

Chapter 1

Stormwater Management and Planning

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1.0 Overview/Purpose

The Drainage Criteria Manual (DCM) – Volume 2, Stormwater Quality Policies, Procedures and Best Management Practices is meant to provide owners, developers, engineers, and contractors with information they will need to comply with local stormwater quality requirements for drainage planning/design relating to new development/significant redevelopment and construction activities. The material in this manual is meant to assist users in determining what requirements apply and what control measures are necessary for a given site. As with any manual, it is impossible to be all-inclusive: addressing every situation. It is the owner's responsibility to ensure that the work at the site is in compliance with all applicable statutes and ordinances. This manual should be used in addition to other references and personal experience.

This manual covers the following areas:

1. Basics of stormwater quality and regulatory requirements.
2. Requirements for the development and implementation of an Erosion and Stormwater Quality Control Plan.
3. Information on the use, design and maintenance of construction control measures that can be used to comply with the Erosion and Stormwater Quality requirements.
4. Information on construction inspection and enforcement.
5. Requirements and procedures for permanent/treatment stormwater quality control measures in new developments/significant redevelopments.

The stormwater quality criteria and requirements of this manual are meant to be in addition to the drainage requirements and criteria listed in the Drainage Criteria Manual, Volume 1. If there are any conflicts or discrepancies between the criteria and requirements of this manual and those in the Drainage Criteria Manual, Volume 1, Engineering Criteria Manual or the City Engineering Standard Specifications, the criteria and requirements in this manual take precedence.

The control measures included in the Drainage Criteria Manual, Volume 2 are not meant to be comprehensive. It is anticipated that as time goes on new technologies will be introduced as well as additional refinement of the current technologies. It is expected that the list of control measures will be expanded as time goes on. Should the owner/engineer desire use of other temporary or permanent treatment control measures, it will be necessary to submit information that supports their use and ability to adequately control stormwater quality. These requests will be reviewed on a case-by-case basis and follow procedures found in Chapters 4 and 7.

2.0 Stormwater Quality Management

Most of the public's concerns with stormwater are usually related to flooding, not water quality. People complain when their basements flood or roads become impassable and the public suffers when severe catastrophic floods cause widespread damage to property and loss of life. Very few people are aware of the water quality impacts that stormwater has on our rivers, streams, or lakes. Stormwater runoff quality can have significant impacts on the receiving waters that affect not only the aquatic ecosystem, but also the quality of

our communities.

2.1 Environmental Impacts of Runoff

Stormwater impacts streams by affecting the stream hydrology, stream morphology, water quality and aquatic ecology. The extent of impact is related to the climate, land use, and the measures implemented to address the impacts.

Briefly, the impacts on streams are:

- **Stream Hydrology:** Urban development affects the environment through changes in the size and frequency of storm runoff events, changes in base flows of the stream and changes in stream flow velocities during storms results in decrease in travel time for runoff. Peak discharges and volumes in a stream can increase from urbanization due to a decrease in infiltration of rainfall into the ground, loss of buffering vegetation and resultant reduced evapotranspiration. This results in more surface runoff and larger loads of various constituents found in stormwater.
- **Stream Morphology:** When the hydrology of the stream changes, it can result in changes to the physical characteristics of the stream. Such changes include streambed degradation, stream widening, and streambank erosion. As the stream profile degrades and the stream tries to widen to accommodate higher flows, instream bank erosion increases along with increases in sediment loads. These changes in the stream bed also result in changes to the habitat of aquatic life.
- **Water Quality:** Water quality is impacted through urbanization as a result of erosion during construction, changes in stream morphology, and washing off of accumulated deposits on the urban landscape. Water quality problems include turbid water, nutrient enrichment, bacterial contamination, organic matter loads, metals, salts, temperature increases and increased trash and debris.

2.2 Stormwater Runoff Constituents and Sources

Urban runoff contains many types and forms of constituents as shown in Table 1-1; some occurring in higher concentrations (see Table 1-2) than found in runoff before development and some that are not naturally present in surface runoff from undeveloped land. Runoff from undeveloped watersheds contains sediment particles, oxygen-demanding compounds, nutrients, metals, and other constituents. Once developed, constituent loads increase because surface runoff volumes increase and the sources of many of these pollutants also increase. Also, additional sources of constituents may exist in a catchment and find their way into runoff. They may include the following:

- Metals, lubricating compounds, solvents, and other constituents originating from vehicles, machinery, and industrial and commercial activities.
- Pesticides, herbicides, and fertilizers.
- Household solvents, paints, roofing materials, and other such materials.
- Pet litter, garbage, and other debris.
- Suspended solids washed off impermeable surfaces.
- Increased soil erosion during construction activities. Table 1-1 lists the common constituents in stormwater runoff and Table 1-2 lists event mean concentrations (mg/L) of constituents observed in a metro Denver study (Colorado Springs information not available).

Table 1-1. Common Urban Runoff Pollutant Sources

(Adapted from: Horner, R.R., J.J. Skupien, E.H. Livingston and H.E. Shaver. 1994. *Fundamentals of Urban Runoff Management: Technical and Intuitional Issues*. Washington, DC: Terrene Institute and EPA.)

Pollutant Category Source	Solids	Nutrients	Pathogens	Dissolved Oxygen Demands	Metals	Oils	Synthetic Organics
Soil erosion	X	X		X	X		
Cleared vegetation	X	X		X			
Fertilizers		X	X	X			
Human waste	X	X	X	X			
Animal waste	X	X	X	X			
Vehicle fuels and fluids	X			X	X	X	X
Fuel combustion						X	
Vehicle wear	X			X	X		
Industrial and household chemicals	X	X		X	X	X	X
Industrial processes	X	X		X	X	X	X
Paints and preservatives					X	X	X
Pesticides				X	X	X	X
Stormwater facilities w/o proper maintenance ¹	X	X	X	X	X	X	X

Table 1-2. Event Mean Concentrations (mg/L) of Constituents in Denver Metropolitan Area Runoff

(per DRURP and Phase I Stormwater CDPS Permit Application for Denver, Lakewood and Aurora)

(Source: Aurora et al. 1992. *Stormwater NPDES Part 2 Permit Application Joint Appendix* and DRCOG 1983. *Urban Runoff Quality in the Denver Region*.)

Constituent	Natural Grassland	Commercial	Residential	Industrial
Total Phosphorus (TP)	0.40	0.42	0.65	0.43
Dissolved or Orthophosphorus (PO ₄)	0.10	0.15	0.22	0.2
Total Nitrogen (TN)	3.4	3.3	3.4	2.7
Total Kjeldahl Nitrogen (TKN)	2.9	2.3	2.7	1.8
Ammonia Nitrogen (NH ₃)	0.1	1.5	0.7	1.2
Nitrate + Nitrite Nitrogen (NO ₃ /NO ₂)	0.50	0.96	0.65	0.91
Lead (Total Recoverable) (Pb)	0.100	0.059	0.053	0.130
Zinc (Total Recoverable) (Zn)	0.10	0.24	0.18	0.52
Copper (Total Recoverable) (Cu)	0.040	0.043	0.029	0.084
Cadmium (Total Recoverable) (Cd)	Not Detected	0.001	Not Detected	0.003
Chemical Oxygen Demand (COD)	72	173	95	232
Total Organic Carbon (TOC)	26	40	72	22-26
Total Suspended Solids (TSS)	400	225	240	399
Total Dissolved Solids (TDS)	678	129	119	58
Biochemical Oxygen Demand (BOD)	4	33	17	29

3.0 Stormwater Permit Regulations

3.1 Clean Water Act Basics

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 establishes minimum stormwater management requirements for urbanized areas in the United States. At the federal level, the EPA is responsible for administering and enforcing the requirements of the Clean Water Act. Section 402(p) of the Clean Water Act requires urban and industrial stormwater be controlled through the NPDES permit program. Requirements affect both construction and post-construction phases of development. As a result, urban areas must meet requirements of Municipal Separate Storm Sewer System (MS4) permits, and many industries and institutions such as state departments of transportation must also meet NPDES stormwater permit requirements. MS4 permittees are required to develop a Stormwater Management Program that includes measurable goals and to implement needed stormwater management controls (i.e., control measures). 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 (MEP)." Although it is not the case for every state, the EPA has delegated Clean Water Act authority to the State of Colorado. The State must meet the minimum requirements of the federal program.

3.2 Colorado's Stormwater Permitting Program

The Colorado Water Quality Control Act (25-8-101 et seq., CRS 1973, as amended) established the Colorado Water Quality Control Commission (CWQCC) within the Colorado Department of Public Health and Environment (CDPHE) to develop water quality regulations and standards, classifications of state waters for designated uses, and water quality control regulations. The Act also established the Colorado Water Quality Control Division (CWQCD) to administer and enforce the Act and administer the discharge permit system, among other responsibilities. Violations of the Act are subject to significant monetary penalties, as well as criminal prosecution in some cases.

Colorado's stormwater management regulations have been implemented in two phases and are included in *Regulation No. 61 Colorado Discharge Permit System (CDPS) Regulations* (CWQCC 2009). After the 1990 EPA "Phase I" stormwater regulation became effective, Colorado was required to develop a stormwater program that covered specific types of industries and storm sewer systems for municipalities with populations of more than 100,000. Phase I affected the City of Colorado Springs, Denver, Aurora, Lakewood, and the Colorado Department of Transportation (CDOT). Phase I requirements included inventory of stormwater outfalls, monitoring and development of municipal stormwater management requirements, as well as other requirements. Construction activities disturbing five or more acres of land were required to obtain construction stormwater discharge permits.

Phase II of Colorado's stormwater program was finalized in March 2001, establishing additional stormwater permitting requirements. Two major changes included regulation of small municipalities ($\geq 10,000$ and $<100,000$ population) in urbanized areas and requiring construction permits for sites disturbing one acre or more. The Phase II regulation resulted in a large number of new permit holders including MS4 permits for El Paso County, City of Fountain, Town of Monument, and City of Manitou Springs. In addition, there are also non-standard MS4 permittees that include entities that are not cities or counties. Non-standard MS4 permittees include entities such as Academy School District 20, Widefield School District 3, Pikes Peak Community College, Harrison School District 2, Falcon School District 49, Cheyenne Mountain School District 12, University of Colorado at Colorado Springs, and Colorado Springs School District 11. MS4 permit holders are required to develop, implement, and enforce a CDPS Stormwater Management Program designed

to reduce the discharge of pollutants from the MS4 to the maximum extent practicable, to protect water quality, and to satisfy the appropriate water quality requirements of the Colorado Water Quality Control Act (25-8-101 et seq., C.R.S.) and the Colorado Discharge Permit Regulations (Regulation 61). Non-standard MS4 permittees may elect to comply with their construction program and post-construction program requirements by following the requirements of the City's or County's construction and post-construction programs.

3.3 City of Colorado Springs MS4 Permit

Stormwater quality protection is authorized by City Code Chapter 3, Article 8 – Storm Water Quality Management and Discharge Control Code. The City's MS4 permit is coordinated by the City's Engineering Division. The MS4 permit requires that they develop and implement certain programs. There are six programs within the MS4 permit and each program has specific tasks that must be achieved or completed within a given time period. The six programs include the following:

1. Commercial/Residential Management Program
2. Illicit Discharges Management Program
3. Industrial Facilities Program
4. Construction Sites Program
5. Pollution Prevention/Good Housekeeping for Municipal Operations
6. Monitoring Program

As a permittee, the City was required to develop, implement, and enforce a pollutant control program to reduce pollutants in stormwater runoff to their MS4 from construction activities that result in land disturbance of one or more acres, including projects less than one acre that are part of a larger common plan of development or sale, as well as address post-construction runoff. Under the post-construction stormwater management in new development and redevelopment provisions, the MS4 permit requires the permittee to develop, implement, and enforce a program to address stormwater runoff from new development and redevelopment projects that disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of development or sale, that discharge into the MS4. The program must ensure controls are in place that would prevent or minimize water quality impacts.

Although MS4 general permits have historically focused on water quality, it is noteworthy that there has been increased emphasis on reducing stormwater runoff through use of Low Impact Development (LID) techniques. The City's MS4 permit language includes the following:

Implement and document strategies which include the use of structural and/or non-structural control measures appropriate for the community, that address the discharge of pollutants from projects, or that follow principles of low-impact development to mimic natural (i.e., pre-development) hydrologic conditions at sites to minimize the discharge of pollutants and prevent or minimize adverse in-channel impacts associated with increased imperviousness.

Similarly, at the national level, the Energy Independence and Security Act of 2007 (Pub.L. 110-140) includes Section 438, Storm Water Runoff Requirements for Federal Development Projects. This section requires:

...any sponsor of any development or redevelopment project involving a federal facility with a footprint that exceeds 5,000 square feet shall use site planning, design, construction, and maintenance strategies for the property to maintain or restore, to the maximum extent technically feasible, the

predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow.

The minimum measures required for development projects to satisfy the City's MS4 permit requirements are described in Section 4.1 of this chapter.

3.4 Total Maximum Daily Loads and Stormwater Management

Section 303(d) of the Clean Water Act requires states to develop a list of water bodies that are not attaining water quality standards for their designated uses, and to identify relative priorities for addressing the impaired water bodies. States must then develop Total Maximum Daily Loads (TMDLs) to assign allowable pollutant loads to various sources to enable the water body to meet the designated uses established for that water body. Implementation plans to achieve the loads specified under TMDLs commonly rely on control measures to reduce pollutant loads associated with stormwater sources.

In the context of this manual, it is important for designers, planners and other stormwater professionals to understand TMDLs because TMDL provisions can directly affect stormwater permit requirements and control measure selection and design. EPA provides this basic description of TMDLs:

A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that load among the various sources of that pollutant. Pollutant sources are characterized as either regulated stormwater, sometimes called "point sources" that receive a waste load allocation (WLA), or nonpoint sources that receive a load allocation (LA). Point sources include all sources subject to regulation under the NPDES program (e.g., wastewater treatment facilities, most municipal stormwater discharges and concentrated animal feeding operations). Nonpoint sources include all remaining sources of the pollutant, as well as anthropogenic and natural background sources. TMDLs must also account for seasonal variations in water quality, and include a margin of safety (MOS) to account for uncertainty in predicting how well pollutant reductions will result in meeting water quality standards.

The TMDL calculation is:

$$\text{TMDL} = \Sigma\text{WLA} + \Sigma\text{LA} + \text{MOS} \quad \text{Equation 1-1}$$

Where:

- ΣWLA = the sum of waste load allocations (point sources),
- ΣLA = the sum of load allocations (nonpoint sources and background)
- MOS = the margin of safety.

Although states are primarily responsible for developing TMDLs, EPA is required to review and approve or disapprove TMDLs. EPA has developed a basic "TMDL Review Checklist" with the minimum recommended elements that should be present in a TMDL document.

Once EPA approves a TMDL, there are varying degrees of impact to communities involved in the process, generally differentiated among whether point sources or non-point sources of pollution are identified in the TMDL. Permitted stormwater discharges are considered point sources. Essentially, this means that wastewater or stormwater permit requirements consistent with waste load allocations must be implemented and are enforceable under the Clean Water Act through NPDES permits.

If the MS4 permittee discharges into a waterbody with an approved TMDL that includes a pollutant-specific waste load allocation under the TMDL, then the CWQCD can amend the permit to include specific requirements related to that TMDL. For example, the permit may be amended to require specific control measures, and compliance schedules to implement the control measures may be required. Numeric effluent limits may also be incorporated under these provisions. TMDLs can have substantive effects on MS4 permit requirements. As an example, the City and County of Denver's MS4 permit has additional requirements to control *E. coli* related to the *E. coli* TMDL approved for the South Platte River (Segment 14). Most stream segments in Colorado Springs are currently listed as impaired for *E. coli*. Information on 303(d) listings and priorities for TMDL development can be obtained from the EPA and CWQCC websites.

4.0 Four Step Process to Minimize Adverse Impacts of Urbanization

The City of Colorado Springs requires the Four Step Process for receiving water protection that focuses on reducing runoff volumes, treating the water quality capture volume (WQCV), stabilizing drainageways, and implementing long-term source controls. The Four Step Process pertains to management of smaller, frequently occurring storm events, as opposed to larger storms for which drainage and flood control infrastructure are sized. Implementation of these four steps helps to achieve stormwater permit requirements. Added benefits of implementing the complete process can include improved site aesthetics through functional landscaping features that also provide water quality benefits. Additionally, volume reduction can decrease required storage volumes, thus increasing developable land. The Four Step Process is applicable to all new and re-development projects with construction activities that disturb 1 acre or greater or that disturb less than 1 acre but are part of a larger common plan of development or sale.

Development is defined as any land disturbing activities.

New development is defined as the development of a previously undeveloped site. Previously undeveloped sites are defined as sites with less than 35% of hard surface coverage in the existing condition.

Redevelopment is defined as the development of a previously developed site. Previously developed sites are defined as sites that are substantially developed with 35% or more of hard surface coverage in the existing condition.

An overview of the Four Step Process follows.

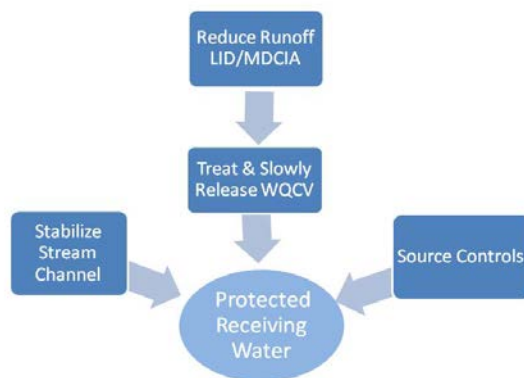


Figure 1-1. The Four Step Process for Stormwater Quality Management

Step 1. Employ Volume Reduction Practices

The following policy dictates volume reduction implementation requirements.

Runoff from impervious areas that are part of a new development or redevelopment project subject to the Four Step Process (i.e., projects for which construction activities disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of development or sale) must reduce runoff peaks, volumes, and pollutant loads from urbanizing areas, and to implement LID strategies, including MDCIA.

Requirements for sites with more than 50% Type D soils, slopes greater 15% on more than 50% of the site, or ground water conditions less than 1' from proposed the finished grade on more than 25% of the site are included below:

- Tracking method and submittal requirement:
 - Utilization of software found on the City website or SWMM Modeling using Cascading Planes.
 - Complete backup calculations will be required to be submitted as part of the Final Drainage Report.

Requirements for all roadway, trail, utility, and sidewalk specific projects not associated with new development are included below:

- Tracking method and submittal requirement:
 - Utilization of software found on the City website or SWMM Modeling using Cascading Planes.
 - Complete backup calculations will be required to be submitted as part of the Final Drainage Report.

Requirements for all sites where building setback requirements result in less than 10' of perimeter set back from proposed buildings for more than 75% of the site perimeter are included below:

- Tracking method and submittal requirement:
 - Utilization of software found on the City website or SWMM Modeling using Cascading Planes.
 - Complete backup calculations will be required to be submitted as part of the Final Drainage Report.

Requirements for all other development and redevelopment sites are included below:

- Applicable sites must meet one of the following standards:
 - Minimum volume reduction through infiltration, evaporation, and evapotranspiration.
 - For the 2-year rainfall event, a minimum of 4%, or
 - For WQCV event, minimum of 10%.
 - Tracking method and submittal requirement:
 - Utilization of software found on the City website or SWMM Modeling using Cascading Planes.
 - Complete backup calculations will be required to be submitted as part of the Final Drainage Report.
 - At least 20-percent of the imperviousness areas are disconnected and drain through a receiving pervious area comprising of at least 10-percent of the disconnected impervious area.
 - Tracking method and submittal requirement:
 - Utilization of software found on the City website or SWMM Modeling using

Cascading Planes.

- Complete backup calculations will be required to be submitted as part of the Final Drainage Report.
- Detailed diagram showing pervious and impervious areas and flow paths.

Any reduction in runoff volume may be deducted from the required WQCV for the site. If the design engineer is able to prove that 80% of the WQCV is infiltrated in compliance with the details of this section, Step 2 requirements are met without additional treatment measures.

The following guidance is related to volume reduction implementation.

LID practices reduce unnecessary impervious areas and route runoff from impervious surfaces over permeable areas to slow runoff (increase time of concentration) and promote infiltration. When LID/MDCIA techniques are implemented throughout a development, the effective imperviousness is reduced, thereby potentially reducing sizing requirements for downstream facilities. In addition, any reduction in runoff volume can be deducted from the required WQCV for the site.

Key LID techniques include:

- **Conserve Existing Features:** During the planning phase of development, identify portions of the site that add value and should be protected or improved. Such areas may include mature trees, stream corridors, wetlands, and NRCS Type A/B soils with higher infiltration rates. In order for this step to provide meaningful benefits over the long-term, natural areas must be protected from compaction during construction through the use of temporary construction fence or equivalent. In areas where disturbance cannot practically be avoided, rototilling and soil amendments should be integrated to restore the infiltration capacity of areas that will be restored with vegetation.
- **Minimize Impacts:** Consider how the site lends itself to the desired development. In some cases, creative site layout can reduce the extent of paved areas, thereby saving on initial capital cost of pavement and then saving on pavement maintenance, repair, and replacement over time. Minimize imperviousness, including constructing streets, driveways, sidewalks and parking lot aisles to the minimum widths necessary, while still providing for parking, snow management, public safety and fire access. When soils vary over the site, concentrate new impervious areas over NRCS Type C and D soils, while preserving NRCS Type A and B soils for landscape areas and other permeable surfaces. Maintaining natural drainage patterns, implementing sheet flow (as opposed to concentrated flow), and increasing the number and lengths of flow paths will all reduce the impact of the development.

Differences between LID and Conventional Stormwater Quality Management

Low Impact Development (LID) is a comprehensive land planning and engineering design approach to managing stormwater runoff with a goal of replicating the pre-development hydrologic regime of urban and developing watersheds. Given the increased regulatory emphasis on LID, volume reduction and mimicking pre-development hydrology, questions may arise related to the differences between conventional stormwater management and LID. For example, Volume 2 has emphasized MDCIA as the first step in stormwater quality planning and has provided guidance on LID techniques such as grass swales, grass buffers, permeable pavement systems, bioretention, and pollution prevention (pollutant source controls). Although these practices are all key components of LID, LID is not limited to a set of practices targeted at promoting infiltration. Key components of LID, in addition to individual control measures, include practices such as:

- An overall site planning approach that promotes conservation design at both the watershed and site levels. This approach to development seeks to "fit" a proposed development to the site, integrating the development with natural features and protecting the site's natural resources. This includes practices such as preservation of natural areas including open space, wetlands, soils with high infiltration potential, and stream buffers. Minimizing unnecessary site disturbances (e.g., grading, compaction) is also emphasized.
- A site design philosophy that emphasizes multiple controls distributed throughout a development, as opposed to a central treatment facility.
- The use of swales and open vegetated conveyances, as opposed to curb and gutter systems.
- Volume reduction as a key hydrologic objective, as opposed to peak flow reduction being the primary hydrologic objective. Volume reduction is emphasized not only to reduce pollutant loading and peak flows, but also to move toward hydrologic regimes with flow durations and frequencies closer to the natural hydrologic regime.

Even with LID practices in place, most sites will also require centralized flood control facilities. In some cases, site constraints may limit the extent to which LID techniques can be implemented, whereas in other cases, developers and engineers may have significant opportunities to integrate LID techniques that may be overlooked due to the routine nature and familiarity of conventional approaches. This manual provides design criteria and guidance for both LID and conventional stormwater quality management, and provides additional facility sizing credits for implementing Step 1, Runoff Reduction, in a more robust manner.

Permeable pavement techniques and green roofs are common LID practices that enhance infiltration and reduce the impacts of paved areas and roofs:

- **Permeable Pavement:** The use of various permeable pavement techniques as alternatives to paved areas can significantly reduce site imperviousness.
- **Green Roofs:** Green roofs can be used to decrease imperviousness associated with buildings and structures. Benefits of green roofs vary based on design of the roof. Research is underway to assess the effectiveness of green roofs in Colorado's semi-arid climate.
- **Minimize Directly Connected Impervious Areas (MDCIA):** Impervious areas should drain to pervious areas. Use non-hardened drainage conveyances where appropriate. Route downspouts across pervious areas, and incorporate vegetation in areas that generate and convey runoff. Three key control measures include:
 - **Grass Buffers:** Sheet flow over a grass buffer slows runoff, encourages infiltration, and enhances sediment removal, reducing effects of the impervious area.
 - **Grass Swales:** Like grass buffers, use of grass swales instead of hardened channels or storm sewers slows runoff and promotes infiltration, also reducing the effects of imperviousness.
 - **Bioretention (rain gardens):** The use of distributed on-site vegetated features such as rain gardens can help maintain natural drainage patterns by allowing more infiltration onsite. Bioretention can also treat the WQCV, as described in the Four Step Process.

Historically, this critical volume reduction step has been overlooked by planners and engineers, despite WQCV reductions allowed based on MDCIA. In addition to benefiting the environment through reduced hydrologic and water quality impacts, volume reduction measures can also have the added economic benefit to the developer of increasing the area of developable land by reducing required detention volumes and potentially reducing both capital and maintenance costs.



Photograph 1-1. Permeable Pavement. Permeable pavement consists of a permeable pavement layer underlain by gravel and sand layers in most cases. Uses include parking lots and low traffic areas, to accommodate vehicles while facilitating stormwater infiltration near its source. Photo courtesy of Bill Wenk.



Photograph 1-2. Grass Buffer. This roadway provides sheet flow to a grass buffer. The grass buffer provides filtration, infiltration, and settling to reduce runoff pollutants.



Photograph 1-3. Grass Swale. This densely vegetated drainageway is designed with channel geometry that forces the flow to be slow and shallow, facilitating sedimentation while limiting

Step 2. Implement Control Measures That Provide a Water Quality Capture Volume with Slow Release

Step 2 requires the implementation of permanent control measures which seek to address water quality impacts from new development and redevelopment. After volume reduction through Step 1, the remaining runoff must be treated through capture and slow release or infiltration of the WQCV to the maximum extent practicable. If the design engineer proves that 80% of the WQCV is infiltrated in accordance with Step 1, Step 2 requirements are met without additional treatment measures. WQCV facilities may provide both water quality and volume reduction benefits, depending on the control measure selected. This manual provides design guidance for control measures providing treatment of the WQCV, including permeable pavement systems with subsurface storage, bioretention, extended detention basins, sand filters, and constructed wetland ponds. Chapter 3 provides background information on the development of the WQCV as well as a step-by-step procedure to calculate the WQCV. A design spreadsheet for permanent water quality facilities is provided on the City's website. Final drainage reports must include the Colorado Springs permanent control measures spreadsheet unless a full hydrograph routing analysis is provided.

The control measures for applicable development and redevelopment sites shall be designed in accordance with this Manual and must meet one of the following design standards listed below:

1. **WQCV Standard:** The control measure is designed to provide treatment and/or infiltration of the WQCV and:
 - a. 100% of the applicable development site is captured to the maximum extent practicable.
2. **Pollutant Removal Standard:** The control measure is designed to treat at a minimum the 80th percentile storm event. The control measure 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 mg/L or less. This standard may not be used on sites where full spectrum detention is required according to DCM Volume 1.
 - a. 100% of the applicable development site is captured to the maximum extent practicable.
3. **Applicable Development Site Draining to a Sub-Regional or Regional WQCV Control Measure:** The sub-regional or regional WQCV control measure must be designed to accept the drainage from the applicable development site in a developed condition and any offsite tributary area in accordance with Chapter 3 Section 3.0. Stormwater from the site must not discharge to a water of the state before being discharged to the sub-regional or regional WQCV control measure. The sub-regional or regional WQCV control measure must meet the design requirements in accordance with this Manual.
4. **Applicable Development Site Draining to a Sub-Regional or Regional Inline WQCV Facility:** The development site drains to a sub-regional or regional inline WQCV facility meeting all requirements in Chapter 1.

Step 3. Stabilize Drainageways

Channel stabilization measures that protect open channels from erosion resulting from increases in frequency, duration, rate, and volume of runoff are required as part of the Four Step Process. The construction and operation of a full spectrum detention facility prior to discharge of developed flows does not remove the requirement for channel stabilization.

If a City channel stabilization fee in-lieu program exists for a specific channel segment, developments adjacent to a channel may participate in that program to fulfill the requirements of Step 3.

Developments adjacent to a channel for which improvements are specified in a DBPS are responsible for completing the specified improvements. If the specified improvements constructed previously, adjacent development is not responsible for re-constructing the improvements if the existing improvements are in good condition. Adjacent to a channel is defined as the first developable property measured perpendicularly from the channel outwards. Dedicating land to the City between the channel and the development area does not relieve this requirement. If specified in a DBPS, improvements are generally considered to be reimbursable according to the fee calculations found in the DBPS. Early coordination with the City is encouraged for improvements which may be reimbursable.

All improvements based on information in a DBPS will be required to follow current criteria while matching the intended function from the DBPS.

If a development is adjacent to a channel where no improvements are specified in a DBPS, improvements are still required as part of Step 3.

Where channel improvements are required, improvements must be constructed or 100% assurances paid prior to building permit issuance. Regardless of the timing of assurances, channel improvements must be constructed prior to issuance of 50% of the building permits for the development.

Downstream impact mitigation and/or channel stabilization may be required due to physical tie-in or hydraulic requirements or if the City Engineer deems it appropriate based on site conditions. Where confusion arises, guidance should be sought from the City Engineer well in advance of a drainage submittal.

Channel analysis with consideration to velocities, shear stresses, existing vegetation, capacity, geomorphic characteristics, and other appropriate engineering variables may be utilized to prove natural channels will remain stable under post development conditions. The analysis must utilize HEC-RAS or an equivalent software and engineering variables and channel characteristics must meet the requirements of Volume 1 of the DCM. If existing channel conditions are adequately shown to be stable and in compliance with City criteria, no additional channel stabilization will be required, unless specified in an approved DBPS.

The requirements under Step 3 apply only to areas within the City limits.

Many drainageways are included in basin master plans or major drainageway plans that identify needed channel stabilization measures to accommodate developed flows. These measures not only protect infrastructure such as utilities, roads and trails, but are also important to control sediment loading from erosion of the channel itself, which can be a significant source of sediment and associated constituents, such as phosphorus, metals and other naturally occurring constituents. If stream stabilization is implemented early in the development process, it is far more likely that natural drainageway characteristics can be maintained with the addition of grade control to accommodate future development. Targeted fortification of a relatively stable drainageway is typically much less costly than repairing a degraded channel. The Drainage Criteria Manual,

Volume 1 provides requirements for channel stabilization, including stabilized natural channels and several engineered channel approaches. This manual also describes a Constructed Wetland Channel approach, which may provide additional water quality and community benefits. Brief descriptions of these three approaches to stabilized channels include:

- **Stabilized Natural Channel.** Natural drainageways in and adjacent to new developments usually receive increased low flows due to urbanization even when upstream detention storage is provided. Urban development causes channels to become destabilized disturbing riparian vegetation and habitat and transporting sediment downstream. Therefore, some level of stream stabilization is always necessary. Small grade control structures sized for low flows are often an effective means of establishing a mild slope for the main channel and arresting stream degradation. Severe bends or cut banks may also need to be stabilized. When site conditions are suitable Constructed Wetland Channels can be implemented. Wetland bottoms use dense natural vegetation to slow runoff and promote settling and biological uptake. These are particularly beneficial in treatment train approaches where pre-sedimentation occurs upstream of the wetland channel. Such efforts to stabilize a natural waterway enhance aesthetics, riparian and stream habitat, and water quality. Drainageway design should always be completed in accordance with master planning documents when available.
- **Constructed Natural Channel.** When upstream flood flows increase so that channel capacity improvements are needed and sufficient right-of-way is available, constructed natural channels can provide benefits similar to natural channels. These channels provide water quality benefits through infiltration and pollutant uptake through vegetation. Grade control structures in these channels also reduce velocities and prevent bed and bank erosion.
- **Engineered Channel:** Engineered channels may be necessary when the upstream basin has developed without detention storage or when adjacent properties are subject to flooding or erosion. These channels are typically lined with rip-rap or cobblestone and do not enhance infiltration or water quality beyond the reduction of bed and bank erosion.

All new and re-development projects, regardless of size, are required to construct or participate in the funding of the construction of the channel stabilization measures if identified in the applicable DBPS. Developers shall be required to show that DBPS recommendations for stabilized or constructed natural channels are not feasible before engineered channels are proposed.

Step 4. Implement Site Specific and Other Source Control Measures

Site specific needs such as material storage or other site operations require targeted source control measures. This is often the case for new development or significant redevelopment of an industrial or commercial site. Chapter 5 includes information on source control practices such as covering storage/handling areas and spill containment and control. All new and re-development that includes outdoor storage or the potential for the introduction of contaminants to the City's MS4 shall be required to implement site specific and/or source control measures to protect receiving waters.

4.1 City of Colorado Springs MS4 Permit and Implementation of the Four-step Process

The entire Four-Step Process is required for all land disturbance activities greater than 1 acre or less than an acre if part of a larger common plan of development or sale. Implementing volume reduction methods as described in Step 1 is an effective means of providing water quality treatment and must be implemented and

quantified in order to contribute to the requirements described in Step 2. Source controls described in Step 4 may also be required under permits issued by other agencies.

5.0 Inline Water Quality Facilities

Stormwater from the site may discharge to a water of the state before being discharged to the sub-regional regional inline WQCV facility if the following requirements are met.

- The inline WQCV facility must be sub-regional or regional and publicly maintained according to the City's permanent control measure operations and maintenance program.
- The inline WQCV facility must be included in a DBPS or MDDP.
- Before discharging to a water of the state, at least 20 percent of the upstream imperviousness of the applicable development site must be disconnected from the storm drainage system and drain through a receiving pervious area control measure comprising a footprint of at least 10 percent of the upstream disconnected impervious area of the applicable development site. The control measure must be designed to meet the requirements contained in this Manual.
- The stream channel between the discharge point of the applicable development site and the inline WQCV facility must be stabilized in accordance with Step 3.
- The inline WQCV facility must be designed and maintained for 100% of the water quality storage volume for the entire tributary area based on future development conditions. This requirement holds even if upstream developments have installed their own onsite WQCV facilities. The only exception to this criterion is when multiple inline regional or sub-regional control measures are constructed in series and a detailed hydrologic model is prepared to show appropriate sizing of each control measure.
- The inline WQCV facility must have capacity to accommodate the drainage from the applicable development site.
- The inline WQCV facility be designed and built to comply with all assumptions for the development activities planned by the permittee within its drainage area, including the imperviousness of its drainage area and the applicable development site.
- Inline WQCV facilities must be designed and implemented with flood control or water quality as the primary use. Recreational ponds and reservoirs may not be considered inline WQCV facilities. Water bodies listed by name in surface water quality classifications and standards regulations (5 CCR 1002-32 through 5 CCR 1002-38) may not be considered inline WQCV facilities.
- The applicant must demonstrate that no intakes for drinking water use exist and no other beneficial uses are expected to be impacted by pollutant discharges from the development project for the State Water upgradient from the inline WQCV facility.
- If the inline WQCV facility is not yet designed and constructed, then Steps 1-4 of the Four Step Process shall be implemented. Options for provision of control measures to treat the water quality

storage volume for the development site include developer participation in the design and construction of the inline WQCV facility, design and construction of an on-site WQCV control measure, or the construction of a temporary control measure. In all cases an adequate facility must be in place and operating prior to Certificate of Occupancy issuance.

When an inline WQCV facility is selected to treat the water quality storage volume for a development, the remaining three steps in the Four Step Process must still be implemented.

6.0 Conclusion

Urban stormwater runoff can have a variety of chemical, biological, and physical effects on receiving waters. As a result, local governments must comply with federal, state and local requirements to minimize adverse impacts both during and following construction. Runoff mitigation measures are based on a Four Step Process focused on reducing runoff volumes, treating the remaining WQCV, stabilizing receiving drainageways and providing targeted source controls for post-construction operations at a site. Stormwater management requirements and objectives should be considered early in the site development process, taking into account a variety of factors, including the effectiveness of the control measure, long-term maintenance requirements, cost and a variety of site-specific conditions. The remainder of this manual provides requirements for selecting, designing, constructing and maintaining stormwater control measures.

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