be determined	Private	Thurston	To be determined
Station 843+25	To be determined	Private	Thurston	To be determined
Station 849+50	To be determined	Private	Thurston	To be determined
Station 880+14	36" RCP Lateral	Mason Lateral	Florida Consolidated Ditch Company	Contractor within ROW
Station 893+00 R – Station 905+50 R	Open Ditch	Mason Lateral	Florida Consolidated Ditch Company	Contractor within ROW
Station 909+00 R – Station 918+50 R	Open Ditch	Mason Lateral	Florida Consolidated Ditch Company	Contractor within ROW
Station 927+00 R – Station 947+50 R	Private Ditch	Private	Craig	Owner
Station 927+00 R – Station 947+50 R	Private Ditch	Private	Craig	Owner
Station 974+00 R – Station 980+00 R	Private Ditch	Private	Puig	Owner
Station 986+60	30" CMP	Private	Webb/Piccoli	Contractor
Station 989+00 R	Stock Pond	Private	Webb	Contractor
Station 993+50R – Station 998+50R	Private Ditch	Private	Webb	Contractor

### 12.2.10. Area-Specific Drainage Requirements and/or Information

#### 12.2.10.1 US 160

Currently, there are 6 curb inlets along the median in US 160 and within the improvements at the existing US 550 and US 160 intersection. US 160 median improvements will require removal and replacement of the inlets. The proposed inlets shall meet allowable street capacity and inlet capacity criteria described in this Section 12 and shall connect to existing pipes in US 160. No new pipe culverts or construction at the outfalls into Wilson Gulch are anticipated.

#### 12.2.10.2 Mason Lateral Irrigation Ditch

The Contractor shall incorporate the Mason Lateral irrigation improvements in accordance with Book 2, Section 6, and the executed Third-Party Agreement between CDOT and the Florida Consolidated Ditch Company.

#### 12.2.10.3 Webb Ranch Stock Ponds

Near station 990+00 on the east side of US 550, there are 3 existing stock ponds within Webb Ranch. Stock ponds impacted by the Highway improvements shall be expanded or relocated as needed to

provide an equivalent storage volume to the existing pond volume and shall route flows in a manner similar to the current condition before it is piped under US 550. The Contractor shall survey the existing ponds to determine the equivalent storage volume.

#### **12.2.10.4 Piccoli Property Stock Pond**

Near station 986+00 on the west side of US 550, there is an existing stock pond within the Piccoli property and adjacent to the proposed Frontage Road. This pond shall be filled by the Contractor to match the surrounding terrain. In the proposed condition, flows from the Webb Stock Pond that are currently piped to the Piccoli pond shall be piped under US 550 and routed to the existing drainage swale immediately south of the existing Piccoli pond.

### **12.3 Construction Requirements**

The Contractor shall map all new and existing (remaining) outfalls for inclusion into CDOT's GIS system.

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

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

The Contractor shall comply with the CDOT *Design Bulletin Pipe Material Selection Policy*, except where required pipe Materials are specified herein. The most current version, as signed by the CDOT Chief Engineer at the time of the Proposal Due Date, shall be utilized.

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

- The Contractor shall sample soil and water.
- References to "Project Manager" in the Guide shall be the Contractor.
- The Contractor shall provide a sampling schedule for pipe selection to CDOT for review 30 Days after issuance of the First Notice to Proceed (NTP1).
- Pipe material selection report shall be submitted as part of the Drainage Reports.
- Storm Drains that are both parallel to and within the strap zone of retaining walls shall be solid wall plastic conduit.

### **12.4 Deliverables**

#### **12.4.1. Drainage Reports**

##### **12.4.1.1 Master Drainage Report**

The Contractor shall prepare a Master Drainage Report and submit it to CDOT for Acceptance concurrent with the Preliminary Design Plans submittal.

##### **12.4.1.2 Interim Drainage Reports**

The purpose of an Interim Drainage Report is to actively capture and document all changes to design between the Master and Final Report submittals. Interim Drainage Reports shall be submitted by the Contractor to CDOT for Acceptance. The Contractor shall create and include an index of changes to design with each Interim Drainage Report submittal.

### **12.4.1.3 Final Drainage Report**

The purpose of the Final Drainage Report is to integrate all Accepted Interim Drainage Reports into one stand-alone report for the Project. The Final Drainage Report shall be prepared by the Contractor and submitted to CDOT for Acceptance prior to Notice of Final Acceptance. The Contractor shall include a summary index that incorporates all interim report changes with the Final Drainage Report submittal. No addenda to the Final Drainage Report shall be permitted.

### **12.4.1.4 Documentation Procedure**

Drainage Reports shall follow the documentation procedure in Chapter 4 of the CDOT *DDM* and 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, but not limited to, catch basins, storm drain systems, cross drains, ditches, swales, detention/infiltration 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 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 this Section 12 and all drainage 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.

In addition to the documentation procedure in Chapter 4 of the CDOT *DDM*, the Contractor shall 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.

### **12.4.1.5 Drainage Report Outline**

The Drainage Reports shall use the report outline below as guidance. The report outline shall also address the documentation requirements set forth in Chapter 4 of CDOT's *DDM*. New sections or additional subsections shall be added as necessary to fully document the design:

1. TABLE OF CONTENTS
2. INTRODUCTION
  - A. Location of Improvements
  - B. Description of Improvements
  - C. Discussion of Drainage Investigation

3. CROSS DRAINAGE, DRAINAGEWAY, AND IRRIGATION DITCH CROSSINGS
  - A. Location and General Discussion
  - B. Hydrology and Design Flow Development
    - i. Information Sources
  - C. Agency Coordination (i.e., FEMA, Local Agencies)
  - D. Description of Structural Design (i.e., for non-CDOT standard concrete box culverts)
  - E. Hydraulic Design
  - F. Irrigation Ditch Crossings
  - G. Drainageways and Floodplains
  - H. Scour Analysis
  - I. Bank Stabilization
4. ROADWAY DRAINAGE SYSTEMS
  - A. General Discussion
  - B. Design Coordination
    - i. Adjacent Segments
    - ii. Agency Coordination
  - C. Drainage Basin Delineations and Characterization
    - i. Existing Basins
    - ii. Proposed Basins
  - D. Hydrology and Design Flow Development
  - E. Pavement, Median and Roadside Drainage
    - i. Inlet/Catch Basin Spacing Design
    - ii. Storm Drain Design
    - iii. Roadside Ditch and Channel Design
    - iv. Erosion Control Design
5. PERMANENT BEST MANAGEMENT PRACTICES
  - A. Assumptions and Methodologies
    - i. Allowable Release Rate Discussion
  - B. Hydrology and Hydraulics
    - i. Storage and Outlet Design Documentation
6. REFERENCES
7. APPENDICES
  - A. Hydrologic Analysis
    - i. On Site Hydrology
    - ii. Off Site Hydrology
    - iii. Precipitation Data
    - iv. Soil Survey
    - v. Land Use
    - vi. FEMA Maps
  - B. Hydraulic Analysis
    - i. Spread width, Inlet and Storm Drain Calculations

- ii. Roadside Ditch and Channel Calculations
  - iii. Hydraulic Grade Line Calculations
  - iv. Drain Outfalls, Scour and Erosion Control Calculations
  - v. Sub-Drainage Systems
- C. Permanent Best Management Practices
- i. Extended Detention Basin Calculations
  - ii. Stage Storage Calculations
  - iii. Trickle Channel Calculations
  - iv. Water Quality Structure Calculations
- D. Basin Maps
- i. Existing and Proposed On-Site Basin Maps
  - ii. Off-Site Basin Maps (full size 22-inch by 34-inch sheets)
- E. Pipe Material Selection Report
- F. Maintenance Exhibit

The Contractor shall submit to CDOT the Master Drainage Report, all Interim Drainage Reports, and the Final Drainage Report for Acceptance. All Drainage Reports shall be signed and sealed. The Contractor also shall submit to CDOT an electronic copy of all signed and sealed drainage reports in a format compatible with Adobe .PDF. All drainage reports shall include electronic copies of all computer analysis input and output files in the native file format.

#### **12.4.2. Water Quality Reports**

If the Contractor elects to install PWQ CM, a Water Quality Report will be required in accordance with CDOT *DDM*.

#### **12.4.3. Drainage Design Plans**

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

The Contractor shall submit all applicable plans with each drainage report.

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

##### **1. PLAN VIEW**

- A. 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.
- B. Provide the location of all existing and proposed inlets, maintenance access Structures, 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 identification (ID), station and offset, item, length, pay depth, and notes.
- C. Provide all existing and proposed grading.

D. Provide all Utility locations and Relocations.

E. Provide location of ROW lines.

**2. PROFILES**

A. 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 and EGL for the 10-year and 100-year event.

B. 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, 50 and 100 year design discharge, tailwater, and headwater elevation on all applicable profile sheets for cross drains.

**3. DRAINAGE DETAILS**

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

**4. PERMANENT WATER QUALITY CM DETAILS FOR EXTENDED DETENTION BASIN (EDB) (If needed)**

A. 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, micro-pool, emergency spillway, and outlet structure. Include all locations of Utilities and property lines. Include point labels to define location and elevations within the facility.

B. Provide a table summarizing each point label. The table shall include at a minimum the point label, station and offset, northing, easting, elevation, and notes.

C. Provide a cross section of the EDB from where flows enter the pond to the outlet structure. Label elevations for the Water Quality Capture Volume (WQCV). Include slopes and elevations of all features.

D. Provide a geometry plan of the EDB from where flows enter the pond to the outlet structure. Include access Roads.

E. Provide specific details for the forebay, trickle channel, micro-pool, emergency spillway, and outlet Structure.

**5. PWQ CM DETAILS FOR POROUS LANDSCAPE DETENTION (PLD) (If needed)**

A. Provide each PLD in plan view. Provide existing and proposed contours that define limits of overall facility. Include all locations of Utilities, storm and irrigation. Include point labels to define location and elevations within the facility.

B. Provide a table summarizing each point label. The table shall include at a minimum the point label, station and offset, northing, easting, elevation, and notes.

C. Provide a cross section of the PLD from where flows enter the pond to the outlet structure. Label elevations for the WQCV. Include slopes and elevations of all features.

- D. Provide a geometry plan of the EDB from where flows enter the pond to the outlet structure.
- E. Provide specific details for the growing medium and geomembrane and underdrain if required.

#### 12.4.4. Drainage As-Constructed Documents

##### 12.4.4.1 Drainage As-Constructed Documents

The Contractor shall provide accurate as-constructed survey of the constructed drainage systems for the Project per the requirements of Book 2, Section 9.

The Contractor shall submit As-Constructed Documents to CDOT for Acceptance per the requirements of Book 2, Section 3.

Clearly label and locate all items of Work with station, offset, coordinates, and elevation information based on surveys of what was actually built in the field. Provide summaries of all As-Constructed drains with the following hydraulic information, at a minimum: pipe/culvert size, invert elevations and slope.

#### 12.5 Deliverables

The Contractor shall submit the following to CDOT (and all applicable review agencies) for Review, Acceptance, or Approval:

**Table 12-4 Deliverables**

<b>Deliverable</b>	<b>Review, Acceptance, or Approval</b>	<b>Schedule</b>
Temporary Drainage Plans	Acceptance	Within 14 Days prior to the implementation of each TCP
Sampling Schedule for Pipe Selection	Review	30 Days after issuance of NTP1
Master Drainage Report	Acceptance	Concurrent with Preliminary Design Plans
Interim Drainage Reports	Acceptance	Prior to the RFC Documents submittal
Final Drainage Report	Acceptance	Prior to Project Final Acceptance
Revised Final Drainage Report (as required)	Acceptance	Prior to Project Final Acceptance
Drainage As-Constructed Documents	Acceptance	Per the requirements of Book 2, Section 3
Temporary Drainage As-Constructed Documents	Acceptance	To be maintained during the duration of the Project
Pond Certification Letter *	Acceptance	Prior to Final Acceptance
Information required for the statewide notification compliance portal *	Acceptance	Prior to Final Acceptance

\* These deliverables are required only if PWQ CMs are provided.

#### 12.6 Project Special Provisions

The following Project Special Provisions supplement or modify the CDOT Standard Specifications for Road and Bridge Construction and take precedence over the CDOT Standard Specifications and plans.

The Contractor is responsible to have a copy of the CDOT Standard Specifications at all times on the Project Site.

### **Index of Project Special Provisions**

Revision of Section 603                      Reinforced Concrete Pipe

#### **REVISION OF SECTION 603 REINFORCED CONCRETE PIPE**

Subsection 603.03 shall include the following:

The Contractor shall provide a mockup for any connection between HDPE pipe and concrete drainage facilities for CDOT Review and Acceptance prior to construction.

Subsection 603.07 shall include the following:

Joint systems for cross drains and storm drains shall be watertight. All storm drain and cross drain segments between junction structures, including inlets, and between the ends of cross drains must be video or television (TV) inspected following installation and backfill. Video/TV inspection shall be sufficient to clearly inspect the circumference of each joint to verify joint construction is in accordance with the manufacturer's recommendations and Contract Documents. The Contractor shall provide a DVD of videos and inspection reports for each inspected segment. Reports shall identify the location of any discovered deficiencies and the proposed method of correction. Prior to construction, the Contractor must submit a Method Statement for constructing watertight joints for Approval by CDOT. Construction and inspection of joints shall be performed by the Contractor in accordance with methods approved by CDOT. Should any installations fail to meet the requirements, it shall be corrected at the Contractor's expense so that inspection requirements are satisfied.

Subsection 603.07(a) shall include the following:

Joints for all circular and elliptical reinforced pipes shall be made with confined rubber gaskets. Reinforced 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 603.07(c) shall include the following:

All welding of HDPE pipe and fittings shall be performed by qualified and certified personnel. Certifications shall be provided to CDOT prior to performing any welding for the Project.