PREFACE

SHORT NAME:

The standards and criteria set forth herein, including any approved revision, amendments, and supplements, may be referred to, in shorter form, as the City of Aurora, "STORM DRAINAGE CRITERIA."

PURPOSE:

The purpose of these criteria is to set forth certain rules and regulations to assure the health, safety, welfare, and property of the City and citizens may be safeguarded and protected through the proper control and drainage of storm and surface waters; and, further, to assure that there will be a certain uniformity in performance with respect to the design and construction of any drainage facility and with respect to the control of the quality of stormwater drainage. Consequently, any time that it can be shown that an alternate design analysis or procedure will provide performance equal to or better than the suggested methods of design analysis, said alternate may be approved by the Department of Aurora Water.

In addition, the purpose of these criteria is to establish minimum drainage and erosion and sediment control requirements to protect, to the greatest extent practicable, life, property, and the environment from loss, injury, and damage by stormwater runoff, erosion, sediment transport, ponding, flooding, landslides, accelerated soil creep, settlement and subsidence, excessive dust, and other potential hazards, caused by grading, construction activities and denuded soils.

AUTHORITY:

The Director of Aurora Water is authorized to promulgate said rules and regulations under the provisions of Article IV, Chapter 2 of the City Code.

CONTENTS:

These criteria set forth the minimum engineering and technical criteria for the analysis and design of drainage systems.

EFFECTIVE DATE:

These criteria shall become effective October 11, 2010. All revisions and amendments shall become effective immediately upon publication of notice that such revisions and amendments have been prepared.

Director of Aurora Water Department

CITY OF AURORA

CITY OF AURORA
STORM DRAINAGE DESIGN AND TECHNICAL CRITERIA

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CITY OF AURORA
STORM DRAINAGE DESIGN AND TECHNICAL CRITERIA

CHAPTER 1.00 INTRODUCTION

1.10 PURPOSE AND SCOPE

The purpose of this manual is to present the design criteria and regulations governing storm drainage and stormwater in the City of Aurora. All planning and design must provide control of storm drainage with regard to quantity and quality to protect the health, safety, welfare, and property of the citizens and the City. Conformity with these criteria will provide uniform performance of the storm drainage system as a whole. These criteria are intended to supplement the Urban Drainage and Flood Control District's "Urban Storm Drainage Criteria Manual" (USDCM). The USDCM, including volumes 1 through 3 and any amendments issued by the District, is to be considered a part of these criteria and shall be consulted for all policies and technical criteria not included or modified herein.

1.20 CITY CODE PROVISIONS (NOTE: This section will be revised periodically for changes to City Code.)

The Aurora City Code Chapter 138 and Chapter 70 provide the authority for the Director of Aurora Water to promulgate "reasonable rules and regulations...to facilitate the proper administration of this article" (SEC. 138-363, SEC. 138-438, SEC. 70-171). Additional information on the powers of the City to regulate drainage improvements can be found in the USDCM Volume-1, Section on "Drainage Law." These criteria are consistent with the requirements of the City Code and are intended to meet that mandate. The City Engineer has been designated by the Director of Aurora Water to enforce City Code regulations through review of all drainage studies and design plans, and through control of building permits. Both the Aurora Water and the Public Works Departments must approve any storm drainage improvement.

1.30 ABBREVIATIONS

BMPs	Best Management Practices
COA	City of Aurora
CDOT	Colorado Department of Transportation
CMP	Corrugated Metal Pipe
ESCP	Erosion and Sediment Control Plan associated with construction activities
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
CUHP	Colorado Urban Hydrograph Procedure
RCP	Reinforced Concrete Pipe
NRCS	National Resource Conservation Service
SWMM	Stormwater Management Model
SWQCP	Stormwater Quality Control Plan
UD&FCD	Urban Drainage and Flood Control District
USDCM	Urban Storm Drainage Criteria Manual
WQCV	Water Quality Capture Volume

CHAPTER 2.00 SUBDIVISION PLANNING AND SUBMITTAL REQUIREMENTS

2.10 REGULATIONS (NOTE: This section to be revised periodically for changes to City Code)

City Code ordinances specifically addressing drainage requirements for subdivisions are reproduced in the following:

Sec. 138-361. Definitions.

The following words, terms and phrases, when used in this article, shall have the meanings ascribed to them in this section, except where the context clearly indicates a different meaning:

Drainage basin development fee means the per-acre fee levied and assessed upon each vacant and undeveloped lot and parcel of land within the city for the purpose of funding the construction and installation of major facilities in accordance with the drainage master plan.

Drainage basin plans means those plans which describe flood control and storm drainage channels, structures, sewers and facilities for conveyance, control or storage of stormwater in individual drainage basins. Upon approval by the director of water, such plans shall become detailed subsections of the drainage master plan.

Drainage facilities means all manmade structures or natural watercourses owned, operated or maintained by the city which are used for the conveyance, control or storage of stormwater arising within the city limits or within drainage basins which discharge into the city limits.

(1) *Major facilities* means those drainage facilities identified in the drainage master plan which provide for the conveyance or detention of stormwater from areas equal to or greater than 160 acres. Examples of major facilities include but are not limited to stream channels, grade control structures, and regional detention ponds.
(2) *Minor facilities* means those drainage facilities which provide for the conveyance or detention of stormwater from areas of less than 160 acres. Examples of minor facilities include but are not limited to storm sewers, overflow tracts, and drainage ditches.

Drainage master plan means the overall plan developed by the director of water which addresses various matters relating to storm drainage within the city, including the identification of drainage and flooding problems, the compilation of base data related to rainfall and runoff, proposals for controlling stormwater flows, and cost control measures regarding the construction, operation and maintenance of drainage facilities. Such plan shall identify the principal features of the storm drainage system and shall consist of approved drainage basin plans, drainage basin maps, basic drainage concepts and related calculations, and any other items deemed appropriate by the director of water.

Monthly usage fee means the monthly fee imposed on each and every lot or parcel of land within the city to pay for the operation, maintenance, improvement, and replacement of drainage facilities.

Storm drainage system means all drainage facilities owned, operated or maintained by the city which are used for the conveyance, control or storage of stormwater to, through and from drainage areas to points of final outlet, including but not limited to any and all of the following: conduits, canals, ditches, channels, streams, gulches, gullies, flumes, culverts, streets, curbs, gutters, catch basins, detention and retention ponds, siphons, bridges, pump stations, and all features appurtenant thereto.

Subdivider means the owner or developer of a subdivision or any other lot or parcel of land proposed for development.

(Code 1979, § 17-17; Ord. No. 2005-74, § 1, 10-10-2005)
Cross references: Definitions generally, § 1-2.

Sec. 138-362. Liability.

Large floods from stormwater runoff may occasionally occur which exceed the prudent design capacity of the drainage facilities constructed or maintained by funds made available under this article. This article does not imply that the real property liable for the drainage basin development and monthly usage fees established in this article will always be free from stormwater flooding or flood damage nor shall this article create any liability on the part of or cause of action against the city or any officer, agent or employee thereof for any flood damage that may result from storms or the runoff thereof or purport to reduce the necessity for obtaining flood insurance.
(Code 1979, § 17-27)

Sec. 138-363. Rules and regulations.

It shall be the duty of the director of water to promulgate reasonable rules and regulations to facilitate the proper administration of this article.
(Code 1979, § 17-18; Ord. No. 2005-74, § 1, 10-10-2005)

Sec. 138-364. Master plan.

(a) Adequate drainage and control of stormwater is an integral and important part of any development. Proper drainage planning shall be considered to be an essential element of the overall comprehensive plan. A drainage master plan shall be developed by the director of water. Such plan shall be revised when information so warrants, as determined by the director of water. The purpose of the drainage master plan shall be to:

> (1) Establish the boundaries of drainage basins which are either directly located or contribute to stormwater flows within the city.

(2) Offer a means of identifying and alleviating both present and future drainage and flooding problems while reasonably maintaining the environmental and aesthetic values of drainageways.
(3) Present, in an organized fashion, basic data and information regarding the relationship between rainfall and stormwater flows.
(4) Offer an effective means by which subdividers and the city may cooperate in controlling stormwater flows.
(5) Provide the city with a process for scheduling the installation of major facilities.

(b) The city may solicit the cooperation of other governmental entities in providing drainage facilities in drainage basins or parts thereof, which extend outside the city limits for the purpose of carrying out the drainage master plan.

(c) Notwithstanding any other provision in this article to the contrary, the city shall be deemed to be providing drainage facilities to any property within the city when stormwater from such property is accepted or capable of being accepted in any of the following types of facilities: publicly dedicated or owned streets, alleys, utility easements, gutters, ditches, catch basins, pans, drop structures, pipes, lined or unlined channels, natural drainageways, or any other publicly owned or operated facility used for the transportation of stormwater.

(Code 1979, § 17-19; Ord. No. 2005-74, § 1, 10-10-2005)

Sec. 138-365. Dedication of easements; construction of minor facilities.

(a) Every subdivider shall provide, without cost to the city, an easement of not less than 16 feet in width up to such maximum width as is necessary to accommodate drainage from a 100-year storm for the purpose of constructing and maintaining drainage facilities for the transmission, through the subdivider's property, of all stormwater generated upstream from the subdivision. Notwithstanding this requirement, any natural drainageway having an identifiable bed and banks which traverses any subdivider's property shall not be encroached upon or altered so as to render the drainageway less suitable to accept and transport stormwater which has historically flowed through such drainageway. The maximum width of the storm drainage easement to be provided by the subdivider shall be reasonably determined by the directors of utilities and public works.

(b) Wherever possible, existing street patterns may be utilized for the purpose for which an easement would otherwise be required. Alternatively, the city may, at its sole option, waive the requirement for granting such an easement.

(c) It shall be the responsibility of the subdivider, at his or her sole expense, to construct or provide for the construction of all minor facilities required within his or her subdivision for the acceptance and transmission of all stormwater generated outside of his or her subdivision, as though such water was in fact generated from land in its fully developed state. It shall further be the duty of the subdivider, at his or her sole expense, to construct or provide for the construction of all minor facilities required for the acceptance and transmission of all stormwater generated from within his or her subdivision, as though such subdivision was in fact fully developed, or as may otherwise be approved by the directors of utilities and public works.

(Code 1979, § 17-23)

Sec. 138-366. Construction of major facilities.

(a) Under this article, responsibility for the construction of major facilities shall be apportioned between the city and the subdivider. It shall be the responsibility of the city to construct or provide for the construction of grade control structures and regional detention ponds required for the adequate drainage, control and conveyance of stormwater generated within a subdivision, including the drainage, control and conveyance of stormwater generated outside of such subdivision as though such water was generated from land in its fully developed state. It shall be the responsibility of the subdivider, at his or her sole expense, to provide for earthwork, erosion protection and revegetation associated with stream channelization required for the adequate drainage, control and conveyance of such water.

(b) Subject to the approval of the city council, the director of water shall create a schedule for the construction of major facilities, and the city and the subdivider shall make a good faith effort to complete such construction in accordance therewith. This schedule shall be modified annually to reflect the availability of funds and other relevant considerations. The director of water shall consider the following matters in establishing and modifying the schedule:

(1) The need to protect existing development from flood damage and other events detrimental to the public health and safety;
(2) The need to prevent the violation of other local, state and federal laws or regulations;
(3) The need to prepare land for development; and
(4) The desirability of constructing such facilities solely for the purpose of complying with the drainage master plan.

(c) If a subdivider desires to construct major facilities for his or her subdivision prior to the sequence established by the approved schedule, such construction may be allowed at the subdivider's sole expense provided that:

(1) The health and safety of the public and its property is neither damaged nor diminished;
(2) A violation of local, state and federal laws or regulations will not occur;
(3) The plans for such construction meet all city criteria and are approved by the directors of public works and utilities; and
(4) Such construction will not adversely impact any other landowners within the area or, if such an impact will result, the affected landowners agree to such construction.

(d) If such out-of-sequence construction is in accordance with the city's infrastructure planning, the city may enter into an agreement with the subdivider, wherein the subdivider may recapture a portion of the funds expended for the construction of grade control structures and regional detention ponds.
(e) Agreements for reimbursement for the out-of-sequence construction of grade control structures and regional detention ponds shall not provide for any payment to the subdivider of an

amount which exceeds the actual costs incurred by the subdivider in the construction of such facilities, exclusive of any finance or interest charges, plus ten percent. This amount shall also constitute reimbursement in full to the subdivider for all nonconstruction expenses. The subdivider shall be responsible for all contracts associated with the construction of such facilities.

(f) Following construction by a subdivider of any major facilities, record drawings signed by a professional engineer and bearing his or her seal shall be presented to the city for its review. Such plans must be reviewed by the directors of utilities and public works prior to the city's acceptance of such facilities. All major facilities and facilities appurtenant thereto, which are constructed under this section, shall, upon written acceptance by the city and fulfillment of the one-year warranty period, become city property and the city shall thereafter be responsible for the operation and maintenance of such.

(Code 1979, § 17-24; Ord. No. 2005-74, § 1, 10-10-2005)

Sec. 138-367. Preliminary and final drainage plans.

(a) Under this article, every subdivider shall, at his or her sole expense, be required to:

(1) Establish, locate or otherwise define the boundaries of all subdrainage areas within his or her subdivision;
(2) Establish, locate or otherwise define the alignment and boundary of any natural drainageway or existing drainage facilities and private drainage works within his or her subdivision;
(3) Submit for review and approval by the directors of utilities and public works, prior to the final approval of any subdivision plat or site plan, a preliminary storm drainage plan for his or her subdivision, which shall include preliminary drawings of all proposed drainage facilities, drainage studies and reports, design computations, estimated costs of construction, and such other information as may be required to ensure that stormwater originating both from his or her proposed subdivision and lands lying up gradient from such subdivision will be adequately drained and controlled; and
(4) Convey to the city by dedication, deed and bill of sale, free and clear of all liens and encumbrances and in consideration of the city thereafter maintaining and operating such, all constructed drainage facilities, including adequate easements or rights-of-way within his or her subdivision necessary for the maintenance, repair or replacement of such facilities, which conform to the drainage master plan and which, in the opinion of the director of water, could reasonably be considered to be an integral part of the storm drainage system.

(b) The directors of water and public works shall not approve any proposed storm drainage plan or construction of drainage facilities or accept any constructed drainage facilities which do not conform to the drainage master plan or such reasonable rules and regulations as may be promulgated to ensure the adequate drainage and control of stormwater.

(c) The directors of utilities and public works shall not recommend approval for any subdivision plat or site plan which does not conform to the drainage master plan or such rules and regulations.

(d) After the final approval of any subdivision plat, site plan, or part thereof for which final approval is requested and prior to the issuance of any building permits, the subdivider shall, at his or her sole expense, prepare and submit for review and approval by the directors of utilities and public works a final storm drainage plan, including detailed construction drawings, plans, profiles and specifications for the construction and installation of all drainage facilities necessary for the drainage and control of all stormwater within his or her subdivision and the conveyance of such water to a safe discharge or outflow point. Such plan shall conform to the approved preliminary drainage plan for the subdivision and the drainage master plan and shall bear the seal of a registered professional engineer of the state. The subdivider shall also prepare and submit an estimated construction schedule in accordance with chapter 147 of this Code. Prior to the issuance of any building permit, the subdivider must complete any and all improvements which may be necessary to remove the underlying subdivision from a 100-year floodplain.

(e) The directors of utilities and public works may recommend another temporary discharge or outflow point at which the water will be received by an open channel or other minimum, temporary or substitute facility to carry the water, provided that it is technically feasible and not detrimental to the health, safety and welfare of the public. The city council may, in the interest of the health, safety and welfare of the public, direct the purchase of land or construction of drainage facilities as shown in the drainage master plan.

(f) The approval of any preliminary or final drainage plan under this section shall be valid for a period of one year from the date such approval is given.

(g) Land not otherwise excluded or exempted under this section shall be ineligible for replatting or resubdividing if:

(1) Drainage basin development fees have not been assessed;
(2) Drainage facilities have not been built in accordance with accepted plans and specifications;
(3) Preliminary drainage plans have not been submitted; or
(4) The subdivider has failed to comply with all of the requirements of this section.

(h) Land may be replatted or resubdivided without additional assessment of drainage basin development fees or construction of additional drainage facilities if the drainage plan submitted with the replat or resubdivision indicates that no new drainage facilities are required as a result thereof, provided that:

(1) Drainage basin development fees have been paid; and
(2) Drainage facilities have been built in accordance with accepted plans and specifications.

(Code 1979, § 17-25; Ord. No. 2005-74, § 1, 10-10-2005)

Sec. 138-368. Requirements for mains, structures or facilities.

(a) It shall be unlawful for any person to construct, install, place or attempt to construct, install or place any storm drainage system extension or related subsurface structure or facility within any public street, avenue, alley or other public way or to discharge into a public right-of-way or easement, without first having entered into a storm drainage system extension agreement with the utility enterprise. The agreement shall provide for the dedication of all storm drainage system improvements so constructed or installed to the utility enterprise upon such terms and conditions as the director of water may determine.

(b) Application for a storm drainage system extension agreement shall be made to the utility enterprise on forms provided by the director of water. The applicant shall provide all necessary technical information and data regarding the proposed storm drainage system improvements as may be required by the director.

(c) Following execution of the storm drainage extension agreement and prior to commencing construction or installation of any storm drainage system improvements, each applicant shall procure a public improvement permit from the city. Application for such permit shall be made to the public works department on forms provided by the director of public works.

(d) At the time of filing the permit application, each applicant shall pay a public improvement permit fee. Such fee shall be promulgated by the director of public works in accordance with the provisions of section 2-587 of this Code. The proceeds of such fee shall be used to defray the costs associated with the inspection and acceptance of storm drainage system extensions and related subsurface structures or facilities. In addition to such fee, any person requesting inspection of a storm drainage system extension or related subsurface structure or facility at any time other than normal city business hours shall reimburse the city for all reasonable costs expended in making such inspection.

(e) Contractors responsible for construction or installation shall comply with the licensing, permitting, and bonding requirements set forth in article V of chapter 126 of this Code.

(f) No person may enter into a storm drainage system extension agreement or be issued a public improvement permit, nor may any contractor be allowed to perform work under any such agreement or permit when such person or contractor has failed to diligently complete and discharge his or her performance and warranty obligations under a prior agreement or permit.

(g) All fees collected pursuant to this section shall be credited to and deposited in an account of the public works department in the general fund.

(h) It shall be the responsibility of the applicant or the developer of the subject property to obtain any permits required for the construction, placement or installation of the proposed drainage facilities under section 404 of the Clean Water Act or any other applicable federal or state statute, rule or regulation. Unless otherwise agreed to by the director of water, it shall be the

responsibility of the applicant to obtain any floodplain map amendments or revisions required as the result of the construction, placement or installation.

(Code 1979, § 17-26; Ord. No. 99-84, § 6, 11-29-99; Ord. No. 2005-74, § 1, 10-10-2005)

Specific regulations concerning floodplains are included in Chapter 4.00 of this manual.

Specific regulations concerning stormwater quality are included in Chapter 3.00 and Chapter 8.00 of this manual.

2.20 MASTER DRAINAGE REPORT

The Master Drainage Report is an integral part of the Planning and Engineering approval process. The Master Drainage Report is required to be submitted as part of the Framework Development Plan (FDP) or the General Development Plan (GDP) in the Planning Department's zoning process. See Section 3.20 for other times a Master Drainage Report is required. The report must be approved by the Public Works Department and the Aurora Water Department prior to the FDP approval. The Master Drainage Report will review at a conceptual level the feasibility, design characteristics and phasing of the proposed development with regard to drainage. The cover for the report shall include the title of the project (full plat name if available), Owner's name, address, phone number and point of contact, Engineer's name, address, phone number, point of contact and approval block. The Master Drainage Report shall be structured and labeled in accordance with the following outline and contain the applicable information listed. Master drainage reports must be prepared by a qualified Professional Engineer licensed in the State of Colorado, or under their direct supervision, whose seal and signature shall be affixed to the report and all plan sheets.

2.21 Report Outline

A. INTRODUCTION

1. Location
   a. Adjacent arterial and collector streets and surrounding developments and their associated subdivision names if platted
   b. Township, range, section, ¼ section
   c. Vicinity map

2. Proposed Development
   a. Land uses and associated densities and imperviousness

B. HISTORIC DRAINAGE

1. Description of Property
   a. Area in acres, soils, ground cover, topography, hydrologic soil groups, etc.
   b. General historic drainage patterns

2. Overall Basin Description
    a. Off-site basins including impacts to the existing property
    b. Major drainage ways and whether they have FEMA regulated floodplains
    c. Existing major irrigation facilities such as ditches and canals on the property or within 100-feet of the property, which will influence or be influenced by the local drainage
    d. Reference major drainage way planning studies such as flood hazard delineation reports, outfall system plans, major watershed planning reports, existing master drainage plans, flood insurance studies and flood insurance rate maps
    e. Existing drainage patterns through the property including existing land uses and associated imperviousness
    f. Outfalls downstream from the property

C. DESIGN CRITERIA

1. List References
    a. Existing drainage reports for surrounding properties
    b. Urban Storm Drainage Criteria Manual (USDCM)
    c. City Master Plan and floodplain studies

2. Hydrologic Criteria
    a. Calculation method
    b. Detention volume computation method
    c. Design frequencies

3. Hydraulic Criteria

D. DRAINAGE PLAN

1. General Concept
    a. Discuss drainage concept and typical drainage patterns
    b. Discuss impacts from offsite basins to the property including conveyance concepts through the property
    c. Coordination requirements with surrounding developments
    d. Discuss coordination and compliance with other existing master drainage reports and resolution of any proposed changes from approved reports
    e. Discuss any conveyance elements required to pass the major flows to a major drainage way
    f. Discuss the content of tables, charts, figures, plates or drawings presented in the report

2. Specific Details
    a. Discuss drainage problems encountered and associated solutions

b. Discuss plan for existing drainageways or creeks, i.e., preserve natural drainageways or channelize. Plan should be coordinated with the associated land use planning documents.
c. Detention ponding plan
d. Water quality BMP plan including whether the BMP's provided are regional water quality BMP's identified in an Outfall Systems Plan
e. Identify onsite/offsite right-of-way/easement requirements for drainage facilities
f. Discuss maintenance responsibilities and maintenance access to drainageways, detention ponds and Water Quality BMP's
g. Identify drainageway public improvements required with the development and their funding source, i.e., channels, grade control structures, revetments, regional drainage facilities, bridges, culverts crossing arterial roadways or collectors, including preliminary culvert sizes, etc.
h. Discuss the impacts of the property's runoff to downstream properties
i. Discuss how the drainageway public improvements correlate to the public improvements plan for the FDP
j. Identify input criteria and output data for CUHP/SWMM modeling program, if used
k. Identify measures taken to ensure compliance with special watershed requirements, i.e., Aurora Reservoir or Cherry Creek Reservoir watersheds
l. Discuss alternatives considered to enhance stormwater quality within each proposed publicly owned and maintained drainageway or detention pond. Discuss measures incorporated into the design to preserve or enhance any designated open space within drainageways or detention ponds and coordination of multiple uses with the stormwater management uses.

E. CONCLUSIONS

1. Compliance with Standards
2. Summary of Concept
   a. Degree of protection to existing site
   b. Measures taken to provide adequate on-site drainage and enhancement to stormwater quality
   c. Effect of proposed development on adjacent, upstream, and downstream sites under both existing and future buildout conditions

F. LIST OF REFERENCES

G. APPENDIX

1. Hydrologic Computations
2. Hydraulic Computations
3. Copies of graphs, tables, and nomographs used

2.22 Master Drainage Plan

The master drainage plan must be prepared on a 24" x 36" or 22" x 34" plan sheet(s) showing the concepts of the proposed drainage plan. The plan should show the following as a minimum:

A. Vicinity map

B. Sufficient detail to identify drainage flows entering and leaving the development and general drainage patterns

C: Conceptually, identify any main facilities on the property, i.e., irrigation ditches, existing and proposed detention and water quality BMP's (including conceptual volume requirements and release rates), existing and proposed culverts crossing arterial or collector streets with sizes labeled, drainage channels (constructed or natural), etc. These facilities should be clearly labeled whether they are major, publicly owned and maintained facilities (generally serving 160 acres or more of tributary area) or are privately owned and maintained facilities.

D. Existing topography at 2-foot contour interval. Contours will be extended beyond the property lines a minimum of 50 feet

E. Detailed floodplain limits with Base Flood Elevations, if available, from Flood Insurance Rate Maps, Flood Insurance Studies, Flood Hazard Area Delineation or other best available information

F. Drainage basin boundaries in sufficient detail to depict drainage patterns (onsite and offsite) and design points, basin size, minor and major runoff at design points (off-site basins may be shown on 8-1/2 x 11 or 11 x 17 maps bound within the drainage report), drainage flow patterns and arrows

G. Conceptual locations for grade control structures, major storm sewers, bank revetment, etc.

H. Legend to define map symbols

I. Model schematics used for the CUHP/SWMM modeling programs (can be included with the calculations). The model schematics shall depict all drainage basins, conveyance elements, storage elements and junctions.

J. Any other information deemed necessary to the project

K. Approval block, City of Aurora benchmark, north arrow, scale and the following note:

> "City of Aurora plan review is only for general conformance with City of Aurora Design Criteria and the City Code. The City is not responsible for the accuracy and adequacy of the design, of dimensions and elevations which shall be confirmed and correlated at the job site. The City of Aurora**,** through the approval of this document**,** assumes no responsibility for the completeness and/or accuracy of this document."

L. Seal and Signature of the Professional Engineer who prepared the plan.

M. For drafting standards, scales, and other standard requirements, see Sections 2.00 through 3.03 of the City of Aurora "Roadway Design and Construction Specifications."

2.30 PRELIMINARY DRAINAGE REPORT

2.31 General

The purpose of the Preliminary Drainage Report is to identify problems and propose solutions to convey storm drainage through any new development. The effects of off-site drainage areas on the development and the effects of the development on downstream properties must be thoroughly assessed. The Preliminary Drainage Report shall address the entire property boundary for new plats or site plans, whichever is greater.

The report shall include a preliminary drainage plan that is sufficient to identify drainage facilities to the extent necessary, to identify the specific areas of land to be used for drainage purposes, identify easement locations, resolve any floodplain regulatory issues, and establish concepts for grading and stormwater management on the site, quantitatively and qualitatively. All reports shall be typed on 8 ½" x 11" paper and properly bound with durable covers. The cover shall include the full subdivision plat name, the Owner's name, address, phone number, point of contact, the Engineer's name, address, phone number, point of contact and approval block. Supporting calculations, charts, and design aids shall be included in the appendix. Plan sheets shall be included in a pocket at the back of the report. Drainage reports must be prepared by a qualified Professional Engineer licensed in the State of Colorado, or under their direct supervision, whose seal and signature shall be affixed to the report and all plan sheets.

A preliminary drainage report must be approved prior to approval of any Subdivision Plat or Site Plan.

2.32 Report Format and Required Information

The following outline is a structured format to provide consistency in drainage reports and to speed the review. The applicant is required to structure the report in this format, label each heading as shown, and address the items identified. Sections that are not applicable should be shown but noted as "N/A." The same format shall be used for the Final Drainage Report with changes as noted in Section 2.40. Additional information may be requested for complex sites or to ensure the concept for grading and drainage of the site is viable.

A. INTRODUCTION

1. Location
    a. Adjacent streets, subdivision name, lot and block, site plan name (if any)
    b. Vicinity map

c. Surrounding developments

2. Proposed Development
   a. Property description - soils, topography, hydrologic soil groups, etc.
   b. Type of development: Use, proposed density, composite percent of impervious area
   c. Requested variances from this Storm Drainage and Technical Criteria Manual, which may include exemption requests for stormwater detention or the use of stormwater BMPs onsite.

B. HISTORIC DRAINAGE (keep discussion to "historic" or existing conditions under this heading)

1. Overall Basin Description
   a. Off-site basins
   b. Major drainage ways including whether there are FEMA regulated floodplains

2. Drainage Patterns Through Property

3. Outfalls Downstream from Property

C. DESIGN CRITERIA

1. List References
   a. Existing drainage reports for surrounding properties
   b. USDCM
   c. City Master Plan and floodplain studies

2. Hydrologic Criteria
   a. Rainfall source and P_1 identified
   b. Calculation method
   c. Detention volume computation method
   d. Design frequencies

3. Hydraulic Criteria

   a. Reference sources other than USDCM
   b. Identify design storm frequencies used for pipes and inlets, either public or private – sizing is not required and shall be submitted with the final drainage report
   c. Water surface profile method
   d. Major drainageways

D. DRAINAGE PLAN

1. General Concept
   a. Conveyance of off-site drainage; proposed downstream outfall
   b. Coordination with surrounding developments
   c. Detention ponding/water quality BMP plan, identify ownership/maintenance responsibilities

2. Specific Details

   a. Discuss each basin or sub-basin including land use and minor and major storm flow patterns through the basin. When there is a minor storm sewer system available/proposed it must be considered plugged for the major storm. Therefore, the report must present the minor and major flow routing.
   b. The report must address how TOD and Urban Center developments will intercept and convey non-TOD or non-Urban Center upstream development runoff.
   c. Detention pond location and outfall.
   d. Emergency overflow paths for sump inlets and detention ponds. Sump inlet emergency overflow paths may be done with the individual basin/sub-basin discussion above.
   e. Solutions to problems encountered.
   f. Discuss the proposed permanent BMPs. See Section 3.70 Subparagraph 1 for more information on permanent BMPs. Do not provide discussion on construction BMPs.
   g. Phasing of construction and provisions for drainage during phasing.
   h. Discuss open channel concepts, whether they preserve an undisturbed cross-section or are an improved channel. Include in the discussion toe protection, bank revetment, grade control structure requirements and entity responsible for installation.
   i. Discuss stabilization requirements for any roadside ditches.
   j. Discuss how the requirements set forth in the approved Outfall Systems Plan have been met, if applicable.
   k. Any other information deemed necessary to the project.

E. CONCLUSIONS

1. Compliance with Standards

2. Summary of Concept
   a. Degree of protection to existing site
   b. Measures taken to provide adequate on-site drainage and enhancement to stormwater quality

c. Effect of proposed development on adjacent, upstream, and downstream sites under both existing and future buildout conditions

F. LIST OF REFERENCES

G. APPENDIX

1. Hydrologic Computations
   a. Use standard forms
   b. Land use assumptions
   c. Minor and major storm runoff computations for historic and developed runoff conditions
   d. Detention and water quality volume required and provided calculations

2. Hydraulic Computations
   a. Open channel design (normal depth, culvert calculations)
   b. Street and drive capacities
   c. Drainage tract sizing
   d. Detention pond capacity

3. Copies of graphs, tables, and nomographs used

2.33 Preliminary Drainage Letters

A Preliminary Drainage Letter (letter) will only be allowed with prior approval and must be for projects within areas that have a previously approved drainage plan. It will usually be for pad sites within previously approved commercial sites or for minor changes to existing properties. The letter shall be addressed to the Public Works Department, Engineering Control Division to the attention of the Senior Engineer. It is not required to be bound as in a full report. The letter must be signed and sealed by a qualified Professional Engineer licensed in the State of Colorado.

The letter needs to identify the full subdivision plat name, the project's location, the project land use, any minor drainage changes to the previously approved drainage study and how it will be in general conformance with the previously approved drainage study. Percent impervious calculations may need to be attached documenting changes to basin areas, impervious values, C-values, flows, volumes or other drainage characteristics established in a previously approved drainage report.

Drawings do not need to be a part of the letter. However, if one is used it must be an 8-1/2 x 11 or 11 x 17 size attached to the letter.

2.34 Preliminary Drainage Plan

The preliminary drainage report must include a 24" x 36" plan sheet showing the details of the proposed drainage plan. The plan shall show the following as a minimum:

A. Existing topography at 2 feet contour interval and proposed grading at 2 feet contour interval minimum. Contours will be extended 50-feet beyond the property lines or as necessary to show how the proposed contours tie into the existing topography.

B. Proposed buildings and finished floor elevation for commercial and multi-family sites.

C. Floodplain limits and water surface elevations using F.I.R.M. maps, FHAD maps, where applicable, or where calculated.

D. Drainage basin boundaries and design points. Basin size, minor and major runoff at design points. Off-site basins may be shown on 8-1/2 x 11 or 11 x 17 topographic maps bound within the drainage report. Off-site flows. Drainage flow patterns and arrows. The flow data for the minor and major flows may be presented in tabular form. The tabular form must include design points, basin designations, minor and major flows and accumulated (routed) flows.

E. Location of all existing and proposed drainage facilities and public improvements. Location of all proposed stormwater quality enhancement facilities (permanent BMPs).

F. Existing and proposed easements (drainage, utility, fire lane, etc.), and tract dimensions.

G. Detention ponding limits, 10-year and 100 year volumes (including water quality capture volume, if used), water surface elevations for the 10-year and 100-year pond volumes and water quality capture volumes, release rates, maximum depth, emergency overflow location and direction, and other water quality BMP data as needed for the BMP proposed.

H. Labeling of all proposed drainage facilities, either public or private, inlets, pipes, swales, tracts, etc., with the design storm frequency, e.g., private storm sewer, 5-year storm capacity." A general note covering the above can be placed on all plans in lieu of labeling all facilities.

I. Preliminary cross-sections of proposed retaining walls and/or critical drainage flow paths.

J. Any other information deemed necessary to the project.

K. Vicinity map, City of Aurora benchmark, and the following note:

> "City of Aurora plan review is only for general conformance with City of Aurora Design Criteria and the City Code. The City is not responsible for the accuracy and adequacy of the design, of dimensions and elevations which shall be confirmed and correlated at the job site. The City of Aurora**,** through the approval of this document**,** assumes no responsibility for the completeness and/or accuracy of this document."

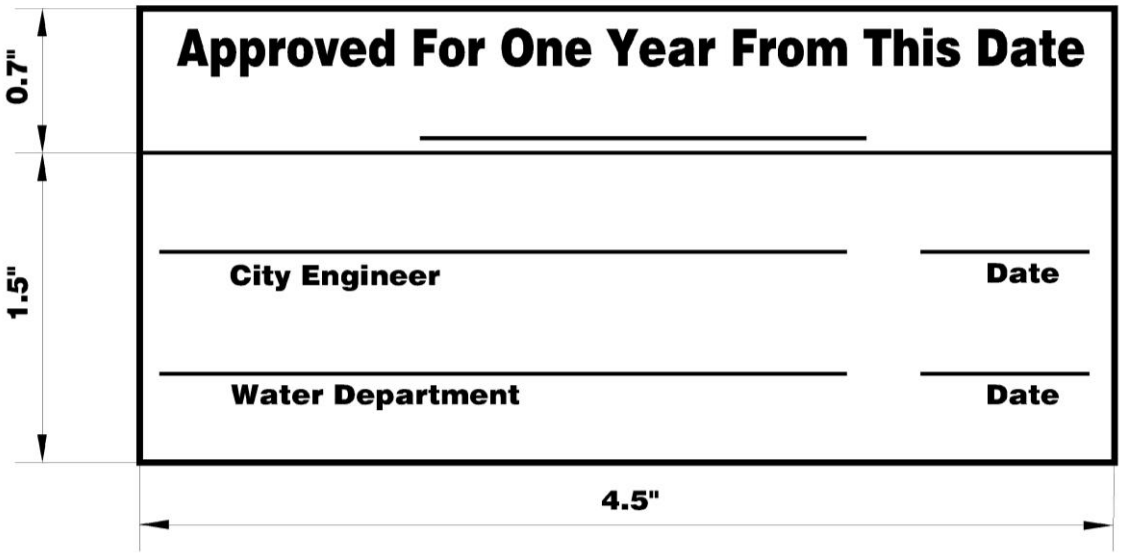
L. Seal and Signature of the Professional Engineer who prepared the plan. Electronic seals (plotted) on plans are acceptable. Only original signatures in black, indelible ink on mylars will be accepted.

M. Preliminary plan and profiles are required for channels. Show typical cross-sections, including the normal depth, and the conceptual location of grade control structures, bank revetment, and as-built profiles of existing utilities crossing the channels.

N. For drafting standards, scales, and other standard requirements, see Sections 2.00 through 3.03 of the City of Aurora "Roadway Design and Construction Specifications", latest edition.

2.35 Approval Blocks

The title page of the report and the lower right hand corner of all drawings shall have the following approval block:



APPROVAL BLOCK

2.40 FINAL DRAINAGE REPORT

2.41 General

The Final Drainage Report shall be a detailed study and analysis of the proposed development. It shall include calculations for all runoff and for all drainage structures or facilities within the development. Final drainage reports must be prepared by a qualified Professional Engineer licensed in the State of Colorado, or under their direct supervision, whose seal and signature shall be affixed to the report and all plan sheets.

Construction plans for all drainage structures, grading plans, and street grades where applicable, shall be considered part of the Final Drainage Report. **The construction plans and Final Drainage Report must be approved before the Engineering Division will sign building permits**. Minor utility service lines may be shown on a combined final grading and utility plan if approved by the Aurora Water Department.

2.42 Final Drainage Report Format and Required Information

The report shall provide more detailed information than the preliminary drainage report, with the same format as described in Section 2.32, except as noted below. Should the drainage concept change between the Preliminary Drainage Study approval and the Final Drainage Study submittal, the Final Drainage Study submittal shall address those changes under the "Drainage Plan" heading of the report (D.1.a. through.1.c. as needed). In addition to the items listed in Section 2.31, 2.32 and 2.34, the following information is required for approval of the Final Drainage Report:

A. Report
   1. In-depth description of the proposed drainage plan. (Identify in report as D.1.d.)
   2. Detailed hydrologic calculations for the historic and developed conditions of the minor and major storm at all critical design points. (Replaces Item G.1.c.)
   3. Detailed hydraulic calculations for sizing of all drainage facilities, calculations of hydraulic and energy grade lines for all 2-year and/or 100-year storm sewers and 100-year channels and calculations for all storm sewer or culvert outfalls' outlet protection. (Identify in report as Item G.2.e.)
   4. A separate section to address the **Stormwater Quality Control Plan** with in-depth description of the proposed stormwater quality enhancement measures (permanent BMPs). See Section 3.70, Subparagraph 1 for more details.
   5. Detailed calculations for sizing of all permanent BMP's and associated outlets. (Identify as item G.2.f.)

B. Final Drainage Plan
   1. Complete grading plan with finished floor elevations of all structures.
   2. Additional area grading plan for single-family detached development, with proposed contours and spot elevations around buildings. See Section 2.07 of the City of Aurora "Roadway Design and Construction Specifications" for more detailed requirements on grading plans.
   3. Size and location of all drainage facilities with details provided as necessary. Make reference to City of Aurora standard details where applicable. Note: if special structures (inlets, manholes, wingwalls, etc.) are required structural calculations must be submitted with the civil plans for review and approval.
   4. Size and locations of all stormwater quality enhancement facilities (permanent BMPs), with necessary details.
   5. Cross sections of drainageways and tracts.
   6. Type of curb and gutter, gutter flow.
   7. All easements and right-of-way.

8. 100-year flood level in all streets in which the curb is overtopped during the 100-year storm. Plot hydraulic grade lines for all 2-year and/or 100-year storm sewers and channels (10-year HGL if required in channels).
9. All other items identified in Sections 2.32 through 2.35 above.

2.50 REVIEW PROCESS

2.51 Preliminary Drainage Report or Preliminary Drainage Letter Submittal

The Preliminary Drainage Report/letter must be submitted concurrently with any application for Site Plan or Contextual Site Plan. The procedure for review and approval is as follows:

A. Submit one report and plan sheet to the Engineering Services Section of the Engineering Division for review. Engineering personnel will sign the Development Application Form for a plat or site plan when requested, provided the report has been received, the report/letter review fee paid and a copy of the plat or site plan accompanies the Development Application. Contact the Public Works' Engineer of the Day for the fee amount.

B. The report/letter will be reviewed by Engineering and will be returned to the consultant with comments. The consultant or local representative will be notified by phone and facsimile when the submittal is ready to be picked up.

C. The consultant will make necessary revisions and resubmit according to the instructions checked on the City of Aurora routing slip, which is returned with the report/letter. **Each resubmittal must include all previously reviewed reports/letters with prints and the routing slip**. **Incomplete submittals or non-responsive resubmittals may be rejected and returned without review.**

D. When indicated on the City of Aurora routing slip, the consultant will submit a clean report/letter and mylar of the drainage plan for signatures. The approved copy will remain on file in the Engineering Division. Refer to Section 2.03.4.06 of the City of Aurora "Roadway Design and Construction Specifications" for requirements on the Seal and Signature of the Professional Engineer who prepared the report/letter and the plan.

E. The review and revisions cycle normally corresponds closely to the Planning Department schedule for plat and other site plan review. However, meeting this schedule depends on the quality of the Preliminary Drainage Report and City personnel workload. **The Preliminary Drainage Report/Letter must be approved two City workdays prior to the Planning Commission meeting**.

2.52 Final Drainage Report Submittal

The Final Drainage Report must be submitted with civil construction plans for water, sewer, streets, and grading as a complete package. The submittal can be made during the processing of

planning documents, if desired. **Approval of the civil plan package is required prior to Engineering Division approval of building permits**. The procedure is as follows:

A. Request a pre-submittal meeting with the Public Works' Engineering Control Division. The submittal package, including the final drainage study and plan, will have a "table top" review for completeness of the submittal. After this meeting the plans will either be returned for additional information or be allowed to be submitted.

B. Submit one set of civil construction plans (or, the number of sets requested in the pre-submittal meeting) and Final Drainage Reports and the civil plans review fee to the Engineering Services Section to be logged in for review. The plans will be routed to other departments as necessary. If necessary, plans will be routed to Urban Drainage and Flood Control District, or, other applicable agencies, for review to ensure compliance with their criteria. Contact the Public Works' Engineer of the Day for fee amounts.

C. The civil construction plan package will be returned to the consultant with comments and requested revisions. The consultant or local representative will be notified by phone and facsimile when the submittal is ready to be picked up.

D. The consultant will make necessary revisions and resubmit according to the items checked on the City of Aurora routing slip. **Each resubmittal must include all previously reviewed prints/reports and the routing slip**.

E. When indicated on the routing slip, the consultant will submit a clean report and mylar of all construction plans for signatures. The approved copies will remain on file in the Engineering Division. Approval of the Final Drainage Report and Civil Construction Plans by all departments is required for Engineering Division approval of building permits.

F. The review and revision cycle is based on the Development Review Process as outlined in the City of Aurora Development Handbook. Quality plans meeting all City of Aurora standards and criteria will save time for all involved. If the civil plans and drainage report cannot be approved with the third submittal, the review of the plans will start over and a new review fee will be required. Excessive phone calls during the review only serve to increase review time.

CHAPTER 3.00 STORM DRAINAGE POLICY

3.10 GENERAL

The City of Aurora has established a storm drainage and flood control system which is treated as a utility much the same as the water and sanitary sewer systems. The Aurora Water Department administers the program with technical assistance from the Public Works Department. Thus, both departments review and approve all storm drainage facilities.

3.20 MASTER PLANS

Proper planning is essential for a coordinated and comprehensive drainage system. The City has a number of regional master plans. These include multi-phase subdivisions, Transit Oriented Developments, Urban Centers and large business or industrial parks, and some major drainage basins. New developments are required to conform to the master plans in which the developments are located. Check with City personnel for availability of master plans.

A master drainage plan is required prior to approval of any planned community zoned district or site plan in excess of 80 acres or any phased commercial/industrial development in excess of 10 acres.

Stormwater quality control and enhancement (permanent BMPs) must also be addressed in the master drainage plan.

3.30 MINOR AND MAJOR STORMS

Urban drainage design includes both a minor and a major storm drainage system. The minor system prevents damage from regularly occurring storms and typically consists of storm sewers and low flow channels. The major system prevents damage or loss of life from large magnitude, but relatively rare storms. The streets, storm sewers, and major drainageways combine to provide safe conveyance of major storms.

3.31 Design Frequencies

All storm drainage plans must evaluate the effects of both minor and major storms on the storm drainage system. Consideration should also be given to nuisance runoff from irrigation, snowmelt, etc. The following table lists the minor and major storm frequencies for design and evaluation:

DESIGN STORM FREQUENCIES

Land Uses or Type of Facility	Minor Storm	Major Storm
Residential, Business, and Industrial	2-year[(1)]	100-year
City Center Zone	5-year[(1)]	100-year
Transit Oriented Developments, Urban Centers	N/A	100-year
Open Channels, Culverts, Bridges	See USDCM	100-year
Detention Ponds	(2)	100-year[(2)]

(1) Frequency for sizing of storm sewers (most cases). Storm sewer flows originating from a location with a larger design storm frequency shall continue with that frequency to a logical point of outfall.

(2) Detention ponds shall be evaluated for multiple discharges (10-year and 100-year storms). Single stage discharges (100-year) will only be allowed with prior approval by the City.

3.32 Street Flow Capacities

The primary purpose of streets is for traffic. However, streets are also an integral part of the storm drainage system and can be used for storm runoff within reasonable limits. The allowable street flows shall be calculated by multiplying the theoretical capacity by the reduction factor from Figure ST-2 of the USDCM. Figures 4A and 4B present the allowable 2-year and 100-year street flow capacities for different street classifications.

The USDCM shall govern for street capacities except as modified as follows:

ALLOWABLE PAVEMENT ENCROACHMENT
AND DEPTH OF FLOW

	Street Classification	Maximum Encroachment or Depth
Minor Storm	All	No curb overtopping[(1)]
Major Storm	Local, Collector, Arterial & all TOD and Urban Streets[(3)]	Maximum depth of water over gutter flowline shall not exceed 12"[(2) (4)]

(1) Water may spread to back of walk where mountable curb and attached walk are used. For mountable curb with detached walk, water may spread to crown of street (no crown overtopping) or six-inch depth at the curb flowline, whichever is less.

(2) Flows exceeding these criteria shall warrant over sizing storm sewers or beginning of an off-street open channel system. See Section 6.44.

(3) For parking lots, whether or not used as detention, the maximum depth allowed is 1.5' for a driving lane and 1.0' for a parking space.

(4) Where TOD or Urban Centers have on-street parking, the maximum depth is six-inches at the flowline of the parking curb or the curb extension. Flows exceeding these depths may be considered on a case-by-case basis provided measures are in place to adequately protect structures and other improvements. Wave action caused by vehicular traffic must be taken into account.

3.33 Emergency Overflow

All overflow paths shall be designed to convey the emergency overflow of upstream property with no damage to downstream property (structures). The upstream property must be analyzed based on the future, fully developed land use. The emergency overflow shall consist of the 100-year future, fully developed, undetained runoff, unless detention facilities are regional facilities owned and maintained by the City or UDFCD. In this case the detained, 100-year release rate shall be used.

3.40 IRRIGATION DITCHES

Irrigation ditches shall not be used to transmit storm runoff. Use of any irrigation ditch shall be only with the written approval of the ditch owner.

Designs using irrigation ditches will not be approved if an alternative exists.

3.50 EASEMENTS AND TRACTS

Easements are required for all public storm sewers. The minimum width shall be 16 feet and an additional 10 feet is required for each utility sharing the easement.

Open channels, creeks, and streams, including major drainageways and emergency overflow tracts, shall be dedicated to the City as right-of-way when requested by the City and no later than the first plat adjacent to the drainage facility. The right-of-way width will be determined based on the proposed design and maintenance access requirements.

Where there is not a 100-year capacity storm sewer underneath, emergency overflow tracts must be concrete lined as shown in the latest version of the "Roadway Design and Construction Specifications" and the tract dedicated to the City, otherwise, overflow tracts may be designed as grass-lined swales. The tracts are normally required where sump streets are drained between residential lots to a drainageway, or when there are back draining cul-de-sacs.

All emergency overflow tracts shall be designed for a 100-year storm, assuming the minor storm sewer inlets are plugged.

3.60 DETENTION PONDING

3.61 General

On-site detention is required for all new development, expansion, and redevelopment. Required minimum detention volume and maximum release rates shall be determined based on the criteria in Chapter 6 or as established by approved master plans.
Detention may be provided by means of open space detention or parking lot. Underground detention may be used only as a last resort and must be approved by the City, when all other alternatives are exhausted. Rooftop detention is generally not an acceptable alternative, unless it is incorporated with a "Green Roof" concept. This concept will be allowed on a case-by-case basis through the review and approval process of the drainage reports/letters. Designers are also required to add any required water quality capture volume (WQCV) to the flood detention volume. The WQCV itself shall be increased by 20% to account for sedimentation.

Detention ponds should be designed as landscaped areas with multiple use provisions (recreation, aesthetic, wildlife needs, etc.). Within TOD's and Urban Centers the detention ponds should be designed to be architecturally compatible with the urban environment of the development. The landscape concepts, slope, and wall treatments should be identified on the landscape plan and site plan submitted to the City Planning Department. Planting lists need to take into account periodic to continual water saturation. The detailed design of a detention pond

should provide for safe pedestrian and maintenance ingress and egress, with a slope not steeper than 4:1 or a stepped, pedestrian accessible treatment provided. The design should require minimal maintenance.

3.62 Requirements

1. Detention facilities' volumes shall be designed in accordance with Section 6.30, and emergency overflow and its flow path downstream shall be explicitly addressed in the design. The 100-year peak inflow shall be used as a minimum basis for designing emergency overflow structures.

2. All new developments and redevelopments must dedicate drainage easements for their private detention ponds and Water Quality BMP's, including any "Green Roofs". This easement is required to allow City personnel emergency access to the facilities. A note must be added to the site plans or contextual site plans indicating who will be responsible for the maintenance of these facilities, i.e., the property owner, HOA or metro district. It is the underlying responsibility of the property owner to ensure the private detention and water quality BMP's are maintained and they continue to serve the intended stormwater management function.

3. Maintenance access must be provided to the top of the detention pond outlet structure and to BMP control structures that may be located within the detention pond. It shall be a minimum width of eight-feet with a two-foot recovery zone on each side of the access. Centerline radii less than 50-feet will require the access to be widened to accommodate the turning movement of maintenance vehicles, i.e., tandem axle dump trucks. In no case shall the centerline radii be less than 30-feet. The maximum grade shall be 10 percent. Where tributary areas are less than five acres in size the maximum longitudinal slope may be considered on a case by case basis for approval of up to 4:1 (horizontal:vertical).

3.63 Certification

All stormwater detention and all permanent stormwater quality BMP facilities must be certified after final landscaping is implemented and before a certificate of occupancy can be issued. The developer shall have a Colorado licensed Professional Engineer certify the detention pond and all permanent stormwater quality BMPs are built according to the approved plans and specifications, and the required detention volume, including the WQCV, when used, are met. The statement shall provide surveyed elevations of critical design components, including inverts, of outlet structures geometry, overflow spillways or weirs. The pond depths relative to the original design must also be in conformance so release rates will not be significantly impacted. The as-built freeboard shall also be identified. The certification shall include the City's plan approval number to assist City staff in their review of the certificate. Detention ponds used as sedimentation basins through a phased construction development shall also be required to have the detention facilities recertified prior to each phase of the development's final certificate of occupancy.

The following note shall appear next to each detention pond plan and permanent stormwater quality BMP on the construction drawings:

> "**The developer shall have a licensed Professional Engineer certify each stormwater detention pond and/or water quality BMP is built according to the approved plans and specifications and the required detention volume, including the WQCV when used, is met. The certification shall also verify all pertinent dimensions, elevations, required outlet orifice plates for detention and WQCV and other permanent BMPs requirements are installed per the approved plans and specifications, and shall show the as-built volumes for the 100-year, 10-year storm events, and for the WQCV and other pertinent dimensions, elevations and capacity requirements associated with the WQ BMP used. The certification shall be provided to the City of Aurora Engineering Control Section Senior Engineer before a certificate of occupancy will be issued**."

3.64 Exemptions

Exemptions from the detention requirement may be granted at the option of the City under the following conditions:

1. Storm runoff is discharged directly into an improved major drainageway or regional detention pond which has capacity for developed flows and results in no adverse impacts.

2. Runoff from single-family developments which have five dwelling units per acre or less, discharge to an improved publicly dedicated storm drain facility, and result in no adverse impacts.

3.70 STORMWATER QUALITY CONTROL

The City Council finds and determines there is a public need to control the quality of stormwater drainage flowing through the municipal storm sewer and into the waters of the United States and, further, this is a matter that affects the public health, safety, and welfare of the inhabitants of the City. Therefore, it is necessary for the City to provide a comprehensive system of regulation and enforcement for the control of the quality of stormwater drainage, which includes erosion and sediment control during construction and permanent facilities for water quality enhancement. For additional information see Chapter 8 of this manual and the City of Aurora Rules and Regulations Regarding Stormwater (Quality) Discharge for Construction Activities.

It is the City's policy that:

1. All new developments and redevelopments are required to develop and implement a **Stormwater Quality Control Plan (SWQCP)** in conjunction with the overall drainage plan for the site. Requests for exemption from permanent water quality requirements shall be submitted in writing through the preliminary drainage study, preliminary drainage letter and/or the final drainage study. The request shall describe in detail why

the exemption applies to the proposed development or redevelopment. All decisions made by the Director of Aurora Water (or his designated representative) on exemption requests shall be final.

The SWQCP shall discuss and propose the solutions to permanently enhance the quality of stormwater runoff through the site.

The SWQCP plan shall be developed by applying the permanent water quality "Best Management Practices" (BMPs) described in Volume 3 of the USDCM. The SWQCP shall be shown in a separate section of the drainage report. Proposed permanent stormwater quality enhancement facilities shall be sized and located on the drainage map.

The following are required in the SWQCP as a minimum:

a. Reduce runoff and maximize stormwater infiltration, by minimizing directly connected impervious areas to the extent possible and preserving riparian habitat and broad shallow drainageways. Infiltration-type structural BMPs shall be designed to capture and treat the runoff from at least a 2-year storm event.

b. Provide minimum water quality capture volume (WQCV) as described in Volume 3 of the USDCM. The WQCV shall be increased by 20% to account for sedimentation and shall be in addition to the required flood detention volume when used in conjunction with a flood control detention basin.

The different methods for minimizing directly connected impervious areas and for providing WQCV are described in Volume 3 of the USDCM and are not repeated in this manual. Additional specialized BMPs must be considered for transit oriented developments, urban centers, commercial or industrial sites.

2. All new developments and redevelopments, if not excepted, are required to prepare and institute a **Stormwater Management Plan (SWMP)** associated with construction activities. The **SWMP** must be submitted to the City for approval prior to obtaining a Stormwater Quality Permit. The Stormwater Quality Permit must be obtained before any construction, excavation, or grading is allowed to begin. A Building Permit shall not be issued until a Stormwater Quality Permit is issued. Under an active Stormwater Quality Permit, the Permittee is responsible for and is subject to any liability for drainage, erosion, and sediment control for the permitted site.

   This permit is in addition to other permits required by the City, State, or Federal government.

   Details of requirements, design criteria, and exemptions for the SWMP are found in the City of Aurora Rules and Regulations Regarding Stormwater (Quality) Discharge for Construction Activities (latest edition).

3. Vehicular maintenance access must be provided to the top of the detention and water quality pond outlet structure and to fore bays, if used.

4. The permanent Water Quality BMP's outlet structure, if required for the selected BMP, shall be located within the pond embankment to facilitate vehicular maintenance access. Wing walls may be required to meet the access requirements.

5. An **Inspection and Maintenance Plan** (I & M Plan) shall also be prepared in accordance with City Code Section 138-442.5(c). It shall be submitted with the civil construction plans for review and approval. As part of this plan there is a requirement for regular inspection and maintenance of the BMPs designed and constructed from the SWQCP. The I & M Plan requirements may be found in the appendices found at the end of this drainage manual. The I & M Plan requirements include a condition for a "qualified inspector" to perform all inspections of permanent stormwater BMP facilities. A qualified inspector of permanent stormwater BMP facilities is generally defined as:

   An inspector is qualified to perform inspections of permanent stormwater BMPs if they have basic knowledge of the City of Aurora *Storm Drainage Design & Technical Criteria*, the City Code relating to stormwater, and can demonstrate a basic understanding of the design and function of stormwater management and BMP facilities. In addition, the person performing these inspections must satisfy one of the following:

   - Hold one of the following: Licensed PE in the State of Colorado, CPESC, CFM, Licensed Landscape Architect, or;
   - Have two or more years of full time experience as a stormwater inspector or erosion control supervisor, or;
   - Have four or more years of experience in landscape maintenance that includes the maintenance of permanent stormwater BMP facilities.

6. Permanent water quality detention BMP's shall not be in series unless the water quality treatment provided at the most downstream facility is demonstrated to provide at least the minimal treatment required by the criteria. Or, site specific calculations are presented demonstrating the total BMP performance meets or exceeds the standard criteria.

7. Permanent offline water quality detention BMP's shall be hydraulically disconnected from open channels.

8. Public streets within projects shall be included in the project's water quality facilities.

9. In addition to the requirements in Sections 1 through 8 above, all developments and redevelopments within the Cherry Creek Basin shall also comply with the latest edition of the "Cherry Creek Reservoir Watershed Stormwater Quality Regulation" as promulgated by the Cherry Creek Basin Water Quality Authority as well as the requirements of the Cherry Creek Reservoir Control Regulation (5CCR 1002-72). The Cherry Creek Basin Water Quality Authority shall also review all development and redevelopment proposals in the basin for water quality impacts and mitigation. Construction adjacent to any stream within the Cherry Creek Basin shall protect all native

soils and vegetation within the stream corridor, from the top of the bank to the top of the bank as well as the area to be dedicated for stream and trail corridor use.

Figure 5 shows the boundary of the Cherry Creek Basin Watershed.

10. When using details from the Urban Drainage and Flood Control District's drainage manuals, these details do not typically identify the required dimensions, steel reinforcing, etc. The sizing and dimension information must be provided on the construction plans if these details are used.

CHAPTER 4.00 FLOODPLAIN REGULATIONS

4.10 GENERAL

Floodplain regulations are detailed in Article III, Chapter 70 of the City Code. Portions of the code provisions are included in this section. These requirements are intended to "promote and protect the public health, welfare, and safety in order that citizens and property owners can remain under the national flood insurance program."

The major concerns in floodplain regulations are as follows:

1. Prevention of excessive erosion, flood heights, or flow velocities.
2. Protection of any use within or adjacent to a floodplain from damage.
3. Control or alteration of natural floodplains and channels.
4. Prevention of barriers which would divert flood waters and increase flood hazards in other areas.

4.20 FLOODPLAIN MAPPING

The "Flood Insurance Rate Map" (FIRM) approved by the Federal Emergency Management Agency shall be used to delineate floodplains. The maps are available for review in the Engineering Division. When the FIRM is not available, the "Flood Hazard Area Delineation" as provided in basin master plans by UD&FCD may be used.

Floodplain limits shall be determined by scaling distances from the established Flood Insurance Study's flood profile (when available or applicable) and by plotting the flood elevation based on existing topography. Where a conflict exists between this information and actual field conditions, the Director of Aurora Water (or his designated representative) will make the necessary determination.

4.21 Floodways

Within the 100-year floodplain is the main flow area called the floodway. The floodway is also delineated on the Flood Insurance Rate Maps. The floodway is an area of special flood hazard where the following provision apply (City Code 70-139C):

"(1) Encroachments, including fill, new construction, substantial improvements, and other development, are prohibited unless certification by a registered professional engineer specializing in the field of hydraulics and hydrology or architect is provided, demonstrating that encroachments shall not result in any increase in flood levels during the occurrence of the base flood discharge.

(2) If Subsection (d)(1) of this section is satisfied, all new construction and substantial improvements shall comply with all applicable flood hazard reduction provisions of Section 70.141.

(3) The storage or processing of materials that are buoyant, flammable, explosive, or could be injurious to human, animal, or plant life in the time of flooding are prohibited."

4.22 Map Revisions

Whenever a development alters or improves a major drainageway, the developer is responsible for making revisions to the floodplain maps at his expense. All plans, details, calculations, and other requirements must be submitted through the City to FEMA according to their criteria. The City shall notify the Colorado Water Conservation Board and the UD&FCD as required.

The City will issue building permits based on approval of drainage design plans as well as compliance with all other City requirements. A Conditional Letter of Map Revision (CLOMR) must be issued by FEMA prior to the City issuing a building permit. "As built" surveys, which verify that construction matches the plans, must be submitted for construction in or near the floodplain prior to issuance of a certificate of occupancy. All necessary documentation must also have been approved by the City and submitted to FEMA to process the Letter of Map Revision (LOMR).

When construction in the drainageway is completed, the developer shall, at his expense, prepare and submit through the City to FEMA all required documents to obtain FEMA's approval and issuance of a LOMR.

4.30 FREEBOARD AND SETBACKS

4.31 Residential Construction

New construction and substantial improvement of any residential structure shall have the lowest floor, including basement and crawl space, elevated a minimum of 2 feet above the 100-year flood elevation.

The lowest point on any lot shall be a minimum of 1 foot above the 100-year flood elevation.

4.32 Non-residential Construction

New construction and substantial improvement of any commercial, industrial, or other nonresidential structure shall either have the lowest floor, including basement, garden level or crawl space, elevated 1 foot above the 100-year flood elevation or, together with attendant utility and sanitary facilities, meet the requirements in Sub-section 70-141(b)(2) of the City Code.

4.33 Setbacks

Setback requirements will be determined based on the potential erosion and stream bank failure hazards. A minimum of 15 feet for any structure is required, with greater setbacks required as conditions warrant.

4.34 Elevation Certificates

Elevation certificates shall be provided prior to certificate of occupancy for those structures adjacent to drainage ways with 100-year base flood elevations identified, or, as may additionally be identified on an approved grading plan or area grading plan.

4.40 CHANNELIZATION AND ENCROACHMENTS

Proposals to channelize and encroach on major drainageways will be reviewed on a case-by-case basis. Where drainageways have been designated to remain in their natural state, encroachments or alterations will not be allowed. The primary consideration will be consistency with the drainageway treatment upstream and downstream.

When channel improvements are allowed or required, the improvements must be in complete conformance with the Urban Drainage and Flood Control District Design and Maintenance Eligibility Standards.

4.50 VARIANCES

Any variances from standard requirements must be approved in writing by the Director of Aurora Water. This procedure is normally satisfied by approval of the Final Drainage Report with the variance explained in the text of the report.

The information in this section is a brief summary of the City Code provisions. Special exception procedures and other detailed information should be reviewed in Chapter 70 of the City Code

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CHAPTER 5.00 HYDROLOGIC CRITERIA

5.10 INTRODUCTION

Basic information for calculating peak flows and runoff volumes is presented in this chapter. The Rational Method shall be used for small basins and the Colorado Urban Hydrograph Procedure for large basins. Consideration will be given to other methodologies on a case-by-case basis. Particular attention should be given to accurate computation of time-of-concentration.

5.20 RATIONAL METHOD

The Rational Method is applied for small drainage areas when peak runoff is needed for the sizing of storm sewer systems. See USDCM Volume I, Runoff Section, Table RO-1. The method is based on the following formula:

$$Q = CIA \qquad (5.1)$$

where Q = Peak discharge (cfs)
C = Runoff coefficient from Table 1
I = Rainfall intensity (inches/hour)
A = Drainage area (acres)

Form SF-1 presents the standard form to be used for computing the time of concentration.

5.21 Time of Concentration (Tc)

For urban areas, the time of concentration consists of an inlet time or overland flow time (t_i) plus the time of travel (t_t) in a storm sewer, paved gutter, roadside drainage ditch, drainage channel, or other drainage facilities. For non-urban areas, the time of concentration consists of an overland flow time (t_i) plus the time of travel (t_t) in a combined form, such as a small swale, channel, or drainageway. The latter portion (t_t) of the time of concentration is estimated from the hydraulic properties of the storm sewer, gutter, swale, ditch, or drainageway. Inlet time, on the other hand, will vary with surface slope, depression storage, surface coefficient, antecedent rainfall, and infiltration capacity of the soil, as well as distance of surface flow.

The time of concentration (t_c) shall be calculated using the following equation for both urban and non-urban areas:

$$t_c = t_i + t_t \qquad (5.2)$$

where t_c = time of concentration (minutes)
t_i = initial, inlet, or overland flow time (minutes)
t_t = travel time in the ditch, channel, gutter, storm sewer, etc. (minutes)

A. Non-Urbanized Basins

The initial or overland flow time (t_i) is calculated using the following equation:

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{\sqrt[3]{S}} \qquad (5.3)$$

where t_i = initial or overland flow time (minutes)
C_5 = runoff coefficient for 5-year frequency
L = length of overland flow, (ft., 500 ft. max.)
S = average basin slope (ft/ft)

The equation shall be used for distances not more than 500 feet. For longer basin lengths, the runoff will be considered in a combined form and the travel time (t_t) shall be calculated using the hydraulic properties of the swale, ditch, or channel, or estimated using Figure 1. The time of concentration is then the sum of the initial flow time (t_i) and the travel time (t_t) in accordance with equation 5.2. **The minimum t_c shall be ten minutes under non-urbanized conditions**.

B. Urbanized Basins

The time of concentration (t_c) to the first design point after urbanization shall be the lesser value calculated using the equation in A. above (substituting appropriate values for the urbanized conditions, with a maximum length of overland flow of 300 feet) or the following:

$$t_c = \frac{L'}{180} + 10 \qquad (5.4)$$

Where t_c = time of concentration (minutes)

L' = length of flow to first design point from the most remote point (feet)

Normally the above equation will govern the time of concentration in urbanized basins.

The travel time (t_t) portion of the time of concentration shall be computed using the hydraulic properties of the ditch, channel, curb and gutter, storm sewer, or calculated using Figure 1. **The minimum t_c under urbanized conditions shall be five minutes**.

5.22 Rainfall Intensity

The intensity, I, is the average rainfall rate in inches per hour for a duration equal to the time-of-concentration. An approximation for the rainfall intensity can be determined using the following equation:

$$I = \frac{28.5\ P_1}{(10 + T_C)^{0.786}} \qquad (5.5)$$

Where:

I = rainfall intensity (inches per hour)

P_1 = one-hour rainfall depth (inches) from Figures RA-1 through RA-6 in USDCM, Volume 1

T_c = time of concentration (minutes).

5.23 Runoff Coefficient (C)

The runoff coefficient (C) represents the integrated effects of infiltration, evaporation, retention, flow routing, and interception, all which affect the time distribution and peak rate of runoff. Table 1 presents the recommended values of C for the various recurrence frequency storms. The values are presented for different surface characteristics as well as for different aggregate land uses. The coefficients for the various surface areas should normally be used to develop a composite value for parcels with site plans.

5.30 COLORADO URBAN HYDROGRAPH PROCEDURE

The Colorado Urban Hydrograph Procedure (CUHP) was originally developed for the Denver area at the time the Urban Storm Drainage Criteria Manual was prepared. See USDCM, Volume 1, "Runoff", Table RO-1 – Applicability of Hydrologic Methods for watershed sizes from zero to greater than 3,000 acres. The procedures for the CUHP, as explained in the USDCM, Volume 1 "Runoff," shall be followed in the preparation of drainage reports and storm drainage facility designs in the City of Aurora. A maximum unit time of five minutes shall be used for basins having watershed areas of one square mile or less. For larger areas, the unit time shall be less than or equal to 1/3 of the time to peak of the unit hydrograph, with a maximum value of 15 minutes.

The recommended infiltration rates and storage values in the USDCM shall be used unless soils reports justify otherwise.

When working on a larger or a non-homogeneous watershed, especially when preparing a master drainage plan, it is necessary to divide the watershed into smaller and somewhat homogeneous sub-basins. The storm hydrograph for each sub-basin can be calculated using the CUHP. Then, the individual sub-basin hydrographs shall be routed and combined to give a storm hydrograph for the entire watershed.

Calculations may be performed with available computer programs. Refer to Chapter 7.

5.40 STORM FLOW ANALYSIS

When analyzing flood peaks and volumes, the proposed land use runoff coefficients shall be used. Coefficients for undeveloped off-site land areas shall be estimated based on existing or most probable zoning. All off-site land shall be assumed to be fully developed. Small on-site

drainage detention facilities will normally be disregarded in the analysis of downstream flows and for consideration of emergency overflows through an area.

Where drainage reports exist for adjacent sites, the reports shall be reviewed and coordinated with the proposed development.

CHAPTER 6.00 HYDRAULIC CRITERIA

6.10 GENERAL

The USDCM shall be used for detailed design information and as a design aid of open channels, erosion control, and hydraulic structures. Information contained in this chapter is not intended to provide everything necessary for a complete design.

6.20 OPEN CHANNELS

Where possible natural channels shall be maintained and stabilized for developed runoff conditions. See the USDCDM, Volume 1, Major Drainage for specific criteria.

Open channels shall be designed for the 100-year frequency storm, shall conform to the criteria in the Major Drainage part of the USDCM and shall be consistent with or provide equivalent improvements to the approved Outfall Systems Plan. The design must conform to the Urban Drainage and Flood Control District's maintenance eligibility requirements. The effects of the minor storm shall also be analyzed. Whenever practical, open channels shall have slow flow characteristics, be wide and shallow, provide adequate maintenance access, incorporate features to make it compatible with the surrounding land uses, and be natural in appearance. Open channels should be designed to integrate recreation and aesthetic needs, protect wildlife, support plant populations, and allow for bicycle and pedestrian trails. The designer shall coordinate the channel plans with the Parks, Recreation, and Open Space Department relative to trails and open space uses, Aurora Water Department relative to maintenance requirements and the Planning Department relative to site plan landscape requirements.

Channels should be designed to avoid supercritical flows and flow near critical depth. Concrete-lined and irrigated, turf-lined channels are not acceptable. The general geometry characteristic shall be in accordance with the following:

a. Side Slopes. Side slopes shall be as flat as practical. Side slopes of 4:1 or flatter shall be normally considered for all areas to be revegetated.

b. Depth. The maximum design depth of flow for the major storm should be limited to 3.5 feet, although maximum depths of 5.0 feet may be acceptable where good channel maintenance may be expected and durations of peak flows are short. The maximum depth of flow does not include the low flow channel depth in a composite channel design. The design depth of flow for the minor storm runoff should not be less than 1.0 feet.

   Critical depths shall be investigated for both the major and minor storm runoffs and these values shall be identified in the drainage report.

c. Freeboard. Except where localized overflow in certain areas is desirable for additional ponding benefits or other reasons, the minimum allowable freeboard shall be 2.0 feet.

d. Bottom Width. Normally the bottom width should be at least six to eight times the depth of flow. Technically, the bottom width should be designed to satisfy the hydraulic capacity of the cross-section recognizing the limitations on velocity, depth, and Froude number.

Channel bottom cross-slope for dry bottom channels should be at least 2%.

e. Slope of Channel. Stabilized channels normally will have slopes of 0.2 to 0.6%. Stable slopes for channels shall be determined by using Outfall Systems Plans, where applicable, or, other technical analysis where necessary. Where the natural topography is steeper than desirable, drop structures may have to be utilized. Drop structures shall be used where head cutting is evident.

f. Curvature. Generally, the centerline curvature should not have a radius less than twice the design flow top width, but not less than 100 feet.

g. Trickle Channels and low flow channels. Trickle channels will not be used unless authorized by the City Engineer. On larger major drainageways or in channels located on sandy soils, a low flow channel may be more appropriate. The capacity of a trickle or low flow channel shall be determined according to the USDCM.

h. Design Velocity. The maximum velocity for the major storm design runoff shall not exceed 5.0 feet per second in erosive soils, and shall not be more than 7.0 feet per second for erosion resistant soils. More stringent criteria may apply where soil conditions warrant. The Froude number shall be less than 0.5 in erosive soils and 0.8 in non-erosive soils.

Minimum velocities for all channels shall not be less than 2.0 feet per second for the minor storm runoff.

i. Roughness Coefficient (n). The values for Manning's "n" shall not be less than those specified in Table 2. Design values for the roughness coefficient shall be appropriate for the post development vegetative cover. Capacity analysis using an adjusted n-value shall be required in accordance with the USDCM.

j. Storm Sewer Connections. Provide details of storm sewer outfall connections and outfall details to the channel.

k. Erosion. All channels shall be designed with the proper and adequate erosion control features, including toe protection against meandering low flows. Outlets from storm sewers, culverts, and tributary channels will have adequate riprap, cutoff walls, or other features to protect the outlet and the receiving channel from the inflow point to the trickle or low flow channel.

l. Continuous maintenance access, in the form of a trail, must be provided. The trail must be at least eight-feet wide. It need not be paved but it must be of all-weather construction

and capable of sustaining loads caused by maintenance equipment. Maximum longitudinal slope for maintenance-only trails is 10%. Maximum slope for multi-purpose recreational trails is 5%. Centerline radii less than 50-feet will require the access to be widened to accommodate the turning movement of maintenance vehicles, i.e., tandem axle dump trucks. In no case shall the centerline radii be less than 30-feet Maintenance access shall be provided to the upstream and downstream of all drop structures. Appropriate turnarounds shall be provided as needed for maintenance equipment.

Paved trails are encouraged to allow for recreational use of the trails. Pavement shall be six-inch minimum thickness of concrete and eight to ten-feet wide with two-foot recovery zones on both sides of the paved trail. See the Parks, Recreation, and Open Space standards for additional information on trail types.

m. Water Surface Profiles. A water surface profile, using HEC2, HECRAS, or other appropriate backwater computations, is required. The profile shall be shown on final drawings. Profiles must account for all losses due to transitions, structures, obstructions, etc. The energy grade line may also be required. Submit paper and electronic copies of each profile with each submittal for review and approval. The submittal shall cover all design storms necessary.

n. Compliance With Environmental Regulatory Requirements. Proof of compliance with all applicable regulations, including Section 404 Permits, are considered to be part of the design.

Both natural and artificial channels have been allowed in the City. Either type of channel will be considered based upon existing conditions in an area. However, natural channels are normally preferred. Whenever feasible, the design of wetland bottomed channels is encouraged to slow down runoff and allow time for settling and biological uptake.

Concrete-lined channels are not recommended because of their appearance, high maintenance costs and their non-value in improving water quality. When riprap is used for channel lining, the protected area shall be covered with soil and revegetated above the 10-year developed flows.

o. Main Extension Agreements. Prior to the start of construction of any channel work the contractor is required to execute a main extension agreement through the Aurora Water Department.

6.30 DETENTION/RETENTION

6.31 Design Frequency

All detention facilities for new developments or redevelopments that disturb greater than or equal to five acres shall be designed to include the UDFCD's Full Spectrum Detention volume and the 100-year detention volumes in the following manner. Up to one half of the Full Spectrum Detention may be included within the 100-year detention volume flood pool.

The principles of low impact development (LID) may be used to mimic natural hydrologic conditions (i.e., pre-development) to minimize adverse in-channel impacts associated with increased imperviousness in lieu of Full Spectrum Detention. Detailed analysis will be required to show that the LID principles proposed mimic the natural hydrologic conditions (i.e., pre-development).

Full Spectrum Detention may be omitted from an individual site when a downstream facility provides for regional treatment of stormwater quality. Where Full Spectrum Detention is not included in the detention facility, the detention facility shall be designed for the 10-year and the 100-year storm frequencies, or full conveyance of the developed condition's undetained flow to a downstream regional detention facility shall be required.

6.32 Freeboard

The minimum freeboard for open space detention facilities is one-foot (1.0') above the computed 100-year water surface elevation. The emergency overflow weir sill shall be set at the freeboard elevation.

6.33 Volume and Release Rates

a) When the detention facility discharges into an existing storm sewer, street, or improved drainageway, the minimum detention volume shall be determined using the following equation (see Paragraph c) for additional limitations):

$$V = KA$$

For the 100-year, $K_{100} = (1.78I-0.002I^2-3.56)/900$ (6.1)

For the 10-year, $K_{10} = (0.95I-1.90)/1000$ (6.2)

Where V = required volume for the 100- or 10-year storm (acre-feet)

I = Developed basin imperviousness (%)

A = Tributary area (acres)

The maximum release rates at the ponding depths corresponding to the 10- and 100-year volumes are as follows:

Allowable release rates for detention ponds - CFS/ACRE

	SCS Hydrologic Soil Group		
Storm Frequency	A	B	C&D
10-year	0.13	0.23	0.30
100-year	0.50	0.85	1.00

The predominant soil group for the total basin area tributary to the detention pond shall be used for determining the allowable release rate.

b) When the detention facility discharges into an adjacent undeveloped property or unimproved drainageway, the minimum detention volume shall be the greater value calculated using the equation in a) above or the FAA Method (Rational Method). The allowable release rates for the FAA Method shall be the historic, undeveloped flow rates from the basin tributary area.

c) The procedures for sizing detention volumes as described in a) and b) above, shall be used only for on-site detention facilities and facilities serving tributary catchments less than 90 acres in size. For larger water sheds or when preparing a master drainage plan, the Colorado Urban Hydrograph Procedure (CUHP) shall be used in conjunction with hydrograph and reservoir routing in the sizing of detention ponds.

d) Pond volume shall be calculated using the prismoidal formula:

$$V = \frac{(A1 + A2 + \sqrt{A1xA2}\,)Depth}{3} \qquad (6.3)$$

6.34 Emergency Overflow

Emergency overflow shall be designed using the 100-year peak inflow as a minimum basis.

6.35 Erosion Protection at Pipe Outlets

All storm sewers outfalling into a detention pond shall have adequate erosion protection and energy dissipation at the outlets. The method of protection shall be designed in accordance with the criteria of Volume 2 of the USDCM.

6.36 Signing for Detention Pond Outlet

The detention pond outlet is designed to control the release rates from the pond. It shall be designed in a way to minimize unauthorized modifications which affect proper function. A sign with a minimum area of 0.75 square feet shall be attached to the outlet or posted nearby with the following message:

"WARNING
Unauthorized Modification of
this Outlet is a Zoning Code Violation"

6.37 Retention

The use of retention may only be used with prior approval, on a case by case basis, from the City Engineer. A detailed analysis for determining retention volume requirements will be required once the City Engineer's approval is granted.

No credit shall be taken for infiltration or depression storage in establishing the minimum volume. The retention pond shall be designed as a dry pond. Therefore, a pump system shall be installed to drain the pond down to an acceptable outfall location in a reasonable amount of time following the abatement of storm runoff. A storm sewer force main may be required to discharge the pond volume to an acceptable outfall.
An emergency overflow from the retention area must be provided. The capacity of the overflow shall be at least the 100-year flood. One-foot minimum freeboard above the maximum retention volume water surface shall be provided. The emergency overflow sill elevation shall occur at the freeboard elevation.

6.38 State Engineer's Office

Any dam constructed for the purpose of storing water, with a surface area, volume, or dam height as specified in Colorado Revised Statutes 37-87-105 as amended, shall require the approval of the plans by the State Engineer's office. Those facilities subject to State Statutes shall be designed and constructed in accordance with the criteria of the state. Proof of the State Engineer's approval must be provided to the City.

6.39 Other Requirements

In addition to the above criteria, the design of all open space detention and regional detention ponds shall meet the following criteria:

- Side slopes shall be 4:1 or flatter.

- Pond bottom shall include a trickle channel having a capacity of at least 3% of the inflow discharge. The longitudinal slope for trickle channels shall be at least 0.4% for concrete bottoms, and at least 1% for other bottoms. Trickle channels may not be required for water quality ponds.

- The pond bottom cross slope shall be at least 2%.

- Maintenance access ramps to the pond bottom shall be provided and must be at least eight-feet wide and 10% longitudinal slope or flatter. Where tributary areas are less than five acres in size the maximum longitudinal slope may be considered on a case by case basis for approval of up to a 4:1 (horizontal:vertical). The ramp need not be paved but must be of all weather construction and capable of sustaining loads caused by maintenance equipment during saturated soil conditions. If the ramp is paved, it shall be at least six-inches thick of concrete (no asphalt) and be elevated to the 5-year flood elevation in the pond. A ramp must also be extended to the top of the outlet structure. The ramps shall be a minimum width of eight-feet with a two-foot recovery zone on each side of the access. Radii less than 50-feet will require the access to be widened to accommodate the turning movement of maintenance vehicles, i.e., tandem axle dump trucks. In no case shall the radii be less than 30-feet.

- Trash racks for flood detention pond outlets (not water quality outlets) must have a net opening area of at least four times the area of the outlet orifice, but in no event less than three square feet. Trash rack bar spacing shall not exceed six-inches and shall be no larger than half the diameter or the smallest dimension of the outlet orifice. Refer to Volume 2 of the USDCM for trash rack sizing.

- Tributary inflow points to the ponds shall be adequately protected to prevent erosion. Inflow facilities to wetland bottom ponds shall have their inverts at least two-feet above the pond bottom to allow for deposition of sediment.

- Designs shall consider safety of the public.

6.40 STORM SEWERS

The design of storm sewers shall be in accordance with USDCM chapter on "Storm Sewers." Storm sewers shall be normally designed to convey the minor storm flood peaks without surcharging the sewer. The minimum flow velocity in storm sewers shall be 2 fps to allow for self-cleansing.

Form SF-2 presents the standard form for the sizing of storm sewers using the Rational Method procedure.

6.41 Materials

Pipe material shall be in conformance with the Public Utility Improvements, Rules & Regulations Regarding Standards & Specifications, latest edition. Resistivity tests are required before metal pipe will be considered. The structural strength of the pipe shall withstand H-20 design load.

6.42 Minimum Sizes

Storm sewer laterals and mains shall not be less than 18-inch diameter. Laterals which are privately maintained may be smaller, but will be reviewed on a case-by-case basis.

6.43 Manhole Spacing and Size

Diameter or Vertical Rise	Maximum Manhole Spacing (Ft.)
18" - 36"	400
42" - 60"	500
66" and larger	750

Diameter	Barrel Size (Ft.)
27" or less	5
30" - 48"	6

See detail 102 (5 of 5) of the "Public Utility Improvements Rules and Regulations Regarding Standards and Specifications" for additional allowance on manhole size. Manholes with pipes larger than 48 inches shall require special vault design.

6.44 Hydraulic Design

The 2-year capacity storm sewers shall be designed with no surcharging. Any 2-year capacity storm sewers shall be considered plugged during a 100-year storm. 100-year capacity storm sewers shall be designed with maximum surcharging to be a minimum of one-foot below proposed grade. When designing a major storm sewer system that does not convey the entire 100-year flow, the split flow must be routed appropriately. In general, when 100-year flows exceed 250 cfs or the drainage tributary area exceeds 160 acres open channel flow shall be provided.

Drainage reports shall include hydraulic grade line calculations including losses from friction, transitions, bends, junctions, and other losses. The storm sewer plan and profiles shall show the 2-year hydraulic grade line for 2-year systems and the 100-year hydraulic grade line for 100-year systems.

6.45 Alignment

Manholes are required wherever there is a change in size, direction, elevation, grade, or at lateral storm sewer junctions. Manholes may be waived for a short lateral, which has a diameter of less than half of the storm sewer trunkline diameter. Storm sewer lines shall be placed within the pavement of public streets. Prior City approval is needed for placing storm sewer within the public streets' tree lawns or medians. When there is a size change the crowns of the two pipes shall match vertically.

The minimum vertical separation to a water or sanitary sewer line is two feet. Lesser clearance requires a concrete encasement or approved support for the affected utility.

Horizontal alignment between manholes shall be straight.

6.50 STORM INLETS

6.51 Types of Inlets

There are basically three types of inlets: curb opening, grated, and combination inlets. Inlets are further classified as being on a "continuous grade" (on grade) or in a sump. The term "continuous grade" refers to an inlet so located that the grade of the street has a continuous slope past the inlet and, therefore, ponding does not occur at the inlet. The sump condition exists whenever water ponds because the inlet is located at a low point. A sump condition can occur at a change in grade of the street from negative to positive, or at an intersection due to the crown slope of a cross street.

In the City of Aurora, the only accepted storm inlet in the public right-of-way or for public ownership is the Type R modified curb-opening inlet. Grated and combination inlets may be used in private areas, or only with the written approval of the City Engineer. Grated inlets located in areas where bicycle or pedestrian traffic is expected shall have bicycle/pedestrian-safe grates.

6.52 Inlet Design

The length of opening required for curb-opening inlets shall be based on UDFCD's UD-INLET spreadsheets or the inlet capacity charts and design procedures included at the end of this manual (Figures 2 and 3).

The minimum length for a single curb-opening inlet is 5 feet and the maximum length is 15 feet. If the required length exceeds 15 feet, multiple inlets shall be used, or a structural design (with calculations submitted for approval) of the inlet, stamped and signed by a Professional Engineer, is required. These calculations and details shall be included with the first review of the civil submittal for the project. The maximum length of an inlet shall be 30-feet.

Inlets greater than ten feet in depth require structural design and details be submitted for review and approval. The calculations and details shall be included with the first review of the civil submittal for the project.

Design procedures for private grated and private combination inlets can be found in the USDCM chapter on "Street/Inlets/Storm Sewers."

To compensate for effects which decrease the capacity of the inlets such as debris plugging, pavement overlaying, and variations in design assumptions, the theoretical capacity calculated for the inlets designed using Figures 2 and 3 (UD-INLET has its own clogging factors) shall be reduced by the following reduction factors to determine the allowable capacity of the inlet:

Inlet Type	Percentage of Theoretical Capacity Allowed
Curb Opening	80%
Grated	50%
Combination	65%

The size of outlet pipes from storm water inlets shall be based upon the design flow rate at the inlet, but shall not be less than 18 inches in diameter.

All inlets in sump condition must provide an emergency overflow. All emergency overflows shall be designed for a 100-year storm, assuming the storm sewer pipes are plugged.

Inlets shall be sized with the appropriate design storm for the system. If an inlet is designed for the 2-year design storm, then, it must be considered plugged during the 100-year storm.

Computations for storm sewer design and storm inlet design shall be submitted on forms similar to those included in this manual for approval. Adequate details of inlets, manholes, and other appurtenances shall be included in the overall drainage plan submitted for approval.

6.53 Inlet Location

Inlets shall be normally located in a low point, or at a point on a continuous grade where the minor or major storm runoff exceeds the allowed six-inch or 12-inch curb and gutter's flowline depth, respectively.

In order to eliminate the use of cross-pans as much as possible, inlets shall be required at the upstream of streets intersection and drive entrances when there is an existing or proposed public storm sewer available.

Also, to minimize icing problems in the winter, additional inlets may be required on the south side of the street to capture any snowmelt before it has a chance to freeze up. Inlets will also be added on superelevated arterial streets where the cross-slope approaches zero percent during the superelevation transitions and where median breaks occur for intersections within superelevated streets.

Other requirements on storm inlets can be found in Section 4.03 of the City of Aurora "Roadway Design and Construction Specifications."

6.60 CULVERTS

6.61 General

A culvert is considered to be any structure which connects two open channels. The culvert shall be designed to convey the 100-year frequency flow. The headwater depth will be limited by upstream conditions, but in no case shall exceed 1.5 times the culvert diameter, or 1.5 times the culvert rise dimension for shapes other than round. Excessive ponding above culvert entrances will not be acceptable if damage appears likely to surrounding property or to the roadway.

Culverts shall be designed with an emergency overflow path above. The emergency overflow path shall not encroach onto any residential lots. The emergency overflow capacity shall be 100% of the whole culvert capacity for the major storm for culverts with cross-sectional area less than 20 square feet, and for culverts with cross-sectional area greater than or equal to 20 square feet, the overflow capacity shall be 100% of the capacity provided by the first 20 square feet plus 20 percent of the capacity provided for the additional area as established by the formula:

$$\% \text{ overflow} = (100\%)\ \frac{20+(A-20).20}{A} \qquad (6.5)$$

where "A" is the area of the culvert opening in square feet.

6.62 Culvert Hydraulics

The culvert including inlet and outlet structures shall convey water, sediment, and debris at all stages of flow.

Culvert capacity shall be analyzed using Bureau of Public Roads, Hydraulic Engineering Circular 5. Inlet and outlet control conditions shall be analyzed. Calculations shall be submitted on forms included in this manual (Standard Form SF-5).

When evaluating the capacity of a culvert, the following data shall be used:

Roughness coefficient:	Table 3
Entrance loss coefficients:	Table 4

Nomographs and capacity curves:

All culverts:	Bureau of Public Roads, Hydraulic Engineering circulars 5 and 10, or USDCM "Culverts" chapter
Concrete pipe:	Concrete Pipe Design Manual, ACPA, Vienna, Virginia

6.63 Design Standards

a. End Treatment

Flared end sections or headwalls with wing walls are required. Inlets shall be designed to minimize head losses. Approved erosion control shall be provided at all culvert outlets. For high flow culverts the outlet protection shall include some form of a stilling basin. The downstream sill elevation for the basin will be two-feet below the invert of the culvert outlet, unless otherwise approved.

b. Slopes

Culvert slopes shall prevent silting, yet avoid excessive velocities. Generally, the minimum culvert slope is 0.50%. Minimum barrel velocity is 3 fps and maximum is 12 fps.

c. Minimum Size

Culverts shall not be smaller than 24-inch diameter. When box culverts reach a width of eight-feet, the minimum height shall be six-feet.

d. Materials

Culverts shall be concrete unless otherwise approved by the City Engineer.

All culverts shall be designed to withstand H-20 loading in accordance with AASHTO "Standard Specifications for Highway Bridges" and with the pipe manufacturer's recommendation.

6.70 HYDRAULIC STRUCTURES

The design of hydraulic structures, including riprap protection, drop structures, check structures, energy dissipaters, bridges, etc., shall be in accordance with the USDCM chapters on "Major Drainage" and "Hydraulic Structures."

For all riprap protection, Type M riprap shall be used as a minimum. When soil riprap is used Type L shall be used and be mixed with 30% soil to 70% riprap.

Check structures shall have a minimum of eight-feet of riprap placed at the downstream face of the structure as part of the check structure. Concrete check structures shall be formed, reinforced concrete structures designed to not overturn when the channel bed has reached its stabilized slope. Check structures shall also be embedded sufficiently deep to resist under mining due to piping of soils. Geotechnical and structural calculations shall be submitted for review during the civil plans review.

CHAPTER 7.00 COMPUTER PROGRAMS

There are many computer programs on the market for the analysis and design of storm water facilities. However, to assist in the review of design computations and to promote uniformity of results, the designer should use the following computer software which have been developed under the support of several Denver Metropolitan Cities and Counties and the Urban Drainage and Flood Control District:

CUHP-2005, latest edition: Colorado Urban Hydrograph Procedure computer model, developed for urban runoff prediction. Submit paper and electronic copies with each submittal.

EPA SWMM 5.0, latest edition: Modified EPA runoff block of the SWMM package, used with CUHP-2005 as a watershed modeling and flow routing for urban areas. EPA SWMM 5.0 is the only routing program acceptable to the City, except where older versions of UDSWMM will continue to be used in certain drainage basins. Submit paper and electronic copies with each submittal.

UD-RATIONAL, latest edition: When dealing with a drainage network, RATIONAL can accumulate flow times and peak runoff rates with detailed tabulations of computations.

NEO-UDSEWER, latest edition: Storm Sewer Design and Flow Analysis

UD-INLET, latest edition: Street Hydraulics and Inlet Sizing

UD-CHANNELS, latest edition: Design of Open Channels – This spread sheet is good for preliminary design of open channels. More detailed analysis will be required for final approval of channel design.

UD-CULVERT, latest edition: Design of Culverts

Other computer software widely used in the design of stormwater facilities may be approved by the City on a case-by-case basis.

To compute water surface profiles in open channels and drainageways, the designer shall use the computer programs HEC-2 or HEC-RAS developed by the Army Corps of Engineers. Submit paper and electronic copies with each submittal.

Computer spreadsheets may be used if they conform to the City of Aurora standard forms.

CHAPTER 8.00 REGULATIONS ON STORMWATER QUALITY CONTROL

8.10 INTRODUCTION

The City of Aurora has a permitting program for grading, erosion and sediment control, and stormwater discharge on public and private construction projects within City of Aurora jurisdiction. The goals of this permitting program is to implement effective erosion and sediment control Best Management Practices (BMPs) as a standard for all land disturbance activities to reduce increases in erosion and sedimentation over predevelopment conditions. When undeveloped land is converted to urban uses, a significant amount of sediment can erode from a construction site and be transported to adjacent properties and receiving waters. Erosion caused by construction and downstream sedimentation can cause property damage and degrade the quality of streams and lakes. Sediment is a transport mechanism for many stormwater pollutants. Sediment can disturb riparian and aquatic habitat and, since eroded sediments often contain significant phosphorus, can lead to unwanted algae growth in lakes and reservoirs.

The City of Aurora is committed to protecting water resources and ensuring future development continues in an environmentally sound manner.

8.20 POLICY AND REQUIREMENTS

8.21 Control of Stormwater Discharges from Construction Sites and Other Land Disturbances Refer to the City of Aurora Rules and Regulations Regarding Stormwater (Quality) Discharge for Construction Activities, latest edition, for specific requirements on erosion and sediment control associated with construction activities.

8.22 Cherry Creek Watershed Projects located within the Cherry Creek Watershed shall also comply with the Cherry Creek Basin Water Quality Authority's "Cherry Creek Reservoir Watershed Stormwater Quality Requirements, latest edition, as well as the requirements of the Cherry Creek Reservoir Control Regulation No. 72.

TABLES, FIGURES, STANDARD FORMS, and APPENDICES

TABLE 1
RUNOFF COEFFICIENTS AND PERCENTS IMPERVIOUS

LAND USE OR SURFACE CHARACTERISTICS	PERCENT IMPERVIOUS	FREQUENCY			
		2	5	10	100
Business:					
Commercial Areas	95	.87	.87	.88	.89
Neighborhood Areas	85	.60	.65	.70	.80
Residential:					
Single-Family (**)	(*)	.40	.45	.50	.60
Multi-Unit (detached)	60	.45	.50	.60	.70
Multi-Unit (attached)	75	.60	.65	.70	.80
1/2 Acre Lot or Larger	(*)	.30	.35	.40	.60
Apartments	80	.65	.70	.70	.80
Industrial:					
Light Areas	80	.71	.72	.76	.82
Heavy Areas	90	.80	.80	.85	.90
Parks, Cemeteries	5	.10	.10	.35	.60
Playgrounds	10	.15	.25	.35	.65
Schools	50	.45	.50	.60	.70
Railroad Yard Areas	15	.40	.45	.50	.60
Undeveloped Areas:					
Historic Flow Analysis, Greenbelts, Agricultural	2	(See "Lawns")			
Off-Site Flow Analysis (when land use not defined)	45	.43	.47	.55	.65

TABLE 1 (continued)

RUNOFF COEFFICIENTS AND PERCENTS IMPERVIOUS

LAND USE OR SURFACE CHARACTERISTICS	PERCENT IMPERVIOUS	FREQUENCY			
		2	5	10	100
Streets:					
Paved	100	.87	.88	.90	.93
Gravel	40	.15	.25	.35	.65
Concrete Drive and Walks	96	.87	.87	.88	.89
Roofs	90	.80	.85	.90	.90
Lawns, Sandy Soil (A and B Soils):	2				
2% Slope		.05	.06	.08	.10
2-7% Slope		.10	.11	.13	.15
>7% Slope		.15	.16	.18	.20
Lawns, Clay Soil (C and D Soils):	5				
2% Slope		.13	.14	.15	.17
2-7% Slope		.18	.19	.20	.22
>7% Slope		.25	.27	.30	.35

NOTE: These Rational Formula coefficients may not be valid for large basins

(*)See Figures *RO-3 through RO-5* of USDCM Volume 1 for percent impervious.

(**)Up to 5 units per acre. Single-family with more than 5 units per acre, use values for multi-unit/detached

.

TABLE 2

Roughness Coefficients ("*n*") for Channel Design

(after Chow 1959)

Channel Type	Roughness Coefficient (*n*)		
	Minimum	Typical	Maximum
I. Excavated or Dredged			
1. Earth, straight and uniform			
a. Gravel, uniform section, clean	0.022	0.025	0.030
b. With short grass, few weeds	0.022	0.027	0.033
2. Earth, winding and sluggish			
a. Grass, some weeds	0.025	0.030	0.033
b. Dense weeds or aquatic plants	0.030	0.035	0.040
c. Earthy bottom and rubble/riprap sides	0.028	0.030	0.035
3. Channels not maintained, weeds and brush uncut			
a. Dense weeds, high as flow depth	0.050	0.080	0.120
b. Clean bottom, brush on sides	0.040	0.050	0.080
II. Natural streams (top width at flood stage 100 ft)			
1. Streams on plain			
a. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. Clean, winding, some pools and shoals, some weeds and stones	0.035	0.045	0.050
c. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150
III. Lined or Built-Up Channels			
1. Concrete			
a. Towel/float finish	0.011	0.015	0.016
b. Shotcrete	0.016	0.020	0.025
2. Gravel bottom with sides of:			
a. Formed concrete	0.017	0.020	0.025
b. Random stone in mortar	0.020	0.023	0.026
c. Dry rubble or riprap	0.023	0.033	0.036
3. Wetland Bottom Channels	See Figure 6		
4. Grass-Lined Channels and Swales	See Figure 7		

(Source: USDCM, Volume 1, Major Drainage, 04/2008)

TABLE 2 (continued)

Large Conduits:	
Concrete:	Manning's n
Precast concrete pipe, ordinary joint alignment	0.013
Poured in place, steel forms, projections 1/8" or less	0.013
Poured in place, smooth wood forms, projections 1/8" or less	0.013
Poured in place, ordinary work with steel forms	0.014
Poured in place, ordinary work with wood forms	0.015
Steel:	
Structural plate corrugated, 2"x6" corrugations, 5' to 20' diameter	$\frac{0.0377}{D^{0.078}}$
Corrugated pipe, 1"x3" corrugations, 3' to 8' diameter	$\frac{0.0306}{D^{0.075}}$
Plastic/HDPE:	
Pipe with smooth interior wall	0.012

TABLE 3
MANNING'S n - VALUES FOR CULVERTS

CONCRETE PIPE: n = 0.013

CORRUGATED STEEL PIPE: (1)

	Annular 2 2/3 x ½ in.	1 ½ x ¼ in.		Helical 2 2/3 x ½ in.					
Corrugations	All Diameters	8 in.	10 in.	12 in.	18 in.	24 in.	36 in.	48 in.	60 in. and Larger
Unpaved	0.024	0.012	0.014	0.011	0.013	0.015	0.018	0.020	0.021
25% Paved	0.021					0.014	0.017	0.020	0.019

	Annular 3 x 1 in.	Helical – 3 x 1 in.					
		48 in.	54 in.	60 in.	66 in.	72 in.	78 in./Larger
Unpaved	0.027	0.023	0.023	0.024	0.025	0.026	0.027
25% Paved	0.023	0.020	0.020	0.021	0.022	0.022	0.023

	Annular 5 x 1 in.	Helical – 5 x 1 in.			
		54 in.	60 in.	66 in.	78 in./Larger
Unpaved	0.025	0.022	0.023	0.024	0.025
25% Paved	0.022	0.019	0.020	0.021	0.022

All pipe with smooth interior or fully paved	All Diameters n = 0.012

STRUCTURAL PLATE METAL PIPE: (1)

Corrugations 6 x 2 in.	Diameters			
	5 ft.	7 ft.	10 ft.	15 ft.
Plain-unpaved	0.033	0.032	0.030	0.028
25% Paved	0.028	0.027	0.026	0.024

(1) Source: Modern Sewer Design, American Iron and Steel Institute, Third Edition 1995

TABLE 4
CULVERT ENTRANCE LOSSES
(Source: USDCM, Volume 2)

Type of Entrance	Entrance Coefficient, Ke
Pipe	
Headwall	
Grooved edge	0.20
Rounded edge (0.15D radius)	0.15
Rounded edge (0.25D radius)	0.10
Square edge (cut concrete and CMP)	0.40
Headwall and 45° Wingwall	
Grooved edge	0.20
Square edge	0.35
Headwall with Parallel Wingwall Spaced 1.25D Apart	
Grooved edge	0.30
Square edge	0.40
Beveled edge	0.25
Projecting Entrance	
Grooved edge (RCP)	0.25
Square edge (RCP)	0.50
Sharp edge, thin wall (CMP)	0.90
Sloping Entrance	
Mitered to conform to slope	0.70
Flared-end Section	0.50
Box, Reinforced Concrete	
Headwall Parallel to Embankment (no wingwalls)	
Square edge on 3 edges	0.50
Rounded on 3 edges to radius of 1/12 barrel dimension	0.20
Wingwalls at 30° to 75° to barrel	
Square edged at crown	0.40
Crown edge rounded to radius of 1/12 barrel dimension	0.20

TABLE 4 (continued)
CULVERT ENTRANCE LOSSES
(Source: USDCM, Volume 2)

Type of Entrance	**Entrance Coefficient, Ke**
Box, Reinforced Concrete (continued)	
Wingwalls at 10° to 30° to barrel Square edged at crown	0.50
Wingwalls parallel (extension of sides) Square edged at crown	0.70

NOTE: The entrance loss coefficients are used to evaluate the culvert or sewer capacity operating under outlet control.

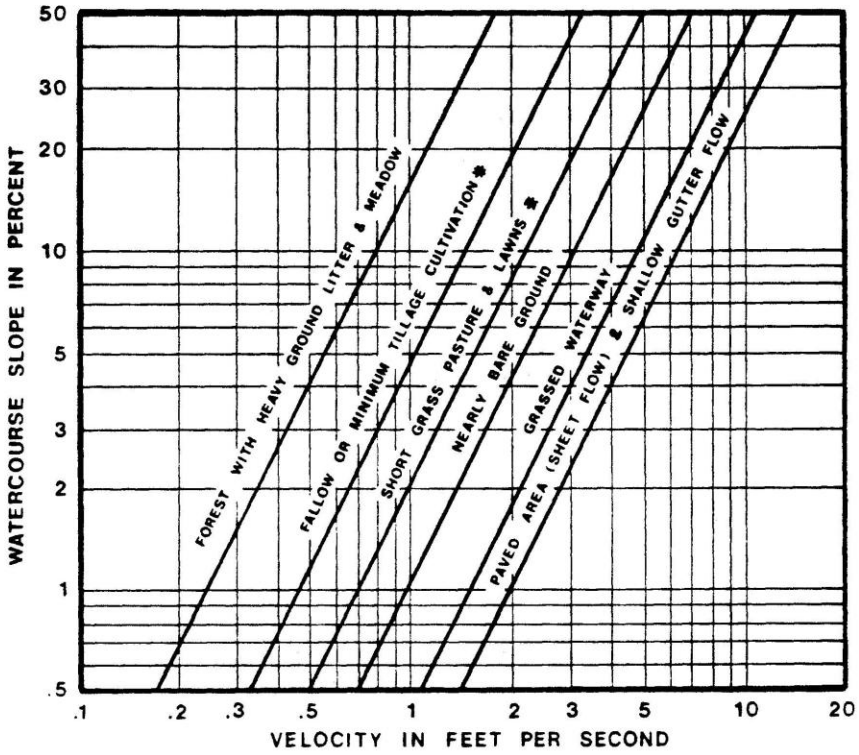
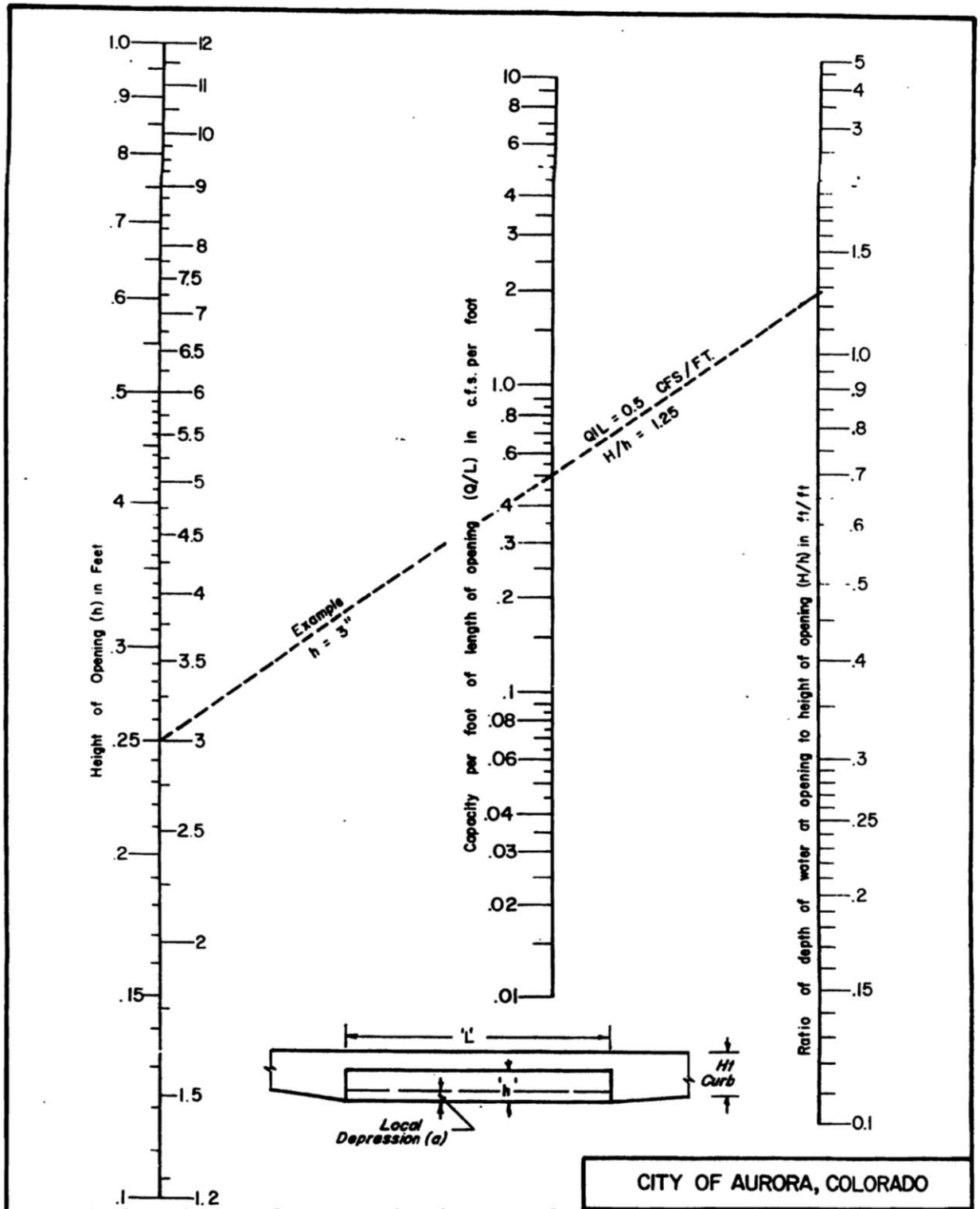


Figure RO-1—Estimate of Average Overland Flow Velocity for Use With the Rational Formula

FIGURE 1



Note: Apply reduction factor to the theoretical capacity determined from nomograph to arrive at the allowable inlet capacity (refer to Section 6.52).

CITY OF AURORA, COLORADO

NOMOGRAPH FOR CAPACITY OF CURB OPENING INLETS AT SUMP

f.w.	6-M-72

FIGURE 2

Rev. 1/00

9.2010

CAPACITY OF CURB OPENING INLETS IN A LOW POINT OR SUMP

The capacity of a curb opening inlet in a sump or low point varies directly with the length of the inlet and the depth of water at the entrance. The inlet will operate as a weir until the water submerges the entrance. When the depth of water is about twice the height of the entrance or more, it will operate as an orifice. Between these two depths it will operate somewhere between the two.

The nomograph (FIG. 2) is based on the following conditions:

(1) The curb opening inlet (no grate) is located at a low point in the grade.

(2) All flow coming to the inlet must eventually enter the inlet and will pond until sufficient head is built up so the outflow through the inlet will equal the peak inflow from the gutters.

The hydraulic basis of the nomograph is as follows:

(1) For heads (depths of water) up to the height of the opening.

($H/h \leq 1$), the inlet is assumed to act as a weir with the flow passing through critical depth at the entrance and following the formula

$$Q = 3.087\ LH^{3/2}$$

(2) For heads equal to or greater than twice the height of opening $H/h \geq 2$, the inlet is assumed to act as an orifice following the formula

$$Q/L = 5.62\ h^{3/2}\ (H'/h)^{1/2}$$

This is a rearrangement of the standard orifice formula $Q = CA\sqrt{2gH'}$ with $C = 0.7$ and H' equal to the head on the middle of the inlet opening ($H' = H - \frac{h}{2}$).

(3) For heads with H/h between 1 and 2, a transition was used as the operation of the inlet is indefinite.

Procedure:

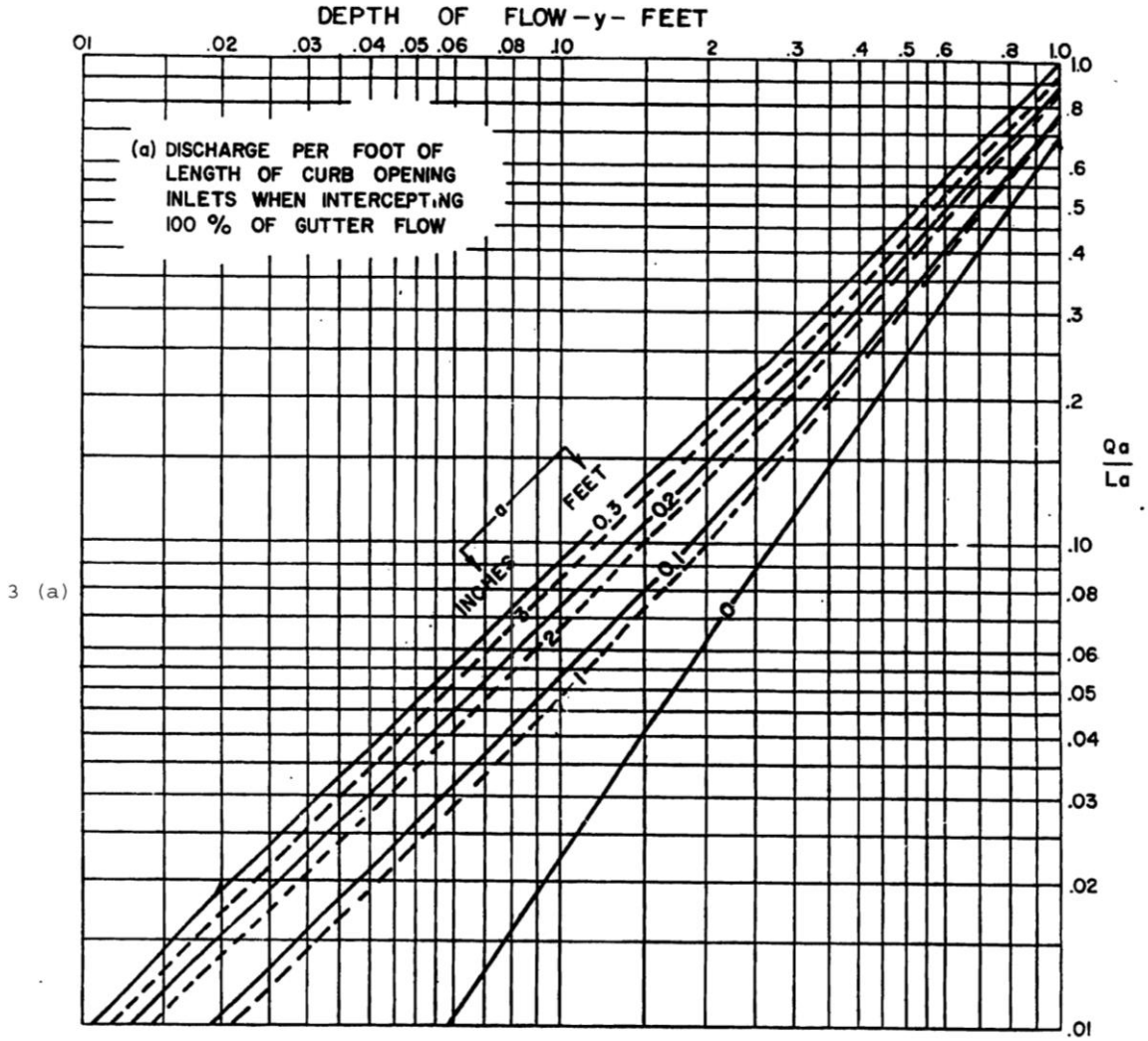
Enter the nomograph with any two of the three values H, Q/L. H/h, and read the third.

Where h = total height of opening in feet
L = total length of opening in feet
H = depth of water at the entrance in feet
Q = total peak rate of flow to the inlet in CFS

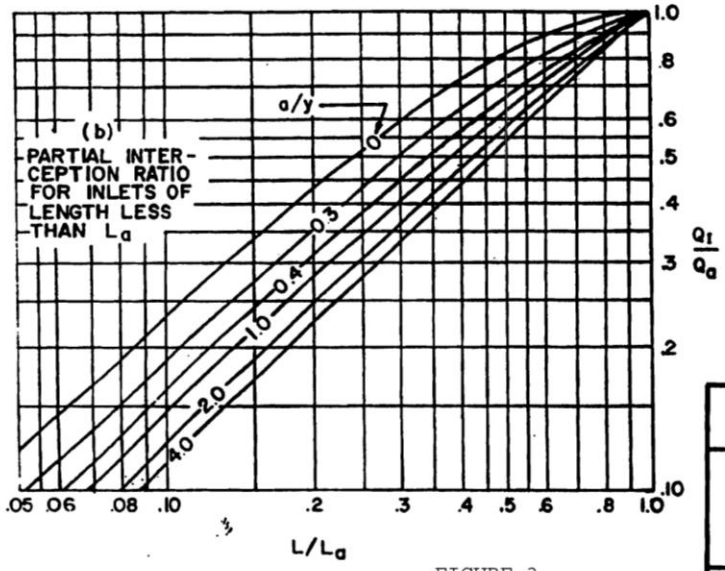
Normally Q, H, and h will be known, and the nomograph can be used to determine the length of opening L. The spread of the water on the street will depend upon the cross slope of the pavement.

FIGURE 2 (CONTINUED)

3 (a)



3 (b)



Note: Reduction factor for allowable inlet capacity is not included in the nomographs (refer to Section 6.52).

CITY OF AURORA, COLORADO
CAPACITY OF CURB OPENING INLETS ON CONTINUOUS GRADE

FIGURE 3

CAPACITY OF CURB OPENING
INLETS ON A CONTINUOUS GRADE

The capacity of a curb opening inlet on a continuous grade varies directly with:

a. Depth of water at the inlet entrance

b. Length of clear opening

The depth of water at the inlet entrance for a given discharge varies directly with:

a. Cross slope of the pavement at the curb

b. Amount of warping or depression of the gutter flow line at the inlet

c. Roughness of the flow line

Inversely with:

a. Longitudinal slope of the gutter

The capacity of a curb opening inlet when intercepting 100 per cent of the flow in the gutter is given by the formula:

$$Q = 0.7\ L\ (a + y)^{3/2}$$

Where
y = depth of flow in approach gutter
a = depth of depression of F.L. at inlet
L = length of clear opening

The capacity of a curb opening inlet is increased by allowing part of flow to pass the opening. Ten to fifteen per cent of the flow is usually passed.

To size an opening the following information must be known:

1. Height of the curb opening.

2. Depth (a) of flow line depression, if any, at the inlet.

3. Design discharge (Q) in the gutter or information as to drainage area, rainfall intensity, and runoff coefficients from which a design can be estimated. Any carryover from a previous inlet must be included.

4. Depth of flow in normal gutter for the particular longitudinal and cross slopes at the inlet in question. This may be determined from the street capacity charts.

FIGURE 3 (CONTINUED)

PROCEDURE

1. Enter FIG. 3 (a) with depth of flow, y, and gutter depression at the inlet, a, and determine Qa/La the interception per foot of inlet opening if the inlet were intercepting 100% of the gutter flow.

2. Determine length of inlet La required to intercept 100% of the gutter flow. La = total gutter flow Qa divided by the factor Qa/La.

3. Compute ratio L/La where L = actual length of inlet in question.

4. Enter FIG. 3 (b) with L/La and a/y and determine ratio Q/Qa, the proportion of the total gutter flow intercepted by the inlet in question.

5. Flow intercepted, Q, is this ratio Q/Qa times the total gutter flow Qa.

6. Flow carried over to next inlet is Qa - Q.

FIGURE 3 (CONTINUED)

Figure 4 A

ALLOWABLE 2-YR FLOW, HALF STREET CAPACITY

Mountable curb with attached walk: water may spread to back of walk
Mountable curb with detached walk: water may spread to street crown, no overtopping
Vertical curb & gutter: maximum 6" water depth at flowline, no curb overtopping
Reduction Factor applied per Figure ST-2 of USDCM, Volume 1

Flow Q in cfs

Slope	Local	Local	Local	Local	Collector	Collector	Collector	Arterial 4 Ln	Arterial 4-Ln	Arterial 6 Lane
%	I	II	II Alt	III	2-Lane	2-Lane Alt	4-Lane	Raised Med	Paint Med	Raised Median
0.5	6.5	4.9	5.5	8.1	8.1	6.6	8.1	8.1	8.1	8.1
1.0	9.2	6.9	7.8	11.5	11.5	9.3	11.5	11.5	11.5	11.5
1.5	11.3	8.4	9.5	14.0	14.0	11.4	14.0	14.0	14.0	14.0
2.0	13.0	9.7	11.0	16.2	16.2	13.1	16.2	16.2	16.2	16.2
2.5	12.6	9.5	10.7	15.8	15.8	12.8	15.8	15.8	15.8	15.8
3.0	11.9	8.9	10.1	14.9	14.9	12.1	14.9	14.9	14.9	14.9
3.5	11.5	8.6	9.7	14.4	14.4	11.6	14.4	14.4	14.4	14.4
4.0	10.8	8.1	9.2	13.5	13.5	11.0	13.5	13.5	13.5	13.5
4.5	10.5	7.9	8.9	13.1	13.1	10.6	13.1	13.1	13.1	13.1
5.0	10.1	7.5	8.5	12.5	12.5	10.2	12.5	12.5	12.5	12.5
5.5	9.9	7.4	8.4	12.4	12.4	10.0	12.4	12.4	12.4	12.4
6.0	9.7	7.2	8.2	12.1	12.1	9.8	12.1	12.1	12.1	12.1
6.5	9.6	7.2	8.1	12.0	12.0	9.7	12.0	n/a	n/a	n/a
7.0	9.2	6.9	7.8	11.5	11.5	9.3	11.5	n/a	n/a	n/a
7.5	9.3	7.0	7.9	11.6	11.6	9.4	11.6	n/a	n/a	n/a
8.0	9.1	6.8	7.7	11.3	11.3	9.2	11.3	n/a	n/a	n/a

Figure 4 B

ALLOWABLE 100-YR FLOW, FULL WIDTH STREET CAPACITY

12" deep at flowline
Theoretical flows computed by Manning formula
Reduction Factor applied per Figure ST-2 of USDCM, Volume 1

Flow Q in cfs

Slope	Local	Local	Local	Local	Collector	Collector	Collector	Arterial 4 Ln	Arterial 4-Ln	Arterial 6 Lane
%	I	II	II Alt	III	2-Lane	2-Lane Alt	4-Lane	Raised Med	Paint Med	Raised Median
0.5	150	141	148	133	143	121	155	156	157	157
1.0	212	199	209	188	202	171	219	221	222	222
1.5	260	244	256	231	247	209	268	270	272	272
2.0	252	237	248	224	240	203	260	262	264	264
2.5	235	221	231	208	224	189	242	244	246	246
3.0	221	207	217	196	210	178	227	229	231	231
3.5	211	198	207	187	200	170	217	219	220	221
4.0	204	191	201	181	194	164	210	212	213	214
4.5	198	186	195	176	189	160	204	206	207	208
5.0	190	178	187	168	181	153	196	197	198	199
5.5	184	173	181	163	175	148	190	191	193	193
6.0	177	166	174	157	168	142	182	184	185	185
6.5	179	168	176	158	170	144	184	n/a	n/a	n/a
7.0	174	163	171	154	166	140	179	n/a	n/a	n/a
7.5	169	158	166	149	160	136	174	n/a	n/a	n/a
8.0	162	152	160	144	154	131	167	n/a	n/a	n/a

Figures 4A & 4B (Continued)

The following assumptions are used:

- 2% slope from top of curb to ROW and 10% slope up beyond ROW
- Manning's n = 0.016 for asphalt, 0.013 for concrete, 0.035 for landscaped areas
- Flows are computed with Haestad's Flowmaster program using the Cox Method for weighting Manning's n roughness coefficients
- Flows are computed for regular standard street cross-sections with leveled flowlines. Submit separate calculations for special street cross-sections, e.g. tipped, superelevated, etc.

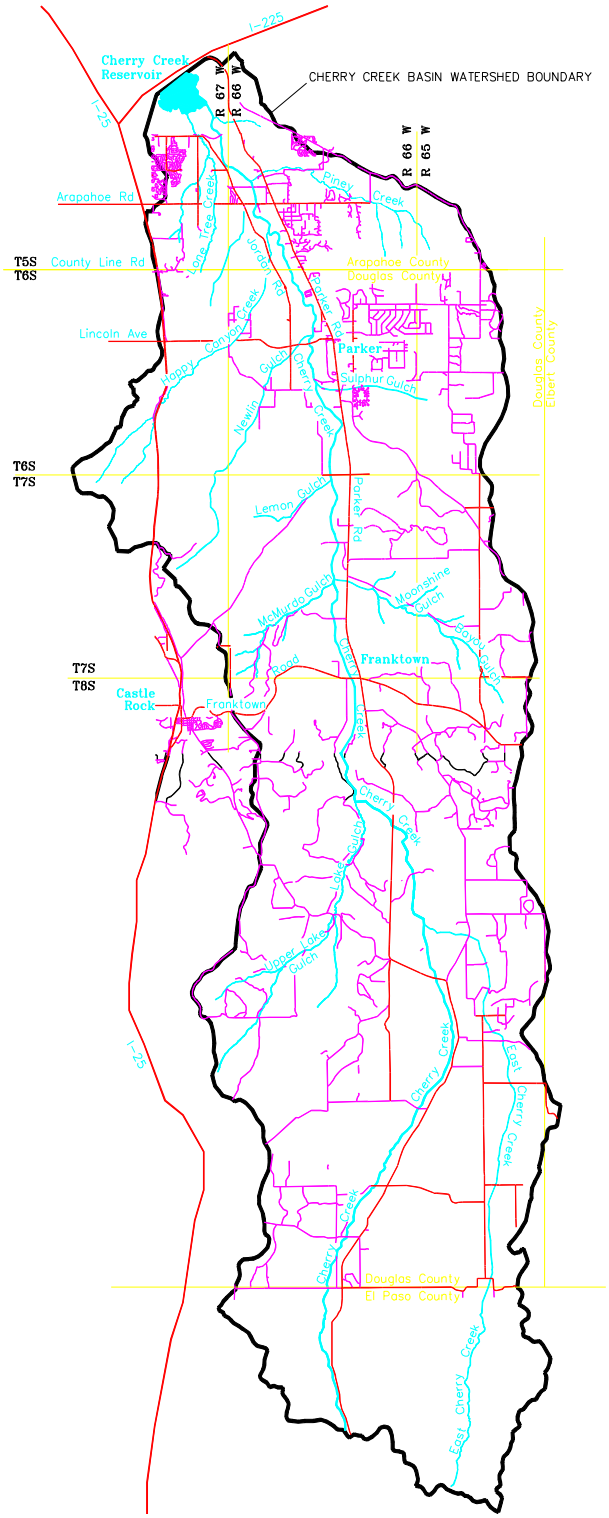


Figure 5. Cherry Creek Reservoir Watershed

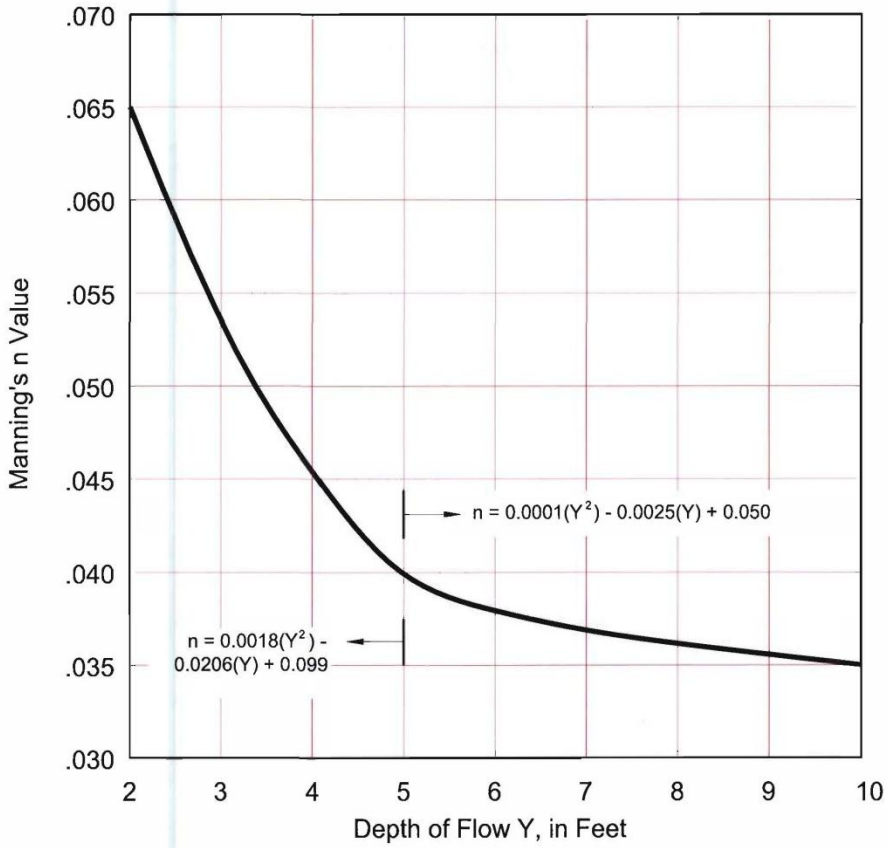
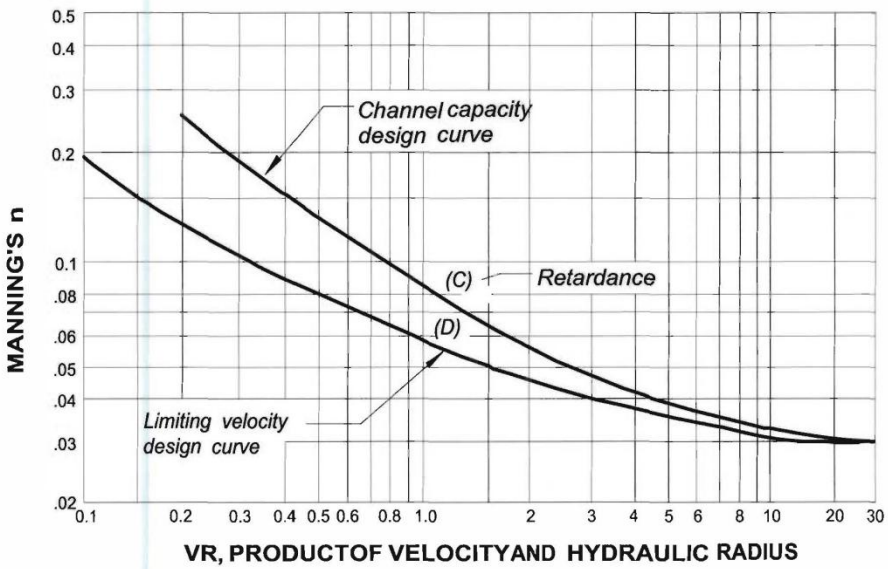


Figure MD-9a—Manning's *n* vs. Depth for Low-Flow Section in a Composite Channel.

(Source: USDCM, Volume 1, Major Drainage, 04/2008)

FIGURE 6



From "Handbook of Channel Design For Soil and Water Conservation,: U.S. Department of Agriculture, Soils Conservation Service, No. SCS-TP-61 March, 1947, Rev. June, 1954

Figure MD-9b—Manning's *n* vs. *VR* for Two Retardances in Grass-Lined Channels.

(Source: USDCM, Volume, Major Drainage, 04/2008)

FIGURE 7

STANDARD FORM SF-1

TIME OF CONCENTRATION

SUBDIVISION _____

CALCULATED BY _____ DATE _____ $t_c = t_i + t_t$

SUB-BASIN DATA			INITIAL/OVERLAND TIME (t_i)			TRAVEL TIME (t_t)				t_c CHECK (URBANIZED BASINS)			FINAL t_c	REMARKS
DESIG: (1)	AREA Ac (2)	C_5 (3)	LENGTH Ft (4)	SLOPE % (5)	t_i Min (6)	LENGTH Ft (7)	SLOPE % (8)	VEL. FPS (9)	t_t Min (10)	COMP. t_c (11)	TOTAL LENGTH Ft (12)	$t_c = (L/180)+10$ Min (13)	Min (14)	

CALCULATED BY _____

DATE _____

CHECKED BY _____

STANDARD FORM SF- 2

STORM DRAINAGE SYSTEM DESIGN (RATIONAL METHOD PROCEDURE)

JOB NO _____

PROJECT _____

DESIGN STORM _____

STREET		DESIGN POINT	DIRECT RUNOFF							TOTAL RUNOFF				STREET		PIPE			TRAVEL TIME			REMARKS
			AREA DESIGN	AREA (AC)	RUNOFF COEFF	t_c (MIN)	C·A (AC)	I IN/HR	Q (CFS)	t_c (MIN)	Σ(C·A) (AC)	I (IN/HR)	Q (CFS)	SLOPE · (%)	STREET FLOW(CFS)	DESIGN FLOW(CFS)	SLOPE (%)	PIPE SIZE	LENGTH (FT)	VELOCITY (FPS)	t_t (MIN)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
1																						
2																						
3																						
4																						
5																						
6																						
7																						
8																						
9																						
10																						
11																						

STANDARD FORM SF-3

CURB OPENING IN A SUMP

Given: (a) Discharge Q = CFS

(b) Curb Type 6" V.C. or Type 4" Combination

(c) Street Section =

Solution:

H (depth @ opening) = inches

h (height of opening) = inches

H/h = =

From Chart:

Q/foot of opening =

L required = =_____feet

STANDARD FORM SF-4

CURB OPENING (INTERCEPTION)

Given: (a) discharge Q = _____ CFS

(b) street slope S = _____ '/,

(c) curb type 6" VC or Type 4" Combination

(d) street section =

Solution:

Qa/La =

La = = (length for total interception)

L/La = =

a/y = .25/ =

Q/Qa =

Q = = CFS (Intercepted)

Qc = = CFS (carryover to next inlet)

SUBDIVISION_____
LOCATION_____
COMPUTATIONS BY_____ DATE_____
SUBMITTED BY_____ DATE_____
(Engineering Firm)

CITY OF AURORA, COLORADO
STORM DRAINAGE SPECIFICATIONS

STANDARD FORM SF-5

STANDARD CULVERT DESIGN FORM

PAGE_____ OF_____

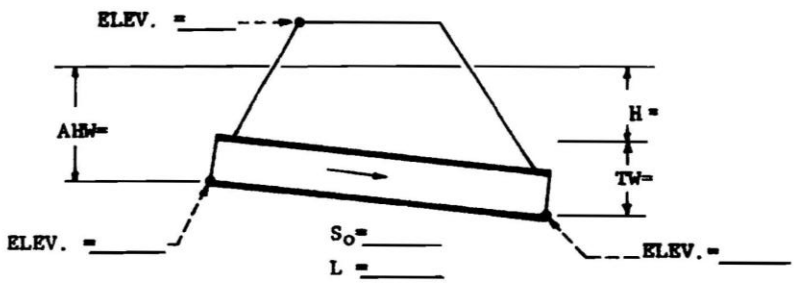
HYDROLOGIC AND CHANNEL INFORMATION

STATION:_____

STORM FREQ. DATA: INITIAL DESIGN STORM = _____YR
MAJOR DESIGN STORM = _____YR

Q_1 = _____ cfs(Initial Storm), ; TW_1= _____ (Estimated)

Q_2 = _____ cfs (Major Storm) ; TW_2= _____



FOR OUTLET CONTROL

(1) H.W. = $H + h_o - L S_o$

(2) For TW<D ; $h_o = \frac{d_c+D}{2}$ or T.W. (whichever is greater)

TW≥D ; h_o = T.W.

(3) For Box Culvert: $d_c = 0.315(Q/B)^{2/3} \leq D$ Use Q/B = q

CULVERT DESCRIPTION (Entrance Type)	Q or q	SIZE	HEADWATER COMPUTATION										CONTROL-LING HW	OUTLET VELOCITY	COST	COMMENTS
			INLET CONT.		OUTLET CONTROL HW=H + h_o - LS_o											
			HW/D	HW	K_e	H	d_c	$\frac{d_c+D}{2}$	TW	h_o	LS_o	HW				

9.2010

A P P E N D I C E S

Instructions & Inspection and Maintenance Plan Template Appendix

Appendix A

Stormwater Maintenance Agreement Template

Appendix B

General Location and Description of Stormwater Management Facilities Example

Appendix C

Standard Operation Procedures for:

- **Extended Detention Basins (EDBs)**
- **Grass Buffers and Grass Swales (GB-GS)**
- **Bioretention (BRCs) aka Porous Landscape Detention (PLDs)**
- **Sand Filter Basins (SFBs)**

Appendix D

Inspection Forms

Appendix E

Maintenance Forms

Appendix F

Annual Inspection and Maintenance Reporting Form

Appendix G

Inspection and Maintenance Site Plan(s) Check Lists

Instructions and Maintenance Plan Template Appendix

Instructions for Preparing a Stormwater Facility Inspection & Maintenance Plan (I & M Plan)

Stormwater Management Facility Inspection and Maintenance (I&M) Plan Template

Instructions for Preparing a Stormwater Facility
Inspection & Maintenance Plan (I & P Plan)

Inspection and Maintenance (I & M) Plans are required to be provided for all permanent water quality best management practices (BMPs) installed on a site. See City Code Section 138-442.5(c). The purpose of the I & M plan is to provide information to the person or entity responsible for inspection and maintenance of the facility to ensure the facility is adequately maintained to function as designed. The information provided in the I & M will help the maintenance personnel understand the facility; will provide guidance for inspection and maintenance operations specific to the type of facility; and will provide mechanisms for ensuring the long-term maintenance of the facility is performed.

Preparing the I & M Plan

1. Access the City of Aurora's website at www.auroragov.org
2. Download the Stormwater Management Facility I & M Plan template and insert the project specific information on the Title Sheet.
3. Download the Stormwater Maintenance Agreement template. Insert the project specific information, execute, and submit the document to the city of Aurora Water staff for recordation. Do this for as many agreements needed. Obtain copies of the fully executed and recorded Stormwater Maintenance Agreement(s) for the project and include in Appendix A
4. Download Appendix B and insert the project specific information.
5. Download the Standard Operating Procedure (SOP) for the specific type(s) of permanent BMPs contained on the project (this document is generic and requires no additional information unless the BMP differs significantly from the standard).
6. Download the Inspection and Maintenance forms for each permanent BMP facility type.
7. Download the Annual Inspection and Maintenance Reporting Form.
8. Prepare a Stormwater Facilities Map in conformance with the Stormwater Facilities example drawing and checklist.
9. Prepare Stormwater Facility Plans and Detail Drawings for each storm water facility, in accordance with the Example Drawings and Checklists for Stormwater Facility Plans and Details.

Assemble the I & M Plan in the following order:

Title Sheet
Stormwater Management Facility Inspection and Maintenance Plan
Appendix A – Maintenance Agreement(s)
Appendix B – Description of Stormwater Facilities
Appendix C – BMP Facility SOPs (for each type of facility)
Appendix D – Inspection Form for each facility
Appendix E – Maintenance Form for each type of facility
Appendix F – Annual Inspection and Maintenance Reporting Form
Appendix G – Stormwater Facilities map; Facility Plan and Detail Drawings

One copy of the I & M Plan shall be provided to the City of Aurora as part of the Civil Construction Plans for review and approval. However, an executed copy of the Maintenance Agreement is not required until the first Certificate of Occupancy (C.O.), unless no C.O. is required. Then, it is required prior to Civil Construction Plans approval.

Stormwater Management Facility Inspection and Maintenance (I&M) Plan Template

for:

Insert Development Name

Located at:

Insert Address

Prepared for:

Insert Property Owner Name, Address and Phone no.

Prepared by:

Insert Name; Address and Phone No.

Insert Date Prepared

Approved For One Year From This Date

_____

_____ _____

City Engineer **Date**

_____ _____

Water Department **Date**

Reference:

This plan is adapted from Southeast Metro Stormwater Authority, *OPERATION AND MAINTENANCE (O & M) MANUAL*, and Town of Parker, Colorado, *STORMWATER PERMANENT BEST MANAGEMENT PRACTICES (PBMP) LONG-TERM OPERATION AND MAINTENANCE MANUAL*, October 2004

Stormwater Management Facility
Inspection and Maintenance (I&M) Plan

Table of Contents

I. Compliance with Stormwater Facility Maintenance Requirements

II. Inspection & Maintenance- Annual Reporting

III. Preventative Measures to Reduce Maintenance Costs

IV. Access and Easements

V. Safety

VI. Field Inspection Equipment

VII. Inspecting Stormwater Management Facilities
A. Inspection Procedures
B. Inspection Report
C. Verification of Inspection and Form Submittal

VIII. Maintaining Stormwater Management Facilities
A. Maintenance Categories
B. Maintenance Personnel
C. Maintenance Forms

Appendices

Appendix A - Maintenance Agreement(s)
Appendix B - Description of Stormwater Management Facilities
Appendix C - Standard Operation Procedures (SOP) for Extended Detention Basins; Grass Buffers and Grass Swales; Bioretention Cells aka Porous Landscape Detention; and Sand Filter Basin BMPs
Appendix D - Inspection Form(s)
Appendix E - Maintenance Form(s)
Appendix F - Annual Inspection and Maintenance Submittal form
Appendix G - Stormwater Facilities Map; Facility plan and detail sheets

Stormwater Management Facility
Inspection and Maintenance (I&M) Plan

I. Compliance with Stormwater Facility Maintenance Requirements

All property owners are responsible for ensuring stormwater facilities installed on their property are properly maintained and function as designed. <<Insert Property Owner's Name>> may elect to assign many of the management and maintenance functions described in this plan to a third party. <<Insert Property Owner's Name>> is aware of their responsibilities regarding stormwater facility maintenance. Maintenance agreement(s) associated with this property are provided in Appendix A.

II. Inspection & Maintenance – Annual Reporting

Requirements for the inspection and maintenance of stormwater facilities, as well as reporting requirements are included in this Stormwater Management Facility Inspection and Maintenance (I&M) Plan.

Verification that the Stormwater facilities have been properly inspected and maintained; submittal of the required Inspection and Maintenance Forms and Inspector qualifications shall be provided to the City of Aurora on an annual basis. The annual reporting form shall be provided to the City of Aurora prior to May 31st of each year.

Copies of the Inspection and Maintenance forms for each of the stormwater facilities are located in Appendix D and E. A standard annual reporting form is provided in Appendix F. Each form shall be reviewed and submitted by the property owner or property manager to:

City of Aurora
Operations Compliance Division
Aurora Water – Stormwater/Wastewater Operations
13646 East Ellsworth Avenue
Aurora, Colorado 80012

III. Preventative Measures to Reduce Maintenance Costs

The most effective way to maintain your water quality facility is to prevent the pollutants from entering the facility in the first place. Common pollutants include sediment, trash & debris, chemicals, dog wastes, runoff from stored materials, illicit discharges into the storm drainage system and many others. <<Insert Property Owner's Name>>'s maintenance program includes measures to address these potential contaminants. Depending on the storm water quality facilities installed on the site the maintenance program includes:

- Educate property owners/residents to be aware of how their actions affect water quality, and how they can help reduce maintenance costs.
- Keep properties, streets and gutters, and parking lots free of trash, debris, and lawn clippings.

- Ensure the proper disposal of hazardous wastes and chemicals.
- Plan lawn care to minimize the use of chemicals and pesticides.
- Sweep paved surfaces regularly and dispose the sweepings properly.
- Be aware of automobiles leaking fluids. Use absorbents such as cat litter to soak up drippings – dispose of properly.
- Re-vegetate disturbed and bare areas to maintain vegetative stabilization.
- Clean out the upstream components of the storm drainage system, including inlets, storm sewers and outfalls.
- Do not store materials outdoors (including landscaping materials) unless properly protected from runoff.

IV. Access and Easements

<<Insert Property Owner's Name>> shall prepare a drawing showing all stormwater management facilities located on the site including designated access locations as well as a required easements. Refer to the Stormwater Facilities Map located in Appendix G for access and easement locations.

V. Safety

Keep safety considerations at the forefront of inspection procedures at all times. Likely hazards should be anticipated and avoided. <<Insert Property Owner's Name>> personnel should never enter a confined space (outlet structure, manhole, etc) without proper training or equipment. A confined space should never be entered without at least one additional person present and without using appropriate personal protection equipment.

If a toxic or flammable substance is discovered, leave the immediate area and call 911.

Vertical drops and fall hazards may be encountered in areas located within and around the facility. <<Insert Property Owner's Name>> shall avoid walking on top of retaining walls or other structures that have a significant vertical drop. If a vertical drop is identified that is greater than 48" in height, make the appropriate note/comment on the maintenance inspection form.

If any hazard is found within the facility area that poses an immediate threat to public safety, call 911.

VI. Field Inspection Equipment

<<Insert Property Owner's Name>>'s inspectors shall have the appropriate equipment to take to the field. This is to ensure the safety of the inspector and allow the inspections to be performed as efficiently as possible. Below is a list of the equipment that may be necessary to perform the inspections of all Stormwater Management Facilities:

- Protective clothing and boots.
- Safety equipment (vest, hard hat, confined space entry equipment).

- Communication equipment.
- Inspection and Maintenance Plan for the site including stormwater management facility location maps.
- Clipboard.
- Stormwater Facility Maintenance Inspection Forms (See Appendix D).
- Manhole Lid Remover
- Shovel.

Some of the items identified above need not be carried by the inspector (manhole lid remover, shovel, and confined space entry equipment). However, this equipment should be available in the vehicle driven to the site.

VII. Inspecting Stormwater Management Facilities

The quality of stormwater entering the waters of the state relies heavily on the proper operation and maintenance of permanent best management practices. Stormwater management facilities shall be periodically inspected to ensure they function as designed. The inspection will determine the appropriate maintenance required for the facility.

A. Inspection Procedures

All stormwater management facilities shall be inspected by a qualified individual at a minimum of once per year. See the City of Aurora *Storm Drainage Design & Technical Criteria* Manual for general guidelines for an inspector. Inspections will follow the inspection guidance found in the SOP for the specific type of facility. (Appendix C of this plan).

B. Inspection Report

<<Insert Property Owner's Name>>'s personnel or inspector conducting the inspection activities shall complete the appropriate inspection report for the specific facility. Inspection reports are located in Appendix D.

The following information explains how to fill out the Inspection Forms:

General Information

This section identifies the facility location, person conducting the inspection, the date and time the facility was inspected, and approximate days since the last rainfall. Property classification is identified as single-family residential, multi-family residential, commercial, or other.

The reason for the inspection is also identified on the form depending on the nature of the inspection. All facilities shall be inspected on an annual basis at a minimum. In addition, all facilities shall be inspected after a significant precipitation event to ensure the facility is draining

appropriately and to identify any damage that occurred as a result of the increased runoff.

Inspection Scoring

For each inspection item, a score must be given to identify the urgency of required maintenance. The scoring is as follows:

0 = No deficiencies identified.

1 = Monitor – Although maintenance may not be required at this time, a potential problem exists that will most likely need to be addressed in the future. This can include items like minor erosion, concrete cracks/spalling, or minor sediment accumulation. This item should be revisited at the next inspection.

2 = Routine Maintenance Required – Some inspection items can be addressed through the routine maintenance program (See SOP in appendix C). This can include items like vegetation management or debris/trash removal.

3 = Immediate Repair Necessary – This item needs immediate attention because failure is imminent or has already occurred. This could include items such as structural failure of a feature (outlet works, forebay, etc), significant erosion, or significant sediment accumulation. This score should be given to an item that can significantly affect the function of the facility.

N/A This is checked by an item that may not exist in a facility. Not all facilities have all of the features identified on the form (forebay, micro-pool, etc.).

Inspection Summary/Additional Comments

Additional explanations to inspection items, and observations about the facility not covered by the form, are recorded in this section.

Overall Facility Rating

An overall rating must be given for each facility inspected. The overall facility rating should correspond with the highest score (0, 1, 2, 3) given to any feature on the inspection form.

C. Verification of Inspection and Form Submittal

The Stormwater Management Facility Inspection Form provides a record of inspection of the facility. Inspection Forms for each facility type are provided in Appendix D. Verification of the inspection of the stormwater facilities, the facility inspection form(s), and Inspector Qualifications shall be provided to

the City of Aurora on an annual basis. The verification and the inspection form(s) shall be reviewed and submitted by <<Insert Property Owner's Name>> or his property manager.

Refer to Section II of this Plan regarding the annual reporting of inspections.

VIII. Maintaining Stormwater Management Facilities

Stormwater management facilities shall be properly maintained to ensure they operate correctly and provide the water quality treatment for which they were designed. Routine maintenance performed on a frequently scheduled basis, can help avoid more costly rehabilitative maintenance that results when facilities are not adequately maintained.

A. Maintenance Categories

Stormwater management facility maintenance programs are separated into three broad categories of work. These categories are based largely on the Urban Drainage and Flood Control District's Maintenance Program for regional drainage facilities. The categories are separated based upon the magnitude and type of the maintenance activities performed. A description of each category follows:

Routine Work

The majority of this work consists of scheduled mowings and trash and debris pickups for stormwater management facilities during the growing season. This includes items such as the removal of debris/material that may be clogging the outlet structure well screens and trash racks. It also includes activities such as weed control, mosquito treatment, and algae treatment. These activities normally will be performed numerous times during the year. These items can be completed without any prior correspondence with the City of Aurora; however, completed inspection and maintenance forms shall be submitted to the City of Aurora for each inspection and maintenance activity with the annual report.

Restoration Work

This work consists of a variety of isolated or small-scale maintenance and work needed to address operational problems. Most of this work can be completed by a small crew, with minor tools, and small equipment. The <<Insert Property's Owner's Name>> shall correspond with the City of Aurora and submit completed maintenance forms to the City of Aurora for each maintenance activity.

Rehabilitation Work

This work consists of large-scale maintenance and major improvements needed to address failures within the stormwater management facilities. This work requires consultation with the city of Aurora and may require an engineering design with construction plans to be prepared for review and approval. This work may also require more specialized maintenance equipment, surveying, construction permits or assistance through private contractors and consultants. If these items are needed the <<Insert Property Owner's Name>> shall correspond with the City of Aurora and submit completed maintenance forms to the City of Aurora for each maintenance activity.

B. Maintenance Personnel

<<Insert Property Owner's Name>>'s maintenance personnel shall be qualified to properly maintain stormwater management facilities. Inadequately trained personnel can cause additional problems resulting in additional maintenance costs.

C. Maintenance Forms

The Stormwater Management Facility Maintenance Form provides a record of maintenance activities. Maintenance Forms for each facility type are provided in Appendix E. Maintenance Forms shall be completed by the <<Insert Property Owner's Name>>'s contractor completing the required maintenance items. The form shall then be reviewed by the <<Insert Property Owner's Name>> or an authorized agent of the property owner and submitted on an annual basis to the City of Aurora.

Refer to Section II of this Plan regarding the annual reporting of inspections and maintenance activities performed.

A P P E N D I X A

Stormwater Maintenance Agreement Template

STORMWATER MAINTENANCE AGREEMENT

BETWEEN

THE CITY OF AURORA, acting by and through its

Utility Enterprise

and

_____

THIS STORMWATER MAINTENANCE AGREEMENT, dated for reference this __ day of _____, 20___ is made by and between the City of Aurora, a Colorado home rule city and _____ (hereinafter, the "Owner") and the City of Aurora, (hereinafter, the "City"), agree as follows:

Paragraph 1. The Owner owns the parcel of land known as Lot _____, Block _____, _____ Subdivision Filing No._____, County of _____, State of Colorado (hereinafter, the "Property"). The Owner has installed, or caused to be installed, upon the Property the permanent stormwater best management practices (BMPs). Certain inspections and maintenance of those BMPs are required under the Owner's Inspection and Maintenance Plan, also referred to as the Operations and Maintenance Manual dated _____, 20__ and approved by the City of Aurora (hereinafter, the "IM Plan") which is attached to and made a part of this Stormwater Maintenance Agreement as Exhibit "A". The Owner agrees, at the Owner's sole expense, to inspect, maintain, and to ensure proper functioning of the BMPs, in accord with and as set out in the IM Plan, as set forth herein below. If the Owner conveys the Property, Owner shall provide a copy of the IM Plan along with a copy of this Agreement to the Grantee. Upon conveyance, Owner shall thereafter be relieved of its obligations under this Agreement. However, such obligations shall run with the Property and become the obligation of Grantee.

Paragraph 2. In accordance with the City of Aurora Municipal Code 138-442.5**,** the Owner has submitted an IM Plan (Exhibit A). That IM Plan was approved by the City on _____, 20__. The Owner has also submitted the Drainage Plan. That Drainage Plan was approved by the City on _____, 20__.

Paragraph 3**.** The Owner shall inspect the BMPs at least once every calendar year, and shall submit written inspection reports to Aurora Water prior to May 31st of that calendar year. The City is under no obligation whatsoever pursuant to this Agreement to notify the Owner of any failure to submit inspection reports.

Paragraph 4. The Owner shall promptly perform all maintenance and shall report maintenance activities to Aurora Water in accordance with the requirements set forth in the IM Plan.

Paragraph 5. Subject to the notice and Owner's right to cure requirements of City of Aurora Municipal Code Section 138-442.5, in the event that the Owner fails to inspect, maintain, or repair any BMP, Owner agrees that the City, at the City's sole discretion, shall have the right to enter upon the Property without warrant or further process of law and may make whatever inspection. Following the City's compliance with the notice requirements of 138-442.5 and Owner's right to cure any deficiencies noted, if the Owner fails to timely cure such deficiencies, the City shall have the right to enter upon the Property without warrant or further process of law and may complete whatever maintenance or repair may be needed, all at the Owner's sole cost. The City shall bill the Owner by invoice for any costs incurred by the City, including but not limited to personnel, contracting, labor, or materials, and the Owner shall pay those costs within thirty (30) City business days of the invoice date.

Paragraph 6**.** This Agreement shall be binding upon the Owner and the Owner's heirs, successors, and assigns. This Agreement shall be recorded at the Clerk and Recorder's Office. The benefits and burdens of this Agreement shall run with the land.

Paragraph 7. Governing Law. This Agreement is subject to and shall be interpreted under the law of the State of Colorado, and the Charter, City Code, ordinances, rules and regulations of the City of Aurora, Colorado, a Colorado home rule city. The Parties agree that this Agreement shall be deemed to have been made in, and the place of performance is deemed to be in the City of Aurora, Colorado.

Paragraph 8. Appropriation and availability of funds. In accord with the Colorado Constitution, Article X, Section 20, and the City Charter, performance of the City's obligations under this Agreement is expressly subject to appropriation of funds by the City Council and the availability of those funds for expenditure.

Paragraph 9. No Third Party Beneficiary. It is expressly understood and agreed that enforcement of the terms and conditions of this Agreement, and all rights of action relating to such enforcement, shall be strictly reserved to the Parties hereto, and nothing contained in this Agreement shall give or allow any such claim or right of action by any other or third person or entity on this Agreement. It is the express intention of the Parties hereto that any person or entity, other than the Parties to this Agreement, receiving services or benefits under this Agreement shall be deemed to be incidental beneficiaries only.

Paragraph 10. Amendments. This Agreement may be amended only by prior writing executed by duly authorized representatives of the Property Owner and the City, and recorded in the records of the Clerk and Recorder's Office.

Paragraph 11. Headings. The headings of the several paragraphs of this Agreement are inserted only as a matter of convenience and for reference and do not define or limit the scope or intent of any provisions of this Agreement and shall not be construed to affect in any manner the terms and provisions hereof or the interpretation or construction thereof.

Paragraph 12. Entire Agreement. This Agreement, together with all exhibits attached hereto, constitutes the entire agreement between the Parties hereto, and all other representations or statements heretofore made, verbal or written, are merged herein, and this Agreement may be amended only in writing, and executed by duly authorized representatives of the Parties hereto.

Paragraph 13. Nonwaiver Of Rights. No waiver of default by the City of any of the terms, covenants, and conditions hereof to be performed, kept, and observed by the Owner shall be construed, or shall operate, as a waiver of any subsequent default of any of the terms, covenants, or conditions herein contained to be performed, kept, and observed by the Owner.

Paragraph 14. Waiver. This Agreement is for the benefit of the Owner. The Owner does hereby waive, remise, and release any claim, right, or cause of action the Owner may have or which may accrue in the future, whether under theories of contract or any other cause of action whatsoever, against the City arising in whole or in part from this Agreement.

FOR THE CITY OF AURORA:

By: _____ this _____ day of _____, 20___.

Approved as to Form:

_____

FOR THE OWNER:

By: _____ this _____ day of _____, 20___.

_____
(printed name)

By: _____ this _____ day of _____, 20___.

_____
(printed name)

By: _____ this _____ day of _____, 20___.

_____
(printed name)

(The Acknowledgement (notarization) will vary for Owner depending on if Owner is an individual, corporation or partnership. Also, where there is mortgage on the property, the mortgage holder must sign the Subordination section of this Agreement.)

ACKNOWLEDGEMENT
(For an individual acting in his or her own right)

State of _____)
)
County of _____)

The foregoing instrument was subscribed and affirmed before me this _____day of _____, 20___, by _____.

_____

Notary Public

My Commission Expires: _____

ACKNOWLEDGEMENT
(For a Corporation)

State of _____)
)
County of _____)

The foregoing instrument was subscribed and affirmed before me this _____day of _____, 20____, by _____ of _____, a _____ corporation, on behalf of the corporation.

_____
Notary Public

My Commission Expires: _____

ACKNOWLEDGEMENT
(For a Partnership)

State of _____)
)
County of _____)

The foregoing instrument was subscribed and affirmed before me this _____day of _____, 20____, by _____, as _____, on behalf of _____, a partnership.

_____
Notary Public

My Commission Expires: _____

ACKNOWLEDGEMENT
(For an individual acting as principal by an attorney in fact)

State of _____)
)
County of _____)

The foregoing instrument was subscribed and affirmed before me this _____day of _____, 20____, by _____, as an attorney in fact on behalf of _____.

_____

Notary Public

My Commission Expires: _____

ACKNOWLEDGEMENT
(By any public officer, trustee, or personal representative)

State of _____)
)
County of _____)

The foregoing instrument was subscribed and affirmed before me this _____day of _____, 20____, by _____, as _____.

_____
Notary Public

My Commission Expires: _____

SUBORDINATION

_____, as holder of a mortgage or other lien or interest described as

_____upon the parcel of land known as Lot _____, block _____, _____ Subdivision, Parcel Number _____, hereby intentionally and unconditionally subordinates that mortgage or other lien or interest in favor of this Stormwater Maintenance Agreement.

By: _____ this _____ day of _____, 20____.

State of _____)
)
County of _____)

The foregoing Subordination was acknowledged before me this _____ day of _____, 20___ by _____ as the Authorized Agent of _____
_____ on behalf of
_____
_____.

_____
Notary Public

My Commission Expires: _____

EXHIBIT A
Inspection and Maintenance Plan

A P P E N D I X B

General Location and Description of Stormwater Management Facilities Example

Appendix B

General Location and Description of Stormwater Management Facilities Example

A. General Site Description

Insert General Site Description (example below)

Residential Site, Traditions Subdivision Filing No. 1, is located at the southeast corner of East 6th Avenue and Harvest Road approximately one mile east of Gun Club Road. The 81-acre site consists of 250 single-family residential units.

B. General Stormwater Management Description

Insert General Description of stormwater facilities for the site (example below)

All stormwater is conveyed via curb and gutter and conventional reinforced concrete pipe (RCP) storm sewer to one detention basin that provides detention and water quality treatment. The water quality facility is a constructed wetlands facility. Developed runoff is released at or below historic rates for the 10-year and 100-year storm events.

C. Stormwater Facilities Site Plan

Inspection or maintenance personnel may utilize the Stormwater Facilities Map located in Appendix G for locating the stormwater facilities within this development.

D. On-Site Stormwater Management Facilities

List all facilities for each of the types (see examples provided below)

Volume Reduction Facilities

Residential Site utilizes Level I MDCIA – All impervious surfaces are routed over grass buffer strips. Gutter downspouts are disconnected from the storm conveyance system and are routed over grassed areas.

Storage Facilities (Detention)

Detention for Residential Site is provided in a Detention Pond located at the southeast corner of East 6th Avenue and Harvest Road.

Water Quality Facilities

Residential Site utilizes one constructed wetlands basin for providing water quality capture volume for the site.

Source Control Best Management Practices

Residential Site does not include any nonstructural BMPs.

A P P E N D I X C

Standard Operating Procedures

For:

Extended Detention Basins (EDBs)

Grass Buffers and Grass Swales (GB-GS)

Bioretention Cell (BRCs) aka Porous Landscape Detention (PLDs)

Sand Filter Basins (SFBs)

A P P E N D I X C – 1

Extended Detention Basins

Standard Operation Procedures
for
Inspection and Maintenance

Extended Detention Basins (EDBs)

September 2010

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EDB-1 BACKGROUND

Extended Detention Basins (EDBs) are one of the most common types of Stormwater Management Facilities utilized within the Front Range of Colorado. An EDB is a sedimentation basin designed to "extend" the runoff detention time, but to drain completely dry sometime after stormwater runoff ends. The EDB's drain time for the water quality portion of the facility is typically 40 hours. The basins are considered to be "dry" because the majority of the basin is designed not to have a significant permanent pool of water remaining between runoff events.

EDBs are an adaptation of a detention basin used for flood control, with the primary difference is the addition of forebays, micro-pools and a slow release outlet design. Forebays are shallow concrete "pans" located at the inflow point to the basin and are provided to facilitate sediment removal within a contained area prior to releasing into the pond. These forebays collect and briefly hold stormwater runoff resulting in a process called sedimentation, dropping sediment out of the stormwater. The stormwater is then routed from the forebay into the concrete trickle channel and upper basin, the large grassy portion of the basin. The EDB uses a much smaller outlet that extends the emptying time of the more frequently occurring runoff events to facilitate pollutant removal. An EDB should have a small micro-pool just upstream of the outlet. This micro-pool is designed to hold a small amount of water to keep sediment and floatables from blocking the outlet orifices.

EDB-2 INSPECTING EXTENDED DETENTION BASINS (EDBs)

EDB-2.1 Access and Easements

Inspection or maintenance personnel may utilize the stormwater facility map located in Appendix G containing the location(s) of the access points and maintenance easements of the EDB(s) within this development.

EDB-2.2 Stormwater Management Facilities Locations

Inspection or maintenance personnel may utilize the stormwater facility map located in Appendix G containing the location(s) of the EDB(s) within this development.

EDB-2.3 Extended Detention Basin (EDB) Features

EDBs have a number of features that are designed to serve a particular function. Many times the proper function of one feature depends on another. For example, if a forebay is not properly maintained, it could negatively affect the performance of a feature downstream (trickle channel, micro-pool, etc.). Therefore, it is critical that each feature of the EDB is properly inspected and maintained to ensure the overall facility functions as it was intended. Below is a list and description of the most common features within an EDB and the corresponding maintenance inspection items that can be anticipated:

Table EDB-1
Typical Inspection & Maintenance Requirements Matrix

EDB Features	Sediment Removal	Mowing/ Weed control	Trash & Debris Removal	Erosion	Overgrown Vegetation Removal	Standing Water (mosquito/ algae control)	Structure Repair
Inflow Points (outfalls)	X		X				X
Forebay	X		X				X
Low-flow channel	X		X	X	X		X
Bottom Stage	X	X	X	X	X	X	
Micro-pool	X		X		X	X	X
Outlet Works	X		X				X
Emergency Spillway			X	X	X		X
Upper Stage			X	X			
Embankment		X		X	X		

EDB-2.3.1 Inflow Points

Inflow Points or Outfalls into EDBs are the point source of the stormwater discharge into the facility. An inflow point is commonly a storm sewer pipe with a flared end section that discharges into the EDB. In some instances, an inflow point could be a drainage channel or ditch that flows into the facility.

An energy dissipater (riprap or hard armor protection) is typically immediately downstream of the discharge point into the EDB to protect from erosion. In some cases, the storm sewer outfall can have a toe-wall or cut-off wall immediately below the structure to prevent undercutting of the outfall from erosion.

The typical maintenance items found with inflow points are as follows:

a. Riprap Displaced – Many times, because the repeated impact/force of water, the riprap can shift and settle. If any portion of the riprap apron appears to have settled, soil is present between the riprap, or the riprap has shifted, maintenance may be required to ensure future erosion is prevented. Depending on the nature of the maintenance the use of heavy equipment and proper bedding material may be required to repair the riprap. See Section EDB-3.5 – EDB-3.8.

b. Erosion Present/Outfall Undercut – In some situations, the energy dissipater may not have been sized, constructed, or maintained appropriately and erosion has occurred. Any erosion within the vicinity of the inflow point will require maintenance to prevent damage to the

structure(s) and sediment transport within the facility. If there is any question to whether the original design is inadequate, a qualified engineer should review the situation to avoid chronic maintenance repairs if it is a design issue.

c. Sediment Accumulation – Because of the turbulence in the water created by the energy dissipater, sediment often deposits immediately downstream of the inflow point. To prevent a loss in hydraulic performance of the upstream infrastructure, sediment that accumulates in this area must be removed in a timely manner.

d. Structural Damage – Structural damage can occur at anytime during the life of the facility. Typically, for an inflow, the structural damage occurs to the pipe flared end section (concrete or steel). Structural damage can lead to additional operating problems with the facility, including loss of hydraulic performance.

e. Woody Growth/Weeds Present – Undesirable vegetation can grow in and around the inflow area to an EDB that can significantly affect the performance of the drainage facilities discharging into the facility. This type of vegetation includes trees (typically cottonwoods) and dense areas of shrubs (willows). If woody vegetation is not routinely mowed/removed, the growth can cause debris/sediment to accumulate, resulting in blockage of the discharge. Also, tree roots can cause damage to the structural components of the inflow. Routine maintenance is essential for trees (removing a small tree/sapling is much cheaper and "quieter" than a mature tree). In addition, noxious weeds growing in the facility can result in the loss of desirable native vegetation and impact adjacent open spaces/land.

EDB-2.3.2 Forebay

A forebay is a solid surface (pad), typically constructed of concrete, immediately downstream of the inflow point. The forebay is designed to capture larger particles and trash to prevent them from entering the main portion of the EDB. The solid surface is designed to facilitate mechanical sediment removal (skid steer). The forebay typically includes a small diameter discharge pipe or v-notch weir on the downstream end and designed to drain the forebay in a specified period of time to promote sedimentation. The forebays vary in size and depth depending on the design and site constraints.

The typical maintenance items found with forebays are as follows:

a. Sediment/Debris Accumulation – Because this feature of the EDB is designed to provide the initial sedimentation, debris and sediment frequently accumulate in this area. If the sediment and debris is not

removed from the forebay on a regular basis, it can significantly affect the function of other features within the EDB. Routine sediment removal from the forebay can **significantly** reduce the need for dredging of the main portion of the EDB using specialized equipment (long reach excavators). Routine removal of sediment from the forebay can **substantially** decrease the long-term sediment removal costs of an EDB.

b. Concrete Cracking/Failing – The forebay is primarily constructed of concrete, which cracks, spalls, and settles. Damage to the forebay can result in deceased performance and impact maintenance efforts.

c. Drain Pipe/Weir Clogged – Many times the drainpipe or weir can be clogged with debris, and prevent the forebay from draining properly. If standing water is present in the forebay (and there is not a base flow), the forebay is most likely not draining properly. This can result in a decrease in performance and create potential nuisances with stagnant water (mosquitoes).

d. Weir/Drain Pipe Damaged – Routine maintenance activities, vandalism, or age may cause the weir or drain pipe in the forebay to become damaged. Weirs are typically constructed of concrete, which cracks and spalls. The drainpipe is typically smaller in diameter and constructed with plastic, which can fracture.

EDB-2.3.3 Trickle Channel (Low-Flow)

The trickle channel conveys stormwater from the forebay to the micro-pool of the EDB. The trickle channel is typically made of concrete. However, grass lined (riprap sides protected) is also common and can provide for an additional means of water quality within the EDB. The trickle channel is typically 6-9 inches in depth and can vary in width.

The typical maintenance items found with trickle channels are as follows:

a. Sediment/Debris Accumulation – Trickle channels are typically designed with a relatively flat slope that can promote sedimentation and the collection of debris. Also, if a trickle channel is grass lined it can accumulate sediment and debris at a much quicker rate. Routine removal of accumulated sediment and debris is essential in preventing flows from circumventing the trickle channel and affecting the dry storage portion of the pond.

b. Concrete/Riprap Damage – Concrete can crack, spall, and settle and must be repaired to ensure proper function of the trickle channel. Riprap can also shift over time and must be replaced/repaired as necessary.

c. Woody Growth/Weeds Present – Because of the constant moisture in the area surrounding the trickle channel, woody growth (cottonwoods/willows) can become a problem. Trees and dense shrub type vegetation can affect the capacity of the trickle channel and can allow flows to circumvent the feature.

d. Erosion Outside of Channel – In larger precipitation events, the trickle channel capacity will likely be exceeded. This can result in erosion immediately adjacent to the trickle channel and must be repaired to prevent further damage to the structural components of the EDB.

EDB-2.3.4 Bottom Stage

The bottom stage is at least 1.0 to 2.0 feet deeper than the upper stage and is located in front of the outlet works structure. The bottom stage is designed to store the smaller runoff events, assists in keeping the majority of the basin bottom dry resulting in easier maintenance operations, and enhances the facilities pollutant removal capabilities. This area of the EDB may develop wetland vegetation.

The typical maintenance items found with the bottom stage are as follows:

a. Sediment/Debris Accumulation – The bottom stage can frequently accumulate sediment and debris. This material must be removed to maintain pond volume and proper function of the outlet structure.

b. Woody Growth/Weeds Present - Because of the constant moisture in the soil surrounding the micro-pool, woody growth (cottonwoods/willows) can create operational problems for the EDB. If woody vegetation is not routinely mowed/removed, the growth can cause debris/sediment to accumulate outside of the micro-pool (see EDB 2.3.5), which can cause problems with other EDB features. Also, tree roots can cause damage to the structural components of the outlet works. Routine management is essential for trees (removing a small tree/sapling is much cheaper and "quieter" than a mature tree).

c. Bank Erosion – The bottom stage is usually a couple feet deeper than the other areas of the ponds. Erosion can be caused by water dropping into the bottom stage if adequate protection/armor is not present. Erosion in this area must be mitigated to prevent sediment transport and other EDB feature damage.

d. Mosquitoes/Algae Treatment – Nuisance created by stagnant water can result from improper maintenance/treatment of the bottom stage. Mosquito larvae can be laid by adult mosquitoes within the permanent pool. Also, aquatic vegetation that grows in shallow pools of water can decompose causing foul odors. Chemical/mechanical treatment of the

bottom stage may be necessary to reduce these impacts to adjacent homeowners.

e. Petroleum/Chemical Sheen – Many indicators of illicit discharges into the storm sewer systems will be present in the bottom stage area of the EDB. These indicators can include sheens, odors, discolored soil, and dead vegetation. If it is suspected that an illicit discharge has occurred, contact the supervisor immediately. Proper removal/mitigation of contaminated soils and water in the EDB is necessary to minimize any environmental impacts downstream.

EDB-2.3.5 Micro-pool

The micro-pool is a concrete or grouted boulder walled structure directly in front of the outlet works. At a minimum, the micro-pool is 2.5 feet deep and is designed to hold water. The micro-pool is critical in the proper function of the EDB; it allows suspended sediment to be deposited at the bottom of the micro-pool and prevents these sediments from being deposited in front of the outlet works causing clogging of the outlet structure, which results in marshy areas within the top and bottom stages.

The typical maintenance items found with micro-pools are as follows:

a. Sediment/Debris Accumulation – The micro-pool can frequently accumulate sediment and debris. This material must be removed to maintain the micro pool volume, depth, and proper function of the outlet structure.

b. Woody Growth/Weeds Present - Because of the constant moisture in the soil surrounding the micro-pool, woody growth (cottonwoods/willows) can create operational problems for the EDB. If woody vegetation is not routinely mowed/removed, the growth can cause debris/sediment to accumulate outside of the micro-pool, which can cause problems with other EDB features. Also, tree roots can cause damage to the structural components of the outlet works. Routine management is essential for trees (removing a small tree/sapling is much cheaper and “quieter” than a mature tree).

c. Mosquitoes/Algae Treatment – Nuisance created by stagnant water can result from improper maintenance/treatment of the micro-pool. Mosquito larvae can be laid by adult mosquitoes within the permanent pool. If mosquitoes are breeding within the micro-pool this may also be an indication there is significant sediment build-up that is reducing the depth of the micro-pool. Also, aquatic vegetation that grows in shallow pools of water can decompose causing foul odors. Chemical/mechanical treatment of the micro-pool may be necessary to reduce these impacts to adjacent homeowners.

d. Petroleum/Chemical Sheen – Many indicators of illicit discharges into the storm sewer systems will be present in the micro-pool area of the EDB. These indicators can include sheens, odors, discolored soil, and dead vegetation. If it is suspected that an illicit discharge has occurred, contact the supervisor immediately. Proper removal/mitigation of contaminated soils and water in the EDB is necessary to minimize any environmental impacts downstream.

EDB-2.3.6 Outlet Works

The outlet works is the feature that drains the EDB in specified quantities and periods of time. The outlet works is typically constructed of reinforced concrete into the embankment of the EDB. The concrete structure typically has steel orifice plates anchored/embedded into it to control stormwater release rates. The larger openings (flood control) on the outlet structure typically have trash racks over them to prevent clogging. The water quality orifice plate (smaller diameter holes) will typically have a well screen covering it to prevent smaller materials from clogging it. The outlet structure is the single most important feature in the EDB operation. Proper inspection and maintenance of the outlet works is essential in ensuring the long-term operation of the EDB.

The typical maintenance items found with the outlet works are as follows:

a. Trash Rack/Well Screen Clogged – Floatable material entering the EDB will most likely make its way to the outlet structure. This material is trapped against the trash racks and well screens on the outlet structure (which is why they are there). This material must be removed on a routine basis to ensure the outlet structure drains in the specified design period.

b. Structural Damage - The outlet structure is primarily constructed of concrete, which can crack, spall, and settle. The steel trash racks and well screens are also susceptible to damage.

c. Orifice Plate Missing/Not Secure – Many times residents, property owners, or maintenance personnel will remove or loosen orifice plates if they believe the pond is not draining properly. Any modification to the orifice plate(s) will significantly affect the designed discharge rates for water quality and/or flood control. Modification of the orifice plates is not allowed without approval from the City of Aurora Public Works Department, Engineering Control Division.

d. Manhole Access – Access to the outlet structure is necessary to properly inspect and maintain the facility. If access is difficult or not available to inspect the structure, chances are it will be difficult to maintain as well.

e. Woody Growth/Weeds Present - Because of the constant moisture in the soil surrounding the outlet works, woody growth (cottonwoods/willows) can create operational problems for the EDB. If woody vegetation is not routinely mowed/removed, the growth can cause debris/sediment to accumulate around the outlet works, which can cause problems with other EDB features. Also, tree roots can cause damage to the structural components of the outlet works. Routine management is essential for trees (removing a small tree/sapling is much cheaper and "quieter" than a mature tree).

EDB-2.3.7 Emergency Spillway

An emergency spillway is typical of all EDBs and designed to serve as the overflow in the event the volume of the pond is exceeded. The emergency spillway is typically armored with riprap (or other hard armor) and is sometimes buried with soil. The emergency spillway is typically a weir (notch) in the pond embankment. Proper function of the emergency spillway is essential to ensure flooding does not affect adjacent properties.

The typical maintenance items found with emergency spillways are as follows:

a. Riprap Displaced – As mentioned before, the emergency spillway is typically armored with riprap to provide erosion protection. Over the life of an EDB, the riprap may shift or dislodge due to flow. Depending on the nature of the maintenance the use of heavy equipment and proper bedding material may be required to repair the riprap. See Section EDB-3.5 – EDB-3.8.

b. Erosion Present – Although the spillway is typically armored, stormwater flowing through the spillway can cause erosion damage. Erosion must be repaired to ensure the integrity of the basin embankment, and proper function of the spillway.

c. Woody Growth/Weeds Present – Management of woody vegetation is essential in the proper long-term function of the spillway. Larger trees or dense shrubs can capture larger debris entering the EDB and reduce the capacity of the spillway.

d. Obstruction Debris – The spillway must be cleared of any obstruction (man-made or natural) to ensure the proper design capacity.

EDB-2.3.8 Upper Stage (Dry Storage)

The upper stage of the EDB provides the majority of the water quality flood detention volume. This area of the EDB is higher than the bottom stage and

typically stays dry, except during storm events. The upper stage is the largest feature/area of the basin. Sometimes, the upper stage can be utilized for park space and other uses in larger EDBs. With proper maintenance of the bottom stage, micro-pool, and forebay(s), the upper stage should not experience much sedimentation; however, bottom elevations should be monitored to ensure adequate volume.

The typical maintenance items found with upper stages are as follows:

a. Vegetation Sparse – The upper basin is the most visible part of the EDB, and therefore aesthetics is important. Adequate and properly maintained vegetation can greatly increase the overall appearance and acceptance of the EDB by the public. In addition, vegetation can reduce the potential for erosion and subsequent sediment transport to the other areas of the pond.

b. Woody Growth/Undesirable Vegetation – Although some trees and woody vegetation may be acceptable in the upper basin, some thinning of cottonwoods and willows may be necessary. Remember, the basin will have to be dredged to ensure volume, and large trees and shrubs will be difficult to protect during that operation.

c. Standing Water/Boggy Areas – Standing water or boggy areas in the upper stage is typically a sign that some other feature in the pond is not functioning properly. Routine maintenance (mowing, trash removal, etc) can be extremely difficult for the upper stage if the ground is saturated. If this inspection item is checked, make sure you have identified the root cause of the problem.

d. Sediment Accumulation – Although other features within the EDB are designed to capture sediment, the upper storage area will collect sediment over time. Excessive amounts of sedimentation will result in a loss of storage volume. It may be more difficult to determine if this area has accumulated sediment without conducting a field survey.

Below is a list of indicators:

1. Ground adjacent to the trickle channel appears to be several inches higher than the concrete/riprap trickle channel.
2. Standing water or boggy areas in upper stage
3. Uneven grades or mounds
4. Bottom Stage, Micro-pool, or Forebay has excessive amounts of sediment

e. Erosion (banks and bottom) – The bottom grades of the dry storage area are typically flat enough that erosion should not occur. However, inadequate vegetative cover may result in erosion of the upper stage.

Erosion that occurs in the upper stage can result in increased dredging/maintenance of the bottom stage/micro-pool.

f. Trash/Debris – Trash and debris can accumulate in the upper area after large events, or from illegal dumping. Over time, this material can accumulate and clog the EDB outlet works.

g. Maintenance Access – Most EDBs typically have a gravel/concrete maintenance access path to either the upper stage or forebay. This access path should be inspected to ensure the surface is still drivable. Some of the smaller EDBs may not have maintenance access paths; however, the inspector should verify that access is available from adjacent properties.

EDB-2.3.9 Miscellaneous

There are a variety of inspection/maintenance issues that may not be attributed to a single feature within the EDB. This category on the inspection form is for maintenance items that are commonly found in the EDB, but may not be attributed to an individual feature.

a. Encroachment in Easement Area – Private lots/property can sometimes be located very close to the EDBs, even though they are required to be located in tracts with drainage easements. Property owners may not place landscaping, trash, fencing, or other items within the easement area that may adversely affect maintenance or the operation of the facility.

b. Graffiti/Vandalism – Damage to the EDB infrastructure can be caused by vandals. If criminal mischief is evident, the inspector should forward this information to the Aurora Police Department.

c. Public Hazards – Public hazards include items such as vertical drops of greater than 4-feet, containers of unknown/suspicious substances, exposed metal/jagged concrete on structures. **If any hazard is found within the facility area that poses an immediate threat to public safety, call 911 immediately!**

d. Burrowing Animals/Pests – Prairie dogs and other burrowing rodents may cause damage to the EDB features and negatively affect the vegetation within the EDB.

e. Other – Any miscellaneous inspection/maintenance items not contained on the form should be entered here.

EDB-2.4 Inspection Forms

EDB Inspection forms are located in Appendix D. Inspection forms shall be completed by the person(s) conducting the inspection activities. Each form shall be reviewed and submitted by the property owner or property manager to the City of Aurora per the requirements of the Inspection and Maintenance Plan. These inspection forms shall be kept indefinitely and made available to the City of Aurora upon request.

EDB-3 MAINTAINING EXTENDED DETENTION BASINS (EDBS)

EDB-3.1 Maintenance Personnel

Maintenance personnel must be qualified to properly maintain EDBs. Inadequately trained personnel can cause additional problems resulting in additional maintenance costs.

EDB-3.2 Equipment

It is imperative the appropriate equipment and tools are taken to the field with the operations crew. The types of equipment/tools will vary depending on the task at hand. Below is a basic list of tools, equipment, and material(s) that may be necessary to perform maintenance on an EDB:

1.) Loppers/Tree Trimming Tools
2.) Mowing Tractors
3.) Trimmers (extra string)
4.) Shovels
5.) Rakes
6.) All Surface Vehicle (ASVs)
7.) Skid Steer
8.) Back Hoe
9.) Track Hoe/Long Reach Excavator
10.) Dump Truck
11.) Jet-Vac Machine
12.) Engineers Level (laser)
13.) Riprap (Minimum - Type M, or as shown on the approved civil plans)
14.) Filter Fabric
15.) Erosion Control Blanket(s)

16.) Seed Mix (See seed mix in the *Rules and Regulations Regarding Stormwater (Quality) Discharge for Construction Activities*, Std Det. SM, Seeding & Mulching)

17.) Illicit Discharge Cleanup Kits

18.) Trash Bags

19.) Tools (wrenches, screw drivers, hammers, etc)

20.) Chain Saw

21.) Confined Space Entry Equipment

22.) Approved Stormwater Facility Inspection and Maintenance Plan

Some of the items identified above may not be needed for every maintenance operation. However, this equipment should be available to the maintenance operations crews should the need arise.

EDB-3.3 Safety

Vertical drops may be encountered in areas located within and around the facility. Avoid walking on top of retaining walls or other structures having a significant vertical drop. If a vertical drop within the EDB is identified as greater than 48" in height, make the appropriate note/comment on the maintenance inspection form.

EDB-3.4 Maintenance Forms

The EDB Maintenance Form provides a record of each maintenance operation performed by maintenance contractors. The EBD Maintenance Form shall be filled out in the field after the completion of the maintenance operation. Each form shall be reviewed and submitted by the property owner or property manager to the City of Aurora per the requirements of the Inspection and Maintenance Plan. The EDB Maintenance form is located in Appendix E.

EDB-3.5 Maintenance Categories and Activities

A typical EDB Maintenance Program will consist of three broad categories of work. Within each category of work, a variety of maintenance activities can be performed on an EDB. A maintenance activity can be specific to each feature within the EDB, or general to the overall facility. This section of the SOP explains each of the categories and briefly describes the typical maintenance activities for an EDB.

A variety of maintenance activities are typical of EDBs. The maintenance activities range in magnitude from routine trash pickup to the reconstruction of drainage infrastructure. Below is a description of each maintenance activity, the objectives, and frequency of actions:

EDB-3.6 Routine Maintenance Activities

The majority of this work consists of regularly scheduled mowing and trash and debris pickups for stormwater management facilities during the growing season. This includes items such as the removal of debris/material that may be clogging the outlet structure well screens and trash racks. It also includes activities such as weed control, mosquito treatment, and algae treatment. These activities normally will be performed numerous times during the year. These items can be completed without any prior correspondence with the City of Aurora; however, completed inspection and maintenance forms shall be submitted to the City of Aurora for each inspection and maintenance activity in accordance with the Inspection and Maintenance Plan.

The Maintenance Activities are summarized below, and further described in the following sections.

TABLE – EDB-2
Summary of Routine Maintenance Activities

Maintenance Activity	Minimum Frequency	Look for:	Maintenance Action
Mowing	Twice annually	Excessive grass height/aesthetics	Mow grass to a height of 4" to 6"
Trash/Debris Removal	Twice annually	Trash & debris in EDB	Remove and dispose of trash and debris
Outlet Works Cleaning	As needed - after significant rain events – twice annually min.	Clogged outlet structure; ponding water	Remove and dispose of debris/trash/sediment to allow outlet to function properly
Weed control	Minimum twice annually	Noxious weeds; Unwanted vegetation	Treat w/ herbicide or hand pull; Consult the local weed specialist
Mosquito Treatment	As needed	Standing water/mosquito habitat	Treat w/ EPA approved chemicals
Algae Treatment	As needed	Standing water/ Algal growth/green color	Treat w/ EPA approved chemicals

EDB-3.6.1 Mowing

Occasional mowing is necessary to limit unwanted vegetation and to improve the overall appearance of the EDB. Native vegetation should be mowed to a height of 4-to-6 inches tall. Grass clippings should be collected and disposed of properly.

Frequency – Routine - Minimum of twice annually or depending on aesthetics.

EDB-3.6.2 Trash/Debris Removal

Trash and debris must be removed from the entire EDB area to minimize outlet clogging and to improve aesthetics. This activity must be performed prior to mowing operations.

Frequency – Routine – Prior to mowing operations and minimum of twice annually and should be done after significant storm events.

EDB-3.6.3 Outlet Works Cleaning

Debris and other materials can clog the outlet work's well screen, orifice plate(s) and trash rack. This activity must be performed anytime other maintenance activities are conducted to ensure proper operation.

Frequency - Routine – After significant rainfall event or concurrently with other maintenance activities.

EDB-3.6.4 Weed Control

Noxious weeds and other unwanted vegetation must be treated as needed throughout the EDB. This activity can be performed either through mechanical means (mowing/pulling) or with herbicide. Consultation with the local Weed Inspector is highly recommended prior to the use of an herbicide. All herbicide applications should be applied in accordance with the manufacturer's recommendations.

Frequency – Routine – As needed based on inspections.

EDB-3.6.5 Mosquito/Algae Treatment

Treatment of permanent pools is necessary to control mosquitoes and undesirable aquatic vegetation that can create nuisances. Only EPA approved chemicals/materials can be used in areas that are warranted.

Frequency – As needed.

EDB- 3.7 Minor Maintenance Activities

This work consists of a variety of isolated or small-scale maintenance or operational problems. Most of this work can be completed by a small crew, tools, and small equipment. These items require prior correspondence with the City of Aurora Water Staff and require completed inspection and maintenance forms to be submitted to the City of Aurora Water Staff for each inspection and maintenance activity.

Table – EDB-3
Summary of Minor Maintenance Activities

Maintenance Activity	Minimum Frequency	Look for:	Maintenance Action
Sediment Removal*	As needed; typically every 1 –2 years	Sediment build-up; decrease in pond volume	Remove and dispose of sediment
Erosion Repair	As needed, based upon inspection	Rills/gullies forming on side slopes, trickle channel, other areas	Repair eroded areas Revegetate; address source of erosion
Vegetation Removal/Tree Thinning	As needed, based upon inspection	Large trees/wood vegetation in lower chamber of pond	Remove vegetation; restore grade and surface
Drain Cleaning/Jet Vac	As needed, based upon inspection	Sediment build-up /non draining system	Clean drains; Jet Vac if needed

*Usually from the forebay, trickle channel, and/or micro-pool

EDB-3.7.1 Sediment Removal

Sediment removal is necessary to maintain the original design volume of the EDB and to ensure proper function of the infrastructure. Regular sediment removal (minor) from the forebay, inflow(s), and trickle channel can significantly reduce the frequency of major sediment removal activities (dredging) in the upper and lower stages. The minor sediment removal activities can typically be addressed with shovels and smaller equipment.

Stormwater sediments removed from EDBs do not meet the criteria of "hazardous waste". However, these sediments are contaminated with a wide array of organic and inorganic pollutants and handling must be done with care. Sediments from permanent pools must be carefully removed to minimize turbidity, further sedimentation, or other adverse water quality impacts. Sediments should be transported by motor vehicle only after they are dewatered. All sediments must be taken to a landfill for proper disposal. Prompt and thorough cleanup is important should a spill occur during transportation.

Frequency – Nonroutine – As necessary based upon inspections. Sediment removal in the forebay, trickle channel, and micro-pool may be necessary as frequently as every 1-2 years.

EDB-3.7.2 Erosion Repair

The repair of eroded areas is necessary to ensure the proper function of the EDB, minimize sediment transport, and to reduce potential impacts to other features. Erosion can vary in magnitude from minor repairs to trickle

channels, energy dissipaters, and rilling to major gullies in the embankments and spillways. The repair of eroded areas may require the use of excavators, earthmoving equipment, riprap, concrete, erosion control blankets, and turf reinforcement mats. Major erosion repair to the pond embankments, spillways, and adjacent to structures will require consultation with the City of Aurora Water and Engineering Staff.

Frequency – Nonroutine – As necessary based upon inspections.

EDB-3.7.3 Vegetation Removal/Tree Thinning

Dense stands of woody vegetation (willows, shrubs, etc) or trees can create maintenance problems for the infrastructure within an EDB. Tree roots can damage structures and invade pipes/channels thereby blocking flows. Also, trees growing in the upper and lower stages of the EDB will most likely have to be removed when sediment/dredging operations occur. A small tree is easier to remove than a large tree, therefore, regular removal/thinning is imperative. All trees and woody vegetation that is growing in the bottom of the EDB or near structures (inflows, trickle channels, outlet works, emergency spillways, etc) should be removed. Any trees or woody vegetation in the EDB should be limited to the upper portions of the pond banks.

Frequency – Nonroutine – As necessary based upon inspections.

EDB-3.7.4 Clearing Drains/Jet-Vac

An EDB contains many structures, openings, and pipes that can be frequently clogged with debris. These blockages can result in a decrease of hydraulic capacity and create standing water in areas outside of the micro-pool. Many times the blockage to this infrastructure can be difficult to access and/or clean. Specialized equipment (jet-vac machines) may be necessary to clear debris from these difficult areas.

Frequency – Nonroutine – As necessary based upon inspections.

EDB-3.8 Major Maintenance Activities

This work consists of larger maintenance/operational problems and failures within the stormwater management facilities. All of this work requires consultation with the City of Aurora to ensure the proper maintenance is performed. This work requires the City of Aurora Water Staff review the original design before approval of the proposed maintenance. **A public improvements permit shall be required for all major maintenance activities.** This work may also require more specialized maintenance equipment, design/details, submittal of plans to the City of Aurora for review and approval, surveying, or assistance through private contractors and consultants.

Table – EDB-4
Summary of Major Maintenance Activities

Maintenance Activity	Minimum Frequency	Look for:	Maintenance Action
Major Sediment Removal	As needed – based upon scheduled inspections	Large quantities of sediment; reduced pond capacity	Remove and dispose of sediment. Repair vegetation as needed
Major Erosion Repair	As needed – based upon scheduled inspections	Severe erosion including gullies, excessive soil displacement, areas of settlement, holes	Repair erosion – find cause of problem and address to avoid future erosion
Structural Repair	As needed – based upon scheduled inspections	Deterioration and/or damage to structural components – broken concrete, damaged pipes, outlet works	Structural repair to restore the structure to its original design

EDB-3.8.1 Major Sediment Removal

Major sediment removal consists of removal of large quantities of sediment or removal of sediment from vegetated areas. Care shall be given when removing large quantities of sediment and sediment deposited in vegetated areas. Large quantities of sediment need to be carefully removed, transported and disposed of. Vegetated areas need special care to ensure design volumes and grades are preserved.

Major sediment removal activities will require larger and more specialized equipment. The major sediment activities will also require surveying with an engineer's level, and consultation with the City of Aurora Water and Engineering Staff to ensure design volumes/grades are achieved. Pond volume recertification will be required in accordance with the City of Aurora's drainage criteria manual.

Frequency – Nonroutine – Repair as needed based upon inspections.

EDB-3.8.2 Major Erosion Repair

Major erosion repair consists of filling and revegetating areas of severe erosion. Determining the cause of the erosion as well as correcting the condition that caused the erosion should also be part of the erosion repair. Care should be given to ensure design grades and volumes are preserved. Any condition/repair affecting design grades or pond volumes requires consultation with the City of Aurora Water and Engineering Staff.

Frequency – Nonroutine – Repair as needed based upon inspections.

EDB-3.8.3 Structural Repair

An EDB includes a variety of structures that can deteriorate or be damaged during the course of use and routine maintenance. These structures are constructed of steel and concrete that can degrade or be damaged and may need to be repaired or re-constructed from time to time. These structures include items like outlet works, trickle channels, forebays, inflows and other features. In-house operations staff can perform some of the minor structural repairs. Major repairs to structures may require input from a structural engineer and specialized contractors. Consultation with the City of Aurora and Engineering Staff shall take place prior to all structural repairs.

Frequency – Nonroutine – Repair as needed based upon inspections.

Reference:

This plan is adapted from Southeast Metro Stormwater Authority, *OPERATION AND MAINTENANCE (O & M) MANUAL,* **and Town of Parker, Colorado,** *STORMWATER PERMANENT BEST MANAGEMENT PRACTICES (PBMP) LONG-TERM OPERATION AND MAINTENANCE MANUAL*, October 2004

A P P E N D I X C – 2

Grass Buffers and Grass Swales

Standard Operation Procedures
for
Inspection and Maintenance

Grass Buffers and Grass Swales
(GB-GS)

September 2010

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GB-GS-1 BACKGROUND

Grass Buffers and Grass Swales are common types of Stormwater Management Facilities utilized within the Front Range of Colorado. Grass Buffers and Grass Swales promote filtration, infiltration, and settling to reduce runoff volume.

Grass Buffers are uniformly graded and densely vegetated areas of turf grass. They are designed to accommodate sheet flow rather than concentrated or channelized flow. They are typically located adjacent to impervious areas such as parking lots or along roads. Grass Buffers are designed to evenly distribute runoff across the width of the buffer to achieve uniform sheet-flow conditions. A flow spreader may be incorporated for this purpose. In some cases, grass buffers may have underdrain systems.

Grass Swales are densely vegetated drainage ways with low-pitched side slopes that collect and convey runoff. Design of their longitudinal slope and cross section forces the flow to be slow and shallow, thereby facilitating sedimentation while limiting erosion. Berms or check dams may be installed perpendicular to the flow to decrease the slope and slow down the flow. Grass swales are used in open space and landscaped areas to collect and convey overland flows, and can be used as an alternative to curb and gutter (when approved by the City Engineer) to collect and convey street flows. Some grass swales are designed with underdrain systems.

GB-GS-2 INSPECTING GRASS BUFFERS AND SWALES (GB-GS)

GB-GS-2.1 Access and Easements

Inspection and maintenance personnel may utilize the stormwater facility map located in Appendix G containing the locations of the access points and maintenance easements of the GB-GSs within this development.

GB-GS-2.2 Stormwater Management Facilities Locations

Inspection and maintenance personnel may utilize the stormwater facility map located in Appendix G containing the locations of the GB-GSs within this development.

GB-GS-2.3 Grass Buffer - Grass Swale (GB-GS) Features

GB-GSs are unique stormwater quality facilities, in that they are typically viewed as landscaping or ground cover, and are often overlooked as water quality treatment facilities. GB-GSs have a number of features designed to serve a particular function. It is important for maintenance personnel to understand the function of each of these features. Below is a list of the common features of a Grass Swale or Grass Buffer and the corresponding maintenance inspection items anticipated:

Table GB-GS-1
Typical Inspection & Maintenance Requirements Matrix

	Sediment Removal	Mowing Weed control	Trash & Debris Removal	Erosion	Removal/ Replacement	Structural Repair
Swale Bottom	X	X	X	X		
Side Slope		X	X	X		
Buffer Strip	X	X	X	X		
Inflows	X	X	X	X	X	X
Underdrain System*					X	
Grade Control/Level Spreader				X		X
Irrigation System					X	

*If the design and inspection allows, flushing of the system may be all that is needed.

GB-GS-2.3.1 Grass Swale Bottom and Side Slopes; Grass Buffer Strips

Grass Swales and Grass Buffers require general maintenance of the turf grass and repair of any rill or gully development. The bottom and side slopes of grass swales and the area of grass buffer strips should be maintained with dense vegetative cover, and should not be eroded or bare. Inspection over the first few years will help to determine if any problems are developing.

The typical maintenance items required at the side slopes and bottoms of grass swales and within grass buffer areas are as follows:

a. Sediment Accumulation – The purpose of the grass swale or buffer is to slow down flow and allow sedimentation to occur. To prevent a loss in performance of the swale or buffer, sediment that accumulates must be removed on a timely basis.

b. Vegetation Sparse – Grass Swales and Buffers rely on a healthy, dense cover of grass to decrease the flow velocities and promote sedimentation and infiltration. Grasses that are diseased, dying or otherwise damaged should be replaced. All bare areas should be reseeded or patched. Causes which contribute to the damaged grass cover, including lack of adequate irrigation, traces of pedestrian or vehicular traffic, uncontrolled weeds, excessive sedimentation accumulation, etc., should be identified and remedied.

c. Erosion Present – Lack of adequate vegetative cover or excessive flow velocities may result in rill or gully development, and erosion of the swale or buffer strip. Erosion will require maintenance to prevent further damage to the area and to prevent sediment transport.

d. *Standing Water/Boggy Areas* – Grass swales and buffers are generally intended to drain and be dry in between rain events. If areas of standing water are present, the swale or buffer may need to be evaluated for proper grade to ensure drainage or the addition of underdrains. In some cases, where underdrains are used, the underdrains should be inspected to ensure that they are not clogged.

GB-GS-2.3.2 Inflow Points

Inflow points are the points of stormwater discharge into the swale or buffer. Inflow points are typically pipe outfalls, other grass swales or buffers, or curb cuts from upstream impervious areas, such as parking lots. Some form of energy dissipation is typically provided immediately downstream of the inflow point into the grass swale or buffer. Energy dissipation devices may include riprap aprons, or flow spreader devices.

The typical maintenance items required at inflow points are as follows:

a. Riprap Displaced/Rundown Damaged – Often, because of, the repeated impact/force of water, the riprap can shift and settle. If any portion of the riprap rundown or apron appears to have settled, if soil is present between the riprap, or if the riprap has shifted, maintenance may be required to ensure future erosion is prevented.

b. Erosion Present/Outfall Undercut – In some situations, an energy dissipater may have not been provided, or may not have been sized, constructed, or maintained appropriately and erosion has occurred. Any erosion within the vicinity of the inflow point will require maintenance to prevent damage to the structure(s) and sediment transport within the facility.

c. Sediment Accumulation – Because of the turbulence in the water created by the energy dissipater, sediment often deposits immediately downstream of the inflow point. To prevent a loss in performance, sediment that accumulates in this area must be removed on a timely basis.

GB-GS-2.3.3 Underdrain System

Some grass swales and buffers that have a flatter slope or soils which do not allow adequate percolation or are in areas with a continuous base flow may have been installed with an underdrain system. Underdrains typically consist of a layer of geotextile fabric, gravel storage area and perforated PVC pipe. The geotextile fabric is utilized to prevent the filter material from entering the underdrain system. The gravel storage area allows for storage of treated stormwater runoff prior to the discharge of the runoff through the perforated PVC pipe.

The typical maintenance activities required for the underdrain system are as follows:

With proper maintenance of the grassed areas, there should be a minimum amount of maintenance required on the underdrain system. Generally the only maintenance performed on the underdrain system is jet-vac cleaning in the event it becomes clogged.

GB-GS-2.3.4 Grade Control Level Spreader

Grass swales installed in areas with steep longitudinal slopes often necessitate the use of grade control checks or drop structures. Grade control structures are typically either concrete walls or rip rap structures that serve to provide a reinforced drop at specific locations in the channel, reducing the longitudinal slope between the control structures.

Level Spreaders are installed on the upstream of grass buffers to evenly distribute flows along the design length. Level spreaders may consist of slotted curbing, modular block porous pavement, level walls or other spreader devices.

The typical maintenance activities required for grade control structures and level spreaders are as follows:

a. Erosion present – Grade control structures and level spreaders are provided to reduce the potential for erosion of the grassed swale or buffer areas. Erosion within the vicinity of the control structure or level spreader indicates the structure is not functioning as intended and requires maintenance to prevent future erosion and damage. Or, review the original design if erosion becomes chronic.

b. Structural damage – Structural damage can occur at anytime along the life of the facility. Typically, structural damage occurs with the deterioration of concrete, including cracking, spalling or settling and the erosion and deterioration of the riprap structures. Level spreaders may settle unevenly creating low areas, which concentrate the flows. Partial or full replacement may be required depending on the extent of the damage.

GB-GS-2.3.5 Irrigation

Grass Buffers and Grass Swales depend on healthy, dense turf grass to function, and therefore require an irrigation system, to provide a consistent water supply. Typically, the condition of the grass cover will provide evidence of the effectiveness and maintenance needs of the irrigation system.

The typical maintenance activities required for irrigation systems are as follows:

Irrigation systems will generally require routine periodic maintenance and adjustment to ensure proper amounts of water are being applied given the weather conditions, and that they are providing coverage to all areas of the grass to eliminate bare spots.

GB-GS-2.3.6 Miscellaneous

There are a variety of inspection/maintenance issues that may not be attributed to a single feature within the GB-GS. This category on the inspection form is for maintenance items commonly found in the GB-GS, but may not be attributed to an individual feature.

a. Encroachment in Easement Area – The City of Aurora requires GB-GS be located in tracts or drainage easements. Property owners may not place landscaping, trash, fencing, or other items within the easement area that may adversely affect maintenance or the operation of the facility.

b. Public Hazards – Public hazards include items such as containers of unknown/suspicious substances, and exposed metal/jagged concrete on structures. **If any unkown/suspicious hazard is found within the facility area that poses an immediate threat to public safety, call 911 immediately.**

c. Burrowing Animals/Pests– Prairie dogs and other burrowing rodents may cause damage to the GB-GS features and negatively affect the vegetation within the GB-GS.

d. Other – Any miscellaneous inspection/maintenance items not contained on the form should be entered here.

GB-GS-2.4 Inspection Forms

GB-GS Inspection forms are located in Appendix D. Inspection forms shall be completed by the person(s) conducting the inspection activities. Each form shall be reviewed and submitted by the property owner or property manager to the City of Aurora per the requirements of the Inspection and Maintenance Plan. These inspection forms shall be kept indefinitely and made available to the City of Aurora upon request

GB-GS-3 MAINTAINING GRASS BUFFERS & GRASS SWALES (GB-GS)

GB-GS-3.1 Maintenance Personnel

Maintenance personnel must be experienced to properly maintain GB-GSs. Inadequately trained personnel can cause additional problems resulting in additional maintenance costs.

GB-GS-3.2 Equipment

It is imperative the appropriate equipment and tools are taken to the field with the operations crew. The types of equipment/tools will vary depending on the task at hand. Below is a basic list of tools, equipment, and material(s) that may be necessary to perform maintenance on a GB-GS:

1.) Mowing Tractors
2.) Trimmers (extra string)
3.) Shovels
4.) Rakes
5.) All Surface Vehicle (ASVs)
6.) Engineers Level (laser)
7.) Erosion Control Blanket(s)
8.) Mulch
9.) Sod or Seed (See seed mix in the *Rules and Regulations Regarding Stormwater (Quality) Discharge for Construction Activities*, Std Det. SM, Seeding & Mulching)
10.) Illicit Discharge Cleanup Kits
11.) Trash Bags
12.) Jet-Vac Equipment
13.) Stormwater Facility Inspection and Maintenance Plan

Some of the items identified above may not be needed for every maintenance operation. However, this equipment should be available to the maintenance operations crews should the need arise.

GB-GS-3.3 Maintenance Forms

The GB-GS Maintenance Form provides a record of each maintenance operation performed by maintenance contractors. The GB-GS Maintenance Form shall be filled out in the field after the completion of the maintenance operation. Each form shall be reviewed and submitted by the property owner or property manager to the City of Aurora per the requirements of the Inspection and Maintenance Plan. The GB-GS Maintenance form is located in Appendix E.

GB-GS-3.4 Maintenance Categories and Activities

A typical GB-GS Maintenance Program will consist of three broad categories of work: Routine, Minor and Major. Within each category of work, a variety of maintenance activities can be performed on a GB-GS. A maintenance activity can be specific to each feature within the GB-GS, or general to the overall facility. This section of the SOP explains each of the categories and briefly describes the typical maintenance activities for a GB-GS.

A variety of maintenance activities are typical of GB-GSs. The maintenance activities range in magnitude from routine trash pickup to the reconstruction of the GB-GS or underdrain system. Below is a description of each maintenance activity, the objectives, and frequency of actions.

GB-GS-3.5 Routine Maintenance Activities

The majority of this work consists of scheduled mowing, trash and debris pickups and landscape care for the GB-GS during the growing season. It also includes activities such as weed control. These activities normally will be performed numerous times during the year. These items do not require any prior approval by the City of Aurora, however, completed inspection and maintenance forms shall be submitted to the City of Aurora for each inspection and maintenance activity in accordance with the Inspection and Maintenance plan.

The Routine Maintenance Activities are summarized below, and further described in the following sections.

Table GB-GS-2
Summary of Routine Maintenance Activities

Maintenance Activity	Minimum Frequency	Indication Action is Needed:	Maintenance Action
Trash/Debris Removal	Twice annual and before mowing	Trash & debris in GB-GS	Remove and properly dispose of trash and debris
Mowing	Routine – as necessary to maintain 2" – 4" grass height	Excessive grass height/aesthetics	2"-4" grass height for turf grass; 4" to 6" for native grass
Irrigation (Automatic)	Three times annually	Areas of insufficient or excess watering; broken or missing parts	SPRING: start up system; test for even coverage and correct timer settings SUMMER: test for even coverage and correct timer settings FALL: drain and winterized system (follow watering regulations)
Irrigation (Not Automatic)	As needed to maintain healthy grass	Areas of insufficient or excess watering	Water as needed to maintain healthy grass; (follow watering regulations)
Weed Control	Minimum twice annually	Noxious weeds; Unwanted vegetation	Treat w/herbicide or hand pull; consult a local Weed Inspector
Mosquito Treatment	As needed, based upon inspections	Standing water/ mosquito habitat	Perform maintenance to eliminate standing water*; Treat w/ EPA approved chemicals
Level Spreader (Grass Buffer only)	As needed, based upon inspections	Evidence of uneven flow/localized erosion	Look for cause; repair, fill or revegetate areas of erosion
Rodent Damage	As needed, based upon inspections	Holes, small piles of dirt, raised burrows	Evaluate damage; contact PROS or Division of Wildlife for guidance

*See Section GB-GS-2.3.1d for further discussion

GB-GS-3.5.1 Trash/Debris Removal

Trash and debris must be removed from the GB-GS area to allow for proper functioning and to improve aesthetics. This activity must be performed prior to mowing operations.

Frequency – Routine – Prior to mowing operations and a minimum of twice annually.

GB-GS-3.5.2 Mowing

Routine mowing of the turf grass embankments is necessary to maintain an appropriate grass height and to improve the overall appearance of the GB-GS. Turf grass should be mowed to a height of 2 to 4- inches (4 – 6- inches for native grass) and shall be bagged to prevent potential contamination of the filter media, especially if there is an underdrain system.

Frequency – Routine – as necessary to maintain grass height.

GB-GS-3.5.3 Irrigation

Irrigation systems should be maintained in proper working order to provide an adequate water supply to support the grass cover. When automatic irrigation systems are not available, alternate methods for providing a water supply during times of drought must be provided.

Automatic irrigation systems should be maintained routinely throughout the growing season to ensure that they are providing the appropriate amounts of water, and are providing complete coverage of the area. Sprinkler heads should be adjusted as necessary, and checked for broken or missing parts.

Frequency - Routine as needed throughout the growing season, plus the following:

SPRING: Start up the system and test for even coverage and correct timer settings.
SUMMER: Test for even coverage and correct timer settings.
FALL: Drain and winterize the system.

GB-GS-3.5.4 Weed Control

Noxious weeds and other unwanted vegetation must be treated as needed throughout the GB-GS. This activity can be performed either through mechanical means (mowing/pulling) or with herbicide. Consultation with a local Weed Inspector is highly recommended prior to the use of herbicide. Herbicides should be utilized sparingly and as a last resort. All herbicide applications should be in

accordance with the manufacturer's recommendations.

Frequency – Routine – As needed based upon inspections.

GB-GS-3.5.5 Mosquito Treatment

GB-GS facilities are intended to drain, and should not have areas of standing water which creates mosquito habitat. Causes of the standing water or boggy conditions should be investigated and remediated as necessary to eliminate the standing water. Only EPA approved chemicals should be applied in accordance with the recommendations of the manufacturer. See Section GB-GS-2.3.1d.

Frequency – As needed based upon inspections.

GB-GS-3.5.6 Level Spreader (Grass Buffer only)

Evidence of uneven flow and localized erosion downstream of the level spreader indicates the flow is not evenly distributed along the length of the spreader. Areas of erosion should be repaired, filled and revegetated. Causes for the erosion should be investigated and repaired.

Frequency – As needed based upon inspections.

GB-GS-3.5.7 Rodent Damage

Small holes, piles of dirt, and raised burrows are evidence of rodent damage. Damaged areas should be repaired and revegetated. Consultation with an animal control specialist or the Division of Wildlife may be required for persistent problems.

Frequency – As needed based on inspections.

GB-GS-3.6 Minor Maintenance Activities

This work consists of a variety of isolated or small-scale maintenance/operational problems. Most of this work can be completed by a small crew, hand tools, and small equipment. These items require approval by the City of Aurora. Completed inspection and maintenance forms shall be submitted to the City of Aurora for each inspection and maintenance activity.

Table GB-GS-3
Summary of Minor Maintenance Activities

Maintenance Activity	Minimum Frequency	Indication Action is Needed:	Maintenance Action
Sediment Removal	As needed.	Sediment build-up.	Remove and properly dispose of sediment
Erosion Repair	As needed, based upon inspection	Rills and gullies forming on slopes and other areas	Repair eroded areas & revegetate; address cause
Vegetation Removal	As needed, based upon inspection	Trees, willows, shrubs impeding flow	Remove vegetation; restore correct grade and surface
Revegetation	As needed, based upon inspection	Areas without grass	Replace grass by sodding or seeding
Irrigation (Automatic)	As needed, based upon inspection.	Evidence of broken or missing parts	Replace parts and test system
Level Spreader (Grass Buffer Only)	As needed, based upon inspection.	Evidence of uneven flow; erosion; or rills/gullies	Repair sections of level spreader and address cause
Fertilization or Soil Amendment	As needed, minimize fertilization	Grass with pale color; areas with poor grass growth not due to irrigation problems	Consult with turf specialist; Test soil
Vehicle Tracks (Along Roadways)	As needed, based upon inspection	Depressions from vehicle tracks; vegetation damage	Repair and fill depressions; sod or seed damaged areas

GB-GS-3.6.1 Sediment Removal

Sediment removal is necessary to ensure proper function of the grass swale or buffer. Care should be taken when removing sediment to prevent damage to the turf grass and surrounding areas. Excessive amounts of sediment are an indication of upstream erosion or lack of adequate BMPs during construction activities. Causes for contributions of excess sediment should be investigated and addressed.

Frequency – As needed based upon inspections.

GB-GS-3.6.2 Erosion Repair

The repair of eroded areas is necessary to ensure the proper functioning of the GB-GS, to minimize sediment transport, and to reduce potential impacts to other features. Erosion can vary in magnitude from minor repairs to vegetation and embankments, to rills and gullies in the embankments and inflow points. The repair of eroded areas may require the use of excavators, riprap, new poured-in-

place concrete, and sod. Extreme care should be taken when utilizing motorized or heavy equipment to ensure damage to the underdrain system, if present, does not occur. Major erosion in a GS-GB is generally the result of excessive velocities caused by steep slopes. It may be necessary to make design improvements to the swale or buffer when erosion becomes a major maintenance item.

Frequency – As necessary, based upon inspections.

GB-GS-3.6.3 Vegetation Removal

Weeds, Shrubs, Willows and other unwanted vegetation that develops in the grass swale or buffer area may impede the flow and cause standing water or back flow problems. It is necessary to remove unwanted vegetation as soon as it appears. Remove the unwanted vegetation, and restore the correct grade. Revegetate with seed or sod. Supplement irrigation as needed until new vegetation is sufficiently established.

Frequency – As necessary, based upon inspections.

GB-GS -3.6.4 Revegetation

Bare areas should be repaired as soon as possible. Repair bare areas with appropriate grass seed or sod. Supplement irrigation as needed until new vegetation is sufficiently established. Causes of the problem, such as inadequate water supply or diseased grasses, should be investigated and resolved.

Frequency – As necessary, based upon inspections.

GB-GS-3.6.5 Irrigation (Automatic)

Irrigation systems require routine maintenance in accordance with the manufacturer's recommendations (valves, timer, etc.), and maintenance of the pipe and heads to ensure even coverage is being applied, and there are no missing or broken parts. Timing systems should be checked to verify the correct amount of water is being applied to the grassed areas for the seasonal conditions.

Frequency – As necessary, based upon inspections.

GB-GS-3.6.6 Level Spreader

Level Spreaders that are no longer level, or have developed damaged areas of cracking or spalling, allow flows to concentrate in these depressed areas instead of being distributed over the length of the structure. Also, build up of grasses

along the edge of the spreader may create an uneven flow distribution. Rills, gullies and other erosion that develop downstream of level spreaders should be repaired and reseeded or sodded. Causes of the erosion should be investigated and addressed.

Frequency – As necessary, based upon inspections.

GB-GS-3.6.7 Fertilization/Soil Amendment

Grass Buffers and Swales rely on healthy, dense turf in order to function properly. Grasses that appear to be diseased, dying or unhealthy may require amendments. Fertilizers should be applied in the minimum amounts recommended by the manufacturer. Check for insect infestation also.

Frequency – As necessary, based upon inspections.

GB-GS-3.6.8 Vehicle Tracks

GB-GSs adjacent to roadway sections or drive aisles in parking lots may be damaged by vehicle tracks. Rutted areas should be filled in and revegetated as soon as possible. Frequent problems associated with vehicle traffic (such as around corners) may require a barrier or sign to avoid vehicular traffic within the grassed areas.

Frequency – As necessary, based upon inspections.

GB-GB-3.7 Major Maintenance Activities

This work consists of larger maintenance/operational problems and failures within the stormwater management facilities. All of this work requires consultation with the City of Aurora Water Staff to ensure the proper maintenance is performed. This work requires the City of Aurora Water and Engineering Staff review the original design and construction drawings to assess the situation before approval of the proposed maintenance. This work may also require more specialized maintenance equipment, design/details, submittal of plans to the City of Aurora for review and approval, surveying, or assistance through private contractors and consultants.

Table GB-GS-4
Summary of Major Maintenance Activities

Maintenance Activity	Minimum Frequency	Look for:	Maintenance Action
Major Sediment/Pollutant Removal	As needed – based upon scheduled inspections	Large quantities of sediment	Remove and dispose of sediment. Repair vegetation as needed
Major Erosion Repair	As needed – based upon scheduled inspections	Severe erosion including gullies, excessive soil displacement, areas of settlement, holes	Repair erosion – find cause of problem and address to avoid future erosion
Structural Repair	As needed – based upon scheduled inspections	Deterioration and/or damage to structural components – level spreader, grade control structures, irrigation components, and ponding water.	Structural repair to restore the structure to its original design
GB-GS Rebuild	As needed – due to complete failure of BMP	Removal of filter media and underdrain system	Contact City of Aurora Water Staff

GB-GS-3.7.1 Major Sediment/Pollutant Removal

Major sediment removal consists of removal of large quantities of pollutants/sediment /landscaping material. Stormwater sediments removed from GB-GSs do not meet the regulatory definition of "hazardous waste". However, these sediments can be contaminated with a wide array of organic and inorganic pollutants and handling must be done with care to insure proper removal and disposal. Sediments should be transported by motor vehicle only after they are dewatered. All sediments must be taken to a licensed landfill for proper disposal. Should a spill occur during transportation, prompt and thorough cleanup and disposal is imperative. Vegetated areas need special care to ensure design volumes and grades are preserved or may need to be replaced due to the removal activities.

Frequency – Non-routine – Repair as needed, based upon inspections.

GB-GS-3.7.2 Major Erosion Repair

Major erosion repair consists of filling and revegetating areas of severe erosion. Determining the cause of the erosion as well as correcting the condition that caused the erosion should also be part of the erosion repair. Care should be given to ensure design grades and volumes are preserved.

Frequency – Non-routine – Repair as needed, based upon inspections.

GB-GS-3.7.3 Structural Repair

A GB-GS generally includes level spreader and grade control structure that can deteriorate or be damaged during the service life of the facility. These structures are constructed of steel and concrete that can degrade or be damaged and may need to be repaired or re-constructed from time to time. Major repairs to structures may require input from a structural engineer and specialized contractors. Consultation with the City of Aurora Water and Engineering Staff shall take place prior to all structural repairs.

Frequency – Non-routine – Repair as needed, based upon inspections.

GB-GS-3.7.4 GB-GS Rebuild

In very rare cases, a GB-GS may need to be rebuilt. Generally, the need for a complete rebuild is a result of improper construction, improper maintenance resulting in structural damage to the underdrain system, if present, or extensive contamination of the GB-GS. Consultation with the City of Aurora Water and Engineering Staff shall take place prior to any rebuild project.

Frequency – Non-routine – As needed based upon inspections.

Reference:

This plan is adapted from Southeast Metro Stormwater Authority, *OPERATION AND MAINTENANCE (O & M) MANUAL,* **and the Douglas County, Colorado,** *STANDARD OPERATING PROCEDURE FOR EXTENDED DETENTION BASIN (EDB) INSPECTION AND MAINTENANCE,* July 2005

A P P E N D I X C – 3

Bioretention Cell

aka

Porous Landscape Detention

Standard Operation Procedures
for
Inspection and Maintenance

Bioretention Cell (BRCs)
aka
Porous Landscape Detention (PLDs)

September 2010

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BRC/PLD-1 BACKGROUND

Bioretention Cell (BRC) aka Porous Landscape Detention (PLD) is a common type of Stormwater Management Facility utilized within the Front Range of Colorado. BRCs/PLDs consist of a low-lying vegetated area underlain by a sand bed with an underdrain pipe. A shallow surcharge zone exists above the BRC/PLD for temporary storage of the Water Quality Capture Volume (WQCV). During a storm, accumulated runoff ponds in the vegetated 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 sewer. The BRC/PLD provides for filtering, adsorption, and biological uptake of constituents in stormwater[1]. The popularity of BRCs/PLDs has increased because they allow the WQCV to be provided on a site that has little open area available for stormwater management.

BRC/PLD-2 INSPECTING BIORETENTION CELL (CELL) aka POROUS LANDSCAPE DETENTION (PLD)

BRC/PLD-2.1 Access and Easements

Inspection or maintenance personnel may utilize the stormwater facility map located in Appendix G containing the locations of the access points and maintenance easements of the BRCs/PLDs within this development.

BRC/PLD-2.2 Stormwater Management Facilities Locations

Inspection or maintenance personnel may utilize the stormwater facility map located in Appendix G containing the locations of the BRCs/PLDs within this development.

BRC/PLD-2.3 Bioretention Cell (BRC) aka Porous Landscape Detention (PLD) Features

BRCs/PLDs have a number of features designed to serve a particular function. Many times the proper function of one feature depends on another. It is important for maintenance personnel to understand the function of each of these features to prevent damage to any feature during maintenance operations. Below is a list and description of the most common features within a BRC/PLD and the corresponding maintenance inspection items anticipated:

[1] Design of Stormwater Filtering Systems, Centers for Watershed Protection, December 1996

Table BRC/PLD-1
Typical Inspection & Maintenance Requirements Matrix

	Sediment Removal	Mowing Weed control	Trash/ Debris Removal	Erosion	Overgrown Vegetation Removal	Removal/ Replacement	Structure Repair
Inflow Points	X		X				X
Landscaping	X	X	X	X	X		
Filter Media	X	X	X	X	X	X	
Underdrain System						X	
Overflow Outlet Works	X		X				X
Embankment		X	X	X	X		

BRC/PLD-2.3.1 Inflow Points

Inflow points or outfalls into BRCs/PLDs are the point of stormwater discharge into the facility. An inflow point is commonly a curb cut with a concrete or riprap rundown. In limited cases, a storm sewer pipe outfall with a flared end section may be the inflow point into the BRC/PLD.

An energy dissipater (riprap or concrete wall) is typically immediately downstream of the discharge point into the BRC/PLD to protect the BRC/PLD from erosion. In some cases, the storm sewer outfall can have a toe-wall or cut-off wall immediately below the structure to prevent undercutting of the outfall from erosion.

The typical maintenance items required at inflow points are as follows:

a. Riprap Displaced – Many times, because of the repeated impact/force of water, the riprap can shift and settle. If any portion of the riprap rundown or apron appears to have settled, soil is present between the riprap, or the riprap has shifted, maintenance may be required to ensure future erosion is prevented.

b. Erosion Present/Outfall Undercut – In some situations, the energy dissipater may not have been sized, constructed, or maintained appropriately and erosion has occurred. Any erosion within the vicinity of the inflow point will require maintenance to prevent damage to the structure(s) and sediment transport within the facility. It is imperative material utilized to correct erosion problems within the filter media meets the requirements for filter media as shown on the approved construction drawings.

c. Sediment Accumulation – Because of the turbulence in the water created by the energy dissipater, sediment often deposits immediately downstream of the inflow point. To prevent a loss in performance of the upstream

infrastructure, sediment that accumulates in this area must be removed on a timely basis.

d. Structural Damage – Structural damage can occur at anytime during the life of the facility. Typically, for an inflow, the structural damage occurs to the concrete or riprap rundown or pipe flared end section (concrete, HDPE, or steel). Structural damage can lead to additional operating problems with the facility, including loss of hydraulic performance.

BRC/PLD-2.3.2 Landscaping

The landscaped area consists of specific plant materials and associated landscaping mulch in the bottom of the BRC/PLD. These plantings provide several functions for the BRC/PLD. Planting not only provides an aesthetic value for the BRC/PLD, but in many cases assists with biological uptake or removal of pollutants.

The plants are carefully selected for use in the BRCs/PLDs. Plants utilized in BRCs/PLDs must be able to grow in dry sandy soils but also be able to withstand frequent inundation by stormwater runoff. These plants also must be able to withstand a variety of pollutants commonly found in stormwater runoff. In addition, plants utilized in BRCs/PLDs cannot have a deep extensive root system that may cause maintenance difficulty or damage to the facility.

The typical maintenance activities required within the landscape areas are as follows:

a. Woody Growth/Weeds Present – Undesirable vegetation can grow in and around the landscaped area in the BRC/PLD that can significantly affect the performance of the facility. This type of vegetation includes dense areas of shrubs (willows), grasses and noxious weeds. If undesired vegetation is not routinely mowed/removed, the growth can cause debris/sediment to accumulate, resulting in blockage of the filter media. Also, shrub, grass and weed roots can cause damage to the filter media and underdrain system. Routine management is essential to prevent more extensive and costly future maintenance.

b. General Landscape Care – The landscape elements of the BRC/PLD are the same as any other landscape area and need to be provided with regular care. Landscape mulch will need to be removed and replaced to ensure the aesthetics of the BRC/PLD.

BRC/PLD-2.3.3 Filter Media

The filter media is the main pollutant removal component of the BRC/PLD. The filter media generally consists of 18-inches of a mixture of washed sand and

peat. The filter media removes pollutants through several different processes, including sedimentation, filtration, absorption, infiltration and microbial uptake.

Sedimentation is accomplished by the slow release of stormwater runoff through the filter media. This slow release allows sediment particles to be deposited on the top layer of the filter media where they are easily removed through routine maintenance. Other pollutants are also removed through this process because many pollutants utilize sediment as a transport mechanism.

Filtration is the main pollutant removal mechanism of BRCs/PLDs. When the stormwater runoff migrates down through the filter media, many of the particulate pollutants are physically strained out as they pass through the filter bed of sand and are trapped on the surface or among the pores of the filter media.[2]

Absorption results from the peat utilized in the filter media. Organic materials have a natural ability to attach to soluble nutrients, metals and organic pollutants. This attachment then prevents these pollutants from leaving the BRC/PLD.

BRCs/PLDs not lined with an impervious liner allow for infiltration into the native soils. This process also allows for additional pollutant removal.

Microbes that naturally occur in the filter media can assist with pollutant removal by breaking down organic pollutants.

The typical maintenance activities required within the filter media areas are as follows:

a. Infiltration Rate Check – The infiltration rate of the BRC/PLD needs to be checked in order to ensure proper functioning of the BRC/PLD. Generally, a BRC/PLD should drain completely within 12-hours of a storm event. If drain times exceed the 12-hour drain time then maintenance of the filter media shall be required.

b. Sediment Removal – Although BRCs/PLDs should not be utilized in areas where large concentrations of sediment may enter the BRC/PLD, it is inevitable that some sediment will enter the BRC/PLD.

c. Filter Replacement - The top layers of the filter media are the most susceptible to pollutant loading and therefore may need to be removed and disposed of properly on a semi-regular basis when infiltration rates slow.

[2] Design of Stormwater Filtering Systems, Centers for Watershed Protection, December 1996

BRC/PLD-2.3.4 Underdrain System

The underdrain system consists of a layer of geotextile fabric, gravel storage area and perforated PVC pipes. The geotextile fabric is utilized to prevent the filter media from entering the underdrain system. The gravel storage area allows for storage of treated stormwater runoff prior to the discharge of the runoff through the perforated PVC pipe.

The typical maintenance activities for the underdrain system are as follows:

With proper maintenance of the landscape areas and filter media, there should be a minimum amount of maintenance required on the underdrain system. Generally the only maintenance performed on the underdrain system is jet-vac cleaning.

BRC/PLD-2.3.5 Overflow Outlet Works

Generally, the initial runoff ("first flush") or WQCV during the storm event contains the majority of the pollutants. BRCs/PLDs are designed to treat only the WQCV and any amount over the WQCV is allowed to go to a detention facility without water quality treatment. The overflow outlet works allows runoff amounts over the WQCV to exit the BRC/PLD to the detention facility. The outlet works is typically constructed of a reinforced concrete box in the embankment of the BRC/PLD. The concrete structure typically has a steel grate to trap litter and other debris from entering the storm sewer system. Proper inspection and maintenance of the outlet works is essential in ensuring the long-term operation of the BRC/PLD.

The most typical maintenance items found with overflow outlet works are as follows:

a. Structural Damage - The overflow outlet structure is primarily constructed of concrete, which can crack, spall, and settle. The steel grate on the overflow outlet structure is also susceptible to damage.

b. Woody Growth/Weeds Present – The presence of plant material not part of the original landscaping, such as wetland plants or other woody growth, can clog the overflow outlet works during a larger storm event, causing flooding damage to adjacent areas. This plant material may indicate a clogging of the filter media and may require additional investigation.

c. Trash/Debris – Trash and debris can accumulate in the upper area after large events, or from illegal dumping. Over time, this material can clog the BRC/PLD outlet works.

BRC/PLD-2.3.6 Embankments

Some BRCs/PLDs utilize irrigated turf grass embankment to store the WQCV.

The typical maintenance activities required with the embankments areas are as follows:

a. Vegetation Sparse – The embankments are one of the most visible parts of the BRC/PLD, and therefore aesthetics is important. Adequate and properly maintained vegetation can greatly increase the overall appearance of the BRC/PLD. Vegetation can reduce the potential for erosion and subsequent sediment transport to the filter media, thereby reducing the need for more costly maintenance.

b. Erosion – Inadequate vegetative cover may result in erosion of the embankments. Erosion that occurs on the embankments can cause clogging of the filter media. Repair to these erosion areas including revegetation is required.

BRC/PLD-2.3.7 Miscellaneous

There are a variety of inspection/maintenance issues that may not be attributed to a single feature within the BRC/PLD. This category on the inspection form is for maintenance items that are commonly found in the BRC/PLD, but may not be attributed to an individual feature.

a. Encroachment in Easement Area – Private lots/property can sometimes be located very close to the BRCs/PLDs, even though the City of Aurora requires BRCs/PLDs be located, at a minimum, within drainage easements. Property owners may not place landscaping, trash, fencing, or other items within the easement area that may adversely affect maintenance or the operation of the facility.

b. Graffiti/Vandalism – Vandals can cause damage to the BRC/PLD infrastructure. If criminal mischief is evident, the inspector should forward this information to the Aurora Police Department.

c. Public Hazards – Public hazards include items such as containers of unknown/suspicious substances, and exposed metal/jagged concrete on structures. **If any unkown/suspicious hazard is found within the facility area that poses an immediate threat to public safety, call 911 immediately.**

d. Other – Any miscellaneous inspection/maintenance items not contained on the form should be entered here.

BRC/PLD-2.4 Inspection Forms

BRC/PLD Inspection forms are located in Appendix D. Inspection forms shall be completed by the person(s) conducting the inspection activities. Each form shall be reviewed and submitted by the property owner or property manager to the City of Aurora per the requirements of the Inspection and Maintenance Plan. These inspection forms shall be kept indefinitely and made available to the City of Aurora upon request.

BRC/PLD-3 MAINTAINING BIORETENTION CELL aka POROUS LANDSCAPE DETENTIONS (PLD)

BRC/PLD-3.1 Maintenance Personnel

Maintenance personnel must be experienced to properly maintain BRCs/PLDs. Inadequately trained personnel can cause additional problems resulting in additional maintenance costs.

BRC/PLD-3.2 Equipment

It is imperative the appropriate equipment and tools are taken to the field with the operations crew. The types of equipment/tools will vary depending on the task at hand. Below is a basic list of tools, equipment, and material(s) that may be necessary to perform maintenance on a BRC/PLD:

1.) Mowing Tractors
2.) Trimmers (extra string)
3.) Shovels
4.) Rakes
5.) All Surface Vehicle (ASVs)
6.) Skid Steer
7.) Back Hoe
8.) Track Hoe/Long Reach Excavator
9.) Dump Truck
10.) Jet-Vac Machine
11.) Engineers Level (laser)
12.) Riprap (Minimum - Type M)
13.) Geotextile Fabric
14.) Erosion Control Blanket(s)
15.) Sod
16.) Illicit Discharge Cleanup Kits

17.) Trash Bags

18.) Tools (wrenches, screw drivers, hammers, etc)

19.) Confined Space Entry Equipment

20.) Approved Stormwater Facility Inspection and Maintenance Plan

21.) ASTM C-33 Sand

22.) Peat

23.) Wood Landscaping Mulch

Some of the items identified above may not be needed for every maintenance operation. However, this equipment should be available to the maintenance operations crews should the need arise.

BRC/PLD-3.3 BRC/PLD Maintenance Forms

The BRC/PLD Maintenance Form provides a record of each maintenance operation performed by maintenance contractors. The BRC/PLD Maintenance Form shall be filled out in the field after the completion of the maintenance operation. Each form shall be reviewed and submitted by the property owner or property manager to the City of Aurora per the requirements of the Inspection and Maintenance Plan. The BRC/PLD Maintenance form is located in Appendix E.

BRC/PLD-3.4 BRC/PLD Maintenance Categories and Activities

A typical BRC/PLD Maintenance Program will consist of three broad categories of work: Routine, Minor and Major. Within each category of work, a variety of maintenance activities can be performed on a BRC/PLD. A maintenance activity can be specific to each feature within the BRC/PLD, or general to the overall facility. This section of the SOP explains each of the categories and briefly describes the typical maintenance activities for a BRC/PLD.

A variety of maintenance activities is typical of BRCs/PLDs. The maintenance activities range in magnitude from routine trash pickup to the reconstruction of the BRC/PLD filter media or underdrain system. Below is a description of each maintenance activity, the objectives, and frequency of actions:

BRC/PLD-3.5 Routine Maintenance Activities

The majority of this work consists of scheduled mowings, trash and debris pickups and landscape care for the BRC/PLD during the growing season. It also includes activities such as weed control. These activities normally will be performed numerous times during the year. These items do not require any prior approval by the City of Aurora, however, completed inspection and maintenance forms shall be submitted to the City of Aurora for each inspection and maintenance activity in accordance with the Inspection and Maintenance Plan.

The Routine Maintenance Activities are summarized below, and further described in the following sections.

Table BRC/PLD-2
Summary of Routine Maintenance Activities

Maintenance Activity	Minimum Frequency	Look for:	Maintenance Action
Mowing	Twice annually	Excessive grass height/aesthetics	2"-4" grass height
Trash/Debris Removal	Twice annually	Trash & debris in BRC/PLD	Remove and dispose of trash/debris
Overflow Outlet Works Cleaning	As needed - after significant rain events – twice annually minimum	Clogged outlet structure; ponding water above outlet elevation	Remove and dispose of debris/trash/sediment to allow outlet to function properly
Weed Control	As needed, based upon inspection	Noxious weeds; Unwanted vegetation	Treat w/herbicide or hand pull; consult a local Weed Inspector

BRC/PLD-3.5.1 Mowing

Routine mowing of the turf grass embankments is necessary to improve the overall appearance of the BRC/PLD. Turf grass should be mowed to a height of 2 to 4-inches and shall be bagged to prevent potential contamination of the filter media.

Frequency – Routine - Minimum of twice annually or depending on aesthetics.

BRC/PLD-3.5.2 Trash/Debris Removal

Trash and debris must be removed from the entire BRC/PLD area to minimize outlet clogging and to improve aesthetics. This activity must be performed prior to mowing operations.

Frequency – Routine – Prior to mowing operations and minimum of twice annually.

BRC/PLD-3.5.3 Overflow Outlet Works Cleaning

Debris and other materials can clog the overflow outlet work's grate. This activity must be performed anytime other maintenance activities are conducted to ensure proper operation.

Frequency - Routine – After significant rainfall event or concurrently with other maintenance activities.

BRC/PLD-3.5.4 Weed Control

Noxious weeds and other unwanted vegetation must be treated as needed throughout the BRC/PLD. This activity can be performed either through mechanical means (mowing/pulling) or with herbicide. Consultation with a local Weed Inspector is highly recommended prior to the use of herbicide. Herbicides should be utilized sparingly and as a last resort. All herbicide applications should be in accordance with the manufacturer's recommendations.

Frequency – Routine – As needed based on inspections.

BRC/PLD-3.6 MINOR MAINTENACE ACTIVITIES

This work consists of a variety of isolated or small-scale maintenance/operational problems. Most of this work can be completed by a small crew, hand tools, and small equipment. These items require approval by the City of Aurora Water Staff. Completed inspection and maintenance forms shall be submitted to City of Aurora for each inspection and maintenance period. In the event the BRC/PLD needs to be dewatered, care should be given to ensure sediment, filter material and other pollutants are not discharged. All dewatering activities shall be coordinated with the City of Aurora Water Staff.

Table BRC/PLD-3
Summary of Minor Maintenance Activities

Maintenance Activity	Minimum Frequency	Look for:	Maintenance Action
Sediment/Pollutant Removal	As needed; Based on infiltration test	Sediment build-up; decrease in infiltration rate	Remove and dispose of sediment
Erosion Repair	As needed, based upon inspection	Rills/gullies forming on embankments	Repair eroded areas & revegetate; address cause
Jet Vac/Cleaning underdrain system	As needed, based upon inspection	Sediment build-up /non draining system	Clean drains; Jet-Vac if needed

BRC/PLD-3.6.1 Sediment/Pollutant Removal

Sediment/Pollutant removal is necessary to ensure proper function of the filter media. The infiltration rate of the BRC/PLD needs to be checked in order to ensure proper functioning of the BRC/PLD. Generally, a BRC/PLD should drain completely within 12-hours of a storm event. If drain times exceed the 12-hour drain time then maintenance of the filter media shall be required.

Generally, the top 3-inches of filter media should be removed at each removal period. Additional amounts of filter media may need to be removed if deeper sections of the filter media are contaminated. New filter media will need to replace the removed filter media. It is critical only sand meeting the American Society for Testing and Materials (ASTM) C-33 standard be utilized in the replacement of the filter media (Note: The update to the UDFCD's Volume III manual, to be released in late 2010, may have new filter media guidelines).

ASTM C-33 Sand Standard

US Standard Sieve Size (Number)	Total Percent Passing (%)
9.5 mm (3/8 inch)	100
4.75 mm (No. 4)	95-100
2.36 mm (No. 8)	80-100
1.18 mm (No. 16)	50-85
600μm (No. 30)	25-60
300μm (No.50)	10-30
150μm (No. 100)	2-10

In addition, only Peat Moss meeting the following specifications shall be utilized with the filter media.

pH (Units)	**7.6**
Total Salts (MMHOS/CM, 1:5)	**2.28**
Organic Matter (%)	**20.22**
Moisture (%)	**21.43**
Dry Matter Basis:	
Nitrogen - Total (%)	**0.780**
Nitrogen - Organic (%)	**0.773**
Nitrogen - Ammonia (PPM)	**46.8**
Nitrogen - Nitrate (PPM)	**31.3**
Total Phosphorus **(%) as P** **(%) as P_2O_5**	 **0.103** **0.237**
Total Potassium **(%) as K** **(%) as K_2O**	 **0.138** **0.166**
Carbon / Nitrogen Ratio	**13.6**

Other types of sand or soil material may lead to clogging of the BRC/PLD (Note: The update to the UDFCD's Volume III manual, to be released in late 2010, may have new filter media guidelines). The minor sediment removal activities can typically be addressed with shovels, rakes, and smaller equipment. Major sediment removal activities will require larger and more specialized equipment. Extreme care should be taken when utilizing motorized or heavy equipment to ensure damage to the underdrain system does not occur. The major sediment removal activities will also require surveying with an engineer's level, and consultation with the City of Aurora Water and Engineering Staff to ensure design volumes/grades are achieved.

Stormwater sediments removed from BRCs/PLDs do not meet the regulatory definition of "hazardous waste". However, these sediments can be contaminated with a wide array of organic and inorganic pollutants and handling must be done with care. Sediments should be transported by motor vehicle only after they are dewatered. All sediments must be taken to a licensed landfill for proper disposal. Should a spill occur during transportation, prompt and thorough cleanup and disposal is imperative.

Frequency – Non-routine – As necessary, based upon inspections and infiltration tests. Sediment removal in the forebay and trickle channel may be necessary as frequently as every 1-2 years.

BRC/PLD-3.6.2 Erosion Repair

The repair of eroded areas is necessary to ensure the proper functioning of the BRC/PLD, to minimize sediment transport, and to reduce potential impacts to other features. Erosion can vary in magnitude from minor repairs to filter media and embankments, to rills and gullies in the embankments and inflow points. The repair of eroded areas may require the use of excavators, earthmoving equipment, riprap, concrete, and sod. Extreme care should be taken when utilizing motorized or heavy equipment to ensure damage to the underdrain system does not occur. Major erosion repair to the pond embankments, spillways, and adjacent to structures will require consultation with the City of Aurora Water and Engineering Staff.

Frequency – Non-routine – As necessary, based upon inspections.

BRC/PLD-3.6.3 Jet-Vac/Clearing Drains

A BRC/PLD contains an underdrain system that allows treated stormwater runoff to exit the facility. These underdrain systems can develop blockages resulting in a decrease of hydraulic capacity and creating standing water. Many times the blockage to this infrastructure can be difficult to access and/or clean. Specialized equipment (jet-vac machines) may be necessary to clear debris from these difficult areas.

Frequency – Non-routine – As necessary, based upon inspections.

BRC/PLD-3.7 MAJOR MAINTENANCE ACTIVITIES

This work consists of larger maintenance/operational problems and failures within the stormwater management facilities. All of this work requires consultation with the City of Aurora Water and Engineering to ensure the proper maintenance is performed. This work requires Staff review the original design and construction drawings to assess the situation before approval of the proposed maintenance. This work may also require more specialized maintenance equipment, design/details, submittal of plans to the City of Aurora for review and approval, surveying, or assistance through private contractors and consultants.

Table BRC/PLD-4
Summary of Major Maintenance Activities

Maintenance Activity	Minimum Frequency	Look for:	Maintenance Action
Major Sediment/Pollutant Removal	As needed – based upon scheduled inspections	Large quantities of sediment; reduced pond capacity	Remove and dispose of sediment. Repair vegetation as needed
Major Erosion Repair	As needed – based upon scheduled inspections	Severe erosion including gullies forming, excessive soil displacement, areas of settlement, holes	Repair erosion – find cause of problem and address to avoid future erosion
Structural Repair	As needed – based upon scheduled inspections	Deterioration and/or damage to structural components – broken concrete, damaged pipes & outlet works	Structural repair to restore the structure to its original design
BRC/PLD Rebuild	As needed – due to complete failure of BRC/PLD	Removal of filter media and underdrain system	Contact the City of Aurora Water and Engineering Staff

BRC/PLD-3.7.1 Major Sediment/Pollutant Removal

Major sediment removal consists of removal of large quantities of pollutants/sediment/filter media/landscaping material. Extreme care should be taken when utilizing motorized or heavy equipment to ensure damage to the underdrain system does not occur. Some BRCs/PLDs also contain an impermeable liner that can be easily damage if care is not taken when removing the filter media. Stormwater sediments removed from BRCs/PLDs do not meet the regulatory definition of "hazardous waste". However, these sediments can be contaminated with a wide array of organic and inorganic pollutants and handling must be done with care to ensure proper removal and disposal. Sediments should be transported by motor vehicle only after they are dewatered. All sediments must be taken to a licensed landfill for proper disposal. Should a spill occur during transportation, prompt and thorough cleanup and disposal is imperative. Vegetated areas need special care to ensure design volumes and grades are preserved or may need to be replaced due to the removal activities. Any condition repair affecting design grades or pond volumes requires consultation with the City of Aurora Water and Engineering Staff

Frequency – Non-routine – Repair as needed, based upon inspections.

BRC/PLD-3.7.2 Major Erosion Repair

Major erosion repair consists of filling and revegetating areas of severe erosion. Determining the cause of the erosion as well as correcting the condition that caused the erosion should also be part of the erosion repair. Care should be given to ensure design grades and volumes are preserved. Extreme care should be taken when utilizing motorized or heavy equipment to ensure damage to the underdrain system does not occur.

Frequency – Non-routine – Repair as needed, based upon inspections.

BRC/PLD-3.7.3 Structural Repair

A BRC/PLD generally includes a concrete overflow outlet structure that can deteriorate or be damaged during the service life of the facility. These structures are constructed of steel and concrete that can degrade or be damaged and may need to be repaired or re-constructed from time to time. Major repairs to structures may require input from a structural engineer and specialized contractors. Consultation with the City of Aurora Water and Engineering Staff shall take place prior to all structural repairs.

Frequency – Non-routine – Repair as needed, based upon inspections.

BRC/PLD-3.7.4 BRC/PLD Rebuild

In very rare cases, a BRC/PLD may need to be rebuilt. Generally, the need for a complete rebuild is a result of improper construction, improper maintenance resulting in structural damage to the underdrain system, or extensive contamination of the BRC/PLD. Consultation with the City of Aurora Water and Engineering Staff shall take place prior to any rebuild project. Recertification of the BRC/PLD in accordance with the City's drainage criteria manual is required.

Frequency – Non-routine – As needed based upon inspections.

Reference:

This plan is adapted from Southeast Metro Stormwater Authority, *OPERATION AND MAINTENANCE (O & M) MANUAL,* **and the Douglas County, Colorado,** *STANDARD OPERATING PROCEDURE FOR EXTENDED DETENTION BASIN (EDB) INSPECTION AND MAINTENANCE,* July 2005

A P P E N D I X C – 4

Sand Filter Basins

Standard Operation Procedures

for

Inspection and Maintenance

Sand Filter Basins
(SFBs)

September 2010

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SFB-1 BACKGROUND

Sand Filter Basins (SFBs) are a common type of Stormwater Management facility utilized within the Front Range of Colorado. A SFB consists of a sedimentation chamber, a flat surfaced area of sand (sometimes covered with grass or sod), a filtration chamber, and a flat sand filter bed with an underdrain system. A surcharge zone exists within the sedimentation and filtration chambers for temporary storage of the Water Quality Capture Volume (WQCV). During a storm, runoff enters the sedimentation chamber, where the majority of sediments are deposited. The runoff then enters the filtration chamber where it ponds above the sand bed and gradually infiltrates into the underlying sand filter, 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 sewer. SFBs provide for filtering and absorption of pollutants in the stormwater[3]. The popularity of SFBs has grown because they allow the WQCV to be provided on a site that has little open area available for stormwater management. However, there are limitations on their use due to potential clogging from large amounts of sediment.

SFB-2 INSPECTING SAND FILTER BASINS (SFBs)

SFB-2.1 Access and Easements

Inspection and maintenance personnel may utilize the stormwater facility map located in Appendix G containing the locations of the access points and maintenance easements of the SFBs within this development.

SFB-2.2 Stormwater Management Facilities Locations

Inspection and maintenance personnel may utilize the stormwater facility map located in Appendix G containing the locations of the SFBs within this development.

SFB-2.3 Sand Filter Extended Detention Basin (SFB) Features

SFBs have a number of features designed to serve a particular function. Many times the proper function of one feature depends on another. It is important for maintenance personnel to understand the function of each of these features to prevent damage to any feature during maintenance operations. Below is a basic list and description of the most common features within a SFB and the corresponding maintenance inspection items that may be anticipated:

[3] Design of Stormwater Filtering Systems, Centers for Watershed Protection, December 1996

TABLE SFB-1
Typical Inspection & Maintenance Requirements Matrix

	Sediment Removal	Mowing Weed control	Trash/ Debris Removal	Erosion	Overgrown Vegetation Removal	Removal/ Replacement	Structure Repair
Inflow Points/Splitter Box	X		X				X
Sedimentation Chamber	X	X	X	X	X		
Filter Media	X	X	X	X	X	X	
Underdrain System						X	
Overflow Outlet Works	X		X				X
Embankment		X	X	X	X		

SFB-2.3.1 Inflow Points/Splitter Box

Inflow points or outfalls into SFBs are the point of stormwater discharge into the facility. An inflow point is commonly a curb cut with a concrete or riprap rundown or a storm sewer pipe outfall with a flared end section.

In some instances SFBs are designed to treat only the WQCV. The WQCV is a volume of water that runs off a site during an 80th percentile event. Any amount over the WQCV is allowed to go to a detention facility without water quality treatment. The splitter box is generally constructed of reinforced concrete. The splitter box typically has a lower wall height that will trap the required WQCV. Volumes over the WQCV are allowed to spill over the wall and enter a storm sewer system that conveys the runoff to a detention facility. Proper inspection and maintenance of the splitter box is essential in ensuring the long-term operation of the SFB.

An energy dissipater is typically immediately downstream of the splitter box, at the discharge point into the SFB, to protect the sedimentation and filtration chambers from erosion. In some cases, the splitter box outfall can have a toe-wall or cut-off wall immediately below the structure to prevent undercutting of the outfall from erosion.

Where there is detention included with the SFB an energy dissipater (riprap or hard armor protection) is typically immediately downstream of the discharge point into the SFB to protect from erosion. In some cases, the storm sewer outfall can have a toe-wall or cut-off wall immediately below the structure to prevent undercutting of the outfall from erosion.

The typical maintenance activities required at inflow points are as follows:

a. *Riprap Displaced* – Many times, because of the repeated impact/force of water, riprap can shift and settle. If any portion of the riprap apron appears to have settled, soil is present between the riprap, or the riprap has shifted, maintenance may be required to ensure future erosion is prevented.

b. *Sediment Accumulation* – Because of the turbulence in the water created by the energy dissipater, sediment often deposits immediately downstream of the inflow point. To prevent a loss in performance of the upstream infrastructure, sediment that accumulates in this area must be removed on a timely basis.

c. *Structural Damage* – Structural damage can occur at anytime during the life of the facility. Typically for an inflow, the structural damage occurs to the pipe flared end section (concrete or steel). Structural damage can lead to additional operating problems with the facility, including loss of hydraulic performance.

SFB-2.3.2 Sedimentation Chamber (Forebay)

The sedimentation chamber is located adjacent to the splitter box (inflow point) and generally consists of a flat irrigated turf grass area followed by a water trapping device allowing water to be briefly held in the sedimentation chamber before being released into the filtration chamber. This slowing of the runoff allows sediments/trash to be deposited in the sedimentation chamber (forebay) and not the filtration chamber where they can cause clogging of the filter media.

The typical maintenance activities required within the sedimentation chamber are as follows:

a. *Mowing/woody growth control/weeds present* - Routine mowing of the turf grass within the sediment chamber is necessary to improve the overall appearance and to ensure proper function of the SFB. Turf grass should be mowed to a height of 2 to 4- inches and shall be bagged to prevent potential contamination of the filter media. Before mowing any trash/debris should be removed and properly disposed. If undesirable vegetation is not routinely mowed/removed, the growth can cause debris/sediment to accumulate, resulting in blockage of the filter media. Also, shrub, grass and weed roots can cause damage to the filter media and underdrain system. Routine management is essential to prevent more extensive and costly future maintenance.

SBF-2.3.3 Filter Media

The filter media is the main pollutant removal component of the SFB. The filter media consists of 18-inches of washed sand. The filter media removes pollutants through several different processes, including sedimentation, filtration, infiltration and microbial uptake.

Sedimentation is accomplished by the slow release of stormwater runoff through the filter media. This slow release allows for sediment particles that were not deposited in the sedimentation chamber to be deposited on the top layer of the filter media where they are easily removed through routine maintenance. Other pollutants are also removed through this process because they are attached to sediment.

Filtration is the main pollutant removal mechanism of SFBs. When the stormwater runoff migrates down through the filter media, many of the particulate pollutants are physically strained out as they pass through the filter bed of sand and are trapped on the surface or among the pores of the filter media.

SFBs not lined with an impervious liner allow for infiltration into the native soils. This process also allows for additional pollutant removal.

Microbes that naturally occur in the filter media can assist with pollutant removal by breaking down organic pollutants.

The typical maintenance activities required within the filter media areas are as follows:

a. *Mowing/woody growth control/weeds present* - Noxious weeds and other unwanted vegetation must be treated as needed throughout the SFB. This activity can be performed either through mechanical means (mowing/pulling) or with herbicide. Consultation with a local Weed Inspector is highly recommended prior to the use of herbicide. Herbicides should be utilized sparingly and as a last resort. All herbicide applications should be in accordance with the manufacturer's recommendations.

b. *Sediment/Pollutant Removal* – Although SFBs should not be utilized in areas where large concentrations of sediment and other pollutants will enter the SFB, it is inevitable some sediment and other pollutants will enter the SFB. Most sediment will be deposited in the sedimentation chamber (forebay), however finer suspended particles will migrate to the filter media. These sediments need to be removed to ensure proper infiltration rates of the stormwater runoff.

c. *Filter Replacement* - The top layers of the filter media are the most susceptible to pollutant loading and therefore may need to be removed and disposed of properly on a semi-regular basis when infiltration rates slow.

d. *Infiltration Rate Test* - An infiltration test may be necessary to ensure proper functioning of the filter media. The infiltration test can be conducted by filling the sand filter with water to the design elevation shown on the design drawings. The sand filter needs to drain completely within 24-hours of the filling. If the drain time for the basin is longer than 24-hours, the filter is in need of maintenance.

SFB-2.3.4 Underdrain System

The underdrain system consists of a layer of geotextile fabric, gravel storage area and perforated PVC pipes. The geotextile fabric is utilized to prevent the filter media from entering the underdrain system. The gravel storage area allows for storage of treated stormwater runoff prior to the discharge of the runoff through the perforated PVC pipe.

The typical maintenance activities required for the underdrain system are as follows:

With proper maintenance of the filter media and sediment chamber, there should be a minimum amount of maintenance required on the underdrain system. Generally, the only maintenance performed on the underdrain system is jet-vac cleaning.

SFB-2.3.5 Outlet Works

Where SFBs do not have a detention component the outlet works may take the place of the splitter box. If this is the case the outlet works includes an overflow. The overflow outlet works allows runoff amounts exceeding the WQCV to exit the SFB to the detention facility.

When the SFB does have a detention component the outlet works is typically constructed of reinforced concrete into the embankment of the SFB. The concrete structure typically has steel orifice plates anchored/embedded into it to control stormwater release rates. The larger openings (flood control) on the outlet structure typically have trash racks over them to prevent clogging. Proper inspection and maintenance of the outlet works is essential in ensuring the long-term operation of the SFB.

The typical maintenance activities required for the overflow outlet works are as follows:

a. *Trash Rack/Well Screen Clogged in an SFB with Detention Component* – Floatable material entering the SFB will most likely make its way to the outlet structure. This material is trapped against the trash racks and well screens on the outlet structure (which is why they are there). This material must be removed on a routine basis to ensure the outlet structure drains in the specified design period.

b. *Structural Damage* - The overflow outlet structure is primarily constructed of concrete, which can crack, spall, and settle. The steel grate on the overflow outlet structure (is so equipped), steel trash racks and well screens (if so equipped) are also susceptible to damage.

c. *Orifice Plate Missing/Not Secure in an SFB with Detention Component* – Many times residents, property owners, or maintenance personnel will remove or loosen orifice plates if they believe the pond is not draining properly. Any modification to the orifice plate(s) will significantly affect the designed discharge rates for flood control. Modification of the orifice plates is not allowed without approval from the City of Aurora Public Works Department, Engineering Control Division.

d. *Mowing/woody growth control/weeds present* – SFBs without the detention component the presence of plant material not part of the original landscaping, such as wetland plants or other woody growth, can clog the overflow outlet works during a larger storm event, causing flooding damage to adjacent areas. This plant material may indicate a clogging of the filter media and may require additional investigation.

   In SFBs with the detention component woody vegetation not routinely mowed/removed may cause additional sediment/debris to accumulate around the outlet works. Any tree roots present can cause damage to the structural components of the outlet works. Routine management is essential for trees (removing a small tree/sapling is much cheaper and "quieter" than a mature tree).

SFB-2.3.6 Embankments

Some SFBs utilize irrigated turf grass embankments to store the required volume.

The typical maintenance activities required for the embankments areas are as follows:

a. Vegetation Sparse – The embankments are one of the most visible parts of the SFB and, therefore, aesthetics is important. Adequate and properly maintained vegetation can greatly increase the overall appearance of the SFB. Also, vegetation can reduce the potential for erosion and subsequent

sediment transport to the filter media, thereby reducing the need for more costly maintenance.

b. Erosion – Inadequate vegetative cover may result in erosion of the embankments. Erosion that occurs on the embankments can cause clogging of the filter media.

c. Trash/Debris – Trash and debris can accumulate in the upper area after large events, or from illegal dumping. Over time, this material can clog the SFB filter media and outlet works.

d. Mowing/woody growth control/weeds present – The presence of plant material not part of the original landscaping, such as wetland plants or other woody growth, can result in difficulty in performing maintenance activities. These trees and shrubs may also damage the underdrain system of the SFB. This plant material may indicate a clogging of the filter media and may require additional investigation.

SFB-2.3.7 Emergency Overflow

An emergency spillway is typical of all SFBs and designed to serve as the overflow in the event the volume of the pond is exceeded. The emergency spillway is typically armored with riprap (or other hard armor), and is sometimes buried with soil or may be a concrete wall or other structure. The emergency spillway is typically a weir (notch) in the basin embankment. Proper function of the emergency spillway is essential to ensure flooding does not affect adjacent properties.

The typical maintenance activities required for the emergency overflow areas are as follows:

a. *Riprap Displaced* – As mentioned before, the emergency spillway is typically armored with riprap to provide erosion protection. Over the life of an SFB, the riprap may shift or become dislodged due to flow.

b. *Erosion Present* – Although the spillway is typically armored, stormwater flowing through the spillway can cause erosion damage. Erosion must be repaired to ensure the integrity of the basin embankment, and proper function of the spillway.

c. *Mowing/weed/woody growth control* – Management of woody vegetation is essential in the proper long-term function of the spillway. Larger trees or dense shrubs can capture larger debris entering the SFB and reduce the capacity of the spillway. These trees and shrubs may also damage the underdrain system of the SFB.

d. Obstruction/Debris – The spillway must be cleared of any obstruction (man-made or natural) to ensure the proper design capacity.

SFB-2.3.8 Miscellaneous

There are a variety of inspection/maintenance issues that may not be attributed to a single feature within the SFB. This category on the inspection form is for maintenance items commonly found in the SFB, but may not be attributed to an individual feature.

a. Encroachment in Easement Area – Private lots/property can sometimes be located very close to the SFBs, even though they are required to be located in tracts with drainage easements. Property owners may not place landscaping, trash, fencing, or other items within the easement area that may adversely affect maintenance or the operation of the facility.

b. Graffiti/Vandalism – Vandals can cause damage to the SFB infrastructure. If criminal mischief is evident, the inspector should forward this information to the Aurora Police Department.

c. Public Hazards – Public hazards include items such as vertical drops of greater than 4-feet, containers of unknown/suspicious substances, and exposed metal/jagged concrete on structures. **If any unkown/suspicious hazard is found within the facility area that poses an immediate threat to public safety, call 911 immediately.**

d. Other – Any miscellaneous inspection/maintenance items not contained on the form should be entered here.

SFB-2.4 Inspection Forms

SFB Inspection forms are located in Appendix D. Inspection forms shall be completed by the person(s) conducting the inspection activities. Each form shall be reviewed and submitted by the property owner or property manager to the City of Aurora per the requirements of the Inspection and Maintenance Plan. These inspection forms shall be kept indefinitely and made available to the city of Aurora upon request.

SFB-3 MAINTAINING SAND FILTER BASINS (SFBs)

SFB-3.1 Maintenance Personnel

Maintenance personnel must be qualified to properly maintain SFBs. Inadequately trained personnel can cause additional problems resulting in additional maintenance costs.

SFB-3.2 Equipment

It is imperative that the appropriate equipment and tools are taken to the field with the operations crew. The types of equipment/tools will vary depending on the task at hand. Below is a basic list of tools, equipment, and material(s) that may be necessary to perform maintenance on a SFB:

1.) Mowing Tractors
2.) Trimmers (extra string)
3.) Shovels
4.) Rakes
5.) All Surface Vehicle (ASVs)
6.) Skid Steer
7.) Back Hoe
8.) Track Hoe/Long Reach Excavator
9.) Dump Truck
10.) Jet-Vac Machine
11.) Engineers Level (laser)
12.) Riprap (Minimum - Type M)
13.) Geotextile Fabric
14.) Erosion Control Blanket(s)
15.) Sod
16.) Illicit Discharge Cleanup Kits
17.) Trash Bags
18.) Tools (wrenches, screw drivers, hammers, etc)
19.) Confined Space Entry Equipment
20.) Approved Stormwater Facility Inspection and Maintenance Plan
21.) ASTM C-33 Sand

Some of the items identified above may not be needed for every maintenance operation. However, this equipment and material should be available to the maintenance operations crews should the need arise.

SFB-3.3 Safety

Vertical drops may be encountered in areas located within and around the SFB. Avoid walking on top of retaining walls or other structures having a significant vertical drop. If a vertical drop within the pond is identified as greater than 48-inches in height, make the appropriate note/comment on the maintenance inspection form.

SFB-3.4 SFB Maintenance Forms

The SFB Maintenance Form provides a record of each maintenance operation performed by maintenance contractors. The SFB Maintenance Form shall be filled out in the field after the completion of the maintenance operation. Each form shall be reviewed and submitted by the property owner or property manager to the City of Aurora per the requirements of the Inspection and Maintenance Plan. The SFB Maintenance form is located in Appendix E.

SFB-3.5 SFB Maintenance Categories and Activities

A typical SFB Maintenance Program will consist of three broad categories of work: Routine, Minor and Major. Within each category of work, a variety of maintenance activities can be performed on a SFB. A maintenance activity can be specific to each feature within the SFB, or general to the overall facility. This section of the SOP explains each of the categories and briefly describes the typical maintenance activities for a SFB.

A variety of maintenance activities are typical of SFBs. The maintenance activities range in magnitude from routine trash pickup to the reconstruction of the SFB filter media or underdrain system. Below is a description of each maintenance activity, the objectives, and frequency of actions:

SFB-3.6 Routine Maintenance Activities

The majority of this work consists of scheduled mowings, trash and debris pickups for the SFB during the growing season. It also includes activities such as weed control. These activities normally will be performed numerous times during the year. These items typically do not require any prior correspondence with the City of Aurora, however, completed inspection and maintenance forms shall be submitted to the City of Aurora for each inspection and maintenance in accordance with the Inspection and Maintenance Plan.

The Routine Maintenance Activities are summarized below, and further described in the following sections.

TABLE SFB-2
Summary of Routine Maintenance Activities

Maintenance Activity	Minimum Frequency	Look for:	Maintenance Action
Mowing	Twice annually	Excessive grass height/aesthetics	2”-4” grass height
Trash/Debris Removal	Twice annually	Trash/debris in SFB	Remove and dispose of trash and debris
Splitter Box/Overflow Outlet Works Cleaning	As needed - after significant rain events – twice annually minimum	Clogged outlet structure; ponding water	Remove and dispose of debris/trash/sediment to allow outlet to function properly
Woody growth control /Weed removal	Minimum twice annually	Noxious weeds; Unwanted vegetation	Treat w/herbicide or hand pull; consult a local Weed Inspector

SFB-3.6.1 Mowing

Routine mowing of the turf grass embankments and turf grass located in the sedimentation chamber (forebay) and embankment is necessary to improve the overall appearance of the SFB and ensure proper performance of the sediment chamber. Turf grass should be mowed to a height of 2 to 4-inches and shall be bagged to prevent potential contamination of the filter media.

Frequency – Routine - Minimum of twice annually or depending on aesthetics.

SFB-3.6.2 Trash/Debris Removal

Trash and debris must be removed from the entire SFB area to minimize outlet clogging and to improve aesthetics. This activity must be performed prior to mowing operations.

Frequency – Routine – Prior to mowing operations and minimum of twice annually.

SFB-3.6.3 Splitter Box/ Outlet Works Cleaning

Debris and other materials can clog the splitter box/outlet work’s grate or orifice plate(s) and trash rack. This activity must be performed anytime other maintenance activities are conducted to ensure proper operation.

Frequency - Routine – After significant rainfall event or concurrently with other maintenance activities.

SFB- 3.6.4 Woody Growth Control/Weed Removal

Noxious weeds and other unwanted vegetation must be treated as needed throughout the SFB. This activity can be performed either through mechanical means (mowing/pulling) or with herbicide. Consultation with a local Weed Inspector is highly recommended prior to the use of herbicide. Herbicides should be utilized sparingly and as a last resort. All herbicide applications should be in accordance with the manufacturer's recommendations.

Frequency – Routine – As needed based on inspections.

SFB-3.7 Minor Maintenance Activities

This work consists of a variety of isolated or small-scale maintenance/operational problems. Most of this work can be completed by a small crew, hand tools, and small equipment. These items require prior approval from the City of Aurora Water Staff. Completed inspection and maintenance forms shall be submitted to the City of Aurora Water Staff for each inspection and maintenance period. In the event the SFB needs to be dewatered, care should be given to ensure sediment, filter material and other pollutants are not discharged. All dewatering activities shall be coordinated with the City of Aurora Water Staff.

TABLE SFB-3
Summary of Minor Maintenance Activities

Maintenance Activity	Minimum Frequency	Look for:	Maintenance Action
Sediment/Pollutant Removal	As needed; typically every 1 –2 years	Sediment build-up in sedimentation chamber and filter media; decrease in infiltration rate	Remove and dispose of sediment
Erosion Repair	As needed, based upon inspection	Rills/gullies on embankments or sedimentation in the forebay	Repair eroded areas & revegetate; address cause
Jet-Vac/Cleaning Underdrains	As needed, based upon inspection	Sediment build-up /non-draining system	Clean drains; Jet-Vac if needed

SFB-3.7.1 Sediment Removal/Pollutant Removal

Sediment removal is necessary to ensure proper function of the filter media. The infiltration rate of the SFB needs to be checked in order to ensure proper functioning of the SFB. Generally, a SFB should drain completely

within 24-hours of a storm event. If drain times exceed the 24-hour drain time then maintenance of the filter media shall be required.

At a minimum, the top 3-inches of filter media should be removed at each removal period. Additional amounts of filter media may need to be removed if deeper sections of the filter media are contaminated. New filter media will need to be placed back into the SFB when the total amount of sand removed reaches 9-inches. This may take multiple maintenance events to accomplish. It is critical only sand meeting the American Society for Testing and Materials (ASTM) C-33 standard be utilized in the replacement of the filter media. (Note: The update to the UDFCD's Volume III manual, to be released in late 2010, may have new filter media guidelines).

ASTM C-33 Sand Standard

US Standard Sieve Size (Number)	Total Percent Passing (%)
9.5 mm (3/8 inch)	100
4.75 mm (No. 4)	95-100
2.36 mm (No. 8)	80-100
1.18 mm (No. 16)	50-85
600μm (No. 30)	25-60
300μm (No.50)	10-30
150μm (No. 100)	2-10

Other types of sand and soil material may lead to clogging of the SFB. (Note: The update to the UDFCD's Volume III manual, to be released in late 2010, may have new filter media guidelines). The minor sediment removal activities can typically be addressed with shovels, rakes and smaller equipment.

Stormwater sediments removed from SFBs do not meet the regulatory definition of "hazardous waste". However, these sediments can be

Stormwater sediments removed from SFBs do not meet the regulatory definition of “hazardous waste”. However, these sediments can be contaminated with a wide array of organic and inorganic pollutants and handling must be done with care to ensure proper removal and disposal. Sediments should be transported by motor vehicle only after they are dewatered. All sediments must be taken to a licensed landfill for proper disposal. Should a spill occur during transportation, prompt and thorough cleanup and disposal is imperative.

Frequency – Non-routine – As necessary, based upon inspections. Sediment removal in the sedimentation chamber (forebay) may be necessary as frequently as every 1-2 years.

SFB-3.7.2 Erosion Repair

The repair of eroded areas is necessary to ensure the proper functioning of the SFB, to minimize sediment transport, and to reduce potential impacts to other features. Erosion can vary in magnitude from minor repairs to filter media and embankments, to rills, and gullies in the embankments and inflow points. The repair of eroded areas may require the use of excavators, earthmoving equipment, riprap, concrete, and sod. Extreme care should be taken when utilizing motorized or heavy equipment to ensure damage to the underdrain system does not occur. Major erosion repair to the pond embankments, spillways, and adjacent to structures will require consultation with the City of Aurora Water and Engineering Staff.

Frequency – Non-routine – As necessary, based upon inspections.

SFB-3.7.3 Jet-Vac/Clearing Drains

A SFB contains an underdrain system that allows treated stormwater runoff to exit the facility. These underdrain systems can develop blockages that can result in a decrease of hydraulic capacity and also create standing water. Many times the blockage to this infrastructure can be difficult to access and/or clean. Specialized equipment (jet-vac machines) may be necessary to clear debris from these difficult areas.

Frequency – Non-routine – As necessary, based upon inspections.

SFB-3.8 Major Maintenance Activities

This work consists of larger maintenance/operational problems and failures within the stormwater management facilities. All of this work requires approval from the City of Aurora to ensure the proper maintenance is performed. This work requires the City of Aurora Water Staff review the original design and construction drawings to assess the situation before approval of the proposed maintenance activities. This work may also require more specialized

maintenance equipment, design/details, submittal of plans to the City of Aurora for review and approval, surveying, or assistance through private contractors and consultants. In the event the facility needs to be dewatered, care should be given to ensure sediment, filter material and other pollutants are not discharged. Consultation with the City of Aurora Water Staff is required prior to any dewatering activity.

TABLE SFB-4
Summary of Major Maintenance Activities

Maintenance Activity	Minimum Frequency	Look for:	Maintenance Action
Major Sediment/Pollutant Removal	As needed – based upon scheduled inspections	Large quantities of sediment in the sedimentation chamber (forebay) and/or filter media; reduced infiltration rate /capacity	Remove and dispose of sediment. Repair vegetation as needed
Major Erosion Repair	As needed – based upon scheduled inspections	Severe erosion including gullies, excessive soil displacement, areas of settlement, holes	Repair erosion – find cause of problem and address to avoid future erosion
Structural Repair	As needed – based upon scheduled inspections	Deterioration and/or damage to structural components – broken concrete, damaged pipes & outlet works	Structural repair to restore the structure to its original design
SFB Rebuild	As needed – due to complete failure of SFB	Removal of filter media and underdrain system	Contact the City of Aurora Water and Engineering Staff

SFB-3.8.1 Major Sediment/Pollutant Removal

In very rare cases the filter media of the SFB may be so badly contaminated the entire 18-inches of the filter media may need to be removed.

Major sediment/pollutant removal consists of removal of large quantities of sediment/filter media. Major sediment removal activities will require larger and more specialized equipment. Extreme care should be taken when utilizing motorized or heavy equipment to ensure damage to the underdrain system does not occur. The sediment/filter media needs to be carefully removed, transported and properly disposed. Vegetated areas need special care to ensure design volumes and grades are preserved or may need to be replaced due to the removal activities. The major sediment removal

activities will require surveying with an engineer's level, and consultation with the City of Aurora Water and Engineering Staff to ensure design volumes/grades are achieved. Stormwater sediments removed from SFBs do not meet the regulatory definition of "hazardous waste". However, these sediments can be contaminated with a wide array of organic and inorganic pollutants and handling must be done with care to insure proper removal and disposal. Sediments should be transported by motor vehicle only after they are dewatered. All sediments must be taken to a licensed landfill for proper disposal. Should a spill occur during transportation, prompt and thorough cleanup and disposal is imperative.

Frequency – Non-routine – Repair as needed, based upon inspections.

SFB-3.8.2 Major Erosion Repair

Major erosion repair consists of filling and revegetating areas of severe erosion. Determining the cause of the erosion as well as correcting the condition that caused the erosion should also be part of the erosion repair. Care should be given to ensure design grades and volumes are preserved. Consult with the City of Aurora Water and Engineering Staff. Extreme care should be taken when utilizing motorized or heavy equipment to ensure damage to the underdrain system does not occur.

Frequency – Non-routine – Repair as needed, based upon inspections.

SFB-3.8.3 Structural Repair

A SFB generally includes a splitter box (if no detention component) or concrete outlet structure that can deteriorate or be damaged during the service life of the facility. These structures are constructed of steel and concrete that can degrade or be damaged and may need to be repaired or re-constructed from time to time. Major repairs to structures may require input from a structural engineer and specialized contractors. Consultation with the City of Aurora Water and Engineering Staff shall take place prior to all structural repairs.

Frequency – Non-routine – Repair as needed, based upon inspections.

SFB-3.8.4 SFB Rebuild

In very rare cases a SFB may need to be rebuilt. Generally, the need for a complete rebuild is a result of improper construction, improper maintenance resulting in structural damage to the underdrain system, or extensive contamination of the SFB. Consultation with the City of Aurora Water and Engineering Staff shall take place prior to any rebuild project.

Frequency – Non-routine – As needed, based upon inspections.

Reference:

This plan is adapted from Southeast Metro Stormwater Authority, *OPERATION AND MAINTENANCE (O & M) MANUAL,* **and the Douglas County, Colorado,** *STANDARD OPERATING PROCEDURE FOR EXTENDED DETENTION BASIN (EDB) INSPECTION AND MAINTENANCE,* July 2005

A P P E N D I X D

Inspection Forms

EXTENDED DETENTION BASIN (EDB)
INSPECTION FORM

Date:_____

Subdivision/Business Name:_____ Inspector:_____

Subdivision/Business Address:_____

Weather: _____

Date of Last Rainfall:_____ Amount:_____Inches

Property Classification: Residential Multi Family Commercial Other:_____
(Circle One)

Reason for Inspection: Routine Complaint After Significant Rainfall Event
(Circle One)

INSPECTION SCORING - For each facility inspection item, insert one of the following scores:

0 = No deficiencies identified
1 = Monitor (potential for future problem)
2 = Routine maintenance required
3 =Immediate repair necessary
N/A = Not applicable

FEATURES

1.) Inflow Points
- ____Riprap Displaced
- ____Erosion Present/Outfall Undercut
- ____Sediment Accumulation
- ____Structural Damage (pipe, end-section, etc.)
- ____Woody Growth/Weeds Present

2.) Forebay
- ____Sediment/Debris Accumulation
- ____Concrete Cracking/Failing
- ____Drain Pipe/Wier Clogged (not draining)
- ____Wier/Drain Pipe Damage

3.) Trickle Channel (Low-flow)
- ____Sediment/Debris Accumulation
- ____Concrete/Riprap Damage
- ____Woody Growth/Weeds Present
- ____Erosion Outside Channel

4.) Bottom Stage (Micro-Pool)
- ____Sediment/Debris Accumulation
- ____Woody Growth/Weeds Present
- ____Bank Erosion
- ____Mosquitoes/Algae Treatment
- ____Petroleum/Chemical Sheen

5.) Outlet Works
- ____Trash Rack/Well Screen Clogged
- ____Structural Damage (concrete,steel,subgrade)
- ____Orifice Plate(s) Missing/Not Secure
- ____Manhole Access (cover, steps, etc.)
- ____Woody Growth/Weeds Present

6.) Emergency Spillway
- ____Riprap Displaced
- ____Erosion Present
- ____Woody Growth/Weeds Present
- ____Obstruction/Debris

7.) Upper Stage (Dry Storage)
- ____Vegetation Sparse
- ____Woody Growth/Undesirable Vegetation
- ____Standing Water/Boggy Areas
- ____Sediment Accumulation
- ____Erosion (banks and bottom)
- ____Trash/Debris
- ____Maintenance Access

8.) Miscellaneous
- ____Encroachment in Easement Area
- ____Graffiti/Vandalism
- ____Public Hazards
- ____Burrowing Animals/Pests
- ____Other

Inspection Summary / Additional Comments:_____

OVERALL FACILITY RATING (Circle One)

0 = No Deficiencies Identified
1 = Monitor (potential for future problem exists)
2 = Routine Maintenance Required
3 = Immediate Repair Necessary

This inspection form shall be kept indefinitely and made available to the City of Aurora upon request.

GRASS BUFFER-GRASS SWALE
INSPECTION FORM

Date:_____

Subdivision/Business Name:_____ Inspector:_____

Subdivision/Business Address:_____ _____

Weather: _____

Date of Last Rainfall:_____ Amount:_____ Inches

Property Classification: Residential Multi Family Commercial Other:_____
(Circle One)

Reason for Inspection: Routine Complaint After Significant Rainfall Event
(Circle One)

INSPECTION SCORING - For each facility inspection item, insert one of the following scores:

0 = No deficiencies identified
1 = Monitor (potential for future problem)
2 = Routine maintenance required
3 =Immediate repair necessary
N/A = Not applicable

FEATURES

1.) Grass Swale Bottom & Side Slopes
____Sediment/Debris Accumulation
____Vegetation Cover
____Erosion Present
____Standing Water/Boggy Areas

2.) Grass Buffer
____Sediment/Debris Accumulation
____Vegetation Cover
____Erosion Present
____Standing Water/Boggy Areas

3.) Inflow Points
____Rip Rap Displaced/Rundown or Pipe Damage
____Erosion Present/Outfall Undercut
____Sediment Accumulation

4.) Underdrain System
____Standing water/Not draining
____Evidence of clogged system

5.) Grade Control
____Erosion Present
____Structural Damage

6.) Level Spreader
____Erosion Present
____Structural Damage
____Unlevel/Uneven Distribution of flow

7.) Irrigation
____General Grass Condition
____Bare Spots
____Broken sprinkler heads

8.) Miscellaneous
____Encroachment in Easement Area
____Public Hazards
____Burrowing Animals/Pests
____Other

Inspection Summary / Additional Comments:_____

OVERALL FACILITY RATING (Circle One)
0 = No Deficiencies Identified
1 = Monitor (potential for future problem exists)
2 = Routine Maintenance Required
3 = Immediate Repair Necessary

This inspection form shall be kept indefinitely and made available to the City of Aurora upon request.

BIORETENTION CELL (BRC) or POROUS LANDSCAPE DETENTION (PLD) INSPECTION FORM

Date:_____

Subdivision/Business Name:_____ Inspector:_____

Subdivision/Business Address:_____ _____

Weather: _____

Date of Last Rainfall:_____ Amount:_____ Inches

Property Classification: Residential Multi Family Commercial Other:_____
(Circle One)

Reason for Inspection: Routine Complaint After Significant Rainfall Event
(Circle One)

INSPECTION SCORING - For each facility inspection item, insert one of the following scores:

0 = No deficiencies identified
1 = Monitor (potential for future problem)
2 = Routine maintenance required
3 =Immediate repair necessary
N/A = Not applicable

FEATURES

1.) Inflow Points
- ____Rip Rap Displaced/Rundown or Pipe Damage
- ____Erosion Present/Outfall Undercut
- ____Sediment Accumulation
- ____Structural Damage

2.) Filter Media
- ____Infiltration Rate Check
- ____Sediment Removal
- ____Filter Replacement

3.) Landscaping
- ____Woody Growth/Weeds Present
- ____General Landscape Care

4.) Underdrain System
- ____Evidence of clogged system (jet-vac cleaning required)

6.) Embankments
- ____Vegetation Sparse
- ____Erosion Present

5.) Overflow Outlet Works
- ____Structural Damage
- ____Woody Growth/Weeds Present
- ____Trash/Debris

7.) Miscellaneous
- ____Encroachment in Easement Area
- ____Graffiti/Vandalism
- ____Public Hazards
- ____Other

Inspection Summary / Additional Comments:_____

OVERALL FACILITY RATING (Circle One)

0 = No Deficiencies Identified
1 = Monitor (potential for future problem exists)
2 = Routine Maintenance Required
3 = Immediate Repair Necessary

This inspection form shall be kept indefinitely and made available to the City of Aurora upon request.

SAND FILTER BASIN (SFB)
INSPECTION FORM

Date:_____

Subdivision/Business Name:_____ Inspector:_____

Subdivision/Business Address:_____

Weather: _____

Date of Last Rainfall:_____ Amount:_____Inches

Property Classification: Residential Multi Family Commercial Other:_____
(Circle One)

Reason for Inspection: Routine Complaint After Significant Rainfall Event
(Circle One)

INSPECTION SCORING - For each facility inspection item, insert one of the following scores:

0 = No deficiencies identified
1 = Monitor (potential for future problem)
2 = Routine maintenance required
3 =Immediate repair necessary
N/A = Not applicable

FEATURES

1.) Inflow Points/Splitter Box
- ____Riprap Displaced
- ____Sediment Accumulation
- ____Structural Damage (pipe, end-section, etc.)
- ____Trash/Debris

2.) Sedimentation Chamber
- ____Mowing /weed/woody growth control
- ____Erosion Present
- ____Trash/Debris
- ____Sediment Accumulation

3.) Filter Media
- ____Mowing /weed/woody growth control
- ____Sediment/Pollutant Removal
- ____Filter Replacement
- ____Infiltration Rate Check

4.) Underdrain System
- ____Evidence of clogged system (jet-vac cleaning required)

5.) Outlet Works
- ____Structural Damage (concrete,steel,subgrade)
- ____Mowing /weed/woody growth control

6.) Embankments
- ____Vegetation Sparse
- ____Erosion Present
- ____Trash/Debris
- ____Mowing /weed/woody growth control

7.) Emergency Overflow
- ____Riprap Displaced
- ____Erosion Present
- ____Woody Growth/Weeds Present
- ____Obstruction/Debris

8.) Miscellaneous
- ____Encroachment in Easement Area
- ____Graffiti/Vandalism
- ____Public Hazards
- ____Other

Inspection Summary / Additional Comments:_____

OVERALL FACILITY RATING (Circle One)

0 = No Deficiencies Identified
1 = Monitor (potential for future problem exists)
2 = Routine Maintenance Required
3 = Immediate Repair Necessary

This inspection form shall be kept indefinitely and made available to the City of Aurora upon request.

A P P E N D I X E

Maintenance Forms

EXTENDED DETENTION BASIN (EDB)
MAINTENANCE FORM

Subdivision/Business Name:_____ Completion Date:_____

Subdivision/Business Address:_____ Contact Name:_____

Maintenance Category: Routine Restoration Rehabilitation
(Circle All That Apply)

MAINTENANCE ACTIVITIES PERFORMED

ROUTINE WORK

____ MOWING
____ TRASH/DEBRIS REMOVAL
____ OUTLET WORKS CLEANING (TRASH RACK/WELL SCREEN)
____ WEED CONTROL (HERBICIDE APPLICATION)
____ MOSQUITO TREATMENT
____ ALGAE TREATMENT

RESTORATION WORK

____ SEDIMENT REMOVAL
- ____ FOREBAY
- ____ TRICKLE CHANNEL
- ____ INFLOW

____ EROSION REPAIR
- ____ INFLOW POINT
- ____ TRICKLE CHANNEL

____ VEGETATION REMOVAL/TREE THINNING
- ____ INFLOW(S)
- ____ TRICKLE CHANNEL
- ____ UPPER STAGE
- ____ BOTTOM STAGE

____ REVEGETATION
____ JET-VAC/CLEARING DRAINS
- ____ FOREBAY
- ____ OUTLET WORKS
- ____ INFLOWS

REHABILITATION WORK

____ SEDIMENT REMOVAL (DREDGING)
- ____ BOTTOM STAGE
- ____ UPPER STAGE

____ EROSION REPAIR
- ____ OUTLET WORKS
- ____ UPPER STAGE
- ____ BOTTOM STAGE
- ____ SPILLWAY

____ STRUCTURAL REPAIR
- ____ INFLOW
- ____ OUTLET WORKS
- ____ FOREBAY
- ____ TRICKLE CHANNEL

OTHER_____
_____
_____

ESTIMATED TOTAL MANHOURS: _____

EQUIPMENT/MATERIAL USED: _____

_____

_____

COMMENTS/ADDITIONAL INFO:

_____

_____

This Maintenance Activity Form shall be kept indefinitely and made available to the City of Aurora upon request.

GRASS BUFFERS AND GRASS SWALES
(GB-GS)
MAINTENANCE FORM

Subdivision/Business Name:_____ Completion Date:_____

Subdivision/Business Address:_____ Contact Name:_____

Maintenance Category: (Circle all that apply) Routine Restoration Rehabilitation

MAINTENANCE ACTIVITIES PERFORMED

ROUTINE WORK

____ MOWING
____ TRASH/DEBRIS REMOVAL
____ OUTLET WORKS CLEANING (TRASH RACK/WELL SCREEN)
____ WEED CONTROL (HERBICIDE APPLICATION)

RESTORATION WORK

____ SEDIMENT REMOVAL
- ____ INFLOW POINT
- ____ SWALE BOTTOM
- ____ SIDE SLOPE
- ____ BUFFER STRIP

____ EROSION REPAIR
- ____ INFLOW POINT
- ____ SWALE BOTTOM
- ____ SIDE SLOPE
- ____ BUFFER STRIP
- ____ GRADE CONTROL/LEVEL SPREADER

____ REVEGETATION
- ____ SWALE BOTTOM
- ____ SIDE SLOPE
- ____ BUFFER STRIP

REHABILITATION WORK

____ SEDIMENT REMOVAL (DREDGING)
- ____ SWALE BOTTOM
- ____ INFLOW POINT

____ EROSION REPAIR
- ____ INFLOW POINT
- ____ SWALE BOTTOM
- ____ SIDE SLOPE
- ____ BUFFER STRIP

____ STRUCTURAL REPAIR
- ____ INFLOW
- ____ UNDERDRAIN
- ____ LEVEL SPREADER

OTHER_____
_____
_____
_____
_____
_____

ESTIMATED TOTAL MANHOURS: _____

EQUIPMENT/MATERIAL USED: _____

_____

_____

COMMENTS/ADDITIONAL INFO: _____

_____

This Maintenance Activity Form shall be kept indefinitely and made available to the City of Aurora upon request.

BIORETENTION CELL (BRC) or POROUS LANDSCAPE DETENTION (PLD)

MAINTENANCE FORM

Subdivision/Business Name:_____ Completion Date:_____

Subdivision/Business Address:_____ Contact Name:_____

Maintenance Category: (Circle all that apply) Routine Restoration Rehabilitation

MAINTENANCE ACTIVITIES PERFORMED

ROUTINE WORK

____ MOWING
____ TRASH/DEBRIS REMOVAL
____ OUTLET WORKS CLEANING (TRASH RACK/WELL SCREEN)
____ WEED CONTROL (HERBICIDE APPLICATION)

RESTORATION WORK

____ SEDIMENT REMOVAL
- ____ INFLOW POINT
- ____ OUTLET WORKS
- ____ FILTER MEDIA

____ EROSION REPAIR
- ____ INFLOW POINT
- ____ EMBANKMENTS
- ____ OUTLET WORKS

____ REVEGETATION
- ____ EMBANKMENTS

____ JET-VAC/CLEARING DRAINS
- ____ OUTLET WORKS
- ____ INFLOWS
- ____ UNDERDRAIN SYSTEM

OTHER_____ _____
_____ _____
_____ _____
_____ _____
_____

REHABILITATION WORK

____ SEDIMENT REMOVAL (DREDGING)
- ____ FILTER MEDIA
- ____ INFLOW POINT

____ EROSION REPAIR
- ____ OUTLET WORKS
- ____ EMBANKMENTS
- ____ BOTTOM STAGE

____ STRUCTURAL REPAIR
- ____ INFLOW
- ____ OUTLET WORKS
- ____ FILTER MEDIA

ESTIMATED TOTAL MANHOURS: _____

EQUIPMENT/MATERIAL USED: _____

_____

_____

COMMENTS/ADDITIONAL INFO: _____

_____

This Maintenance Activity Form shall be kept indefinitely and made available to the City of Aurora upon request.

SAND FILTER BASIN (SFB)
MAINTENANCE FORM

Subdivision/Business Name:_____ Completion Date:_____

Subdivision/Business Address:_____ Contact Name:_____

Maintenance Category: Routine Restoration Rehabilitation
(Circle all that apply)

MAINTENANCE ACTIVITIES PERFORMED

ROUTINE WORK

____ MOWING
____ TRASH/DEBRIS REMOVAL
____ OUTLET WORKS CLEANING (TRASH RACK/WELL SCREEN)
____ WEED CONTROL (HERBICIDE APPLICATION)

RESTORATION WORK

____ SEDIMENT REMOVAL
- ____ INFLOW POINT/SPLITTER BOX
- ____ OUTLET WORKS
- ____ FILTER MEDIA
- ____ SEDIMENTATION CHAMBER
- ____ EMERGENCY OVERFLOW

____ EROSION REPAIR
- ____ INFLOW POINT/SPLITTER BOX
- ____ OUTLET WORKS
- ____ EMBANKMENTS
- ____ SEDIMENTATION CHAMBER
- ____ EMERGENCY OVERFLOW
- ____ FILTER MEDIA

____ REVEGETATION
____ JET-VAC/CLEARING DRAINS
- ____ INFLOWS
- ____ OUTLET WORKS
- ____ UNDERDRAIN

REHABILITATION WORK

____ SEDIMENT REMOVAL (DREDGING)
- ____ FILTER MEDIA
- ____ SEDIMENTATION CHAMBER

____ EROSION REPAIR
- ____ INFLOW POINT/SPLITTER BOX
- ____ OUTLET WORKS
- ____ EMBANKMENTS
- ____ SEDIMENTATION CHAMBER
- ____ EMERGENCY OVERFLOW
- ____ FILTER MEDIA

____ STRUCTURAL REPAIR
- ____ INFLOW POINT/SPLITTER BOX
- ____ OUTLET WORKS
- ____ FILTER MEDIA
- ____ SEDIMENTATION CHAMBER
- ____ EMERGENCY OVERFLOW

OTHER_____
_____
_____

ESTIMATED TOTAL MANHOURS: _____

EQUIPMENT/MATERIAL USED: _____

_____

_____

COMMENTS/ADDITIONAL INFO: _____

_____

This Maintenance Activity Form shall be kept indefinitely and made available to the City of Aurora upon request.

A P P E N D I X F

Annual Inspection and Maintenance Reporting Form

Annual Inspection and Maintenance Reporting Form
for
Stormwater Facilities

(This form shall be submitted to the City of Aurora prior to May 31 of each year along with the Inspection Forms and Maintenance Forms as required for the property/subdivision)

Date: _____

To: **City of Aurora**
Water Department
Attn: Operations Compliance Division
13646 East Ellsworth Avenue
Aurora, Colorado 80012

Re: **Certification of Inspection and Maintenance; Submittal of forms**

Property/Subdivision Name: _____

Property Address: _____

Contact Name: _____

I verify that the required stormwater facility inspections and required maintenance have been completed in accordance with the Stormwater Facilities Maintenance Agreement and the Inspection and Maintenance Plan associated with the above referenced property.

The required Stormwater Facility Inspection and Maintenance forms are hereby provided.

_____	_____
Name of Party Responsible for Inspection & Maintenance	Property Owner
_____	_____
Authorized Signature	Signature

A P P E N D I X G

Inspection and Maintenance Site Plan(s)

Check Lists

Facilities Map Checklist

EDB Checklist

GB-GS Checklist

BRC/PLD Checklist

SFB Checklist

INSPECTION AND MAINTENANCE SITE PLANS
STORMWATER FACILITIES MAP
CHECKLIST FOR REQUIRED ITEMS

Stormwater facilities map shall include:

- ☐ Labels for all streets (includes line work for edge of street and street name)
- ☐ Line work for right-of-way lines, lot lines, and tracts
- ☐ Line work and labels for all major drainage ways
- ☐ Label roadways, developments, etc adjacent to project site
- ☐ Labels for all BMPs being constructed on project site including a summary table when multiple BMPs are present
- ☐ Legend for identifying features/line types on drawing (optional)

INSPECTION AND MAINTENANCE SITE PLANS
EXTENDED DETENTION BASIN (EDB)
CHECKLIST FOR REQUIRED ITEMS

PLAN AND PROFILE SHEET

Plan view shall include:

- ☐ Location and labels for all major features of EDB (inflow structure(s), forebay, micro-pool, trickle channel, access road, outlet work(s), spillway, maintenance access ramps, embankment, etc.)
- ☐ Contours
- ☐ Other utilities in vicinity of EDB
- ☐ Cross-reference to EDB Operation and Maintenance Details sheet
- ☐ Line work for right-of-way lines, lot lines, easements, and tracts
- ☐ Hatch indicating permanent water elevation in micro-pool.

Profile view shall include:

- ☐ Location and labels for all major features of EDB (inflow structure(s), forebay, micro-pool, trickle channel, access road, outlet work(s), spillway, maintenance access ramps, embankment, etc.)
- ☐ Invert elevations at major features of EDB (inflow structure(s), forebay, micro-pool, outlet work(s))
- ☐ Permanent pool elevation of micro-pool
- ☐ Water quality water surface elevation
- ☐ Water surface elevation of all applicable storm events
- ☐ Label for upper and bottom stages for EDB

DETAIL SHEET

Detail sheet shall include:

- ☐ Volume provided by the EDB forebay and micro-pool, including the WQCV
- ☐ WQCV drain time
- ☐ Seed mix
- ☐ Total mow area including approximate mow boundaries on each side of EDB
- ☐ Duplicate the following tables from the “Standard Operation Procedure for Extended Detention Basin Inspection and Maintenance” document:

- Inspection and Maintenance Requirements at Specific EDB Features
- Summary of Routine Maintenance Activities for an EDB
- Summary of Minor Maintenance Activities for an EDB
- Summary of Major Maintenance Activities for an EDB

☐ Water quality outlet works detail

☐ Water quality plate detail

☐ Maintenance access road detail

☐ Trickle channel typical section

☐ Forebay edge detail (or cross section) which includes maximum allowed sediment depth in forebay

☐ Forebay release structure detail

☐ Spillway detail(s), including cutoff wall

INSPECTION AND MAINTENANCE SITE PLANS
GRASS SWALES/GRASS BUFFERS (GS/GB)
CHECKLIST FOR REQUIRED ITEMS

PLAN SHEET

Plan view shall include:

- ☐ Location of grass swale(s) and/or buffer(s)
- ☐ Contours
- ☐ Line work for right-of-way lines, lot lines, easements, and tracts
- ☐ Labels for streets adjacent to grass swale(s)/buffer(s)
- ☐ Line work for all storm sewer structures
- ☐ Cross-reference to Grass Swale/Buffer Operation and Maintenance Details sheet

DETAIL SHEET

Detail sheet shall include:

- ☐ Duplicate the following tables from the "Standard Operation Procedure for Grass Swales/Grass Buffers Inspection and Maintenance" document:
  - Typical Inspection and Maintenance Requirements Matrix
  - Summary of Routine Maintenance Activities
  - Summary of Minor Maintenance Activities
  - Summary of Major Maintenance Activities
- ☐ Typical grass swale and/or buffer section including typical horizontal and vertical dimensions, side slopes, subgrade material, and underdrain (if applicable).
- ☐ Underdrain details (if applicable) including trench dimensions, perforated PVC dimensions, and trench fill material.

INSPECTION AND MAINTENANCE SITE PLANS
BIORETENTION CELL (BRC)
aka
POROUS LANDSCAPE DETENTION (PLD)
CHECKLIST FOR REQUIRED ITEMS

PLAN SHEET

Plan view shall include:

- ☐ Location and labels for all major features of BRC/PLD (inlet pipe, overflow outlet structure, outlet pipe, etc.)
- ☐ Line work for underdrains
- ☐ Line work for right-of-way lines, lot lines, easements, and tracts
- ☐ Contours
- ☐ Other utilities in vicinity of BRC/ PLD
- ☐ Cross reference to Bioretention Cell/Porous Landscape Detention Operation and Maintenance Details sheet

DETAIL SHEET

- ☐ WQCV provided by the BRC/PLD
- ☐ WQCV drain time
- ☐ Duplicate the following tables from the "Standard Operation Procedure for Bioretention/Porous Landscape Detention Inspection and Maintenance" document:
    - Inspection and Maintenance Requirements at Specific BRC/PLD Features
    - Summary of Routine Maintenance Activities for a BRC/PLD
    - Summary of Minor Maintenance Activities for a BRC/PLD
    - Summary of Major Maintenance Activities for a BRC/PLD
- ☐ Overflow outlet box detail/typical cross section
- ☐ Typical BRC/PLD cross section (include label for depth of WQCV)
- ☐ Underdrain detail including labels for the depth and type of fill materials and diameter of perforated pipe
- ☐ Rundown cross section and details (if applicable).

INSPECTION AND MAINTENANCE SITE PLANS
SAND FILTER BASIN (SFB)
CHECKLIST FOR REQUIRED ITEMS

PLAN SHEET

Plan sheet shall include:

- ☐ Location and labels for all major features of SFB (inlet pipe, energy dissipation structures, maintenance access road, overflow outlet structure, outlet pipe, spillway, etc.)
- ☐ Line work for underdrains
- ☐ Line work for right-of-way lines, lot lines, easements, and tracts
- ☐ Contours
- ☐ Other utilities in vicinity of SFB
- ☐ Cross reference to Sand Filter Basin Operation and Maintenance Details sheet

DETAIL SHEET

Detail sheet shall include:

- ☐ WQCV provided by the SFB
- ☐ WQCV drain time
- ☐ Duplicate the following tables from the “Standard Operation Procedure for Sand Filter Basin Inspection and Maintenance” document:
  - Inspection and Maintenance Requirements at Specific SFB Features
  - Summary of Routine Maintenance Activities for a SFB
  - Summary of Minor Maintenance Activities for a SFB
  - Summary of Major Maintenance Activities for a SFB
- ☐ Overflow outlet box detail/typical section
- ☐ Typical SFB cross section (include label for depth of WQCV)
- ☐ Underdrain detail including labels for the depth and type of fill materials and diameter of perforated pipe