City of Westminster Storm Drainage Design and Technical Criteria

Manual 2019 Edition

WESTMINSTER

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CHAPTER 1
GENERAL PROVISIONS

1.1 TITLE

These CRITERIA together with all future amendments shall be known as the "City of Westminster Storm Drainage Design and Technical Criteria" (hereafter called CRITERIA) being part of the City of Westminster Municipal Code (hereafter called CITY CODE).

1.2 APPLICABILITY

These CRITERIA shall apply to all land within the City of Westminster (hereafter called CITY). These CRITERIA shall apply to all facilities constructed within CITY right-of-way (ROW) easements dedicated for public use and to all privately owned and maintained STORMWATER INFRASTRUCTURE.

1.3 PURPOSE

The design and construction of STORMWATER INFRASTRUCTURE in the CITY is expected to conform to best practices for storm drainage conveyance, flood control and stormwater treatment as set forth in Urban Drainage Flood Control District's (UDFCD's), DBA Mile High Flood District (MHFD), "Urban Storm Drainage Criteria Manual" (hereafter called the MANUAL) and as modified in these CRITERIA. Flood control is critical to protect life and property. Stormwater treatment processes are expected to be designed using a multi-barrier approach to improve stormwater quality to pre-developed conditions and protect the natural environment.

Presented in these CRITERIA are the minimum design and technical criteria for the analysis and design of STORMWATER INFRASTRUCTURE. All subdivisions, re-subdivisions, planned unit developments (PUDs), or any other proposed construction submitted for approval under the provisions of the CITY CODE shall include a storm drainage system analysis that conforms to best practices and appropriate storm drainage system construction plans in conformance with the requirements of these CRITERIA. Submittals are also expected to include a detailed plan for operations and maintenance (O&M) in accordance with these CRITERIA. The CITY shall have the right to require additional information with any phase of the analysis as conditions may warrant.

1.4 AUTHORITY

The CRITERIA has been enacted by ordinance (Resolution 22, Series 2000, dated February 28, 2000) pursuant to applicable sections of the CITY CODE and Title 31 of Article 16 of the Colorado Revised Statutes (C.R.S.) and shall have the same force and effect as all other ordinances of the CITY.

Title 31 of Article 15, C.R.S., grants municipalities the power to establish, improve, and regulate improvements including, but not limited to, streets and sidewalks, water and water works, sewers and sewer systems, and water pollution controls. In addition, a municipality may, among other powers, deepen, widen, cover, wall, alter or change the channel of watercourses.

1.5 AMENDMENT AND REVISIONS

These CRITERIA may be amended as new technology is developed and/or experience is gained in the use of these CRITERIA indicating a need for revision. It is the intent of the City Council to vest wide rule-making authority in the City Manager to the extent such rule-making authority is exercised consistent with the objectives of these CRITERIA. For the purpose of avoiding City Council involvement in the technical refinement of these CRITERIA, the City Council finds that such responsibility is best delegated to the CITY's technical staff acting under the supervision of the City Manager. Thus, the City Manager or designated representative shall have the full power and authority to amend these CRITERIA. Such amendments shall be effective immediately upon their approval by the City Manager or designated representative who shall certify their incorporation into these CRITERIA with a written addendum to these CRITERIA.

1.6 STORMWATER MANAGEMENT REQUIREMENTS UNDER THE CLEAN WATER ACT

The Federal Water Pollution Control Act of 1972, as amended (33 U.S.C. 1251 *et seq.*), is commonly known as the Clean Water Act and established minimum stormwater management requirements for urbanized areas in the United States. At the federal level, the Environmental Protection Agency (EPA) is responsible for administering and enforcing the requirements of the Clean Water Act. Section 401(p) of the Clean Water Act requires urban and industrial stormwater be controlled by through the National Pollutant Discharge Elimination System (NPDES) permit program. Requirements affect both construction and post-construction phases of development. As a result, urban areas must meet requirements of the Municipal Separate Storm Sewer System (MS4) Permits. MS4 permittees are required to develop a Stormwater Management Program that includes measurable goals and to implement needed stormwater management controls. MS4 permittees are also required to assess controls and the effectiveness of their stormwater programs and to reduce the discharge of pollutants to the "maximum extent practicable". The EPA has delegated Clean Water Act authority to the State of Colorado, and the State must meet the minimum requirements of the federal program.

The Colorado Water Quality Control Division (WQCD) administers and enforces the requirements of the Colorado Discharge Permit System (CDPS) stormwater program. For the CITY, the WQCD has issued a Phase II General Stormwater MS4 Permit.

1.7 DRAINAGE CRITERIA

The CRITERIA are intended to establish minimum guidelines, standards, and methods for the effective planning and design of STORMWATER INFRASTRUCTURE. The CRITERIA may be revised and updated as necessary to reflect advances in the field of urban drainage engineering and urban water resources management.

THE POLICY OF THE CITY REQUIRES THAT ALL STORMWATER INFRASTRUCTURE BE PLANNED AND DESIGNED IN ACCORDANCE WITH THE CRITERIA SET FORTH IN THIS DOCUMENT, UDFCD'S URBAN STORM DRAINAGE CRITERIA MANUAL, AS APPLICABLE, AND IN ACCORDANCE WITH CITY CODE.

Due to the dynamic nature of urbanization, the needs of the public will change with time requiring adjustment of design concepts. Therefore, a time limitation on the accepted construction plans and permits shall be established:

IF THE CONSTRUCTION OF ANY STORMWATER INFRASTRUCTURE IS NOT INITIATED WITHIN A ONE-YEAR PERIOD FROM THE TIME OF CONSTRUCTION PLAN ACCEPTANCE OR IF CONSTRUCTION ACTIVITIES HAVE BEEN ABANDONED FOR A PERIOD OF ONE-YEAR, THE CONSTRUCTION PLANS AND DRAINAGE REPORTS MAY BE REEVALUATED AND ARE SUBJECT TO REVISION AND RECONSIDERATION BY THE CITY.

1.8 REGIONAL AND LOCAL PLANNING

Since drainage considerations and problems are regional in nature and do not respect jurisdictional boundaries, a successful plan must emphasize regional cooperation in accomplishing goals.

1.8.1 Basin Transfer

Colorado drainage law recognizes the inequity of transferring the burden on managing storm drainage from one location or property to another. Liability questions also arise when the historic drainage continuum is altered. The diversion of storm runoff from one basin to another should be avoided unless specific and prudent reasons justify and dictate such a basin transfer. Planning and design of STORMWATER INFRASTRUCTURE should not be based on the premise that problems can be transferred from one location to another.

The subdivision process can and generally will significantly alter the historic or natural drainage paths. When the development of a subdivision results in a drainage system that discharges back into the natural drainageway at or near the historic location and in a manner which closely resembles the historic condition, the drainage system is generally acceptable. However, when the subdivision drainage system does not return the storm water to the historic drainageway at or near the historic location, then inter-basin transfer may result. In addition, if the proposed development significantly increases the tributary drainage area, then inter-basin transfer into the property may also have occurred. This inter-basin transfer shall not be allowed since it may violate a basic drainage law principle by discharging water onto a subservient property in a manner or quantity that does more harm than formerly.

THE POLICY OF THE CITY SHALL BE TO RESTRICT INTER-BASIN TRANSFER OF STORM DRAINAGE RUNOFF AND TO MAINTAIN THE HISTORIC DRAINAGE PATH WITHIN THE BASIN.

1.8.2 Master Planning

Drainage planning is required for all new developments. In recognition that drainage boundaries are non-jurisdictional, the CITY has participated in regional basin-wide master plans in partnership with UDFCD to outline required MAJOR DRAINAGEWAY SYSTEMS. The CITY will also develop and participate in future master plans.

THE POLICY OF THE CITY SHALL BE TO DEVELOP REGIONAL DRAINAGE MASTER PLANS, WHICH WILL SET FORTH SITE REQUIREMENTS FOR NEW DEVELOPMENT AND

IDENTIFY THE REQUIRED IMPROVEMENTS ALONG MAJOR DRAINAGEWAY SYSTEMS. CITY MAY REQUIRE DEVELOPERS TO CONSTRUCT THE DRAINAGEWAY SYSTEM IMPROVEMENTS IN ACCORDANCE WITH MASTER DRAINAGE PLANS.

1.8.3 Special Planning Areas

Presently, there may be areas where drainage problems currently exist. Any development or redevelopment in these areas may compound the existing drainage problems. The CITY may define certain areas within the CITY due to specific drainage concerns such as undersized STORMWATER INFRASTRUCTURE, areas of uncontrolled flows, or areas with inadequate upstream detention.

THE POLICY OF THE CITY SHALL BE TO REQUIRE ADDITIONAL DRAINAGE ANALYSIS AND TO IDENTIFY ADDITIONAL STORMWATER INFRASTRUCTURE REQUIRED FOR DEVELOPMENT AND REDEVELOPMENT IN AREAS WHERE DRAINAGE PROBLEMS MAY CURRENTLY EXIST.

1.9 Local and Major Drainage Systems

The LOCAL DRAINAGE SYSTEM consists of water quality and conveyance measures within or adjacent to the development that are required to convey the minor and major storm runoff to the MAJOR DRAINAGE SYSTEM. The MAJOR DRAINAGE SYSTEM serves more than the subdivision or property in question.

Every urban area has three separate and distinct drainage systems whether or not they are actually planned or designed. The STORMWATER TREATMENT FACILITY, the MINOR DRAINAGE SYSTEM, and the MAJOR DRAINAGE SYSTEM combine to form the total drainage system.

A STORMWATER TREATMENT FACILITY is designed to remove undesirable sediment pollutants and trash from storm runoff. This system minimizes pollutant and sediment discharge, keeps rivers and streams cleaner, maintains quality of water resources, and helps to maintain riverine habitat. Urban development is a source for oils, pesticides, fertilizers, dirt, trash, and debris which can be transported by storm runoff. STORMWATER TREATMENT FACILITIES in conformance with the MANUAL can help to remove these undesirable elements from storm runoff.

The MINOR DRAINAGE SYSTEM is designed to transport the storm runoff from 5-year frequency events with a minimum disruption to the urban environment. Minor storm drainage can be conveyed in the curb and gutter area of the street (subject to street classification and capacity, as defined herein), in the storm sewers, or in other conveyance facilities.

The MAJOR DRAINAGE SYSTEM is designed to convey storm runoff from the 100-year recurrence interval storm with minimal health and life hazards, damage to structures, and interruption to traffic and services. Major storm flows can be carried in the urban street system (within acceptable depth criteria), channels, storm sewers, and other conveyance facilities.

THE POLICY OF THE CITY REQUIRES THAT ALL DEVELOPMENTS INCLUDE THE PLANNING, DESIGN, AND IMPLEMENTATION OF THE STORMWATER TREATMENT

SYSTEM, THE MINOR DRAINAGE SYSTEM (5-YEAR RECURRENCE INTERVAL STORM), AND THE MAJOR DRAINAGE SYSTEM (100-YEAR RECURRENCE INTERVAL STORM).

The definition of a MAJOR DRAINAGEWAY SYSTEM is necessary for the clarification and administration of these CRITERIA. For the purpose of these CRITERIA, a MAJOR DRAINAGEWAY SYSTEM shall be defined as follows:

THE POLICY OF THE CITY SHALL BE TO DEFINE A MAJOR DRAINAGEWAY AS ANY DRAINAGE FLOW PATH WITH A TRIBUTARY AREA OF 130 ACRES OR MORE.

A MAJOR DRAINAGEWAY SYSTEM shall be designed to convey runoff from the 100-year recurrence interval storm minimizing health and life hazards, damage to structures, and interruption to traffic and services.

THE POLICY OF THE CITY SHALL BE TO DEFINE THE 100-YEAR RECURRENCE INTERVAL STORM FLOW RATES THAT ARE USED IN THE DESIGN OF MAJOR DRAINAGEWAY SYSTEMS GIVEN IN THE FLOOD HAZARD AREA DELINEATION (FHAD) STUDIES AS ACCEPTED BY THE UDFCD AND ADOPTED BY THE CITY.

1.10 Wetlands

Wetlands are defined as those areas that are inundated or saturated by surface or groundwater of a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

The United States Army Corps of Engineers (USACE) will make the final determination whether "Waters of the U.S." (WOTUS), which includes wetlands, exist on the project site. If WOTUS do not exist or exist but will not be impacted, there is no requirement to advise the USACE and go through the permit process.

The policy of the CITY shall be as follows:

IF WETLANDS ARE FOUND ON THE SITE, THE CITY WILL REQUIRE A DETERMINATION OF THEIR EXTENT AND THE NEED TO COMPLY WITH EXISTING REGULATORY REQUIREMENTS AT THE FEDERAL AND STATE LEVELS.

All developments or redevelopments containing wetlands will be required to initiate the pre-application process with the USACE to establish a field review date and request a permit determination. The permit determination is at the sole discretion of the USACE. If required by the USACE, the developer shall obtain an individual or nation-wide permit as determined by the USACE.

The developer will be required to apply for any other permits deemed necessary by the CITY, federal, or state agencies including water quality certification.

1.11 REVEGETATION

Revegetation is critical to the proper functioning of detention basins, retention ponds, wetland basins, and riparian areas. Revegetation is also necessary to stabilize adjacent

areas disturbed during construction. Successful revegetation is required to close-out common regulatory permits associated with working in waterways, including CITY Land Disturbance Permit (LDP), State of Colorado stormwater discharge permits and, USACE 404 permits. Because of Colorado's semi-arid climate, prevalence of introduced weeds, and difficult soil conditions encountered on many projects, revegetation can be challenging and requires proper planning, installation, and maintenance to be successful. The CITY recommends that developers include a revegetation specialist (i.e., ecologist, landscape architect, and wetland scientist) who is experienced in restoration ecology and local native plant communities as part of the overall project team to assist with project planning, direction, construction observation, monitoring, and long-term maintenance supervision for revegetation aspects of drainage projects. Early involvement of qualified professionals can help to identify site constraints and site preparation requirements, identify sensitive areas that should be protected during construction, select appropriate plants and installation procedures, and develop plans for continued plant establishment once the construction phase is complete.

1.12 MAINTENANCE AND EASEMENTS

Drainage easements shall be shown on the Official Development Plans (ODPs) and Final Plats. The drainage easements shall state that the CITY has the right of access to all stormwater conveyance and treatment facilities.

The policy of the CITY requires that maintenance access be provided to all STORMWATER INFRASTRUCTURE to assure continuous operational capability of the system. The property owners shall be responsible for the maintenance of all STORMWATER INFRASTRUCTURE located on their property including inlets, pipes, culverts, channels, ditches, hydraulic structures, and STORMWATER TREATMENT FACILITIES, unless such responsibility is modified by written agreement with the City. If the owners fail to adequately maintain said facilities, the City shall have the right to enter said property for the purpose of O&M. All such maintenance costs incurred by the City will be assessed to the property owners, including overhead and administrative costs.

Minimum required drainage and maintenance access easements widths for public facilities:

PUBLIC DRAINAGE FACILITY	MINIMUM EASEMENT WIDTH
Storm sewer*	
(a) Less than 36" diameter	Easement of 20 feet or twice the invert depth, whichever is greater
(b) Greater than 36" diameter	Easement of 25 feet or twice the invert depth, whichever is greater
Open Channels	Minimum shall include the channel, freeboard, and maintenance access road

* All storm sewer shall be centered in the easement.

1.13 REVIEW AND ACCEPTANCE

The City Engineer shall have the full authority to review the analysis and design of STORMWATER INFRASTRUCTURE for compliance with these CRITERIA. An acceptance by the City Engineer does not relieve the owner, engineer, or designer from the responsibility of ensuring that the calculations, plans, specifications, construction, and record drawings are in compliance with these CRITERIA. Any acceptance by the City Engineer shall not result in any liability to the CITY or the City Engineer for any claim, suit, loss, damage, or injury resulting from the use or implementation of the accepted drainage analysis documents. Nothing in these CRITERIA shall be construed to circumvent Section 11-6-5(B)(3) of the CITY CODE pertaining to the responsibility for reports, studies, and designs.

Per C.R.S. Section 32-11-221(1), improvements to drainage and flood control facilities, beyond the MINOR DRAINAGEWAY SYSTEM, and including where stream improvements are proposed, the storm drainage system outlets directly to a stream, or the 100-year floodplain delineation is to be modified, must be approved by UDFCD. In these cases, the City will refer submittals to UDFCD. In these cases, all drainage reports and construction plans must be prepared in accordance with UDFCD policies and criteria, construction drawings must be approved by UDFCD prior to construction, and the storm drainage system improvements including requirements for vegetation must be inspected and accepted by UDFCD for inclusion in their maintenance program.

The CITY is a participant in the National Flood Insurance Program (NFIP) which is administered by the Federal Emergency Management Agency (FEMA). As such, if the proposed construction encroaches, alters, or modifies the 100-year floodplain as regulated by FEMA, it shall be the developer's responsibility and financial obligation to meet and fulfill all of FEMA's rules and regulations with respect to the NFIP and to prepare any revisions and appeals that may be necessary as a result of the proposed development.

The policy of the City requires that all new development and redevelopment shall participate in the required STORMWATER INFRASTRUCTURE as set forth below:

1. DESIGN AND CONSTRUCT THE LOCAL DRAINAGE SYSTEM AS DEFINED BY THE PHASE III DRAINAGE REPORT AND CONSTRUCTION DRAWINGS;

2. DESIGN AND CONSTRUCT THE CONNECTION OF THE LOCAL DRAINAGE SYSTEM TO THE MAJOR DRAINAGE SYSTEM;

3. DESIGN AND CONSTRUCT THE MAJOR DRAINAGE SYSTEM WITHIN OR ADJACENT TO THE DEVELOPMENT IN ACCORDANCE WITH THE DRAINAGE "MASTER PLANS" AS REQUIRED BY THE CITY;

4. DEVELOP A WRITTEN PLAN FOR SUSTAINABLE O&M;

5. PROVIDE THE CITY AS-BUILT RECORD DRAWINGS; AND

6. PROVIDE DOCUMENTATION OF FEMA APPROVAL.

1.14 INTERPRETATION

In the interpretation and application of the provisions of these CRITERIA, the following shall govern:

- In its interpretation and application, the provisions of these CRITERIA shall be regarded as the minimum requirements for the protection of the public health, safety, comfort, convenience, prosperity, and welfare of the residents of the CITY.

- Whenever a provision of these CRITERIA or any provision in any law, ordinance, resolution, rule, or regulation of any kind contain any restriction covering any of the same subject matter, whichever restrictions are more restrictive or impose higher standards of requirements shall govern.

- These CRITERIA shall not abrogate or annul any permits, accepted storm drainage reports, approved construction plans, easements, or covenants granted before the effective date of these CRITERIA.

1.15 ENFORCEMENT RESPONSIBILITY

It shall be the duty of the City Council acting through the City Manager or designated representative to enforce the provisions of these CRITERIA.

1.16 VARIANCES

Variances from these CRITERIA must be requested and may be considered at the discretion of the City Engineer or designated representative on a case-by-case basis. No variance shall be considered without clear and convincing evidence produced by the requesting party indicating that it is not feasible or practical to meet the CRITERIA; and that the variance would not adversely affect the protection of the health, safety, convenience, prosperity, or welfare of the public. Such evidence in support of the variance shall be contained in a required drainage report. No variance can be given that would remove any requirement of the MS4 permit. Acceptance of the drainage report by the CITY shall constitute approval of the variance. The requesting party agrees to indemnify and hold harmless the CITY, its agents, and its employees from and against all claims, damages, losses, and expenses including but not limited to attorney's fees arising out of or resulting from the variance.

1.17 ABBREVIATIONS

As used in these CRITERIA, the following abbreviations shall apply:

ADA	Americans with Disabilities Act
BFE	Base Flood Elevation
CDOT	Colorado Department of Transportation
CDPS	Colorado Discharge Permit System
CLOMR	Conditional Letter of Map Revision

CMP	Corrugated Metal Pipe
C.R.S.	Colorado Revised Statutes
CUHP	Colorado Urban Hydrograph Procedure
EDB	Extended Detention Basin
EGL	Energy Grade Line
EPA	Environmental Protection Agency
EURV	Excess Urban Runoff Volume
FEMA	Federal Emergency Management Agency
FHAD	Flood Hazard Area Delineation
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FSD	Full Spectrum Detention
GI	Green Infrastructure
HDPE	High Density Polyethylene
HGL	Hydraulic Grade Line
LDP	Land Disturbance Permit
LID	Low Impact Development
LOMR	Letter of Map Revision
mg/L	milligrams per liter
MS4	Municipal Separate Storm Sewer System
NFIP	National Flood Insurance Program
NPDES	National Pollutant Discharge Elimination System
ODP	Official Development Plan
O&M	Operations and Maintenance
PDP	Preliminary Development Plan
PICP	Permeable Interlocking Concrete Pavement
PUD	Planned Unit Development
PVC	Polyvinyl Chloride
RCBC	Reinforced Concrete Box Culvert
RCP	Reinforced Concrete Pipe
ROW	Right-of-Way
SCS	Soil Conservation Service
SWMM	Stormwater Management Model
TSS	Total Suspended Solids

UDFCD	Urban Drainage and Flood Control District (DBA Mile High Flood District)
USACE	United States Army Corp of Engineers
WOTUS	Waters of the United States
WQCD	Water Quality Control Division
WQCV	Water Quality Capture Volume

1.18 DEFINITIONS

As used in these CRITERIA, the following definitions shall apply:

CITY – City of Westminster, in the State of Colorado, acting by and through the CITY MANAGER, Mayor, and CITY Council.

CITY CODE – The Westminster Municipal Code, latest edition.

CRITERIA – City of Westminster Storm Drainage Design and Technical Criteria.

LOCAL DRAINAGE SYSTEM – Consists of curb and gutter, inlets and storm sewers, culverts, bridges, swales, ditches, channels, detention ponds, green infrastructure (GI) and other STORMWATER INFRASTRUCTURE within or adjacent to the development that are required to convey the minor and major storm runoff to the MAJOR DRAINAGEWAY SYSTEM. Part of the MINOR DRAINAGEWAY SYSTEM.

MAJOR DRAINAGE SYSTEM (MAJOR STORM) – A drainage system designed for the major storm event which includes the MINOR DRAINAGE SYSTEM.

MAJOR DRAINAGEWAY BASIN – Any basin which has a tributary area equal to or greater than 130 acres.

MAJOR DRAINAGEWAY SYSTEM – Any drainage flow path with a tributary area of 130 acres or more.

MANUAL– The Urban Drainage and Flood Control District "Urban Storm Drainage Criteria Manual", latest edition.

MINOR DRAINAGE SYSTEM (MINOR STORM) – A drainage system designed for the minor storm event.

MINOR DRAINAGEWAY BASIN – Any basin which has a tributary area less than 130 acres.

MINOR DRAINAGEWAY SYSTEM – All storm drainage systems (including storm sewer, open channel, etc.) not classified as a MAJOR DRAINAGEWAY SYSTEM.

STANDARDS AND SPECIFICATIONS – Reference is made to the CITY STANDARDS AND SPECIFICATIONS FOR THE DESIGN AND CONSTRUCTION OF PUBLIC IMPROVEMENTS, latest edition.

STORMWATER INFRASTRUCTURE – Includes all stormwater conveyance (including curb and gutter, inlets, storm sewer, culverts, open channel) and STORMWATER TREATMENT FACILITIES.

STORMWATER TREATMENT FACILITY – Constructed facility or technology designed to reduce stormwater runoff volume, peak flow and pollutants before discharging to receiving waters and/or the CITY'S MS4.

CHAPTER 2
DRAINAGE REPORT REQUIREMENTS

2.1 REVIEW PROCESS

Stormwater management is a subsystem of all urbanization. The planning of STORMWATER INFRASTRUCTURE must be included in the urbanization process. The first step is to include STORMWATER INFRASTRUCTURE planning with all regional and local development master plans. Drainage reports associated with the project must be submitted for review and approval and shall address the multipurpose use of land for stormwater management.

Drainage reports describe stormwater conveyance, storage and treatment functions. When a channel is planned as a conveyance feature, it requires an outlet as well as downstream storage space. When the space requirements are considered, the provision for adequate drainage becomes a competing use for space along with other land uses. If adequate provision is not made in a land use plan for the drainage requirements, stormwater runoff will conflict with other land uses resulting in water damages, impairment, and even disruption of other urban systems.

THE POLICY OF THE CITY SHALL BE TO CONSIDER STORMWATER INFRASTRUCTURE A SUBSYSTEM OF THE OVERALL URBAN SYSTEM AND TO REQUIRE PLANNING FOR ALL DEVELOPMENTS INCLUDING THE ALLOCATION OF SPACE FOR STORMWATER INFRASTRUCTURE.

All subdivisions, re-subdivisions, PUDs, or other development shall submit drainage reports, in accordance with these CRITERIA.

The type of report required are as follows:

- **Phase I Report** must accompany the Preliminary Development Plan (PDP) submittal.
- **Phase II Report** must accompany the ODP submittal.
- **Phase III Report** must accompany the civil construction drawings.
- **Drainage Conformance Letter** will be required in lieu of a full report, if there is a study for the overall development in which the property is a part, unless significant changes are being proposed.

If a PDP and ODP are being reviewed concurrently, only a Phase II report will be required.

One PDF copy shall be submitted to the CITY for review. Washed out or unreadable portions of the report are unacceptable and could warrant re-submittal. The report shall be prepared by or supervised by a Professional Engineer licensed in Colorado who shall seal and sign all reports.

The applicant shall note that approval of construction plans, specifications, and associated engineering reports by the CITY shall only indicate that the plans, specifications, and reports are in general conformance with the City's submittal requirements, current design criteria, standard engineering principles and practices, and previously approved plans and reports. Approval shall not indicate that all assumptions, calculations, and conclusions contained within the drainage reports and/or construction plans have been thoroughly verified by City staff.

At all times, the Professional Engineer submitting the construction plans, specifications, and drainage reports shall be solely responsible for their accuracy and validity.

THE POLICY OF THE CITY SHALL BE TO REVIEW ALL DRAINAGE STUDIES ONLY FOR GENERAL CONFORMANCE WITH SUBMITTAL REQUIREMENTS, CURRENT DESIGN CRITERIA, AND STANDARD ENGINEERING PRINCIPLES AND PRACTICES. THE CITY'S REVIEW AND ACCEPTANCE OF THE DRAINAGE REPORTS AND RELATED CONSTRUCTION DRAWINGS DOES NOT RELIEVE THE ENGINEER OF RECORD OF ANY LIABILITY DUE TO ERRORS, OMISSIONS, OR VIOLATIONS OF SUBMITTAL REQUIREMENTS, CURRENT DESIGN CRITERIA OR CITY OF WESTMINSTER STANDARDS AND SPECIFICATIONS FOR THE DESIGN AND CONSTRUCTION OF PUBLIC IMPROVEMENTS (STANDARDS AND SPECIFICATIONS).

THE CITY OF WESTMINSTER ASSUMES NO RESPONSIBILITY FOR COMPLETENESS OTHER THAN AS STATED ABOVE.

If during the construction process or at any time within the warranty period of the completed improvements, any deficiencies or errors are discovered in the construction plans, specifications, drainage reports, or the actual constructed improvements, the CITY shall have the right to require the developer to make any and all corrections which may be deemed necessary by the CITY. The costs associated with any such corrections shall be the sole responsibility of the developer. (See Section 11-6-5(B)(3) of the CITY CODE.)

2.2 PHASE I DRAINAGE REPORT

A Phase I Drainage Report must be submitted during the zoning process as part of the PDP. This report will review at a conceptual level the feasibility and design characteristics of the proposed development and DRAINAGE SYSTEM. The Phase I Drainage Report shall be in accordance with the following outline and contain the applicable information listed:

2.2.1 Report Contents

I. TITLE PAGE

A. Subdivision name that matches the PDP title including lot and block number
B. Identified as a Phase I report
C. Name of owner including contact information

D. Name of company and engineer preparing the report along with contact information
E. Date of preparation including any revision dates
F. Project number associated with the PDP

II. STANDARD STATEMENT I:

I hereby affirm that this report and plan for the Phase I drainage design of the development, _____, was prepared by me (or under my direct supervision) in accordance with the provisions of the City of Westminster Storm Drainage Design and Technical Criteria for the owners thereof. I understand that the City of Westminster does not and will not assume liability for stormwater infrastructure designed by others. I am also aware of the provisions of Section 11-6-5(B) of the CITY CODE as it pertains to the City's review.

(Affix signed seal from Colorado licensed Professional Engineer)

III. GENERAL LOCATION AND DESCRIPTION

A. Location - provide a general location map including the following:

1. Scale of 1-inch = 1000 feet to 1-inch = 4000 feet
2. All streets and highways within and adjacent to the site or the area to be served by the drainage improvements
3. Quarter Section, Section, Township and Range
4. All MAJOR DRAINAGEWAY SYSTEMS and STORMWATER INFRASTRUCTURE within or adjacent to the site
5. Names of surrounding developments
6. Provide sufficient detail to identify drainage flows entering and leaving the proposed development
7. Drainage flow paths from the upstream end of any off-site basin to the receiving MAJOR DRAINAGEWAY SYSTEMS
8. Identify any major facilities (e.g. drainageways, irrigation ditches, existing detention facilities, culverts, and storm sewers) along the flow path to the receiving MAJOR DRAINAGEWAY SYSTEM
9. Major basins and sub-basins identified

B. Description of Property

1. Area in acres
2. Type of ground cover and vegetation
3. Soil type
4. Proposed land use

IV. DRAINAGEWAY BASINS

A. MAJOR DRAINAGEWAY BASIN Description

1. Reference to applicable MAJOR DRAINAGEWAY BASIN planning studies, FHAD reports, and flood insurance rate maps (FIRM). Applicable studies can be found on the UDFCD website at https://udfcd.org/mapping and FIRM maps can be downloaded from the FEMA website at https://msc.fema.gov/portal/home Copies of **pertinent** sections of the studies or maps must be presented in the appendix.
2. MAJOR DRAINAGEWAY BASIN characteristics such as existing and proposed land uses within the basin.
3. Discussion of existing drainage patterns.
4. Identification of all water supply ditches within 150-feet of the property boundary.
5. Identification including any ownership of all water bodies which either influence or may be influenced by the local drainage. Identification of all dams under the State Engineer's Office jurisdiction including the dam's current rating, status, and pertinent sections and drawings of the dam breach analysis.

B. Sub-Basin Description and Design – items discussed in this section are as follows:

1. Any Master Plan improvements designated for the site including flood insurance studies (FIS), or overall studies for the specific area, and a statement about whether they are still valid or complete.
2. Existing drainage patterns of the property including any off-site drainage that the property must accommodate, including any current drainage problems or concerns both on and off-site.
3. Identification of any wetlands present and any mitigation or replacement required.
4. Anticipated and proposed drainage patterns and facilities including permanent stormwater quality treatment necessary.
5. Downstream drainage flow patterns and the impact of the proposed development under existing and fully developed basin conditions. This must include the ultimate outfall point to a MAJOR DRAINAGEWAY SYSTEM.
6. Assumptions, techniques, and methodologies used.

V. SUMMARY

Overall summary including conclusions and professional opinions on the existing STORMWATER INFRASTRUCTURE and the proposed facilities.

VI. REFERENCES

Reference all criteria, master plans, FHADs, FIRMs, and technical information used to support the conceptual design of the proposed DRAINAGE SYSTEM.

2.2.2 Drawing Contents

I. FLOODPLAIN INFORMATION

A. A copy of the site outlined on the FIRM panel associated with the DRAINAGE BASIN.

II. DRAINAGE PLAN

A. Map(s) of the proposed development at a scale of 1" = 20' to 1" = 100' shall be included. The plan shall show the following:

1. Existing contours shown at a minimum of 5-foot intervals (as appropriate for the site size and topography) for the entire project area.
2. Existing off-site contours shown in intervals consistent with the on-site information. Off-site topography shall extend to any feature or grade change that will affect the proposed development.
3. Approved grading plans (shown in contour intervals consistent with the on-site information) for all adjacent properties which have not yet been constructed (if applicable).
4. Existing vegetation and location, type, and size of significant trees.
5. All existing wetlands areas.
6. All existing STORMWATER INFRASTRUCTURE both on-site and off-site that will impact or be impacted by the proposed development.
7. MAJOR DRAINAGEWAY SYSTEMS and the approximate 100-year floodplain limits based on the most current available information.
8. The approximate 500-year floodplain limits based on the most current available information (if located in the vicinity of a critical facility as defined in Section 11-8-2 of the CITY CODE).
9. Proposed major STORMWATER INFRASTRUCTURE in a detail consistent with the PDP.
10. MAJOR DRAINAGEWAY BASIN boundaries and sub-basin boundaries in a detail consistent with the PDP.
11. Any off-site feature influencing the proposed development and the proposed drainage system.
12. Proposed drainage flow paths.
13. Legend to define map symbols.
14. Title block with revision dates in lower right corner.

2.3 PHASE II DRAINAGE REPORT

The purpose of the Phase II Drainage Report is to refine the conceptual DRAINAGE SYSTEM and identify in greater detail issues which may occur both on-site and off-site as a result of the proposed development. The Phase II Drainage Report shall be submitted with the application for the ODP. The Phase II Drainage Report must be written in such a manner and contain enough detail to be self-explanatory (i.e., possession of previous or related drainage studies is not necessary to understand the Phase II Drainage Report).

2.3.1 Report Contents

The Phase II Drainage Report shall be in accordance with the following outline and contain the applicable information listed:

I. TITLE PAGE

A. Subdivision name that matches the ODP title including lot and block number
B. Identified as a Phase II Drainage Report
C. Name of owner including contact information
D. Name of company and engineer preparing the report along with contact information
E. Date of preparation including any revision dates
F. Project number associated with the ODP

II. STANDARD STATEMENT I:

I hereby affirm that this report and plan for the Phase II drainage design of the development, _____, was prepared by me (or under my direct supervision) in accordance with the provisions of the City of Westminster Storm Drainage Design and Technical Criteria for the owners thereof. I understand that the City of Westminster does not and will not assume liability for stormwater infrastructure designed by others. I am also aware of the provisions of Section 11-6-5(B) of the City CODE as it pertains to the City's review.

(Affix signed seal from Colorado licensed Professional Engineer)

GENERAL LOCATION AND DESCRIPTION

A. Location – provide a general location map including the following:

1. Scale of 1-inch = 1000 feet to 1-inch = 4000 feet.
2. All streets and highways within and adjacent to the site or the area to be served by the drainage improvements.
3. Quarter Section, Section, Township and Range.

4. All MAJOR DRAINAGEWAY SYSTEMS and STORMWATER INFRASTRUCTURE within or adjacent to the site.
5. Names of surrounding developments.
6. Provide sufficient detail to identify drainage flows entering and leaving the proposed development.
7. Drainage flow paths from the upstream end of any off-site basin to the receiving MAJOR DRAINAGEWAY SYSTEM.
8. Identify any major facilities (e.g. drainageways, water supply ditches, existing detention facilities, culverts, and storm sewers) along the flow path to the receiving MAJOR DRAINAGEWAY SYSTEM.
9. MAJOR DRAINAGEWAY BASINS and sub-basins identified.

B. Description of Property

1. Area in acres
2. Type of ground cover and vegetation
3. Soil type
4. Proposed land use

III. DRAINAGEWAY BASINS

A. MAJOR DRAINAGEWAY BASIN Description

1. Reference to applicable MAJOR DRAINAGEWAY SYSTEM planning studies, FHAD, and FIRM. Applicable studies can be found on the UDFCD website at https://udfcd.org/mapping and FIRM maps can be downloaded from the FEMA website at https://msc.fema.gov/portal/home Copies of **pertinent** sections of the studies or maps must be presented in the appendix.
2. MAJOR DRAINAGEWAY BASIN characteristics such as existing and proposed land uses.
3. Soil type
4. Discussion of existing drainage patterns.
5. Identification of all irrigation facilities within the major basin.
6. Identification including ownership of all lakes and ponds which either influence or may be influenced by the local drainage.

B. Sub-Basin Description and Design

1. How the sub-basin is affected by any identified planning studies encompassing the sub-basin.
2. Existing drainage patterns of the property including any off-site drainage that the property must accommodate. Include any current drainage problems or concerns both on and off-site.
3. Identification of any wetlands present and any mitigation or replacement required.
4. Proposed drainage patterns and facilities including permanent stormwater quality treatment.

5. Downstream drainage flow patterns and the impact of the proposed development under existing and fully developed basin conditions. This must include the ultimate outfall point downstream of the property.
6. Assumptions, techniques, and methodologies used.

IV. DRAINAGE DESIGN CRITERIA

A. Development Criteria Reference

1. Identification of previous drainage studies (master plans, previously accepted Phase I Drainage Report, etc.) for the site or adjacent to the site that influence or are influenced by the proposed STORMWATER INFRASTRUCTURE.
2. Any modifications to previous studies that will be required.

B. Hydrologic criteria

1. Design rainfall data and source of the data.
2. Design recurrence intervals used for minor and major storms.
3. Runoff calculation methods.

C. Hydraulic criteria

1. Methodologies used to approximate the size of proposed storm sewer including recurrence interval.
2. Methodologies used to size STORMWATER TREATMENT FACILITIES.

V. DRAINAGE FACILITY DESIGN

A. General concept

1. Proposed drainage patterns and system.
2. Accommodation of off-site runoff upstream of proposed development.
3. Effect of site development on downstream properties.
4. Any impacts on existing floodplains of MAJOR DRAINAGEWAY SYSTEMS and the requirements if altering the existing 100-year floodplain.
5. Any impacts on the existing 500-year floodplain (if located in the vicinity of a critical facility as defined in Section 11-8-2 of the CITY CODE).

B. Specific details

1. Description of existing and proposed sub-basins and design points.
2. Groundwater depth and how (if applicable) it will need to be accommodated with the proposed development.
3. Approximate location of storm collection points and storm conveyance network.
4. Discuss how the drainage design will provide treatment to improve stormwater quality.
5. Location and description of STORMWATER TREATMENT FACILITIES such as rain gardens or Extended Detention Basins (EDBs).
6. Ultimate downstream release point to a MAJOR DRAINAGEWAY SYSTEM and discussion of impact to the existing downstream facilities in order to accommodate the proposed site development.

C. List of required permits and approvals*

1. Land Disturbance
2. Floodplain development permit (if any work is performed within a regulated floodplain)
3. Conditional Letter of Map Revision (CLOMR) and Letter of Map Revision (LOMR)
4. No rise certificate (if working within a floodway)
5. USACE 404 permit (if affecting jurisdictional WOTUS)
6. State dewatering permit (if groundwater needs to be pumped off-site during construction)
7. Colorado CDPS General Stormwater Construction permit (if limits of disturbance is more than one acre including staging, stockpiling, and erosion control.)
8. Any approvals from ditch companies or private irrigation facility owners.

***The developer or the consultant is responsible for obtaining any and all permits, licenses, and any other documentation/ correspondence that are necessary to address any additional issues such as wetlands, floodplains, irrigation facilities, groundwater dewatering, and protection of existing utilities.**

VII. SUMMARY

A. Overall summary including conclusions and professional opinions of the existing and proposed facilities.

VIII. REFERENCES

A. Reference all criteria, master plans, FHADs, FIRMs, and technical reports used to support the conceptual design of the proposed DRAINAGE SYSTEM.

IX. APPENDICES

A. Hydrologic Computations

1. Tables, charts and spreadsheets utilized in hydrologic computations.
2. Time of concentration and runoff coefficients for each basin and sub-basin.
3. Summary runoff tables of historic and fully developed runoff peaks of the minor and major storms at specific design points including any off-site flow. See Figure 200 for example.

B. Hydraulic Computations

1. Tables, charts and spreadsheets utilized in hydraulic computations.
2. Existing and proposed culvert capacities.
3. Open channel typical sections, capacity, and depths.
4. Stormwater treatment facility sizing including GI and/or detention pond.
5. Downstream drainage system capacity to the MAJOR DRAINAGEWAY SYSTEM.

C. Floodplain map

D. A copy of the site outlined on the FIRM panel associated with the drainage basin.

E. Soils information from Soil Conservation Service (SCS) or relevant portions of the Geotechnical Report.

F. Excerpts from previously accepted studies. Only include pertinent portions of the study.

G. Approval and/or Agreement Letter(s)

1. Approval letter(s) from other jurisdictions, canal companies, pond owners, etc., (if required).
2. All permits, licenses, etc., for any wetland removal or mitigation as required by the USACE.
3. CLOMR for any floodplain modifications.

2.3.2 Drawing Contents

I. EXISTING CONDITIONS

Map at a scale of 1"=20' to 1"=100' shall be included and contain the following depiction of the **existing** conditions:

A. Topography with contours shown with **minimum** intervals of one foot to five feet for the entire project area or as appropriate for the site size and topography.

B. Drainage patterns including drainage basins and significant design points

C. Drainage and irrigation facilities

D. Stormwater treatment facilities

E. 100-Year floodplain and floodway limits based on the most current available information with the Base Flood Elevation (BFE) if known.

F. Wetlands

G. Vegetation and location, type and size of significant trees

II. PROPOSED DRAINAGE PLAN

Map(s) of the proposed development at a scale of 1" = 20' to 1" = 100' to include the following:

A. Existing off-site topography with contours shown in intervals consistent with the on-site information. Off-site topography shall extend to any feature or grade change that will affect the proposed development.

B. Accepted grading plans (shown in contour intervals consistent with the on-site information) for all adjacent properties which have not yet been constructed (if applicable).

C. All existing wetlands areas.

D. All existing STORMWATER INFRASTRUCTURE both on-site and off-site that will need to be considered in the design.

E. MAJOR DRAINAGEWAY SYSTEMS and the approximate proposed 100-year floodplain limits if the project will alter the existing floodplain.

F. Proposed site plan with contours and drainage flow paths. Include approximate finished floor elevation of all existing and proposed structures on and off site.

G. MAJOR and MINOR DRAINAGEWAY BASIN boundaries and design points in a detail consistent with the ODP.

H. Proposed STORMWATER INFRASTRUCTURE in a detail consistent with the ODP.

1. Storm sewer inlets and pipe network
2. Swales, culverts, and other major conveyance structures
3. Location approximate size of stormwater quality treatment facilities

I. Runoff summary table of the minor and major storm events – see Figure 200 for example

J. Legend to define map symbols – see Figure 200 for example

K. Title block with revision dates in lower right corner

2.4 PHASE III DRAINAGE REPORT

The purpose of the Phase III Drainage Report is to finalize the proposed DRAINAGE SYSTEM discussed in the Phase II Drainage Report and to present the final design details and calculations. This report must be written in such a manner and contain enough detail to be self-explanatory (i.e., possession of the Phase I and Phase II Drainage Reports for adjacent sites or any regional master plan is not necessary to understand the Phase III Drainage Report).

The Phase III Drainage Report shall be submitted with the final construction drawings. The Phase III Drainage Report (which updates the Phase II Drainage Report) must be reviewed and accepted by the Engineering Division before the final plat will be signed by the CITY or prior to issuing a LDP.

IT IS THE CITY'S POLICY THAT ALL STORMWATER TREATMENT FACILITIES ARE PROPERTY OPERATED AND MAINTAINED IN ACCORDANCE WITH SECTION 8-11 OF CITY CODE. O&M REQUIREMENTS SHALL BE DOCUMENTED AS PART OF THE FINAL DESIGN OF ALL PERMANENT STORMWATER TREATMENT FACILITIES.

An **O&M MANUAL** shall be submitted as a separate document and be included in the appendix of the Phase III Drainage Report. This shall contain a detailed outline of the recommended care schedule of any permanent STORMWATER TREATMENT FACILITIES as defined in Chapter 8 of this CRITERIA.

See I.(B) in this section for an outline of required information.

The Phase III Drainage Report shall be prepared in accordance with the outline shown in Section 2.3.1 **with the following additions**:

I. TITLE PAGE

A. Subdivision name that matches the final plat title including lot and block number
B. Identified as a Phase III Drainage Report
C. Name of owner including contact information
D. Name of company and engineer preparing the report along with contact information
E. Date of preparation including any revision dates
F. Permit number associated with the LDP

STANDARD STATEMENT I:

I hereby affirm that this report and plan for the Phase III drainage design of the development, _____, was prepared by me (or under my direct supervision) in accordance with the provisions of the City of Westminster Storm Drainage Design and Technical Criteria for the owners thereof. I understand that the City of Westminster does not and will not assume liability for stormwater infrastructure designed by others. I am also aware of the provisions of Section 11-6-5(B) of the City CODE as it pertains to the City's review.

(Affix signed seal from Colorado licensed Professional Engineer)

STANDARD STATEMENT 2: (following Standard Statement 1)

__(Name of Owner)__ hereby affirms that the stormwater infrastructure for the development, _____, shall be constructed according to the design presented in this report. I understand that the City of Westminster does not and will not assume liability for stormwater infrastructure designed and/or certified by my engineer. I understand that the City of Westminster reviews drainage plans but cannot, on behalf of __(Name of Owner)__ and/or their successors and/or assigns assume future liability for improper design. I am also aware of the provisions of Section 11-6-5(B) of the City CODE as it pertains to the City's review.

I HAVE READ AND UNDERSTAND THE O&M OF THE STORMWATER TREATMENT FACILITIES SECTION OF THIS REPORT AND SHALL ENSURE ALL REQUIREMENTS AND RECOMMENDATIONS ARE FOLLOWED.

THIS STIPULATION PERTAINS TO MYSELF, AS THE CURRENT OWNER, AND ALL SUBSEQUENT OWNERS

_____

Name of Owner

Authorized Signature/Title

II. APPENDICES

A. Hydraulic Computations

1. Existing and proposed culvert capacities.
2. Storm sewer profiles including energy grade line (EGL) and hydraulic grade line (HGL) elevations with the associated hydraulic computations.
3. Gutter and street cross-section capacities compared to the maximum allowable street flows.
4. Storm inlet capacity including inlet control rating at connection to storm sewer.
5. Open channel design: depth, capacity, velocity, and Froude number calculations.
6. Check drop and/or channel drop structure design calculations.
7. STORMWATER TREATMENT FACILITY sizing including GI and detention to follow criteria set forth in the latest edition of the MANUAL.
8. Stormwater treatment outlet design.
9. Downstream drainage system capacity to the MAJOR DRAINAGEWAY SYSTEM.
10. Rip-rap design calculations.
11. A completed Post-Construction Stormwater Management Design Standards Form.
12. A completed Post Construction Stormwater Management Exclusions Form if applicable.

B. An **O&M Manual** for STORMWATER TREATMENT FACILITIES shall be submitted as a separate document and be included as an appendix of the Phase III Drainage Report. Contents shall include at minimum the following information:

1. Responsible parties for O&M.
2. Description of required O&M specific for the site.
3. For facilities with landscaping, recommendation of fertilization type and amount to minimize downstream pollutant and nutrient loading.
4. Recommended intervals for each type of O&M aspect.
5. Refer to UDFCD for maintenance recommendations and include cut sheets for proposed facilities in the appendices.
6. A drawing depicting the above information including location of appurtenances mentioned in the text and a table including schedule of required and recommended maintenance.
7. Provide any available manufacturer specific O&M cut sheets and inspection recommendations.
8. Annual inspection and maintenance forms are required prior to final acceptance and must be submitted by the owner to the City prior to March 31st of each year.

III. REPORT DRAWINGS

The report drawings shall follow the requirements presented in Section 2.3.2 and include any updates and detailed sizing information.

2.5 CONSTRUCTION DRAWINGS

Where drainage improvements are to be constructed, plans for these improvements shall be part of the construction drawing package for the site improvements and shall be accompanied by the Phase III Drainage Report. Acceptance of the final construction drawings by the City Engineer is a condition of issuance of construction permits. The construction drawings for the STORMWATER INFRASTRUCTURE improvements will include:

1. Storm sewers, inlets, outlets, and manholes with pertinent elevations, dimensions, type, and horizontal control indicated.

2. Culverts, end sections, and inlet/outlet protection with dimensions, type, elevations, and horizontal control indicated.

3. Channels, ditches, and swales (including side/rear yard swales) with lengths, widths, cross-sections, slopes, and erosion control (i.e. rip-rap, concrete, grout) indicated.

4. Check dams, channel drops, and other required erosion control facilities.

5. EDB details including forebay, trickle channel, outlet structure, overflow weir, maintenance road, and pertinent cross sections.

6. Details of GI including filter material, underdrains, liners, construction method notes, and pertinent cross-sections.

7. Other drainage related structures and facilities (including underdrains, sump pump lines, and irrigation diversion structures).

8. Overlot grading plan.

9. Summary runoff table per Figure 200 including drainage basin and design point notations.

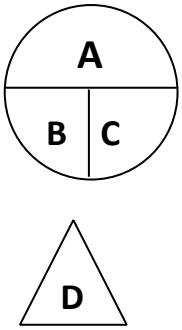
10. Detailed grading plan providing rear lot elevations, front lot elevations, slopes and flow direction

11. Any and all wetland mitigation details

The information required for the construction drawings shall be in accordance with sound engineering principles, these CRITERIA, the STANDARDS AND SPECIFICATIONS and the MANUAL. Construction drawings shall include geometric, dimensional, structural, foundation, bedding, hydraulic, and other details as needed to construct the STORMWATER INFRASTRUCTURE. All sheets in the construction drawings shall be sealed and signed by a Professional Engineer registered in the State of Colorado certifying that the accepted Phase III Drainage Report and drawings are in accordance with the CRITERIA, STANDARDS AND SPECIFICATIONS and the MANUAL.

FIGURE 200
SUMMARY RUNOFF TABLE NOTATIONS
(to be placed on the drainage plan)

A = Basin Designation
B = Area in acres
C = Composite Runoff Coefficients for the minor and major storm events
D = Design Point Designation



Summary Runoff Table

Design Point	Contributing Basins	Runoff Peak Minor Event (cfs)	Runoff Peak Major Event (cfs)

CHAPTER 3
RAINFALL AND RUNOFF

3.1 INTRODUCTION

Presented in this section are the accepted methods to find rainfall data and calculate runoff utilizing the Rational Method and the Colorado Urban Hydrograph Procedure (CUHP). All hydrological analysis within the jurisdiction of these CRITERIA shall utilize the rainfall data presented in Chapter 5, Volume 1 of the MANUAL for calculating storm runoff design peaks and volumes to be used in the preparation of STORMWATER INFRASTRUCTURE design, drainage reports, and construction drawings.

THE POLICY OF THE CITY ALLOWS STORM RUNOFF DESIGN FLOWS TO BE DETERMINED BY EITHER THE RATIONAL METHOD OR THE CUHP WITHIN THE LIMITATIONS AS SET FORTH IN THESE CRITERIA AND THE MANUAL.

Below is a table presented in the MANUAL that is adopted by the CITY:

Watershed Size (acres)	Is the Rational Method Applicable?	Is CUHP Applicable?
0 to 90	Yes	Yes
90 to 160	No	Yes
160 to 3,000	No	Yes[1]
Greater than 3,000	No	Yes (subdividing into smaller catchments required)[1]

1. Subdividing into smaller subcatchments and routing the resultant hydrographs using SWMM may be needed to accurately model a catchment with areas of different soil types or percentages of imperviousness.

3.2 COLORADO URBAN HYDROGRAPH PROCEDURE DESIGN STORMS

For drainage basins greater than 90 acres, or for smaller basins that will involve stormwater routing, the CUHP in conjunction with EPA's Stormwater Management Model (SWMM) shall be the method of analysis. This procedure is outlined in Chapters 5 and 6, Volume 1 of the MANUAL.

3.3 THE RATIONAL METHOD DESIGN STORMS

For urban catchments that are not complex (i.e. no routing involved) and are generally 90 acres or less in size, it is acceptable to use the Rational Method for design storm analysis. Rainfall data and runoff analysis using the Rational Method is outlined in Chapter 5 and 6, Volume 1 of the MANUAL.

3.4 DESIGN FREQUENCIES FOR COLLECTION AND CONVEYANCE

The design methods and frequencies for determining runoff including the Rational Method and the CUHP are presented in the most recent version of the MANUAL.

THE POLICY OF THE CITY ALLOWS THE MINOR STORM FREQUENCY TO BE THE 5-YEAR EVENT, AND THE MAJOR STORM FREQUENCY TO BE THE 100-YEAR EVENT. STORMWATER COLLECTION AND CONVEYANCE INFRASTRUCTURE MAY BE DESIGNED TO ACCOMMODATE THE MINOR EVENT UNLESS THE MAJOR EVENT CANNOT SAFELY REACH THE STORMWATER TREATMENT FACILITY VIA OVERLAND FLOW. IN THIS CASE, STORMWATER COLLECTION AND CONVEYANCE INFRASTRUCTURE MUST BE DESIGNED TO ACCOMMODATE THE MAJOR EVENT.

3.5 STORM FLOW ANALYSIS

When determining the design storm flows rates, the engineer shall follow particular criteria and guidelines to assure that minimum design standards and uniformity of drainage solutions are maintained throughout the CITY. The information presented herein shall be used by the design engineer as the minimum acceptable criteria for determining the design storm runoff rates. It is still the responsibility of the design engineer to exercise sound engineering judgment in the design of the STORMWATER INFRASTRUCTURE (see CITY CODE Section 11-6-5(B)).

THE POLICY OF THE CITY IS TO REQUIRE THE EVALUATION OF OFF-SITE FLOW CONDITIONS FOR ALL RUNOFF ANALYSIS. MAJOR DRAINAGE SYSTEMS SHALL BE DESIGNED FOR THE FULLY DEVELOPED STORM RUNOFF **WITHOUT** ACCOUNTING FOR THE BENEFITS OF ON-SITE OR OFF-SITE DETENTION THAT IS NOT MAINTAINED BY A PUBLIC AGENCY.

3.5.1 On-Site Flow Analysis

When analyzing the storm peaks and volumes, the design engineer shall use the proposed fully-developed land use plan to determine runoff coefficients. In addition, the engineer shall take into consideration the changes in drainage flow patterns (from the undeveloped site conditions) caused by the proposed street alignments. When evaluating surface flow times, the proposed lot grading shall be used to calculate the time of concentration or the CUHP parameters.

The drainage analysis shall assume that any active water supply ditch does not intercept any storm runoff.

3.5.2 Off-Site Flow Analysis

Where the off-site area is currently undeveloped, the runoff rates shall be calculated assuming the off-site area is fully developed. The off-site area's potential land use shall be defined by the CITY's Planning Division. Where the off-site area is fully or partially developed, the storm runoff shall be based upon the existing land uses and topographic features.

MAJOR DRAINAGE SYSTEMS shall be designed for the fully developed storm runoff **without** accounting for the benefits of on-site or off-site detention that is not maintained by a public agency. No credit is given for detention not maintained by a public agency systems for several reasons including (1) history has shown that many existing small- and medium-sized detention ponds are not properly maintained resulting in peak runoff releases which exceed the design conditions, (2) studies completed through the UDFCD have shown that the combined runoff rates from several detention ponds releasing at historic rates will not achieve a combined historic runoff rate due to the matching of the hydrograph peaks, and (3) many minor storm pond outlets are so small that, for practical purposes, any debris can obstruct the outlet causing stormwater to be released via the overflow weir greater than the designed release rate.

CHAPTER 4
STORMWATER COLLECTION AND CONVEYANCE

4.1 INTRODUCTION

Stormwater collection and conveyance is comprised of streets, inlets, pipes, manholes, outlets, and other appurtenances. The location of inlets is determined by the street capacities for various drainage classifications. Placement of the stormwater collection and conveyance infrastructure should enable safe passage of vehicular traffic during minor storm events, and manage flooding that maintains public safety during major storm events.

Except as modified herein, all stormwater collection and conveyance will be designed in accordance with the STANDARDS AND SPECIFICATIONS and the MANUAL.

4.2 STREETS

The criteria presented in this section shall be used in the evaluation of the allowable drainage encroachment for public streets both the major and minor storm events (as defined in Chapter 3).

Streets are an integral part of the urban drainage system and may be used for transporting storm runoff within specified design limits. The design engineer should recognize that the primary purpose of a street is for traffic; and therefore, the use of streets for transporting storm runoff must be restricted.

NOTE: Cross-pans are prohibited to cross arterial streets and collector streets. Cross-pans are not allowed on local streets except at locations where traffic stops are intended at intersections.

The streets in the CITY are classified for drainage use according to the traffic classification for which the street is designed. Classifications are local, major and minor collector, and major and minor arterial. The allowable drainage encroachment into the driving lanes is more restrictive for the higher street classifications. The encroachment limits of storm runoff for each traffic classification and storm condition are set forth in the following table. (Note: For state and federal highways, the governing agency may apply more restrictive criteria.)

DRAINAGE CLASSIFICATION	MINOR STORM	MAJOR STORM (Maximum theoretical street encroachment)
Local	No curb overtopping for a 6-inch vertical curb. Flow may spread to the back of the sidewalk for a 4-inch combination curb and sidewalk.	Residential dwellings and public, commercial and industrial buildings shall be no less than 12 inches above the major stormwater surface elevation. The depth of water at the gutter flowline shall not exceed 12 inches.
Major and Minor Collector	No curb overtopping. Flow spread must leave at least one 10-foot lane free of water, 5 feet either side of the street crown.	
Major and Minor Arterial	No curb overtopping. Flow spread must leave at least two 10-foot lanes free of water, 10 feet each side of the street crown of median.	Residential dwellings and public, commercial and industrial buildings shall be no less than 12 inches above the major stormwater surface elevation. To allow for emergency vehicles, the depth of water shall not exceed 6 inches at the street crown or 12 inches at the gutter flowline whichever is more restrictive.

4.3 STORM INLETS

There are three types of inlets allowed within the CITY: curb opening, grated, and combination inlets. Other types of inlets will be considered on a case-by-case basis. Inlets are further classified as being "continuous grade" or “sump”. The term "continuous grade" refers to an inlet located such that the grade of the street has a continuous slope past the inlet. The “sump” condition exists whenever the inlet is located at a low point. A “sump” condition can occur at a change in grade of the street from positive to negative or at an intersection due to the crown slope of a cross street.

4.3.1 Standard Inlets

The standard inlets permitted for use in the CITY are:

INLET TYPE	PERMITTED USE
Curb Opening Inlet Type R	All street types. Minimum inlet length is 5 feet.
Grated Inlet Type C	All streets with a roadside median ditch. Private areas where pedestrian use is limited.
Grated Inlet Type 13	Private areas with a valley gutter only. Must use a “Bicycle Safe” grate.
Combination Inlet Type 13	Private areas only. Must use a "Bicycle Safe" grate.

4.3.2 Inlet Hydraulics, Sizing, and Spacing

The procedures and basic data used to define the capacities of the standard inlets under various flow conditions are found in Volume 1, Chapter 7, Section 3 of the MANUAL for curb opening inlets. The calculated inlet capacity must be compatible with the allowable street capacity discussed in Section 4.2.1.

The optimum spacing of storm inlets is dependent upon several factors including traffic requirements, contributing land use, street slope and capacity, amount of flow bypassed at the upstream inlet, and distance to the nearest outfall system.

Design software available in the MANUAL will be accepted as design aids. See accepted parameters later in this chapter.

4.4 PIPE HYDRAULICS

Storm sewer pipes shall be designed to convey the storm flows that exceed the allowable street capacity. To ensure that this objective is achieved, the HGL of the storm sewer pipe shall be calculated by accounting for the total hydraulic losses which include pipe friction, expansion, contraction, bend, and junction losses. EGL calculations may also be required. The methods for estimating these losses are presented in the MANUAL Volume 1 Chapter 7 Section 4. Design software available on the UDFCD website can also be utilized. Acceptable roughness coefficients (“n”-values) to be used for various pipe materials is presented in Table 401 at the end of this chapter.

The HGL for all storm sewer pipes for the minor and major storm events shall be shown on the profile sheets and included in the Phase III Drainage Report.

IT IS THE POLICY OF THE CITY THAT STORM SEWER PIPES SHALL BE DESIGNED TO CONVEY THE MINOR STORM WITHOUT SURCHARGING AND THE HGL OF THE MAJOR STORM EVENT SHALL BE 6-INCHES BELOW PROPOSED GRADES.

IF THE MAJOR STORM EVENT TO A STORMWATER TREATMENT FACILITY CANNOT BE ACHIEVED THROUGH STORM SEWER CONVEYANCE AND OVERLAND FLOW, THE STORM SEWER PIPES MUST BE DESIGNED TO CONVEY THE MAJOR STORM EVENT.

4.5 PIPE SIZE AND MATERIAL

The minimum allowable pipe size and material for public storm pipes is 15" RCP for laterals (inlet to manhole), and 18" RCP for main lines. Any private landscape drains shall not be green PVC as to distinguish from sanitary sewers.

4.6 MANHOLES

Manholes or maintenance access ports will be required whenever there is a change in size, direction, elevation, slope, or at a junction of two or more sewers. Also, the maximum spacing between manholes for various pipe sizes shall be in accordance with the table below:

DIAMETER OF PIPE	MAXIMUM ALLOWABLE DISTANCE BETWEEN MANHOLES
15" to 36"	400 feet
42" and larger	500 feet

The required manhole size shall be as follows:

STORM SEWER DIAMETER	SUM OF PIPE DIAMETER (3 or More)	MANHOLE DIAMETER
15" to 18"	less than 54"	4'
21" to 27"	less than 72"	5'
30" to 33"	less than 90"	6'
36" and larger	greater than 90"	Refer to the STANDARD

Larger manhole diameters or a junction structure may be required when storm sewer alignments are not straight through, more than one storm sewer line goes through the manhole, or pipe entry angles do not allow adequate space between pipes at the manhole.

"Tee" manholes are acceptable for storm sewers equal to or larger than 60-inch in diameter.

TABLE 401

STREET CAPACITY	**N-VALUE**
Asphalt street with concrete curb and gutter	0.016
Concrete street and curb/gutter	0.013
PIPE CAPACITY	
Reinforced Concrete Pipe (RCP)	0.013
Polyvinyl Chloride (PVC) Pipe	0.011
High Density Polyethylene (HDPE) Pipe	0.012
Corrugated Metal Pipe (CMP)	0.020

CHAPTER 5
CULVERTS

5.1 INTRODUCTION

A culvert is defined as a conduit, open on both ends, for the passage of surface drainage water under a highway, railroad, canal, or other embankment (except detention pond outlets). Culverts may be constructed with many shapes and materials.

This chapter addresses the hydraulic function of culverts (i.e., conveyance of surface water through embankments such as roadways and railroads). Structural considerations, such as the design requirements to support loads, are not addressed in this chapter. The chapter is primarily focused on design of culverts. When designing a culvert that will include a path, also see the Stream Access and Recreational Channels Chapter in the MANUAL.

A careful approach to design is essential, for new and retrofit situations, because crossings often significantly influence upstream and downstream flood risks, floodplain management, and public safety. Multiple factors have a bearing on the hydraulic capacity and overall performance of a structure. These include the size, shape, slope, material, inlet configuration, outlet protection, and other variables. Sizes and shapes of culverts vary from small circular pipes to extremely large arch sections used in place of a bridge. In addition to the primary function of conveying flow, culverts can create conditions upstream that are suitable for wetland growth. Aesthetic considerations should also be incorporated into a design, such as visually integrating a crossing into the surrounding landscape. This can be achieved through thoughtful grading, landscaping and wall design including finishing.

5.2 CULVERT DESIGN CONSIDERATIONS

Culvert designs should consider major and minor storms as well as more frequent lower flow conditions. There are two basic types of flow conditions in culverts: (1) inlet control and (2) outlet control. For each type of control, a different combination of factors is used to determine the hydraulic capacity of the culvert. The determination of actual flow conditions can be difficult; therefore, the designer must check for both types of control and design for the most adverse condition.

Design of a culvert installation is more difficult than the process of sizing culverts, since other considerations arise with site-specific factors. Evaluate several combinations of entrance types, invert elevations, and pipe diameters to determine the optimal design.

Headwalls and wing walls or flared-end sections at the inlet and outlet should be considered by the design engineer. Flared-end sections are only allowed on pipes with diameters of 42 inches (or equivalent for non-round pipe) or less.

The CITY's minimum requirements are as follows:

- Within the CITY ROW, culverts shall be constructed from concrete. Other construction materials are subject to written approval by the City Engineer.
- Minimum cross-sectional area of 2.8 ft^2 for arch shapes.
- Minimum cross-sectional area of 3.3 ft^2 for elliptical shapes.
- Roadside ditch culverts for driveways shall be a minimum of 15-inch diameter for round pipe or a minimum cross-sectional area of 1.6 ft^2 for other shapes.
- CMPs are not permitted to be used as culvert materials within CITY ROW.
- At the discretion of the CITY additional protection also be required at the inlet and outlet due to the potential scouring or erosive velocities.

5.3 CULVERT CONSTRUCTION AND MAINTENANCE CONSIDERATIONS

Reinforced Concrete Box Culverts (RCBC) can be constructed with generally any rectangular cross-section with the limitations being the physical site constraints and the structural requirements. Pre-cast box culverts are also available in several standard dimensions.

The CITY may require culvert designs to also meet design criteria for UDFCD maintenance eligibility.

5.4 CROSS-STREET AND OVERTOPPING FLOW

Culverts must`` be designed and constructed to carry the full 100-year flood flow event. Roadways are considered to be a portion of the storm drainage system and can become inundated with storm flows in an urban drainage system when the runoff in a gutter spreads across the street crown to the opposite gutter or when cross-pans are used. Additionally, when the flow in a drainageway crosses or runs parallels to a roadway and then exceeds the capacity of an associated culvert, it can subsequently overtop the crown of the roadway. For this localized flooding condition, where a drainageway overtops a roadway at the culvert crossing, the only allowable condition is a 12-inch surcharge measured at the gutter flowline and only within local or collector roadways. No other surcharge conditions are allowed on any other roadways.

Additionally, the maximum headwater depth for the 100-year design flows at the culvert entrance shall not exceed 1.5 times the culvert diameter or 1.5 times the rise dimension for non-round pipe shapes.

Under no circumstances shall the 100-year storm flow encroach on any structure.

5.5 SAFETY GRATES

Always consider the use of safety grates at inlets to culverts and underground pipes while also evaluating hydraulic forces and clogging potential. Several fatalities can be attributed to the lack of a safety grate on small (< 42-inch) pipes and long culverts. At

the same time, field experience has shown that undersized or poorly designed grates can become clogged during heavy runoff and the culvert may be rendered ineffective. Based on UDFCD investigations of culvert related fatalities, safety grating should be required when any of the following conditions are or will be true:

- It is not possible to "see daylight" from one end of the culvert to the other,
- The culvert is less than 42 inches in diameter, or
- Conditions within the culvert (bends, obstructions, vertical drops) or at the outlet are likely to trap or injure a person.

Exceptions to the above criteria consist of street curb-opening inlets and driveway culverts that are subject to a ponding depth of no more than 12 inches at the flow-line and culvert entrances that are made inaccessible to the public by fencing.

The safety grate design process is a matter of identifying all safety hazard aspects and then taking reasonable steps to minimize them while providing adequate inflow capacity to the culvert. Generally, the most common aspect to consider in evaluating the safety hazard of a culvert is the possibility of a person, especially children, being carried into the culvert or becoming pinned at the culvert entrance by flowing water approaching the inlet. Inlets to culvert shall have the following design elements:

- Large, sloped grates anchored well in front of the culvert entrance.
- Access shall be via a manhole behind the headwall, a hatch within the grate, or a hinged grate. Consider the option to lock access behind the safety grate.
- The bars on the face of the grate must be parallel to flow and spaced to provide no more than 5-inch clear openings.
- Transverse support bars located at the back of the grate must be as few as possible, but sufficient to keep the grate from collapsing under full hydrostatic loads.
- Grating is not allowed at the outlet of a culvert or storm drain.

5.6 BRIDGES

Bridges are used to carry roadways, railroads, shared-use paths, and utilities over surface waters. Generally, a bridge is defined as having a span of 20 feet or more, as opposed to a culvert. If a bridge is not sized properly with regard to the design flow, overtopping and flooding will occur, leading to public hazards, erosion damage, and possible structural failure. However, bridge design also includes assumption of a certain level of risk that is usually determined by the owner or local jurisdiction. This section provides a brief overview of hydraulic design of bridges, and includes references for additional design guidance. Structural design is not addressed here – for that information, readers are directed to the American Association of State Highway and Transportation Officials (Standard Specifications for Highway Bridges. There are many references for bridge

hydraulics, some of which are available online. A key source of information is the Federal Highway Administration.

The Colorado Department of Transportation (CDOT) also provides a good reference on bridge design and hydraulics in Chapter 10 of the CDOT Drainage Design Manual. This is available on their website, www.coloradodot.info. Most roadway bridges are designed to pass the 100-year flood event. However, other types of bridges (such as for shared-use paths) may allow a greater risk and lesser design capacity.

If the bridge is located within a regulatory floodplain, special consideration must be given to the impacts of the bridge on 100-year floodplain water surface elevations. At a minimum a floodplain development permit will be required. Impacts to federally designated floodplains may require a LOMR with FEMA and a CLOMR prior to beginning construction.

CHAPTER 6
OPEN CHANNELS

6.1 INTRODUCTION

Open channels are designed for collection and conveyance of stormwater. This chapter focuses on the design of constructed channels and swales using natural concepts. These measures include maintaining or establishing an effective planimetric channel form, cross sectional shape, and longitudinal slope, implementing grade control and bank protection, and establishing and maintaining a favorable mix of riparian vegetation.

Streams and their floodplains require space to remain fully functional. Ample space needs to be provided both horizontally and vertically. Horizontal space is necessary to allow the stream to naturally flex and adjust for dynamic equilibrium. As relative roughness increases, flow velocity and erosive force decreases as the wetted channel width increases for a given flood discharge. Therefore, wide floodplains are generally more stable than narrow floodplains for a given flow rate.

6.2 NATURAL CHANNELS

The hydraulic properties of natural channels vary along the channel reach. The channel can be controlled to the extent desired or altered to meet given requirements. The initial decision to be made regarding natural channels is whether or not the channel is to be protected from erosion due to high velocity flows or protected from excessive silt deposition due to low velocities.

Many natural channels in urbanized and to-be-urbanized areas have mild slopes, are reasonably stable, and are not in a state of serious degradation or aggradation. However, if a natural channel is to be used for conveying storm runoff from an urbanized area, the altered nature of runoff peaks, duration, and volumes from development causes channel degradation. Detailed hydraulic analysis will be required for natural channels in order to identify its erosion tendencies. Some modifications of the natural channel may be required to assure a stabilized condition.

The hydraulic analysis necessary to assure the adequacy of natural channels vary for every waterway.

Photograph 7.1 Natural Channel on Little Dry Creek

At a minimum, the design engineer must prepare and provide cross-sections of the channel, define the water surface profile for the minor and major design storm, determine the major and minor storm velocities, determine the Froude number, investigate the bed and bank material to determine erosion tendencies, and study the bank slope stability of the channel under future flow conditions. Since supercritical flow does

not normally occur in natural channels, the results of the hydraulic analysis should not reflect supercritical flow.

6.3 SWALES

Swales are defined as constructed channels that convey low-flow storm runoff between points of concentration, such as detention outfalls, downstream to receiving facilities, such as storm inlets or natural drainageways. Swales can also be grass-lined permeable channels that collect storm runoff sheet flow from adjacent lands and convey that flow downstream. Swales are not trickle channels.

Grass-lined swales are the preferred intermediate drainageways between runoff sources and downstream STORMWATER INFRASTRUCTURE. The grass stabilizes the body of the channel, consolidates the soil mass of the bed, reduces the erosion on the channel surface, and controls the movement of soil particles along the channel bottom. The presence of grass in channels creates a turbulence which results in loss of energy and increased flow impedance. The channel storage, the lower velocities, and the potential multiple-use benefits of the greenbelt obtained from grass-lined channels create significant advantages over other artificial channels.

Impervious concrete lined channels are discouraged and are only allowed by approval of the City Engineer. All swales must be within the drainage access easement dedicated to the CITY. Regardless of where the swale is located the underlining property owner is responsible for maintenance and upkeep to ensure proper functioning.

6.4 ROCKS AND BOULDERS

In conditions where rock protection is required, it is recommended that soil riprap, void-filled riprap, or boulders be used. The riprap layer is designed to remain stable and provide protection during the extreme events. Refer to the MANUAL as well as UDFCD specifications for rocks and boulders.

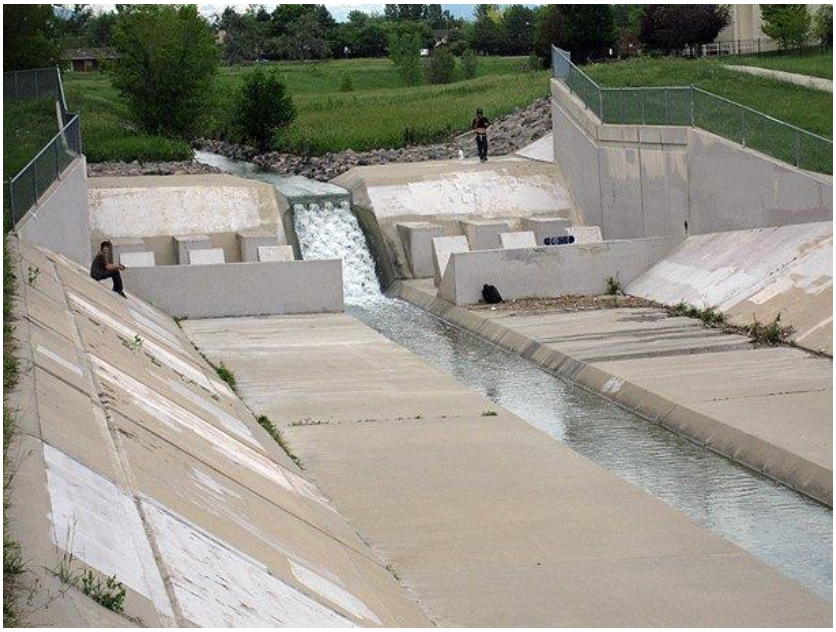
- For small installations, and where vegetation is not anticipated, riprap over bedding material may be used.
- Soil riprap is intended for use in applications where vegetative cover can be established and where the shear stress, imposed by frequently occurring flows, is less than the resistive strength of the vegetation and soil.
- Void-filled riprap must contain a well-graded mix of cobbles, gravels, sands, and soil. In applications where it is difficult to establish vegetation or prolonged impingement of water is expected void-filled, riprap should be used.

Boulder-lined channels and revetment solely consisting of rip-rap are generally discouraged and shall be permitted only on a case-by-case basis. If the project constraints suggest the use of a rock-lined channel, the design engineer must present the concept and justification to the City Engineer for consideration and approval.

Willow staking is discouraged and will be allowed in select areas only.

6.5 CONCRETE-LINED CHANNELS

Concrete-lined channels for drainageways are not permitted.



6.6 OTHER CHANNEL LINING TYPES

The City encourages the exploration of alternative products that can be utilized in an environmentally friendly and cost-effective application. The use of various types of fabrics in construction and geotechnical engineering for the placement of a slope revetment mat, erosion control or soil lifts has increased tremendously. Products which consist of discrete concrete blocks on a continuous fabric backing are included in this category of channel lining.

Synthetic fabric erosion control mats are not allowed in any application.

6.7 DESIGN REQUIREMENTS

Evaluating channel and floodplain hydraulics is a key component of any stream project. Hydraulic modeling provides insight into flow properties including water surface elevation, depth, velocity, shear stress, and Froude Number. Understanding these flow properties is necessary to assess risks associated with structure flooding and channel erosion and can help guide the design of stream capacity and stabilization improvements.

All channels shall convey the 100-year peak flow within the main channel and overbank area assuming a fully developed basin. Channel designs should consider major and minor storms as well as more frequent lower flow conditions. All design calculations shall be in accordance with the MANUAL.

Plan and profile drawings shall be prepared and provided showing the 100-year water surface profile, floodplain, floodway, and the details of erosion protection. Appropriate allowances for known future bridges or culverts, which would affect the floodplain delineation, shall be included in the analysis. The 100-year floodplain and floodway shall

be defined so that the floodplain can be zoned and protected in accordance with the CITY's floodplain regulations. The first-floor elevation for all structures constructed along the channel shall be a minimum of 1-foot above the 100-year water surface elevation and be outside the 100-year floodplain.

A maintenance access road at least 12-feet wide shall be constructed where feasible. The access road should be constructed of concrete and meet the specifications for construction of a sidewalk.

A drainage and maintenance access easement shall be dedicated to the CITY. However, the maintenance of the channel, overbank areas, and hydraulic structures shall be the responsibility of the property owner.

IT IS THE POLICY OF THE CITY TO MAKE A DETERMINATION WHETHER A NATURAL CHANNEL MUST MEET MAINTENANCE ELIGIBILITY REQUIREMENTS OF UDFCD. IF DETERMINED NECESSARY, THE NATURAL CHANNEL MUST MEET THE ELIGIBILITY REQUIREMENTS FOR THE UDFCD MAINTENANCE PROGRAM. UDFCD WILL INSPECT CONSTRUCTION AND REVEGETATION AS PART OF THEIR APPROVAL PROCESS. THE PROPERTY OWNER IS RESPONSIBLE FOR OBTAINING ALL UDFCD APPROVALS AND COORDINATING ALL NECESSARY INSPECTIONS.

6.8 WATER SUPPLY DITCHES

In urbanizing areas, the conflict between the natural flow of surface water and irrigation ditches, which bisect many drainage basins, continues to be a difficult condition to resolve taking into consideration the rights and liabilities of upstream property owners and irrigation ditch owners. Several natural drainageways have been blocked by irrigation ditches, although they were constructed long before the basin became urbanized. This special area of urban storm runoff points to the need for good land use requirements, as well as identification of potential problem areas.

There are many irrigation ditches and small reservoirs in the CITY. The ditches and reservoirs have historically intercepted the storm runoff from the rural and agricultural type basins, generally without major problems. With urbanization of the basins, however, the storm runoff has increased in rate, quantity, and frequency. Irrigation facilities can no longer be utilized indiscriminately as drainage facilities; therefore, policies have been established to achieve compatibility between urbanization and the irrigation ditch facilities. In evaluating the interaction of irrigation ditches for the purpose of basin delineation, the ditch should not be utilized as a basin boundary due to the limiting flow capacity of the ditch. Ditches will generally be flowing full or near full during heavy storms; therefore, the tributary basin runoff would flow across the ditch.

The CITY recognizes that historically irrigation ditches have been used as outfall points for the storm drainage system in some areas. This practice is now prohibited.

IT IS THE POLICY OF THE CITY THAT DRAINAGE OF NEW OR RE-DEVELOPMENT OF AN AREA MAY NOT OUTFALL TO AN IRRIGATION DITCH, EVEN IF A HISTORICAL OUTFALL EXISTS.

IT IS THE POLICY OF THE CITY THAT DRAINAGE ANALYSIS SHALL ASSUME THAT AN IRRIGATION DITCH DOES NOT INTERCEPT THE STORM RUNOFF FROM THE UPPER

BASIN AND THAT THE UPPER BASIN IS TRIBUTARY TO THE BASIN AREA DOWNSTREAM OF THE DITCH.

IT IS THE POLICY OF THE CITY THAT ALL NEW OR RE-DEVELOPMENT PROJECTS SHALL DIRECT STORM RUNOFF INTO HISTORIC AND NATURAL DRAINAGEWAYS AND SHALL NOT DISCHARGE INTO AN IRRIGATION CANAL OR DITCH EXCEPT AS REQUIRED BY WATER RIGHTS.

CHAPTER 7
HYDRAULIC STRUCTURES

7.1 INTRODUCTION

Hydraulic structures are used to guide and control water flow in streams. Structures described in this chapter consist of grade control structures and outfall structures for various applications and conditions. As discussed in the Chapter 6, urbanization increases the rate, frequency and volume of runoff in natural streams and, over time, this change in hydrology may cause streambed degradation, otherwise known as down cutting or head cutting. Stabilization improvements to the stream are necessary prior to or concurrent with development in the watershed. The energy associated with flowing water has the potential to damage hydraulic structures especially in the form of erosion. Hydraulic structures are used to control the energy and minimize the damage potential of runoff. Typical hydraulic structures can include rip-rap, energy dissipaters, check dams, and drop structures.

Boulder Drop Structures at Lowell Blvd.

7.2 GRADE CONTROL STRUCTURES

Stabilization improvements to the stream are necessary prior to or concurrent with development in the watershed. “Drop structures” are broadly defined. Drop structures provide protection for high velocity hydraulic conditions that allow a drop-in channel grade over a relatively short distance. They provide controlled and stable locations for a hydraulic jump to occur, allowing for a more stable channel downstream where flow returns to subcritical.

Grade control structures shall be designed for fully developed future basin conditions, in accordance with zoning maps, master plans, and other relevant documents. The effects of future hydrology and potential down cutting will negatively impact the channel.

Use of sandstone or other sedimentary rock is prohibited.

Where possible, it is encouraged to use recycled cobble boulders or sculpted concrete in place of mined granite.

Metal drop structures or sheet pile are considered on a case by case basis as approved by the City Engineer.

Recycled Boulders from Fairplay, CO

7.2.1 Grouted Stepped Boulder Drop Structures

Grouted stepped boulder drop structures have gained popularity in the UDFCD region due to close proximity to high-quality rock sources, design aesthetics, and successful applications. The quality of rock used and proper grouting procedure are very important to the structural integrity. To improve appearance, cover the grouted boulders above the low-flow section and on the overbanks with local topsoil and revegetate. This material has potential to wash out but when able to become vegetated, has a more attractive and natural appearance.

7.2.2 Sculpted Concrete

Concrete faux rock is simply concrete that is sculpted, carved, textured, and colored to emulate real rock. In the past, sculpted concrete has been successfully used for retaining wall type structures and stream grade control structures. It can be an aesthetic alternative to grouted boulders in locations where natural sedimentary rock might be expected.

Poured concrete is encouraged over the use of shotcrete. Color additives must be added to the concrete and must never be painted on. Color and texture of final structure must match the bedrock in the area.

Sculpted Concrete Drop Structure on Airport Creek West of Sheridan Blvd.

7.2.3 Vertical Drop Structures

Vertical concrete drop structures are discouraged and will only be allowed on a case-by-case basis with permission from the City Engineer.

7.3 PIPE OUTFALLS AND RUNDOWNS

Pipe outlets represent a persistent problem due to concentrated discharges and turbulence of flow reaching this point of transition into a channel. Too often, the designer focuses efforts on a culvert inlet and its sizing with outlet hydraulics receiving only passing attention. Appropriate pipe end treatment and downstream erosion protection at pipe outfalls is critical to protect the structural integrity of the pipe and to maintain the stability of the adjacent slope.

7.3.1 Pipe Outfalls

IT IS THE POLICY OF THE CITY THAT ALL PIPE OUTLETS MUST INCORPORATE ENERGY DISSIPATION AND EROSION PROTECTION. THE CITY RESERVES THE RIGHT TO REQUIRE ADDITIONAL ENERGY DISSIPATION AND EROSION PROTECTION.

7.3.2 Rundown Channels

The use of rundowns to convey storm runoff down a channel bank is discouraged due to their high rate of failure and the resulting maintenance and repair burden. Instead, use a pipe to convey runoff to a point just above the channel invert (normally 1 foot for small receiving streams or ponds and up to 2 feet for large receiving channels). Loose riprap rundown channels are not allowed.

7.4 DAMS AND LEVEES

Dam and levee safety is the subject of the federal government's National Dam Safety and National Levee Safety Programs. The State Engineer's Office determines whether a dam (2 CCR 402-1 Rule 4.2.5 Dams) or a levee (2 CCR 408-1 Rule 4 Definitions) is or will be jurisdictional based on the height of the dam embankment, storage volume, or the surface area of a reservoir. Jurisdictional dams and levees are classified by the State Engineer's Office as either low, moderate or high hazard structures depending on downstream conditions. Dams are classified as high hazard structures when, in the event of failure, there is a potential loss of life. Dams presently rated as low or moderate hazard structures may be changed to a high hazard rating if development occurs within the potential path of flooding due to a dam breach. In this case, the reservoir owners are liable for the cost of upgrading the structure to meet the higher hazard classification. Dams and levees are not allowed.

CHAPTER 8
STORMWATER TREATMENT FACILITIES

8.1 INTRODUCTION

The criteria presented in this section shall be used in the design and evaluation of STORMWATER TREATMENT FACILITIES. The main purpose of a STORMWATER TREATMENT FACILITY is to treat and attenuate the excess storm runoff from developed areas. Any special design conditions and criteria, which are not defined by these CRITERIA, shall be reviewed and approved by the City Engineer before proceeding with design.

THE POLICY OF THE CITY REQUIRES ON-SITE TREATMENT FOR ALL NEW DEVELOPMENT, EXPANSION, AND REDEVELOPMENT. THE REQUIRED MINIMUM DETENTION VOLUMES AND MAXIMUM RELEASE RATES FOR WATER QUALITY, THE MINOR STORM, AND THE MAJOR STORM SHALL BE IN ACCORDANCE WITH THE PROCEDURE AND DATA SET FORTH IN THESE CRITERIA.

8.2 STORMWATER TREATMENT FACILITY DESIGN STANDARDS

The facility design standards in this section comply with the minimum requirements listed below as outlined in CHAPTER 1 of the CRITERIA:

- One hundred percent (100%) of the applicable development site must be captured using the Water Quality Capture Volume (WQCV) method before discharging to the CITY storm sewer system or state waters. Twenty percent (20%) of the site may be excluded, not to exceed 1 acre, when it is determined that it is not practicable to capture runoff from portions of the site that will not drain towards control measures. In addition, it must be determined that the implementation of a separate control measure for that portion of the site is not practicable. Refer to the MANUAL for WQCV design procedures.
- Sites that drain to regional facilities are subject to additional treatment requirements in accordance with the most recent WQCD General Stormwater MS4 Permit.
- Sites under redevelopment greater than an acre and more than 75% imperviousness and it is not practicable to meet the WQCV method standard, must still provide treatment. The recommended treatment includes infiltration, evaporation, or evapotranspiration, which captures a quantity of water equal to 30% of what the calculated WQCV would be if all impervious area for the applicable redevelopment site discharged without infiltration.

If one hundred percent (100%) of the applicable development site cannot practicably be treated, documentation describing this justification must be provided in the Phase III Drainage Report.

Alternate design standards described in the most recent WQCD General Stormwater MS4 Permit may be considered on a case-by-case basis.

All treatment facilities incorporating flood control must be designed to release water within 72 hours to comply with Colorado Water Rights Law.

THE POLICY OF THE CITY REQUIRES THE SUBMITTAL OF A POST-CONSTRUCTION STORMWATER MANAGEMENT DESIGN STANDARDS FORM THAT OUTLINES THE TYPE OF DESIGN STANDARD BEING UTILIZED FOR A STORMWATER TREATMENT FACILITY.

8.3 EXCLUDED SITES

The CITY may choose to exclude sites or portions of sites from the requirements of this section when allowed by the most recent WQCD General Stormwater MS4 Permit on a case-by-case basis.

THE POLICY OF THE CITY REQUIRES THE SUBMITTAL OF A POST-CONSTRUCTION STORMWATER MANAGEMENT EXCLUSIONS FORM THAT ESTABLISHED JUSTIFICATIONS FOR ANY EXCLUSION TO THE MINIMUM DESIGN STANDARD REQUIREMENTS.

8.4 STORMWATER TREATMENT FACILITIES

Water quality is an important concern of watershed management. Stormwater Treatment Facilities are used to maintain or improve water quality and sometimes provide flood control to developed and disturbed land. The type of technology used to achieve these goals will vary depending on the size of the contributing area, space constraints, soil type and targeted pollutants. Accepted forms of treatment are as follows:

- Grass buffer,
- Grass swale,
- Rain garden,
- Sand filter,
- Permeable interlocking concrete pavement (PICP), and
- EDB.

Refer to table EDB-4 near the end of this chapter and the MANUAL for the steps involved in choosing the appropriate STORMWATER TREATMENT FACILITY.

IT IS THE POLICY OF THE CITY THAT ALL TREATMENT FACILITIES SHALL BE PRIVATELY OWNED AND MAINTAINED UNLESS OTHERWISE AGREED TO IN WRITING BY THE CITY. OTHER TYPES OF PERMANENT STORMWATER QUALITY FACILITIES NOT INCLUDED IN THIS SECTION SHALL BE CONSIDERED BY THE CITY ON A CASE-BY-CASE BASIS.

- UNDERGROUND VAULTS AND TANKS SPECIFICALLY DESIGNED FOR DETENTION ARE PROHIBITED AND SHALL NOT BE CONSIDERED IN THE DESIGN PROCESS.
- INLET FILTRATION BAGS ARE PROHIBITED AND SHALL NOT BE CONSIDERED IN THE DESIGN PROCESS.
- HYDRODYNAMIC SEPARATORS SHALL BE DESIGNED TO TREAT STORMWATER RUNOFF IN A MANNER EXPECTED TO REDUCE THE EVENT MEAN CONCENTRATION OF TOTAL SUSPENDED SOLIDS (TSS) TO A MEDIAN VALUE OF 30 MILLIGRAMS PER LITER (MG/L) OR LESS.

THE CITY RECOGNIZES THAT TECHNOLOGY IS CONSTANTLY EVOLVING. THE POLICY OF THE CITY IS TO CONSIDER ADDITIONAL RESOURCES, REFERENCES, AND STANDARDS NOT EXPLICITLY STATED IN THESE CRITERIA THAT APPLY TO EMERGING TECHNOLOGIES.

8.4.1 Grass Buffer

Description – Grass buffers are densely vegetated strips of grass designed to accept sheet flow from upgraded development. Properly designed grass buffers play a key role in Low Impact Development (LID), enabling infiltration and slowing runoff. Grass buffers provide filtration (straining) of sediment. Buffers differ from swales in that they are designed to accommodate overland sheet flow rather than concentrated or channelized flow.

A flush curb allows roadway runoff to sheet flow through grass buffer. Photo courtesy of Muller Engineering

Site Selection – Grass buffers can be incorporated into a wide range of development settings and are encouraged whenever possible.

Buffers should be designed to receive sheet-flow runoff from impervious areas. This may require a level spreader. See the MANUAL for guidance regarding when a level spreader is required and for design considerations.

Runoff can be directly accepted from a parking lot, roadway, or the roof of a structure, provided the flow is distributed in a uniform manner over the width of the buffer. This can be achieved through the use of flush curbs, slotted curbs, or level spreaders where needed. Grass buffers are often used in conjunction with grass swales. They are well suited for use in riparian zones to assist in stabilizing channel banks adjacent to MAJOR DRAINAGEWAY SYSTEMS and receiving waters. These areas can also sometimes serve multiple functions such as recreation.

8.4.2 Grass Swale

Description – Grass swales designed for treatment differ from swales designed solely for conveyance (see Chapter 6). They are densely vegetated trapezoidal or triangular channels with low-pitched side slopes designed to convey runoff slowly. Grass swales have low longitudinal slopes and broad cross-sections that convey flow in a slow and shallow manner, thereby facilitating sedimentation and filtering (straining) while limiting erosion. Berms or check dams may be incorporated into grass swales to reduce velocities and

Grass swale that provides treatment for roadway runoff in a residential area. Photo courtesy of Bill Ruzzo.

encourage settling and infiltration. When using berms, an underdrain system should be provided. Grass swales are an integral part of the LID concept and may be used as an alternative to a curb and gutter system.

Site Selection – Grass swales are well suited for sites with low to moderate slopes. Drop structures or other features designed to provide the same function as a drop structures (e.g., a driveway with a stabilized grade differential at the downstream end) can be integrated into the design to enable use of this technology at a broader range of site conditions. Grass swales provide conveyance so they can also be used to replace curb and gutter systems making them well suited for roadway projects.

8.4.3 Bioretention

Description – Bioretention consists of an engineered, depressed landscaped area designed to capture and filter and infiltrate the WQCV. Facilities that utilize bioretention are frequently referred to as rain gardens.

Photograph 3-A. This rain garden provides bioretention of pollutants, as well as an attractive amenity. Treatment should improve as vegetation matures.

The design of a rain garden may provide detention for events exceeding that of the WQCV. There are generally two ways to achieve this. The design can provide the flood control volume above the WQCV or it can provide and slowly release the flood control volume in an area downstream of one or more rain gardens. Rain gardens shall be designed to release the WQCV at a minimum of 12 hours. See the Storage chapter in Volume 2 of the MANUAL for more information.

This infiltrating technology requires consultation with a geotechnical engineer when proposed adjacent to a structure. A geotechnical engineer can assist with evaluating the suitability of soils, identifying potential impacts, and establishing minimum distances between the technology and structures.

Site Selection – This technology allows WQCV treatment within one or more areas designated for landscape (see the MANUAL for suggested vegetation). In this way, it is an excellent alternative to EDBs for small sites. A typical rain garden serves a tributary area of one impervious acre or less, although they can be designed for larger tributary areas. Multiple installations can be used within larger sites. Rain gardens should not be used when a baseflow is anticipated. They are typically small and installed in locations such as:

- Parking lot islands,
- Street medians,
- Landscape areas between the road and a detached walk, and
- Planter boxes that collect roof drains.

Bioretention requires a stable watershed. Retrofit applications are typically successful for this reason. When the watershed includes phased construction, sparsely vegetated

areas, or steep slopes in sandy soils, consider another technology or provide pretreatment before runoff from these areas reaches the rain garden. The surface of the rain garden must be flat. For this reason, rain gardens can be more difficult to incorporate into steeply sloping terrain; however, terraced applications of these facilities have been successful in other parts of the country.

Vegetation – The choice of vegetation must be native plantings that will thrive in the rain garden environment. Temporary irrigation shall be used until the vegetation is established, then it must rely on storm events for survival.

8.4.4 Extended Detention Basin

Description – An EDB is a sedimentation basin designed to detain stormwater for many hours after storm runoff ends. This technology is similar to a detention basin used for flood control; however, the EDB uses a much smaller outlet that extends the emptying time of the more frequently occurring runoff events to facilitate pollutant removal.

Photograph 5-A. This EDB includes a concrete trickle channel and a micropool with a concrete bottom.

The EDB's minimum 40-hour drain time for the WQCV is required to remove a significant portion of TSS. The basins are sometimes called "dry ponds" because they are designed not to have a significant permanent pool of water remaining between storm runoff events.

Site Selection – EDBs are well suited for watersheds with at least five impervious acres up to approximately one square mile of watershed. Smaller watersheds can result in an orifice size prone to clogging. Larger watersheds and watersheds with baseflows can complicate the design and reduce the level of treatment provided. EDBs are also well suited where flood detention is incorporated into the same basin. The depth of groundwater should be investigated. Groundwater depth should be 2 or more feet below the bottom of the basin in order to keep this area dry and maintainable.

IT IS THE POLICY OF THE CITY THAT EDB DESIGN SHALL UTILIZE THE FULL SPECTRUM DETENTION (FSD) METHOD OUTLINED IN THE MANUAL. ONLY DRY DETENTION BASINS WILL BE AN ACCEPTED ALTERNATIVE. UNDERDRAINS SHALL NOT BE ROUTED THROUGH THE POND, BUT CAN CONNECT TO THE OUTLET STRUCTURE DOWNSTREAM OF THE WATER QUALITY ORIFICE PLATE.

ALL NEW EDB FACILITIES SHALL INCLUDE (AT A MINIMUM) A FOREBAY, TRICKLE CHANNEL, MAINTENANCE ACCESS AND OUTLET STRUCTURE WITH A MICROPOOL. WATER QUALITY SHALL BE INCORPORATED UNLESS OTHERWISE HANDLED SEPARATELY FROM THE EDB.

Forebay – For tributary basins less than 20 impervious acres, the EDB shall include a concrete forebay sized according to Table EDB-4 in this Chapter. Basins greater than 20 impervious acres should consider a berm/pipe configuration and designed in accordance to the MANUAL.

Trickle Channel – All detention ponds shall include a concrete 2-4.5 foot "U" shaped trickle channel with concrete curbs. Ease of sediment removal shall be a consideration in choosing the size of the trickle channel. Capacity of the trickle channel shall be in accordance to Table EDB-4. The bottom of the pond must be able to drain into the trickle channel during establishment period of the vegetation and beyond. Other materials may be considered on a case-by-case basis.

Outlet Structure Details – Table OS-1 within the MANUAL provides a list of outlet structure details and their appropriate uses. **These standard details are not intended to be used on construction plans without proper modifications according to the accepted Phase III Drainage Report.**

Micropools – Micropools are required for all outlet structures and are incorporated to minimize orifice plate clogging. Secondary trash racks shall be designed to allow the micropool and primary trash rack to be readily accessible for maintenance purposes. The size of the micropool shall be in accordance to the MANUAL and Table EDB-4. All micropools shall be contained within the outlet structure.

Water Quality Orifice Plate – Shall be sized and constructed according to the MANUAL. Treatment train systems involving multiple detention or other treatment facilities in series will be evaluated on a case by case basis.

Initial Surcharge Volume – All EDB designs must consider the initial surcharge volume (ISV) above the micropool water surface elevation. The ISV elevation shall be at least 4-inches in depth. Whenever possible, the surface area should be contained within the outlet structure and trickle channel, and shall not spread to the landscaped area outside of the trickle channel. If the ISV encroaches into the landscaped area, rock or other water tolerant treatments shall be installed within this zone. The ISV is assumed to be incorporated into the WQCV when designing the orifice plate and does not need to be considered in addition to the WQCV.

Freeboard Requirements – The minimum freeboard is 1-foot above the computed water surface elevation for the 100-year storm.

Overflow Weir and Emergency Spillway – These facilities shall be designed in accordance to the MANUAL. The bottom of the weir may be placed at the 100-year water surface elevation. Capacity of the weir shall be at a minimum the undetained 100-year event tributary to the EDB including any offsite flow. All emergency spillway designs shall consider the downstream conditions and shall not contribute to or cause unsafe or destructive drainage conditions. All spillways shall be armored with buried rip-rap and include a concrete cut-off wall as recommended in the MANUAL.

Depth Requirements – The maximum design depth of ponding in the major storm shall be 8 feet. Deeper ponds may be accepted on a case-by-case basis.

Grading Requirements – Slopes on earthen embankments shall not be steeper than 4 (horizontal) to 1 (vertical). All earthen slopes shall be covered with topsoil and re-vegetated with grass or native vegetation. The minimum bottom slope shall be 3% percent measured perpendicular to the trickle channel. According to the CITY's landscaping regulations, no walls taller than 4 feet shall be allowed without a 7-foot

horizontal step in between. Any wall higher than 30 inches shall obtain a building permit through the Building Division.

Detention ponds that are designated as a park or other multi-use area, may have additional requirements as determined by the CITY.

Maintenance Access – Maintenance access shall be outlined in the required O&M Manual. Access must be extended to the forebay and outlet structure. Maintenance access roadways can be either a 10-inch thick section of vehicle tracking control rock mixed with Class 5 road base over compacted subgrade, or permeable pavement product such as grasscrete or modular plastic pavers filled with either gravel or grass.

Vegetation Requirements – All detention ponds shall be vegetated in accordance with the ODP. Soil must be placed such that the pond bottom drains into the trickle channel during the vegetation establishment period.

Table EDB-4 (on the next page) summarizes criteria outlined in the MANUAL for the design of the forebay, trickle channel, micropool and ISV.

Table EDB-4. EDB component criteria

	On-Site EDBs for Watersheds up to 1 Impervious Acre[1]	EDBs with Watersheds between 1 and 2 Impervious Acres[1]	EDBs with Watersheds up to 5 Impervious Acres	EDBs with Watersheds over 5 Impervious Acres	EDBs with Watersheds over 20 Impervious Acres
Forebay Release and Configuration	EDBs should not be used for watersheds with less than 1 impervious acre.	Release 2% of the undetained 100-year peak discharge by way of a wall/notch configuration	Release 2% of the undetained 100-year peak discharge by way of a wall/notch configuration	Release 2% of the undetained 100-year peak discharge by way of a wall/notch configuration	Release 2% of the undetained 100-year peak discharge by way of a wall/notch or berm/pipe[2] configuration
Minimum Forebay Volume		1% of the WQCV	2% of the WQCV	3% of the WQCV	3% of the WQCV
Maximum Forebay Depth		12 inches	18 inches	18 inches	30 inches
Trickle Channel Capacity		≥ the maximum possible forebay outlet capacity	≥ the maximum possible forebay outlet capacity	≥ the maximum possible forebay outlet capacity	≥ the maximum possible forebay outlet capacity
Micropool		Area ≥ 10 ft^2	Area ≥ 10 ft^2	Area ≥ 10 ft^2	Area ≥ 10 ft^2
Initial Surcharge Volume		Depth ≥ 4 inches	Depth ≥ 4 inches	Depth ≥ 4 in. Volume ≥ 0.3% WQCV	Depth ≥ 4 in. Volume ≥ 0.3% WQCV

[1] EDBs are not recommended for sites with less than 2 impervious acres. Consider a sand filter or rain garden.

[2] Round up to the first standard pipe size (minimum 8 inches).

8.4.5 Sand Filters

Photograph 6-A. *This sand filter is located next to a parking lot, is accessible for maintenance, yet screened from public view by a landscape buffer.*

Description – A sand filter is a filtering or infiltrating technology that consists of a surcharge zone underlain by a sand bed with an underdrain system. During a storm, accumulated runoff collects in the surcharge zone and gradually infiltrates into the underlying sand bed, filling the void spaces of the sand. The underdrain gradually dewaters the sand bed and discharges the runoff to a nearby channel, swale, or storm drain. It is similar to a technology designed for bioretention in that it utilizes filtering, but differs in that it is not specifically designed for vegetative growth. The absence of vegetation in a sand filter allows for active maintenance at the surface of the filter, (i.e., raking for removing a layer of sediment). For this reason, sand filter criteria allows for a larger contributing area and greater depth of storage. A sand filter is also a dry basin, which can be designed to include the flood control volume above the WQCV or Excess Urban Runoff Volume (EURV).

Site Selection – Sand filters require a stable watershed. When the watershed includes phased construction, sparsely vegetated areas, or steep slopes in sandy soils, consider another technology or provide pretreatment before runoff from these areas reach the sand filter.

8.4.6 Permeable Interlocking Concrete Pavement

Description – PICP is one of several different types of permeable pavement systems. The PICP wearing course consists of concrete blocks that, when placed together, create spaces between the blocks where runoff can enter the pavement. Typically, the blocks contain ridges along the sides that create these spaces and help ensure that the blocks are installed correctly. The spaces between the blocks are filled with aggregate. Depending on the manufacturer, these spaces should provide an open surface that is between 5 % and 15% of the pavement surface. Subsurface design and construction considerations must be engineered in accordance with manufacturer's specifications and the MANUAL.

Site Selection – PICP is appropriate for areas with low to high traffic volume and lower vehicle speeds. Applications include:

- Intersections,
- Parking lots,
- Residential streets,
- Sidewalks/pedestrian areas,
- Emergency vehicle and fire access lanes, and
- Equipment storage areas.

Use the herring bone pattern and units with an overall length to thickness (aspect) ratio of three or less for vehicular applications. When Americans with Disabilities Act (ADA) accessibility is needed, select units with a maximum opening of 0.5 inches.

PICP over public utility easements will be reviewed on a case-by-case basis with special subgrade design considerations.

Other permeable pavement may be accepted upon approval of the CITY.

8.5 OPERATIONS AND MAINTENANCE OF STORMWATER TREATMENT FACILITIES

An important part of all STORMWATER TREATMENT FACILITIES is the continued maintenance of the facilities to ensure that they will function as designed. Maintenance is necessary to preclude the facility from becoming unhealthy and to retain its effectiveness. Sediment and debris must be periodically removed from channels, storm sewers, and detention ponds. Trash racks and street inlets must be regularly cleared of debris to maintain system capacity. Channel bank erosion, damage to drop structures, crushing of pipe inlets and outlets, and general deterioration of the facilities must be repaired in order to avoid reduced conveyance capacity, unsightliness, and ultimate failure.

Maintenance responsibility of drainage facilities shall be outlined on PDPs, ODPs, and Phase III Drainage Reports. In addition, an O&M Manual will be required as a separate document to be given to the responsible party for maintenance. This document will be inserted as an appendix in the Phase III Drainage Report. See Chapter 2 for more details on O&M requirements.