

CITY OF BOULDER
DESIGN AND CONSTRUCTION STANDARDS

CHAPTER 7
STORMWATER DESIGN

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
7.01 GENERAL	1
(A) INTENT.....	1
(B) COMPREHENSIVE FLOOD AND STORMWATER AND GREENWAYS MASTER PLANS.....	1
(C) REFERENCE STANDARDS	1
(D) FLOODPLAINS	1
(E) STORMWATER QUALITY AND EROSION CONTROL	1
(F) WETLANDS PROTECTION	2
(G) STREETS	2
(H) IRRIGATION DITCHES AND LATERALS.....	2
(I) MULTIPLE FUNCTIONS OF MAJOR DRAINAGEWAYS	2
(J) DEFINITIONS	3
7.02 CONCEPTUAL DRAINAGE REPORT AND STORMWATER PLAN.....	4
(A) GENERAL.....	4
(B) CONCEPTUAL DRAINAGE REPORT	5
(C) CONCEPTUAL STORMWATER PLAN.....	5
7.03 PRELIMINARY DRAINAGE REPORT AND STORMWATER PLAN.....	5
(A) GENERAL.....	5
(B) PRELIMINARY DRAINAGE REPORT.....	5
(C) PRELIMINARY STORMWATER PLAN	8
7.04 FINAL DRAINAGE REPORT AND STORMWATER PLAN	9
(A) GENERAL.....	9
(B) FINAL DRAINAGE REPORT	9
(C) FINAL STORMWATER PLAN.....	11
(D) STORMWATER CONSTRUCTION PLANS AND DRAWINGS	11
7.05 HYDROLOGY	12
(A) GENERAL.....	12
(B) STORM FREQUENCY.....	13
(C) RAINFALL	13
(D) RUNOFF	13
7.06 MATERIALS AND INSTALLATION.....	13
7.07 OPEN DRAINAGEWAYS	13
(A) GENERAL.....	13
(B) DRAINAGEWAY TYPES.....	14
(C) DRAINAGEWAY FLOW COMPUTATION	16

(D)	DRAINAGEWAY DESIGN STANDARDS	16
(E)	HYDRAULIC STRUCTURES	18
7.08	STORM SEWERS.....	19
(A)	SYSTEM DESIGN	19
(B)	LOCATION.....	19
(C)	DEPTH	19
(D)	SIZE	19
(E)	SLOPE	20
(F)	ALIGNMENT.....	20
(G)	SEPARATIONS AND CROSSINGS.....	20
(H)	TAPS.....	20
(I)	GROUND WATER BARRIERS	20
(J)	EXTENSIONS	20
(K)	MANHOLES.....	20
(L)	HYDRAULIC DESIGN.....	21
7.09	INLETS	21
(A)	SPECIFICATIONS.....	21
7.10	STREET DRAINAGE	22
(A)	FUNCTION OF STREETS IN THE DRAINAGE SYSTEM	22
(B)	STREET CLASSIFICATION AND ALLOWABLE RUNOFF ENCROACHMENT.....	23
(C)	HYDRAULIC STREET CAPACITY.....	23
(D)	CROSS STREET FLOW.....	23
7.11	CULVERTS	24
(A)	SYSTEM DESIGN	24
(B)	HYDRAULIC DESIGN.....	24
(C)	STRUCTURAL DESIGN	24
(D)	SPECIFICATIONS.....	24
7.12	DETENTION.....	26
(A)	SYSTEM DESIGN	26
(B)	DESIGN FREQUENCY, HYDRAULIC DESIGN, AND STORAGE REQUIREMENTS	26
(C)	DETENTION POND DESIGN.....	27
7.13	CONSTRUCTION STORMWATER MANAGEMENT.....	27
(A)	INTENT.....	27
(B)	STORMWATER MANAGEMENT PLAN REQUIREMENTS.....	27
(C)	INSPECTION AND MAINTENANCE REQUIREMENTS	31
7.14	LAND DEVELOPMENT PLANNING USING LID TECHNIQUES	31
(A)	INTENT.....	31
(B)	REQUIREMENTS FOR ALL DEVELOPMENTS	32
(C)	LID TECHNIQUES	32
7.15	POST-CONSTRUCTION STORMWATER QUALITY REQUIREMENTS.....	32
(A)	INTENT.....	32
(B)	APPLICABLE DEVELOPMENT SITES	32
(C)	REQUIREMENTS	34
7.16	POST-CONSTRUCTION STORMWATER QUALITY TREATMENT APPROACH	36
(A)	SELECTION AND DESIGN OF SCMS	36
(B)	PRELIMINARY INFILTRATION FEASIBILITY SCREENING.....	37

(C)	TREATMENT APPROACH SELECTION	38
(D)	TREATMENT APPROACH DESIGN CRITERIA	41
(E)	SOIL AND INFILTRATION TEST REQUIREMENTS	43
7.17	POST-CONSTRUCTION STORMWATER APPROVAL REQUIREMENTS	45
(A)	GENERAL	45
(B)	STORMWATER AS-BUILT DRAWINGS	46
(C)	POST-CONSTRUCTION ACCEPTANCE INSPECTION REQUIRED.....	46
(D)	VEGETATION WARRANTY REQUIRED	46
7.18	POST-CONSTRUCTION STORMWATER QUALITY INSPECTION AND MAINTENANCE REQUIREMENTS	47
(A)	APPLICABILITY	47
(B)	INSPECTION AND MAINTENANCE REQUIREMENTS FOR SCMS	47
(C)	INSPECTION AND MAINTENANCE GUIDE.....	48

LIST OF TABLES

<u>Number</u>	<u>Page</u>
Table 7-1: Design Storm Frequencies	13
Table 7-2: Manning’s “n” for Storm Sewers	19
Table 7-3: Required Manhole Sizes.....	20
Table 7-4: Standard Inlets.....	22
Table 7-5: Allowable Street Drainage Encroachment	23
Table 7-6: Allowable Cross Street Flow.....	23
Table 7-7: Treatment Approach Selection Criteria.....	40
Table 7-8: Required Inspection Frequency by SCM Type	47

LIST OF FIGURES

<u>Number</u>	<u>Page</u>
Figure 7-1: Water Quality Treatment Approach Hierarchy.....	40

7.01 General

(A) Intent

The Stormwater Design Standards are intended to provide for a comprehensive and integrated stormwater utility system to convey and manage stormwaters in order to mitigate safety hazards and minimize property losses and disruption due to heavy storm runoff and flooding, maintain travel on public streets during storm events, enhance water quality of storm runoff by mitigating erosion, sediment and pollutant transport, control and manage increased runoff due to local development, establish effective long-term management of natural drainageways, and provide for ongoing and emergency maintenance of public stormwater systems. These standards are intended to prevent pollution and degradation of state waters.

The City is an operator of a Phase II Municipal Separate Storm Sewer System (MS4) and is required by the State of Colorado to hold a permit to discharge stormwater from its municipal separate storm sewer system to the waters of the State. The Stormwater Design Standards establish standards implementing the requirements of the MS4 Permit and Chapter 11-5, “Stormwater and Flood Management Utility,” B.R.C. 1981.

(B) Comprehensive Flood and Stormwater and Greenways Master Plans

All improvements proposed to the City’s stormwater system shall conform with the goals, policies, and standards outlined in adopted Comprehensive Flood and Stormwater and Greenways Master Plans.

(C) Reference Standards

Where not specified in these Standards or the B.R.C. 1981, to protect the public health, safety, and welfare, the Director will specify the standards to be applied to the design and construction of stormwater improvements and may refer to one or more of the references listed in the References Section of these Standards.

(D) Floodplains

Where improvements are proposed within a designated 100-year floodplain, as defined on the current FEMA Flood Insurance Rate Map (FIRM) or floodplain mapping adopted by the City, an applicant for construction approval shall satisfy and comply with all applicable regulations and requirements as set forth in Chapter 9-3, “Overlay Districts,” B.R.C. 1981.

(E) Stormwater Quality and Erosion Control

The USDCM, Volume 3, “Best Management Practices,” “Colorado Department of Transportation M-Standards, and/or City of Boulder, “Wetlands Protection Program Best Management Practices” manual shall be applied to address stormwater quality management and erosion control for all proposed projects and developments. An applicant for construction or development approval shall also satisfy and comply with all applicable regulations and requirements as set forth in Chapter 11-5, “Stormwater and Flood Management Utility,” B.R.C. 1981. All stormwater reports and plans shall include necessary analyses, mitigation measures, and improvements needed to meet these stormwater quality and erosion control standards.

(F) Wetlands Protection

Where improvements are proposed within a delineated wetland or wetland buffer area, as defined under the City's wetland protection ordinance, an applicant for construction approval shall satisfy and comply with all applicable regulations and requirements as set forth in Section 9-3-9, "Stream, Wetlands, and Water Body Protection," B.R.C. 1981, including any necessary identification, analyses, avoidance and mitigation measures, and improvements needed to address wetlands protection requirements.

(G) Streets

The primary function of streets is for safe traffic movement; therefore, streets shall be designed and constructed to accommodate runoff and convey it to downstream drainage facilities in order to minimize its interference with traffic. When the stormwater runoff accumulation in the street exceeds allowable limits, storm sewers or other drainage facilities are required to collect and convey the excess runoff.

(H) Irrigation Ditches and Laterals

Where a project or development is proposed adjacent to or impacts an existing irrigation ditch, an applicant for construction approval shall meet the following standards:

- (1) No storm runoff shall be conveyed into an irrigation ditch or lateral without written approval and permission from the affected irrigation ditch company or lateral owner.
- (2) An adequate right-of-way or drainage easement for maintaining the affected irrigation ditch shall be dedicated to the City.
- (3) The irrigation ditch or lateral shall not be relocated, modified, or altered without written approval and permission from the affected irrigation ditch company or lateral owner.
- (4) The irrigation ditch or lateral shall not be used for the following purposes:
 - (a) Basin boundaries to eliminate the contribution of the upper basin area in the evaluation of runoff conditions. Irrigation ditches shall not be assumed to intercept stormwater runoff.
 - (b) Outfall points for new development where runoff into irrigation ditches and laterals has increased in flow rate or volume, or where historic runoff conditions have been changed, without written approval and permission from the affected irrigation ditch company or lateral owner.

(I) Multiple Functions of Major Drainageways

Boulder Creek's numerous tributaries are part of a comprehensive natural open drainageway system. These drainageways provide open corridors and serve multiple functions, including without limitation, stormwater drainage and flood conveyance, wetlands and water quality enhancement, environmental protection and preservation, open space and wildlife areas, and recreational activities and trail corridors. Stormwater improvements impacting these drainageways shall be designed and constructed to respect, restore and enhance these functions in order to maintain the creek corridor ecology, environment and aesthetic value of such drainageways.

(J) Definitions

The words defined in this subsection and used in this Chapter have the meanings established in this section unless the context clearly indicates otherwise:

Applicable development site means (1) any new development or redevelopment site resulting in land disturbance of greater than or equal to one acre, including a site that is less than one acre that is part of a larger common plan of development or sale that would disturb or has disturbed one acre or more, or (2) any development site for which a stormwater detention pond is required under these Standards.

Common plan of development or sale means a plan or sale where multiple separate and distinct construction activities may be taking place at different times on different schedules in a contiguous area, within 1/4 mile, but remain related through such plan or sale.

Construction activity means an activity that disturbs the ground surface and associated activities that include, without limitation clearing, grading, excavation, demolition, installation of new or improved haul roads and access roads, staging areas, stockpiling of fill materials, and borrow areas. Activities from initial ground breaking through final stabilization are construction activities regardless of ownership. Construction activities do not include routine maintenance to maintain the original line and grade, hydraulic capacity, or original purpose of a facility. Activities to conduct repairs that are not part of routine maintenance, activities for replacement, and activities for repaving where underlying or surrounding soil is exposed, cleared, graded, or excavated are all construction activities for the purposes of this chapter.

Control measure means an activity, practice, or structural control used to prevent or reduce the discharge of pollutants to waters of the State. The two categories of control measures are:

Control measure for post-construction stormwater quality, also referred to as a stormwater control measure (SCM), means a permanent device, practice, or method for removing, reducing, retarding, or preventing targeted stormwater runoff constituents, pollutants, and contaminants from reaching receiving waters.

Control measures for erosion and sediment control means a device, practice, or method implemented on a construction site to remove, reduce, retard, or prevent pollutants or pollutant-laden water from discharging off the site. These control measures may be structural (e.g., wattles/sediment control logs, silt fences, earthen dikes, drainage swales, sediment traps, subsurface drains, pipe slope drains, inlet protection, outlet protection, gabions, sediment basins, temporary vegetation, permanent vegetation, mulching, geotextiles, sod stabilization, slope roughening, maintaining existing vegetation, protection of trees, and preservation of mature vegetation) or non-structural (e.g., schedules of activities, prohibitions of practices, pollution prevention and educational practices, and maintenance procedures).

Detention pond means a structural control intended to store increased runoff from developed property and release this runoff at the historic rate that existed prior to development or redevelopment.

LID technique means low impact development technique.

Low Impact Development (LID) technique means a non-structural land development planning and site layout strategy intended to reduce stormwater volume, peak discharge, and pollutant load.

MS4 Permit means the Municipal Separate Storm Sewer System Phase II discharge permit issued by the Colorado Department of Public Health and Environment pursuant to Regulation 61, Colorado Permit Discharge System, 5 CCR 1002-61, and the Colorado Water Quality Control Act, C.R.S. § 25-8-101, *et seq.*, as that permit may be amended in the future.

New development means a vegetative or non-vegetative change in the existing land surface, including without limitation construction activities, compaction associated with stabilization of structures, road

construction, construction or installation of a building or other structure, and creation of impervious surfaces, and land subdivision for a site that does not meet the definition of redevelopment.

Receiving Pervious Area (RPA) means a vegetated pervious area that receives stormwater from an impervious area, thus un-connecting the impervious area from directly discharging stormwater to a local stream, lake, or to the public stormwater utility system.

Redevelopment means the creation or addition of impervious area or paved surface on a site that is already substantially developed with 35% or more existing imperviousness, including without limitation expansion of a building footprint, addition or replacement of a structure, structural development, and construction or replacement of paved surface area.

Stormwater utility system means the municipal storm sewer system that includes without limitation the conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, human-made channels, or storm drains) that discharge to state waters and is owned or operated by the City and designed or used for collecting or conveying stormwater, and is not a combined sewer or part of a publicly owned treatment works.

Stormwater Quality Design Standard means a performance metric from the MS4 Permit that must be demonstrated to be achieved to document compliance with City of Boulder stormwater requirements for applicable development sites. Stormwater Quality Design Standards are volume reduction, Water Quality Capture Volume (WQCV), pollutant removal, and constrained redevelopment site standards, as defined in Subsection 7.16(D).

Treatment area means a single drainage basin or group of drainage basins for which a proposed design completely satisfies a single Stormwater Quality Design Standard.

Unconnected Impervious Area (UIA) means an impervious area that discharges to a RPA and, therefore, does not discharge directly to a local stream, lake, or the stormwater utility system.

Water Quality Capture Volume (WQCV) means the volume equivalent to the runoff from an 80th percentile storm, meaning that 80 percent of the most frequently occurring storms are fully captured and treated and larger events are partially treated.

7.02 Conceptual Drainage Report and Stormwater Plan

(A) General

- (1) If a project is determined to be of sufficient size or complexity, the Director may require the preparation of a Conceptual Drainage Report and Stormwater Plan by the Engineer to assess feasibility of stormwater utility system improvements. The purpose of the Conceptual Drainage Report and Stormwater Plan shall be to demonstrate that required stormwater utility system facilities can be accommodated on the development site and to identify and plan for impacts to neighboring properties and stormwater utility systems.
- (2) The Director reviews Conceptual Drainage Reports and Stormwater Plans for local-level purposes, including conformance with these Standards pertaining to stormwater utility systems.
- (3) Measured or calculated parameters provided in all submitted Conceptual Drainage Reports and Stormwater Plans shall be reported using the English System of Measurement unless Metric System units are the standard expression for the parameter.
 - (a) Land or surface area shall be reported in square feet (ft², sf, or sq.ft.) for projects having a land disturbance area less than one acre and shall be reported to the

nearest tenth of an acre (acre or ac.) for projects having a land disturbance of one acre or greater.

- (b) Water volume shall be provided in cubic feet (ft³ or cu.ft.).
- (c) Soil volume shall be provided in cubic yards (yd³ or cu.yd.).
- (d) Water discharge (also stated as flow rate or flow) shall be provided in cubic feet per second (ft³/s or cfs).
- (e) Infiltration rate shall be reported in inches per hour (in/hr).

(B) Conceptual Drainage Report

The Conceptual Drainage Report shall provide a response for each of the elements listed in the Preliminary Drainage Report narrative requirements, as set forth in Subsection 7.03(B) of these Standards, or if more data is necessary identify the data collection efforts necessary to complete the Preliminary Drainage Report.

(C) Conceptual Stormwater Plan

The Conceptual Stormwater Plan shall address each of the elements listed in the Preliminary Stormwater Plan requirements, sufficient to provide an overall drainage plan, as set forth in Subsection 7.03(C) of these Standards, or if more data is necessary identify the data collection efforts necessary to complete the Preliminary Stormwater Plan.

7.03 Preliminary Drainage Report and Stormwater Plan

(A) General

- (1) The Director may require the preparation of a Preliminary Drainage Report and Stormwater Plan by the Engineer. The Preliminary Drainage Report and Stormwater Plan will be used to assess the impacts and public improvement needs of any proposed project or development site. Approval of the Preliminary Drainage Report and Stormwater Plan shall not be construed as approval of specific design details.
- (2) The Director reviews Preliminary Drainage Reports and Stormwater Plans for local-level purposes, including conformance with these Standards pertaining to stormwater utility systems.
- (3) Measured or calculated parameters provided with the Preliminary Drainage Report and Stormwater Plan shall be consistent with Subsection 7.02(A)(3) of these Standards.

(B) Preliminary Drainage Report

The Preliminary Drainage Report shall define the proposed development site, describe existing conditions, and propose needed stormwater facilities to meet the requirements of these Standards. The Preliminary Drainage Report shall include, at a minimum, narratives addressing the items listed in this subsection except for those items not applicable to the proposed development site. The Preliminary Drainage Report shall include visual representations and/or refer to the Preliminary Stormwater Plan sheet with the corresponding content (see Subsection 7.03(C) of these Standards for Preliminary Stormwater Plan requirements). The Preliminary Drainage Report narrative shall include the following information:

- (1) **Cover Page:** Provide a cover page that includes the site name, site address, submittal and revision dates as applicable, site owner, and preparing Engineer.
- (2) **Site Description**
 - (a) Site Location Description
 - (i) County, city, township, range, section, and ¼ section.
 - (ii) Site vicinity and legal boundaries map.
 - (iii) Adjacent developments and associated land use.
 - (iv) Roadways located within or adjacent to the site.
 - (b) Property Description
 - (i) Site area and proposed area of disturbance in acres.
 - (ii) Existing and proposed site use.
 - (iii) Land surface (vegetation type, topography, slope, buildings, etc.)
 - (iv) Easements within or adjacent to the site.
 - (c) Drainage Description
 - (i) Major and minor drainageways.
 - (ii) Natural drainage features (e.g., streams, lakes, ponds, wetlands, and buffer areas).
 - (iii) Irrigation ditches.
 - (iv) Regulatory floodplain extents.
 - (v) Known drainage issues.
 - (vi) Hydrologic soil group map and description.
 - (vii) Geotechnical and groundwater site investigation results.
 - (viii) Preliminary Infiltration Feasibility Screening results and map (see Subsection 7.16(A) of these Standards).
- (3) **Drainage Basin Description**
 - (a) Major Drainage Basin
 - (i) General description of major drainage basin characteristics and flow patterns.
 - (ii) Flow conveyance from site to receiving major drainageway.
 - (iii) Reference to all applicable planning studies for the major drainageway and, if applicable, describe requirements of these plans for the development site.
 - (iv) Impact of site development on upstream and downstream properties.
 - (v) Impact of site development on downstream natural and constructed open channels and piped stormwater utility systems and the measures proposed to reduce or eliminate those impacts.
 - (b) Site Drainage Basin(s)

- (i) Existing and proposed basin and sub-basin characteristics for the site, including land cover, area, flow patterns, and discharge points for each basin/sub-basin.
 - (ii) Acceptance and conveyance of off-site stormwater into and through the proposed development site.
 - (iii) Overview of all existing and proposed conveyance, detention, and water quality facilities, including rationale, for each basin/sub-basin.
- (4) **Drainage Design Criteria**
- (a) Regulation Applicability
 - (i) Detention requirements (see Section 7.12 of these Standards).
 - (ii) Construction stormwater management requirements (see Section 7.13 of these Standards).
 - (iii) Post-construction stormwater quality requirements (see Section 7.15 of these Standards).
 - (iv) Stream, Wetland, and Waterbody Protection Requirements as set forth in Chapter 9-3, "Overlay Districts," B.R.C. 1981.
 - (v) Other applicable criteria and permits.
 - (b) Site Planning and Constraints
 - (i) Description of previous drainage studies or master plans for the site and adjacent areas and influence on proposed stormwater utility system design.
 - (ii) Description of site constraints caused by structures, utilities, etc. and influence on proposed stormwater utility system design.
 - (iii) Description of Low Impact Development (LID) techniques utilized for stormwater management with reference to completed form(s) as provided by the Director and included as an appendix (see Section 7.14 of these Standards).
 - (c) Hydrologic and Hydraulic Criteria
 - (i) Design storm(s).
 - (ii) Runoff calculation methods.
 - (iii) Detention storage and discharge calculation method.
 - (iv) Velocity and capacity calculation method(s) for inlets and conveyances.
 - (v) Water surface profile and hydraulic grade line (HGL) calculation methods.
 - (d) Post-Construction Stormwater Quality Criteria
 - (i) Selected treatment approach and design standards (see Section 7.16 of these Standards).
- (5) **Stream, Wetland, and Waterbody Impacts**
- (a) Description of floodplain impacts.

- (b) Required modification studies.
- (6) **Stormwater Conveyance Design**
 - (a) Description of proposed conveyance system.
 - (b) Conveyance path to major drainageway and capacity evaluation.
- (7) **Detention and Post-Construction Stormwater Quality Design**
 - (a) Description of each proposed facility (identifier, type, drainage area, size, treatment volumes, components, and function).
 - (b) Description of design compliance with detention and post-construction stormwater quality requirements with reference to completed form(s) as provided by the Director and included as an appendix (see Section 7.15 of these Standards).
- (8) **Conclusions**
 - (a) Drainage plan effectiveness.
 - (b) Compliance with requirements.
 - (c) Exclusions and variances.
- (9) **References:** Reference all standards, criteria, guidance documents, master plans, and technical reports used.
- (10) **Appendices**
 - (a) Completed form(s) documenting post-construction water quality compliance (Section 7.15 of these Standards).
 - (b) Completed form(s) documenting low impact development approaches (Section 7.14 of these Standards).

(C) Preliminary Stormwater Plan

The purpose of the Preliminary Stormwater Plan is to provide visual representations of existing and proposed site conditions to support the Preliminary Drainage Report narrative. The Preliminary Stormwater Plan shall be included with the Preliminary Drainage Report, submitted as a single PDF document. All Preliminary Stormwater Plan sheets shall be prepared on 24-inch by 36-inch paper with appropriate scale ranges. The Preliminary Stormwater Plan shall include plan sheets addressing, at a minimum, the following items, except for those items not applicable to the proposed development site:

- (1) **Overall Drainage Plan**
 - (a) Title block, legend, north arrow, and scale.
 - (b) Existing topographic contours.
 - (c) Property boundary.
 - (d) Major drainage basin boundaries with area, design point, and existing flow rate labels.
 - (e) Drainage flow arrows depicting flow patterns to, from, and within the site.
 - (f) Existing stormwater detention and water quality facility boundaries.

- (g) Easement boundaries.
 - (h) Existing waterways (streams, lakes/ponds, wetlands, and irrigation facilities).
 - (i) Land cover (vegetation and impervious surfaces).
 - (j) Key map depicting extents of detailed drainage plan sheets.
- (2) **Detailed Drainage Plan/s**
- (a) Title block, legend, north arrow, and scale (scale range of 1 inch = 20 feet to 1 inch = 100 feet).
 - (b) Existing (screened) and proposed (solid) topographic contours (2 feet max interval).
 - (c) Location and elevation of all waterways, regulated buffer areas, and 100-year floodplain.
 - (d) Property, right-of-way, and easement boundaries.
 - (e) Drainage basin/sub-basin boundaries with area, design point, and flow/release rate labels.
 - (f) Proposed outfall points and conveyance facilities to major drainageway with design point and flow/release rate labels.
 - (g) Existing and proposed structure boundaries.
 - (h) Existing and proposed stormwater conveyance facilities with size, slope, and material designation (storm sewers, culverts, open channels, inlets, and discharge points).
 - (i) Existing and proposed stormwater detention and water quality facilities with drainage area, surface area, side slope/wall, and component labels.

7.04 Final Drainage Report and Stormwater Plan

(A) General

- (1) The Director may require the preparation of a Final Drainage Report and Stormwater Plan by the Engineer. The report and plan will be used to assess the impacts and public improvements needs of any proposed project or development site.
- (2) The Director reviews Final Drainage Reports and Stormwater Plans for local-level purposes, including conformance with these Standards pertaining to stormwater utility systems.
- (3) Measured or calculated parameters provided with the Final Drainage Report and Stormwater Plan shall be consistent with Subsection 7.02(A)(3) of these Standards.

(B) Final Drainage Report

The Final Drainage Report shall describe the to-be-constructed drainage conditions for the site. The Final Drainage Report shall include, at a minimum, all required narratives of the Preliminary Drainage Report, as set forth in Subsection 7.03(B) of these Standards, and the items listed in this subsection, except for those items not applicable to the proposed development site. The Final Drainage Report shall include visual representations and/or refer to the Final Stormwater Plan

(Subsection 7.04(C) of these Standards) or construction drawings (Subsection 7.04(D) of these Standards) with the corresponding content.

The Final Drainage Report shall include a cover page, following the format set forth in Subsection 7.03(B) of these Standards and a certification page with the following statement prepared by a Professional Engineer licensed in the State of Colorado:

I hereby certify that this Final Drainage Report and Final Stormwater Plan for [Site Name] was prepared by me, or under my direct supervision, in accordance with sound engineering practice and all applicable state, federal and local regulations, including the provisions of the City of Boulder Design and Construction Standards.

Registered Professional Engineer

(Affix Seal)

State of Colorado No. _____

The Final Drainage Report shall include the following information:

- (1) **Site Description:** Updated narratives for all items listed in Subsection 7.03(B)(2) of these Standards.
- (2) **Drainage Basin Description:** Updated narratives for all items listed in Subsection 7.03(B)(3) of these Standards.
- (3) **Drainage Design Criteria:** Updated narratives for all items listed in Subsection 7.03(B)(4) of these Standards.
- (4) **Stream, Wetland, and Waterbody Impacts**
 - (a) Description of floodplain impacts.
 - (b) Required modification studies.
 - (c) Applicable permits obtained.
- (5) **Stormwater Conveyance Design**
 - (a) Description of proposed conveyance system.
 - (b) Conveyance path to major drainageway and capacity evaluation.
 - (c) Storm sewer, culvert, and inlet design (location, size, tributary area, and peak flows).
 - (d) Open channel design (location, size, tributary area, and peak flows).
 - (e) Outfall design (location, peak flows, and energy dissipation).
 - (f) Street drainage (see Section 7.10 of these Standards).
 - (g) Easement requirements.
 - (h) Maintenance requirements.
- (6) **Detention and Post-Construction Stormwater Quality Design**
 - (a) Description of each proposed facility (identifier, type, drainage area, size, treatment volumes, components, and function).
 - (b) Description of design compliance with detention and post-construction stormwater quality requirements with reference to completed form(s) as provided by the Director and included as an appendix (see Section 7.15).

- (c) Inlet design (description of pretreatment measures and energy dissipation).
 - (d) Basin and outlet design (storage volumes and release rates, including overflow spillway).
 - (e) Description of vegetation coverage and planting plan.
 - (f) Description of filter media selection and underdrain configuration.
 - (g) Easement requirements.
 - (h) Description of maintenance requirements with reference to Inspection and Maintenance Guide included as an appendix (see Section 7.18 of these Standards).
- (7) **Conclusions:** Updated narratives for all items listed in Subsection 7.03(B)(8) of these Standards.
- (8) **References:** Updated references for all items listed in Subsection 7.03(B)(9) of these Standards.
- (9) **Appendices**
- (a) Completed form(s) documenting post-construction water quality compliance (Section 7.15 of these Standards).
 - (b) Completed form(s) documenting low impact development approaches (Section 7.14 of these Standards).
 - (c) Inspection and Maintenance Guide (Section 7.18 of these Standards).
 - (d) Hydrologic calculations.
 - (e) Hydraulic calculations.
 - (f) Stormwater conveyance calculations.
 - (g) Detention and permanent water quality calculations.
 - (h) Critical reference information copied to create standalone document.

(C) Final Stormwater Plan

The Final Stormwater Plan shall detail the to-be-constructed drainage conditions for the site and follow the submittal requirements of the Preliminary Stormwater Plan, as set forth in Subsection 7.03(C) of these Standards.

- (1) **Overall Drainage Plan:** Updated plan depicting all items listed in Subsection 7.03(C)(1) of these Standards.
- (2) **Detailed Drainage Plan(s):** Updated plan(s) depicting all items listed in Subsection 7.03(C)(2) of these Standards.

(D) Stormwater Construction Plans and Drawings

Construction Plans and Drawings shall be submitted for review in conjunction with the Final Drainage Report. Preparation of Construction Plans and Drawings shall be consistent with Section 1.03 of these Standards. The following elements pertaining to site stormwater design shall, at a minimum, be included in the Construction Plans and Drawings.

- (1) **Stormwater Conveyance Construction Drawings**
 - (a) Plan drawing(s) depicting all proposed storm sewer and open channel conveyances following the requirements of Subsection 1.03(E)(2) of these Standards.
 - (b) Profile drawing(s) depicting all proposed storm sewer and open channel conveyances following the requirements of Subsection 1.03(E)(3) of these Standards.
- (2) **Detention and Post-Construction Stormwater Quality Construction Drawings**
 - (a) Plan drawing(s) depicting each proposed detention and post-construction stormwater quality facility following the requirements of Subsection 1.3(E)(2) of these Standards and, at a minimum, the following components, if proposed:
 - (i) Inlet and outlet structure locations and energy dissipation measures, including emergency spillways,
 - (ii) Proposed contours for treatment surface area and side slopes/walls,
 - (iii) Facility components (e.g. pretreatment, micropool, underdrain, etc.), and,
 - (iv) Vegetative cover.
 - (b) Profile and/or cross-sectional drawing(s) depicting each proposed detention and post-construction stormwater quality facility following the requirements of Subsection 1.3(E)(3) of these Standards and, at a minimum, the following components, if proposed:
 - (i) Inlet and outlet structure inverts,
 - (ii) Treatment area and side slope/wall surface elevations,
 - (iii) Filter media components and depths, and
 - (iv) Facility component elevations (e.g. pretreatment, micropool, underdrain, etc.).
 - (c) Detail drawing/s depicting each unique detention and post-construction stormwater quality facility component following the requirements of Subsection 1.3(E)(4) of these Standards and, at a minimum for the following components, if proposed:
 - (i) Pretreatment,
 - (ii) Outlet structure,
 - (iii) Underdrain, and
 - (iv) Other unique components.

7.05 Hydrology

(A) General

The methodologies and design standards for determining rainfall and runoff conditions for any development project are based on the standards prescribed in the USDCM, with local revisions as

prescribed in these Standards.

(B) Storm Frequency

Table 7-1, “Design Storm Frequencies,” indicates initial and major design storm frequencies to be used in the stormwater design or any project or development: Table 7-1: Design Storm Frequencies

Land Use	Initial Storm	Major Storm
Single Family Residential	2 Year	100 Year
All Other Uses	5 Year	100 Year
Detention Ponding Design	10 Year	100 Year

(C) Rainfall

The rainfall intensities to be used in computing runoff shall be determined using the USDCM, Volume 1 and the Boulder station of the NOAA Atlas 14 Point Precipitation Frequency Estimates.

(D) Runoff

- (1) **CUHP Method:** For basins larger than 160 acres, the Colorado Urban Hydrograph Procedure (CUHP) method shall be applied in conformance with the USDCM using local rainfall conditions.
- (2) **Rational Method:** For all basins smaller than 160 acres, the rational method, as described in the USDCM, shall be used to calculate runoff for both the initial and major storms.
- (3) **Runoff Coefficient:** The runoff coefficient to be used with the rational method may be determined based on either zoning/land use classifications or types of surface classifications prescribed in the USDCM. A composite runoff coefficient may be calculated using land areas impacted by specific classifications.
- (4) **Intensity:** The rainfall intensity used in the rational method shall be calculated per the USDCM using the NOAA Atlas 14 rainfall depth-duration-frequency data.

7.06 Materials and Installation

Construction of stormwater-related public improvements shall be in compliance with these Standards. All pipe and structures shall be of adequate strength to support trench and AASHTO HS-20 highway loadings. The type of pipe and structures to be installed shall comply with these Standards, and shall be based upon applicable design flows, site conditions, and maintenance requirements.

7.07 Open Drainageways

(A) General

- (1) **Designated Major Drainageways:** The following list identifies designated major drainageways in the City for primary stormwater conveyance:

Designated Major Drainageways		
Bear Canyon Creek	Four Mile Canyon Creek	South Boulder Creek
Bluebell Canyon Creek	Goose Creek	Sunshine Canyon Creek
Boulder Creek	Gregory Canyon Creek	Two Mile Canyon Creek
Boulder Slough	King's Gulch	Viele Channel
Elmer's Two Mile Creek	Skunk Canyon Creek	Wonderland Creek
Dry Creek Ditch No. 2		

- (2) **Design Approach:** Design of public improvements for local drainageways shall ensure opportunities to provide for open conveyance corridors that may serve multiple functions, including without limitation, stormwater drainage and flood conveyance, wetlands and water quality enhancement, environmental protection and preservation, open space and wildlife areas, and recreational activities and trail corridors. Stormwater improvements impacting local drainageways shall be designed and constructed to respect, restore and enhance these functions in order to maintain a natural ecology, environment and aesthetic value of such drainageways.

(B) Drainageway Types

- (1) **Definition:** Drainageways in the City are defined as natural or artificial channels as follows:

- (a) Natural channels include naturally developed creeks, streams and thalwegs, which have been geologically created through the erosion process over time. Boulder Creek is considered a natural channel.
- (b) Artificial channels include those that are designed, constructed, or developed by human effort. Artificial channels may be unlined or lined (where non-erosive conditions for unlined design cannot be met). Artificial channels also include irrigation ditches, roadside ditches, and drainage swales.

- (2) **Natural Drainageways**

- (a) The hydraulic properties of natural drainageways vary along each stream reach and are to be maintained in a naturally occurring and environmental form. Natural drainageways typically have mild slopes, are reasonably stable, and are not in a state of serious degradation or aggradation.
- (b) Where unstable conditions are created through the introduction of urbanized stormwater runoff, which alters the nature of flow peaks and volumes and may cause erosion, mitigation measures may be proposed in the natural drainageway to maintain a stabilized and naturally occurring condition. A detailed analysis will be required for all development proposals affecting natural drainageways in order to identify the impacts of changes in flow characteristics, erosion and sedimentation, wetland losses and water quality conditions.
- (c) Analyses of natural drainageways shall be provided for each project or development application affecting the drainageway. When performed, the Engineer is to prepare cross sections of the drainageway, define water surface profile for the existing and proposed minor and major storm events, investigate the bed and bank material to determine erosion and sediment transport tendencies, identify impacts on the naturally occurring conditions and ecology and study the bank slope and stream bed stability. An analysis shall include engineering calculations to ensure that

supercritical flow conditions do not result from proposed project or development activities. Natural channel improvements that would cause supercritical flow conditions shall not be permitted.

(3) **Unlined Artificial Drainageways**

- (a) Unlined artificial drainageways provide improved channel bottoms that are covered with wetlands, grass, or other vegetation, and may be used where naturally occurring drainageways are not present or as proposed under an adopted stormwater master plan. Designs for unlined drainageways shall comply with these Standards and the USDCM.
- (b) Unlined artificial drainageways are to provide conditions for slower flow velocities, reduced flow energy, increased flow retardance, and increased channel storage. The wetlands, grass, or other vegetation along stream beds and banks are intended to stabilize the channel, consolidate the soil mass of the bed, mitigate erosion, and control soil particles transport along the drainageway. Design of these improvements shall also consider opportunities for accommodating multiple functions along the drainageway, providing for a natural ecology, environment and aesthetic value.
- (c) Structural measures such as rock linings used for revetments, drop structures, scour aprons, or trickle channels may be approved as a means of controlling erosion for unlined artificial drainageways.

(4) **Lined Artificial Channels**

- (a) Where conditions for natural or unlined artificial drainageways are not available, including situations where limited right-of-way, supercritical velocities, or extremely erosive conditions exist, lined artificial channels may be constructed, subject to conformance with adopted stormwater master plans and the review, discretion, and approval of the City. Designs for lined artificial channels shall comply with these Standards and the USDCM. Lined artificial channels typically include rock-lined, grouted rip-rap, and concrete-lined stream beds and banks.
- (b) Rock-lined (rip-rapped) or grouted rip-rap channels are generally discouraged but are much preferred to concrete lined channels. A rock-lined or grouted rip-rap channel may typically be steeper and narrower, due to the higher friction factors of rock, and may include steeper banks or side slopes. The lining shall be capable of withstanding all hydraulic and hydrodynamic forces which tend to overtop the bank, deteriorate the lining, erode the soil beneath the lining, and erode unlined areas, especially for the supercritical flow conditions. If project constraints suggest the use of a rock-lined or grouted rip-rap channels, the Engineer shall present the justification and design concept to the City for consideration.
- (c) Concrete-lined channels are least desirable and may only be approved under severely restrictive circumstances. The concrete lining shall withstand all hydraulic and hydrodynamic forces which tend to overtop the bank, deteriorate the lining, erode the soil beneath the lining, and erode unlined areas, especially for the supercritical flow conditions. If project constraints suggest the use of a concrete lined channel, the Engineer shall present the justification and design concept, including a discussion of non-concrete-lined alternatives and why they are not feasible, to the City for consideration.

- (5) **Roadside Ditches and Drainage Swales:** Roadside ditches and drainage swales are open drainage systems that are not part of the major drainageway system and are used to convey minor and major stormwater runoff in projects and developments and along rural-type

streets. The design of these drainage swales is similar to the design of unlined artificial drainageways on a reduced scale.

(C) Drainageway Flow Computation

Uniform flow and critical flow computations for drainageways shall be performed in accordance with the USDCM.

(D) Drainageway Design Standards

The design standards for drainageways involve a wide range of options intended to create safe, environmental, multipurpose, and aesthetic improvements. The following planning, evaluation, and design standards shall be applied:

(1) Natural Drainageways

- (a) The drainageway and overbank areas necessary to pass 100-year storm runoff are to be reserved for stormwater purposes.
- (b) Water surface profiles shall be defined to identify floodplain conditions.
- (c) Flood fringe filling along naturally defined drainageways, which reduces drainageway flood storage capacity and increases downstream runoff peaks, is to be avoided unless approved as part of an adopted City stormwater master plan.
- (d) Roughness factors (n), which are representative of unmaintained channel conditions, shall be used for the analysis of water surface profiles and to determine velocity limitations
- (e) The Director may allow the placement of erosion control structures, such as drop structures, check dams, revetments, and scour aprons, where they may be necessary to maintain stabilized drainageway conditions, subject to the design requirement that the drainageway conditions remain as near natural as possible.
- (f) Design parameters applicable to artificial drainageways, including without limitation, freeboard height, bed and bank slopes, and curvature, may not necessarily apply to natural drainageways. Significant site planning advantages may be realized by maintaining the natural drainageway, without structured improvements, by allowing drainageway overtopping onto reserved flooding areas designated as open space and wetlands and maintaining irregular waterway features that naturally control flow conditions, improve water quality, preserve stream ecology and enhance community and aesthetic values.

(2) Unlined Artificial Drainageways: Where not specified in these Standards, the design of unlined artificial drainageways shall conform with the USDCM.

- (a) **Longitudinal Channel Slopes:** Channel slopes are dictated by velocity and Froude number requirements. Where natural slopes exceed design slopes, drop structures shall be provided to maintain design velocities and Froude numbers. Normally, grass lined channels will have slopes of 0.2 percent to 0.6 percent.
- (b) **Side Slopes:** Maximum side slopes shall be no steeper than 4:1, unless specific drainageway conditions warrant steeper side slopes as determined by the Director.
- (c) **Depth:** Maximum depth of flow, outside of any low flow or trickle channel, shall be 5 feet. Critical depth shall be determined for both the major and initial storms in order to ensure that supercritical flows do not occur.
- (d) **Bottom Width:** Bottom width shall be consistent with the maximum depth and

velocity standards, and shall accommodate low flows and the development of wetland and water quality enhancement systems.

- (e) **Horizontal Curvature:** The center line curvature shall have a design radius twice the top width for design flow conditions, but not less than 50 feet.
 - (f) **Roughness Coefficient:** Manning's "n," as adjusted by channel bottom conditions outlined in the USDCM, shall be applied.
 - (g) **Cross Sections:** Drainageway cross-sections may be almost any type suitable to the location and to the environmental conditions, subject to conformance with these Standards. Cross sections simulating naturally occurring drainageway corridors are strongly recommended.
 - (h) **Channel Bottom:** The channel bottom is to be designed to convey low flows and enhance water quality in conformance with environmental concerns and regulations. Acceptable channel bottoms, subject to City approval for specific site applications, may include without limitation wetlands or natural vegetation and low flow channels conveying a minimum 3 percent of the design storm flow.
 - (i) **Easement/Right-of-Way:** The minimum drainageway easement/right of way width shall include the bank to bank dimension of the drainageway section, including the normal flow depth and freeboard areas, and adequate maintenance access.
 - (j) **Maintenance Access:** Maintenance access shall be provided along the entire length of all major drainageways and shall connect with a public street to allow access by medium and large scale construction and maintenance equipment. An access road shall be at least 12 feet wide and designed to adequately support the loads of expected maintenance equipment. The maintenance road may be shared as a greenway trail, subject to approval by the City.
 - (k) **Water Surface Profiles:** Water surface profiles shall be determined for all drainageway designs using standard backwater methods, taking into consideration losses due to velocity changes produced by changing channel sections, drops, waterway openings, or obstructions. The water surface and energy gradient profiles shall be shown on the construction plans.
- (3) **Lined Artificial Channels:** Where allowed by the City, lined artificial channels shall be designed in accordance with these Standards and the USDCM, including the following:
- (a) **Easement/Right-of-Way:** The minimum drainageway easement/right of way width shall include the bank to bank dimension of the drainageway section, including the normal flow depth and freeboard areas, and adequate maintenance access.
 - (b) **Maintenance Access:** Maintenance access shall be provided along the entire length of all major drainageways and shall connect with a public street to allow access by medium and large scale construction and maintenance equipment. An access road shall be at least 12 feet wide and designed to adequately support the loads of expected maintenance equipment. The maintenance road may be shared as a greenway trail, subject to approval by the City.
 - (c) **Water Surface Profiles:** Water surface profiles shall be determined for all drainageway designs using standard backwater methods, taking into consideration losses due to velocity changes produced by changing channel sections, drops, waterway openings, or obstructions. The water surface and energy gradient profiles shall be shown on the construction plans.
- (4) **Roadside Ditches and Drainage Swales:** The design of roadside ditches and drainage swales is similar to the standards for unlined channels with modifications for application to

minor storm drainage. The standards are as follows:

- (a) Capacity: Roadside ditches and drainage swales shall have a minimum capacity for the 10-year design storm.
- (b) Flow Velocity: The maximum velocity for the design storm runoff peak is not to exceed 5 feet per second. The Froude number shall be less than 0.8.
- (c) Longitudinal Slope: The slope shall be limited by flow velocity of the design storm. Swale widening or check drops may be required to control velocities.
- (d) Freeboard: Freeboard above the design flow depth shall be at least 6 inches.
- (e) Curvature: The minimum radius of curvature shall be 25 feet.
- (f) Roughness Coefficient: Manning's "n," as adjusted by channel bottom conditions outlined in the USDCM, shall be applied.
- (g) Depth: A drainage swale shall be at least 1 foot deep. A maximum depth for drainage swales shall not exceed 5 feet and shall be dictated by the design flow and cross-sectional standards.
- (h) Side Slopes: Side slopes shall be no greater than 3:1; however, 4:1 side slopes or flatter are recommended for landscaped areas and to enhance water quality.
- (i) Driveway Culverts: Along roadside ditches, driveway culverts shall be sized to pass the design storm flow without overtopping the driveway, having a minimum culvert diameter size of 18 inches in height with at least 6 inches of cover. Flared end sections or headwalls with appropriate erosion protection shall be provided. Given the depth constraints along roadside ditches, more than one culvert may be required to pass the design flow. Maintenance of all driveway culverts shall be the responsibility of the property owner served by the driveway.
- (j) Discharge Points: Roadside ditches and open drainage swales shall discharge directly to the receiving water and shall not discharge to a piped storm sewer system for conveyance to the receiving water body. If discharge to a piped storm sewer system is necessary, a sediment sump and debris grate shall be provided immediately upstream of the discharge point to the storm sewer system. The grate shall be hinged to allow for maintenance access.
- (k) Major Drainage Capacity
 - (i) The major drainage (100-year storm) capacity of roadside ditches is restricted by the maximum flow depth allowed at the street crown or by the ground surface at the edge of the street right-of-way.
 - (ii) The major drainage capacity of drainage swales is restricted to the maximum flow that can be passed without inundation to and damage of downstream properties.

(E) Hydraulic Structures

- (1) **Where Required:** Hydraulic structures are used in open stormwater systems to control the flow of the runoff. The energy associated with flowing water has the potential to create damage to the drainage system, especially in the form of erosion. Hydraulic structures are intended to control the energy of stormwater flow and minimize the damage potential of stormwater runoff. Typical hydraulic structures may include without limitation the following:
 - (a) Channel drop and check structures,

- (b) Rip rap and rock linings,
 - (c) Energy dissipaters and stilling basins,
 - (d) Channel rundowns,
 - (e) Bridges and culverts, and
 - (f) Irrigation ditch crossings.
- (2) **Design Standards:** The standards to be used in the design of hydraulic structures shall be in accordance with these Standards and the USDCM.

7.08 Storm Sewers

(A) System Design

- (1) **Where Required:** Storm sewers shall be required when the other parts of the minor stormwater system, primarily streets, curbs, gutters, and roadside ditches, no longer have the capacity for additional runoff in the initial storm event.
- (2) **Gravity Flow Conditions:** Storm sewers shall be designed for gravity (open) flow conditions, using a “Manning’s” roughness coefficient from Table 7-2, “Manning’s “n” for Storm Sewers.”

Table 7-2: Manning’s “n” for Storm Sewers

Sewer Type	Manning’s “n”
Concrete	0.015
Plastic	0.013
Corrugated Metal	0.013

- (3) **Flow Depth:** Storm sewers are to be designed to carry peak flows at full pipe depth.
- (4) **Pressure Flow Prohibited:** Pressurized surcharged or depressed (inverted siphon) stormwater mains are prohibited in the City’s stormwater system.
- (5) **Continuous Drainage System:** All stormwater drainage facilities shall be a component of a connected and continuous drainage system that does not end in a sump condition and does not discharge to irrigation ditches.

(B) Location

All storm sewer mains shall be installed in public rights-of-way or easements, in conformance with Section 4.04, “Utilities Easements,” of these Standards.

(C) Depth

The cover for all storm sewer mains shall be at least 18 inches deep, measured from the top of pipe to the final surface grade, and shall be capable of withstanding AASHTO HS-20 highway traffic loadings.

(D) Size

Storm sewer mains shall be at least 18 inches in diameter, and storm sewer laterals shall be at least 15 inches in diameter.

(E) Slope

- (1) **Minimum and Maximum:** Minimum allowable slope shall provide flow velocities of at least 2-feet per second and maximum allowable slope shall provide flow velocities no greater than 10feet per second during peak flow conditions.
- (2) **Constant Slope:** All storm sewer mains shall be laid at a constant slope between manholes.

(F) Alignment

- (1) **Straight Alignment:** All storm sewer mains shall be laid in a straight alignment between manholes.
- (2) **Curvilinear Mains Prohibited:** Curvilinear storm sewer mains shall not be allowed.

(G) Separations and Crossings

All collection main separations and crossings of other City utilities shall be designed in compliance with Section 4.06, "Separation of Utilities," of these Standards.

(H) Taps

All taps approved onto an existing storm sewer main shall be made by the City of Boulder Utilities Division and shall be paid for by the applicant. A manhole shall be provided at all taps 6 inches in diameter or larger. Where taps are made to inlet boxes a manhole is not required.

(I) Ground Water Barriers

- (1) **Required:** Where the possibility exists that ground water may be diverted by the construction of new storm sewer mains, ground water barriers shall be constructed within the storm sewer main trench to prevent ground water migration or diversion along the main.
- (2) **Placement:** The Engineer shall determine the location and number of ground water barriers that will be necessary to mitigate any ground water impacts, subject to review and approval by the Director. Any necessary support material required to address ground water concerns, such as soils investigations, engineering calculations and design details, shall be provided by the Engineer.

(J) Extensions

Where required as part of any adopted City master plan or to satisfy stormwater design requirements as part of any proposed project or development, storm sewer mains shall be extended downstream to the major drainageway, and upstream to the far edge of the property being served, to ensure perpetuation of the stormwater collection system.

(K) Manholes

- (1) **Location:** Manholes shall be provided at each storm sewer main connection with another storm sewer main or lateral line, at all changes in grade, slope, alignment and pipe size, at all tap connections 6 inches in diameter or larger, or every 400 feet at a minimum.
- (2) **Size**
 - (a) Table 7-3, "Required Manhole Sizes," indicates required manhole sizes.

Table 7-3: Required Manhole Sizes

Sewer Main Diameter	Manhole Diameter
12 - 18 Inches	4 Feet
21 - 42 Inches	5 Feet
48 - 54 Inches	6 Feet
60 Inches and Larger	Special Detail

- (b) **Special Provisions:** Larger manhole diameters or a junction structure may be required when sewer alignments are not straight through or more than one sewer line passes through a manhole.
- (3) **Maintenance Access:** Direct access by maintenance vehicles shall be provided to each manhole. The access drive shall be an all-weather surface, such as asphalt or concrete paving, adequate gravel base or turf block, minimum 12 feet in width, and shall be capable of supporting maintenance vehicles weighing up to 14 tons.
- (4) **Covers**
 - (a) Manholes that are not located within a public street, alley or driveway section shall be installed with a hinged, gasketed, and locking frame and cover assembly. The assembly shall be an “East Jordan Iron Works” ERGO or ERGO XL assembly.
 - (b) Manholes located within the 100-year floodplain, or in a location where runoff may accumulate and pond, shall be installed with a hinged, gasketed, and locking frame and cover assembly. The assembly shall be an “East Jordan Iron Works” ERGO or ERGO XL assembly.

(L) Hydraulic Design

- (1) **Rational Method:** The rational method, as described in the USDCM, shall be used for the sizing of storm sewer systems.
- (2) **Hydraulic and Energy Grade Line, and Design Losses:** Storm sewers shall be designed to convey the initial storm flow peaks without surcharging the sewer, and the final energy grade line shall be at or below the proposed ground surface. To ensure that this objective is achieved, the hydraulic and energy grade line shall be calculated by accounting for pipe friction losses and pipe form losses as provided in the USDCM.

7.09 Inlets

(A) Specifications

- (1) **Design:** Except as modified in these Standards, storm sewer inlet design shall conform with the standards in the USDCM.
- (2) **Required:** Storm inlets shall be provided at:
 - (a) Areas where street capacity (e.g., allowable design flow spread) would be exceeded without them,
 - (b) At sumps or areas prone to ponding,
 - (c) At median breaks (e.g., where traffic turns across the median),
 - (d) Upstream of speed mitigation and pedestrian structures that would otherwise cause a damming of stormwater runoff,

- (e) Where nuisance flows would otherwise cross a driving lane, and
 - (f) Where curb and gutter ends.
- (3) **Inlet Classification:** Inlets are classified as a sump or continuous grade condition. Sump inlets are inlets located in a low spot or submerged condition. Continuous grade inlets are inlets located along a continuous grade curb and gutter section where bypass flows may occur, and not in a low point.
- (4) **Standard Inlets:** Table 7-4, “Standard Inlets,” indicates the standard inlets permitted for use in the City.

Table 7-4: Standard Inlets

Inlet Type	Drainage Condition	Permitted Use	Percentage of Theoretical Capacity Allowed
Curb Opening Inlet - Type “R”	Continuous Grade or Sump	All Curb and Gutter Street Types	80% (5 Foot Length) 85% (10 Foot Length) 90% (15 Foot Length)
Combination (Curb Opening/Grated) Inlet	Continuous Grade or Sump	All Curb and Gutter Street Types	66%
Grated Area Inlet	Sump	Parking Lots, Alleys	60%

- (5) **Reduction Factors:** In order to account for inlet capacity reductions caused by debris plugging, pavement overlaying, parked vehicles, and other blockage factors, inlet design shall be based on the “percentage of theoretical capacity allowed” as outlined in Table 7-4, “Standard Inlets,” in these Standards.
- (6) **Inlet Spacing**
- (a) Spacing of storm inlets is dependent upon traffic requirements, contributing land use, street slope and distance to the nearest outfall system. The recommended sizing and spacing of the inlets is based upon the interception rate of 70 percent to 80 percent, which has been found to be more efficient than spacing using 100 percent interception rate.
 - (b) Using recommended inlet spacing, only the most downstream inlet is designed to intercept 100 percent of the flow. In addition to recommended interception rates, considerable improvements in overall inlet system efficiency can be achieved if the inlets are located in the sumps created by street intersections.
- (7) **Inlet Grates:** All inlet grates located in a street, alley, parking lot travel lane, bike path, or sidewalk shall utilize a vaned grate on the inlet such as the Denver Type 16 inlet.

7.10 Street Drainage

(A) Function of Streets in the Drainage System

- (1) **Primary Function of Streets:** The primary function of streets is for safe traffic movement; therefore, streets shall be designed and constructed to accommodate runoff and convey it to downstream drainage facilities in order to minimize its interference with traffic. Streets therefore provide an integral part of the stormwater system and are intended to transport local storm runoff within reasonable limits. When the stormwater runoff accumulation in the street exceeds allowable limits, storm sewers or other drainage facilities are required to

collect and convey the excess runoff.

- (2) **Continuous Drainage System:** All stormwater drainage facilities for streets shall be a component of a connected and continuous drainage system that does not end in a sump condition and does not discharge to irrigation ditches.

(B) Street Classification and Allowable Runoff Encroachment

- (1) **Street Classification:** City streets are classified according to the average daily traffic carried and travel routes they provide. Higher category streets, such as arterials and collectors, are required to provide a greater level of access and through travel for emergency purposes during major storm events than lower category streets.
- (2) **Allowable Runoff Encroachment:** A stormwater drainage system (storm sewer or open drainageway) shall be provided where the gutter runoff encroachment reaches the limits outlined in Table 7-5, “Allowable Street Drainage Encroachment.”

Table 7-5: Allowable Street Drainage Encroachment

Street Classification	Minor Storm Maximum Encroachment	Major Storm Maximum Encroachment
Residential and Local Streets	No curb overtopping. Flow may spread to street crown.	Depth at flowline shall not exceed 18 inches.
Collector Streets	No curb overtopping. A minimum one travel lane width shall remain free of drainage encroachment.	Depth at flowline shall not exceed 18 inches.
Arterial Streets	No curb overtopping. A minimum two travel lanes width shall remain free of drainage encroachment.	Depth at crown shall not exceed 6 inches. Depth at flowline shall not exceed 18 inches.
Freeways	No flow encroachment is allowed.	Refer to CDOT Roadway Design Manual

NOTE: Flow encroachment shall not extend beyond property lines.

(C) Hydraulic Street Capacity

- (1) **Allowable Capacity - Minor Storm:** The allowable minor storm capacity of each street section is to be calculated using the modified Manning's formula as described in the USDCM.
- (2) **Allowable Capacity - Major Storm:** The allowable street capacity for the major storm shall be calculated using Manning's formula, dividing the street cross section into the pavement area and sidewalk/grass area, and computing individual flow contributions. An “n” value of 0.016 for pavement and 0.035 for the sidewalk/grass area shall be used.

(D) Cross Street Flow

The standards outlined in Table 7-6, “Allowable Cross Street Flow,” of these Standards shall be used for allowable cross-street flow, where flow passes from one side of the street to the other. The allowable cross-street flow shall be determined using the methods prescribed in the USDCM.

Table 7-6: Allowable Cross Street Flow

Street Classification	Minor Storm Runoff	Major Storm Runoff
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Street Classification	Minor Storm Runoff	Major Storm Runoff
Residential and Local Street	Maximum Depth of 6 Inches in Cross Pan	Maximum Depth of 18 Inches Above Flowline
Collector Street	Where Allowed, Maximum Depth of 6 Inches in Cross Pan	Maximum Depth of 18 Inches Above Flowline
Arterial	Not Allowed	Maximum Depth of 6 Inches Over Street Crown

7.11 Culverts

(A) System Design

- (1) **Required:** Culverts shall be provided for the conveyance of stormwater runoff under a roadway, railroad, driveway, or other crossings of an open drainage system (such as a drainageway or roadside swale). The size, shape, and type of culvert crossings shall be based on the projected runoff volumes, as well as existing topographic conditions. All culvert designs are subject to approval by the Director.
- (2) **Culvert Types:** Typical culvert types include circular, elliptical, or arch pipe sections, and reinforced concrete box culverts.

(B) Hydraulic Design

All culverts shall be designed in accordance with the USDCM. All culvert designs are to include an analysis to determine whether inlet or outlet control conditions govern for both major and minor storm runoff conditions.

(C) Structural Design

The structural design of culverts shall conform to accepted structural engineering practices, the Colorado Department of Transportation design standards and standard specifications, any methods and criteria recommended by the manufacturer for a specific culvert type, and for conditions found at the construction site. As a minimum, all culverts shall be designed to withstand an AASHTO HS-20 traffic loading.

(D) Specifications

- (1) **Size**
 - (a) Culvert design size shall be based upon the following:
 - (i) Runoff volumes for the appropriate design storm.
 - (ii) Required capacity based on roadway classification and allowable street overtopping, as prescribed in Section 7.10, "Street Drainage," of these Standards
 - (b) Culverts shall be at least 18 inches in diameter or height.
- (2) **Inlet and Outlet Sections**
 - (a) All culverts shall be designed with headwalls and wingwalls, or flared end sections at the inlet and outlet. Flared end sections are allowed only on pipe culverts with diameters of 42 inches (or equivalent) or less.

- (b) Erosion protection such as rip-rap, boulder energy dissipators, or adequate vegetation, shall be provided at the inlet or outlet where required to mitigate potential scouring or erosive flow conditions. The Engineer shall propose the erosion protection to be used, subject to approval by the Director.

(3) **Slope and Velocity**

- (a) Culvert slopes shall be designed so that neither silting nor excessive velocities resulting in scour can occur. The minimum design velocity for minor storm conditions shall be 2 feet per second, to provide for self-cleansing of the culvert.
- (b) The maximum culvert velocity is dictated by the channel conditions at the outlet, and the amount of erosion protection or energy dissipation that can be provided to prevent scour or damage.

(4) **Allowable Headwater**

- (a) The maximum headwater / diameter (HW/D) ratio for the 100-year design flows shall be 1.5, and 1.0 for the 10-year design flow. These HW/D ratios are to be applied to culverts at street crossings and should not be applied to outlets from detention ponds or private driveways.
- (b) Ponding above the top of a culvert is not permitted if such ponding could potentially cause property or roadway damage, culvert clogging, saturation of critical embankments, detrimental debris deposition, erosion, or inundation of existing or future utilities, structures, or buildings.

(5) **Trash Racks**

- (a) The installation of a trash rack over a culvert entrance shall be provided as required by the Director where there exists the potential for debris clogging of the culvert or where there is a safety hazard concern for the possibility of people (especially children) being carried into the culvert.
- (b) Trash racks shall be designed to maintain adequate culvert hydraulics, considering the potential for debris buildup and blockage which may render the culvert ineffective. Careful design considerations are to be applied, including without limitation application of the following standards:
 - (i) **Materials:** All trash racks shall be constructed with smooth steep pipe, having an outside diameter of at least 1 ¼ inches. Trash rack ends and bracing shall be constructed with steel angle sections. All trash rack components shall have a corrosion protective finish.
 - (ii) **Design:** Trash racks shall be designed without cross-braces, to minimize debris clogging, and be able to withstand the full hydraulic load of a completely plugged trichroic based on the highest anticipated depth of ponding. The trash rack shall be hinged and removable for maintenance purposes.
 - (iii) **Bar Spacing:** Bar spacing shall provide a maximum clear opening of 6 inches. The longitudinal slope of the trash rack shall be no steeper than 3:1, horizontal to vertical. The entire trash rack shall have a clear opening at least three times the culvert opening area.
- (c) **Hydraulics:** Use the following equation to compute hydraulic losses through trash racks:

$$H_T = 0.11 * (TV/D)^2 * (\sin A)$$

- Where: H_T = Head Loss through the Trichroic (feet)
 T = Thickness of Trichroic Bar (inches)
 V = Velocity normal to Trichroic (fps)
 D = Center-to-Center Spacing of Bars (inches)
 A = Angle of Inclination of Trichroic with Horizontal

The velocity normal to the trichroic shall be computed considering the rack to be 50 percent plugged.

7.12 Detention

(A) System Design

- (1) **Intent:** Detention ponding facilities are intended to store increased runoff from developed property and release this runoff at the historic rate that existed prior to development or redevelopment. By providing detention ponding, increased runoff impacts on downstream facilities may be controlled and minimized to reduce potential damages and the need for greatly expanded stormwater conveyance facilities.
- (2) **Requirements:** Detention ponding for stormwater shall be provided for all new development or redevelopment where the runoff coefficient for the site increased unless one of the following conditions are met:
 - (a) The project site is a single-family lot or a single-family lot split into two single-family lots that is not part of a larger development.
 - (b) Runoff for the project site for the initial and major storm events from the entire tributary basin can be conveyed directly to the major drainage system without adverse impact on upstream, surrounding, or downstream properties and facilities and stormwater detention to meet water quality mitigation measures is not required.
- (3) **Maintenance:** The property owner shall be responsible for maintaining stormwater detention facilities.
- (4) **Easement:** All stormwater detention facilities shall be located in a public easement. The easement shall grant to the City at a no charge a permanent right to inspect, maintain, and reconstruct the stormwater detention facilities. The easement shall be granted on a form provided by the Director. No owner of land or other applicant shall obtain a Final Drainage Plan, unless the owner first grants to the City the easement for all stormwater detention facilities. The City shall have no obligation to the property owner to inspect, maintain, or reconstruct the stormwater facilities.

(B) Design Frequency, Hydraulic Design, and Storage Requirements

- (1) **Design Storms:** Detention ponds shall be designed in accordance with USDCM, Volume 2, Chapter 12.
- (2) **Storage Volume:** The storage volume of runoff to be detained on-site shall be sized to contain 110 percent of the difference between the historic runoff and the initial and major storm runoff, as defined in Table 7-1, projected for the ultimate developed conditions of the entire parcel and tributary basin to be developed or redeveloped.
- (3) **Undetained Site Releases:** On project sites where runoff from portions of the site cannot be detained due to topography or site conditions, free release of runoff may be approved with compensating detention storage design subject to the following conditions:

- (a) Total maximum runoff from the entire parcel and tributary basin to be developed or redeveloped shall not exceed the historic runoff,
- (b) Release rates from the detention ponds shall be reduced by the developed runoff rate from the undetained drainage area,
- (c) The undetained drainage area may not exceed five percent of the entire parcel and tributary basin to be developed or redeveloped, and
- (d) The release rate from the undetained area may not exceed 25 percent of the historic release rate from the entire parcel and tributary basin to be developed or redeveloped.

(C) Detention Pond Design

Except where inconsistent with the requirements in this Subsection 7.12(C), detention pond design shall follow all applicable criteria established in the USDCM, Volume 2 and Volume 3.

- (1) **Surface Ponding Required:** All detention ponds shall be provided as open, surface grade improvements. Underground, enclosed, or roof top detention ponds shall not be permitted unless unusual site conditions and adequate detention performance and maintenance conditions are approved by the Director.
- (2) **Location:** Detention ponds shall be located in open, pervious landscaped areas to enhance site drainage and soil percolation, and to improve water quality.
- (3) **Side Slopes:** Side slopes for detention ponds shall be designed to provide for ease of maintenance and access. Landscaped side slopes are not to exceed 4:1, and vertical or steep walls used as side slopes are to be constructed of durable natural materials, such as rock or timber, with heights no greater than 30 inches to reduce safety hazards.
- (4) **Pond Bottoms:** Pond bottoms are to be pervious and sloped to prevent the collection of standing water, unless a permanent pond or wetland bottom is provided for water quality enhancements. The use of combined water quality and detention facilities shall follow criteria specification provided in the USDCM, Volume 3, Chapter 12 and applicable water quality treatment approach criteria as specified in Section 7.17 of these Standards. Hard-lined trickle channels are not to be constructed in detention ponds unless approved by the Director to address specific drainage problems or safety and environmental hazards.
- (5) **Overflow Release Feature:** All detention ponds shall include an overflow release feature to spill during storm events larger than the major design storm or when release outlets fail. This feature shall be designed to release overflows in a direction and manner that will not adversely affect properties downstream of the detention pond.

7.13 Construction Stormwater Management

(A) Intent

This section implements requirements of Section 11-5-6, “Stormwater Quality Management for Land Development,” B.R.C. 1981, for construction activities and sets standards for stormwater management plans (SWMP) and erosion control plans, their implementation, and the inspection and maintenance of control measures for erosion and sediment control.

(B) Stormwater Management Plan Requirements

A SWMP shall include a narrative and erosion control plans that identify the construction activities

and their associated potential pollutant sources and address the selection, installation, implementation, and maintenance of control measures for erosion and sediment control that reduce the potential for the pollutant sources to enter the stormwater utility system or waters of the State. Control measures for erosion and sediment control shall prevent pollution and degradation of waters of the State. The SWMP shall include and be prepared, updated, and implemented consistent with the following requirements:

- (1) **General Standards:** Control measures for erosion and sediment control shall be constructed and maintained in accordance with the SWMP, the General Permit for Stormwater Discharges Associated with Construction Activity issued by the CDPHE, and the USDCM, Volume 3.
- (2) **Preparation Standards:** The SWMP shall be prepared in accordance with the requirements of the General Permit for Stormwater Discharges Associated with Construction Activity issued by the CDPHE and USDCM, Volume 3. The SWMP shall be prepared in accordance with methods, procedures, and practices that are based on scientific facts, reflect best industry practices and standards, are appropriate for the conditions and pollutant source, and provide appropriate solutions to meet the SWMP requirements of this section, including practice based and numeric effluent limits. The SWMP shall include the following elements:
 - (a) Protection for adjacent properties (including public right-of-way) from erosion and/or sediment deposition.
 - (b) Protection for public streets from the deposit of sediment from runoff or vehicles tracking mud.
 - (c) Stabilization for all disturbed areas as defined in the USDCM and CDPS requirements.
 - (d) Protection for all storm sewer inlets from the entry of sediment-laden water.
 - (e) Protection from encroachment by construction equipment, vehicles, and foot traffic into stormwater infiltration measures to eliminate the possibility of soil compaction and vegetation damage.
 - (f) Long-term stability of cut and fill slopes and the successful establishment of permanent vegetative cover on exposed soil.
 - (g) Selection, installation, implementation, and maintenance of control measures for erosion and sediment control.
- (3) **Control Measures for Erosion and Sediment Control and Potential Pollutant Sources:** All control measures for erosion and sediment control shall meet the following requirements:
 - (a) Control measures for erosion and sediment control shall be installed and made operational prior to the start of construction activity. The control measures for erosion and sediment control shall prevent potential pollutants from leaving the construction site during each phase of construction and shall be continued through final stabilization. Structural control measures for erosion and sediment control shall be maintained in operational condition through final stabilization.
 - (b) Control measures for erosion and sediment control shall be selected, designed, installed, implemented, and maintained to prevent potential pollutants such as, but not limited to, sediment, construction site waste, trash, discarded building materials, concrete truck washout, chemicals, sanitary waste, and contaminated soils in discharges to the stormwater utility system from leaving the construction

- site.
- (c) The SWMP shall address pollutant sources associated with the following activities (if part of the construction activity), and control measures for erosion and sediment control shall be implemented if the source is determined to be present on the site:
 - (i) Land disturbance and soil storage,
 - (ii) Vehicle tracking,
 - (iii) Loading and unloading operations,
 - (iv) Outdoor storage of construction site materials, building materials, fertilizers, and chemicals,
 - (v) Bulk material storage,
 - (vi) Vehicle and equipment maintenance and fueling,
 - (vii) Significant dust or particulate-generating processes,
 - (viii) Routine maintenance activities involving fertilizers, pesticides, detergents, fuels, solvents, and/or oils,
 - (ix) Concrete truck/equipment washing, including the concrete truck chute and associated fixtures and equipment,
 - (x) Dedicated asphalt and concrete batch plants,
 - (xi) Other areas or operations where spills can occur, and
 - (xii) Other non-stormwater discharges including construction dewatering not covered under the CDPS General Permit for Construction Dewatering Discharges and wash water that may contribute pollutants to the stormwater utility system.
 - (d) The SWMP shall include control measures for erosion and sediment control detail drawings for both installation and maintenance. Controls measures should be consistent with USDCM, Volume 3 or Colorado Department of Transportation M & S (Miscellaneous and Signage) Standard Plans.
- (4) **Protection of Control Measures for Post-Construction Water Quality:** Requirements for the design and construction of control measures for post-construction water quality are provided in Sections 7.14 through 7.18 of these Standards. The SWMP shall provide provisions to protect the water quality functions of these control measures for post-construction water quality (SCMs) during construction as listed below:
- (a) Any area consisting of native, un-compacted soil where a SCM will be installed shall be protected from vegetation removal and encroachment by heavy equipment, vehicles, and foot traffic prior to grading and construction. If the area, prior to grading and construction, consists of previously compacted or fill soil, protection from encroachment shall be provided after the soil has been amended or otherwise rehabilitated into an un-compacted condition to promote infiltration of stormwater. Methods and controls for protection of these areas shall be indicated in the SWMP.
 - (b) The use of the SCM area for construction or maintenance materials stockpiles or for storage of construction equipment, wastes, or pollutants is prohibited after construction of the SCM has commenced.

- (5) **Erosion Control Plan:** The SWMP shall include an Erosion Control Plan. Erosion Control Plan drawings shall locate and identify all structural and non-structural control measures for erosion and sediment control for the proposed construction activities. The Erosion Control Plan shall be prepared in accordance with the requirements of the General Permit for Stormwater Discharges Associated with Construction Activity issued by the CDPHE and include the elements listed in form(s) provided by the Director. Erosion Control Plans shall include, at a minimum, three site maps illustrating the initial, interim, and final phases of construction and their associated control measures for erosion and sediment control.

The following Standard Notes shall also be included on Erosion Control Plan(s):

- (a) Temporary Erosion Controls: All temporary erosion control measures for erosion and sediment control shall be installed before any construction activities take place.
- (b) Sediment Controls: Control measures for erosion and sediment control shall be implemented to prevent the release of sediment from construction sites. Vehicle tracking of sediment shall not be allowed to enter the stormwater utility system or waters of the State. Sediment shall not be tracked onto public streets and, if so, shall be immediately removed.
- (c) Water Quality Impacts: Stormwater discharges from construction activities shall not cause or threaten to cause pollution, contamination, or degradation of waters of the State.
- (d) Waste Controls. Solid waste, industrial waste, yard waste, and any other pollutants or waste on any construction site shall be controlled using control measures. Waste and/or recycling containers shall be provided and maintained by the owner or contractor on construction sites where there is the potential for release of waste. Uncontained waste that may blow, wash, or otherwise be released from the site is prohibited. Sanitary waste facilities shall be provided and maintained by the owner or contractor.
- (e) Concrete Waste: Ready-mixed concrete, or any materials resulting from the cleaning of vehicles or equipment containing or used in transporting or applying it, shall be contained with appropriate control measures and ultimately removed for proper disposal. Release of these materials is prohibited.
- (f) Chemical Storage: Bulk storage structures for petroleum products and other chemicals shall have adequate protection so as to contain all spills and prevent any spilled material from entering the stormwater utility system or waters of the State.
- (g) Surface Cover Timing: Cover shall be applied within 14 days to inactive soil stockpiles and shall be maintained for stockpiles that are proposed to remain in place longer than 30 calendar days.
- (h) Project Phasing: All earth disturbances shall be designed, constructed, and completed to limit the exposed area of any disturbed land to the shortest possible period of time.
- (i) Dust Controls: Techniques shall be used to prevent dust, sediment, or debris from blowing off the site.
- (j) Maintenance: Any damage or required maintenance to temporary and permanent controls measures shall be repaired or replaced as soon as possible, immediately in most cases.

- (k) Removal: All control measures for erosion and sediment control shall be removed and disposed within 30 days after final site stabilization is achieved or after the temporary measures are no longer needed, whichever occurs first.
- (l) Responsibility: The erosion control permittee shall be responsible for continued compliance with the requirements of Section 7.13 of the City's Design and Construction Standards during construction activity on the site.

(C) Inspection and Maintenance Requirements

The erosion control permittee shall be responsible for implementation of the SWMP or, if no SWMP is required, the Erosion Control Plan during construction, including inspection and maintenance of the control measures for erosion and sediment control in the approved SWMP and/or Erosion Control Plan. Prior to commencement of work, the erosion control permittee shall ensure that all general contractors, subcontractors, and utility agencies obtain a copy of and comply with the SWMP and/or Erosion Control Plan. The erosion control permittee shall amend the SWMP and/or Erosion Control Plan when site conditions change. The erosion control permittee shall keep the SWMP and/or Erosion Control Plan on site and shall implement and update the SWMP and/or Erosion Control Plan throughout construction and final stabilization of the site in accordance with the following requirements:

- (1) If no SWMP is required, the erosion control permittee shall update the Erosion Control Plan to show currently implemented control measures for erosion and sediment control and installation dates.
- (2) If a SWMP is required:
 - (a) An initial site inspection by the Director is required prior to commencing construction.
 - (b) The erosion control permittee shall amend the SWMP whenever there is a change in design, construction, operation, or maintenance that affects the potential for discharge of pollutants to the stormwater utility system or receiving waters, or if the SWMP proves to be ineffective in controlling pollutants in stormwater discharges associated with construction activities.
 - (c) The erosion control permittee shall inspect all control measures for erosion and sediment control per the frequency outlined in the General Permit for Stormwater Discharges Associated with Construction Activity issued by the CDPHE for the site. Inspections of control measures for erosion and sediment control shall be conducted by an individual who has successfully completed formal training in erosion and sediment control by an organization acceptable to the Director. The erosion control permittee shall provide a certification of successful completion of such training to the Director upon request.
 - (d) The erosion control permittee shall maintain records of inspection on site with the SWMP. Inspection records shall be available at the site at all times. The erosion control permittee shall make the inspection records immediately available to the Director upon request.

7.14 Land Development Planning Using LID Techniques

(A) Intent

All new development and redevelopment shall reduce pollutant impacts of the development site on

receiving waters and reduce or control stormwater volumes by mimicking natural hydraulic conditions using LID techniques. LID techniques seek to minimize impervious areas and protect and create well-draining vegetated areas that promote infiltration and natural hydrologic processes thereby reducing stormwater runoff and pollutant quantities.

(B) Requirements for All Developments

- (1) LID techniques shall be implemented for all new development and redevelopment consistent with the standards in this section.
- (2) Compliance with the requirement to implement LID techniques, including the investigation and analysis of LID techniques and an explanation of the implementation choices made, shall be documented in the Preliminary and Final Drainage Reports when such reports are required. Otherwise, compliance shall be demonstrated in building permit construction documents, on form(s) as provided by the Director, submitted as part of the building permit application.

(C) LID Techniques

LID techniques shall be chosen and applied following the principles summarized in this subsection. Additional guidance on employing LID techniques is provided in USDCM, Volume 3, Chapter 1. The following LID techniques shall be investigated and implemented to the maximum extent practicable:

- (1) **Conserve Existing Amenities:** Planning efforts shall account for and, where practicable, preserve or restore existing site features that naturally retain stormwater on site, including vegetated areas, high infiltrating soils, and natural surface drainage patterns, such as meadows and trees.
- (2) **Minimize Impacts:** Planning efforts shall account for and minimize, where practicable, land disturbance, impervious surface addition, and soil compaction. This may include removing unnecessary impervious areas, minimizing driveway and sidewalk widths, and sequencing construction to minimize compacted areas.
- (3) **Minimize Directly Connected Impervious Areas (MDCIA):** Planning efforts shall account for and minimize impervious areas, such as rooftops and pavement, that directly drain to the stormwater utility system or a local stream without prior stormwater control. This may include using or integrating receiving pervious areas into the site landscape, such as vegetated swales and buffers. Where practicable, site drainage patterns shall be designed to promote sheet flow to vegetated area and roof downspouts shall be disconnected from direct discharge to the storm sewer. Receiving pervious areas shall be designed to slow run-off and promote infiltration.

7.15 Post-Construction Stormwater Quality Requirements

(A) Intent

All new development and redevelopment shall reduce the pollutant impacts of the development site on receiving waters. All applicable development sites shall implement post-construction stormwater quality management practices.

(B) Applicable Development Sites

- (1) **Applicable Development Site:** Applicable development sites are required to implement control measures for post-construction stormwater quality in accordance with the

requirements of Chapter 11-5, “Stormwater and Flood Management Utility,” B.R.C. 1981, and this section, unless the Director has waived the applicable development site requirements pursuant to Subsection 7.15(B)(2) of these Standards.

- (2) **Waiver:** The Director may waive the requirements for applicable development sites in this section if the applicant demonstrates that the requirement of paragraph (a) of this Subsection 7.15(B)(2) is met and that none of the circumstances described in Subsection 7.15(B)(2)(b)(i) through (vi) exist:
- (a) One or more of the following criteria is met:
 - (i) **Pavement Management Sites:** The project proposes the rehabilitation, maintenance, and reconstruction of roadway pavement, which includes roadway resurfacing, mill and overlay, white topping, black topping, curb and gutter replacement, concrete panel replacement, and pothole repair. The purpose of the project must be to provide additional years of service life and optimize service and safety. The project must be limited to the repair and replacement of pavement in a manner that does not result in an increased impervious area, and the infrastructure must not substantially change. The types of projects that meet these criteria include day-to-day maintenance activities, rehabilitation, and reconstruction of pavement. “Roadways” include roads and bridges that are improved, designed, or ordinarily used for vehicular travel and contiguous areas improved, designed, or ordinarily used for pedestrian or bicycle traffic, drainage for the roadway, and/or parking along the roadway. Areas primarily used for parking or access to parking are not roadways, and do not meet these criteria;
 - (ii) **Roadway Redevelopment:** The project is the redevelopment of existing roadway and the project (1) adds less than one acre of paved area per mile of roadway to an existing roadway or (2) does not add more than 8.25 feet of paved width at any location to the existing roadway;
 - (iii) **Existing Roadway Areas:** The project is the redevelopment of existing roadway where the project does not increase the width of the original roadway to two times or more on average. Under this criterion, the applicable development site requirements may not be waived for the entire roadway project but only for the area of the existing roadway. The area of the added new roadway shall be considered an applicable development site;
 - (iv) **Aboveground and Underground Utilities:** The project is the installation or maintenance of underground utilities or infrastructure that does not permanently alter the terrain, ground cover, or drainage patterns from those present prior to the construction activity. The types of projects that meet these criteria include, but are not limited to, activities to install, replace, or maintain utilities under roadways or other paved areas that return the surface to the same condition;
 - (v) **Large Lot Single Family Residential Projects:** The project involves single-family residential lots greater than or equal to 2.5 acres in size per dwelling, with a total lot impervious area of less than 10 percent, and that are not part of a common plan of development,
 - (vi) **Land Disturbance Only Projects:** The project involves land disturbance to undeveloped land (land with no structures, such as buildings, and no

- pavement), and the land will remain undeveloped during and after the disturbance;
- (vii) Stream Stabilization Projects: The project is a stream stabilization project; or
 - (viii) Sidewalk, Bicycle and Multi-Use Paths: The project adds, modifies, or maintains public sidewalk, bicycle path or multi-use path. Bike lanes that are a part of a roadway do not meet this criterion.
- (b) The Director may not waive the requirements for applicable development sites of this section if any of the following circumstances are present:
- (i) Brownfield: The proposed project is located on a site that is considered a brownfield or is otherwise known or believed to have pollutants in the soil or on the ground that, if discharged from the property in stormwater or groundwater, may cause harm to the general public or the environment;
 - (ii) TMDL: The proposed site will, after development, discharge stormwater to a waterbody that is included on the most recent State of Colorado Department of Public Health and Environment §303(d) List of Water-Quality-Limited Segments Requiring TMDLs or for which a Total Maximum Daily Load (TMDL) is in place;
 - (iii) Wetlands: The proposed site will, after development, discharge stormwater to a delineated wetland or wetland buffer area as defined in Chapter 9-3, "Overlay Districts," B.R.C. 1981;
 - (iv) History: A history of flooding or drainage problems is known to exist in, or downstream of, the drainage basin where the site is located, whether documented or undocumented;
 - (v) Master Plan: A City-approved stormwater master plan indicates a need for more stringent regulation of stormwater in the watershed where the proposed project is located in order to avoid, or alleviate, any flood, drainage, or pollution problems; or
 - (vi) Exacerbate Problems: There is reason to believe that construction of the proposed project may further exacerbate existing flood or drainage problems.
- (c) Evidence supporting the waiver pursuant to the criteria of this section shall be provided on forms provided by the Director. The Director may require additional documentation to support the waiver request.
- (d) In granting a waiver, the Director may impose specific conditions on the approval of the waiver necessary to ensure that the criteria in this section are, and will remain, satisfied.

(C) Requirements

Applicable development sites are subject to the following requirements:

- (1) **Stormwater Quality Design Standard Compliance:** Each drainage basin or collection of drainage basins (treatment area) associated with an applicable development site shall meet one of the following Stormwater Quality Design Standards:
 - (a) Runoff Reduction Standard: Control measures for post-construction stormwater quality (SCMs) are selected, designed, and constructed to infiltrate into the ground

where site geology permits, evaporate, or evapotranspire a quantity of water equal to 60% of what the calculated Water Quality Capture Volume (WQCV) would be if all impervious area for the applicable development site discharged without infiltration.

None of the treatment area may be excluded when using the Runoff Reduction Standard.

- (b) **Water Quality Capture Volume Standard:** SCMs are selected, designed, and constructed to provide treatment and/or infiltration of the runoff from the entire treatment area for the 80th percentile, 0.6-inch storm event. Evaluation of minimum drain time shall be based on the pollutant removal mechanism and functionality of the SCM(s) implemented. Consideration of drain time shall include maintaining vegetation necessary for operation of the SCM (e.g., wetland vegetation).

Up to 20 percent, not to exceed one acre, of the treatment area may be excluded when using the WQCV Standard if the Engineer demonstrates that it is not practicable to capture runoff or implement a separate SCM before runoff drains to an offsite discharge point.

- (c) **Pollutant Removal Standard:** SCMs are selected, designed, and constructed to reduce the event mean concentration of total suspended solids (TSS) to a median value of 30 milligrams per liter (mg/L) or less from the entire treatment area for the 80th percentile, 0.6-inch storm event.

Up to 20 percent, not to exceed one acre, of the treatment area may be excluded when using the Pollutant Removal Standard if it is demonstrated that it is not practicable to capture runoff or implement a separate SCM before runoff drains to an offsite discharge point.

- (d) **Constrained Redevelopment Site Standard:** Applicable development sites having an existing impervious area greater than 35 percent and a proposed impervious area greater than 75 percent that can demonstrate the above design standards cannot be practicably met shall meet one of the following standards:

- (i) **Constrained Runoff Reduction Standard:** SCMs are selected, designed, and constructed to infiltrate into the ground where site geology permits, evaporate, or evapotranspire a quantity of water equal to 30 percent of what the calculated WQCV would be if all impervious area for the applicable development site discharged without infiltration.
- (ii) **Constrained WQCV Standard:** SCMs are selected, designed, and constructed to provide treatment and/or infiltration of the runoff from at least 50 percent of the treatment area, including at least 50 percent of the impervious area, for the 80th percentile, 0.6-inch storm event. Evaluation of minimum drain time shall be based on the pollutant removal mechanism and functionality of the SCM(s) implemented. Consideration of drain time shall include maintaining vegetation necessary for operation of the SCM (e.g., wetland vegetation).
- (iii) **Constrained Pollutant Removal Standard:** SCMs are selected, designed, and constructed to reduce the event mean concentration of total suspended solids (TSS) to a median value of 30 mg/L or less for at least 50 percent of the treatment area, including at least 50 percent of the impervious area, for the 80th percentile, 0.6-inch storm event.

- (2) **Required Treatment Approach:** The selection of a required treatment approach shall be determined considering site constraints and infiltration feasibility following the procedure established in Section 7.16 of these Standards.
- (3) **Compliance Documentation Required:** The selected treatment approach and the rationale for such approach selection shall be documented on form(s) as provided by the Director. The form(s) and any supporting data, maps, charts, or calculations shall be provided as part of the Preliminary and Final Drainage Reports.
- (4) **Pretreatment Required:** Pretreatment devices shall be provided for all SCMs to reduce the inflow of trash, debris, and coarse sediment into the SCM. Allowed forms of pretreatment are grass buffers, grass swales, forebays, and inlet sumps. The Director may approve other pretreatment controls if the Director finds the proposed design adequately reduces the inflow of trash, debris and coarse sediment into the SCM.
- (5) **Irrigation Plan Required:** Provisions shall be made to provide water to vegetated SCMs after vegetation installation and in accordance with the Final Drainage Report and as needed to maintain the health of the vegetation. The owner of the SCMs shall be responsible to replace vegetation that is damaged, dead, or otherwise shows signs of poor health to ensure the proper operation of the control measure. The use of native plants in SCMs and other vegetated areas is strongly encouraged as such plants are best suited for local seasonal and climatic conditions.
- (6) **Easement:** All SCMs shall be located in a public easement. The easement shall grant to the City at a no charge a permanent right to inspect, maintain, and reconstruct the SCMs. The easement shall be granted on a form provided by the Director. No owner of land or other applicant shall obtain a Final Drainage Plan, unless the owner first grants to the City the easement for all SCMs.

7.16 Post-Construction Stormwater Quality Treatment Approach

(A) Selection and Design of SCMs

The Engineer for an applicable development site shall apply the SCMs that best address pollutants of concerns and can be implemented on the development site. Infiltration of rainfall and stormwater using volume reduction/green infrastructure SCMs is the preferred treatment approach because it most closely mimics the natural hydrology of undeveloped land and reduces the volume of stormwater that is discharged into the stormwater utility system and to local streams. Therefore, non-structural LID techniques, Receiving Pervious Areas (RPAs), and infiltration-based SCMs shall be used to the degree practicable whenever it is determined that infiltration is feasible. In contrast, the removal of pollutants using underground SCMs is the least desirable treatment approach due to concerns about the practicality and effectiveness of long-term SCM maintenance and the ability of these designs to address pollutants of concern. As a result, the pollutant removal design standard is only allowed when all other treatment approaches have been demonstrated to not be feasible.

This subsection summarizes the required procedure and supporting criteria for the selection and design of SCMs on applicable development sites, which are established in the following subsections of this section:

- (1) **Preliminary Infiltration Feasibility Screening:** Site conditions shall be documented prior to SCM design to support selection of an appropriate water quality treatment approach.
- (2) **Treatment Approach Selection:** Selection of an appropriate SCM shall be based on the

feasibility of onsite infiltration. The required treatment approach is selected based on the hierarchy provided in Figure 7-1. The purpose of this hierarchy is to promote the use of infiltration using green infrastructure as the preferred approach to permanent stormwater quality management.

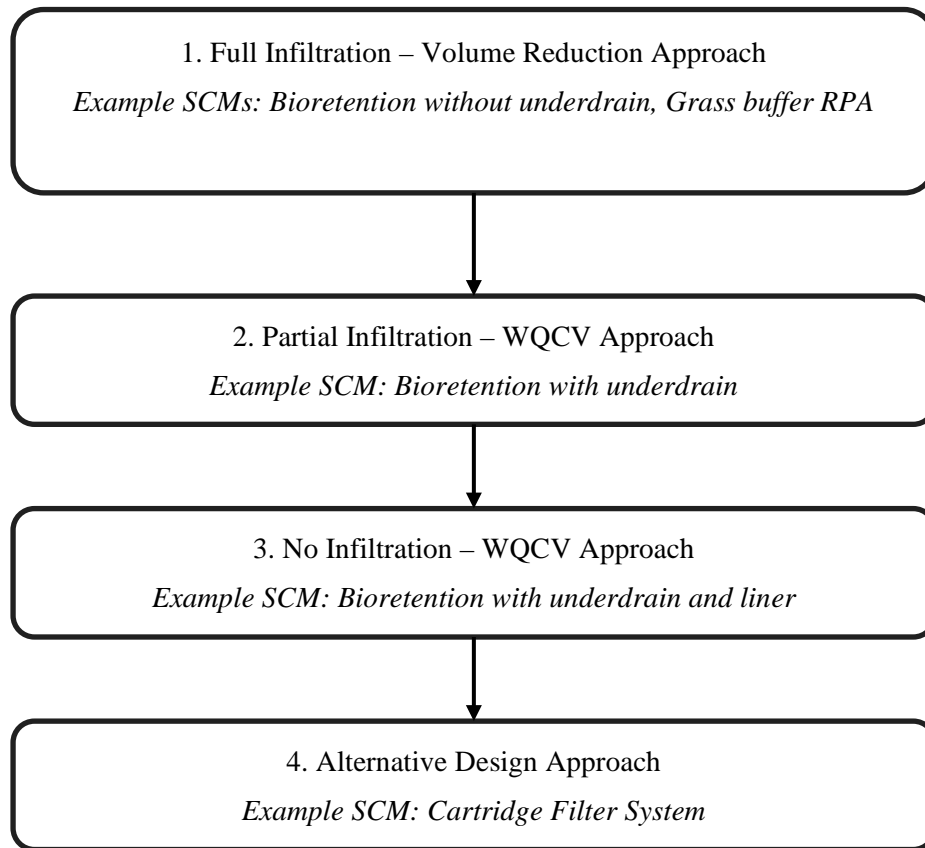


Figure 7-1: Water Quality Treatment Approach Hierarchy

- (3) **Treatment Approach Design Criteria:** Upon selection of a treatment approach, the required design standard and criteria described in Subsection 7.16(D) of these Standards shall be followed to design and document SCM performance.
- (4) **Soil and Infiltration Test Requirements:** The necessity of soil and infiltration testing is dependent on the treatment approach and SCM type. Subsection 7.16.(E) of these Standards explains soil and infiltration testing required to satisfy the Treatment Approach Design Criteria.

(B) Preliminary Infiltration Feasibility Screening

The Engineer shall investigate the site conditions to determine the treatment approach and the Stormwater Quality Design Standards that will be applied to each treatment area. The preliminary infiltration feasibility screening shall be conducted as soon as possible in the design process. The preliminary infiltration feasibility screening does not require field infiltration testing, soil borings, and other detailed tests; however, if the full infiltration treatment approach is indicated to be feasible through this screening process, additional field testing may be required as described in Subsection 7.16(E) of these Standards. The preliminary infiltration feasibility screening shall meet the following requirements:

- (1) Preliminary infiltration feasibility screening shall be conducted for each treatment area

associated with the applicable development site prior to development of the Preliminary Drainage Report.

- (2) The Engineer shall create hydrologic soil group (HSG) maps for each treatment area. Soil gradation assessments or field infiltration testing may be used to confirm HSG mapping or determine infiltration parameters for fill materials.
- (3) The Engineer shall assess the following limitations to infiltration for each treatment area. If one of the following factors is determined to limit infiltration feasibility, documentation shall be provided with Preliminary and Final Drainage Reports:
 - (a) Insufficient hydrologic storage capacity of the underlying soil attributable to shallow bedrock, hardpan layer, seasonal high-water table, or similar subsurface conditions. Underlying soil conditions are not a limitation for consideration of Unconnected Impervious Areas (UIA) to RPA.
 - (b) The potential for groundwater contamination resulting from known or suspected soil contamination or from a proposed land use that is incompatible with the use of infiltration practices (e.g., a concrete batch plant or materials storage and loading site) or similar conditions.
 - (c) Close proximity of SCM locations to drinking water wells or groundwater protection areas.
 - (d) Limited or no suitable area for infiltration attributable to regulatory requirements for the proposed applicable development site, including building set-back or build-to requirements; location or area requirements for rights-of-way, parking, and driveways; floodplain regulations; or other state or local regulatory conditions.
 - (e) Limited suitable area for infiltration attributable to the location of existing structures, pavement, utilities, or similar features that will remain; contractive or expansive soils in close proximity to buildings; or the location or extent of steep slopes, springs, seeps, wetlands, trees, or other natural features that will not or cannot be altered as a result of land development.
 - (f) Close proximity to historical or archeological sites that could be damaged or otherwise negatively impacted by infiltration.
 - (g) Flooding conditions that can be exacerbated by, or limit the function of, an infiltration-based SCM, including a history of frequent flooding at proposed SCM locations or a history of wet or flooded foundations, crawl spaces, or basements on or in close proximity to the applicable development site or its proposed SCM locations, and where these conditions will not be corrected by the proposed project.
- (4) Infiltration feasibility screening results shall be documented in the Preliminary and Final Drainage Reports.

(C) Treatment Approach Selection

The treatment approach is the methodology that will be used to design a SCM, or collection of SCMs, to meet the required Stormwater Quality Design Standard. Four treatment approaches are described in Table 7-7, "Treatment Approach Selection Criteria," and correspond with criteria requirements presented in Subsection 7.16(D) of these Standards. A single SCM design approach shall be initially selected for each treatment area of the applicable development site using the results of the preliminary infiltration feasibility screening and the guidelines presented in Table 7-7, "Treatment Approach Selection Criteria." The selection of the treatment approach shall begin at

the top of the table (with full infiltration) and proceed to the next level down if either the infiltration capacity or infiltration constraints criteria cannot be met. This process continues until both sets of criteria are met for the treatment area. One treatment approach shall be selected for each applicable treatment area.

The Full Infiltration – Volume Reduction approach has two categories depending on the type of SCM being evaluated in the drainage basin:

- (1) **UIA to RPA:** This category is grass swales and grass buffers designed to infiltrate stormwater runoff via disconnection of impervious areas. Infiltration capacity for this category is dependent on identifying UIA:RPA pairs and confirming topsoil suitability.
- (2) **Infiltration SCM:** This category is bioretention, sand filter, permeable pavement or other volume-based SCMs designed to retain runoff from the treatment area. Infiltration capacity for this category is dependent on confirming the infiltration rate of the underlying in-situ soil.

Table 7-7: Treatment Approach Selection Criteria

Treatment Approach	Design Standard Subsection 7.15(E)(1)	Preliminary Infiltration Feasibility Screening Subsection 7.16(B)	
		Infiltration Capacity	Infiltration Constraints
1. Full Infiltration - Volume Reduction A. UIA to RPA B. Infiltration SCM Subsection 7.16(D)(1)	Runoff Reduction	A. UIA to RPA UIA:RPA pairs have been identified and meet run-on ratio guidelines of USDCM, Volume 3, T-0 Volume Reduction. B. Infiltration SCM HSG A or B OR Field tests indicates infiltration rate is greater than one inch per hour.	Underlying soil, groundwater, and geological conditions have sufficient hydrologic capacity to infiltrate 60% of the WQCV. AND No other limitations to full infiltration are present in the treatment area.
2. Partial Infiltration - WQCV Subsection 7.16(D)(2)	WQCV	HSG C or D OR Field tests indicates infiltration rate is less than one inch per hour.	Underlying soil, groundwater, and geological conditions have sufficient hydrologic capacity to support infiltration of a portion of the WQCV. AND No other limitations to partial infiltration are present in the treatment area.
3. No Infiltration - WQCV Subsection 7.16(D)(3)	WQCV	N/A	Underlying soil, groundwater, and geological conditions prevent infiltration and require a lined system.
4. Alternative Design Subsection 7.16(D)(4)	Pollutant Removal OR Constrained Redevelopment Site	N/A	Physical site constraints or risk factors prevent the use of Treatment Approaches 1, 2, and 3 AND Alternative approach must be approved by the Director.

(D) Treatment Approach Design Criteria

The Engineer shall design the SCMs of the selected treatment approach consistent with the requirements of this subsection. Specific types of SCMs are not prescribed for the individual approaches. Any applicable SCM may be used, provided it meets the treatment approach requirements stated herein. In addition to these requirements, SCM designs shall follow the guidance provided in USDCM, Volume 3.

For any of the treatment approaches, a treatment train using a series of SCMs may be used to meet the Stormwater Quality Design Standard for a given treatment area. The series of SCMs must adhere to the requirements of the treatment approach selected for the treatment area and must ultimately, as a group of SCMs, meet the Stormwater Quality Design Standard associated with the treatment approach.

- (1) **Full Infiltration – Volume Reduction Approach:** Full Infiltration is the preferred treatment approach and is required where feasible. Full infiltration designs retain stormwater onsite through the use of RPAs or infiltration SCMs that do not have underdrains. Plugged or capped underdrains may be specified. The following criteria are applicable to full infiltration SCM designs:
 - (a) Runoff Reduction Design Standard: Treatment areas using the Full Infiltration – Volume Reduction Approach shall meet, at a minimum, the requirements of the Runoff Reduction Design Standard of Subsection 7.15(C)(1)(a) of these Standards.
 - (b) Required Sizing Criteria: Preliminary and Final Drainage Reports must document sizing criteria and achieved volume reduction for each SCM following methods specified in USDCM, Volume 3. SCMs must be sized for the full tributary area.
 - (i) UIA to RPAs must comply with run-on ratio, topsoil suitability, and other related criteria as specified in USDCM, Volume 3, T-0 Volume Reduction.
 - (ii) Full infiltration SCMs with a storage component must comply with surface (filter) area, geometry, and drain time requirements as specified in the USDCM, Volume 3 for the appropriate SCM type.
 - (c) Field Infiltration Tests: Field infiltration tests are mandatory for full infiltration SCM designs following the standards in Subsection 7.16(E) of these Standards. Field infiltration test results must be documented in the Preliminary and Final Drainage Reports.
 - (d) Minimum Field Infiltration Rate: Full infiltration SCMs require a field infiltration rate measurement equal to one inch per hour or greater. If field infiltration rates are measured to be less than one inch per hour, a partial infiltration/WQCV approach shall be used consistent with the standards in Subsection 7.16(D)(2) of these Standards.
 - (e) Required Design Factor of Safety: Full infiltration SCMs shall utilize a minimum factor of safety of 2 when using the field-measured infiltration rate in drawdown time calculations.
- (2) **Partial Infiltration – WQCV Approach:** This category of SCMs retains stormwater on site to the extent practical by using underdrains or rate-controlled outlet structures.

RPA's may be used as part of a treatment train to partial infiltration SCMs. The following criteria are applicable to partial infiltration designs:

- (a) **WQCV Design Standard:** Treatment areas using the Partial Infiltration – WQCV Approach shall meet, at a minimum, the requirements of the WQCV Design Standard in Subsection 7.15(C)(1)(b) of these Standards.
 - (b) **Required Sizing Criteria;** Preliminary and Final Drainage Reports must document sizing criteria and achieved runoff volume capture for each SCM following the methods specified in the USDCM, Volume 3. SCMs must be sized for the full tributary area.
 - (i) UIA to RPA's must comply with run-on ratio, topsoil suitability, and other related criteria as specified in USDCM, Volume 3, T-0 Volume Reduction.
 - (ii) Partial infiltration SCMs must comply with surface (filter) area, geometry, and drain time requirements as specified in USDCM, Volume 3 for the appropriate SCM type. The use of underdrains or rate-controlled outlet structures are required components of partial infiltration designs.
 - (c) **Field Infiltration Tests:** The following field infiltration test requirements are applicable to Partial Infiltration – WQCV designs:
 - (i) For UIA-to-RPA's, topsoil suitability must be shown with a soil gradation test as specified in Subsection 7.16(E) of these Standards.
 - (ii) For partial infiltration SCMs with underdrain or rate-controlled outlet, a field infiltration test is not required except when expressly requested by the Director due to a unique design configuration.
- (3) **No Infiltration – WQCV Approach:** No infiltration SCMs are lined systems required by the necessity to prevent infiltration due to underlying soil conditions, high groundwater table, or an otherwise immitigable risk as identified during the preliminary Infiltration feasibility screening. The following criteria apply to no infiltration designs:
- (a) **WQCV Design Standard:** Treatment areas using the No Infiltration – WQCV Approach shall meet, at a minimum, the requirements of the WQCV Design Standard in Subsection 7.15(C)(1)(b) of these Standards.
 - (b) **Required Sizing Criteria:** Preliminary and Final Drainage Reports must document sizing criteria and achieved runoff volume capture for each SCM following methods specified in USDCM, Volume 3. SCMs must be sized for the full tributary area. No infiltration SCMs must adhere to and document compliance with surface (filter) area, geometry, and drain time requirements as specified in USDCM, Volume 3 for the appropriate SCM type.
 - (c) **Field Infiltration Tests:** Field infiltration tests are not required for no infiltration SCMs. Proof of a watertight liner may be requested at the time of installation by the Director based on necessity for risk mitigation.
- (4) **Alternative Design Approach:** The Director may approve an alternative design approach only if the Engineer demonstrates in the Preliminary Drainage Report or a letter to the Director that none of the above three treatment approaches are feasible. The Preliminary Drainage Report or letter shall explain the alternative design approach. The following criteria are applicable to alternative designs:

- (a) Pollutant Removal or Constrained Redevelopment Site Standard. Alternative designs shall meet one of the following:
 - (i) Pollutant Removal Standard in Subsection 7.15(C)(1)(c) of these Standards,
 - (ii) Constrained Runoff Reduction Standard in Subsection 7.15(C)(1)(d)(i) of these Standards,
 - (iii) Constrained WQCV Standard in Subsection 7.15(C)(1)(d)(ii) of these Standards, or
 - (iv) Constrained Pollutant Removal Standard in Subsection 7.15(C)(1)(d)(iii) of these Standards.
- (b) Required Sizing Criteria: Preliminary and Final Drainage Reports must document sizing criteria and applicable performance metrics for each SCM following methods specified in USDCM, Volume 3.
 - (i) For pollutant Removal or Constrained Pollutant Removal Standard designs, the Engineer shall submit TSS reduction metrics applicable to the proposed design. The use and reference of third-party testing data is required when proposing the use of a proprietary device.
 - (ii) Constrained Runoff Reduction Standard designs shall adhere to sizing criteria specified in Subsection 7.16(D)(1) of these Standards.
 - (iii) Constrained WQCV Standard designs shall adhere to sizing criteria specified in Subsection 7.16(D)(2) of these Standards.
- (c) Field Infiltration Tests: The following field infiltration test requirements apply to alternative design approaches:
 - (i) Field infiltration tests are not required when using the pollutant removal or constrained site pollutant removal standard.
 - (ii) Constrained Runoff Reduction Standard designs shall adhere to field infiltration requirements specified in Subsection 7.16(D)(1) of these Standards.
 - (iii) Constrained WQCV Standard designs shall adhere to field infiltration requirements specified in Subsection 7.16(D)(2) of these Standards.

(E) Soil and Infiltration Test Requirements

Requirements for field infiltration testing depend on treatment approach and SCM type as detailed in Subsection 7.16(D) of these Standards. Field infiltration tests are required for all full infiltration SCMs with a storage component. For all UIA to RPA areas, the Engineer must show topsoil suitability with a soil gradation test. When preliminary infiltration feasibility screenings indicate C or D soils, field infiltration testing is optional to explore feasibility of a full infiltration design. Documentation of field infiltration test results must be submitted in Preliminary and Final Drainage Reports.

- (1) **UIA to RPA Soil Test Requirement:** For all UIA to RPA areas, regardless of HSG, onsite topsoil sampling and testing must be conducted to confirm infiltration capacity. Determination of HSG classification based on soil texture analysis shall follow specifications provided in USDCM, Volume 3, T-0 Volume Reduction. At least one

soil gradation test shall be conducted for each proposed RPA. Proposed topsoil and soil amendment additions shall follow criteria specified in Chapter 10 of these Standards.

- (a) **Post-Construction Soil Tests:** Depending on site conditions, the Director may require soil tests to confirm infiltration capacity and adequacy of soil chemistry to support vegetation growth for RPAs after construction is complete. When required, soil test results shall be provided with the submission of as-built drawings.
- (2) **Full Infiltration SCM Field Test Requirements:** The following criteria apply to all full infiltration SCMs with a storage component using the Full Infiltration – Volume Reduction Approach of Subsection 7.16(D)(1) of these Standards:
- (a) **Soil Borings:** Soil borings aid in interpretation of infiltration test results by providing information on groundwater conditions and soil stratification. Therefore, each infiltration test shall be accompanied by a soil boring test to a depth of 10 feet below the lowest planned infiltration elevation (the bottom of the infiltrating SCM). Soil borings performed for a civil site geotechnical analysis that are located within close proximity (less than 50 feet) to the footprint of the SCM may be used. An interpretation of soil boring test results with respect to infiltration shall be provided for each test. This description shall include an assessment of the anticipated seasonal high-water table based on date of soil boring with respect to rainfall patterns, and the presence of hydric soils, redoximorphic features, or other indicator of water table variation.
 - (b) **Allowed Test Methods:** Field infiltration tests shall utilize a double-ring infiltrometer or modified Philip Dunne infiltrometer following the specifications of ASTM D3385 or ASTM 8152, respectively. Alternative infiltration test methods may only be used with approval by the Director. The use of correlation methods based on soil texture applies only to RPA designs using the T-0 factsheet of USDCM, Volume 3. The use of regional soil maps is prohibited for infiltration design or verification purposes.
 - (c) **Number of Tests Required:** At least three infiltration tests shall be conducted for every SCM using the test spacing criteria established below. The Director may require additional tests for large SCMs, greater than 10,000 square feet, or when unique soil or geological conditions are known or suspected at the site.
 - (i) Generally, one infiltration test shall be conducted for every 3,000 to 10,000 square feet of area, depending upon the size of the SCM. Tests shall be spaced appropriately to provide sufficient infiltration rate information across the length and width of the SCM.
 - (ii) For small SCMs, at least one test shall be located within the SCM's footprint. The additional tests can be performed outside the footprint but must be located within 20 feet of the perimeter of the SCM and in soil formations that are representative of the conditions within the footprint of the SCM.
 - (iii) For SCMs that have an area greater than 10,000 square feet, one infiltration test shall be conducted for every additional 10,000 square feet of surface area up to a maximum of five infiltration tests.
 - (d) **Test Elevation:** The elevation of infiltration tests shall be at or below the bottom (lowest planned infiltration elevation) of the SCM. SCMs that are

designed for full infiltration shall not be placed on fill material without prior infiltration tests to confirm full infiltration design feasibility.

- (e) Post-Construction Field Infiltration Tests: The Director may require field infiltration tests to confirm infiltration rates after construction is complete if soil compaction or clogging is known or suspected during construction. When required field infiltration test information shall be provided with the submission of as-built drawings.
- (f) Drainage Report Requirements: The Preliminary and Final Drainage Report shall include the following information for each infiltration test performed.
 - (i) Test location and elevation;
 - (ii) Test method used;
 - (iii) Location of soil boring(s) used to aid test interpretation; and
 - (iv) Soil boring results and how they were used.

7.17 Post-Construction Stormwater Approval Requirements

(A) General

- (1) Applicable development sites shall receive post-construction approval of the stormwater utility system by the Director prior to the issuance of a Certificate of Occupancy pursuant to a building permit or a Certificate of Completion for a use established pursuant to a development agreement under Chapter 9-2, "Review Processes," B.R.C. 1981. The Director will base approval on the system's conformance with the approved Final Drainage Report, the requirements of this section, and its readiness for post-construction operation.
- (2) Post-construction approval of the stormwater utility system shall be granted if the following criteria are met:
 - (a) The stormwater as-built drawing provided for the applicable development site demonstrates conformance of the constructed stormwater utility system with the approved Final Drainage Report and readiness for full post-construction operation, and
 - (b) The site's stormwater utility system and all associated SCMs are determined, based on visual inspection by the Director, to be clean; free of sediment, debris, and other obstructions; undamaged; and ready for full post-construction operation.

If these criteria are not met, the Director may require the preparation, submittal, and approval of a revised Final Drainage Report and/or corrective actions at the applicable development site before granting post-construction approval. Corrective actions may include cleaning or repair of the stormwater utility system, SCMs, or detention ponds, including, but not limited to, the removal of sediment, debris, or other obstructions; the removal of construction-related wastes or stockpiles; the installation of permanent slope stabilization or energy dissipation measures; the removal, replacement, or installation of vegetation; and soil amendment or soil media replacement in infiltration-based SCMs.

- (3) Post-construction approval of the stormwater utility system by the Director indicates that the system was constructed in conformance with City requirements, is currently operating as expected, and stormwater as-built drawings have been approved. Approval also means that the system must comply with the requirements for post-construction inspection and maintenance established in Section 7.18 of these Standards and Chapter 11-5, “Stormwater and Flood Management Utility,” B.R.C. 1981.
- (4) In no way does post-construction approval imply City ownership, maintenance, operation, or any other liability for any accepted, privately-owned, stormwater utility system, SCM, or detention pond.

(B) Stormwater As-Built Drawings

The preparation of stormwater as-built drawings is required for all applicable development sites to document the as-constructed condition of SCMs. The as-built drawings shall indicate where the as-constructed condition differs from the final approved technical drawings following the provisions of Subsection 1.3(G) of these Standards. An engineering certification of elevations shall be included as an attachment to the stormwater as-built drawings.

The figures and drawings depicting the items listed below shall be included with the as-built requirements in Chapter 1 of these Standards to provide a reference for the information provided in the Final Drainage Report. Specific as-built drawings pertaining exclusively to the conditions of the SCM are required and shall depict both plan and profile views as described below:

- (1) **Plan Drawing/s:** Illustrate and label in plan view the components of the SCM, including inlet and outlet locations, embankments, treatment surface area, utility easements, vegetated cover, and other critical drainage elements. Indicate where the as-constructed conditions differ from the final approved technical drawings.
- (2) **Profile Drawing/s:** Illustrate and label in profile view the elevations of SCM components, including filter media depth, bottom elevation, embankment slopes, inlet/outlet inverts, and other critical drainage components. Indicate where the as-constructed conditions differ from the final approved technical drawings.

(C) Post-Construction Acceptance Inspection Required

- (1) Each SCM must pass a post-construction inspection by the Director to confirm SCMs, including RPAs, are clean, have established vegetation, and are fully operational in keeping with their approved design. After these conditions are met, the SCM is considered fully functional and subject to Section 7.18 of these Standards.
- (2) The post-construction acceptance inspection shall occur after submittal of the complete as-built drawings to the Director. No application for inspection is required, as submittal of the stormwater as-built drawings will signify the project’s readiness for inspection. An inspection will not be performed in the event of submittal of incomplete drawings. Confirmation of information on the stormwater as-built drawings will also be included in the inspection.

(D) Vegetation Warranty Required

The Director may require a financial guarantee for vegetation installed within SCMs consistent

with the requirements of Subsection 11-5-6, “Stormwater Quality Management for Land Development,” B.R.C. 1981. The financial guarantee may be held for up to three years and will be released after an inspection confirms the vegetation within each SCM is in good health.

7.18 Post-Construction Stormwater Quality Inspection and Maintenance Requirements

(A) Applicability

The owner of SCMs of an applicable development site shall protect, inspect, maintain, repair, and reconstruct SCMs and associated drainage infrastructure on the property to ensure full, functional operation in accordance with the requirements in this section and pursuant to Chapter 11-5, “Stormwater and Flood Management Utility,” B.R.C. 1981.

(B) Inspection and Maintenance Requirements for SCMs

- (1) **Inspection and Maintenance Required:** The owner of SCMs shall inspect and maintain the SCMs as is necessary to ensure their full, functional operation at all times.
- (2) **Inspection Frequency:** The owner of SCMs shall be responsible to inspect the SCMs as often as necessary to assess the need for maintenance. The optimum inspection frequency for SCMs varies depending on a number of factors including, but not limited to, the type of SCM, whether the SCM is vegetated, and activities that have occurred in the area draining to the SCM. SCMs shall be visually inspected:
 - (a) After storms and snow melt to assess whether stormwater in the SCM is draining as expected, and
 - (b) During property landscape maintenance activities to look for build-up or blockages of trash, debris, or sediment; check for damage; and determine current maintenance needs.

Documentation of these inspections is not required. However, the owner of SCMs shall document a detailed visual inspection of their SCM(s) in accordance with the frequencies defined in Table 7-8, “Required Inspection Frequency by SCM Type.” The documented inspection shall be performed between May and August, when vegetation is not dormant and snow does not cover the SCM.

Table 7-8: Required Inspection Frequency by SCM Type

SCM Type	Documented Inspection
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	Frequency
Bioretention (Rain Garden)	Annually
Constructed Wetland Channel	
Constructed Wetland Pond	
Extended Detention Pond	
Grass Buffer	
Grass Swale	
Permeable Pavement	
Receiving Pervious Area (RPA)	
Retention Pond	
Sand Filter	
Other SCM Designs	
Underground SCMs	Every 3 months

- (3) **Inspection Documentation:** Inspections shall be documented using form(s) provided by the Director and located in the Inspection and Maintenance Guide for the SCMs in an appendix to the Final Drainage Report. Inspection documentation shall be kept by the owner of SCMs or their delegated representative for five years and shall be made available by the owner of SCMs or their delegated representative to the Director immediately upon request.
- (4) **Performed Maintenance:** Routine maintenance shall be performed to ensure that SCMs are functioning as designed. Corrective action shall be performed immediately when an inspection indicates the need for maintenance. Routine maintenance varies by SCM type but generally requires the regular removal of trash and debris (e.g., dead leaves, sticks, tree limbs) from inflow, outflow, and water storage areas; removal of sediment at inflows; repair of eroded areas; and general vegetation maintenance (if vegetation is part of the SCM).
- (5) **Transitional Regulations:** For any permanent stormwater quality facilities approved under the City of Boulder Design and Construction Standards in effect prior to the effective date of Ordinance 8324, the property owner shall be responsible for maintaining the stormwater quality facilities. The stormwater quality facilities shall be maintained as recommended in the USDCM and such that the design of the properties of the facility are preserved.

(C) Inspection and Maintenance Guide

An Inspection and Maintenance Guide shall be submitted as an appendix to the Preliminary and Final Drainage Report. This guide shall be provided by the Engineer to the owner of SCMs upon completion of construction and signifies transfer of maintenance responsibilities from the erosion control permittee to the owner of the SCMs. The Inspection and Maintenance Guide

shall provide inspection and maintenance guidelines specific to the SCM type and shall follow the format provided by the Director.