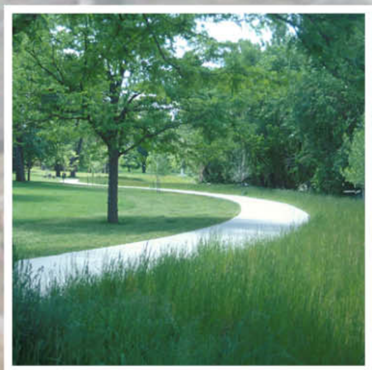
CITY AND COUNTY OF DENVER

Water Quality Management Plan






2004

team

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ACKNOWLEDGEMENTS

This Plan was developed through the collaboration and dedication of many Denver staff, an outside review committee and a diverse project team under the direction of Denver Wastewater Management Division Project Manager Terry Baus, P.E. Significant time was invested in determining the priorities of various Denver staff and departments through a detailed series of interviews. The project team would like to thank all of these individuals for providing their insights and expertise with regard to stormwater quality planning priorities and issues for Denver.

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OTHER ACKNOWLEDGEMENTS

The Urban Drainage and Flood Control District's *Storm Drainage Criteria Manual, Volumes 1-3,* was the foundation for much of this document. Portions of this Manual were paraphrased in several chapters of this Plan, particularly Chapters 6 and 7, which include both paraphrases and direct quotations.

The Greenway Foundation provided attractive photographs of the South Platte River for inclusion in this Plan.

[1] All members of the Advisory Committee participated in interviews with their respective departments, but their names have not been repeated in this interview list.

EXECUTIVE SUMMARY

OVERVIEW

The purpose of this *Denver Water Quality Management Plan* (Plan) is to advance a framework for better integrating stormwater management and water quality protection into planning, engineering, and infrastructure management for the City and County of Denver (Denver). This Plan will serve as a common authoritative reference identifying Denver's commitments, priorities, and strategies for protecting its rivers, streams, lakes, and wetlands from the adverse impacts of urban stormwater runoff. In addition, the Plan provides a practical initial strategy for managing stormwater runoff quality in the near term, while laying the groundwork for a long-term vision. This Plan is relevant to Denver staff, land developers undertaking new or redevelopment projects, other parties conducting activities that impact urban runoff, and citizens who want to support water quality protection in the Denver area. The primary goals of this Plan are identified in Exhibit ES.1. The remainder of this Executive Summary describes the project approach, stormwater quality Best Management Practice (BMP)[1] implementation guidelines, and recommendations resulting from the Plan.

> **EXHIBIT ES.1**
> **PLAN GOALS**
>
> DEVELOP A FRAMEWORK AND SHARED VISION FOR MEETING DENVER'S STORMWATER QUALITY REQUIREMENTS AND GOALS
>
> DEVELOP BMP STRATEGIES THAT WORK IN VARIOUS DENVER SETTINGS
>
> DEVELOP A COMMON FOUNDATION FOR INTERDEPARTMENTAL UNDERSTANDING OF STORMWATER QUALITY REQUIREMENTS AND THEIR ROLE IN THE PLANNING PROCESS
>
> DEVELOP A FRAMEWORK AND PRIORITIES FOR FUTURE WORK NEEDED TO MEET GOALS

APPROACH

This Plan has been developed using a multi-faceted approach to ensure that a practical and innovative strategy for addressing water quality is developed for Denver. Multiple interviews and meetings were conducted with key Denver staff to develop a Plan that will be beneficial to many Denver departments. Key aspects of the project approach include:

- **Extensive collaboration among multiple city departments.** Acceptance and use of this Plan across city departments is critical to its success. This document has been developed through close collaboration and frank discussion among multiple departments within

[1] Best Management Practices (BMPs) include a variety of both structural and non-structural techniques implemented to help minimize pollution of streams, rivers, lakes, and wetlands. BMPs are the foundation of stormwater quality management and regulation and are a key topic throughout this Plan. Representative examples of BMPs include source controls such as proper fertilizer use and structural BMPs such as water quality detention basins and porous landscape detention. See Chapter 6 of this Plan for more information.

Denver including Public Works, Parks and Recreation, Community Planning and Development, Environmental Health, and the City Attorney's Office. By diligently working together to prepare this document, a more unified position and vision for stormwater quality management has emerged. Some of the opportunities and challenges identified during interviews and Advisory Committee meetings are summarized in Exhibit ES.2.

- **Identification and review of regulations and existing Denver planning documents affecting or interfacing with stormwater quality management strategies in Denver.** Many existing and proposed federal, state and local water quality regulations directly influence stormwater quality management in Denver. Key regulations were inventoried and described in order to provide a common basis for understanding stormwater quality management requirements. Similarly, Denver has many excellent planning documents and programs that help guide planning and watershed management decisions. In order to avoid reinventing the wheel, a review and summary of these key documents was completed.

- **Review of similar efforts in other communities with advanced stormwater programs.** Communities throughout the country are reassessing their approach to stormwater and watershed management. Early in development of this Plan, five communities with advanced stormwater programs were identified to explore their approaches, successes, and difficulties in addressing urban runoff. Interviews and review of key documents were conducted for these communities: Portland, Oregon; San Diego, California; Austin, Texas; Prince George's County, Maryland; and Snohomish County, Washington. Findings from this research have been taken into account in development of this Plan with regard to general approach, as well as for recommendations for specific BMPs.

EXHIBIT ES.2
STORMWATER QUALITY MANAGEMENT
OPPORTUNTIES AND CHALLENGES

ADDRESS WATER QUALITY ISSUES (E.G., 303(D) LISTED SEGMENTS, STREAM STANDARDS)

IMPROVE INTERDEPARTMENTAL COOPERATION WITH REGARD TO INTEGRATING WATER QUALITY INTO SITE DEVELOPMENT

COORDINATE COMPATIBLE USES BETWEEN PARKS AND WATER QUALITY FACILITIES

ENHANCE COMPATIBILITY BETWEEN URBAN DESIGN GOALS AND WATER QUALITY FACILITIES

IMPLEMENT EFFECTIVE, SUSTAINABLE, ATTRACTIVE, MULTI-PURPOSE, SAFE AND WELL-DESIGNED BMPS

ENSURE LONG-TERM BMP OPERATION AND MAINTENANCE

DEVELOP FINANCING AND INSTITUTIONAL STRATEGIES FOR REGIONAL BMPS

- **Identification of stormwater BMPs that have been both successful and unsuccessful in the Denver area.** The Project Team spent several days in the field visiting BMP sites in Denver. The strengths and weaknesses observed at these sites have been incorporated into the recommendations and strategies identified in this Plan. Photographs of many of these BMP sites are interspersed throughout this document.

- **Review of new stormwater BMP technology and approaches for potential applicability to Denver.** Policy statements on new BMP technology such as underground proprietary treatment devices have been developed and provided in Chapter 6. Approaches that manage runoff close to the source and promote infiltration through landscape-based strategies are explored for more extensive application in the Denver area. Terms commonly used for these approaches include Minimizing Directly Connected Impervious Area, Smart Growth for Clean Water, and Low Impact Development. Circumstances under which new approaches may be considered are also identified.

- **Development of practical stormwater quality BMP implementation guidelines.** As a result of the initial project tasks described above, the most significant need identified was practical guidance for implementing and managing stormwater quality in Denver. Chapters 6 and 7 provide this guidance, with the Stormwater Quality BMP Implementation Guidelines further summarized below.

- **Accommodation of periodic updates and revisions.** Denver recognizes and intends that this Plan will be a "living" document that will need to be updated periodically to reflect changes in the Denver area, BMP technology, and various regulations and policy shifts. These updates will be posted on Denver's web site, www.denvergov.org. The principles of adaptive management apply to this plan, as is the case for many related Denver planning documents.

STORMWATER QUALITY BMP IMPLEMENTATION GUIDELINES

A top priority identified through departmental interviews and Project Advisory Committee input was the need to provide clear guidance on how stormwater quality management could be effectively accomplished in a variety of development settings. To accomplish this task, the Project Team worked closely with the Project Advisory Committee to develop stormwater quality management strategies for seven common development types, including Ultra Urban, High Density Mixed Use, Campus, Industrial, Low Density Mixed Use, Residential, and Parks and Open Space Natural Areas. The Plan provides design recommendations for these development types addressing several factors:

1. Runoff reduction techniques to decrease runoff volume and reduce the Water Quality Capture Volume[2] requiring treatment.

2. BMPs to treat the Water Quality Capture Volume appropriate for the development type.

3. Flood detention methods to attenuate peak runoff from larger storm events on site.

4. More in depth guidance on specific aspects of BMP implementation.

Sketches and photographs showing how design recommendations can be implemented on typical development sites help to communicate effective stormwater management strategies for the various development types. The Plan's recommended strategies build upon the BMPs in the Urban Drainage and Flood Control District's (UDFCD's) *Urban Storm Drainage Criteria Manual, Volume 3*.

Stormwater quality BMP implementation guidelines for the various development types are further supplemented by implementation details for topics such as roof runoff treatment, stormwater management in parking lots, stormwater runoff distribution approaches, sediment removal traps and forebays, planting/vegetation considerations, and soils. BMP fact sheets describing grass buffers, grass swales, porous pavement, porous pavement detention, porous landscape detention, detention basins, and other approaches are also provided. Although detailed design guidance in the *Urban Storm Drainage Criteria Manual, Volume 3* (UDFCD 1999) is not reproduced in this Plan, the fact sheets provide practical supplemental information for the BMPs on topics such as typical applications, operation and maintenance considerations, landscape considerations, retaining walls, vehicular access, outlets, etc. The final portion of Chapter 6 provides suggestions for better integrating BMP maintenance into stormwater quality planning and provides specific recommendations for maintenance of various BMPs.

RECOMMENDATIONS AND CONCLUSIONS

As is the case with cities throughout the country, Denver is faced with complex regulatory requirements with regard to water quality. Denver's Phase I Colorado Discharge Permit System (CDPS) permit specifies stringent requirements with which Denver must comply or face significant penalties. Fortunately, Denver already has many sound water quality requirements in place in the form of policies and regulations. Specific action items requiring additional work that are not currently included in existing Denver departmental programs are highlighted in Exhibit ES.3. An overall summary of recommendations for on-going and future water quality protection efforts by Denver follows.

[2] The Water Quality Capture Volume is the quantity of stormwater runoff that must be treated in stormwater quality BMPs in Denver. This volume is equivalent to the runoff from an 80th percentile storm, meaning that 80 percent of the most frequently occurring storms are fully captured and treated and larger events are partially treated. In simple terms, this quantity is about half of the runoff from a 2-year storm.

1. All new and redevelopment projects must address water quality in their development plans, complying with the stormwater policies and design criteria specified in the *Urban Storm Drainage Criteria Manual, Volumes 1-3* (UDFCD 1999, 2001) and in Denver's CDPS permit. Particularly critical is the four-step BMP planning process that requires:

    - Implementing stormwater runoff reduction practices.
    - Providing treatment of the Water Quality Capture Volume.
    - Implementing streambank and channel stabilization techniques for any drainageways within or adjacent to a project site.
    - Providing additional treatment for pollution "hot spots."

2. Under Denver's CDPS permit, adverse impacts to receiving waters posed by urban stormwater discharges must be minimized to the "maximum extent practicable." [3] Examples of these adverse impacts can include increased pollutant loading, increased runoff rates and volumes, channel instability, modification of aquatic habitat and increased sediment loading, both during and after construction. It is essential to recognize that, despite the best efforts to control stormwater runoff, there will be some change in receiving water characteristics due to development; therefore, a "zero impact" policy is not realistic or attainable. As a result, Denver advocates management of stormwater through the implementation of BMPs designed in accordance with the guidelines established by UDFCD (UDFCD 1999, 2001), as summarized in #1, above.

EXHIBIT ES.3
NEW ACTION ITEMS

UPDATE DENVER'S *STORM DRAINAGE CRITERIA MANUAL* AND STORMWATER QUALITY CONTROL PLAN GUIDANCE TO REFLECT THE POLICIES, STRATEGIES AND RECOMMENDATIONS OF THIS PLAN

UPDATE DENVER'S STORM SEWER EASEMENT AND INDEMNITY AGREEMENT TO IDENTIFY SPECIFIC BMP MAINTENANCE REQUIREMENTS

EXPAND INTERDEPARTMENTAL AND CITYWIDE PUBLIC EDUCATION ON STORMWATER QUALITY MANAGEMENT

CONDUCT A FEASIBILITY STUDY OF POTENTIAL REGIONAL STORMWATER QUALITY FACILITY LOCATIONS

COMPLETE REGIONAL BMP FINANCING ALTERNATIVES ANALYSIS

CONDUCT WATERSHED-BY-WATERSHED WATER QUALITY ASSESSMENTS

DEVELOP EASY-TO-UNDERSTAND BMP MAINTENANCE GUIDANCE DOCUMENT(S)

SPONSOR PILOT-TESTING OF INNOVATIVE BMPS IN DENVER

[3] See the Glossary for the regulatory definition of "maximum extent practicable."

3. Denver will continue to advocate the use of multiple BMPs, including non-structural measures, source controls, and structural BMPs, to reduce stormwater pollution. Whenever practicable, combining BMPs in series can be very effective in reducing stormwater pollution.

4. The stormwater quality BMP implementation guidelines provided in Chapter 6 of this Plan will be shared with developers and city staff alike to promote better integration of water quality into site designs, including more substantial use of runoff reduction techniques.

5. Denver will work to ensure that water quality is addressed in the very beginning of the site development process so that stormwater quality BMPs are better and more cost effectively integrated into site designs. Various Denver departments (e.g., Public Works, Planning, Parks, Environmental Health) must work together with a shared vision of stormwater quality management to accomplish this goal.

6. Urban stormwater management must be an integral part of site design and take into consideration multiple objectives. As stated in the *Urban Storm Drainage Criteria Manual, Volume 1* (UDFCD 2001), the many competing demands placed on space and resources require that stormwater management strategies take into account water quality enhancement, groundwater recharge, recreation, wildlife habitat, wetland protection, protection of landmarks/amenities, control of erosion and sediment deposition, and creation of open space. In addition, the appearance of BMPs is particularly important; Denver will expect to receive site development plans that feature attractive BMPs that will be viewed as assets by the community. Denver will encourage multi-purpose usage of BMPs; however, compatibility among uses must be demonstrated (e.g., compatibility between recreational areas and detention areas).

7. Planning for water quality must proceed hand-in-hand with drainage planning for quantity (rate and volume). In urban areas, these two planning efforts are inseparable. When these issues are addressed together and early in the site planning process, more efficient, economical and attractive land uses generally result.

8. Denver will continue to review BMP designs for pubic safety and maintenance accessibility, maintainability, documentation of maintenance requirements and schedule, and assured long-term funding for maintenance. Proper maintenance is fundamental to public safety and long-term effectiveness of stormwater BMPs; therefore, Denver will take these steps to promote better long-term maintenance of BMPs:

   - Require inclusion of a simple BMP maintenance plan as part of Denver's Stormwater Quality Control Plan submittal requirements.

   - Require a legally binding description of BMP maintenance requirements and arrangements as part of development plan approval.

   - Clearly identify BMP maintenance requirements in forthcoming updates to Denver's *Storm Drainage Criteria Manual*.

- Prepare easy-to-understand maintenance guidance documents and brochures for both pubic and private facility owners. These documents will be based on maintenance recommendations of UDFCD and the guidelines provided in Chapter 6 of this Plan.

9. The same stormwater quality management expectations and practices that apply to projects in the private sector also apply to projects that are the responsibility of Denver, such as buildings, parks, streets, utilities, etc. When Denver is preparing plans for any such projects or managing, maintaining and/or upgrading existing facilities, potential adverse stormwater quality effects must be evaluated and suitably mitigated.

10. Denver will continue to actively participate in regional water quality management efforts such as those being conducted by South Platte Cooperative for Urban River Evaluation (CURE), the Cherry Creek Basin Stewardship Partners, and the Barr Lake-Milton Reservoir Watershed Group. These on-going efforts emphasize the importance of Denver partnering with neighboring communities to tackle difficult water quality issues. Denver must also stay abreast of forthcoming regulatory changes that affect management of the many lakes and streams within its boundaries.

11. Denver's stormwater management strategies must be consistent with the principles, criteria, and priorities in its multiple planning and technical criteria documents, as described in Chapter 4.

12. Denver will work to remove obstacles to innovative stormwater management approaches by reviewing regulations and codes and, where practical, modifying requirements that conflict with the principles of this Plan. For example, such conflicts may arise with regard to parking lot and curb and gutter design requirements relative to some Low Impact Development approaches.

13. Denver will continue to promote managing and treating stormwater quality using aboveground facilities, rather than in subsurface, "vault-type" treatment devices. Nevertheless, Denver recognizes that there are some cases where the use of such facilities is necessary due to extreme space constraints in smaller redevelopment sites, such as those located in the downtown area.

14. Denver will evaluate the feasibility of collaborating with UDFCD, a university, other local governments, and other organizations to pilot-test innovative BMPs. Denver will continue to actively partner with UDFCD to develop design guidance for "new" BMPs for the Denver area.

15. Denver will continue to educate the public on stormwater quality issues. Additional opportunities for Denver's existing public education program include:

    - Provide additional educational brochures and water pollution prevention resources on the Denver website. For example, as discussed in Chapter 5, many of the national case studies provide extensive web resources.

- Develop pollution prevention programs for specific industries that require further attention and/or partner with entities providing existing programs. For example, the City of Boulder's Partners for a Clean Environment (PACE) program targets and provides educational information to specific industry segments including auto repair, auto body, green building, dental offices, dry cleaning, landscaping, manufacturing, printing, restaurant, and retail sectors. The City of Portland has a similar program. As an alternative to independently developing such programs, Denver can partner with professional organizations and industry groups to support their efforts in this type of training.

- Educate developers and Denver staff on the benefits of land management strategies such as open space/natural areas preservation and/or restoration, riparian buffer zone protection, Smart Growth, Green Development, and Low Impact Development strategies.

- Continue educational campaigns on specific measures to minimize pollution at its source. These efforts will include a multi-faceted approach directed to the public, Denver staff and elected officials, and neighboring communities.

16. Based on an initial reconnaissance level evaluation (as described in Chapter 8), there are promising opportunities for regional water quality BMPs, including large retention basins and wetlands, that could reduce impacts to downstream receiving waters. Methods to finance the development and maintenance of these facilities are urgently needed. In addition, Denver will proceed with more detailed citywide planning to identify and prioritize regional BMP alternatives. As a part of any regional facility evaluation, it will be important to clearly define under what circumstances a developer can have their requirement for onsite water quality treatment waived (e.g., paying a fee-in-lieu-of treatment) due to regional treatment facilities.

17. Closely related to regional water quality facilities is the need to conduct a watershed-by-watershed evaluation of current stream and lake conditions, including steps that are necessary to improve the status quo. The purpose of such an evaluation is to identify watershed-specific goals, priorities, data gaps and practicable mitigation measures that could be developed to strategically improve conditions. It is logical to focus initially on 303(d)-listed streams (i.e., those that are considered to be "impaired" for one or more pollutants) and to work closely with existing efforts such as those of South Platte CURE, the Barr-Milton Watershed Group, and Denver Public Works and Environmental Health.

18. Denver will continue to monitor approaches used throughout the country related to stormwater and watershed management. Lessons learned from case studies evaluated in this Plan will be kept in mind during decision-making and planning for Denver. Examples of common themes from communities with advanced stormwater programs include:

    - Comprehensive approaches are being used to address drainage, flooding, erosion, aquatic life, native habitat, and water quality in an integrated manner.

- Watershed-based approaches are being used for planning and problem solving.
- Geographic Information System (GIS) tools are being used effectively to prioritize stormwater improvements and to more effectively communicate to citizens, staff, and developers.
- Storm runoff volume reduction practices are being used in many of these communities. These practices include a variety of runoff reduction techniques such as grass buffers and swales, green roofs, and other landscape-based approaches.
- The importance of sound long-term maintenance of BMPs is widely recognized, as is the need to provide pubic safety at drainage facilities.
- Strong public education and outreach campaigns in combination with extensive web sites are substantive components of these programs. Education is being aggressively used as a key strategy to improve runoff quality.
- Significant financial investments, often measured in millions of dollars, have been required for many communities to conduct their stormwater quality planning efforts. These communities recognize that comparable future expenditures will be required to implement their plans, and are implementing suitable methods of financing.

19. Because the water quality challenges facing Denver will require significant funding, new and potentially innovative financing strategies that capitalize on public/private partnerships will be investigated.

20. Although this Plan provides a solid framework and foundation for effective stormwater quality management in Denver, follow-up implementation measures are needed to ensure that the principles and practices set forth in this Plan are implemented throughout Denver. An initial implementation plan specifying target timeframe, activities, responsible departments, and approximate costs has been developed in Chapter 9 of this Plan.

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Chapter 1
INTRODUCTION

Protecting and enhancing water quality has long been an important objective in the City and County of Denver (Denver). Additionally, Denver is obligated under penalty of law to comply with the requirements of its Colorado Discharge Permit System (CDPS) municipal stormwater discharge permit. A stronger push towards clean water in Denver has been prompted by recent changes such as:

- Current and anticipated federal and state regulatory and CDPS permit requirements.
- The water quality improvement goals of Mayor Hickenlooper and his Administration.
- Increased recognition of the economic, ecological and social importance of water features for Denver residents, businesses and visitors.
- The need to protect natural resources, including preservation of open space, due to population growth.
- Recognition of the public health, safety and welfare implications of stormwater management programs and facilities.
- Proliferation of new approaches for protecting and improving water quality.

When looking at Denver as a whole, a key influence on stream and lake water quality is urban stormwater runoff from rainfall and snowmelt—the water that runs off streets, parking lots, buildings, ball fields, industrial/commercial sites, residential neighborhoods, etc. Without control measures, or Best Management Practices (BMPs), urban runoff typically adversely affects the physical, chemical and biological characteristics of streams, lakes and wetlands. For example, without mitigation, increased runoff volumes and peak discharges commonly associated with urbanization often cause stream channels to degrade through widening, deepening, accumulation of unsightly sediment deposits, significant modification to aquatic habitat, and other impacts. Elevated concentrations of substances such as gasoline and diesel fuel, oil, grease, fertilizer, heavy metals,

EXHIBIT 1.1
THE SOUTH PLATTE RIVER: AN URBAN AMENITY

Source: The Greenway Foundation.

pesticides, and pet waste can be harmful to aquatic life, native plants and wildlife and/or impair the ability of waterways to support recreation, industrial and municipal water supply, and other beneficial uses.

This chapter defines the purpose, approach, guiding principles, opportunities and challenges, overview, and scope limitations of this Plan, which has been developed to create a framework to enable Denver to address current and future challenges posed by urban runoff.

> **EXHIBIT 1.2**
> **PLAN GOALS**
>
> DEVELOP A FRAMEWORK AND SHARED VISION FOR MEETING DENVER'S STORMWATER QUALITY REQUIREMENTS AND GOALS
>
> DEVELOP BMP STRATEGIES THAT WORK IN VARIOUS DENVER SETTINGS
>
> DEVELOP A COMMON FOUNDATION FOR INTERDEPARTMENTAL UNDERSTANDING OF STORMWATER QUALITY REQUIREMENTS AND THEIR ROLE IN THE PLANNING PROCESS
>
> DEVELOP A FRAMEWORK AND PRIORITIES FOR FUTURE WORK NEEDED TO MEET GOALS

PURPOSE AND GOALS

The purpose of this *Denver Water Quality Management Plan* (Plan) is to advance a framework for better integrating stormwater management and water quality protection into planning, engineering, and infrastructure management for Denver. This Plan will serve as a common authoritative reference identifying Denver's commitments, priorities, and strategies for protecting its rivers, streams, lakes, and wetlands from the adverse impacts of urban stormwater runoff. In addition, the Plan provides a practical initial strategy for managing stormwater runoff quality in the near term, while laying the groundwork for a long-term vision. This Plan is relevant to Denver staff, land developers undertaking new or redevelopment projects, other parties conducting activities that impact urban runoff, and citizens who want to support water quality protection in the Denver area. The primary goals of this Plan follow.

Goal 1: Develop a Framework and Shared Vision for Meeting Denver's Stormwater Quality Requirements and Goals

As is the case in many cities, decision-making in Denver is shared across multiple departments and guided by many rules and regulations with inherently different goals and priorities. Water quality-related issues have historically been addressed primarily through departments such as Public Works and Environmental Health; however, due to the advent of the Phase I stormwater regulation[1], water quality-related issues are increasingly relevant to Parks and Recreation, Community Planning and Development, Asset Management, and other Denver departments.

[1] The U.S. Environmental Protection Agency (EPA) issued the Phase I stormwater regulations requiring National Pollutant Discharge Elimination System (NPDES) point source permit coverage for stormwater discharges from: (1) "medium" and "large" Municipal Separate Storm Sewer Systems (MS4s) generally serving populations of 100,000 or greater; (2) construction activity disturbing 5 or more acres of land; and (3) 10 categories of industrial activity.

A primary goal of this document is to develop a shared vision for achieving Denver's water quality protection requirements under its CDPS stormwater permit. This permit identifies specific requirements intended to decrease the adverse impacts of stormwater discharged from Denver's municipal separate storm sewer system (MS4). This permit clearly identifies binding provisions and serious penalty clauses if violated and essentially states that Denver must aggressively address the problems caused by urban stormwater discharges. State stream standards help to assess whether receiving waters in Denver meet their designated uses such as recreation, aquatic life, and water supply. In the event that streams receiving stormwater discharges from Denver do not meet state-designated stream standards, Denver will likely be required to enter into a more comprehensive regulatory process with additional requirements under the Total Maximum Daily Load (TMDL) process (as discussed in Chapter 3).

In addition to purely regulatory-driven requirements, water quality protection and improvement has been identified as an important goal in the *Denver Comprehensive Plan 2000* (Denver 2000), *Cherry Creek Greenway Corridor Master Plan* (BRW 2000), *Natural Areas Program Field Guide* (Denver Parks and Recreation 2004), *Design Guidelines for Stapleton Water Quality* (Denver 2001), and others. For these reasons, water quality protection and improvement are not only legal requirements, but also high priorities for a city known for its natural beauty. Developing a shared citywide vision and framework will help Denver to achieve its water quality protection goals.

Goal 2: Develop BMP Strategies that Work in Various Denver Settings

Denver's Phase I stormwater permit requirements are based on both structural and non-structural BMPs to minimize the impacts of urban runoff. Design criteria for stormwater management practices appropriate for Denver have been clearly defined in the *Urban Storm Drainage Criteria Manual, Volumes 1 through 3* (UDFCD 1999, 2001) and adopted into Denver's *Storm Drainage Design and Technical Criteria Manual* (Denver 1992). While these documents provide sound engineering guidance on designing these BMPs, less information has been provided on how to best integrate these types of BMPs into specific settings likely to be found in Denver. The *Design Guidelines for Stapleton Water Quality* were successful in helping achieve an integrated water quality plan for the Stapleton Redevelopment area; therefore, this Plan has used a similar approach to provide BMP implementation guidelines for the entire city. To achieve the goal of developing BMP strategies that work in various settings, this Plan assesses a

EXHIBIT 1.3
KENNEDY SOCCER COMPLEX DETENTION BASIN

The final Phase II storm water regulations were published in December 1999 and require NPDES permit coverage for construction activities that disturb 1 to 5 acres and for regulated small MS4s.

variety of existing and new BMPs and identifies implementation strategies appropriate for development types in Denver. These BMP strategies build on the *Urban Storm Drainage Criteria Manual, Volumes 1-3* (UDFCD 1999, 2001), providing additional information on how BMPs can best be integrated into and be more effective for various development types. To the extent possible, the development types in this Plan are consistent with those found in the city's planning document, *Blueprint Denver* (Denver 2000).

Goal 3: Develop a Common Foundation for Interdepartmental Understanding of Stormwater Quality Requirements and Their Role in the Planning Process

In order for any water quality protection strategy to be effective, it needs to be clearly documented, understood, accepted, and implemented across city departments. The strategies in this Plan have been developed based on input from multiple city departments to identify concerns and priorities related to water quality. Early integration of water quality requirements into site designs has been identified as critical for development and redevelopment projects. This Plan is intended to provide a common base of understanding across city departments to facilitate more effective integration of water quality requirements. This Plan also contains a glossary of key terminology to facilitate a common understanding of key concepts by users with varied backgrounds. Concurrent with development of this Plan, the development review process was undergoing review and revision; therefore, additional work will likely be needed to ensure that the priorities of this Plan are integrated into the development review process.

Goal 4: Develop Framework and Priorities for Future Work Needed to Meet Goals

The Wastewater Management Division's initial vision for this Plan identified many potential topics to be addressed. It was not possible to cover all of these topics in detail; therefore, a key goal of this Plan has been to identify topics and issues that will be important to the future of Denver's water quality management strategy, but that were beyond the scope of this document. Recommendations and an initial implementation plan for future work on these topics have been included in the Chapter 9 of this Plan. Representative topics include a watershed-by-watershed assessment of water quality conditions, identification of specific locations for potential future regional water quality treatment facilities, and exploration of funding alternatives for providing regional water quality facilities.

APPROACH

This Plan has been developed using a multi-faceted approach to ensure that a practical and innovative strategy for addressing water quality is developed for Denver. Multiple interviews and meetings were conducted with key Denver staff to develop a Plan that will be beneficial to many Denver departments. Key aspects of the project approach include:

- **Extensive collaboration among multiple city departments.** Acceptance and use of this Plan across city departments is critical to the success of this Plan. This document has been developed through close collaboration and frank discussion among multiple departments within Denver including Public Works, Parks and Recreation, Community Planning and Development, Environmental Health, and the City Attorney's Office. By working together to prepare this Plan, a more unified position and vision for stormwater quality management has emerged.

- **Identification and review of regulations and existing Denver planning documents affecting or interfacing with stormwater quality management strategies in Denver.** Many existing and proposed federal, state and local water quality regulations directly influence stormwater quality management in Denver. Key regulations were inventoried and described in order to provide a common basis for understanding stormwater quality management requirements. Similarly, Denver has many excellent planning documents and programs that help guide planning and watershed management decisions. In order to avoid reinventing the wheel, a review of these key documents was completed.

- **Review of similar efforts in communities with advanced stormwater programs.** Communities throughout the country are reassessing their approach to stormwater and watershed management. Early in the development of this Plan, five communities were identified to explore their approaches, successes and difficulties in addressing urban runoff. Interviews and review of key documents were conducted for these communities: Portland, Oregon; San Diego, California; Austin, Texas; Prince George's County, Maryland; and Snohomish County, Washington. Findings from this research have been taken into account in development of this Plan with regard to general approach, as well as for recommendations for specific BMPs.

- **Identification of stormwater BMPs that have been both successful and unsuccessful in the Denver area.** The Project Team spent several days in the field visiting BMP sites in Denver. The strengths and weaknesses observed at these sites have been taken into account in the recommendations and strategies identified in this Plan. Photographs of many of these BMP sites (both good and bad) are interspersed throughout this Plan.

- **Review of new stormwater BMP technology and approaches for potential applicability to Denver.** Policy statements on new BMP technology such as underground proprietary treatment devices have been developed and provided in Chapter 6. Approaches that manage runoff close to the source and promote infiltration through landscape-based strategies are explored for more extensive application in the Denver area. Terms commonly used for these approaches include Minimizing Directly Connected Impervious

EXHIBIT 1.4
STORMWATER BMPS SHOULD BE DESIGNED AND MAINTAINED TO PROTECT PUBLIC HEALTH AND AVOID NUISANCE CONDITIONS

Area, Smart Growth for Clean Water, and Low Impact Development. Circumstances under which new approaches may be considered are also identified.

- **Development of practical stormwater quality BMP implementation guidelines.** As a result of the initial project tasks described above, the most significant need identified was practical guidance for implementing and managing stormwater quality in Denver. Chapters 6 and 7 provide this guidance. Representative questions considered as part of development of this guidance are summarized in Exhibit 1.5

- **Accommodation of periodic updates and revisions.** Denver recognizes and intends that this Plan will be a "living" document that will need to be updated periodically to reflect changes in the Denver area, BMP technology, and various regulations and policy shifts. These updates will be posted on Denver's web site, www.denvergov.org. The principles of adaptive management apply to this plan, as is the case for many related Denver planning documents.

EXHIBIT 1.5 QUESTIONS CONSIDERED DURING PLAN DEVELOPMENT

- What stormwater quality requirements apply to development and redevelopment sites?
- What are the key regulatory requirements that are prompting mandatory implementation of BMPs on new development and redevelopment sites? Are these requirements anticipated to change in the future and, if so, in what ways?
- What factors influence BMP selection for a given site?
- What selection process should be utilized to determine the most appropriate BMP plan for a particular site?
- What performance criteria or standards apply, if any?
- How do stormwater quality requirements interface with more traditional drainage and flood control requirements?
- To what extent can Denver parks and natural area open spaces be utilized for stormwater quality management? What precautions need to be taken to assure that stormwater management does not impair intended park or natural area open space uses?
- How can BMPs be planned, designed and maintained to be viewed as community assets rather than liabilities?
- How should the BMP selection and design process account for issues such as public safety, maintenance, environmental permitting, and others?

PRINCIPLES AND POLICIES

Early in development of this Plan, the Project Advisory Committee and the Project Team agreed on several foundational principles and policies, including:

- All new and redevelopment projects must address water quality in their development plans, complying with the stormwater policies and design criteria specified in the *Urban Storm Drainage Criteria Manual, Volumes 1-3* (UDFCD 1999, 2001) and in Denver's CDPS permit. Particularly critical is the four-step BMP planning process that requires:

    1. Implementing stormwater runoff reduction practices.

    2. Providing treatment of the Water Quality Capture Volume.

    3. Implementing streambank and channel stabilization techniques for any drainageways within or adjacent to a project site.

    4. Providing additional treatment for pollution "hot spots."

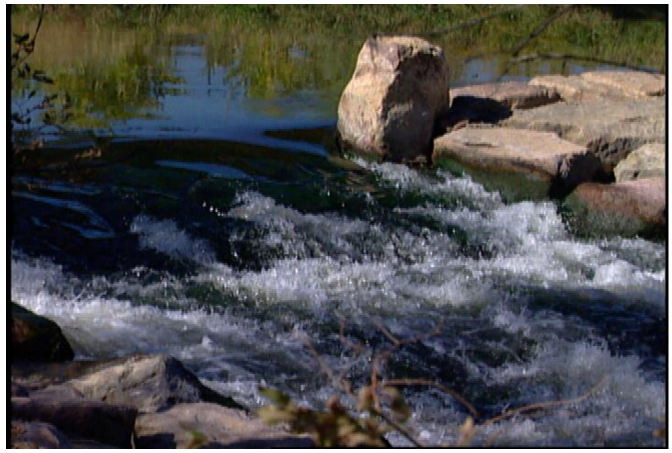
- Under Denver's CDPS permit, adverse impacts to receiving waters posed by urban stormwater discharges must be minimized to the "maximum extent practicable." Examples of these adverse impacts can include increased pollutant loading, increased runoff rates and volumes, channel instability, modification of aquatic habitat and increased sediment loading, both during and after construction. It is essential to recognize that, despite the best efforts to control stormwater runoff, there will be some change in receiving water characteristics due to development; therefore, a "zero impact" policy is not realistic or attainable. As a result, Denver advocates management of stormwater through the implementation of BMPs designed in accordance with the guidelines established by UDFCD (UDFCD 1999, 2001), as summarized above.

- Denver will continue to advocate the use of multiple BMPs, including non-structural measures, source controls, and structural BMPs, to reduce stormwater pollution. Whenever practicable, combining BMPs in series can be very effective in reducing stormwater pollution.

- Urban stormwater management must be an integral part of site design and take into consideration multiple objectives. As stated in the *Urban Storm Drainage Criteria Manual, Volume 1* (UDFCD 2001), the many competing demands placed on space and resources require that stormwater management strategies take into account water quality enhancement, groundwater recharge, recreation, wildlife habitat, wetland protection, protection of landmarks/amenities, control of erosion and sediment deposition, and creation of open space. In addition, the appearance of BMPs is particularly important; Denver will expect to receive site development plans that feature attractive BMPs that will be viewed as assets by the community. Denver will encourage multi-purpose usage of BMPs; however, compatibility among uses must be demonstrated (e.g., compatibility between recreational areas and detention areas).

- Planning for water quality must proceed hand-in-hand with drainage planning for quantity (rate and volume). In urban areas, these two planning efforts are inseparable (UDFCD 2001). When these issues are addressed together and early in the site planning process, more efficient, economical and attractive land uses generally result.

EXHIBIT 1.6
ATTRACTIVE GRADE CONTROL STRUCTURE ON THE SOUTH PLATTE RIVER HELPS TO REDUCE THE IMPACTS OF URBANIZATION



Source: The Greenway Foundation.

- Water quality must be addressed in the very beginning of the site development process to ensure that water quality BMPs are incorporated into the site design. Benefits of this practice include better site designs and more cost-effective BMPs.

- Denver will continue to review BMP designs for pubic safety and maintenance accessibility, maintainability, documentation of maintenance requirements and schedule, and assured long-term funding for maintenance. Proper maintenance is fundamental to public safety and long-term effectiveness of stormwater BMPs.

- Denver strongly prefers managing and treating stormwater quality on the ground surface, rather than in subsurface, vault-type treatment devices. Nevertheless, Denver recognizes that there are some cases where the use of such facilities is necessary. For example, this approach may be acceptable in cases of extreme space constraints that occur on smaller redevelopment sites, which are essentially completely impervious in their current condition, such as some locations in the downtown area. Chapter 6 provides specific guidance on the conditions under which these types of treatment devices may be considered.

- The same stormwater quality management expectations and practices that apply to projects in the private sector also apply to projects that are the responsibility of Denver, such as buildings, parks, streets, utilities, etc. When Denver is preparing plans for any such projects or managing, maintaining and/or upgrading existing facilities, potential adverse stormwater quality effects must be evaluated and suitably mitigated.

OPPORTUNITIES AND CHALLENGES

A primary goal of this Plan is to develop a framework for managing runoff water quality in a manner that is not only effective, but that also takes into consideration the goals of the many city departments and citizens. For these reasons, the Project Team worked closely with an interdepartmental advisory committee and conducted multiple interviews to identify key concerns and priorities of various city departments. As a result, several key opportunities and challenges emerged for this Plan that are summarized in Exhibit 1.7 and discussed in more detail below. This Plan provides a framework for addressing these challenges.

Address Water Quality Issues

Portions of the South Platte River, Sand Creek, Berkley Lake, and other Denver waterbodies do not currently meet state stream standards for one or more constituents, resulting in "listing" of waterbodies on the state's 303(d) list. (See Chapter 3 for more information.) In addition, continued growth will apply increasing pressure on water quality. Working towards attainment of water quality standards and complying with Denver's stormwater CDPS permit are high priorities for Denver and have been strongly emphasized by the Public Works Department and the Mayor's office.

Chapters 6 and 7 of this Plan provide structural and non-structural BMP strategies that can be used to help Denver improve the quality of urban runoff. In addition, stormwater quality BMP implementation guidelines for a variety of land use types are provided to aid developers and planners in selecting strategies that work in various settings. Recommendations regarding future watershed-by-watershed assessments of water quality are also identified in Chapter 9 as an important step to developing and/or advancing basin-specific approaches to water quality issues facing Denver.

Improve Interdepartmental Cooperation With Regard to Water Quality

Stormwater quality treatment requirements are best integrated into the early stages of site design. In many cases, stormwater treatment requirements have

EXHIBIT 1.7

STORMWATER QUALITY MANAGEMENT OPPORTUNTIES AND CHALLENGES

ADDRESS WATER QUALITY ISSUES (E.G., 303(D) LISTED SEGMENTS, STREAM STANDARDS)

IMPROVE INTERDEPARTMENTAL COOPERATION WITH REGARD TO INTEGRATING WATER QUALITY INTO SITE DEVELOPMENT

COORDINATE COMPATIBLE USES BETWEEN PARKS AND WATER QUALITY FACILITIES

ENHANCE COMPATIBILITY BETWEEN URBAN DESIGN GOALS AND WATER QUALITY FACILITIES

IMPLEMENT EFFECTIVE, SUSTAINABLE, ATTRACTIVE, MULTI-PURPOSE, SAFE AND WELL-DESIGNED BMPS

ENSURE LONG-TERM BMP OPERATION AND MAINTENANCE

DEVELOP FINANCING AND INSTITUTIONAL STRATEGIES FOR REGIONAL BMPS not been considered early in the site design, resulting in few effective options for treatment, or installation of unattractive, unsafe, and unmaintainable facilities that become public nuisances, rather than amenities. Community Planning and Development, Parks and Recreation, and Public Works all recognize the importance of early discussion regarding water quality treatment requirements and plans. The stormwater quality BMP implementation guidelines provided in Chapter 6 will help provide developers and planners with reasonable approaches to stormwater treatment that take into consideration multi-departmental goals.

Interdepartmental communication and understanding regarding the legal obligations that Denver has under its CDPS stormwater permit are vitally important to encouraging departments to work cooperatively toward meeting these requirements. Chapter 3 of this Plan provides a common foundation regarding Denver's obligations under its stormwater permit, along with implications of anticipated future regulatory changes.

Coordinate Compatible Uses Between Parks and Water Quality Facilities

Parks, golf courses and natural areas open space are often viewed as opportunities for stormwater detention; however, it is critical that the uses of these areas be taken into account to ensure that usage conflicts are minimized. For example, areas used as soccer fields or golf courses need to drain within a reasonable timeframe to prevent soggy fields that are incompatible with recreational use. Other park and BMP conflicts may relate to safety in areas used for child play, West Nile virus concerns, and/or protection and enhancement of wildlife. This Plan recognizes that conflicts between parks and stormwater BMPs exist in some locations in Denver and care must be taken in the future when selecting, designing, and maintaining BMPs in parks. Public input and acceptance of stormwater BMPs in parks is particularly important, as is public education on the purposes of BMPs. The BMP fact sheets provided in Chapter 6 identify considerations to be taken into account when choosing various BMPs and can provide a starting point to reduce conflicts between park and BMP functions.

Enhance Compatibility Between Urban Design Goals and Water Quality Facilities

Blueprint Denver (Denver 2000) provides a clear vision for Denver's development goals. The Community Planning and Development Department, with the assistance of other Denver departments, has the responsibility of moving Denver towards meeting these goals. In some cases, stormwater BMPs can be difficult to fit into site designs that conform with these design goals. For this reason, interdepartmental agreement regarding BMP design and integration into various settings is important. Chapter 6 provides templates of possible site layouts with BMPs integrated into the designs of various development types. In some cases, on-site stormwater facilities are challenging due to space constraints; in these cases, opportunities for regional stormwater facilities should be explored. Chapter 8 provides conceptual-level locations where regional facilities warrant further exploration.

Implement Effective, Sustainable, Attractive, Multi-purpose, Safe, and Well-Designed BMPs

Denver's CDPS stormwater permit, Denver's *Storm Drainage Design and Technical Criteria Manual* (Denver 1992) and other documents specify water quality treatment requirements for new development and redevelopment projects. In addition to meeting the technical requirements for these BMPs, the Project Advisory Committee and city department staff interviewees agreed that these BMPs also must be sustainable, attractive, multi-purpose, safe, and well-designed (Exhibit 1.8). Ensuring that these requirements and goals are met and that BMPs are maintained on a long-term basis is critical for Denver to successfully minimize the impacts of urban runoff.

EXHIBIT 1.8
SAFE, ATTRACTIVE, MAINTAINABLE INFILTRATION BASIN

Many examples of BMPs that do and do not meet these criteria were identified and visited during the development of this Plan. Early consideration of water quality requirements in the site design can help prevent water quality BMPs from being an "afterthought," which may result in poor BMP design and implementation. Chapter 6 identifies specific considerations when selecting BMPs that provide a foundation for more sustainable, attractive, multi-purpose, safe and well-designed BMPs.

Ensure Long-term BMP Operation and Maintenance

Even when BMPs are thoughtfully designed and properly installed, they can become eyesores, breed mosquitoes, and cease to function if not properly maintained. BMPs can be more effectively maintained when they are designed to allow easy access for inspection and maintenance and take into consideration factors such as property ownership, easements, visibility from easily accessible points, slope, vehicle access, and other factors. Clear, legally-binding written agreements assigning maintenance responsibilities and committing adequate funds for maintenance are also critical. Chapter 3 describes Denver's requirements for BMP maintenance, and Chapter 6 provides BMP maintenance recommendations. In addition, Chapter 5 describes how other communities such as Portland, Oregon have invested in easy-to-understand guidance documents for BMP maintenance that are useful for both private and public owners of BMPs.

Develop Financing and Institutional Strategies for Regional BMPs

The concept of regional stormwater facilities is supported across Denver departments, particularly in redevelopment areas where land is unavailable or at a premium cost. The challenges to implementing regional BMPs lie in three key areas: 1) institutional constraints, 2) land availability, and 3) financing. Chapter 8 provides a conceptual-level assessment of Denver drainages where regional facilities may be realistic. In order to take advantage of these opportunities, a sound financing strategy must be developed. This can be challenging, particularly in areas where development is phased over a number of years. Chapter 9 recommends future work to help develop financing strategies for regional BMPs, including a discussion of institutional opportunities and constraints.

SCOPE LIMITATIONS

In order to develop a meaningful document, the "width" of this Plan's scope has been limited to enable increased "depth" on key subject areas. Related water quality and watershed management topics that are not covered or are only briefly covered in this document include:

- **Construction site stormwater management.** Construction site stormwater management is a critical component of protecting receiving waters and a key requirement of Denver's stormwater CDPS permit. Strong existing guidance on construction site stormwater management is provided by UDFCD, Denver, the Colorado Department of Public Health and Environment (CDPHE), and numerous other entities and is not repeated herein; instead, the focus of this Plan is on permanent, post-development stormwater management strategies.

- **Sanitary wastewater discharges and sanitary sewer overflows.** Although sanitary wastewaster discharges and sanitary sewer overflows (SSOs) are critical aspects of addressing water quality issues in receiving waters, these discharges are believed to be effectively addressed through CDPS permits. For specific water quality problems caused by a combination of wastewater, stormwater, and nonpoint source discharges, an interface with sanitary wastewater discharges will be required under pollutant load allocations under the TMDL process. (See Chapter 3 for more information.)

- **Detailed design criteria for stormwater BMPs.** This document is not intended to be a design manual. To the contrary, excellent BMP design guidance exists in Volume 3 of the *Urban Storm Drainage Criteria Manual* (UDFCD 1999), along with other references (e.g., WEF and ASCE 1992 and 1998; CASQA 2003; City of Portland 2002).

- **Stream channel morphology, sediment transport and channel stabilization and restoration practices.** Topics excluded from discussion include use of turf reinforcement mats, geotextiles, and other comparable materials in drainage channels, other channel stabilization measures including "bioengineering" techniques, hydraulic structures such as energy dissipaters downstream of bridge and culverts, grade control structures, drop structures, etc. Many of these practices either directly or indirectly contribute to stream channel stability and favorable water quality; however, they were deemed to be beyond the scope of this document.

- **Detailed regional water quality facility master planning.** Although an initial glimpse of potential regional water quality BMPs that could be used in Denver's primary drainage areas is provided in Chapter 8, it was beyond the scope of this Plan to address facility master planning in detail. Follow-up work needed for such an effort is defined in Chapter 9.

- **Receiving Water Impact Assessment.** Detailed guidance on this topic is beyond the scope of this Plan. This Plan assumes that in most cases involving typical urban stormwater discharges from development and redevelopment sites, site-specific impact assessments will not be necessary, provided that practices specified in the *Urban Storm Drainage Criteria Manual* (UDFCD 1999, 2001) are implemented.

- **Development of Financing Strategies for Regional BMPs.** Realistic and well-thought-out financing strategies for regional BMPs are necessary for the success of any regional BMP. Exploration of these financing strategies was beyond the scope of this document, but has been recommended as a future task in Chapter 9 of this Plan.

- **Life Cycle Cost Analysis.** Detailed BMP cost data were not included in this Plan. The concept of life cycle costs for BMPs is relevant to BMP selection because it takes into consideration the design, construction, maintenance and rehabilitation costs of the BMP over its expected lifetime. The reader is referred to references for more information on BMP costs in Chapter 6 of this Plan.

PLAN OVERVIEW

Given the purpose, goals, approach, foundational policies, and scope limitations that evolved during the course of this project, the Project Team and Advisory Committee determined that this Plan should address these topics:

- Overview of key drainage basins in the Denver area.

- Discussion of basic tenets of urban runoff impacts.

- Discussion of key current and future regulatory drivers affecting stormwater and receiving waters.

- Identification of key documents (e.g., *Urban Storm Drainage Criteria Manual Volumes 1-3*, *Blueprint Denver*) that this Plan must interface with in order to be effective.

- Identification of strategies that are successfully being used in other communities to address urban runoff.

- Development of stormwater BMP implementation guidelines identifying how these BMPs can be integrated into various development types in Denver.

- Development of BMP fact sheets, implementation details, and maintenance guidelines that identify how BMPs can be better implemented and maintained in Denver.

- A broad-level assessment of potential regional water quality facility locations in Denver.

- Identification of future tasks that need to be completed in order for Denver to achieve its water quality objectives.

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Chapter 2
OVERVIEW OF MAJOR DENVER DRAINAGE BASINS AND POTENTIAL URBAN STORMWATER IMPACTS

A common understanding of Denver drainage basins, lakes, and the potential adverse impacts of stormwater from urbanization is necessary for understanding and applying this Plan. This chapter provides an overview of these topics.

OVERVIEW OF DENVER DRAINAGE BASINS

The City of County of Denver includes approximately 155 square miles of land area (nearly 100,000 acres). Denver receives about 15 inches of rainfall and 55 inches of snowfall each year. Denver's drainageways receive runoff from approximately 190 square miles of land area, some of which is located outside of Denver's jurisdictional boundaries. The South Platte River is the major river basin receiving runoff from Denver, with Sand Creek and Cherry Creek being significant tributaries to the South Platte River (Exhibit 2.1). Relatively small reaches of Clear Creek and Bear Creek, which are also significant tributaries to the South Platte, traverse the northwest and southwest portions of Denver, respectively. While a watershed-by-watershed assessment of water quality issues is beyond the scope of this Plan, readily available basic information on these watersheds is available from the *Denver Storm Drainage Master Plan* (Matrix 2003) and other plans, as summarized in Exhibits 2.2 and 2.3. Specific opportunities for potential regional water quality facilities and more detailed hydrologic characterization of these drainage basins are discussed in Chapter 8.

EXHIBIT 2.1
CHERRY CREEK NEAR THE CONFLUENCE WITH THE SOUTH PLATTE RIVER

Source: The Greenway Foundation.

Exhibit 2.2 Major Denver Drainage Basins

ID	OUTFALL	NAME/LOCATION	AREA (mi²)	COMPOSITE IMPERVIOUSNESS
0058-01	South Platte River	Prairie Gateway	1.59	25.0%
0059-01	South Platte River	Globeville	3.72	51.4%
0060-01	South Platte River	I-70 & Colorado Boulevard	2.73	68.7%
0060-02	South Platte River	I-70 & York	1.47	71.8%
0061-01	South Platte River	27th & Federal	5.17	66.8%
0062-01	South Platte River	Lower Platte Valley	2.73	77.5%
0063-01	South Platte River	Central Platte Valley	2.10	83.2%
0064-01	South Platte River	1st & Federal	0.50	74.4%
0064-02	South Platte River	Valverde	2.66	69.2%
0065-01	South Platte River	Ruby Hill	1.25	70.1%
0065-02	South Platte River	Dartmouth	0.76	86.8%
0067-01	South Platte River	College View	1.29	21.7%
0067-02	South Platte River	West Belleview	4.24	12.5%
0067-03	No Outfall	Marston Lake	1.03	100.0%
3300	Third Creek	Third Creek	16.36	40.1%
3500	Second Creek	Second Creek	8.02	30.4%
3501-01	Second Creek	West Fork Second Creek	3.37	36.8%
3700-01	First Creek	56th to 64th Avenue	5.36	33.4%
3700-02	First Creek	38th to 56th Avenue	2.92	60.6%
3702-01	First Creek	Picadilly & 56th Avenue	1.34	78.0%
3900-01	Irondale Gulch	North Stapleton	0.48	20.4%
3900-02	Irondale Gulch	West of Chambers Road	1.85	40.0%
3900-03	Irondale Gulch	Tower to Chambers Road	2.91	54.7%
3900-04	Irondale Gulch	I-70 to 42nd Avenue	1.83	68.7%
3901-01	Irondale Gulch	Peoria	4.44	43.4%
3901-02	Irondale Gulch	40th & Chambers Road	0.97	64.9%
4000-01	Rocky Mountain Arsenal	Stapleton North	0.78	29.1%
4300-03	Clear Creek	North of I-70	1.79	58.2%
4309-01	Clear Creek	Berkeley Lake	1.83	55.1%
4400-01	Sand Creek	North Stapleton	5.07	42.5%
4400-02	Sand Creek	Quebec Corridor	5.01	65.0%
4400-03	Sand Creek	South Stapleton	1.49	70.8%
4400-04	Sand Creek	East Stapleton	2.77	74.1%
4401-01	Westerly Creek	Stapleton	3.03	50.6%

Exhibit 2.2 Major Denver Drainage Basins				
ID	OUTFALL	NAME/LOCATION	AREA (mi²)	COMPOSITE IMPERVIOUSNESS
4401-02	Westerly Creek	11th Avenue to Montview	2.83	62.6%
4401-03	Westerly Creek	Lowry	3.51	40.6%
4401-04	Westerly Creek	South of Alameda	2.85	55.6%
4500-01	Montclair	City Park	4.30	54.4%
4500-02	South Platte	36th & Downing	1.74	65.2%
4500-03	Montclair	Park Hill	1.51	59.7%
4500-04	Montclair	Park Hill	3.69	54.4%
4600-01	Cherry Creek	Central Business District	2.17	83.2%
4600-02	Cherry Creek	Cherry Creek Mall	4.61	57.7%
4600-03	Cherry Creek	Upper Cherry Creek	5.62	68.9%
4600-04	Cherry Creek	Upper Cherry Creek	5.77	51.3%
4601-01	Goldsmith Gulch	Cherry Creek Outfall	3.92	54.1%
4601-02	Goldsmith Gulch	Middle Goldsmith Gulch	1.34	59.0%
4700-01	Sloan's Lake	West Colfax Avenue	1.59	65.0%
4800-01	Lakewood Gulch	12th & Federal	1.17	59.6%
4801-01	Dry Gulch	12th & Sheridan	0.39	62.0%
4900-01	Weir Gulch	West 6th Avenue	2.30	58.3%
5000-01	I-25 & South Platte	West Washington Park	1.25	71.9%
5000-02	I-25	University & Mexico	5.02	60%*
5100-01	Sanderson Gulch	West Florida Avenue	5.57	54.6%
5200-01	Harvard Gulch	West Fork Second Creek	0.83	63.8%
5200-02	Harvard Gulch	56th to 64th Avenue	6.62	50.4%
5300-01	West Harvard Gulch	West Yale Avenue	1.44	57.1%
5401-01	Greenwood Gulch	South Monaco Parkway	0.16	50%*
5500-01	Bear Creek	Fort Logan	3.12	52.8%
5500-02	Bear Creek	Upper Bear Creek	1.84	45.5%
5500-03	Bear Creek	Academy Park Tributary	0.60	62.7%
5500-04	Bear Creek	Marston Lake North	2.24	46.0%
5500-05	Bear Creek	Pinehurst Tributary	0.72	42.2%
5501-01	Bear Creek	Henry's Lake	1.35	35.0%
5901-01	Dutch Creek	Coon Creek	3.10	53.2%
8056	Barr Lake	Barr Lake	3.86	7.9%
8150	Box Elder Creek	Box Elder Creek	3.10	53.2%
	TOTAL		189.89	

* Approximate - further evaluation pending.

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Insert Exhibit 2.3 Location Map Here

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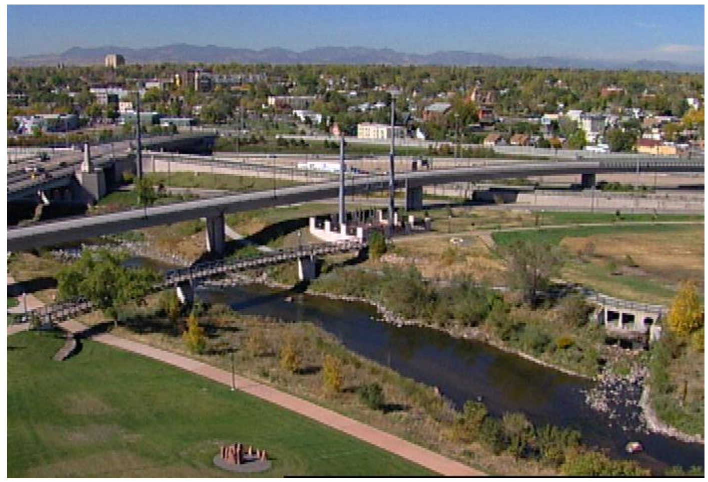
South Platte River

EXHIBIT 2.4
THE SOUTH PLATTE RIVER BASIN IS THE LARGEST DENVER DRAINAGE BASIN AND IS HIGHLY URBANIZED (IN DENVER)



Source: The Greenway Foundation.

The South Platte River is the largest receiving waterway in the Denver metropolitan area and flows from south to north along the I-25 corridor through Denver. Within the city limits of Denver, the South Platte River meanders along a path some 10.5 miles in length from West Dartmouth Avenue to Franklin Street. The drainage basin covers approximately 4,850 square miles extending from the Continental Divide in the Rocky Mountain Front Range to the high plains and foothills of eastern Colorado. The mountainous portion of this basin is generally unsuited for dense development, while the foothills and high plains areas are actively being developed. The intense urbanization in the metropolitan area consists primarily of residential and commercial areas and some industrial regions along the river valley.

The South Platte River flood potential is mitigated by Chatfield Reservoir located on the South Platte River, along with Cherry Creek Reservoir and Bear Creek Reservoir located on major tributaries. Peak 100-year flows of the South Platte vary from 5,000 cubic feet per second (cfs) near Chatfield to 38,000 cfs at the confluence with Sand Creek. Normal discharges in the South Platte River are generally about 100 cfs, but approach about 1,000 cfs during the spring runoff period. Average daily flows are highly affected by treated effluent discharges from Metro Wastewater.

First Creek

The First Creek basin drains an area of 47.2 square miles. The headwaters of First Creek are located in Arapahoe County, south of I-70 and east of E-470. Runoff from the basin flows in a northwesterly direction. First Creek crosses Pena Boulevard just north of 56th Avenue and then flows through the northeastern portion of the Rocky Mountain Arsenal. First Creek is a right-bank tributary to the South Platte River, and outfalls at approximately 128th Avenue. The basin shape is long and narrow, approximately 26 miles long and 2 to 4 miles wide. The average stream slope above Rocky Mountain Arsenal is about 31 feet per mile, and flattens to about 23 feet per mile below Rocky Mountain Arsenal

The upper reaches of First Creek are primarily undeveloped irrigated cropland with wide swales and channels for drainageways. Toward the center of the basin, First Creek bisects Green Valley

Ranch, which consists of medium density, single-family residences. First Creek then enters Rocky Mountain Arsenal with a more incised, low flow channel and wider floodplain areas.

The lower First Creek basin is located downstream from 56th Avenue and Pena Boulevard and continues to the South Platte River. The lower First Creek basin consists of irrigated farmland with pockets of light industrial and residential properties. Conveyance within the lower First Creek drainage consists of broad undefined channels with little or no defined thalweg. Between US-85 and Brighton Boulevard, the channel is incised with a well-defined thalweg. The O'Brian Canal and the Burlington Ditch, which intercept runoff from First Creek, cross First Creek below Rocky Mountain Arsenal.

Second Creek

Second Creek drains about 27 square miles of area to the South Platte River. The basin is about 15 miles long and 3.4 miles wide at its widest point. The drainage basin ranges in elevation from 4,990 feet at the South Platte River to 5,650 feet at the basin divide. Second Creek has a natural irregular channel section in the upper reaches above the O'Brian Canal.

The southern land area within the Second Creek drainage basin in Denver city limits drains via a tributary known as the West Fork of Second Creek. This tributary drains 3.03 square miles of area to Second Creek. The Highline Canal terminates at the West Fork. The sustained unused flow in the Highline Canal is wasted to the West Fork downstream of 64th Avenue, and the flows have eroded the channel on the West Fork. At Tower Road, the West Fork channel is about 15 feet deep with vertical and very steep, unstable banks. The confluence of Second Creek and the West Fork of Second Creek is a wide, relatively flat area supporting a stand of cottonwood trees. Some wetland areas are present in the upper reaches of the West Fork, but, as the channel has eroded, the channel banks have become incised and support only a narrow band of wetland or riparian vegetation. The floodplain is contained within the channel except at road crossings, where overtopping will occur. The banks are unstable and some lateral channel migration may occur during large flows.

Third Creek

Third Creek is an east bank tributary of the South Platte River and is located northeast of Downtown Denver. Third Creek flows through Denver International Airport (DIA) and is experiencing development in the drainage basin. Third Creek drains approximately 31 square miles of area to the South Platte River. The basin is about 14 miles long and 3.2 miles wide at its widest point and ranges in elevation from 4,960 feet at the South Platte River to 5,485 at the basin divide. Third Creek has a natural irregular channel section above the O'Brian Canal, and a small, poorly defined channel section between the O'Brian Canal and the South Platte River. Third Creek is crossed by Highway 85, I-76, the Union Pacific and Burlington Northern Railroads, and the O'Brian Canal, Fulton Ditch, McCann Ditch, and the Burlington Ditch.

Box Elder Creek

Box Elder Creek is located east of the Denver metropolitan area, with a portion of the watershed draining the easternmost portion of Denver. Major tributaries include Bear Gulch and Hayesmount Creek. The watershed is long and narrow, extending from El Paso County in the south a distance of approximately 100 miles to its confluence with the South Platte River in Weld County downstream of the City of Greeley. The watershed encompasses about 370 square miles located in Weld, Adams, Arapahoe and Elbert Counties. Box Elder Creek is generally dry except for short periods of runoff after intense rainfall events, although portions of the creek have a small amount of flow for longer periods. The Box Elder Creek watershed is currently mostly undeveloped grassland and agricultural areas. The portion of the watershed that lies within DIA, however, has some areas that are heavily developed. Developed areas within the DIA property include runways and taxiways, concourses, and support facilities. Additionally, there are scattered relatively low-density housing developments along the central portion of the creek.

Irondale Gulch

The Irondale Gulch basin, which contains approximately 26.7 square miles, lies immediately southwest of First Creek and drains the area from the intersection of I-70 and Arapahoe Road and the Adams County line, through the Montbello area, the Arsenal and Commerce City with an eventual outfall to the South Platte River at approximately East 96th Avenue. The southwest boundary of the basin is primarily the north side of I-70 until it reaches the former Stapleton International Airport, where the basin boundary lies just west of Havana Street. This basin is long and narrow, with a total length of 28 miles to the South Platte River and a width of 1½ to 2 miles. The average slope of the basin is about 26 feet per mile, which remains fairly constant throughout the drainageway. The drainageways through the Arsenal contain several lakes and detention areas. The drainage below the Arsenal is primarily storm sewer or roadside ditches, with capacity for only minor floods.

Clear Creek

Clear Creek is a left bank tributary to the South Platte River, and has its source in the Rocky Mountains west of Denver. Flowing in a generally easterly direction from the Continental Divide, Clear Creek enters the high plains in Golden. Within this lower reach, Clear Creek passes through unincorporated areas of Adams and Jefferson Counties, and the cities of Denver, Arvada, Wheat Ridge and Golden. Clear Creek crosses the northwest corner of Denver for a distance of 0.2 miles in the vicinity of 52nd Avenue and Gray Street.

The drainage area at the mouth is 575 square miles, of which 400 square miles is in the mountain region above Golden. There are 11 major reservoirs in the lower Clear Creek basin, three of which are on-stream and provide some residual flood control effects downstream from each site. Ralston Reservoir was built in 1938 by Denver and receives water from Ralston and South Boulder Creeks. Although Ralston Reservoir is not operated for flood control purposes, there is approximately 2,400 acre-feet of storage available. Maple Grove Reservoir is located on Lena Gulch at West 27th Avenue and has approximately 452 acre-feet of available storage. Leyden

Lake is an irrigation water storage reservoir on Leyden Creek upstream from Indiana Street, and has approximately 550 acre-feet of uncontrolled storage.

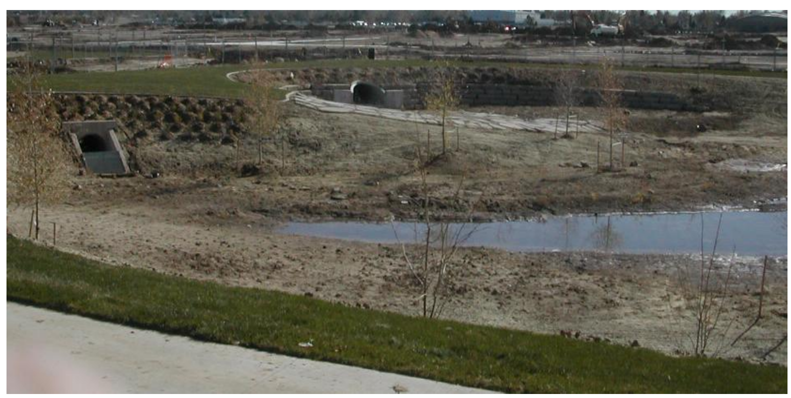
Sand Creek

Sand Creek is an east bank plains tributary of the South Platte River and lies to the east and northeast of Denver's Central Business District. The Sand Creek basin encompasses an area of 189 square miles. The basin is long and narrow, with a length of 32 miles and an average width of 6 miles. Portions of Elbert, Douglas, Arapahoe, Denver, and Adams Counties are included in the drainage area. Sand Creek originates at the confluence of Coal Creek and Murphy Creek. Sand Creek joins the South Platte River in the vicinity of I-270 in Commerce City, north of Denver city limits. The reach of Sand Creek within Denver is located along I-70 near the Stapleton Redevelopment area. Principle tributaries of Sand Creek are Toll Gate Creek and Westerly Creek.

Westerly Creek

The Westerly Creek tributary area consists of approximately 18 square miles of highly developed area from the low rolling divide between Cherry Creek and West Toll Gate Creek to the confluence with Sand Creek. The basin is about 8.5 miles long and 3 miles wide at its widest point. The crescent-shaped area drains in a northwest-to-north direction with an average slope of 0.9 percent.

EXHIBIT 2.5
RECENTLY CONSTRUCTED DETENTION BASIN (VEGETATION NOT YET ESTABLISHED) ON WESTERLY CREEK IN THE STAPLETON REDEVELOPMENT AREA



The Westerly Creek drainage basin is at a state of full development consisting of townhouses, condominiums, apartments, single family homes, motels, large shopping complexes, streets, parking areas, and highways. This development and the 0.9 percent slope contribute to a rapid response time for storm runoff and increased stormwater flows.

The upper reaches of Westerly Creek begin in the City of Aurora. Runoff of peak events is captured in Westerly Creek Dam, built in 1989 on the former Lowry Air Force Base at Alameda and Havana. As Westerly Creek outlets from the dam, it flows in a 48-inch underground pipe. Flows from the Lowry Redevelopment area enter Westerly Creek and then are detained in Kelly Road Dam at 11th Avenue. The channel and culverts from Kelly Road Dam to Montview at the Stapleton Redevelopment area have been improved to handle the 10-year design storm. The Westerly Creek channel through the Stapleton site has been improved to 100-year capacity. All storm outfalls to Westerly Creek within the Stapleton site have regional water quality treatment at the end of pipe.

Cherry Creek

EXHIBIT 2.6
CHERRY CREEK IN DENVER, COLORADO

The Cherry Creek tributary area consists of 410 square miles, 385 square miles of which drain into Cherry Creek Reservoir. The dam is designed to release a maximum of 5,000 cfs to the lower Cherry Creek channel, which has a current capacity of between 4,000 and 11,000 cfs.

The lower Cherry Creek basin (Exhibit 2.6) covers 25.2 square miles, with Goldsmith Gulch contributing 7.7 square miles of the total area. The lower channel of Cherry Creek flows 11.5 miles from the reservoir to the South Platte River confluence in the vicinity of Speer Boulevard.

The lower channel has been improved to contain the 100-year storm from 1st Avenue to the confluence. These improvements generally consist of cleaning, shaping, and landscaping the channel bottom.

Goldsmith Gulch

EXHIBIT 2.7
GOLDSMITH GULCH IN DENVER, COLORADO

The Goldsmith Gulch basin encompasses an area of 7.8 square miles from Arapahoe Road northwest to the confluence with Cherry Creek. Through Denver, the tributary area is primarily urbanized or in the process of development with a mix of commercial and residential construction.

Many channel improvements have been completed along Goldsmith Gulch to reduce the potential of flood damage. The channel has been stabilized (Exhibit 2.7) and regional parks have been constructed in the floodplain. Detention facilities have also been constructed along the channel at Bible Park, Wallace Park, Rosamond Park, and at Iliff and Monaco. Channel slopes are generally mild with several newer drop structures along the reach.

The Highline Canal bisects Goldsmith Gulch at East Cornell Avenue. Goldsmith Gulch passes underneath the Highline Canal and East Cornell Avenue through a concrete box culvert. The upper portion of Goldsmith Gulch includes the T-REX construction site. New storm sewer and detention facilities drain the I-225 and I-25 interchange to Goldsmith Gulch.

Sloan's Lake

The Sloan's Lake drainage basin flows eastward from a high point near 26th Avenue and Garrison Street in Lakewood and outfalls into the South Platte River near Colfax Avenue and Invesco Field. The drainage basin lies within Denver's jurisdiction east of Sheridan Boulevard and is bounded by West 32nd Avenue on the north, Colfax Avenue on the south, Garrison Street on the west, and the South Platte River on the east. The basin totals almost 5.5 square miles within Denver, Lakewood, Edgewater, and Wheatridge. Since the basin is fully developed and heavily urbanized, the major drainageways are not clearly identifiable. Most of the historic drainage channels have either been filled in or built over to the point of obliteration.

The most prominent geographic feature within the basin is Sloan's Lake. The lake, which occupies 176.5 acres of a 290-acre Denver park, has been and continues to be a valuable recreational resource for the metropolitan area. In addition to its scenic and recreational significance, the lake provides the important function of regulating and controlling downstream flows that otherwise would be allowed to run uninhibited through West Denver. The lake reduces peak flow rates from about 2,904 cfs to 166 cfs during the 100-year event.

Lakewood Gulch

Lakewood Gulch is a major drainageway that originates in Lakewood and flows easterly toward the South Platte River between 6th Avenue and Colfax Avenue. The Lakewood Gulch basin consists of approximately 16 square miles beginning in the foothills and extending easterly 10 miles to the South Platte River in the vicinity of Colfax Avenue. The tributary area is essentially fully developed in Denver and in the eastern portion of Lakewood. The basin is also developed in the western portion of Lakewood and Jefferson County.

Dry Gulch

The Dry Gulch basin consists of approximately 3.7 square miles lying predominantly in Lakewood. Dry Gulch is tributary to Lakewood Gulch in the vicinity of 10th Avenue and Perry Street in Denver, and extends westward a length of 5.7 miles along the general alignment of Colfax Avenue to Simms Street. The basin is essentially fully developed, with commercial establishments along Colfax Avenue and residential development comprising the remainder of the basin.

Weir Gulch

Weir Gulch meanders eastward from Green Mountain Village for approximately 8.3 miles to the confluence with the South Platte River in the vicinity of West 9th Avenue. The basin, which comprises some 7.2 square miles, is fully urbanized in Denver and mostly developed west of Sheridan Boulevard in Lakewood.

There are two drainageways tributary to Weir Gulch within Denver. The 1st Avenue tributary to Weir Gulch is located just north of 1st Avenue and flows in an easterly direction. The drainage basin is bounded by 6th Avenue on the north, West Alameda Avenue on the south, Raleigh Street on the east, and Wadsworth Boulevard on the west. This tributary of the Weir Gulch system is approximately 2 miles long and about 0.8 mile wide, with an average slope of 1.5 percent.

The Dakota Avenue Tributary to Weir Gulch lies within Denver's jurisdiction east of Sheridan Boulevard and is located just south of Dakota Avenue flowing in an easterly direction. It is bounded by West Alameda Avenue on the north, West Alaska Avenue on the south, Sheridan Boulevard on the west, and Xavier Street on the east. This tributary is about ¼-mile wide and has an average slope of 1½ percent.

Strip parks have been developed by the Denver Parks and Recreation Department from 1st Avenue to Alameda Avenue along the gulch. This development consists mainly of grassed channels and the installation of asphalt bike paths. Barnum Park is located on each side of 6th Avenue on the west side of Federal Boulevard. Barnum Lake, located south of 6th Avenue, has been improved to contain the 100-year storm within the Weir Gulch channel. The open park area north of 6th Avenue, known as the Federal Boulevard Detention Reservoir, is designed to reduce the 25-year flow to a 10-year flow or less. The lower Weir Gulch channel from Federal to the South Platte River outfall has capacity for the 10-year storm.

Sanderson Gulch

Sanderson Gulch flows 8.63 miles in an easterly direction from South Union Boulevard above Smith Reservoir to the South Platte River in the vicinity of West Florida Avenue. This drainage basin, which encompasses approximately 9 square miles, is fully developed in Denver and is being rapidly urbanized west of Sheridan Boulevard. The entire basin's drainage area extends west to the top of Green Mountain, and channel slopes are generally mild.

Green belts and parks have been located along the Sanderson Gulch floodplain. Drainageway improvements have been constructed to contain the 100-year event within open channels; however, culverts were designed for the 10-year frequency discharge.

West Harvard Gulch

West Harvard Gulch flows east 2.8 miles through Denver to its confluence with the South Platte River in the vicinity of Yale Avenue. The total area of the drainage basin is approximately 1.4 square miles. The average width of the basin is 0.66 mile, and the channel slopes range from 1.3 to 2.4 percent. The basin elevations range from approximately 5,525 feet to 5,250 feet.

The West Harvard Gulch basin is primarily in residential development. Commercial areas are situated along Federal Boulevard, and a light industrial park is located in the basin's lower reaches. Loretto Heights College sits on the ridge that forms the southern boundary of the basin.

In the West Harvard Gulch Basin, the main drainageway was piped in an underground conduit that extended from just above the Colorado and Southern Railroad to Zuni Street. This reach has been restored and an improved grass lined and concrete trickle channel carries the flood events. Channel slopes within this reach are stabilized with grouted sloping boulder drops.

During the 100-year flood event, most of the flood flow will be contained in the channel. At the confluence of the South Platte River, the main channel flows through an 84-inch-diameter concrete pipe. This pipe has inadequate capacity to carry the 100-year flow, resulting in shallow flooding around the Arapahoe Power Plant. Some ponding and overtopping will occur at Zuni, Clay and Decatur Street crossings during the 100-year flood event.

Harvard Gulch

Harvard Gulch flows west through the southern part of Denver for a length of 5.6 miles to reach its confluence with the South Platte River at Wesley Avenue. The total drainage basin area is approximately 7.7 square miles. The Highline Canal meanders through the southeast portion of the basin and intercepts storm flow. Single-family residences primarily urbanize the basin. Commercial development is generally located along Colorado Boulevard, Broadway, and Santa Fe Drive. The residential portion of the basin is very dense with small lots having an estimated 52 percent average imperviousness.

The Harvard Gulch Flood Control project, completed in 1966, was designed for the 10-year flood and included an underground box culvert from Logan Street to the South Platte River. A grass-lined open channel was designed though Logan Park, which also serves as an inlet to a detention pond in the park.

Highway I-25 and the T-REX construction project bisect the upper portion of Harvard Gulch. Drainage improvements for T-REX through the Holly Hills area include several detention/water quality basins as well as a new storm sewer system. The T-REX storm sewer is connected to Denver’s existing storm sewer system at two locations along the west side of I-25: 1) the T-REX storm sewer system to the south outfalls to the Highline Canal; and 2) the storm sewer system to the north outfalls to the existing 36-inch storm sewer within Yale Avenue.

Bear Creek

Bear Creek generally flows eastward from its headwaters at Mount Evans through the towns of Evergreen and Morrison until it reaches the metropolitan area of Denver where it is tributary to the South Platte. The drainage basin is approximately 36 miles long and has an average width of about 9 miles. This encompasses approximately 261 square miles of drainage area. Elevations in the basin range from approximately 14,260 feet at Mount Evans to 5,260 feet at the mouth. Turkey Creek, a major tributary, drains about 52 square miles and enters into Bear Creek approximately 2 miles downstream of Morrison. The majority of the basin is in the mountains, with the remainder draining the foothills and high plains region. The drainage basin area inside the Denver’s city limits is about 12 miles in size.

The completion of Bear Creek dam just downstream of Morrison has had a great effect on the peak discharges of the 8.2-mile Bear Creek reach below the dam. The dam acts as a flood control reservoir that intercepts flows from areas in the upper and middle parts of the basin. At the Bear Creek dam, peak flows from the 100-year event have been reduced from 30,000 cfs to approximately 1,000 cfs through storage in the reservoir.

Marston Lake North (Tributary of Bear Creek)

The Marston Lake drainage basin consists of approximately 2.1 square miles of limited developed area in the southwest corner of Denver. Various areas within the basin are subject to flooding, which could increase in severity and frequency with continued urbanization of the basin without drainageway improvements. The basin originates approximately ½ mile west of Kipling Street between Belleview and Quincy Avenues, and extends approximately 4.4 miles in a northeasterly direction to its confluence with Bear Creek. Continued development in these areas, planned for mostly residential with some light commercial business, is expected to increase runoff rates.

Marston Lake is owned and operated by the Denver Water Board and serves as a major link in the water supply system for Denver and much of the metropolitan area. The lake acts as a sump and is isolated from receiving or discharging stormwater.

The drainage basin traverses various jurisdictions and ownerships including Jefferson County, Denver, Denver Water Board, Marston Water Treatment Plant grounds, Pinehurst Country Club Golf Course, and United Sates Government properties to the south of Fort Logan National Cemetery.

Improvements to the drainageway have been accomplished by Denver Water and UDFCD. The north side of the Marston Lake Dam, which was reconstructed to allow room for an open channel and improved by UDFCD, provides an improved 100-year capacity channel from Old Wadsworth Boulevard to West Quincy Avenue.

OVERVIEW OF LAKES

Denver has many lakes within its boundaries that are managed by Denver Parks and Recreation. Exhibit 2.8 provides an overview of these lakes based on the recently completed *Lake Management and Protection Plan* (Dudley 2004). The Colorado Water Quality Control Commission (CWQCC) has assigned water quality standards to most of these lakes. For lakes without assigned standards, the principles of water quality protection discussed in this Plan remain relevant for supporting healthy, aesthetically pleasing conditions in the lakes.

EXHIBIT 2.8 DENVER LAKE LOCATIONS AND CHARACTERISTICS (DUDLEY 2004)			
Manage-ment Type	**Lake Name**	**Location**	**Characteristics**
Southwest District	Barnum Lake in Barnum Park	West of Federal Blvd. between 6th Ave. and 3rd Ave.	9 acres; 5 feet maximum depth; perimeter: 0.7 mile.
Southwest District	Bear Creek Ponds in Bear Creek Park	Bear Creek Park is located at S. Raleigh Street and W. Hampden Avenue. Located along Kenyon Avenue off of Sheridan Boulevard.	There is a series of four ponds along a soft trail across from the Fort Logan Cemetery. 70 acres of natural areas can be accessed from the south boundary of the park.
Northwest District	Berkeley Lake in Berkeley Park	South of I-70 between Sheridan Blvd. And Tennyson St.	40 acres; 12 feet maximum depth; perimeter: 0.9 miles.
East Montclair District	City Park Lakes	North of 17th Ave. and west of Colorado Blvd. Parking area on the northwest side of the lake between the park and the Denver Zoo.	**Ferril Lake** – 25 acres; 8 feet maximum depth; perimeter 0.8 miles. There is a sediment basin at 17th Street at the point where the storm sewer/city ditch daylights that is 2 acres in size. The sediment basin discharges to Ferril Lake. **Duck Lake** – 6.3 acres; perimeter: 0.4 mile.
Southwest District	Garfield Lake in Garfield Park	South of W. Mississippi Ave. between S. Federal Blvd. and S. Sheridan Blvd.	10 acres; 4 feet maximum depth; perimeter: 0.5 mile.
Southwest District	Harvey Lake in Harvey Park	Between S. Sheridan Blvd. and S. Federal Blvd., just south of W. Evans Ave. and east of S. Tennyson St.	8.5 acres; 14 feet maximum depth; perimeter: 0.4 mile.
Southwest District	Huston Lake in Huston Lake Park	East of S. Federal Blvd. about 4 blocks, between W. Ohio Ave. and W. Kentucky Ave. Southeast of the intersection of Ohio and S. Clay St.	13 acres; 6 feet maximum depth; perimeter: 0.6 mile.
Southwest District	Lake of Lakes (A.K.A. Little Lake Henry)	Carr St. and Quincy Ave.	3.5 acres, perimeter: 0.4 mile.
Southeast District	Lollipop Lake in Garland Park	Between S. Holly St. and S. Kearney St. north of Cherry Creek Dr. N.	4 acres; 8 feet maximum depth; perimeter: 0.4 mile.
Southwest District	Overland Pond in Overland Pond Park	North of W. Florida Ave. between S. Santa Fe Dr. and the South Platte River trail.	1.5 acre; 7 feet maximum depth; perimeter: 0.2 mile.
Northeast District	Parkfield Lake in Developing Park Area	DIA Gateway/Chambers north of I-70.	14 acres; 6 feet mean depth; perimeter: approximately 1 mile.
Northwest District	Rocky Mountain Lake in Rocky Mountain Lake Park	W. 46th Ave. between Federal Blvd. and Lowell Blvd. Parking areas north of 46th Ave.	29 acres; 40 feet maximum depth; perimeter: 0.9 mile.
Northwest District	Sloan's Lake (including Cooper Lake) in Sloan's Lake Park	East of Sheridan Blvd. between W. 25th Ave. and W. 17th Ave.	174 acres; 5 feet deep in the main body of the lake west of the island but upwards of 8 feet deep east of the island; perimeter: 2.6 miles.

EXHIBIT 2.8 DENVER LAKE LOCATIONS AND CHARACTERISTICS (DUDLEY 2004)			
Manage-ment Type	**Lake Name**	**Location**	**Characteristics**
Southwest District	Vanderbilt Pond in Vanderbilt Park	North of W. Tennessee Ave. between S. Santa Fe Dr. and S. Huron St. Access from W. Mississippi Ave.	6 acres; 15 feet maximum depth.
South Denver Park District	Washington Park Lakes	Northeast of the intersection of S. Downing St. and E. Louisiana Ave.	**Smith Lake** – 9 acres; 12 feet maximum depth; perimeter: 0.6 mile. **Grasmere Lake** – 19 acres; 10 feet maximum depth; perimeter: 0.8 mile. **Lily Pond** – 1 acre; 8 feet maximum depth; perimeter: 0.18 mile.
Natural Area	Bluff Lake in Bluff Lake Park	Havana at 32nd Ave.	9 acres
Natural Area	Heron Pond in Northside Park	51st Ave. and Downing St.	3 acres
Denver City Golf Course	Kennedy Lake in J.F. Kennedy Golf Course	10500 E. Hampden Ave.	5 acres; perimeter: 0.4 mile.
Denver City Golf Course	Skeel Reservoir in Wellshire Golf Course	3333 S. Colorado Blvd.	13.4 acres, perimeter: 0.6 mile.
Golf Conces-sion	Overland Lake in Overland Lake Open Space	North of W. Florida Ave. between S. Santa Fe Dr. and the South Platte River trail. Parking area is north of Florida.	11 acres; perimeter 0.7 mile.

EXIBIT 2.9

WELL VEGETATED, NATURAL SHORELINE ALONG BERKELEY LAKE

CHARACTERIZATION OF DENVER LAKE AND STREAM CONDITIONS

In order to protect and enhance the condition of Denver lakes and streams, it is necessary to have a sound scientific understanding of their baseline chemical, physical, and biological conditions and identify key sources of impacts to these water bodies. Because this process is cumbersome, time-consuming, and costly, the Project Team and Advisory Committee determined that the highest priority for this Plan was to identify strategies and tools to minimize stormwater impacts to these water bodies in the near term—this is the focus of Chapter 6, Stormwater Quality BMP Implementation Guidelines. As a result, a watershed-by-watershed assessment of stream conditions was deferred to a future project.

Nonetheless, several key building blocks for watershed-by-watershed assessments have been completed in this Plan in Chapter 3-Regulatory Drivers, Chapter 4-Related Documents, Chapter 5-National Case Studies, and in Chapter 8-Potential Regional Facilities. In Chapter 3, known water-quality limited stream segments in Denver are discussed. In Chapter 4, several on-going regional efforts to assess and address water body conditions are described. In Chapter 5, watershed assessment approaches used by other communities with advanced stormwater programs are described, along with the associated costs of such efforts. In Chapter 8, locations that should be further evaluated for use as regional stormwater quality treatment facilities have been identified. Additionally, Appendix D provides a variety of specific recommendations regarding water quality improvement that were submitted in a report to the Mayor in June (Bergstedt 2004). All of this information will be important in developing targeted approaches to improving conditions in various Denver water bodies and ensuring that the "wheel is not reinvented" with regard to specific watershed efforts.

Another key component when characterizing lakes and streams is having a reasonable understanding of what data sources already exist. A brief list of these sources that, at a minimum, should be included in more detailed watershed analyses includes the following:

- Denver Environmental Health, Environmental Protection Division (DEH-EPD) data set: This data set includes over 25 years of dry-weather monitoring data for the South Platte River system, including surface water, biotic, and sediment samples from both streams and lakes. Additionally, DEH-EPD is compiling a GIS database of stormwater outfalls to model watershed drainage areas (Bergstedt 2004).

- Denver Public Works, Wastewater Management Division dry weather monitoring data: As part of Denver's CDPS stormwater permit, dry weather discharges have been monitored. GIS-based mapping is also being completed to identify discharge points, post-construction BMPs, and other features.

- Barr Lake/Milton Reservoir water quality database: this extensive water quality database, compiled by Hydrosphere in 2004, contains most of the readily available water quality data for the South Platte and its tributaries in the Denver area from Chatfield dam to the Barr/Milton diversion points on the South Platte. One of the reasons that this data set is important is that it includes water quality data from neighboring municipalities that influence conditions in the South Platte.

- South Platte Cooperative for Urban River Evaluation (South Platte CURE) Database: This database focuses on the South Platte River and selected tributaries over the last eight years. Most of this data was also submitted to the Barr Lake/Milton Reservoir effort. South Platte CURE also continues to serve as a data clearinghouse for ongoing monitoring efforts along the South Platte River. This data set has been standardized into a STORET-compatible format and is uploaded to STORET on a periodic basis. South Platte CURE and DEH-EPD coordinate sampling programs and share data to help with stream characterization, but South Platte CURE's primary focus is on point source (sanitary wastewater) discharges.

- Joint Task Force Stormwater Monitoring Data: this dataset includes both the initial Phase I stormwater permit wet weather monitoring data and the ongoing trend analysis data conducted by the U.S. Geological Survey on behalf of Denver, Aurora, Lakewood and UDFCD. This dataset is important because it focuses on stormwater discharges, whereas other monitoring programs have focused on dry weather conditions.

- U.S. Geological Survey (USGS) National Water Database (NWISWeb at http://waterdata.usgs.gov/nwis/): This database can also be queried for water quality and flow data for the Denver area.

- STORET: This is EPA's water quality database that can be queried for historical data available for the Denver area.

- Instream Issues Task Force/Mayor's South Platte River Commission: The *Instream Issues Report, South Platte River Corridor,* as contained in the Appendix to the *Long Range Management Framework South Platte River Corridor* (Mayor's South Platte River Commission 2000) contains segment-by-segment characterizations of the South Platte River.

The following section provides a general overview of the impacts of urbanization on receiving waters that should also be included as a building block to shape future analyses of watershed-specific conditions in Denver. This section emphasizes the importance of a holistic approach to improving receiving water conditions that addresses not only water quality, but also habitat, water quantity (flow regime), aquatic life, and stream channel conditions.

EXHIBIT 2.10

CONFLUENCE OF THE SOUTH PLATTE RIVER AND CHERRY CREEK

OVERVIEW OF THE EFFECTS OF URBANIZATION ON RECEIVING WATERS

A sound understanding of the widely documented (e.g., WEF and ASCE 1992, 1998; Debo and Reese 2002; Horner, et al. 1994; and Schueler and Holland 2000) effects of urban runoff on the physical, chemical, and biological characteristics of receiving waters is important for those involved with mitigating the impacts of urban runoff. The following discussion provides a general overview of the effects of urbanization on receiving waters followed by a more detailed discussion of the physical impacts and chemical characteristics of urban runoff documented both nationally and for the Denver area.

Traditional stormwater management focused on moving water away from people, structures, and transportation systems as quickly and efficiently as feasible. This was accomplished by creating conveyance networks of impervious storm sewers, roof drains, and lined channels, which concentrated runoff flows for discharge to receiving waters. There were many consequences of this traditional approach to drainage such as:

- Increased runoff frequency.
- Increased runoff volume.
- Larger peak discharges.
- Higher flow velocities.
- Change in base flow (dry weather) regime.
- Increased flooding risk.
- Introduction of new pollutant sources and types.
- Increased runoff temperature.
- Loss of riparian zones and wetlands, with associated negative effects.
- Habitat damage and ecosystem disruption associated with stream bed and bank erosion leading to sediment and pollutant transport, channel widening and instability, and destruction of both aquatic and terrestrial physical habitats.
- Increased contaminant transport, leading to increased water quality degradation.
- Production and long-term accumulation of potentially toxic concentrations of contaminants in receiving waters.

It is particularly important to recognize that urban runoff impacts are complex, including chemical, physical, and biological responses. Various experts have developed helpful schemes for categorizing and interrelating adverse receiving water impacts. Two particularly valuable representations are provided in Exhibits 2.11 and 2.12. With increasing frequency, these adverse impacts are being addressed by communities around the U.S. Recognition of these impacts has been a driving force behind federal, state and local government regulations concerning stormwater quality (see Chapter 3). The remainder of this section describes the potential physical and chemical impacts of uncontrolled urban runoff on receiving waters.

EXHIBIT 2.11

ECOLOGICAL IMPACT OF HUMAN-INDUCED ALTERATIONS

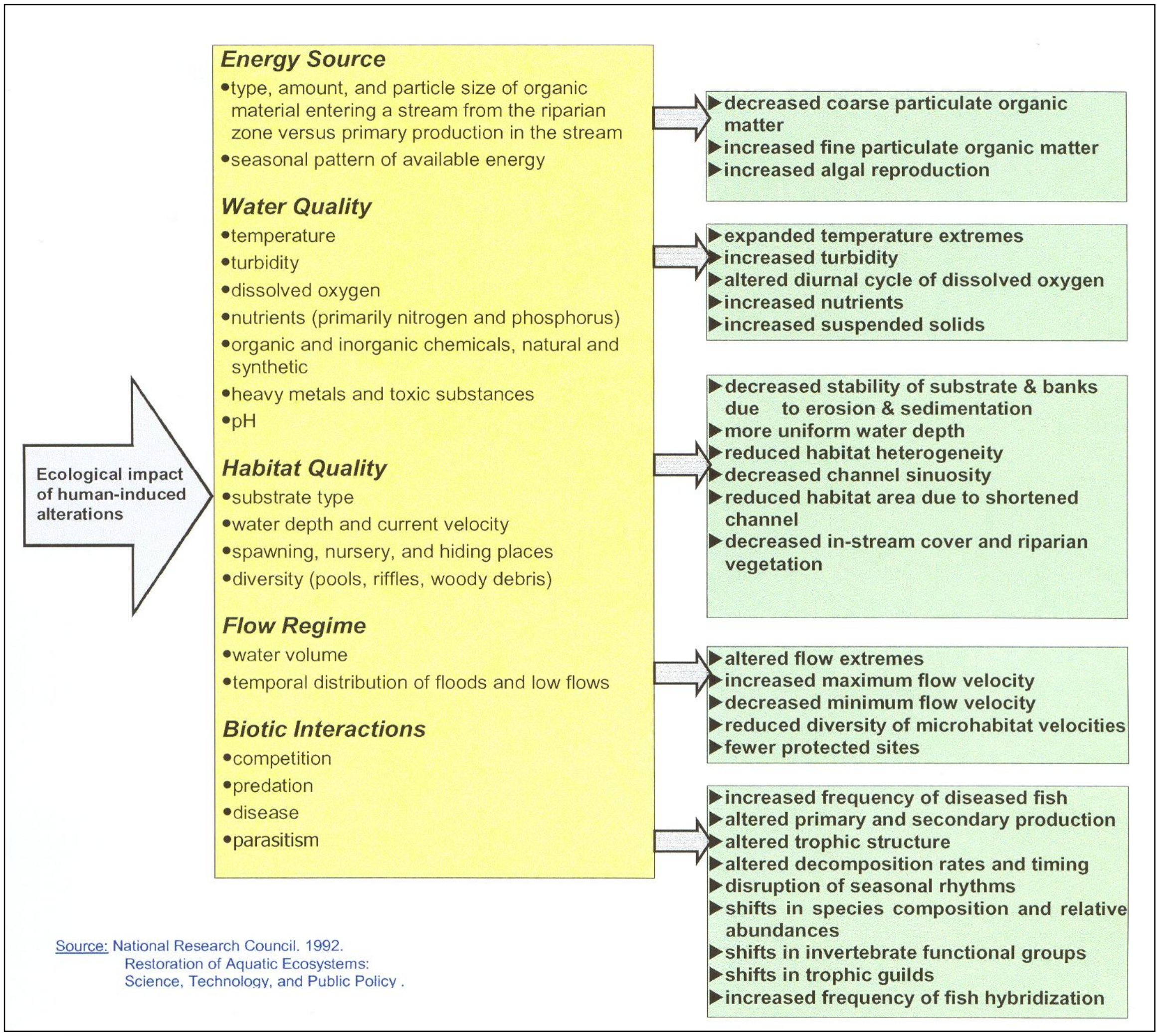
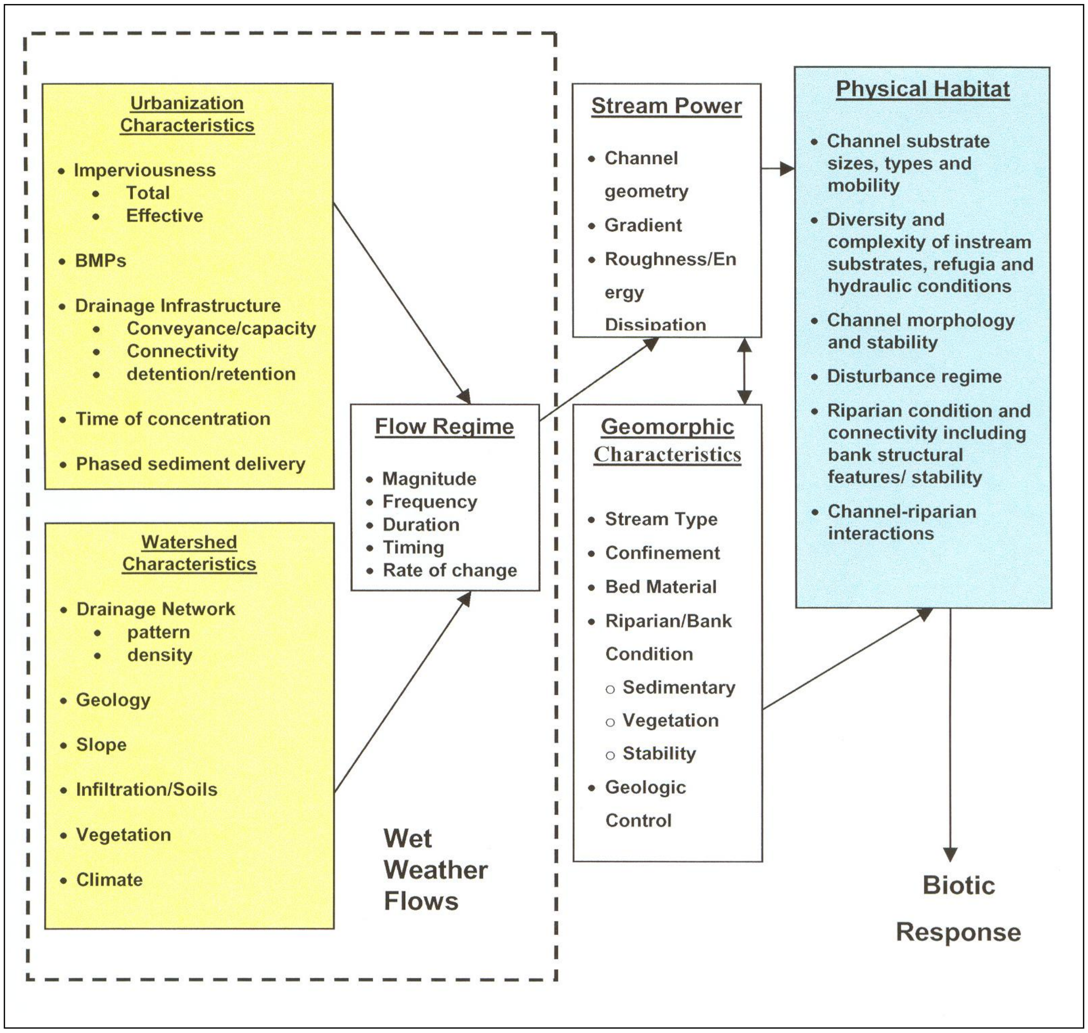


EXHIBIT 2.12
IMPACTS OF URBANIZATION ON PHYSICAL HABITAT AND BIOTA



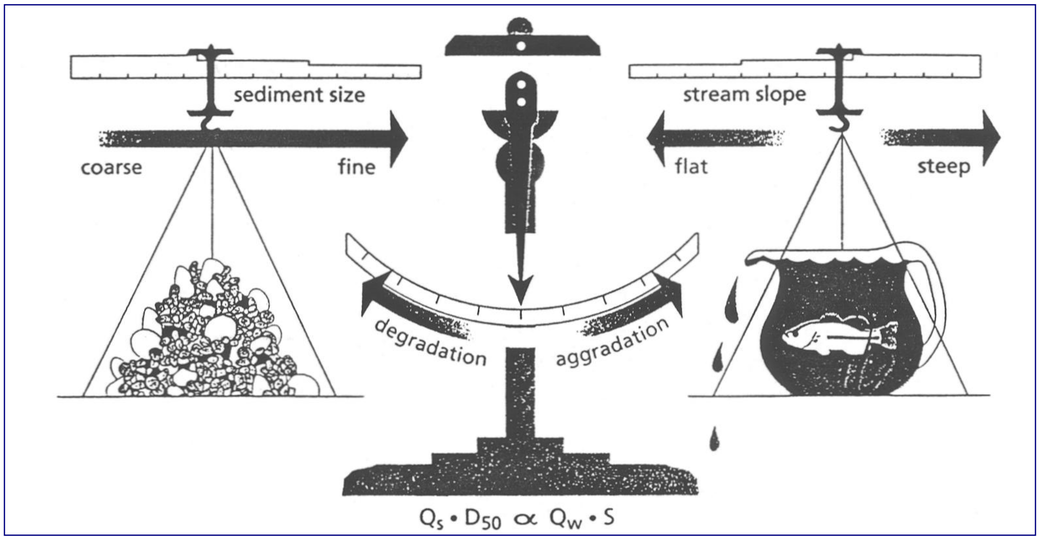
Source: Roesner, L. A. and B. P. Bledsoe. 2003. *Physical Effects of Wet Weather Flows on Aquatic Habitats*. Water Environment Research Foundation: Alexandria, VA. Co-published by IA Publishing: United Kingdom.

Adverse Physical Impacts of Urban Runoff

In the absence of properly designed, constructed, and maintained best management practices (BMPs), urbanization can adversely impact stream channels due to increased peak discharges, increased magnitude and duration of flows, increased sediment loads during construction, and increased erosive forces that are effective at transporting larger-sized particles. This is why volume control for small, frequently occurring storm events is strongly emphasized by UDFCD in Volume 3 of the *Urban Storm Drainage Criteria Manual* (UDFCD 1999).

The widely cited "Lane's Balance" is helpful in understanding the physical impacts of unmitigated urbanization as shown in Exhibit 2.13. This schematic demonstrates that if more runoff is created as a consequence of urbanization, the right side of the scale will drop, and the left side of the scale will rise, thus leading to channel degradation, in the absence of suitable mitigation. By contrast, if excessive sediment is added to the stream during construction, the left side of the scale drops and the right side of the scale rises, leading to aggradation (deposition of sediment in the channel).

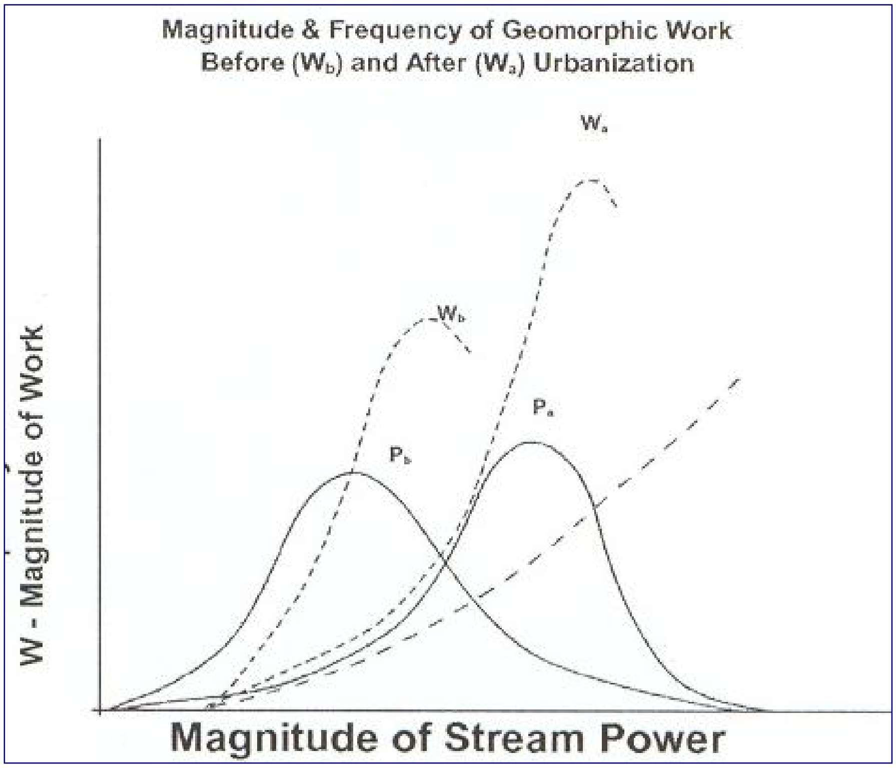
EXHIBIT 2.13
SCHEMATIC OF LANE'S BALANCE DESCRIBING PHYSICAL STREAM PROCESSES



Source: Rosgen, D. 1996. *Applied River Morphology.* Pagosa Springs, Colorado: Wildland Hydrology.

Another potential negative consequence of urbanization is increased stream power (with power meaning the ability of flowing water to alter channel geomorphology), as depicted in Exhibit 2.14. In Exhibit 2.14, comparison of the "before" and "after" curves shows that after urbanization, the stream has a much greater ability to alter the channel and remove sediment from its banks. The problems depicted by Exhibits 2.13 and 2.14 are mitigated through such measures as detention/retention facilities with sophisticated outlet structures that control a wide range of return frequency floods (including small, frequently occurring events that significantly influence channel stability). Other measures include channel stabilization techniques such as grade control structures, toe protection, special stabilization on outer banks at channel bends, etc.

EXHIBIT 2.14
IMPACT OF URBANIZATION ON STREAM GEOMORPHOLOGY



Source: National Research Council, 1992. *Restoration of Aquatic Ecosystems: Science, Technology, and Public Policy*. Washington, DC: National Academy Press.

Chemical Characteristics of Urban Runoff

Urban settings typically contain multiple pollutant sources, as shown in Exhibit 2.15, which lists representative sources of solids, nutrients, pathogens, dissolved oxygen demands, metals, and oils. In addition to these pollutants, Urbonas and Doerfer (2003) have reported that atmospheric dust fallout is a significant contributor to urban runoff pollution in Denver. Some of their key findings include:

1. Atmospheric dust fallout in the Denver area is a significant source of total suspended solids and potentially of other pollutants found in stormwater runoff.

2. Streets, parking lots, sidewalks and roofs all accumulate this type of fallout.

3. Breaking up directly connected impervious areas with landscaping and lawns can help to capture this fallout and minimize its chances of reaching stormwater conveyance systems.

4. The BMPs recommended in UDFCD's *Storm Drainage Criteria Manual*, *Volume 3* are well-suited to removing these types of pollutants.

Another potential pollutant source in Denver involves snow and ice management activities. Storage and disposal of snow that can be contaminated by hydrocarbons and pet waste, as well as the types of chemicals and materials used to melt snow and ice, are both important considerations for runoff quality management. Commonly used de-icers in Denver are highly soluble and have low toxicity to plants and animals; however, in some cases, they may contribute to biochemical oxygen demand (BOD) as they decompose, resulting in lower dissolved oxygen (DO) levels in streams. Denver's snow and ice management practices are addressed under its CDPS stormwater permit requirements.

EXHIBIT 2.15
URBAN RUNOFF POLLUTANT SOURCES

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

Source: Horner, R.R., J.J. Skupien, E.H. Livingston and H.E. Shaver. 1994. *Fundamentals of Urban Runoff Management: Technical and Intuitional Issues*. Washington, DC: Terrene Institute, in cooperation with the Environmental Protection Agency.

Representative concentrations of pollutants in urban runoff have been documented in multiple studies over the last several decades. Several key studies relevant to Denver include:

1) The National Urban Runoff Program (NURP), which was conducted between 1978 and 1983 by the EPA and USGS and included stormwater quality monitoring of 81 outfalls in 28 communities around the U.S. for a total of 2,300 storm events.

2) The National Stormwater Quality Database, Version 1.1, as compiled by Pitt, Maestre and Morquecho (2004) and as available through the website www.unix.eng.ua.edu/~rpitt/Research/ms4/mainms4.shtml. This database contains Phase I stormwater permit monitoring data for over 100 constituents in 65 communities across the U.S. for a total of 3,700 storm events at 350 locations collected over roughly the last 10 years. This database does not include the historical NURP data.

3) The Denver Regional Urban Runoff Program (DRURP) conducted by the Denver Regional Council of Governments (DRCOG) in 1983, providing data for nine basins with various land uses for 15 constituents of concern and for the EPA's "Priority Pollutants." These data have been supplemented with monitoring by UDFCD and were submitted as part of the *Stormwater NPDES Part 2 Permit Application Joint Appendix* (Aurora et al. 1992). Since that time, monitoring in the Denver area has also been completed under the Phase I stormwater permit program.

Data from each of these three sources are tabulated in Exhibits 2.16, 2.17, and 2.18.

EXHIBIT 2.16
NURP SUMMARY DATA MEDIAN EVENT MEAN CONCENTRATIONS FOR URBAN LAND USES FOR VARIOUS CONSTITUENTS BASED ON DATA FROM 28 AMERICAN CITIES[1]

Pollutant	Units	Residential		Mixed		Commercial		Open/ Non-Urban	
		Median	COV[2]	Median	COV	Median	COV	Median	COV
Bio-chemical Oxygen Demand (BOD)	mg/L	10	0.41	7.8	0.52	9.3	0.31	–	–
Chemical Oxygen Demand (COD)	mg/L	73	0.55	65	0.58	57	0.39	40	0.78
Total Suspended Solids (TSS)	mg/L	101	0.96	67	1.14	69	0.85	70	2.92
Total Lead	µg/L	144	0.75	114	1.35	104	0.68	30	1.52
Total Copper	µg/L	33	0.99	27	1.32	29	0.81	–	–
Total Zinc	µg/L	135	0.84	154	0.78	226	1.07	195	0.66
Total Kjeldahl Nitrogen	µg/L	1,900	0.73	1,288	0.50	1,179	0.43	965	1.00
Nitrate + Nitrite	µg/L	736	0.83	558	0.67	572	0.48	543	0.91
Total Phosphorus	µg/L	383	0.69	263	0.75	201	0.67	121	1.66
Soluble Phosphorus	µg/L	143	0.46	56	0.75	80	0.71	26	2.11

[1] Source: EPA, 1999. *Preliminary Data Summary of Urban Stormwater Best Management Practices*. EPA-821-R-99-012.
[2] COV= Coefficient of variation.

Exhibit 2.17 National Stormwater Quality Database Summary (Version 1.1)

	OVERALL		RESIDENTIAL		MIXED RESIDENTIAL		COM-MERCIAL		MIXED COM-MERCIAL		INDUSTRIAL		MIXED INDUSTRIAL		INSTITU-TIONAL		FREEWAYS		MIXED FREEWAYS		OPEN SPACE		MIXED OPEN SPACE	
	MEDIAN	COV	MEDIAN	COV	MEDIAN	COV	MEDIAN	COV	MEDIAN	COV	MEDIAN	COV	MEDIAN	COV	MEDIAN	COV	MEDIAN	COV	MEDIAN	COV	MEDIAN	COV	MEDIAN	COV
Land Use	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drainage Area	56.00	3.64	57.30	4.73	150.80	2.07	38.80	1.22	75.00	2.05	39.00	1.58	127.70	1.96	36.00	0.00	1.61	1.43	63.13	0.29	73.50	1.76	115.36	0.88
% Imperviousness	54.30	0.43	37.00	0.42	44.90	0.28	83.00	0.12	60.00	0.30	75.00	0.30	44.00	0.26	45.00	0.00	80.00	0.13	38.00	0.00	2.00	1.26	34.00	0.14
Precipitation Depth (in)	0.47	0.96	0.46	1.01	0.55	0.79	0.39	1.04	0.47	0.95	0.49	0.96	0.45	0.84	0.18	0.91	0.54	1.05	0.68	0.61	0.48	1.13	0.43	0.88
Runoff (in)	0.18	1.97	0.11	1.96	0.18	1.42	0.23	1.21	0.35	1.10	0.14	2.67	0.29	1.16	0.00	2.09	0.41	1.70	0.28	0.89	0.17	1.31	0.12	1.20
Conductivity (µS/cm @25ºC)	120.00	1.76	96.00	1.51	112.00	1.15	118.50	0.98	103.00	0.59	135.50	1.31	110.50	0.81	-	-	99.00	1.01	418.00	0.56	155.00	0.67	214.70	1.83
Hardness (mg/L CaCO3)	38.00	1.44	32.00	1.04	39.70	1.17	38.90	1.05	35.00	1.83	39.00	1.52	33.00	0.54	-	-	34.00	1.85	83.00	0.28	116.50	0.63	55.00	1.47
Oil and Grease Total (mg/L)	4.00	10.07	3.14	8.04	4.00	2.54	4.70	3.16	4.00	2.93	4.00	12.44	3.30	2.21	-	-	8.00	0.62	4.00	1.63	11.00	1.39	2.00	2.47
pH	7.50	0.10	7.30	0.10	7.50	0.09	7.30	0.10	7.60	0.08	7.50	0.11	7.69	0.11	-	-	7.10	0.11	7.80	0.06	7.70	0.08	7.97	0.07
Temperature (C)	16.45	0.36	16.40	0.36	16.00	0.33	16.00	0.39	15.00	0.35	17.85	0.33	18.00	0.35	-	-	14.00	0.35	16.00	0.30	15.50	0.24	16.00	0.33
TDS (mg/L)	80.00	2.52	70.75	2.05	86.00	2.24	77.00	1.84	69.00	1.94	92.00	3.48	80.00	2.41	52.50	0.67	77.50	0.80	174.00	0.40	113.00	0.70	106.00	2.33
TSS (mg/L)	58.00	1.78	48.00	1.78	67.82	1.58	43.00	1.98	53.50	1.36	76.36	1.54	82.00	1.39	17.00	0.83	99.00	2.53	81.00	1.18	51.00	1.87	78.00	1.40
BOD5 (mg/L)	8.60	1.57	9.00	1.48	7.67	1.30	11.90	1.11	9.00	1.70	9.00	1.71	7.20	1.71	8.50	0.70	8.00	1.26	7.40	0.67	4.20	0.70	6.59	2.40
COD (mg/L)	53.00	1.19	55.00	1.13	42.00	1.42	63.00	1.00	60.00	0.98	60.00	1.19	40.00	1.12	50.00	0.91	100.00	1.06	48.00	0.47	21.00	1.82	39.00	1.54
Fecal Coliform (#/100 mL)	5,081	4.6	7,750	5.1	10,950	3.3	4,550	2.8	4,990	3.2	2,500	5.6	3,033	2.5	-	-	1,700	1.9	730	2.0	3,100	2.9	3,250	2.1
Fecal Streptococcus (#/100 mL)	17,000	3.8	24,000	1.8	26,000	2.2	10,800	2.7	11,000	2.8	13,000	6.9	10,000	2.6	-	-	17,000	1.2	19,000	1.1	24,000	2.6	21,000	2.3
Total Coliform (#/100 mL)	11,000	2.4	-	-	5,467	1.4	-	-	9,000	-	-	-	12,500	2.4	-	-	50,000	1.5	-	-	62,000	-	-	-
Ammonia (mg/L)	0.44	3.57	0.31	1.09	0.40	4.35	0.50	1.20	0.60	0.99	0.50	4.04	0.43	0.72	0.31	0.53	1.07	1.30	0.92	0.53	0.30	1.13	0.51	1.17
N02+NO3 (mg/L)	0.60	1.06	0.59	1.25	0.56	0.99	0.61	1.06	0.56	0.67	0.73	0.95	0.56	0.74	0.60	0.64	0.28	1.23	0.65	0.67	0.59	0.86	0.70	0.94
Nitrogen Kjeldahl Total (mg/L)	1.40	1.35	1.42	1.26	1.33	1.93	1.60	0.94	1.38	0.92	1.40	1.15	1.00	1.54	1.35	0.50	2.00	1.37	1.62	0.93	0.61	1.04	1.20	1.32
Phosphorous Dissolved (mg/L)	0.12	1.58	0.17	0.95	0.12	1.09	0.11	1.25	0.11	2.12	0.11	1.16	0.08	2.25	0.13	0.49	0.20	2.13	0.04	0.84	0.08	1.22	0.09	1.08
Phosphorous Total (mg/L)	0.27	1.51	0.30	1.14	0.27	1.71	0.22	1.15	0.25	1.48	0.26	1.37	0.20	1.52	0.18	0.99	0.25	1.76	0.26	0.79	0.25	3.62	0.27	1.02
Antimony Total (µg/L)	3.20	2.61	28.00	1.48	1.00	2.11	69.00	0.79	15.00	0.99	4.00	3.01	1.00	-	-	-	3.00	0.25	-	-	340.00	-	1.00	0.00
Arsenic Total (µg/L)	3.00	2.42	3.00	2.10	3.10	3.86	2.30	3.15	2.20	1.04	4.00	1.38	3.00	0.96	-	-	2.40	0.70	3.00	0.71	5.00	1.18	4.00	0.78
Arsenic Dissolved (µg/L)	1.50	1.00	1.48	0.50	2.00	0.84	1.50	0.47	1.75	0.20	1.00	0.43	2.00	0.41	-	-	1.43	1.15	-	-	-	-	-	-
Beryllium Total (µg/L)	0.40	2.47	0.50	2.52	0.30	2.70	0.50	1.99	0.35	1.60	0.39	2.50	-	-	-	-	0.30	0.47	27.00	-	-	-	-	-
Cadmium Total (µg/L)	1.00	28.17	0.50	1.67	0.80	3.85	0.84	1.57	0.86	1.11	2.00	2.34	1.00	10.87	0.50	0.69	1.00	0.90	0.50	0.68	0.50	1.69	1.00	1.85
Cadmium Dissolved (µg/L)	0.50	1.14	0.70	0.55	0.30	0.64	0.30	1.34	0.40	0.87	0.60	1.10	0.60	0.58	-	-	0.68	1.03	-	-	-	-	-	-
Chromium Total (µg/L)	7.00	1.48	4.50	1.40	7.00	1.55	6.00	1.35	4.50	1.16	14.50	1.15	8.00	1.69	-	-	8.30	0.71	6.00	0.99	5.00	2.08	5.00	1.49
Chromium Dissolved (µg/L)	2.08	0.73	1.28	0.44	2.00	0.80	2.00	0.59	2.00	0.72	3.00	0.73	2.00	0.69	-	-	2.30	0.70	-	-	-	-	-	-
Copper Total (µg/L)	16.00	2.21	12.00	1.83	17.39	1.33	17.00	1.48	17.00	2.96	22.00	1.99	17.40	0.89	17.00	0.59	34.70	0.95	8.50	1.05	5.30	2.24	11.00	1.47
Copper Dissolved (µg/L)	8.00	1.63	7.00	1.96	5.50	0.86	7.57	0.83	9.50	0.61	8.00	0.67	6.00	0.58	-	-	10.90	1.50	-	-	-	-	1.00	-
Lead Total (µg/L)	16.00	1.85	12.00	1.89	18.00	1.37	18.00	1.59	17.00	1.47	25.00	1.81	18.50	1.50	5.75	0.79	25.00	1.45	10.00	0.90	5.00	2.02	10.00	2.28
Lead Dissolved (µg/L)	3.00	2.02	3.00	1.87	3.00	0.68	5.00	1.59	6.00	0.61	5.00	1.58	5.00	0.97	-	-	1.80	1.65	-	-	-	-	2.00	0.00
Mercury Total (µg/L)	0.20	2.68	0.20	1.17	0.20	1.00	0.20	0.84	0.10	1.12	0.20	2.66	0.25	0.58	-	-	0.19	0.80	-	-	-	-	0.10	1.05
Nickel Total (µg/L)	8.00	2.13	5.40	1.21	7.93	0.83	7.00	3.78	5.00	1.33	16.00	1.24	9.00	0.92	-	-	9.00	0.91	-	-	27.00	0.87	7.00	1.16
Nickel Dissolved (µg/L)	4.00	1.47	2.00	0.51	5.50	0.87	3.00	0.84	3.00	0.57	5.00	1.43	5.00	0.57	-	-	4.00	1.38	-	-	-	-	-	-
Zinc Total (µg/L)	116.51	3.35	73.00	1.30	99.50	1.04	150.00	1.22	132.00	1.70	210.00	2.25	160.00	3.32	305.00	0.81	200.00	1.01	90.00	0.86	39.00	1.32	100.00	1.02
Zinc Dissolved (µg/L)	52.00	3.89	31.50	0.84	48.00	0.88	59.00	1.37	94.00	0.74	111.50	3.62	2100.00	1.18	-	-	51.00	1.86	-	-	160.00	-	14.00	0.61

EXHIBIT 2.18
EVENT MEAN CONCENTRATIONS (MG/L) OF CONSTITUENTS IN DENVER METROPOLITAN AREA RUNOFF, PER DRURP AND PHASE 1 STORMWATER CDPS PERMIT APPLICATION FOR DENVER, LAKEWOOD, AND AURORA[1]

Constituent	Natural Grassland	Commercial	Residential	Industrial
Total Phosphorus	0.4	0.42	0.65	0.43
Dissolved or Ortho-Phosphorus	0.1	0.15	0.22	0.2
Total Nitrogen	3.4	3.3	3.4	2.7
Total Kjeldahl Nitrogen	2.9	2.3	2.7	1.8
Ammonia Nitrogen	0.1	1.5	0.7	1.2
Nitrate + Nitrite Nitrogen	0.5	0.96	0.65	0.91
Lead (Total Recoverable)	0.1	0.059	0.053	0.13
Zinc (Total Recoverable)	0.1	0.24	0.18	0.52
Copper (Total Recoverable)	0.04	0.043	0.029	0.084
Cadmium (Total Recoverable)	Not Detected	0.001	Not Detected	0.003
COD	72	173	95	232
Total Organic Carbon	26	40	72	22-26
Total Suspended Solids	400	225	240	399
Total Dissolved Solids	678	129	119	58
BOD	4	33	17	29

[1] Source: Aurora et al. 1992. *Stormwater NPDES Part 2 Permit Application Joint Appendix.* Based on data reported by DRCOG, 1983. *Urban Runoff Quality in the Denver Region,* as updated with more recent data from UDFCD 1992.

The results in the Denver region parallel, in many respects, the findings of NURP. To the extent that there are discrepancies or inconsistencies between Exhibits 2.16, 2.17 and 2.18, Exhibit 2.18 should govern for projects in Denver. (Note: While these results are representative of general conditions within the Denver region, site-specific data from watershed studies should be used when available.) In general, DRURP identified constituents such as lead, zinc, cadmium, fecal coliform bacteria, and total suspended solids as significant pollutants in urban runoff. Other selected statements from the DRURP summary report (DRCOG 1983) relevant to this Plan include:

- ► Very few EPA Priority Pollutants were detected in runoff samples. Organic pollutants found were particularly sparse, and the most commonly occurring one detected was a pesticide. The most significant non-priority pollutant found was 2, 4-D which is an herbicide.

- ► Pollutant loading per runoff amount was not found to be well related to basin imperviousness or land use. Vague relationships between event mean concentrations and imperviousness were noted, but proved statistically insignificant. Concentrations of pollutants did not vary in a predictable or anticipated pattern.

- A receiving water assessment was included in the program to denote the effects of urban runoff for the South Platte River, which is the ultimate receiving water for both wastewater effluent and urban runoff generated within the Denver metropolitan area. Significant amounts of sediment, bacteria, nutrients, organic matter, and heavy metals were found to enter the river during storm events compared with discharges from wastewater treatment plants over the same time period.

  The investigation of the effects of urban runoff on receiving waters involved three considerations: 1) comparison of pollutant concentrations monitored in the South Platte River during storm events with those occurring during ambient streamflow; 2)comparison of the relative amounts of pollutant loads entering the river from storm runoff with those from municipal wastewater sources; and 3) comparison of pollutant concentrations during periods of storm runoff and ambient streamflow with water quality standards in effect for the study segment of the South Platte River.

  Several water quality constituents had mean concentrations that were greater during storm runoff than during ambient streamflow. Suspended sediment and fecal coliform bacteria exhibited much greater concentrations during storm events, as did oxygen-demanding substances and heavy metals. Total metals concentrations for lead, zinc, copper, cadmium, iron, and manganese during storm-runoff periods were greater than mean ambient concentrations and exceeded established stream standards 100 percent of the time. Effective control of urban runoff to reduce the concentrations of these constituents was identified as being important to improve the quality of water of the South Platte River.

  A comparison of the relative loading from point sources, base flow and urban runoff was necessary to denote the effects of urban runoff on the South Platte River. Results indicated that municipal wastewater discharges contributed the greatest amount of nitrogen, phosphorus, and organic carbon to the river on an annual basis. Total suspended solids and lead loading were shown to be predominantly influenced by contributions from urban runoff.

- The study showed that urban runoff is a significant source of some water pollutants. The most obvious pollutant is total suspended solids. This was true regardless of the existence of major land disturbances causing erosion. Urban runoff was also a significant source of fecal coliform bacteria, oxygen demanding substances, and metals during storms. In addition, nutrients from urban runoff are and will be a problem for lakes and reservoirs.

- Non-storm urban runoff (e.g., dry weather discharges such as irrigation runoff) was also identified as a source of pollutants. This was not expected and was determined indirectly in the study analysis.

Since DRURP, DRCOG has been involved in six watershed studies that were designed to assess the nature, severity and impact of stormwater and/or nonpoint sources on water quality. These efforts characterized urban runoff in relation to development patterns. The results have been developed into predictive planning tools to estimate stormwater and nonpoint source quality, quantity and effects on receiving waters. BMPs have been recommended, updated, and incorporated as an integral component of watershed management plans. Watershed controls include structural systems, nonstructural practices and institutional policies (DRCOG 1998).

SUMMARY

Denver faces a significant challenge in addressing urban runoff water quality issues over a large land area with varied drainage basins. The impacts of urbanization are multi-faceted and require integrated approaches in order to be most effective. The remainder of this Plan provides a framework for an integrated strategy to address these challenges. Additional work in the form of watershed-by-watershed assessments (See Chapter 9) will be needed to achieve Denver's goals in these basins.

Chapter 3
REGULATORY DRIVERS

Denver is committed to protecting and improving water quality conditions in waterbodies receiving stormwater runoff from areas within its boundaries. This commitment is driven not only by local, state, and federal regulations, but also by Denver's staff and citizens who view the lakes, stream, and rivers within Denver as an amenity and a significant part of its natural resources.

The key federal regulation that pushes communities throughout the U.S. toward the goal of "fishable, swimmable waters" is the federal Clean Water Act. This Act establishes a variety of requirements intended to protect and improve conditions in streams, lakes, and wetlands. Aspects of the Clean Water Act particularly relevant to this Plan focus on regulation of stormwater discharges, water quality standards for waterbodies receiving runoff from stormwater discharges, and implications for water quality standards not being attained. The discussion which follows briefly identifies some of the key regulatory drivers relevant to this project that have evolved in large part from the Clean Water Act, including:

- Denver's Phase I Stormwater Colorado Discharge Permit System (CDPS) Permit
- Denver International Airport (DIA) CDPS Permit
- U.S. Environmental Protection Agency's (EPA's) April 2004 Audit of Denver's Stormwater Management Program
- Denver's stormwater-related requirements and regulations
- Other Denver ordinances, rules and regulations
- Colorado Water Quality Control Act and Regulations, including state stream standards
- Total Maximum Daily Loads (TMDLs)
- Regional water quality efforts
- Potential future changes to state and federal water quality permits and regulations

PHASE I STORMWATER CDPS PERMIT

Denver was required to obtain a stormwater discharge permit due to the "National Pollutant Discharge Elimination System Permit Application Regulation for Inclusion of a Stormwater Discharge Regulation," which was issued on November 16, 1990 (Federal Register, Volume 55, No. 222). There are three major objectives of the stormwater discharge permitting program:

- Reduce pollutant loadings in municipal storm sewer discharges to the maximum extent practicable (MEP).

- Eliminate illicit wastewater connections, illegal discharges and non-exempt non-stormwater discharges to municipal storm sewer systems.

- Implement management programs that apply best available technology (BAT), best conventional pollutant control technology (BCT) and, where necessary, water-quality based controls directed at controlling industrial stormwater pollution.

Denver is permitted to discharge municipal stormwater runoff to state waters in the South Platte River watershed under CDPS Permit No. COS-000001, which was renewed on March 20, 2003 and remains effective until April 30, 2008 (CWQCD 2003). This permit covers "all areas within the corporate boundary of Denver served by, or otherwise contributing to discharges to state waters, from municipal separate storm sewers (MS4s) owned or operated by Denver." This includes the storm sewer system at DIA, excluding DIA's industrial system, which is covered under DIA's industrial stormwater permit (COS-000008).

Denver's permit was originally issued in 1996 under the "Phase I" stormwater regulation. The subsequent "Phase II" stormwater regulation, which is best known for the requirements it places on smaller communities, also affected Denver's permit. Examples of key changes to Denver's permit due to the Phase II stormwater regulation included: 1) regulation of one acre or more of disturbance at construction sites, whereas a five-acre trigger was in place under the initial permit; and 2) increased emphasis on public education/outreach.

Denver's current permit specifies stringent requirements with which Denver must comply through a combination of a Stormwater Management Program, regular program review and modification, wet weather monitoring, conformity with a compliance schedule, annual reporting, signatory certification, and other measures. The Stormwater Management Program must address these five major categories: commercial/residential management, illicit discharge management, construction sites, municipal facility runoff controls and industrial facilities runoff. To frame the seriousness and extent of the requirements under this permit, the terms "shall" and "will" are used over 200 times in the permit. Consequences for violations include significant fines and possible imprisonment for knowing violations of the permit. In addition to measures it must implement, Denver is also required to "ensure," "insure," or "assure" the following:

- With regard to new development planning procedures for commercial/residential areas, the permit specifies: "City ordinances and rules shall be revised as necessary to include provisions to ensure that stormwater quality controls installed for significant development or redevelopment are adequately operated and maintained." (Part 1, B. 2.c.).

- With regard to inspection and enforcement procedures as part of project review and approval procedures for new commercial/residential development, the permit specifies: "Developments shall be inspected for compliance to insure that all specified BMPs are constructed in accordance with the approved plan." (Part 1, B. 2.e. iii.).

- With regard to assessing the impacts of flood management projects under the commercial/development management program, the permit specifies: "The permittee shall continue to implement procedures to assure that the impact on water quality is assessed for proposed flood management projects." (Part 1, B. 4.).

- With regard to procedures for site inspection and enforcement at construction sites, the permit specifies: "procedures to insure that BMPs are being installed and maintained according to the approved plan and that sediment sources, materials, equipment maintenance areas (including fueling) and other significant sources of pollution have been addressed" and "enforcement provisions to insure compliance with requirements as defined in Denver ordinances and rules, and approved plans and to insure effective operation and maintenance of BMPs." (Part 1, B. 2.d.3.a.i. & iii.).

A brief overview of the specific types of requirements in the permit includes the following:

EXHIBIT 3.1
OVERVIEW OF DENVER'S STORMWATER PERMIT REQUIREMENTS

RESIDENTIAL/COMMERCIAL MANAGEMENT PROGRAM

ILLICIT DISCHARGE MANAGEMENT PROGRAM

INDUSTRIAL FACILITIES PROGRAM

CONSTRUCTION SITES PROGRAM

MUNICIPAL FACILITY RUNOFF CONTROL PROGRAM

WET WEATHER MONITORING PROGRAM

Residential/Commercial Management Program

1. Maintenance of Structural Controls—implement a program of routine maintenance activities for municipally owned structural controls to reduce pollutants.
2. New Development Planning Procedures—continue to implement comprehensive planning procedures and enforce controls to reduce the discharge of pollutants after construction is complete from areas of new development and significant redevelopment.
3. Public Street Maintenance—continue to operate and maintain public streets, roads and municipal parking lots in a manner so as to reduce the discharge of pollutants (including those related to road repair, street sweeping, snow removal, sanding activities and herbicide application).
4. Assess Impacts of Flood Management Projects—continue to implement procedures to assure that the impact on water quality is assessed for proposed flood management projects.
5. Pesticide, Herbicide, and Fertilizer Application—continue to implement controls to reduce the discharge of pollutants related to application of pesticides, herbicides, and fertilizers.

Illicit Discharges Management Program

1. Prevention of Illicit Discharges and Improper Disposal—continue to implement an ongoing program to detect and remove (or require the discharger to the MS4 to obtain a separate CDPS permit for) illicit discharges and improperly disposed materials into the MS4 in accordance with this program area.
2. Ongoing Field Screening—continue to implement an ongoing program to screen the MS4 for illicit discharges, illegal dumping and illicit connections.

3. Investigation of Suspected Illicit Discharges—continue to implement a program to locate and eliminate suspected sources of illicit connections and improper disposal.

4. Procedures to Prevent, Contain, and Respond to Spills—continue to implement a program to prevent, contain, and respond to spills that may discharge into the MS4.

5. Educational Activities to Promote Public Reporting of Illicit Discharges and Improper Disposal—continue to implement a plan to promote and facilitate public reporting of the presence of illicit discharges or improper disposal of materials into the MS4.

6. Public Educational Activities to Promote Proper Management and Disposal of Potential Pollutants—continue to implement a plan to promote the proper management and disposal of used motor vehicle fluids and household chemical wastes, and to reduce or eliminate the discharge of other pollutants to the MS4.

7. Household Chemical Waste Collection Programs—continue to sponsor a door-to-door household hazardous waste collection program, or substitute an equivalent program that has the same result of making reasonably available to Denver residents the means to recycle/properly dispose of the more common household chemical wastes.

8. Control of Sanitary Sewer Seepage into the MS4—continue the existing program to detect and eliminate sources of sanitary sewer seepage into the MS4.

<u>Industrial Facilities Program</u>—Develop and implement a program to promote proper management of industrial sites regarding stormwater quality and industrial BMPs. The program shall provide education and outreach on pollutants in stormwater discharges to municipal systems from industrial facilities that the permittee determines are contributing or have the potential to contribute a substantial pollutant loading to the MS4.

<u>Construction Sites Program</u>

1. Procedures for Site Planning—continue to implement procedures for site planning that incorporate consideration of potential water quality impacts from construction sites within Denver.

2. Structural and Non-Structural BMPs—continue to implement requirements for the selection, implementation, installation, and maintenance of appropriate BMPs at construction sites.

3. Procedures for Site Inspection and Enforcement—continue to implement procedures for inspection and enforcement of control measures at construction sites.

4. Training and Education for Construction Site Operators—continue to develop, support and encourage attendance at an education and training program for construction site operators.

Municipal Facility Runoff Control Program—continue to implement runoff control plans for specified Denver-owned and/or operated facilities that do not have independent CDPS stormwater permits. New plans shall be developed for any new facilities. Currently covered facilities include:

- Vehicle maintenance facilities (maintenance includes equipment rehabilitation, mechanical repairs, painting, fueling and lubrication).
- Asphalt and concrete batch plants which are not already individually permitted.
- Solid-waste transfer stations.
- Exposed stockpiles of materials, including stockpiles of road deicing salt, salt and sand, sand, rotomill material.
- Sites used for snow dumps, and/or for temporary storage of sweeper tailings or other waste piles.

Wet Weather Monitoring Program—continue to implement a wet weather monitoring program to assess wet weather conditions, particularly urban stormwater effects on state waters. Denver, Aurora, Lakewood, and Urban Drainage and Flood Control District (UDFCD) work together (as the Joint Stormwater Task Force) on this program, with actual monitoring conducted by the U.S. Geological Survey (USGS). Samples are collected from receiving waters at five locations: an upstream site, a downstream site, an intermediate site, one major tributary, and a tributary to a major tributary. The monitoring program was designed based on land use considerations, and sampling is conducted based on the rising limb of the hydrograph associated with a precipitation event. The monitoring program was initiated in 1997, with active monitoring beginning in 1998 and continuing through the present. The four-year baseline monitoring period associated with Denver's first permit term is complete, with a second four-year period in progress for purposes of trend analysis (SAIC 2004).

DENVER INTERNATIONAL AIRPORT (DIA) CDPS PERMIT

When the Colorado Water Quality Control Division (CWQCD) renewed Denver's municipal stormwater permit in May of 2003, the permit additions included coverage of the MS4 system at DIA. Similar to other U.S. airports, prior to 2002, DIA was already covered under an industrial stormwater permit (COS-000008) which includes industrial activities such as aircraft deicing. Denver's renewed MS4 permit provides an implementation schedule to bring the airport into MS4 permit compliance with the rest of Denver. As a result, the areas of the airport that are not impacted by industrial activity will follow the same policies, rules and regulations regarding stormwater discharges as the rest of Denver. Extensive coordination between the Department of Public Works and the Department of Aviation is ongoing. Development parcels at the airport will be handled in the same manner as development parcels elsewhere in Denver.

DIA is also covered under a CDPS stormwater construction permit and a Minimum Industrial Discharge (MINDI) permit. The *Roadmap to Development Review, Permitting, and Construction Sites Program Process, Wastewater Management Division Rules and Regulations* *and MS4 Permit Requirements* was developed in December 2003 (Denver 2003) and can be referenced for more information on DIA's construction-related stormwater management requirements.

EPA'S APRIL 2004 AUDIT OF DENVER'S STORMWATER MANAGEMENT PROGRAM

During April 2004, EPA Region 8 conducted an audit of Denver's permitted stormwater management program. Appendix B contains a summary of the "action items" from this audit, combined with Denver's responses to EPA's comments. The goal of the audit was to determine the overall success and effectiveness of Denver's compliance with the conditions and requirements of its CDPS permit. The audit included interviews, file review and field inspections. As a result of the final report prepared by SAIC, Denver was required to provide written responses within 60 days on the action items identified by EPA. Overall, the audit indicated that Denver was "well along with the implementation of its MS4 program and has achieved many positives in its program; however, some concerns have been identified." EPA's general program findings included:

- Denver has an effective public education and outreach program.
- Denver inspectors thoroughly understand their responsibilities, the MS4 permit requirements, and how to implement these requirements.
- Denver has areas of its program where additional coordination between Denver departments and between Denver and the CWQCD would be beneficial.
- Denver has not adequately implemented all standardized procedures throughout the MS4 program. (Better documentation is needed.)
- Denver has not designated a staff person to be responsible for the stormwater runoff control program at its municipal facilities.

Overall, the comments on the program were positive, with required changes to the program generally characterized as "administrative loose ends" that are relatively easily addressed, as described in Denver's responses to the audit in Appendix B.

DENVER'S STORMWATER QUALITY RELATED POLICIES

The Wastewater Management Division of the Department of Public Works is organized to operate the sewerage system of Denver and to implement and enforce the "Rules and Regulations Governing Sewerage Charges and Fees and Management of Wastewater" and Chapter 56, Articles 91 through 107 of the Revised Municipal Code. A variety of drainage and stormwater-quality-related requirements are identified, the most explicit of which are in Chapter 10, Section 10.17 of the rules and regulations. Because the requirements of this section provide a critical foundation for this Plan, the requirements of Section 10.17 are reproduced in full as follows:

Pursuant to the terms, conditions and requirements of CDPS Permit No. COS-000001, issued to the City and County of Denver by the State of Colorado; the City is required to implement specific programs to control discharges to and from the Municipal Separate Storm Sewer System (MS4) owned or operated by the City and County of Denver. Elements of these mandatory programs require that the City take steps to minimize the discharge of sediment, debris, and other pollutants from construction sites; and provide for enhancing the water quality of storm runoff from fully developed sites.

a. Technical Criteria. The minimum technical requirements for all proposed required BMPs relating to water quality are to be based on those specified in the UDFCD Criteria Manual, Volume 3, Best Management Practices, September 1992 and as may be amended.

b. Water Quality Requirements.

1. *All development and re-development projects that are located within the Corporate Boundaries of the City and County of Denver shall include in their design, specific measures to enhance the water quality of storm-generated runoff from the fully developed project site. All Best Management Practices (BMPs) identified in the UDFCD Volume 3 Manual are applicable to development and re-development projects within the City and County of Denver.*

2. *All facilities designed to provide detention of storm-generated runoff for drainage and flood control purposes shall be required to provide water quality enhancement through the use of a timed-release water quality outlet structure or an approved alternative.*

3. *Timed release water quality outlet structures shall be designed to allow either a 40-hour or 12-hour drain time of a portion of the runoff identified as the Water Quality Capture Volume. The drain time is dependent on the type of proposed detention facility. At a minimum, the determination of the Water Quality Capture Volume and design requirements for timed-release outlet structures shall conform to the methods and procedures outlined in the Urban Storm Drainage Criteria Manual, Volume 3.*

EXHIBIT 3.2
SELECTED REQUIREMENTS FOR DEVELOPMENT AND REDEVELOPMENT PROJECTS IN DENVER

PROVIDE BMPS TO ENHANCE STORMWATER RUNOFF

PROVIDE TIMED RELEASE OF THE WATER QUALITY CAPTURE VOLUME FOR SITES REQUIRED TO DETAIN RUNOFF FOR DRAINAGE PURPOSES

SUBMIT A STORMWATER QUALITY CONTROL PLAN TO ADDRESS WATER QUALITY ISSUES AND IDENTIFY BMPS FOR THE SITE

4. *All sites that are not required to provide detention of storm runoff for drainage and flood control purposes may still be required to detain for water quality purposes.*

c. *Waivers. Upon application, review, and approval of said application, waivers from the requirement to detain solely for water quality purposes may be granted.*

d. *Stormwater Quality Control Plans. All development, re-development, or other construction projects, regardless of size, are required to submit a Stormwater Quality Control Plan that addresses water quality issues and describes all permanent water quality "Best Management Practices" to be used on the fully developed site. The type and scope of this plan varies with the size of the site. Review and approval of this plan by the Manager or his/her duly authorized agents is required before any Wastewater Management Division Permits are issued that relate to the project.*

e. *Plan submittals. Plans and drawings relating to water quality issues that are submitted for review and approval shall conform to the requirements set forth in the Wastewater Management Division's 1995 guidebook entitled "Stormwater Quality Control Plans: An Information Guide" and as may be amended from time to time.*

f. *Fees. At the time of issuance of an applicable Sewer Use and Drainage Permit, a non-refundable review fee shall be paid to the City and County of Denver. The amount of such fee shall be charged as established by the Manager.*

g. *Compliance with Chapter Required for Site Development Plan(s) Approval. No Site Development Plan(s) shall be approved unless said plan(s) include water quality enhancing measures consistent with the requirements of this Chapter and related land development regulations.*

Other key aspects of the Wastewater Management Division regulations that outline requirements related to stormwater quality and quantity and/or elucidate the permitting process related to stormwater and new developments include the following:

- Sewer Use & Drainage Permit (Section 2.17): A sewer use and drainage permit must be obtained for any new structure or addition to an existing structure. A permit may also be required for any situation which may affect storm drainage, the sanitary sewer system or the storm sewer system. A permit may also be required for any situation which requires review by the Wastewater Management Division. No repair or replacement of any building sewer is allowed prior to the issuance of a Sewer Inspection Permit.

- Prohibited Discharges to the Storm Sewer System (Section 7.01): Discharges of polluted water, waste or materials into Denver's storm sewers or into water courses that traverse Denver are prohibited. Discharges of industrial or commercial wastewater or any polluted or contaminated water upon any sidewalk, street, alley, or any gutter are also prohibited. Other prohibitions are also identified.

- Subdivision/Planned Unit Development/Planned Building Group/Planned Development (Chapter 9): Specific requirements for storm drainage studies, development site plans, construction drawings, grading plans, and protective covenants are outlined. Drainage plans must provide for detention of the 100-year storm event in compliance with the UDFCD's *Storm Drainage Criteria Manual* and current Wastewater Management Division criteria. The owner/maintenance organization is required to be responsible for and pay for all installation and maintenance costs related to on-site storm sewers and storm drainage control facilities. A pre-application conference with the Wastewater Management Division is offered, but not required, to ensure that the developer is properly informed regarding requirements, criteria, and problems related to drainage.

  Section 9.04 identifies the Wastewater Management Division-related requirements that must be fulfilled on the Building Department Inspection Record form in order to receive a Certificate of Occupancy:

  a. A Sewer Use and Drainage Permit has been issued.

  b. Construction of all required storm and sanitary drainage facilities has been completed and accepted by the City.

  c. The Certificate of Inspection for all storm drainage and sanitary sewer facilities has been submitted.

  d. The building sewer connection has been inspected by the Division and a Sewer Inspection Permit has been issued.

  e. All fees required by the City and County of Denver have been received by the City.

  f. All other requirements of the Sewer Use and Drainage Permit have been completed.

- Water Quality, Grading, and Erosion Control (Chapter 10): Requirements related to earth disturbance are specified to ensure that soil erosion and sedimentation (and changed water flow characteristics) are controlled to the extent necessary to avoid damage to personal and real property, and to prevent pollution of the MS4 and receiving waters. Post-construction requirements are specified in Section 10.17, as previously discussed.

- Storm Drainage Planning and Design (Chapter 11): This chapter requires that all developers plan, design and install storm drainage facilities in compliance with the *Denver Storm Drainage Master Plan* to insure coordinated development of a system which is self-sufficient in each storm drainage basin. Drainage facilities are also required to comply with the *Denver Comprehensive Plan* in cases where future land uses are a consideration in the development of storm drainage facilities. Drainage facilities are also required to comply with the *Denver Storm Drainage Design and Technical Criteria Manual* and UDFCD's *Urban Storm Drainage Criteria Manual*. Specific storm drainage design criteria are provided for various development types. For example, the initial storm drainage system for commercial/industrial areas must be planned based on the 5-year storm and major drainage systems must be based on the 100-year storm. On-site stormwater runoff detention facilities are required to attenuate the peak flow conditions for both the 100-year and 10-year storm events under fully developed conditions. Other requirements apply for residential development, Planned Urban Developments (PUDs), etc.

The requirements of Chapter 11 are relevant to this Plan for a variety of reasons. One key issue is understanding the difference between requirements for detaining stormwater from a water quantity management perspective and the requirement for detaining stormwater from a water quality perspective. Chapter 11 identifies the water quantity management requirements important for stormwater conveyance systems, whereas Chapter 10 identifies the requirements for the "water quality capture volume" necessary for water quality protection. The water quality capture volume is calculated in accordance with the *Urban Storm Drainage Criteria Manual, Volume 3* (UDFCD 1999) based on smaller, frequently occurring storms (e.g., typically less than the 1-year storm), whereas the water quantity management requirements are based on the 2-, 5-, 10- and/or 100-year storms, depending on the type of development. Opportunities for integration of these requirements are explored further in Chapter 6 of this Plan.

- Floodplain Management (Chapter 12): This chapter focuses on requirements and prohibitions on development or alteration of property within the Regulatory Floodplain of Denver, except pursuant to the terms of a Sewer Use and Drainage Permit issued by Denver which authorizes such development or alterations.

In summary, Denver has specific rules and regulations in place for managing stormwater quality and quantity. This Plan plays a supporting role relative to these rules, providing approaches and strategies to facilitate better implementation of these rules and regulations.

OTHER DENVER ORDINANCES, RULES AND REGULATIONS

In addition to Denver's rules and regulations that directly relate to water quality, other rules and regulations can restrict the types of stormwater quality management strategies that are implemented at a site. For example, many rules and guidelines exist as part of zoning codes and urban design guidelines specific to various development areas. A review of these rules and guidelines was beyond the scope of this Plan, but would be a valuable step in ensuring that there are not unnecessary hurdles and restrictions that prevent innovative stormwater quality management. As an example, there may be requirements for curbs and gutters or minimum street widths that, under some conditions, would prohibit implementation of certain Low Impact Development techniques.

COLORADO WATER QUALITY CONTROL ACT AND REGULATIONS

The *Colorado Water Quality Control Act* (CRS 25-8-101 through 25-8-702) provides the policy direction to "conserve, protect, maintain, and improve, where necessary and reasonable, the quality of state waters." The act also authorizes water pollution prevention, abatement and control programs. In Colorado, the Colorado Water Quality Control Commission (CWQCC) regulates water quality and is responsible for establishing classifications and standards to protect beneficial uses of streams, lakes and groundwater in the state (CRS 25-8-201 through 25-8-406). Discharge permits to waterbodies are issued in a manner intended to protect these beneficial uses. For this reason, the underlying classifications and standards are relevant to Denver in terms of its stormwater discharge permit, even though the permit itself contains no numeric standards.

A variety of standards for physical and chemical constituents have been developed for Colorado streams based on their assigned classifications. A brief overview of the subset of use classifications relevant to streams and/or lakes in the Denver area from the *Basic Standards and Methodologies for Surface Water* (5 CCR 1002-31) includes the following:

- Recreation Class 1—Primary Contact: "These surface waters are suitable or intended to become suitable for recreational activities in or on the water when the ingestion of small quantities of water is likely to occur…Waters shall be presumed to be suitable for Class 1 uses and shall be assigned a class 1a or class 1b classification unless a use attainability analysis demonstrates that there is not a reasonable potential for primary contact uses to occur in the water segment(s) in question within the next 20 years."

- Agriculture: "These surface waters are suitable or intended to become suitable for irrigation of crops usually grown in Colorado and which are not hazardous as drinking water for livestock."

- Aquatic Life Class 1 Warm Water: "These are waters that (1) currently are capable of sustaining a wide variety of warm water biota, including sensitive species, or (2) could sustain such biota except for correctable water quality conditions."

- Aquatic Life Class 2 Warm Water: "These are waters that are not capable of sustaining a wide variety of cold or warm water biota, including sensitive species, due to physical habitat, water flows or levels, or uncorrectable water quality conditions that result in substantial impairment of the abundance and diversity of species."

- Domestic Water Supply: "These surface waters are suitable or intended to become suitable for potable water supplies. After receiving standard treatment (defined as coagulation, flocculation, sedimentation, filtration, and disinfection with chlorine or its equivalent), these waters will meet Colorado drinking water regulations and any revisions, amendments, or supplements thereto."

In addition to these classifications, the majority of the streams and lakes in the Denver area are also classified as "Use Protected" which means that that the CWQCC has determined that the waters do not warrant the special protection provided by the "outstanding waters" designation or the "antidegradation review" process. (Use-protected waters are allowed to degrade to the level of water quality standards and are not considered "reviewable waters" under the antidegradation regulation [CWQCD 2001].) A variety of criteria can be applied to result in a segment being use-protected, one example of which is an Aquatic Life Warm Water Class 2 designation.

Under its CDPS stormwater permit, Denver is permitted to discharge to multiple locations in the South Platte River basin with stream standards assigned by the CWQCC as summarized in Exhibit 3.3. (See Chapter 2, Exhibit 2.3 for stream locations.) The specific numeric standards associated with these classifications are provided in *Colorado Department of Public Health and Environment Water Quality Control Commission Regulation 38 Classification and Numeric Standards South Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin*, as summarized in Appendix A of this Plan.

One recent change to the classifications that is noteworthy with regard to water quality issues affecting DIA arose from the difficulty of several streams in the DIA drainage basin meeting stream standards for dissolved oxygen (DO). In the July 2004 Triennial Review hearing for the South Platte, Denver proposed adoption of ambient-based DO standards for Second Creek, Third Creek, and Box Elder Creek based on the demonstration that "natural conditions or a combination of natural and irreversible anthropogenic conditions preclude the attainment of the existing DO standards for those streams." DIA is located in the Third Creek headwaters. In its proposal, Denver (2004) stated:

> Stormwater runoff from the airport has enhanced instream flows; however, this runoff may carry aircraft deicing fluid, which has the potential to exert an oxygen demand when the aircraft deicing fluid biodegrades. To minimize human-induced conditions, DIA has satisfied regulatory requirements for implementation of all best practical, available, and economically achievable technology for the control of aircraft deicing fluid. Denver considers the establishment of DIA in this watershed as an irreversible condition because the airport is a permanent part of the landscape and is an important part of the state economy. Deicing will continue to be a requirement for ensuring the safety of air travel.

Denver also conducted a Receiving Water Study to evaluate the aquatic communities of Second Creek, Third Creek, and Box Elder Creek. The study demonstrated that ambient-quality-based DO standards will protect instream classified uses (Denver 2004).

Exhibit 3.3 **Denver Receiving Water Descriptions and Classifications** (CWQCD 2003)			
Receiving Water	**Basin & Segment**	**Designated Use[1]**	**Classification**
Box Elder Creek	Middle South Platte River, Segment 5	UP	Aquatic Life Warm 2, Rec. 1a, Agriculture
Bear Creek	Bear Creek, Segment 2	UP	Aquatic Life Warm 1, Rec. 1a, Water Supply, Agriculture
Grasmere Lake	Upper South Platte River, Segment 17a	UP	Aquatic Life Warm 1, Rec. 1a, Agriculture
Lakewood Gulch	Upper South Platte River, Segment 16	UP	Aquatic Life Warm 2, Rec. 1a, Agriculture
Sloan's Lake	Upper South Platte River, Segment 17b	n/a	Aquatic Life Warm 1, Rec. 1a, Agriculture
Cherry Creek	Cherry Creek, Segment 3	UP	Aquatic Life Warm 2, Rec. 1a, Water Supply, Agriculture
City Park Lake	Upper South Platte River, Segment 17a	UP	Aquatic Life Warm 1, Rec. 1a, Agriculture
Sand Creek	Upper South Platte River, Segment 16a	n/a	Aquatic Life Warm 2, Rec. 1a, Agriculture
Rocky Mtn. Lake	Upper South Platte River, Segment 17a	UP	Aquatic Life Warm 1, Rec. 1a, Agriculture
Berkeley Lake	Upper South Platte River, Segment 17a	UP	Aquatic Life Warm 1, Rec. 1a, Agriculture
Clear Creek	Clear Creek, Segment 15	UP	Aquatic Life Warm 1, Rec. 1a, Water Supply, Agriculture
First Creek	Upper South Platte River, Segment 16c	UP	Aquatic Life Warm 2, Rec. 1a, Agriculture
Second Creek	Upper South Platte River, Segment 16d	UP	Aquatic Life Warm 2, Rec. 1a, Agriculture
Third Creek	Upper South Platte River, Segment 16e	UP	Aquatic Life Warm 2, Rec. 1a, Agriculture
Bowles Lake	Upper South Platte River, Segment 17c	n/a	Aquatic Life Warm 1, Rec. 1a, Agriculture
Smith Lake	Upper South Platte River, Segment 17a	n/a	Aquatic Life Warm 1, Rec. 1a, Agriculture
South Platte River	Upper South Platte River, Segment 14	n/a	Aquatic Life Warm 1, Rec. 1a, Water Supply, Agriculture
South Platte River[2]	Upper South Platte River, Segment 15	UP	Aquatic Life Warm 2, Rec. 1a, Water Supply, Agriculture

Exhibit Notes: [1] UP = use protected, n/a = not applicable; [2] Segment 15 of the South Platte River is immediately downstream of Denver's boundary, but is relevant to Denver from a regional water quality planning perspective.

TOTAL MAXIMUM DAILY LOADS (TMDLs)

Although numeric discharge limits are not generally required under stormwater discharge permits, stormwater and nonpoint source discharges can be affected by numeric stream standards when streams do not attain their designated uses. Specifically, the federal Clean Water Act provides for the total maximum daily load (TMDL) process to allocate pollutant loads or potential pollutant loads among all identified discharge sources so that the combined discharges do not cause the water quality standards for a given waterbody to be exceeded under existing and future conditions (DRCOG 1998). A simplified formula for the components of a TMDL is represented as follows:

TMDL = WLA + LA + NBG + MOS

where:

- WLA = wasteload allocation representing the portion of loading capacity attributed to point sources and piped stormwater (permitted wet weather stormwater runoff and dry weather flows)
- LA = load allocation representing the portion of loading capacity attributed to nonpoint sources
- NBG = natural background representing the portion of loading capacity attributed to natural background conditions (generally a component of the LA)
- MOS = margin of safety portion of loading capacity attributed to uncertainty

It is important to note that the *Clean Water Plan* (DRCOG 1998) differentiates between wet weather and dry weather conditions as follows:

TMDL (dry weather) =

WLA (piped dry weather runoff & point sources) + NBG (low flow) + Margin of Safety (MOS)

TMDL (wet weather) =

WLA (unit area stormwater & point sources) + LA (unit area) + NBG (high flow) + MOS

Given that TMDLs are driven by the 303(d) list, it is critical that water quality planning in Denver take into consideration known stream segments that do not attain stream standards. The CWQCD's draft 303(d) list for 2004, which was released in November 2003, identified several stream segments receiving stormwater discharges from Denver that do not attain stream standards, as summarized in Exhibit 3.4. The segment listings in this table are generally consistent with similar information contained in Denver's current stormwater permit.

Exhibit 3.4 CWQCD Preliminary 303(d) List for 2004			
ID	**Segment Description**	**Portion**	**Parameters**
COSPCL15	Clear Creek, Youngfield St. to S. Platte River	All	fecal coliform
COSPUS14	S. Platte River, Bowles Ave. to Burlington Ditch	All	Nitrate, fecal coliform, E. coli
COSPUS15[1]	S. Platte River, Burlington Ditch to Big Dry Creek	Cadmium upstream of MWRD, E. coli from Clear Creek to Fulton Canal diversion and Burlington canal headgate to MWRD	Cadmium[2], E. coli
COSPUS16a	Tributaries to S. Platte River, Chatfield Reservoir to Big Dry Creek	Lower portion of Sand Creek	Selenium, fecal coliform, E. coli
COSPUS16c	Tributaries to S. Platte River, Chatfield Reservoir to Big Dry Creek except specific listings	East Tollgate Creek, West Tollgate Creek, Tollgate Creek[3]	Selenium
COSPUS17a	Washington Park Lakes, City Park Lake, Rocky Mountain Lake, Berkeley Lake	Berkeley Lake	Arsenic

Exhibit Notes:

[1] Segment 15 of the South Platte River is immediately downstream of Denver's boundary, but is relevant to Denver from a regional water quality planning perspective. Segment 15 also receives treated municipal wastewater discharges from the Metro Wastewater Reclamation District (MWRD), which serves much of Denver.

[2] The cadmium listing is associated with the ASARCO plant.

[3] None of the specific stream segment portions listed for COSPUS16c receive runoff from Denver.

During wet weather periods, stormwater and nonpoint source discharges are expected to be the leading contributors of elevated bacteria (i.e., fecal coliform, *e. coli*) in these stream segments, which are all required to meet the stringent Recreation Class 1a standards. Leading sources of bacteria are expected to include pet waste, waterfowl, and wildlife. Most of these sources are difficult, if not impossible, to control and will be a challenge for Denver to address. Denver's efforts to develop a better understanding of the bacteria sources include an outfall investigation study in the Upper Central Platte Valley of the South Platte River. The Wastewater Management Division accelerated its broken tap and illicit connection program to upgrade sewer conditions in this area. Additionally, the Wastewater Management Division supported a study based on an antibiotic resistance analysis for fecal coliform to try to better define the sources of the bacteria (e.g., animal or human sources) (Baus 2004). Unfortunately, the results of this study were relatively inconclusive; however, additional opportunities exist to support ongoing bacterial source tracking studies being conducted by the Colorado School of Mines (Munakata-Marr 2004).

Metals listed in Exhibit 3.4 may be associated with wastewater treatment plant discharges, stormwater, and/or naturally elevated conditions. Nitrate concentrations in Exhibit 3.4 are primarily associated with municipal wastewater treatment plant discharges. The draft TMDL for nitrate on Segment 14 of the South Platte River states, "Stormwater runoff from nonpoint sources does not contribute significantly to the nitrate impairment" (South Platte CURE 2003).

In Denver's stormwater permit, the CWQCD (2003) states that a TMDL for the parameters listed in Exhibit 3.4 will be developed at some point in the future and that this could have an impact on future permit requirements. The CWQCD (2003) further notes in the permit that for the parameters potentially related to stormwater discharges, development of the TMDLs is expected to include the effects of precipitation-related events. The TMDL development may indicate that discharges from Denver's MS4 have a reasonable potential to cause exceedances of the applicable stream standards and provide a loading allocation that includes stormwater discharges. If this is the case, the CWQCD states that the permit could be amended to include additional requirements for the discharges to the TMDL segments. Such requirements would likely be based on BMPs as opposed to numeric limits (CWQCD 2003). Looking to the future, however, it is important to consider the possibility that federal and state agencies could regulate urban stormwater discharges on the basis of numeric standards, rather than the current BMP-based approach.

With regard to addressing stream segments requiring TMDLs, it is important to recognize Denver's participation in the South Platte Cooperative for Urban River Evaluation (South Platte CURE) (as discussed later in this chapter). The members of South Platte CURE cooperatively share in-stream monitoring data, conduct modeling, and work toward cooperative development of TMDLs on stream segments requiring them, as is the case of Segment 14 of the South Platte for nitrate.

Although Barr Lake (COSPMS03) and Milton Reservoir (COSPMS03) are not listed as receiving streams in Denver's permit, it is important to note that these two lakes are listed on the 303(d) list for non-attainment of the pH standard. During 2003, the CWQCD provided a 319 grant to assemble data on conditions in these reservoirs, which could eventually lead to a TMDL on these waterbodies. In the 319 grant application, Denver was identified as contributing over 75 percent of the drainage to these reservoirs; therefore, water quality issues in these waterbodies may also be relevant to Denver from a planning perspective. Denver is listed as a stakeholder in the Barr Lake/Milton Reservoir group.

REGIONAL EFFORTS AND AGREEMENTS

Denver participates in several regional efforts related to water quality planning and improvement efforts. Key efforts discussed in this section that are vital to future water quality planning in Denver include:

- Denver Regional Council of Governments (DRCOG)/*Clean Water Plan*
- Joint Stormwater Task Force (Denver, Aurora, Lakewood and UDFCD)
- South Platte Cooperative for Urban River Evaluation (South Platte CURE)
- Cherry Creek Stewardship Partners
- Barr Lake/Milton Reservoir Watershed Association
- Selenium Stakeholders Group

Denver Regional Council of Governments/Clean Water Plan

Denver participates in the Denver Regional Council of Governments (DRCOG), which is responsible under state and federal statutes for regional water quality planning in the Denver area. In this capacity, DRCOG prepares and updates the *Clean Water Plan*, which is the management plan for achieving water quality standards pursuant to Sections 208, 303(e), and 305(b) of the federal Clean Water Act. In keeping with this Act, the region's goal is to "restore and maintain the chemical and physical integrity, in order to assure a balanced ecological community, in waters associated with the region." The objectives, policies and guidelines used in water quality planning and wastewater management, as described in the *Clean Water Plan*, are intended to steer the regional water quality planning process. The *Clean Water Plan* describes wastewater management strategies, watershed water quality programs, wasteload allocations, stream standards, priority regional projects, nonpoint source control strategies and stormwater management programs. The plan provides a regional context for protecting and maintaining water quality through integrated watershed management processes. The objectives, policies and guidelines used in water quality planning and wastewater management are described in the plan. Denver is part of the "South Platte Urban Watershed," which is recognized in the *Clean Water Plan*.

Exhibit 3.5

Clear Choices for Clean Water Brochure

Joint Stormwater Task Force

Denver, Aurora, Lakewood and UDFCD work together as the Joint Stormwater Task Force to implement a variety of stormwater-permit-related requirements such as public education and stormwater monitoring. The original purpose of this group was to submit a joint Phase I stormwater permit application in 1992; however, the group has continued to work together to implement requirements of the Phase I permit through collaboration on a variety of projects. For example, the group prepared the "Clear Choices for Clean Water" brochures to educate the public on stormwater pollution prevention and continues to coordinate the wet weather monitoring program under the Phase I permits. Most recently, the group has developed an educational booklet targeting industrial stormwater BMP maintenance and management (Doerfer 2004).

South Platte Cooperative for Urban River Evaluation (CURE)

The South Platte Cooperative for Urban River Evaluation (CURE) was formed in 1999 for a variety of purposes related to water quality on the South Platte River and its tributaries in the metro Denver area. South Platte CURE is a non-profit Colorado corporation primarily made up of municipal entities (i.e., municipal wastewater treatment providers, municipal stormwater agencies, local health departments, and municipal drinking water providers). Specific stream segments addressed by South Platte CURE include Segments 6, 14 and 15 of the South Platte River; Cherry Creek below Cherry Creek Reservoir; Bear Creek below Bear Creek Reservoir; Clear Creek below the ditch diversions near Golden; and Sand Creek. Denver is a financially supporting member of South Platte CURE. A few representative purposes of South Platte CURE include:

- Coordinate water quality monitoring and data sharing at permanent trend monitoring locations and for special studies. Exhibit 3.6 identifies these monitoring locations.

- Maintain, improve and operate low-flow point source and nonpoint source water quality models for use in water quality decisions related to discharge permits.

- Cooperatively develop recommendations for TMDLs and wasteload allocations.

Some specific South Platte CURE activities of particular relevance to Denver include:

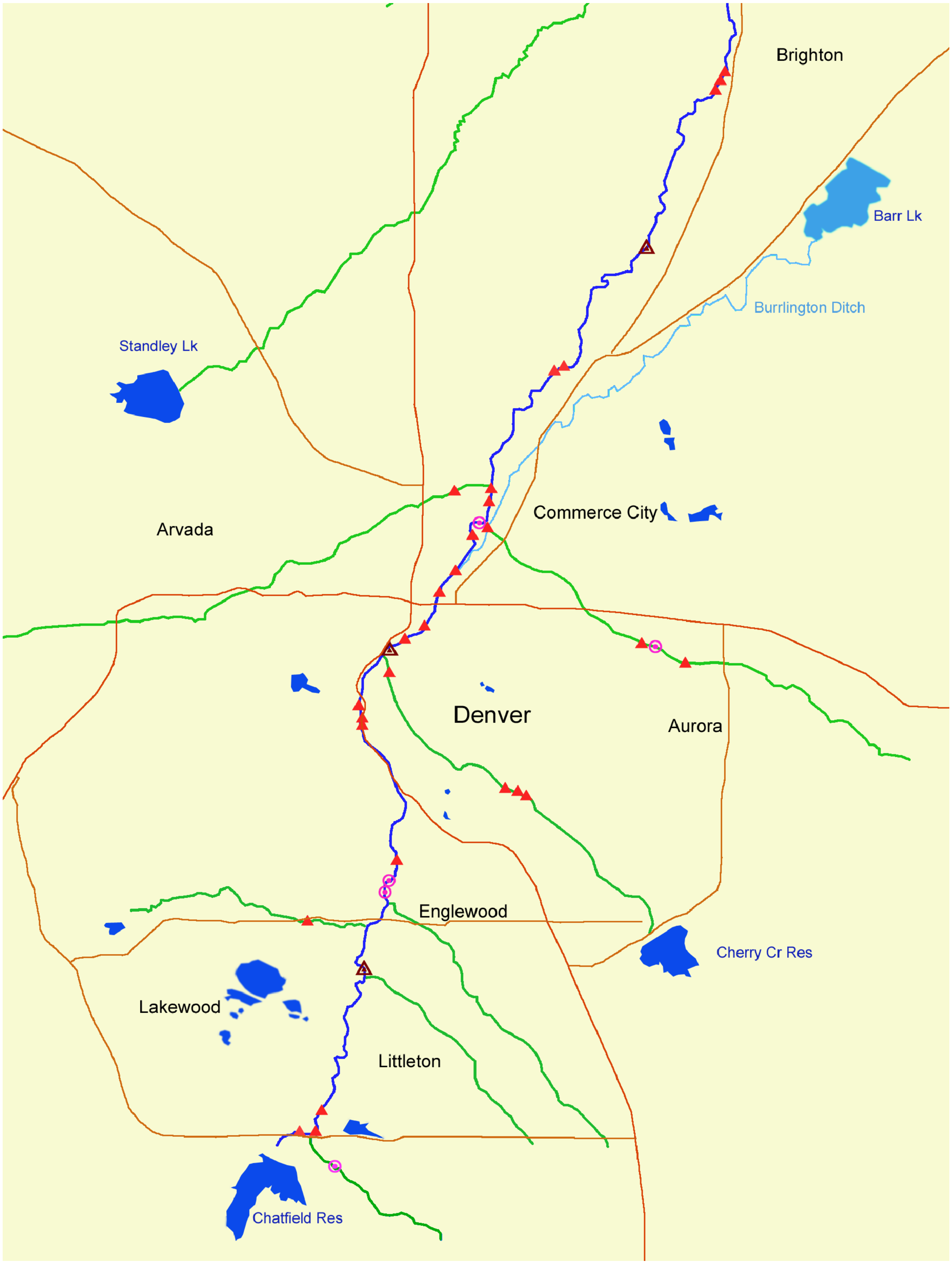
- A proposed 309 pilot project study that would recalculate the use-specific Table Value Standards (i.e., stream standards) based on the proposed changes to aquatic life use classifications.

- Cooperative modeling and development of a nitrate TMDL for Segment 14 of the South Platte River. (Segment 14 includes the portion of the South Platte River from Bowles Avenue in Littleton to the Burlington Ditch.)

- A copper study to evaluate the potential of a site-specific standard for copper on Segment 15 of the South Platte River, which is on the “Monitoring and Evaluation” portion of the 303(d) list. (Segment 15 includes the portion of the South Platte River from Burlington Ditch to below the confluence with Big Dry Creek.) The study is using a variety of techniques to assess the toxicity of copper in the stream to determine the potential appropriateness of a site-specific stream standard for copper for Segment 15 of the South Platte River. Stormwater has been discussed as the major source of copper affecting attainment of stream standards. In the July 2004 Triennial Review for the South Platte River, South Platte CURE formally proposed site-specific standards for copper as a result of this study (South Platte CURE 2004).

- Ongoing studies and modeling related to sulfate and dissolved oxygen (DO) on the South Platte River.
- Standardizing and uploading instream data for relevant stream segments into STORET (EPA's water quality database) for public retrieval.
- Cooperative monitoring of South Platte River Segments 6, 14, and 15 as part of TMDL development. Monitoring includes nutrients, microbiology, and selected metals.

EXHIBIT 3.6 SOUTH PLATTE CURE MONITORING LOCATIONS
(Map Source: South Platte CURE 2004)



Cherry Creek Stewardship Partners

Denver is a signatory to the Cherry Creek Watershed Water Quality and Resource Stewardship Regional Memorandum of Understanding (MOU), along with Arapahoe County, Douglas County, the City of Glendale, the City of Greenwood Village, the Town of Parker, and the City of Centennial. This MOU evolved from the "Smart Growth for Clean Water—Cherry Creek Watershed Partnership" project. The purpose of the Smart Growth project was to "promote the establishment of a continuous natural greenway and innovative watershed enhancements to protect the water quality and the public enjoyment of Cherry Creek, its tributaries, and the Lake." The overall goals of the Partnership are "to promote the long-term improvement of water quality in the Cherry Creek Basin through land conservation and innovative streamside and watershed enhancements; to promote regional cooperation on these issues; to enhance coordination among land use and water quality leaders; and to pursue funding strategies for these activities."

Several specific goals in the MOU that are particularly relevant to this Plan include the following:

- Support smart growth practices to mitigate development-induced water quality impacts.
- Provide buffers to development.
- Provide recommendations on urban design to protect Cherry Creek as a natural amenity.
- Support regional approaches to water quality improvement in the Cherry Creek basin, throughout Douglas and Arapahoe Counties, and in Denver.

Barr Lake/Milton Reservoir Watershed Association

Denver is an active participant in the Barr Lake/Milton Reservoir Watershed Association, which includes stakeholders assembled to evaluate water quality in Barr Lake and Milton Reservoir, including upstream impacts from the Denver metropolitan area. The stakeholders group includes representatives from permitted wastewater dischargers, recreation and aquatic interests, agriculture, industry, water utilities, and local governments. The watershed study area includes a system of canals and streams draining to Barr Lake and Milton Reservoir, located northeast of Denver. Barr Lake is about 15 miles northeast of Denver, and Milton Reservoir is about 20 miles further to the northeast.

Since Denver discharges both stormwater and wastewater into the basin, Denver is providing support in establishing a watershed association and participating in the 319 project to develop a better understanding of water quality issues in the basin. Part of this project includes development of a comprehensive water quality database.

Selenium Stakeholders Group

The Selenium Stakeholders Group consists of the City of Aurora, Conoco, Inc. (now Suncor Energy), Ultramar Diamond Shamrock (now Valero Energy), and Metro Wastewater

Reclamation District. This group is studying the elevated selenium concentrations on Sand Creek (Segment 16a) and the South Platte River (Segment 15). As a result of a stipulation for a temporary modification to the selenium standard on these segments, the Stakeholder Group has developed and is implementing a study plan to develop site-specific criteria for selenium based on data collection and exploration of other options (Lord-Reeves 2003). After three years of data collection, the data collected have not given a clear indication of the sources of selenium within the City of Aurora; therefore, the City of Aurora has undertaken additional studies such as geologic evaluations to explore the potential existence of selenium-bearing rock units within the Tollgate Creek basin (Piatt-Kemper 2003). Both the CWQCD and the parties involved in the Selenium Stakeholders Group recognize that selenium is a statewide issue and agencies within the state are looking at a more statewide solution to the selenium standard issue. The efforts of this group should continue to be monitored for those stream segments receiving runoff from Denver, particularly those that do not currently meet the selenium stream standards. The selenium issue on Sand Creek also highlights the importance of working with neighbors such as Aurora to address these multi-jurisdictional problems.

At the July 2004 Triennial Review, the CWQCD proposed a temporary modification for the chronic dissolved selenium standard on Sand Creek of 19.3 μg/L. This temporary modification was also proposed for East and West Tollgate Creeks and Tollgate Creek through February 2010 (CWQCD 2004).

OTHER FEDERAL AND STATE REGULATIONS

In addition to the specific regulations, permits and efforts already discussed, a wide variety of federal and state environmental regulations have the potential to affect water quality management in the Denver area. An exhaustive review of these regulations is beyond the scope of this Plan; however, a brief bullet list of some laws, regulations, and issues that may be potentially relevant includes:

- National Environmental Protection Act (e.g., for federally funded transportation projects)
- Groundwater Management Regulations (e.g., dewatering, discharges to groundwater)
- Resource Conservation and Recovery Act
- Individual Sewage Disposal Systems (ISDS) Regulations
- Safe Drinking Water Act/Source Water Protection
- Threatened and Endangered Species Act
- Wetlands (i.e., sections 401 and 404 of the 1987 Clean Water Act amendments)
- 401 Certification
- Colorado water law (e.g., affects length of time stormwater may be detained)

Additionally, those managing stormwater planning should be particularly aware of the following common environmental issues and/or permit requirements:

- Hazardous Materials and Phase 1 Site Assessments: Many old industrial areas occur in Denver; some of those areas have had releases of hazardous materials or contain hazardous substances. Several Superfund sites exist (such as the ASARCO Globeville Smelter and Koppers facility) in and around the Denver area. In these areas, a Phase I

Environmental Site Assessment should be conducted in accordance with ASTM Standard E 1527-00 and new federal standards expected to be circulated by the EPA in late 2004 or early 2005 to identify potential environmental risks and liabilities to the project and construction worker health and safety. This site assessment should consist of a site inspection, records review, and report.

- Spill Reporting at Construction Sites: Contain and clean up spills such as, but not limited to, wash water, paint, automotive fluids, fuel or other petroleum based products, solvents, oils, or soaps, as soon as possible. Do not bury or wash spills into the storm drain or stream. Report all releases of materials into the environment to the Colorado Department of Public Health and Environment (CDPHE) 24-hour Environmental Emergency Spill Reporting Line (877-518-5608).

- Section 404 Permit: Section 404 of the Clean Water Act is administered by the U.S. Army Corps of Engineers (USACE) and regulates filling Waters of the U.S. Section 404 permits from the USACE are required for the placement of dredged or fill materials into waters of the U.S., including wetlands. Dredged or fill material includes any solid material commonly used in construction such as, but not limited to, soil, concrete, metal structures, rock, and pipe. There are various types of Section 404 Permits, including Nationwide Permits, which are issued for activities with relatively minor impacts. An Individual Permit is issued for more major impacts such the relocating of a stream or creek segment, or filling over 0.5 acre of a jurisdictional wetlands. For information about what type of 404 permit may be required, contact the USACE Denver Regulatory office (303-979-4120).

- Threatened and Endangered Species: In the Denver area, wetlands are potential habitat to three federally listed threatened and endangered species, which are protected under the Endangered Species Act. Before the USACE issues a Section 404 Permit, it requires the proposed project have clearance for: 1) Ute Ladies' tresses orchid (Spiranthes diluvialis), 2) Colorado butterfly plant (Gaura neomexicana ssp. coloradensis), and 3) Preble's meadow jumping mouse (Zapus hudsonius preblei). A habitat suitability assessment is sufficient to determine if habitat for these species occurs in the proposed project area. If habitat for any of these species, or any other federally listed species (there are over 30 in Colorado), is suspected of occurring in a project area, a trapping or flowering period survey should be conducted to confirm absence or presence.

- Section 401 Permit: If an Individual Permit is needed from the USACE, a Section 401 Water Quality Certification, issued by the CDPHE Water Quality Control Division (CWQCD), is required for a proposed project to fulfill regulatory requirements of Section 401 of the Clean Water Act. Specific requirements of this permit application and permit may be obtained from the CWQCD (303-692-3500 or http://www.cdphe.state.co.us/wq/PermitsUnit/wqcdpmt.html).

- Construction Stormwater Permit: Discharges of stormwater runoff from construction sites disturbing one acre or more of land and certain types of industrial facilities require a Colorado Discharge Permit System Stormwater Permit. The Stormwater Permit application needs to include a Stormwater Management Plan (SWMP), which details erosion and runoff control measures, such as, but not limited to, a revegetation plan and silt fencing, to prevent surface stormwater quality degradation. Current BMPs are to be presented in the SWMP. Specific requirements of the permit application and permit may be obtained from the CWQCD (same contact information as above).

- Construction Dewatering (Discharge or Infiltration) Permit: Discharges of water encountered during excavation or work in wet areas may require a discharge permit. If the water is discharged to waters of the state, a Construction Dewatering Discharge Permit is required. If the water is discharged to land and allowed to infiltrate, approval from the CWQCD is required. Specific requirements of this permit application and permit may be obtained from the CWQCD (same contact information as above).

- Minimal Industrial Discharge Permit: Discharges of small quantities of wastewater or wastewater requiring minimal treatment, such as that resulting from hydrostatic testing or certain wash waters, may require a Minimal Industrial Discharge Permit (MINDI). Specific requirements of this permit application and permit may be obtained from the CWQCD (same contact information as above).

CURRENT AND FUTURE COMPLIANCE IMPLICATIONS OF EVOLVING REGULATIONS

Water quality regulations continue to evolve at both the state and federal levels. Changes to these regulations have the potential to impact water quality management in Denver for both point and nonpoint source discharges. Although stormwater and nonpoint source discharges continue to be based on BMPs instead of numeric criteria, these discharges can be drawn into the regulatory process through TMDLs when stream standards are not attained; therefore, regulatory changes that impact stream standards and classifications have significant relevance for stormwater discharges. Several key regulatory changes that are in progress can be reviewed through the *Section 309 Report* (CWQCD 2003) and through the activities of the Colorado Water Quality Forum (CWQF) work groups that explore topics such as impacted water supplies, nutrient criteria, sediment guidance, TMDL/303(d) issues, and water quality trading concepts. The CWQF work group activities are often driven by changes at the EPA under its Clean Water Act programs. (See http://www.is.ch2m.com/cwqf/ for a list of current CWQF work groups and topics.) Highlights of several emerging regulations are provided below based on the efforts of the CWQF work groups.

Section 309 Report and Potential Aquatic Life Classification Changes

In December 2003, the CWQCD released the *Section 309 Report*, which focused on review of the state standards-setting and classification process. This document provides a basic "road map" of water-quality-related regulatory issues that the state may consider over the next few years. The purpose of the *Section 309 Report* is to assess whether regulatory or policy changes are warranted based on the unique attributes of Colorado waterbodies. Some of the key considerations in the report were affected by the *Arid West Water Quality Research Project*

(Pima County Wastewater Management Department 2003). Some of the specific topics addressed in the *Section 309 Report* (CWQCD 2003) included:

- The physical, chemical, flow, and habitat characteristics associated with waterbodies, including the ephemeral or effluent-dependent nature of many waterbodies.
- The potential need for refined designated uses and additional site-specific standards.
- The benefit of maintaining the functions of constructed water conveyance and storage facilities.
- The nature of the current use-attainability analysis process and any necessary adjustments.
- The benefits associated with maintaining downstream ecosystems that are dependent, at least in part, upon the continuation of effluent discharges.

The study process identified a wide variety of distinguishing features of Colorado waterbodies, with particular focus upon natural and human-induced variations in the flow regimes, variabilities in habitat and biological diversity, and the impact of effluent returns on otherwise water-short stream systems.

One key area of discussion with potential relevance to Denver is the identification of potential "refined designated uses" under the state use classification system, primarily with regard to aquatic life classifications. Based on a "strawman" proposal presented by the state, the idea of adopting additional aquatic life use classifications to more accurately describe the actual use of stream systems and establish appropriate accompanying water quality standards is one key potential area of change. These types of revisions would be most significant for "effluent dependent" or "effluent dominated" waterbodies or those that have experienced significant hydrologic modifications. The key implication of such a revised classification system is the removal of needless "impairment" listings under the TMDL program.

Triennial reviews of Colorado's major river basins will serve as an opportunity to field-test a variety of aquatic life classification modifications and bring them before the Commission at the Basic Standards Rulemaking Hearing in July of 2010 (CWQCD 2003). Currently, the aquatic life classification system includes three categories: Aquatic Life Warm 1 and 2 and Aquatic Life Cold. The new proposed system includes nine principal use classifications that are developed from combining cold water aquatic life, transition zone aquatic life or warm water aquatic life with the categories of aquatic life for lakes/reservoirs, streams with fish, or streams with no fish. In addition to the principal use classifications, several sub-classifications could also be assigned to account for influences from treated effluent or hydrologic/habitat modifications, including considerations such as:

- Effluent dependent: Waters that would otherwise have an "Aquatic Life-Streams—No Fish" classification, but which have flows adequate to support fish due to treated effluent.

- Effluent dominated: Waters that would have an "Aquatic Life-Streams-Fish" classification without the presence of treated effluent, but for which the flow for the majority of the year consists of treated effluent.
- Hydrologic/Habitat Modifications: Waters that are affected by irreversible human impacts (e.g., water rights diversions, stormwater flows, and agricultural return flows) such that the resulting expected condition differs from that for the associated principal use classification. (The Hydrologic/Habitat Modification sub-classification would only apply when supporting data demonstrates that the modifications are significant enough to change the expected condition.)

The new proposed system embodies the concept of defining an "expected condition" for each of the nine principal use classifications. Expected conditions would not be based on the pristine or totally un-impacted reference condition, but rather on the characteristics of the aquatic community that "…generally would be anticipated without the influence of major human modifications."

Other concepts explored under the *Section 309 Report* include the "net environmental benefit" concept, which is basically a potential relaxation of standards/effluent limitations on point sources discharging to "water-short" stream systems in order to encourage the continued "beneficial" discharge of the ecosystem-sustaining flows (CWQCD 2003).

Although the *Section 309 Report* itself did not result in any recommended changes to state statutes, the concepts and issues raised could impact future policies, potentially as early as the Basic Standards Rulemaking Hearing in July of 2005. The CWQCD will continue its work with stakeholders to develop a state policy on the potential use of the net environmental benefit concept by October of 2004, which could also be brought before the CWQCC in July of 2005. The CWQCD will also initiate a pilot program to explore refined designated aquatic life use categories.

Possible Stream Standard Changes Under Consideration for July 2005

A variety of issues will be considered at the July 2005 Rulemaking Hearing, in addition to the aquatic life issues discussed above. Some of these issues have implications for stormwater. A brief overview includes changes to organic chemical standards (will be addressed in 2004 in combination with Regulation 41, Basic Standards for Groundwater); revised table value criteria for ammonia, cadmium, copper, antimony, arsenic and uranium; selenium criteria (when developed by EPA); options for decoupling the aquatic life class 2 and use-protected designations; and other issues (CWQF 2003).

Source Water Protection

Source water (i.e., drinking water supply source) protection activities have a link to stormwater issues in that raw water quality for drinking water may be affected by pollutants in stormwater discharges. Sediment, nutrients, pesticides, pathogens, and other pollutants in source waters can decrease treatability, increase treatment costs, and ultimately increase risks to public health.

Water utilities typically respond to deteriorating raw water quality by increasing chemical dosages or adding additional processes. As an alternative or supplement to treatment changes, managers may consider promoting BMPs to protect raw water quality.

A study funded by the American Water Works Association Research Foundation and the Water Environment Research Foundation (AWWARF and WERF 2003) to address these issues found that moderate deteriorations in raw water quality such as a 25 percent increase in solids and total organic carbon (TOC) levels can increase routine operating costs by roughly 10 percent. Many BMPs can prevent water quality deterioration when targeted to major pollutant source areas. AWWARF and WERF note that funding a fraction of BMP implementation costs can be a cost-effective means of reducing routine operating costs for some utilities. AWWARF and WERF recommend that utilities in developing watersheds should promote low impact development practices to reduce long-term water quality degradation. The study recommended that utilities can help protect source quality and reduce treatment costs at minimal expense by forming partnerships with watershed stakeholders. Utility participation in protection efforts helps leverage funds and prioritizes the watershed as a drinking water catchment.

Due to the high cost of treatment plant capital improvements relative to watershed BMPs, AWWARF and WERF recommend that utilities should consider long-term investment in source protection measures in order to reduce the need for major process changes. Utilities should also consider non-economic benefits of source protection, including the public health benefit of reduced exposure to pesticides, pathogens, and emerging contaminants (AWWARF and WERF 2003).

Nutrient Criteria

In September 2002, the CWQCD presented its *Nutrient Criteria Development Plan* to EPA in response to EPA's January 9, 2001 Federal Register notice that was intended to address nutrient over-enrichment in the nation's surface waters. According to EPA (1996), nitrogen and phosphorus are among the leading causes of water quality impairment in the U.S., with 40 percent of rivers and 51 percent of lakes having designated uses impairments from excess nutrients.

EPA has called for states to develop region-specific nutrient criteria for different types of waterbodies to account for the wide natural variation in nutrient loading. For rivers and streams, the CWQCD anticipates developing a statewide approach with regionalization for establishing nutrient criteria. Key elements of the conceptual approach include:

- Assessments conducted at the basin or sub-basin level (it is anticipated that in some cases site-specific standards may need to be implemented where basin or sub-basin level assessments are not refined enough to account for local conditions).
- Criteria based on comparisons to "expected conditions."
- Criteria based on biological endpoints of the algal community that are linked to the designated uses.

Colorado is working on the nutrient criteria using a phased approach, which will first focus on developing nutrient standards for selected targeted waterbodies that have significant nutrient issues and that are high on the priority list. Nutrient criteria for Colorado lakes and rivers will be based on the causal parameters nitrogen and phosphorus, as well as the response parameters Chlorophyll-a, algal communities and transparency (Secchi depth or turbidity). Other possibilities for causal parameters that will be considered include orthophosphate, total Kjeldahl nitrogen, ammonia, nitrate, and dissolved organic carbon (DOC). Additional response parameters such as dissolved oxygen, pH, plankton or macrophyte biomass, percent cover, and species composition may also be considered. Considerations in the form of the criteria may include spatial scale, temporal cycles such as diel or seasonal cycles, and determination of attainment. Colorado anticipates developing numeric criteria (CWQCD 2002).

Of particular relevance to Denver is that the CWQCD is starting with "High Priority Sites" first, one of which is Barr Lake. Barr Lake is located outside of Denver's boundaries, but it eventually receives runoff from much of the metro Denver area and was named as a receiving water in Denver's initial CDPS permit. Although Barr Lake is not a direct receiving water for Denver stormwater, EPA has provided the states with the following regulations in CFR Part 131.10(b):

> *"... in designating uses of a waterbody and the appropriate criteria for those uses, the State shall take into consideration the water quality standards of downstream waters and shall ensure that its water quality standards provide for the attainment and maintenance of the water quality standards of downstream waters."*

EPA (Grubbs 2001) provides additional guidance stating:

> *"...even if a state identifies waters that are not threatened or impaired from nutrient overenrichment, they should also consider whether the nutrient levels in this waterbody could contribute to an impairment downstream before determining that nutrient criteria are not needed. If it is likely that a downstream impairment is occurring, yet quantified criteria in downstream waters have not been established, then a state/tribe should consider employing nutrient load reduction strategies for the upstream waters. EPA recommends that these nutrient load reduction strategies are effective ways of reducing the effects on downstream uses, prior to adopting any specific nutrient criteria values."*

Colorado's timeline with regard to nutrient criteria includes developing interim measures by December 2004 that will provide nutrient triggers and screening-level measures such as add-on narratives to the Basic Standards and site-specific standards through the 303(d) listing process. Current timelines identify the 2010 Basic Standards Rulemaking Hearing as the target date for adopting nutrient criteria into the state standards (CWQCD 2002).

Sediment Deposition

In May 2002, the CWQCD, CWCC, and the Colorado Sediment Task Force released the "Provisional Implementation Guidance for Determining Sediment Deposition Impacts to Aquatic Life in Streams and Rivers," building upon draft guidance originally issued in 1998. This guidance provides an interpretation of the CWQCC's "narrative standards" as they apply to sediments which may form deposits detrimental to the attainment of aquatic life uses, as described in the Basic Standards and Methodologies for Surface Water, Regulation 31 (5CCR 1002-31). The guidance is intended as a first step toward providing a consistent approach to implementation of the statewide narrative basic standard that addresses sediment deposition, which is an important cause of impacts to aquatic life. The guidance applies to "substances, primarily sediment caused by human induced erosion, which create a stress to aquatic life through the deposition of materials." The guidance provides a means for the CWQCD and the CWQCC to consider the impacts of bottom deposits on the attainment of the aquatic life uses, particularly with regard to assessing the status of water quality as required in §305(b) of the federal Clean Water Act, and establishing a listing of waterbodies requiring TMDLs under §303(d) of the Act (CWQCC et al. 2002). Because stormwater can be a leading contributor of sediments to streams, Denver should actively participate in activities that involve development of guidance and regulations related to the sediment narrative standard.

Pollutant Trading

Pollutant trading is a concept being explored by the CWQF and the CWQCD. The concept is also defined by EPA (2003) in its "Water Quality Trading Policy." Various pollutant-trading programs in Colorado have focused primarily on lakes and reservoirs such as phosphorus trading programs in Lake Dillon and Cherry Creek Reservoir and a relatively young selenium-trading program in the Grand Valley. The CWQCD is in the process of developing the state "Water Quality Trading Guidance" document that includes topics such as pre- and post-TMDL trading. Progress on this document has potential relevance to Denver's stormwater discharges for streams with TMDLs.

SUMMARY

As is the case with cities throughout the U.S., Denver is faced with complex regulatory requirements with regard to water quality. The Phase I CDPS permit specifies stringent requirements with which Denver must comply or face significant penalties. Fortunately, Denver already has many sound water quality requirements in place in the form of policies and regulations. It will be imperative for Denver to continue to actively interface with regional water quality efforts and to stay abreast of forthcoming regulatory changes.

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Chapter 4
RELATIONSHIP TO OTHER DOCUMENTS

Denver has completed multiple documents that provide important interfaces with water quality planning. Some of the key documents, which were completed either by Denver or related entities, are briefly summarized in this chapter, including:

- *Urban Storm Drainage Criteria Manual, Volumes 1-3*
- *Denver Storm Drainage Design and Technical Criteria Manual*
- *Denver Storm Drainage Master Plan and other drainage master plans*
- *Standards, details and technical criteria documents*
- *Metro Vision 2020 and the Clean Water Plan*
- *Water Quality Improvement in the South Platte River, Report to the Mayor*
- *Denver Comprehensive Plan 2000*
- *Blueprint Denver*
- *Denver Parks and Recreation Game Plan*
- *Natural Areas Program Field Guide*
- *Design Guidelines for Stapleton Water Quality*
- *Long Range Management Framework South Platte River Corridor*
- *Cherry Creek Greenway Corridor Master Plan*
- *Cherry Creek Watershed Smart Growth for Clean Water Report*
- *Lake Management and Protection Plan*

Basic familiarity with these documents is important to this Plan for several reasons. The first four documents listed identify already-established, accepted criteria and strategies for managing stormwater in the Denver area. This Plan does not reinvent the wheel with regard to these documents, rather it builds upon them. Documents such as the *Denver Comprehensive Plan 2000*, *Blueprint Denver,* and the *Denver Parks and Recreation Game Plan* summarize some of the existing goals of various city departments with which this Plan must interface in order to be most effective. Documents such as *Metro Vision 2020*, the *Clean Water Plan*, the *Long Range Management Framework South Platte River Corridor*, the *Cherry Creek Greenway Corridor Master Plan, Cherry Creek Watershed Smart Growth for Clean Water,* and *Natural Areas Program Field Guide* are an important interface with regard to regional water quality goals and goals for specific river corridors. The *Lake Management and Protection Plan* is important because it provides the framework for maintenance and protection of Denver lakes. *Design Guidelines for Stapleton Water Quality* is included because this Plan builds upon many of the strategies developed and accepted in the Stapleton guidelines. Highlights of each of these documents follow.

URBAN STORM DRAINAGE CRITERIA MANUAL, VOLUMES 1-3

The Urban Drainage and Flood Control District (UDFCD) was established by the Colorado legislature for the purpose of assisting local governments in the Denver metropolitan area with multi-jurisdictional drainage and flood control problems. Since 1969, UDFCD has maintained and distributed the *Urban Storm Drainage Criteria Manual*, which consists of three volumes.

Volumes 1 and 2 (UDFCD 2001) provide guidance for planning and design of drainageway channels, storage facilities, culverts, hydraulic structures, and other structures. Volume 3 (UDFCD 1999) provides guidance for the selection and design of stormwater quality BMPs. The policies and design criteria set forth in these documents are the foundation of the stormwater BMP information provided in this Plan.

Since the primary focus of this Plan is stormwater quality management, the topics covered in Volume 3 are particularly salient and include:

- General principles of stormwater quality management
- Guidance for BMP planning for new development and redevelopment
- Structural BMP design criteria, details and forms to facilitate design
- BMP maintenance recommendations
- Recommended BMPs for industrial and commercial sites
- Nonstructural BMPs
- Construction-phase BMPs, including erosion and sediment control

The basic philosophy of stormwater quality management presented in Volume 3 is based on this four-step process:

1. Employ runoff reduction practices such as reducing paved area, providing grassed buffers and swales, and "minimizing directly connected impervious area" (MDCIA).

2. Provide treatment for the "water quality capture volume" (WQCV) through implementation of various BMPs that detain or infiltrate runoff.

3. Stabilize downstream drainageways.

4. Provide BMPs for specific industrial and commercial uses.

More detail on these practices and their applications in Denver is provided in Chapter 6 of this Plan.

DENVER STORM DRAINAGE DESIGN AND TECHNICAL CRITERIA MANUAL

In 1999, Denver updated the *City and County of Denver Storm Drainage Design and Technical Criteria Manual*. (Note: This Manual is being updated again in 2005.) This manual provides the minimum design and technical criteria for the analysis and design of storm drainage facilities. The criteria require that all subdivisions, re-subdivisions, planned unit developments, or any other regulated proposed development provide adequate storm drainage system analysis and appropriate drainage system design in accordance with the manual requirements, which are consistent with UDFCD's *Storm Drainage Criteria Manual*. Denver's manual provides drainage plan submittal requirements along with drainage policies and floodplain regulations of the city. The manual then provides engineering criteria for topics such as rainfall/design storms, runoff, open channel design, storm sewers, storm sewer inlets, streets, culverts, hydraulic structures, erosion control, detention and standard forms for use in design. The manual provides specific design standards for flood detention in open space, parking lots and underground facilities. The manual refers the user to the *Urban Storm Drainage Criteria Manual, Volume 3* (UDFCD 1999) for addressing water quality requirements.

DENVER STORM DRAINAGE MASTER PLAN AND OTHER DRAINAGE MASTER PLANS

In December 2003, Denver completed the first phase of a three-phase *Storm Drainage Master Plan* (Matrix 2003), which identifies capital improvements related to flood hazard reduction and improving drainage conveyance for 15 major drainage basins within Denver. The document will help Denver comply with its stormwater permit because it provides an inventory of stormwater systems and recommends regional capital improvements. The *Storm Drainage Master Plan* also integrates several different documents and programs into a comprehensive Public Works management program. Although the *Storm Drainage Master Plan* does not address stormwater quality issues, its comprehensive GIS mapping, database, hydrology and report provide a strong base of information useful to this Plan. In particular, a description of the drainage basins in the *Storm Drainage Master Plan* is provided in Chapter 2 along with opportunities for integration of regional stormwater quality facilities in Chapter 8.

Working with UDFCD, Denver has also completed multiple drainage master plans for specific drainage basins. These plans are important to water quality planning and should be referenced with regard to stormwater-related improvements in various drainage basins. As examples, three particularly relevant plans include:

- *Preliminary Design Report for the Upper Central Platte Valley South Platte River Restoration* (McLaughlin Water Engineers 1998). The plan covers a one-mile reach of the South Platte River directly west of downtown between 8th Avenue and I-25. The goals of this plan include: flood damage reduction, elimination of Zuni Power Plant dam, fish habitat improvements, recreation improvements, wildlife habitat and wetland improvements, and improved access.

- *Stormwater Outfall Systems Plan Stapleton Area* (McLaughlin Water Engineers 1995). This plan provides a comprehensive plan for development of a drainage outfall system to serve the Stapleton redevelopment area. Primary streams addressed include Sand Creek and Westerly Creek.

- *Major Drainageway Planning South Platte River, Chatfield Dam to Baseline Road, Phases A and B* (Wright Water Engineers 1984). This three-volume series covers a 40-mile reach of the South Platte River from the Chatfield Dam to the City of Brighton. The purpose of Phase A of the report was to develop alternatives to solve flooding problems, while maintaining a balance of different uses of the river such as water supply, recreation and open space, to name a few. Phase B of the report provided preliminary designs for engineering and flood-related aspects of the river and a master plan for recreation, landscaping, and wildlife along the corridor.

STANDARDS, DETAILS AND TECHNICAL CRITERIA DOCUMENTS

Denver has several existing documents that specify standards, details and other technical criteria that may be applicable to stormwater BMP and site designs and should be adhered to as appropriate. These documents include:

- *Storm Drainage and Sanitary Construction Detail and Technical Specifications* (City and County of Denver Department of Public Works Engineering Division 2003)
- *Standards and Details for City Engineering, Section I, Minor Projects* (City and County of Denver Department of Public Works Engineering Division 2002)
- *Standard Details* (City and County of Denver Department of Public Works Wastewater Management Division 1995)

METRO VISION 2020 AND THE CLEAN WATER PLAN

Metro Vision 2020 (DRCOG 1998) is the long-range growth strategy for the Denver region. (Note: *Metro Vision 2030* was being completed concurrently to development of this Plan and should be referenced for possible changes.) It examines both the current and preferred pattern of development to the year 2020. One of the six core values included in *Metro Vision 2020* is environmental quality. The plan acknowledges that the location and type of growth and land development have significant effects on air and water and that these issues are truly regional in nature. The *Clean Water Plan* was identified as the mechanism by which regional water quality issues should be addressed (DRCOG 1998).

The Denver Regional Council of Governments (DRCOG) is responsible under state and federal statutes for regional water quality planning in the Denver area. In this capacity, DRCOG prepares and updates the *Clean Water Plan*, which is the management plan for achieving water quality standards pursuant to Section 208 of the federal Clean Water Act. The most recent update to the *Clean Water Plan* is titled *Metro Vision 2020 Clean Water Plan Policies, Assessments and Management Programs* (DRCOG 1998). The document describes wastewater management strategies, watershed water quality programs, nonpoint source control strategies, stormwater management programs, wasteload allocations, stream standards and priority regional projects. The plan covers a 25-year planning process with additional wastewater treatment facility planning data for up to a 50-year horizon. The *Clean Water Plan* also provides a regional context for protecting and maintaining water quality through integrated watershed management processes (DRCOG 1998). The BMPs and other water quality measures proposed in this Plan should be consistent with the measures identified in the *Clean Water Plan*.

The *Clean Water Plan* states that the goal for the region is "to restore and maintain the chemical and physical integrity [of waterbodies] in order to assure a balanced ecological community in waters associated with the region." Five key objectives were adopted as part of *Metro Vision 2020* to support a proactive "bottom-up" planning process with regional coordination, including:

1. A locally defined balanced ecological community will be achieved through implementation of water quality protection and appropriate water resource management

initiatives, provided that a balance will be maintained between the natural environment and those designated uses of the resource.

2. The chemical and physical integrity of the region's aquatic environments will be restored and maintained through a coordinated watershed management process.

3. Effective wastewater treatment will be identified through a regional process, with local implementation of wastewater management strategies.

4. Effective and balanced stormwater and nonpoint source management will best be achieved through local implementation processes.

5. Effective and cost-efficient water quality management and supply will require an integrated resource management program.

One of the key strategies identified in the *Clean Water Plan* for water quality protection is watershed planning. The document recognizes eleven designated watersheds, three of which receive runoff from Denver, primarily the South Platte Urban and Cherry Creek watersheds, and, to a lesser extent, Box Elder Creek. The document provides a summary of water quality and regulatory information relevant to each of these watersheds that should be considered for future water quality planning in these areas.

WATER QUALITY IMPROVEMENT IN THE SOUTH PLATTE RIVER, REPORT TO THE MAYOR

Concurrent to the development this Plan, the Mayor's Office commissioned an evaluation of information regarding water quality in the South Platte River through Denver, which culminated in the report *Water Quality Improvement in the South Platte River, Report to the Mayor* (Bergstedt 2004). The findings of that report parallel and support the recommendations contained in this Plan. Bergstedt's report is provided in Appendix C of this Plan, with key recommendations paraphrased as follows:

1. Increased communication and streamlining of procedures between various departments with responsibilities affecting the South Platte River is needed.

2. Long-range regional initiatives and near-term program support with regard to stormwater inputs to the river are necessary to adequately protect water quality in the river.

3. Recommendations related to regional stormwater initiatives include:

    a. Promote a Denver-inspired regional watershed initiative, building on existing efforts (including this Plan).

    b. Enforce existing stormwater ordinances with regard to installation and maintenance of BMPs.

   c. Fund and empower the Natural Areas Program to help reduce contamination before it reaches the river.

4. To address sewerage infrastructure and contamination issues:

   a. Pursue additional storage in Chatfield Reservoir for additional base flow storage and timely water releases to promote dilution of sewer discharges, particularly during drought conditions.

   b. Continue to support water quality improvement efforts of wastewater treatment plants discharging to the river.

   c. Continue diligent monitoring, improvement and coordination efforts related to the sanitary sewer system, especially in northwest Denver.

DENVER COMPREHENSIVE PLAN 2000

Exhibit 4.1
Comprehensive Plan 2000

The *Denver Comprehensive Plan 2000: A Vision for Denver and Its People* provides a comprehensive framework for addressing long-term issues such as environmental sustainability, land use, mobility, Denver's legacies, housing, economic activity, neighborhoods, education, human services, arts/culture, and metropolitan cooperation. The *Denver Comprehensive Plan 2000* then outlines a long-term implementation strategy to achieve the goals identified for each of these issues. One of the primary goals with regard to Denver's long-term physical environment is environmental sustainability, specifically "preserving and enhancing the natural environment." The *Denver Comprehensive Plan 2000* states:

> *Denver's relationship with the environment is above all a matter of balance. Clean water, clean air, clean parks and streets, efficient use and reuse of resources, and protection of the mountain parks and open spaces must be abiding goals.*
>
> *Most basic to sustainable quality of life in Denver and the region are the land we live on, the air we breathe, the water we drink and the natural beauty we enjoy. The greatest challenge to the environment in the early 21st century is managing growth—slowing the loss of land, the consumption of resources, the congestion, and the human stress created by urban sprawl. At the same time, the public-policy challenge to develop and implement balanced and sustainable growth strategies addressing equity, stewardship and cooperation becomes more critical.*

As part of its "Vision of Success" for environmental sustainability, the following selected statements pertaining to water quality are provided:

- Water Quality: Water quality will improve, and waterways and groundwater will be cleaned up and "greened" up.

- Pollution Prevention: More residents and businesses will be directly involved in voluntary pollution prevention programs, reducing the need for government intervention.

- Natural and Wildlife Habitat: Denver's natural stream corridors and wetlands will be preserved and maintained for wildlife habitat.

Five specific objectives with supporting strategies are identified to achieve the goal of environmental sustainability. These objectives are listed below, along with some selected implementation strategies specifically relevant to water quality planning.

Objective 1: Burdens and Benefits—Distribute environmental burdens and benefits.

- Encourage redevelopment of vacant, underutilized and environmentally compromised land known as brownfields.

- Promote public-private sector involvement and cooperation with citizens to formulate plans and actions that achieve shared responsibilities and benefits.

- Continue to implement the environmental review function as a tool to address pollution prevention and improve environmental quality.

Objective 2: Stewardship of Resources—Ensure environmental stewardship of natural resources, taking into account the entire ecosystem, not just human needs. Preventing pollution will be the action of first choice in accomplishing this objective.

- Promote environmental sustainability within neighborhoods by educating and encouraging residents to adopt environmentally friendly ways of living, such as recycling, water conservation, use of renewable resources, and low-impact methods of transportation.

- Conserve water and improve water quality by…identifying opportunities for City agencies to use native flora in landscape designs.

- Conserve land by:

    - Promoting infill development within Denver at sites where services and infrastructure are already in place.

    - Designing mixed-use communities and reducing sprawl, so that residents can live, work and play within their own neighborhoods.

    - Adopting construction practices in new developments that minimize disturbance of the land.

  - Protecting natural corridors, wetlands and floodplains from the encroachment of development.

  - Encouraging the redevelopment of brownfields.

- Preserve and restore, wherever possible, natural habitat for wildlife and plants native to the region, such as those at the Rocky Mountain Arsenal National Wildlife Area, Bear Creek Park, Bear Valley Park, and the Cherry Creek corridor.

Objective 3: Environmental Policy—Develop environmental protection policies that take advantage of market forces and provide for regulatory flexibility while meeting the City's environmental objectives. Encourage policies and actions that consider environmental quality, economic prosperity, and social equity as complementary, not conflicting, goals.

- Establish specific measurable goals for the environment, formulate strategies to accomplish them, and create timelines for implementation.

- Encourage decision-making throughout Denver government that recognizes long-term impacts on the environment, such as making lifecycle cost analysis the basis for economic decisions.

- Adopt procedures and regulations that are appropriate to the nature and scale of problems and that reduce waste.

- Provide market-based incentives and tax incentives to encourage sustainable development.

- Encourage effective voluntary environmental management programs and activities that require less government intervention. The private sector has found pollution prevention to be profitable, and many businesses are voluntarily embracing opportunities to create a more sustainable environment.

Objective 4: The Environment and the Community—Achieve environmental sustainability in all aspects of planning, community and building design, and transportation. Encourage implementation of recommended strategies within neighborhoods, citywide, and throughout the metropolitan region.

- Respect, conserve and expand wildlife habitat, watersheds, open space and other natural resources when planning, designing and building new projects.

- Use neighborhood development, such as Stapleton, as projects that incorporate principles of sustainable development at the community level. Use these neighborhoods as models to encourage sustainable development throughout the city over time.

- Introduce natural ecosystem strategies into the maintenance of our public and private lands.

Objective 5: The Environment and the Region—Encourage the broad participation and cooperation of the entire metropolitan community on environmental sustainability issues, including transit, air and water quality, protection of floodways and wildlife habitat, and recreational areas and bike paths.

- Support and use DRCOG's *Metro Vision 2020* Plan, which has been incorporated into *Denver Comprehensive Plan 2000*.
- Continue Denver's leadership in metropolitan forums on smart growth, air quality, water, energy, natural resources and wildlife, recycling, climate, and other key environmental issues.
- Partner with other metropolitan jurisdictions to distribute environmental burdens and benefits.
- Cooperate with neighboring jurisdictions to develop shared open space and outdoor recreation amenities.
- Maintain existing connections and develop new connections among open space areas within Denver and with those of our neighbors.

BLUEPRINT DENVER

Blueprint Denver, An Integrated Land Use and Transportation Plan (Denver 2000) presents a planning and development strategy "for improving Denver by shaping the places where we live, travel, work, shop and play." *Blueprint Denver* serves as the first step in implementing and making concrete the vision outlined in *Denver Comprehensive Plan 2000*. *Blueprint Denver* adheres to and promotes five elements in *Metro Vision 2020*, as paraphrased below:

- Adhere to an established urban growth boundary.
- Provide substantial open space.
- Provide a balanced, multi-modal transportation system.
- Provide urban centers, such as Downtown and Cherry Creek.
- Support sustainable development to protect regional air and water quality.

A central concept of *Blueprint Denver* that is directly relevant to this Plan is the goal of directing growth to "Areas of Change" and managing and limiting growth in "Areas of Stability." Areas of Stability include the vast majority of Denver and are primarily the fairly stable residential neighborhoods where minimal change is expected during the next 20 years. The goal is to maintain the character of these areas, yet accommodate some new development and redevelopment to prevent stagnation. Meanwhile, the vast majority of new development will be funneled to areas that will benefit from and thrive on an infusion of population, economic activity and investment; these places are Areas of Change (Denver 2000). These Areas of

EXHIBIT 4.2
BLUEPRINT DENVER AREAS OF CHANGE

DISTRICTS
- DOWNTOWN
- CHERRY CREEK
- LOWRY
- STAPLETON
- GATEWAY

NEIGHBORHOODS
- BRIGHTON BOULEVARD
- NORTHEAST DOWNTOWN
- JEFFERSON PARK-HIGHLAND

TRANSIT-ORIENTED DEVELOPMENT
- WEST COLFAX LIGHT RAIL STATION AREA
- GATES LIGHT RAIL STATION AREA (I-25/BROADWAY)
- SOUTHEAST LIGHT RAIL CORRIDOR
- WEST EVANS LIGHT RAIL CORRIDOR

TOWN CENTERS
- ALAMEDA TOWNCENTER

CORRIDORS
- WEST 38TH PEDESTRIAN SHOPPING CORRIDOR
- MORRISON ROAD PEDESTRIAN SHOPPING CORRIDOR
- EAST COLFAX (LINCOLN TO COLORADO) PEDESTRIAN SHOPPING CORRIDOR
- THE CENTRAL INDUSTRIAL AREA RIVER CORRIDOR
- SOUTH FEDERAL BOULEVARD COMMERCIAL CORRIDOR
- HAMPDEN COMMERCIAL CORRIDOR
- EAST COLFAX (EAST OF COLORADO BLVD)

COMMERCIAL CORRIDOR
- SOUTH BROADWAY COMMERCIAL CORRIDOR

Change will provide the most opportunities for implementing new and/ or improved stormwater-related infrastructure and BMPs. Although 26 specific Areas of Change are identified in *Blueprint Denver* (see Exhibit 4.2), these can be lumped into three general categories:

- Downtown
- Large development areas such as Lowry, Stapleton and Gateway
- Areas where land use and transportation are closely linked

Another key aspect of *Blueprint Denver* is its definitions of land-use building blocks. Adoption of these building blocks into this Plan will help to promote better interfacing among multiple departments as part of the planning and development review process. The land-use building blocks defined in *Blueprint Denver* include:

- Districts (types: downtown, employment, industrial, campus, entertainment/cultural/civic and parks and open space)
- Residential areas (types: mixed-use, urban residential, single-family/duplex residential, and single-family residential)
- Centers (types: regional center, town center, neighborhood center, and transit-oriented development)
- Corridors (types: pedestrian, shopping, commercial)

Finally, *Blueprint Denver* recognizes the critical role that land-use regulations play in shaping development and ensuring that development fits into the public infrastructure. *Blueprint Denver* also identifies various development standards that impact site designs including factors such as setbacks, parking locations, off-street parking requirements, and landscaping, among others. These requirements have the potential to impact locations and space allocated to water quality treatment facilities. As part of *Blueprint Denver*, significant revisions to zoning and development standards are recommended. Ideally, water quality treatment requirements could be integrated into future changes to these regulations, standards, and design review process.

DENVER PARKS AND RECREATION GAME PLAN

In 2003, Denver completed the *Denver Parks and Recreation Game Plan: Creating A Strategy for Our Future,* which provides a master plan for Denver's parks and recreation future. The *Denver Parks and Recreation Game Plan* was created through a two-year public process and provides a 50-year vision and strategic framework plan for transforming Denver into a "City in a Park." The proposed physical plan to create a City in a Park is organized into three sections, according to a scale that moves from home and neighborhood to Denver's park and open space role in the region. Design ideas, planning and process principles, supporting analyses, measurable indicators, standards or benchmarks, and cost estimates are provided. As a master plan, the *Denver Parks and Recreation Game Plan* makes few specific recommendations for individual parks. Rather, it provides an overall assessment of the park system and a framework for making decisions.

The *Denver Parks and Recreation Game Plan* reflects city residents' desire for diverse recreational experiences along Denver's waterways such as canoeing, kayaking, green connections to the water's edge, and new parkway connections next to the water, especially along the Platte at South Platte River Drive. Residents are also interested in more opportunities to learn about water quality, native landscapes, and wildlife. Both natural areas and active parks supporting recreation are desired.

Exhibit 4.3
Denver Parks and Recreation Game Plan

Several specific goals identified in the *Denver Parks and Recreation Game Plan* that are beneficial in terms of stormwater quality management include:

- Provide a tree-canopy cover of 15 to 18 percent in urban residential areas and 10 percent in the central business district by 2025.
- Provide at least one-half acre of public open space within one-half mile of every resident's home that can be reached without crossing a major barrier.
- Provide 8-10 acres of parkland for every 1,000 residents.
- Provide significant natural area acreage in each quadrant of the city.

- Encourage more natural open space in the design of new parks and the retrofitting of established parks.

- Restore and protect existing natural open spaces.

- Install a detached sidewalk with tree lawn where feasible; tree lawns should be at least 8 feet wide.

- Ensure safe access to urban waterways from major residential areas.

- Expand natural open space along the Platte, Cherry Creek, and the gulches, improving habitat for urban wildlife.

- Increase the number and range of parks along the waterways, including some larger parks that support active recreation.

- Identify priority corridors and areas needing protection or preservation, including: the Cherry Creek Corridor; First, Second and Third Creeks; Westerly Creek; and eastern drainageways connecting Aurora Reservoir with Rocky Mountain Arsenal.

Many of the long-term goals presented in the *Denver Parks and Recreation Game Plan* are beneficial to stormwater quality management. This Plan should reinforce these goals and seek opportunities for mutually beneficial projects.

NATURAL AREAS PROGRAM FIELD GUIDE

The *Natural Areas Program Field Guide* (Denver Parks and Recreation 2004) is currently being developed to educate Denver staff and citizens about the purpose and activities of the Denver Natural Areas Program. The guide helps citizens and Denver staff understand how their activities affect natural areas and wildlife. The guide is divided into the following eight sections: rivers; creeks and other waterways; wetlands; prairies and grasslands; woodlands and forests; wildlife and wildlife habitats; community participation; and good land stewardship.

DESIGN GUIDELINES FOR STAPLETON WATER QUALITY

In 2001, the Denver Planning Board adopted the *Design Guidelines for Stapleton Water Quality: Patterns for Integrating Water Quality Treatment into the Community, An Addendum to the Stapleton Rules and Regulations*. This document provided specific guidelines for developing water quality controls adapted to the highly urbanized setting of the Stapleton Redevelopment area. Parcel-specific BMPs were developed along with a set of details that identified specific opportunities for water quality treatment. Both structural and non-structural BMPs were identified. The document also emphasized opportunities of integrating regional water quality and quantity stormwater controls.

In many ways, the *Design Guidelines for Stapleton Water Quality* laid the foundation for this Plan. A few selected guiding principles of *Design Guidelines for Stapleton Water Quality* that are instructional for this Plan include:

- Supporting the precepts of the related Stapleton drainage and development plans and Denver's stormwater permit.
- Providing development parcel BMPs that respect the design requirements and challenges of urban development.
- Providing an appropriate combination of structural and nonstructural BMPs that work at the site.
- Creating designs that promote a healthy aquatic ecology, provide for sustainability, and minimize maintenance and human intervention.

LONG RANGE MANAGEMENT FRAMEWORK SOUTH PLATTE RIVER CORRIDOR

In 2000, the Mayor's South Platte River Commission completed the *Long Range Management Framework South Platte River Corridor* for the purposes of providing a framework for future decision-making and management of the 10.5-mile South Platte River Corridor within Denver's boundaries. The corridor includes 330 acres of land and water within the 100-year floodplain of the South Platte River. The document is intended to provide guidance for continued multi-objective management and project coordination in the corridor. Conclusions and recommendations were developed in four key areas, as summarized in the document's Executive Summary:

1. **Development of a Vision and Management Philosophy**: An update of the original vision statement developed by the Mayor's South Platte River Commission in 1995 was defined as:

   > *We want the South Platte River Corridor to be known and cherished by the citizens of the City and County of Denver. If we care for our River, protect its natural resources and help restore its beauty and quality, the South Platte will provide present and future generations unmatched opportunities for recreation, education and enjoyment.*

   In addition to the vision statement, the Commission also recommended that the City designate and manage the entire Corridor (as defined in the Greenway Ordinance) as a City "Active Use" Natural Area, with Conservation and Preservation Natural Area designations to be applied to areas needing special protection. It was further recommended that an Adaptive Management approach be applied to overall corridor management, whereby management of land and water resources toward identified goals is continually monitored, evaluated and adapted to integrate best management practices and to respond to changing conditions over time.

2. **Identification of a Management Structure**: Create a South Platte River Corridor Council made up of all major city agencies working on the River, as well as a number of other stakeholder groups. This advisory group should be empowered by ordinance,

and initially staffed administratively out of Denver Parks and Recreation. It should be co-chaired and convened by the Manager of Parks and Recreation and a community leader appointed by the Mayor. It will meet quarterly to review and make recommendations on all activities taking place on the River Corridor. It will also engage subcommittees to address a variety of topics needing more detailed attention (e.g., water quality, regional cooperation).

3. **Achievement of an Integrated and Balanced Management Approach**: Use the carefully developed and agreed-upon Guiding Principles and Goals and Objectives laid out in the document as a framework for management decisions. The goals and objectives address multiple issues such as wildlife, recreation, water quality and flood control issues, public safety, regional cooperation and partnership, and public involvement.

4. **Develop Resources Necessary to Meet the Challenges**: Through the creation of the South Platte River Corridor Council and the initiatives of its members, work collaboratively to identify and attract funding for multi-objective projects. Wherever possible, utilize partnerships with existing non-profits and others to support and build upon programs that meet common goals and objectives.

CHERRY CREEK GREENWAY CORRIDOR MASTER PLAN

Cherry Creek, from the Cherry Creek Reservoir to its confluence with the South Platte River in downtown Denver, meanders through twelve miles of diverse vegetation and wildlife habitats, rural, suburban, and urban developments, three governmental jurisdictions, seven neighborhoods, and public as well as privately-controlled lands (BRW 2000). As one of the last remaining natural environments within an otherwise urbanized setting, the Cherry Creek corridor provides a unique opportunity to become one of the metropolitan area's major open space resources. The *Cherry Creek Greenway Corridor Master Plan* (BRW 2000), also referred to as the Cherry Creek South Corridor Master Plan Report, provides an overall master plan for the eight-mile portion of Cherry Creek between University Boulevard and the Cherry Creek Dam. Two of the primary purposes of the plan are to "firmly establish the long-term protection and enhancement of its environmental resources" and "expand opportunities for open space." This plan should be taken into account with regard to stormwater quality planning in the Cherry Creek corridor area.

Exhibit 4.4
Cherry Creek Stewardship Partners Plays an Important Role for Cherry Creek

CHERRY CREEK WATERSHED SMART GROWTH FOR CLEAN WATER REPORT

Denver continues to be very involved in the planning and implementation of regional watershed and water quality-based land-use initiatives in the Cherry Creek Basin. Historically, the Cherry

Creek Stewardship Partners had operated successfully as an informal coalition of interests from throughout the watershed. The work of the partners culminated in 2002 with the completion of the *Cherry Creek Watershed 'Smart Growth for Clean Water'* Report (Cherry Creek Stewardship Partners 2003) and the *Cherry Creek Basin Open Space, Conservation and Stewardship Plan* (The Trust for Public Land 2002). These plans engaged a broad cross-section of interests within the watershed and specified goals and objectives for realizing land protection and water quality goals. Some of the key findings of the Smart Growth for Clean Water project included:

- The practice of engaging the development community, local land use agencies and interested citizens in the watershed planning process is a key component of making "smart growth for clean water" techniques viable in a watershed.
- There are excellent data sources available on conditions in the Cherry Creek watershed.
- The watershed can go beyond the level of water quality enhancement mandated by existing regulations.
- There are available solutions that can be implemented to minimize or remove barriers that block implementation of smart growth practices within the development community and local government planning agencies.
- Funding and marketing options exist that can provide economic incentives for innovative planning and design and help fund water quality projects.

LAKE MANAGEMENT AND PROTECTION PLAN

Exhibit 4.5
Wetland Portion of Lake in Garland Park

Denver has many agencies that are concerned with maintaining the functions of the lakes within the city. The agencies tackle the issues based upon their specific mission. The purpose of the *Lake Management and Protection Plan*, which was written concurrently with this Plan, is to provide these agencies with a document that summarizes the conditions of the lakes, discusses potential overlap or conflict between various issues/uses for the lakes and identifies future strategies that the agencies can implement (Dudley 2004).

More specifically, the plan documents the history and current status of the lakes in Denver parks. This includes basic location, size, and depth information, and as much information on uses and overall health of the lakes as could be documented. Historical records concerning improvement projects, as well as planned improvement projects, are also included. The primary challenges for managing and protecting the lakes are discussed (e.g., habitat, water quality, geese) and similarities or conflicts among these challenges are evaluated. The plan provides potential near- and long-term strategies for enhancing and protecting the lakes, emphasizing sustainable strategies (Dudley 2004).

The *Lake Management and Protection Plan* has direct relevance to this Plan in terms of maintenance of ponds with stormwater functions (Chapter 6), as well as with regard to potential future watershed-by-watershed assessments described in Chapter 9.

SUMMARY

Denver has completed multiple planning and technical criteria documents that are directly relevant to stormwater quality planning. It is important that this Plan be consistent with the principles, criteria, and priorities included in these documents and recognize that strong coordination among Denver departments is essential for long-term success.

Chapter 5
NATIONAL CASE STUDIES

As part of Denver's commitment to not "reinvent the wheel" with regard to stormwater quality management, five communities with reputations for advanced stormwater management programs were selected for review. These communities and the aspect of their program of primary focus for purposes of this Plan include:

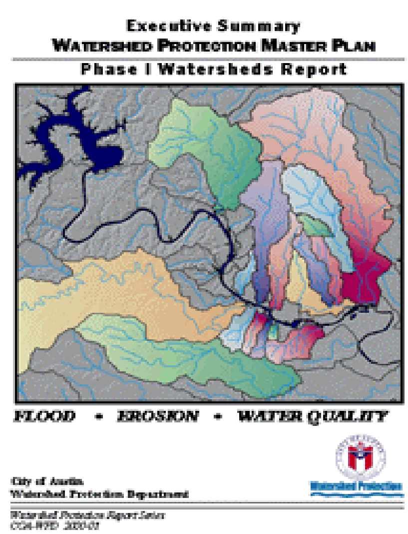
- City of Austin, Texas: Watershed Protection Master Plan
- City of Portland, Oregon: Clean Rivers Plan
- Snohomish County, Washington: Drainage Needs Report
- City of San Diego, California: Think Blue San Diego!
- Prince George's County, Maryland: Low Impact Development

Although the climates in most of these communities differ from Denver, the planning process that each has undertaken is relevant nonetheless. The level of detail and topics addressed in the case studies vary depending on the specific reason that the community was selected. For example, fairly detailed discussions of the planning processes implemented in Austin, Portland and Snohomish County are provided, while more topic-specific information is provided for San Diego with regard to public education and for Prince George's County with regard to Low Impact Development. Interviews with key managers, literature reviews and website reviews were completed to obtain information on each of the communities' programs. The highlights of each are provided in the remainder of this chapter, along with a summary of key themes relevant to Denver's stormwater planning process.

CITY OF AUSTIN, TEXAS: WATERSHED PROTECTION MASTER PLAN

EXHIBIT 5.1

AUSTIN WATERSHED MASTER PLAN



In 2001, the City of Austin, Texas completed a multi-year, $2.1 million watershed protection report titled the *Watershed Protection Master Plan Phase I Watersheds Report* (Exhibit 5.1). This plan is cutting-edge in many ways, two of which include: 1) its integrated approach to flooding, erosion and water quality issues; and 2) its extensive use of Geographic Information Systems (GIS) as a tool for watershed planning. Some of the highlights of this plan follow.

As background, Austin formed its Watershed Protection Department in 1996 from several existing departments to reduce the impact of flooding, erosion and water pollution on the community in order to protect lives, property and the environment. To accomplish this mission, the Watershed Protection Department completed Phase I of a Watershed Protection Master Plan to better prioritize service needs and refine program direction.

The master plan included an extensive public input process that resulted in multiple goals and objectives. The first part of the plan details the development of a system to identify and assess the severity of problem areas, including methods to assign numeric scores to the problem areas, which could in turn be used in GIS mapping. Once this system was developed, each stream segment was assessed regarding creek and local flooding, erosion, and water quality degradation. The water quality assessment, referred to as the environmental integrity index, included not only chemical constituents, but also sediment quality, physical integrity, recreation/aesthetics, aquatic life support, and channel stability. Following the assessments, the stream segments were scored and mapped with GIS. Integrated problem area watershed maps were developed by overlaying the results of individual assessments to identify areas of concurrent flooding, erosion, and water quality problems.

The next step in the process was to inventory potential solutions to the identified problems. From this inventory, a set of preferred solutions was developed for various situations. Exhibit 5.2 summarizes the preferred solutions by watershed type developed as a result of the Master Plan.

EXHIBIT 5.2
CITY OF AUSTIN PREFERRED ALTERNATIVES BY WATERSHED TYPE

RURAL WATERSHEDS	**DEVELOPING WATERSHEDS**	**URBANIZED WATERSHEDS**
Rural Watershed Characteristics	**Developing Watershed Characteristics**	**Urbanized Watershed Characteristics**
Future Impervious Cover <15%	Existing Impervious Cover >15% Net Future Impervious Cover Increase >5%	Existing Impervious Cover >50% Net Future Impervious Cover Increase <5%
Solution Options for Flood Control	**Solution Options for Flood Control**	**Solution Options for Flood Control**
No flooding problems in Barton Creek	• Property Acquisition (Buyouts) for Flood Control • Flood Detention • Channelization • Flow Diversion: Channels and Tunnels • Replacement of Structural Constrictions • Levees and Floodwalls	• Property Acquisition (Buyouts) for Flood Control • Flood Detention • Channelization • Flow Diversion: Channels and Tunnels • Replacement of Structural Constrictions • Levees and Floodwalls
Solution Options for Erosion and Water Quality	**Solution Options for Erosion and Water Quality**	**Solution Options for Erosion and Water Quality**
• Geomorphically-Referenced River Engineering (GRRE) • Wet Pond/Wetlands • Retention-Irrigation Ponds	• Reinforced Earth [erosion side slope projects] • Gabions/Concrete Riprap [erosion side slope proj.] • Geomorphically-Referenced River Engineering (GRRE) • Erosion Detention • Erosion Detention + Wet Ponds • Erosion Detention + Wet Ponds + Baseflow Extended Detention • Retention-Irrigation Ponds	• Reinforced Earth [erosion side slope projects] • Gabions/Concrete Riprap [erosion side slope proj.] • Geomorphically-Referenced River Engineering (GRRE) • Erosion Detention [Little Wal. & Shoal headwaters] • Wet Ponds/Wetlands • Wet Ponds + Baseflow Extended Detention

To address the problems characterized by the watershed studies, the Master Plan identified the need to implement a combination of watershed solutions including:

- Capital Infrastructure Projects: Over $800 million in capital funds to construct integrated watershed protection facilities including detention ponds, channel stabilization projects, and other flood, erosion, and water quality controls.
- Operating Program Enhancements: Additional funding of $2 to 5 million per year for infrastructure maintenance, development review and inspection, public education, and design support.
- Regulatory Modifications: Changes to various codes and criteria to improve customer service, provide developer incentives, reduce long-term maintenance needs, and prevent the creation of new watershed problems in the future.

If the additional resources and funding are made available, the city anticipates that it can meet its erosion and flood goals; however, the city does not expect to be able to attain all of its water quality goals based on its Phase I Master Plan solutions. Some of the reasons identified in the report and in a follow-up interview with Jean Drew, the city's Watershed Master Plan Coordinator, include:

- Limited regional retrofit opportunities in urban watersheds and inadequate regulatory controls in areas outside the city's jurisdiction.
- Setting potentially unrealistically high water quality goals. (For example, restoration of base flows is a significant problem that is not easily addressed.)
- Inability of the Master Plan "scoring" system to credit non-structural BMP methods in reducing pollution. (For example, improved lawn care practices were not considered as a quantifiable factor in nutrient reductions in streams.)

Follow-up interviews with Jean Drew, City of Austin, and Michael Barrett, University of Texas, identified some of the challenges encountered during the Austin Watershed Master Plan process that have applicability to Denver's on-going and future work, including:

- Striking a balance between extensive public involvement and keeping the project moving forward in a timely manner.
- Striking a balance between multiple priorities within city departments.
- Agreeing on level of detail/refinement in assessing the problem (e.g., assigning numeric scores to problems has its benefits and limitations).
- Agreeing on appropriate level of refinement/precision for modeling results.
- Providing an adequate level of cost projections for future work, while still working within the framework of a planning-level document.

- Securing future funding to implement the projects identified in the plan.

Several specific aspects of the City of Austin's watershed program that are relevant to Denver's efforts include:

- Capital projects are financed by bond monies, transfers from the Watershed Protection Department's normal operating funds, Urban Water Quality Ordinance fees and Regional Stormwater Management Participation Fees.

- All water quality controls within the City of Austin's jurisdiction must achieve a minimum runoff capture volume of at least the first one-half inch of runoff from the contributing area once a site reaches 20 percent impervious cover, and the volume increases based on percent impervious cover. Under the Save Our Spring (SOS) regulations in the Barton Springs Zone, higher capture volumes are required for meeting the pollution reduction standard of "no increase in the average annual pollutant load," and there is no minimum impervious cover trigger. It is possible that capture volumes could be increased as a potential modification of the requirements under the Phase I Report.

- Runoff treatment standards are based on providing treatment equivalent to a sedimentation/filtration system designed in accordance with the City of Austin's Environmental Criteria Manual.

- Austin encourages redevelopment as a means of promoting infill development. The Master Plan notes that waiving existing development standards is one mechanism to promote redevelopment; however, a consequence of waiving development standards is worsening of inner city flooding, erosion and water quality problems.

- In the urbanized/developed watersheds in Austin, impervious cover is already high and stream channel enlargement processes are already advanced. Since Austin's preferred solutions for runoff treatment are detention/retention pond solutions or wetlands that require land availability (Exhibit 5.3), Austin worked to inventory as many potential pond locations as practical.

EXHIBIT 5.3
ATTRACTIVE WETLAND/POND IN AUSTIN

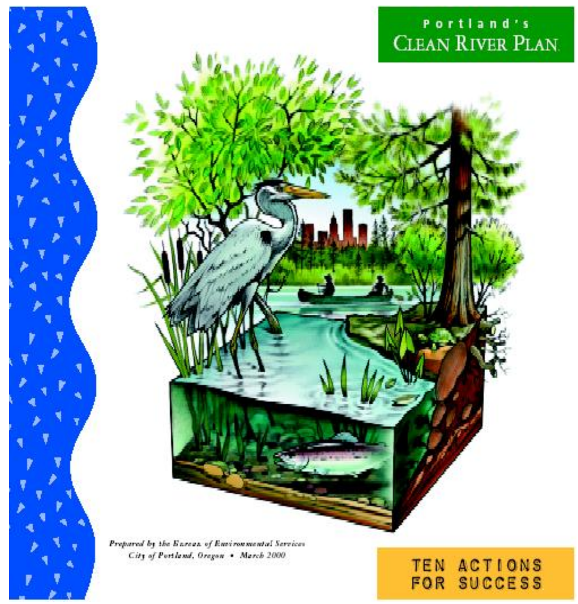
- Austin has pursued projects under its Regional Stormwater Management Program for potential retrofits to provide water quality functions. These projects have also taken into consideration Low Impact Development techniques. As part of the Watershed Protection

Department's analysis, Austin determined that runoff from at least 25 percent of existing development needs to be treated to have a significant impact on water quality. For high-priority receiving waters, runoff from preferably up to 50 percent of existing development should be treated. More detailed site-specific investigations were identified as necessary to determine the best combinations of large-scale regional water quality ponds and existing pond retrofits.

CITY OF PORTLAND, OREGON: CLEAN RIVER PLAN

The Bureau of Environmental Services in Portland, Oregon, is responsible for treating wastewater, providing stormwater drainage services, reducing stormwater pollution, restoring native vegetation and improving water quality in rivers and streams. The Bureau serves over 500,000 people in an 85,000-acre area comprised of four major watersheds. There are two key components of their program: the *Stormwater Management Manual*, updated in 2002, and *Portland's Clean River Plan*, which was released in 2000 and revolves around "ten actions for success" and which identified $877 million worth of needed projects. The *Clean River Plan* is the primary focus of this discussion.

EXHIBIT 5.4
PORTLAND'S CLEAN RIVER PLAN



Because much of Portland's effort was driven by significant problems relating to combined sewer overflows (CSOs), *Portland's Clean River Plan* provides a cutting-edge perspective on reducing storm flow volumes in concert with improving water quality through a variety of innovative approaches. The plan, itself, provides a concise big-picture vision, along with specific goals, in the form of a relatively brief, full-color document that can be widely distributed and understood by citizens and officials with widely varying backgrounds. Some of the highlights of *Portland's Clean River Plan* follow.

One of the main thrusts of *Portland's Clean River Plan* is to address the city's water quality problems using solutions that address more than one problem at a time in order to minimize costly single-purpose infrastructure such as large pipes, expanded treatment plants and pump stations. The planning strategy involved reviewing each of the four watersheds using consistent assessment strategies and solution option evaluations. As was the case for the City of Austin, numeric scoring criteria were developed and assigned as part of the process.

As a result of this process, "Ten Actions" to improve the rivers, along with cost estimates for the program over a 20-year planning horizon, were developed. A brief overview of these actions follows. Actions that are particularly innovative and/or potentially applicable to Denver are discussed in more detail.

- **Plant trees, native vegetation and create buffers and shade along streams (Cost: $54 million).** Tree planting is particularly important to Portland due to stream temperature standard violations and threatened and endangered fish species issues. The presence of woody debris in streams is also important for fish habitat. The city has a program for partnerships with streamside landowners to preserve natural riparian vegetation, plant trees and native vegetation, and remove invasive, non-native plants. There is also a goal to increase urban canopy. The adoption and enforcement of existing and new development standards to protect existing stream buffers and create new stream buffers is also high priority.

- **Reduce stormwater flow and pollutants reaching streams (Cost: $53 million).** The primary focus is Low Impact Development techniques including disconnecting downspouts, expanding the roof garden program, and a series of pilot projects to reduce stormwater flows. Examples of pilot projects include stream diversions, downspout disconnection, parking lot detention, eco-roof and landscape infiltration projects. Another priority is to enforce the requirements of the city's Stormwater Management Manual, which strongly encourages Low Impact Development techniques as the first priority, followed by swales, ponds, constructed wetlands, vaults, and other stormwater treatment systems. They also are developing incentive programs for existing developments to provide treatment.

- **Enhance Erosion Control from Construction and Development (Cost: $7 million).** Key actions include providing inspection personnel and equipment, an Erosion Control Certification Program and a Citizen Reporting System for erosion problems.

- **Increase pollution prevention and source control efforts (Cost: $7 million).** This program focuses on removing illicit discharges, increasing outreach to businesses, developing a comprehensive recognition program modeled on the "Eco-Logical Business Program," expanding outreach to medium and small businesses that have non-permitted industries to assist them with techniques to prevent pollution, and enhancing and maintaining the "Soil-Trader" website. Some specific examples of these efforts include partnering with specific industry groups each year to develop a set of BMPs for that industry and developing a technical assistance guide. The Soil Trader website is a way to exchange information to recycle clean excavated soil, rather than dispose of it. Another example includes a five-year pilot project working with dentists to recycle X-ray fixer due to its silver content and lead foil and amalgam from pump traps due to mercury content.

- **Education and Stewardship (Cost: $9 million).** This includes K-12 and adult information programs, stewardship grants to local groups that organize and carry out environmental enhancement work, and development of other educational information. Public education is a key component of the city's overall strategy. Free education programs are offered to schools and communities, in addition to providing community service projects, stewardship grants and curriculum resources for check out. A website has Clean River Games and kid's pages.

- **Floodplain Restoration (Cost: $4.5 million).** This involves acquiring flood-prone properties through willing-seller programs and restoring floodplain functions in specific watersheds.

- **Monitoring and Watershed Assessments (Cost: $7.5 million).** The key purpose of these assessments is to provide information to evaluate how the watersheds change over time. Monitoring is the foundation of the "adaptive management" approach. The monitoring program includes establishing baseline conditions, monitoring water quality for a consistent set of constituents, assessing flooding, fish habitat, riparian vegetation, flow/geomorphology, and stewardship. Additional tracking of program effectiveness is also included.

EXHIBIT 5.5

PORTLAND'S BUREAU COORDINATION NEEDS

ACTION 10 -CITY BUREAU COORDINATION NEEDS

● = MAJOR ◑ = MINOR ○ = NO LINK

FOR ACTION	PDOT: PLANNING - POLICY - STREET DESIGN	PDOT: CONSTRUCTION	PDOT: MAINTENANCE - OPERATIONS	PLAN: POLICY - COMPLIANCE PLAN	PLAN: ZONING - LAND DIVISION CODES	PLAN: COORDINATION	PARKS: URBAN FORESTRY	PARKS: PARKS PLANNING - DEVELOPMENT	PARKS: MAINTENANCE	PDC: URBAN REDEVELOPMENT PLANS	PDC: INCENTIVE PROGRAMS	PDC: DEVELOPMENT PROJECTS	OPDR: FLOODPLAIN REGULATIONS	OPDR: STORMWATER - EROSION CONTROL - GRADING ENFORCEMENT	OPDR: LAND DIVISION - ZONING	WATER: WELL FIELD PROTECTION	WATER: WATER FACILITIES	WATER: WATER CONSERVATION
1 CSO CONTROL	◑	○	●	○	○	○	◑	◑	○	○	○	○	○	○	◑	○	○	◑
2 VEGETATION	●	○	◑	●	●	●	●	●	●	◑	◑	●	○	◑	●	◑	◑	○
3 STORMWATER	●	◑	●	●	●	●	●	◑	◑	◑	◑	●	○	●	○	●	○	○
4 UPGRADE SEWER SYSTEM	○	○	●	○	○	○	◑	◑	○	◑	○	○	○	○	○	○	○	◑
5 EROSION CONTROL	●	●	●	●	◑	◑	◑	◑	◑	○	○	●	○	●	●	○	◑	○
6 POLLUTION PREVENTION SOURCE CONTROL	◑	◑	◑	◑	◑	○	◑	◑	◑	●	●	●	○	◑	◑	●	◑	◑
7 ENVIRONMENTAL EDUCATION STEWARDSHIP	◑	○	◑	●	●	○	●	◑	◑	◑	◑	◑	◑	◑	◑	●	○	●
8 FLOOD PLAIN RESTORATION	◑	○	◑	●	◑	○	●	●	◑	◑	◑	○	●	●	◑	○	◑	○
9 WATERSHED ASSESSMENT	○	○	○	◑	◑	●	◑	◑	○	◑	○	○	◑	○	◑	◑	◑	○

- **Coordination and Partnership. (Cost: included in baseline city budgets).** The matrix in Exhibit 5.5 helps to consolidate which city departments are involved in each of the Clean River Plan goals. Additional coordination with state and federal agencies is also important, particularly with regard to the Threatened and Endangered Species issues.

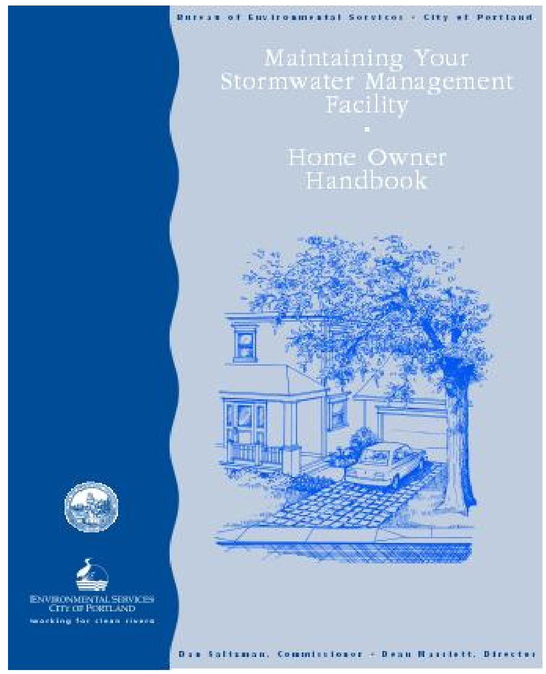
With regard to Portland's *Stormwater Management Manual*, which is the foundation of stormwater management strategy described above, the key strategy being emphasized is on-site stormwater management practices. The city now requires all new development and redevelopment projects to include onsite stormwater facilities. The manual emphasizes the "simplified approach" to stormwater management, which focuses on rooftop systems, porous pavement, planter boxes, vegetated swales, filter strips and basins, sand filters and soakage trenches, and trees. Alternative methods include the more traditional stormwater practices of grassy swales, ponds, constructed wetlands, detention facilities, drywells, manufactured systems, oil/water separators, and stormwater reuse. The manual also provides specific guidance for activity-based pollution controls for fuel-dispensing facilities, above-ground storage of liquid materials, solid waste storage areas, exterior storage of bulk materials, material transfer areas/loading docks, equipment/vehicle washing areas, stormwater disposal for development on recycled land, covered vehicle parking areas, and other requirements. The manual specifically outlines facility landscaping requirements for all BMPs involving vegetation.

This includes recommended plant lists, mulch, irrigation, facility screening, and other measures. Specific operations and maintenance requirements are provided for each BMP.

Property owners are legally responsible for inspecting and maintaining the facilities, and the city has developed illustrated handbooks (Exhibit 5.6) for homeowners and property owners that clearly describe stormwater facility operation and maintenance guidelines, including inspection record forms.

EXHIBIT 5.6

PORTLAND'S BMP MAINTENANCE GUIDANCE



Other highlights of the Portland program with regard to financing and stormwater treatment criteria include:

- Financing is through sewer fees. Sewer rates are expected to increase from $33/month to $97/month by 2020.
- All new development and redevelopment with over 500 sq. ft. of impervious development footprint area is required to comply with Portland's stormwater manual requirements. The requirement is removal of 70 percent of total suspended solids (TSS) from runoff generated by a design storm up to and including 0.83 inches of rainfall over a 24-hour period. In addition to this standard, projects discharging to waterbodies with established TMDLs also have to comply with pollutant removal requirements for that waterbody. On-site infiltration is required to the maximum extent possible due to the CSO problem.
- A new department called the "Sustainable Stormwater Management Group" has been formed to focus solely on stormwater management opportunities in new development and redevelopment and other acute problem areas (Liptan 2003).

SNOHOMISH COUNTY, WASHINGTON

Snohomish County, WA, recently completed a two-year, $12 million study called the *Drainage Needs Report* (Exhibit 5.7). The goals of this report were to develop a better understanding of drainage systems, streams and wetlands and to plan for existing and future infrastructure needs in a way that:

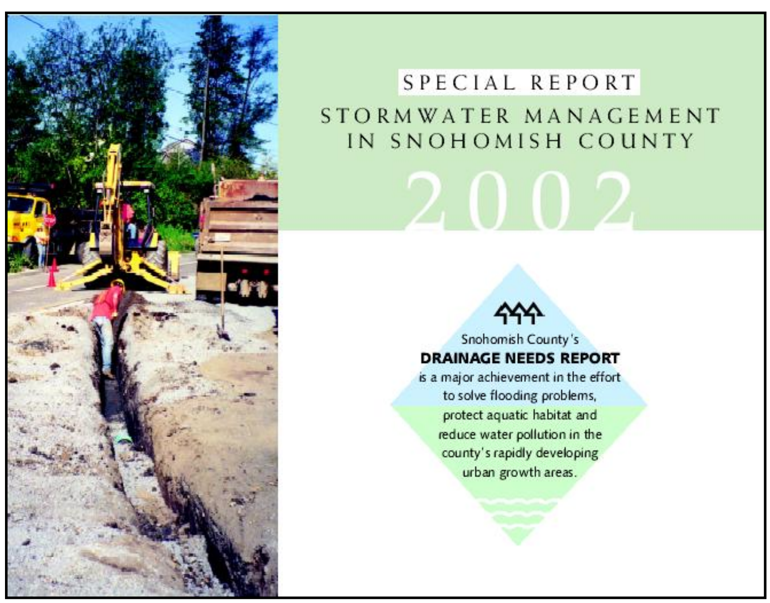
- Reduces road and property flooding
- Protects and enhances aquatic habitat
- Reduces stormwater pollution and erosion from stormwater runoff

Snohomish County's Surface Water Management Division selected this integrated approach because they have found that flooding problems (and their solutions) are usually intertwined with other surface water issues, such as aquatic habitat, water quality and erosion. This is also particularly true in their area due to threatened and endangered species issues. The plan relied heavily on Global Positioning System (GPS) and GIS mapping of drainage systems that covered 73 square miles. As part of the study, 11 individual drainage systems were evaluated in detail regarding the following issues:

- Drainage problem area
- Water quality
- Aquatic habitat
- Size and location of culverts/pipes for drainage and fish passage
- Other drainage-specific information

Studies in the larger basins included significant hydrologic and hydraulic computer modeling. Recommendations for improvements to all of the basins were provided. The study resulted in 378 recommended projects totaling approximately $123 million. The majority ($84 million) of the projects involved flooding issues typically combined with other issues, while $4.1 million addressed water quality only, $6.9 million addressed erosion only and $27 million addressed habitat only.

EXHIBIT 5.7
SNOHOMISH COUNTY DRAINAGE NEEDS REPORT



Specific components of the *Drainage Needs Report* include: a drainage inventory, information on how to use the report, project implementation strategies, guiding principles and methodology for evaluating the drainage basins, overall program recommendations, and study results for each of the 11 basins. The individual basin reports, which formed the basis for the overall report, addressed these topics:

- Basin characteristics
- Hydrologic and hydraulic modeling to address flooding
- Habitat assessment
- Water quality analysis
- Channel erosion assessment
- Capital Improvement Project (CIP) guidelines
- Existing and future problems
- CIP development, alternatives analysis, and recommend solutions
- Recommended plan

GIS and scoring-type approaches were used to prioritize project recommendations. Implementation considerations such as land acquisition, public or private ownership, and whether the project required early action were also noted. Project sequencing, funding, permitting, maintenance, and additional study requirements were also identified.

Several general recommendations of the report included retrofitting detention ponds (Exhibit 5.8) and open ditches to provide water quality benefits and working with landowners to implement BMPs such as preserving streamside vegetation, properly managing livestock, maintaining septic systems, etc.

EXHIBIT 5.8
SNOHOMISH ANNUAL ACHIEVEMENT REPORT HIGHIGHTS DETENTION FACILITY RETROFITS

FEATURED PROJECT:
Detention Facility Retrofit – Silver Firs 5a

WATERSHED: Snohomish

BENEFITS:
- Improves downstream water quality
- Improves ease of maintenance
- Improves detention function

DESCRIPTION:
The existing detention facility rarely detained stormwater and lacked water quality improvement features. To improve the pond's ability to store water, 166 feet of new pipe were installed. A two-cell wet pond (4' deep excavation below the detention volume separated by a berm) was constructed to provide approximately 17,500 cubic feet of water quality volume.

In addition to the *Drainage Needs Report*, there are other key components to the Surface Water Management Division's program. Extensive information is available on their website, including a detailed description and photograph catalogue of water quality problems and a reporting hotline number. Key programs covered by their department include community partnerships, water quality, aquatic habitat, urban drainage, and river flooding. The community partnership program is well developed with specific programs to address native plants, salmon, watershed education, watershed stewardship, and volunteer opportunities. Some of the activity areas highlighted in a recent annual achievement report (2001) include:

- Stormwater detention facility retrofits to incorporate stormwater quality benefits and smaller storm detention into older facilities.

- Detention facility maintenance program. This program has a database inventory of over 800 residential and Public Works drainage facilities, owned and maintained by either the County or homeowners. Over 200 facilities are inspected yearly and County crews maintained approximately 60 facilities in 2001, including some large rehabilitation projects to improve facility performance. The program has a strong public education program, making hundreds of citizen contacts annually. The cost of this program was about $440,000 for the year.

- Large woody debris program. The program involved providing large woody debris to streams for aquatic habitat and streambank stabilization. The cost of the program was $154,000 for the year.

Other aspects of Snohomish County's program, including stormwater treatment criteria, include:

- Annual service charges are billed in conjunction with property taxes based on land use classification and/or amount of impervious surface coverage as identified in their "Index of Land Use Classifications and Rate Categories." In areas designated as Clean Water Districts, representative annual service charges are $33.01/single family parcel up to $99.02/quarter acre of very heavy development.

- Snohomish County's stormwater criteria are based on the Washington Department of Ecology's criteria. "On-site stormwater management" is required for new development if 2,000 square feet or more of impervious area is added or replaced and land-disturbing activity includes 7,000 square feet or greater. Additional measures including "runoff treatment," flow control and other measures are required if the new development creates or adds 5,000 square feet of impervious surface, converts ¾ or more acres of native vegetation to lawn or landscaped areas or converts 2.5 or more acres to pasture. The requirements for redevelopment are similar but provide some flexibility to not discourage redevelopment.

- "On-site stormwater management" (referenced above) requires BMPs that infiltrate, disperse and retain stormwater runoff onsite to the maximum extent feasible without causing flooding or erosion impacts. Roof downspout control BMPs and dispersion and soil quality BMPs (or their functional equivalents) are required to reduce the hydrologic disruption of developed sites. The intent is to use inexpensive practices on individual properties to reduce the amount of disruption to the natural hydrologic characteristics of the site.

- "Runoff treatment" (referenced above) requires construction of stormwater treatment facilities based on pollution generating impervious surfaces (PGIS) and pollution generating pervious surfaces (PGPS).

- Snohomish County has a well organized website with detailed information available at www.surfacewater.info.

- The Surface Water Management Division has about 75 people, who Director Joan Lee, P.E., credits for a high level of competence and cooperation, enabling the success of the program (Lee 2003).

SAN DIEGO, CALIFORNIA

The goals of San Diego's Stormwater Pollution Division and their stormwater program include:

EXHIBIT 5.9

THINK BLUE SAN DIEGO!

- Investigation: This includes testing for pollutants at over 300 locations and recognizing that everyday activities are a key pollutant source.

- Pollution abatement: Key successes have included adjusting sprinklers/watering schedules and working to reduce pollution from construction sites and restaurants.

- Education: Think Blue San Diego (www.thinkbluesd.org) (Exhibit 5.9).

- Enforcement: This includes a Stormwater Code Enforcement Team ("stormwater cops"), citations and fines of $100-10,000/day, and a pollution reporting hotline.

- Additional Funding: The city recognizes its need for more funding for cleaning and maintenance of the storm drain system and has identified obtaining additional funding as a priority.

The City of San Diego has won multiple national awards over the last several years for their public education work related to stormwater. Award-winning aspects include the "Think Blue" campaign and the "Stormwater and You" employee education video. The "Think Blue" education and outreach campaign was chosen as part of EPA's urban city model program in its non-point source pollution toolbox for municipal agencies. With its strong emphasis on public education, Karen Henry, Deputy Director of Public Works, notes that the greatest benefits will be seen in long-term behavioral changes. A user-friendly website is part of their on-going public education program (Exhibit 5.10). The city is conducting annual surveys to try to measure how behavior is changing with regard to water protection practices (Henry 2003).

EXHIBIT 5.10
SAN DIEGO'S USER-FRIENDLY WEBSITE

In addition to the education campaigns, the city also has a formal *Urban Runoff Management Plan* that has identified about $30 million in needed projects. The city recently updated its *Stormwater Standards* (City of San Diego 2003), which identify requirements for stormwater quality treatment. One innovative aspect of this document is that it provides a GIS map of water-quality sensitive areas so that developers and planners are aware of areas requiring special protection. The plan also includes a BMP selection matrix that recommends selection of different BMP types based on the expected pollutants of concern. The document also provides a "standard development project" and "priority project" stormwater BMP requirements matrix.

PRINCE GEORGE'S COUNTY, MARYLAND AND LOW IMPACT DEVELOPMENT

Prince George's County, Maryland, and Associate Director of the Department of Environmental Resources, Larry Coffman, are nationally known for their leadership in implementation of Low Impact Development (LID) strategies beginning in the early 1980s. LID techniques are the focus of this discussion. When discussing LID, it is important to note that many LID techniques have the effect of "minimizing directly connected impervious area," which is a foundational concept of stormwater management in Denver (UDFCD 1999).

LID practices help to control pollutants, reduce runoff volume, manage runoff timing, and address other ecological concerns. The goal of LID is to mimic a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source. Instead of conveying and treating stormwater in facilities located at the bottom of drainage areas, LID addresses stormwater through small, landscape features at the lot level (Exhibits 5.11-5.13). These landscape features, or Integrated Management Practices (IMPs), are the building blocks of LID (Coffman 2001). Examples of LID techniques include bioretention, permeable pavers, tree box planters, rain gardens, and disconnected downspouts.

Larry Coffman (2001) provides the following statement regarding the foundations of LID:

The LID principles and practices are based on what we have learned over the years about stormwater management and the transfer of technology from other fields of engineering and science, such as sanitary engineering, agriculture, forestry, soil science, phytoremediation, bioremediation and ecology. As an example, take a look at the data on the 50-year history of successful land application and treatment of wastewater effluent (slow rate irrigation, overland flow, and high rate infiltration). Add to this the existing and growing body of data on the performance of bioswales, bioretention, filter strips and turf from universities (Maryland, Virginia, and Washington State), Federal Highway Administration, USEPA, and others. When you look at the entire body of related scientific and engineering/environmental technologies, you begin to see the advantages and benefits of LID's multiple systems (treatment train) approach.

An advantage of LID is that it is a comprehensive multi-systems approach that has built-in redundancy, which greatly reduces the possibility of failure. Basic subdivision and infrastructure design features include: reducing the use of pipes, ponds, curbs and gutters; maintaining recharge areas, buffer zones, and drainage courses; using

EXHIBITS 5.11–5.13
LOW IMPACT DEVELOPMENT FEATURES

Source: lowimpactdevelopment.org. From top to bottom: landscaped parking lot infiltration, residential landscaped infiltration and porous pavement.

infiltration swales, grading strategies, and open drainage systems; reducing impervious surfaces and disconnecting those that must be used; and conserving open space. The key factor in the success of LID is to ensure that the landscape practices (such as rain gardens) are attractive and perceived by the property owner as adding value to the property. If these LID practices are viewed as assets, the primary motivation for their long-term maintenance is that of property owners protecting their vested economic interests (Coffman 2001; http://www.lid-stormwater.net/).

Another advantage of the LID approach is with regard to preserving stream integrity. As previously discussed, it is important that a stormwater system specifically addresses the frequent storms that occur on a regular basis (weekly or monthly). By using decentralized site-based source controls, LID uses the stormwater from these more frequent events as a resource and is an effective ecosystem approach. LID techniques can also be combined into "hybrid" programs that address major flood control events, if needed (Coffman 2001; http://www.lid-stormwater.net/).

The Department of Environmental Resources in Prince George's County, Maryland recently presented results of side-by-side monitoring of two small residential watersheds in the Somerset Heights subdivision (Cheng, et al. 2003). One watershed was developed using conventional curb-and-gutter systems, whereas the other was developed using preliminary LID practices, including only grassed swales, bioretention areas, and disconnected impervious areas. It is important to note that the subdivision was designed and constructed prior to development of design criteria for LID practices. Regardless, over a two-year period, statistically significant differences were measured between the two watersheds in the number of runoff events, the total runoff volumes, and in peak event flow rates. Monitoring revealed that the LID watershed had 20 percent fewer runoff events, and the average peak flow rate was only 56 percent of conventional watersheds. Including groundwater/interflow, the total flow volume at the LID site was approximately 80 percent of the conventional site surface runoff. In the LID watershed, peak flow rates were reduced by approximately 44 percent per acre. Since monitoring occurred prior to site stabilization and without full-scale implementation of LID approaches, water quality comparisons between the sites were not considered to be representative of long-term performance according to current LID design practices.

Not all developments in Prince George's County have been planned using LID techniques. Older developments are usually based on more traditional drainage practices and some areas are conducive to "hybrid" approaches that combine traditional drainage practices with LID (Coffman 2003). With regard to long-term maintenance concerns, Coffman notes that several factors can help promote more effective long-term maintenance, including:

- Comprehensive site planning, including conserving natural soils, amending soils with organic materials, providing gentle slopes, and conserving drainage patterns.
- Providing site grading and design that are aesthetically-pleasing amenities and that complement rather than interfere with desirable site uses.
- Providing a "fudge factor" in site designs that allows a certain degree of failure in the system.

- Establishing covenants and outreach programs to train people on how to maintain rain gardens and other features to preserve their function and aesthetics.

SUMMARY

Several big-picture, planning-level lessons from innovative communities relevant to Denver's current stormwater quality planning process include:

- Comprehensive approaches are being used to address drainage, flooding, erosion, aquatic life, habitat, and water quality in an integrated manner.
- Stormwater management approaches that are multi-layered, combining a variety of structural and non-structural practices, are advocated and implemented.
- Watershed-based approaches are being used for planning and problem solving.
- GIS tools are being used effectively to prioritize stormwater improvements and to more effectively communicate to citizens, staff and developers.
- Storm runoff volume reduction practices are being used in the majority of these communities. These practices included a variety of LID techniques such as eco-roofs and rain gardens, tree planting, and irrigation controls.
- Long-term maintenance of BMPs is recognized as being critical to the success of BMPs.
- Strong public education campaigns in combination with extensive web sites are substantive components of these programs with significant budget allocations. Education is not an "afterthought"—it is being aggressively used in several of these communities as a key strategy to improve runoff quality.
- Significant financial investments, spanning from several hundred thousand to several million dollars, have been required for these communities to complete their planning processes. Most of the communities also recognize that significant future expenditures from tens to hundreds of million dollars will be required to meet their future goals and are planning accordingly.

Chapter 6
STORMWATER QUALITY BMP IMPLEMENTATION GUIDELINES

A VISION FOR STORMWATER QUALITY TREATMENT IN DENVER

Implementing stormwater treatment is not just an engineering issue—it involves and affects city planners, park planners, developers, landscape architects, environmental health professionals, and maintenance personnel—as well as the citizenry itself. Each of these participants has a unique perspective regarding how stormwater quality facilities should appear, function, and be maintained. To have meaningful guidelines that are used and promoted by each of these diverse groups, a shared vision for stormwater treatment must be bought into by each of the participants. This chapter presents a shared vision for stormwater quality treatment in Denver, which has emerged from a multi-disciplinary process. The vision is to implement stormwater quality Best Management Practices (BMPs) that are:

- **Functional**. Stormwater quality facilities must accomplish their primary function of effective stormwater quality treatment.
- **Maintainable.** Stormwater BMPs must be sustainable and maintainable for the long term.
- **Attractive.** Stormwater facilities must be compatible with the site's land use and complementary to the site's character.

These goals are at the heart of these stormwater quality BMP implementation guidelines. The techniques in the guidelines are, for the most part, established and approved technologies, having been promoted in the *Urban Storm Drainage Criteria Manual, Volume 3 Best Management Practices* ("Volume 3") (UDFCD 1999) for a number of years. BMPs are structural or non-structural techniques employed to reduce pollutant levels in stormwater runoff to the maximum extent practicable. Structural practices are discussed in this chapter and non-structural practices in Chapter 7. The intent of this guide is not to replace Volume 3 or other technical manuals, but rather to provide specific guidance on how to better integrate BMPs into a variety of development site types. Because some of the language used to describe these methods may be unfamiliar, a glossary has been included at the end of the document to provide additional information.

A NEW STRATEGY FOR STORMWATER QUALITY

This chapter describes a new strategy for managing stormwater quality on individual development sites. The strategy is to create facilities that are *integrated* with the landscape and hard surface elements of a site, *compatible* with the land use and with community goals, *effective* for enhancing stormwater quality, and *sustainable* over the long term.

This is a departure from past practices that dispose of stormwater quickly through a series of inlets and underground pipes that concentrate flows (thereby increasing runoff peak rates, volumes, and pollutant loads in the process), and then attempt to "cure" the problems by using detention basins at the edge of the site. Often, these "corner-of-site" facilities are large, deep basins that detract from the aesthetics of the site, are difficult to maintain, and may be only marginally effective in reducing the impacts of urban runoff.

This new strategy seeks to reduce the size of perimeter detention basins by reducing runoff volumes and distributing stormwater quality treatment throughout the site. This will reduce runoff rates, volumes, and pollutant loads by using landscape areas and porous pavements to infiltrate rainfall into the ground to better reproduce conditions that existed before the site was developed. Elements of the strategy are catching on locally and nationally, being promoted under the terms "low impact development" (LID) (Prince George's County 2000), "smart growth for clean water" (Cherry Creek Stewardship Partners 2003) and "minimizing directly connected impervious areas" (MDCIA) (UDFCD 1999). Regardless of the term, the approaches all manage runoff close to its source and promote infiltration.

This chapter provides guidance for integrating stormwater quality features into a site to form an effective "treatment train"—first reducing, then cleansing runoff—while improving site aesthetics through functional landscaping features, porous pavements, and reduced reliance on large, "forced-fit" detention basins.

Design and Stormwater Quality Principles

The following design and stormwater quality principles provide a foundation for developing a stormwater quality strategy, and are the basis for the recommendations presented in these guidelines.

Principle 1: Consider stormwater quality needs early in the design process.

Left to the end of site development, stormwater quality facilities will often be "shoe-horned" into the site, resulting in forced, constrained approaches. When included in the initial planning for a project, opportunities to integrate stormwater quality facilities into a site can be fully realized. Stormwater quality and flood control requirements are just as fundamental to good site design as other elements such as building layout, grading, parking, and streets. Dealing with stormwater quality after major site plan decisions have been made is too late.

EXHIBIT 6.1
STORMWATER QUALITY PLANNING IN MINNEAPOLIS, MN

This schematic plan designates specific types of stormwater quality treatment facilities along with buildings, roads, and parks.

Principle 2: Take advantage of the entire site when planning for stormwater quality treatment.

Often, stormwater quality and flood detention are dealt with only at the low corner of the site, and ignored on the remainder of the project. The focus is on draining runoff quickly through inlets and storm sewers to the detention facility. In this "end-of-pipe" approach, all the runoff volume is concentrated at one point and designers often find it difficult to fit the required detention into the space provided. This can lead to drainage plans showing proprietary underground treatment devices as discussed later in this chapter, or deep, walled-in basins that detract from a site and are difficult to maintain. Spreading runoff over a larger portion of the site reduces the need for these undesirable alternatives.

EXHIBIT 6.2
INTEGRATED TREATMENT FACILITIES IN BOULDER

This linear treatment area between two bays of parking takes advantage of the landscape strip to infiltrate stormwater.

Principle 3: Reduce runoff rates and volumes to more closely match natural conditions.

Before development, most of the rain that falls on the ground soaks into the soil or is captured by vegetation; very little rainfall runs off and flows downstream. However, after development, rain that falls on roofs and pavement mostly runs off (this is a "runoff event"). Whereas one runoff event per year may be typical prior to development, about 30 runoff events per year may occur after urbanization (Urbonas et al. 1989). Peak flows and volumes of runoff are much greater after urbanization than before development. This increased runoff can be environmentally harmful, causing erosion in stream systems and generating greater pollutant loading downstream.

One of the most effective stormwater quality BMPs—potentially more effective than constructing a detention basin to treat the runoff—is reducing urban runoff volumes to the maximum extent practicable to more closely match natural conditions. The following techniques can be used to achieve this goal:

- **Place stormwater in contact with the landscape and soil.** Instead of routing storm runoff from pavement to inlets to storm sewers to offsite pipes or concrete channels, an approach is recommended that places runoff in contact with landscape areas to slow down the stormwater and promote infiltration.

EXHIBIT 6.3
PLANTER BOX IN BOULDER, CO

These planter boxes fill with water, infiltrating significant amounts of stormwater before overflowing into treatment areas, while appearing beautiful throughout the year.

Porous pavement areas also serve to reduce runoff and encourage infiltration.

EXHIBIT 6.4
GRASS SWALE IN DENVER, CO

Between the parking lot and the street, this swale creates a landscape buffer between two paved areas

- **Apply the principle of minimizing directly connected impervious area (MDCIA).** Volume 3 promotes MDCIA, breaking up areas of imperviousness and directing runoff from roofs and paved areas to grass buffers, swales, and other landscape areas prior to being conveyed off the site. Volume 3 provides a credit against the actual imperviousness of a site for replacing inlets and storm sewers with grass buffers and swales that break up large expanses of paving. Thi s reduces the effective imperviousness of a site, decreasing the required water quality capture volume (WQCV) by as much as 50 percent, depending on the type of site. Fragmenting impervious areas with even small pervious areas can have a significant impact on reducing runoff and the required water quality capture volume. (Water quality capture volume is the quantity of stormwater runoff that must be treated in stormwater quality BMPs in Denver. See glossary for additional information).

- **Reduce the total amount of impervious area on a site.** The less impervious area exists on a site, the less runoff from a site will occur, resulting in a smaller required water quality capture volume. Smaller street sections or porous pavement in fire access lanes, parking lanes, and driveways (using soil reinforcement or modular paving blocks instead) will reduce the total site imperviousness.

- **Select treatment areas that promote greater infiltration.** Porous landscape detention, porous pavement detention, and sand-filter detention promote greater volume reduction than extended detention basins, since runoff tends to be absorbed into the filter media or infiltrate into underlying soils. As such, they are more efficient for reducing runoff volume, and can be sized for 20 percent less treatment volume than extended detention.

By employing these techniques, projects can reduce the increase in runoff and related stream degradation and pollutant loading that comes with conventional development. In addition, some of these techniques will reduce the required water quality capture volume and may help to create a more attractive site. Denver strongly encourages implementation of these runoff reduction techniques on all new projects to the maximum extent practicable.

Principle 4: Integrate stormwater quality management and flood control.

On average, it rains or snows over 70 times per year in the Denver area (Urbonas et al. 1989). More than half of these events produce less than 0.1 inch of precipitation and almost 80 percent of the remainder of the storms amount to less than 0.6 inches. These frequently occurring storms are the events that stormwater quality BMPs are designed to treat. Occasional flooding of streets and low-lying areas can occur during less frequent, larger storms, requiring flood control detention. Both stormwater quality treatment and flood control detention goals can be accomplished on a site through a coordinated design approach.

In cases where an extended detention basin, retention pond, wetland basin, or sand filter basin is used to address stormwater quality, any of these basins can be modified to include flood control detention in addition to the water quality capture volume. This will generally increase the overall size of the basin. In these situations, all the runoff from a site, from small and large storms alike, is routed to the combined detention basin. Site BMPs, like porous landscape detention and porous pavement detention, are intended to promote a stormwater quality function, and are not normally designed to provide flood control detention as well. In these cases, all runoff is directed to the water quality capture volume facility and larger events spill out over the surface or through an inlet and storm sewer to a separate flood control detention basin. (Alternatively, treatment can be provided within depressed parking lot islands, and flood control detention can take place within the parking lot itself, as long as the depth of water being detained is not too deep and drains quickly (at the historic rate) through an inlet. In parking lots, it is not acceptable to rely on slower draining BMPs such as porous landscape detention and porous pavement detention to infiltrate all of the flood detention volumes. More information on combining stormwater quality and flood control detention is discussed in the parking section of the Implementation Details in this chapter.

Principle 5: Develop stormwater quality facilities that enhance the site, the community, and the environment.

EXHIBIT 6.5
DETENTION BASIN IN DENVER

Although this is an attractive and well-constructed detention basin, it creates a gap in the commercial urban fabric of Colfax Avenue.

Stormwater quality areas can add interest and diversity to a site. Gardens, plazas, rooftops, and even parking lots can become amenities and provide visual interest while performing stormwater quality functions and reinforcing urban design goals for the neighborhood and community. Avoiding the placement of stormwater quality facilities along critical street frontage may be necessary to discourage detrimental "gaps" in the continuity of important urban spaces. The integration of BMPs and associated landforms, walls, landscape, and materials can reflect the standards and patterns of a neighborhood and help to create lively, safe, and pedestrian-oriented districts.

The quality and appearance of stormwater quality facilities should reflect the surrounding land use type, the immediate context, and the proximity of the site to important civic spaces. Aesthetics will be a more critical factor in highly visible urban commercial and office areas than at a heavy industrial site. The standard of design and construction should maintain and enhance property values without compromising function. In some cases, this means locating a facility to preserve or enhance natural resources.

Principle 6: Design sustainable facilities that can be safely maintained.

Stormwater quality facilities must be properly and consistently maintained to function effectively and ensure long-term viability. Regular maintenance is also key to public acceptance of these facilities. Typical maintenance operations to consider in designing facilities include:

- Mowing, trimming, and weed control
- Pruning of shrub and tree limbs
- Trash and debris cleanup, especially at grates and flow control structures
- Sediment removal
- Removal, replacement, and revegetation of porous landscape detention media
- Vacuuming/replacement of porous pavement and porous pavement detention media
- Structural repair

Keeping in mind these and other potential maintenance practices, it is also necessary to fully consider how and with what equipment BMPs will be maintained into the future. Facility design should provide for these operations ensuring adequate access with a minimum of disturbance, disruption, and cost. Maintenance should be planned for so that trash, debris, and sediment can be removed on a regular basis.

The last part of this chapter describes ways that Denver can enhance its approach to ensuring that stormwater BMPs are properly maintained. It describes required maintenance operations for a variety of BMPs, frequency of maintenance operations, and identifies parties responsible for maintenance. It recommends that the site developer/designer prepare a simple operations and maintenance plan for the site's stormwater quality and flood control facilities in accordance with UDFCD guidelines, so that maintenance may be carried on in perpetuity.

Principle 7: Design and maintain facilities with public safety in mind.

One of the highest priorities of engineers and public officials is to protect public health, safety, and welfare. Stormwater quality facilities must be designed and maintained in a manner that does not pose health or safety hazards to the public. For the purpose of this discussion, public safety issues are categorized according to public access issues and mosquito/West Nile virus concerns.

Public Access and Safety

- **Pond Edges:**
  - Create safe pond edges with gradually sloping banks within 10 to 20 feet of shoreline
  - Reduce perimeter wall heights as much as practicable
  - Include railings on vertical drops of 30 inches or more (check with City building code)
  - Locate facilities with steep sides away from major pedestrian routes
  - Provide an emergency egress route

- **Visibility**: Avoid walled-in or steeply sloped, remote ponds that provide hiding places for illicit activity. Consider the need for site lighting.

- **Outlet**: Utilize trash/safety rack in accordance with UDFCD design guidance.

Mosquitoes and West Nile Virus

The West Nile virus first appeared in the U.S. in 1999. Dozens of cases of West Nile virus were documented in Colorado during the summer of 2003. Because the virus is spread by mosquitoes that breed in shallow standing water, it is important that stormwater BMPs that detain or retain water are managed properly to avoid serving as breeding grounds for mosquitoes, which pose both health and nuisance issues. BMP designs that reduce the likelihood and extent of shallow standing water should be implemented. If shallow standing water is unavoidable in publicly owned facilities, Denver Department of Environmental Health, Division of Animal Control officials should be notified so that the area can be routinely treated. Owners of privately owned facilities are responsible for treating their facilities, unless extreme circumstances exist.

An important note with regard to BMP selection and mosquitoes is that according to the EPA, healthy wetlands and wetland BMPs are not considered uncontrolled mosquito breeding grounds due to the fact that wetland ecosystems contain numerous fish, insects, amphibians, and birds that feed on mosquitoes (EPA 2003). Moreover, the mosquito species primarily responsible for West Nile virus transmission do not prefer to reproduce in healthy wetlands; instead, they tend to breed in a variety of locations such as abandoned tires, birdbaths, roof gutters, and other artificial containers that lack wetland predators. They are also found in highly polluted environments, contaminated water, and degraded wetlands; therefore, stormwater BMPs and properly designed wetlands can reduce habitat that is suitable to mosquitoes that carry the West Nile virus (EPA 2003). Denver's *Lake Management and Protection Plan* (Dudley 2004) is consistent with EPA's perspective on the West Nile virus and further notes that properly designed wetlands can be an essential part of a healthy, well-balanced lake ecosystem.

Stormwater Quality Design Process

The four-step design process in Volume 3 has become the cornerstone of the Urban Drainage and Flood Control District's (UDFCD's) approach to selecting and implementing BMPs.

1. Reduce runoff volume to the maximum extent practicable.

2. Control the remaining (residual) runoff through BMPs that have the necessary water quality capture volume, with appropriate reduction "credits" for steps taken to reduce runoff volume.

3. Utilize stream channel stabilization techniques for drainageways on, or adjacent to, the site.

4. If a site includes potential pollutant sources, provide additional treatment, including covering of storage/handling areas, spill containment and control, and other best available technologies.

These guidelines deal primarily with the first two steps. Information on stream channel stabilization resources may be found in the BMP Fact Sheets of this chapter and in Volumes 1 and 3 of the *Urban Storm Drainage Criteria Manual* (UDFCD 1999, 2001).

The following process expands on the four steps to create a workable method for addressing stormwater quality and flood control requirements on a site.

1. **Create attractive facilities that add value to the site**. While most designers focus on providing a functional stormwater management system for a site, they should also configure and detail the stormwater system to create an aesthetically pleasing facility. Effective integration of landscape elements and the stormwater system can enhance a project and the community.

2. **Develop an initial site design**.

    - Identify a rough layout of lots, buildings, streets, parking, and landscape areas with a general idea of proposed site grades.

    - Estimate approximate areas associated with roofs, streets, walks, parking lots, and landscaping or open space.

3. **Consider the full range of BMP alternatives**. The stormwater facilities shown in the Development Type Guidelines provide examples of appropriate BMPs for a variety of land uses.

    - Determine which of the seven Development Types in Exhibit 6.6 most closely match the site.

    - Consider the full range of alternative approaches for addressing drainage and stormwater quality for the site, including techniques to reduce runoff and distribute BMPs throughout the site.

    - Test the influence of several alternatives on the overall character and layout of the site, weigh pros and cons of each, and progress towards an optimum approach.

    - Consider long-term or life-cycle costs in the selection of alternative BMPs. These can be assessed by consulting references that discuss life-cycle costs of BMPs

(EPA 1999; Heaney et al. 2002; Watershed Management Institute 1997; Stormtech 2003), or by developing opinions of probable cost for the construction and maintenance of specific BMP alternatives for the site.

- When selecting and designing BMPs that provide for infiltration (i.e., grass buffers and swales, porous pavement detention, porous landscape detention, and sand-filter detention), the designer needs to carefully consider geotechnical and foundation issues and the ability of the property owner to understand and properly maintain these facilities.

4. **Pursue a functional distribution of landscape areas**. Keep detention basins shallow and provide some space for tree and shrub plantings.

    - Provide an area about 10 to 15 percent of the size of the impervious area for stormwater quality treatment. This area may be reduced in later stages of design (e.g., porous pavement detention can usually comprise 25 to 35 percent of the impervious area.)

    - Minimize the number of extended detention basins. When included, locate them near a low-lying area of the site away from pedestrian corridors and gathering places.

    - Porous landscape and porous pavement detention areas should be more numerous, and distributed throughout the site. The Implementation Details section of this chapter shows several examples of how porous landscape detention facilities can be configured adjacent to buildings, in parking lots, and in other landscape areas. In general, it is prudent to locate porous landscape detention in close proximity to the impervious area being served.

5. **Consider surface conveyance as an alternative to pipes**.

    - Consider how runoff will be conveyed to stormwater quality facilities. Conveying flows on the surface is the best method for getting runoff to porous landscape and porous pavement detention because it allows the facilities to be shallow in depth. If flow can be conveyed on the surface in grass swales or in strips of porous pavement, additional stormwater quality benefits will accrue and the required water quality capture volume will be reduced.

    - If runoff must be conveyed under the surface in a pipe, area inlets within a landscaped area are preferred over street or curb inlets, since this gives runoff a chance to sheet flow through vegetation and infiltrate prior to entering the storm sewer. The basin or channel receiving these flows must be deep enough to allow the opposite end of the pipe to empty.

6. **Integrate flood control detention**. Multiple approaches exist for addressing flood control detention that dovetail with stormwater quality management.

- Locate flood control detention in landscape areas and in parking lots.
- Retaining walls that fully enclose a landscape detention area are unacceptable as they create a deep basin without adequate access.

7. **Tailor approach to the specific pollutants of concern**. If downstream receiving waters are threatened by any specific stormwater constituents, such as lakes threatened by excessive phosphorus loading leading to eutrophication, provide BMPs that are particularly effective at addressing that pollutant.
   - The *Denver Lake Management and Protection Pla*n (Dudley 2004) is a good source of information on lakes in the Denver area.
   - Table SQ-6 of Volume 3 provides information on the estimated performance of various BMPs with regard to specific pollutants.
   - The International Stormwater BMP Database (www.bmpdatabase.org) provides good information on the performance of BMPs in various settings and provides data on the effluent quality that may be achieved by various BMPs.

How to Use the Guidelines

These Stormwater Quality BMP Implementation Guidelines are organized in four sections:

1. **Development Type Guidelines.** Guidelines for implementing stormwater quality treatment systems for seven representative land use types are presented. The BMPs shown are tailored to the nature of the particular development type. Use these as a general guide to developing an overall stormwater quality plan. It may be appropriate to combine concepts from two or more development types to address the specific goals or characteristics of a project.
2. **Implementation Details.** Detailed guidance on how to integrate BMPs into a site. Implementation Details relevant to individual Development Types are referenced in the Development Type Guidelines.
3. **BMP Fact Sheets.** Essential planning information for each stormwater quality BMP is summarized on Fact Sheets, including a description of the BMP, a representative illustration, guidance for specific site conditions and requirements, and example images of constructed BMPs.
4. **Maintenance.** Maintenance methods designed to ensure its continued occurrence, as well as required practices for maintenance of each BMP are discussed at the end of this chapter.

DEVELOPMENT TYPE GUIDELINES

Seven development types have been identified to communicate different strategies for stormwater quality treatment. (See Exhibit 6.6, next page). They are:

- Ultra Urban
- High Density Mixed Use
- Campus
- Industrial
- Low Density Mixed Use
- Residential
- Parks and Natural Areas Open Space

The development types evolve from the city "building blocks" defined in *Blueprint Denver,* which is an integrated land use and transportation plan for Denver. As an example, the Ultra Urban development type represents development characteristics of the Downtown, Employment, and Urban Residential building blocks. Because dense developments have been a challenging arena for water quality, they are a main focus of these guidelines. These Development Type Guidelines describe typical characteristics for each development type, as well as potential sites for stormwater quality treatment. Design recommendations have been developed for each that cover these four topics:

1. <u>Runoff Reduction:</u> Techniques that decrease runoff volume and reduce the Water Quality Capture Volume (WQCV) requiring treatment.
2. <u>WQCV Treatment:</u> BMPs that treat the required volume of storm runoff. The BMPs most appropriate for the various sites are summarized in Exhibit 6.7
3. <u>Flood Detention:</u> Methods for attenuating peak runoff from larger storm events on site.
4. <u>Implementation Details</u>: Additional details for specific portions of a site.

Within each topic, the user is directed to additional information on Implementation Details or BMP Fact Sheets in sections following the Development Type Guidelines. Availability of this additional information is indicated by the use of bold text (e.g., **green roof**). A sketch diagram shows how some of the design recommendations may be implemented on a representative site, and additional details and photographs further describe treatment options. These guidelines are recommendations only; the designer may choose to mix and match approaches from different development types to best meet the needs of a particular project.

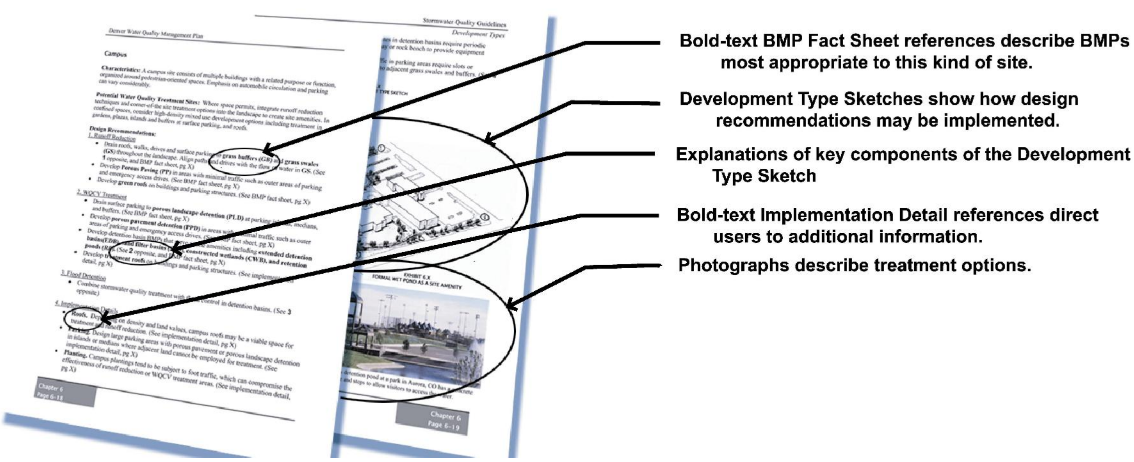


EXHIBIT 6.6 DEVELOPMENT TYPES SUMMARY						
Development Type	**Percentage Landscape**	**Percentage Parking/Paving**	**Building Footprint**	**Parking**	**Blueprint Denver Building Block**	**Examples**
Ultra Urban	0-5%*	0-5%	90-100%	structure	Downtown	LODO
					Employment	Portions of Stapleton and Lowry
					Urban Residential	Capitol Hill
High Density Mixed Use	0-10%*	0-15%	80-90%	structure/ surface	Pedestrian Shopping Corridor	East Colfax Grant-York
					Mixed Use Residential	Golden Triangle
					Transportation Oriented Development (TOD)	Colorado Station (at I-25)
					Neighborhood Centers	Old South Gaylord
Campus	15-30%	10-25%	45-75%	surface/ structure	Campus/Institutional	Auraria, Tech Center
Industrial	10-15%	40-60%	25-50%	surface	Industrial	I-70 Corridor
Low Density Mixed Use	10-25%	30-50%	25-60%	surface	Town Centers	14th and Krameria
					Commercial Corridor	South Colorado Blvd., Colfax
					Regional Centers	University Hills Shopping Center
					Entertainment/Cultural/ Exhibition	Natl. Western, Pepsi Center
Residential	40-70%	5-20%	10-45%	surface	Single Family/Duplex Residential	City Park West Neighborhood
					Single Family Residential	Sloan's Lake Neighborhood, Regis Neighborhood
Parks and Natural Areas Open Space	80-95%	5-15%	0-10%	surface	Parks and Natural Areas Open Space	City Park

* The low percentage of landscape does not preclude the use of porous pavement detention or "planter box" porous landscape detention to provide treatment for the water quality capture volume on Ultra Urban or High Density Mixed Use sites.

EXHIBIT 6.7
BMP APPLICABILITY MATRIX

	Runoff Reduction		Stormwater Quality Detention				Possible Flood Control Detention[5]	
Development Type	Porous Pavement[1]	Grass Buffers and Swales	Porous Landscape Detention[2]	Porous Pavement Detention[1]	Dry Ponds: Extended Detention and Sand Filter Basins[3]	Wet Ponds: Constructed Wetland Basin and Retention Ponds [4]	Landscape Areas	Parking Lots
Ultra Urban								
High Density Mixed Use								
Campus								
Industrial								
Low Density Mixed Use								
Residential								
Parks and Natural Areas Open Space								

KEY	
	Highly applicable
	Somewhat applicable
	Not recommended

Notes:

1. Porous pavement and porous pavement detention may be used in parking areas and other low-use areas where there is no likelihood of groundwater contamination.
2. Porous landscape detention may be applied in the vicinity of buildings, in parking lot islands, and in other landscape areas where there is no likelihood of groundwater contamination or geotechnical concerns. Wherever porous landscape detention is used, geotechnical issues related to building foundation drainage and expansive soils must be addressed.
3. To avoid constrained configurations of forebays, low-flow channels, and outlet structures, extended detention basins are generally recommended only for drainage areas exceeding 1.0 acre, although sand-filter detention basins may be used for areas less than 1.0 acre. Sand-filter detention basins may be considered for use in Ultra Urban and High Density Mixed Use land uses.
4. Constructed wetland basins and retention ponds may only be used for drainage areas exceeding 1.0 acre that have sufficient base flow to support wetlands and permanent pools; water rights considerations need to be addressed.
5. The use of underground vaults for water quality detention is discouraged; however, Denver will consider the use of underground vaults for flood control. Denver's policy on the use of subsurface devices for stormwater quality is discussed in the section entitled Subsurface Treatment Devices in this chapter.

Ultra Urban

Characteristics: Ultra Urban sites are characterized by structured or underground parking, high to mid-rise buildings, and little to no landscape area at grade—most landscape is over structure. Buildings occupy up to 100% of the site. These sites will typically have 5-10% open area as paving or landscape area.

Potential Stormwater Quality Treatment Sites: Area for treatment is limited to roofs, plazas, and courtyards. Treatment generally occurs over or adjacent to buildings in contained systems or planters that drain to the storm sewer.

Design Recommendations:

<u>1. Runoff Reduction</u>

- Develop **green roofs** on buildings and parking structures. (See Implementation Details)
- Develop **porous pavement** in plazas and courtyards. (See BMP Fact Sheet)

<u>2. WQCV Treatment</u>

- Develop treatment roofs on buildings and parking structures. (See Implementation Details)
- Drain roofs to **porous landscape detention** in planters adjacent to buildings. (See note **1** opposite page, and BMP Fact Sheet)
- Drain roofs to **porous pavement detention** or **porous landscape detention** in plazas and courtyards.(See notes **2, 4** opposite page, and BMP Fact Sheets)

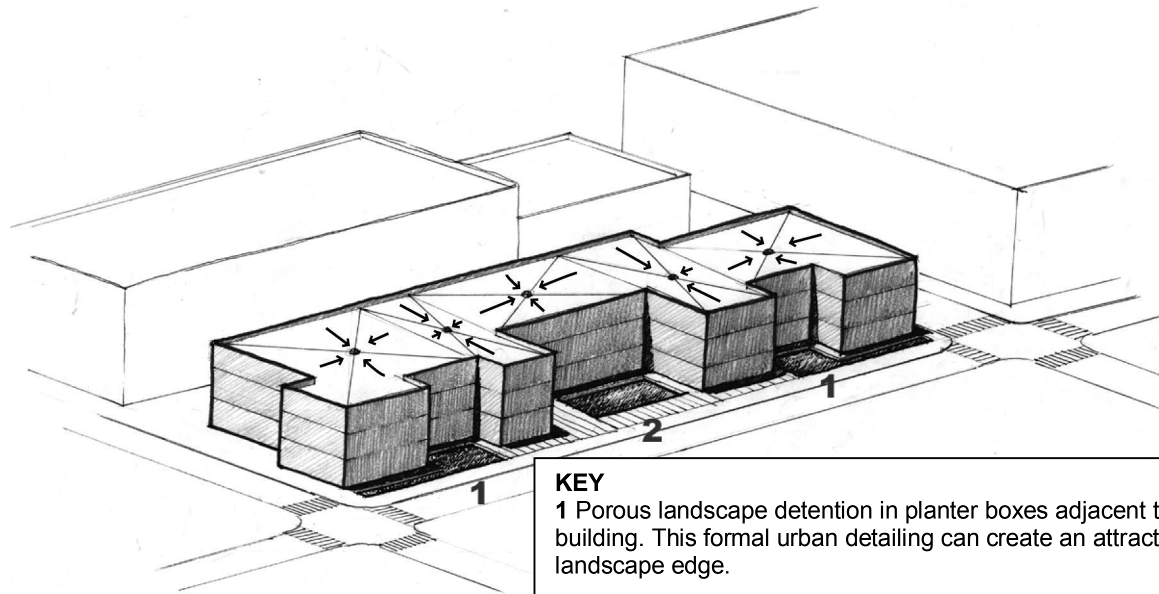
<u>3. Flood Detention</u>

- Direct roof runoff to porous landscape detention. Convey flows in excess of WQCV to below-grade vaults or directly to storm sewers. (See note **3** opposite page)

<u>4. Implementation Details</u>

- **Roofs.** Route drainage from tall buildings through the building. Include on-roof runoff reduction and treatment that can be cost effective on these sites. (See Implementation Detail)
- **Planting.** Provide additional support for plants in urban settings where they are subject to the additional stresses of heat and restricted growing area. (See Implementation Detail)
- **Sediment removal.** Provide for the removal of sediment loads that come from roof runoff, construction, and street maintenance. (See Implementation Detail)

EXHIBIT 6.8
ULTRA URBAN DEVELOPMENT TYPE SKETCH AND ENLARGEMENT



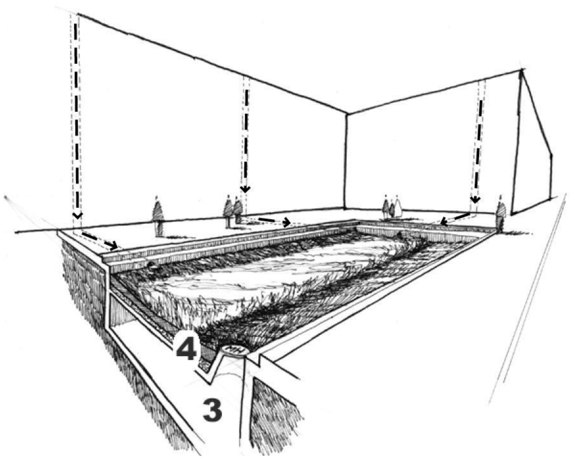
KEY

1 Porous landscape detention in planter boxes adjacent to the building. This formal urban detailing can create an attractive landscape edge.

2 Porous landscape detention in courtyard. (see enlargement below)

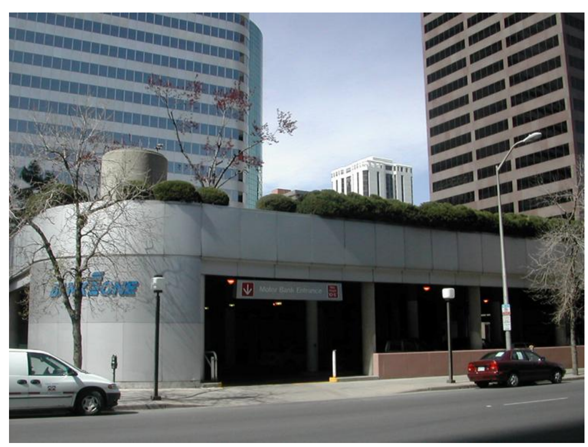
3 Flood storage for 100-year storm in a below-grade vault with adequate maintenance access. (see enlargement below)

4 Porous landscape detention cross section showing planted growing medium with gravel below, contained within a concrete structure and underdrain to address geotechnical concerns around structural foundations. (see enlargement below)



Porous landscape detention in a sunken courtyard garden receives roof runoff from the adjacent courtyard and from pipes or chases penetrating below the first floor.

EXHIBIT 6.9
TYPICAL ULTRA URBAN SITE IN DOWNTOWN DENVER



Porous landscape detention can be integrated into parking garages and other structures such as green roofs. Green roofs can also reduce the storage volume needed.

High Density Mixed Use

Characteristics: High Density Mixed Use sites are characterized by multi-story development with both structured and surface parking. Buildings typically have setbacks from property lines, but rarely more than 5-10 feet on any side. Open space typically consists of paving with some landscape, and accounts for 0-15 percent of the site.

Potential Stormwater Quality Treatment Sites: Treatment may be provided on roofs; plazas; courtyards; islands, buffers, and medians at surface parking; and gardens. Landscape areas may be used to infiltrate stormwater into the ground with sufficient distance from the buildings (consult a geotechnical engineer).

Design Recommendations:

1. Runoff Reduction

- Develop **green roofs** on buildings and parking structures. (See Implementation Detail)
- Develop **porous pavement** in plazas and courtyards. (See BMP Fact Sheet)
- Drain roofs to **grass buffers** or **grass swales** in gardens or planters.
- Drain surface parking to **grass buffers** or **grass swales** at islands and perimeters within parking area. (See BMP Fact Sheets)
- For public projects or privately owned and maintained streets, provide a depressed, continuous planted strip between the sidewalk and the street.

2. WQCV Treatment

- Develop **treatment roofs** on buildings and parking structures. (See note **1** opposite page)
- Develop **porous pavement detention** in plazas and courtyards. (See note **2** opposite page, and BMP Fact Sheet)
- Drain roofs to **porous landscape detention** in gardens or planters. (See note **3** opposite page, and BMP Fact Sheet)
- Drain surface parking to **porous landscape detention** at parking islands, medians, and buffers. (See BMP Fact Sheets)

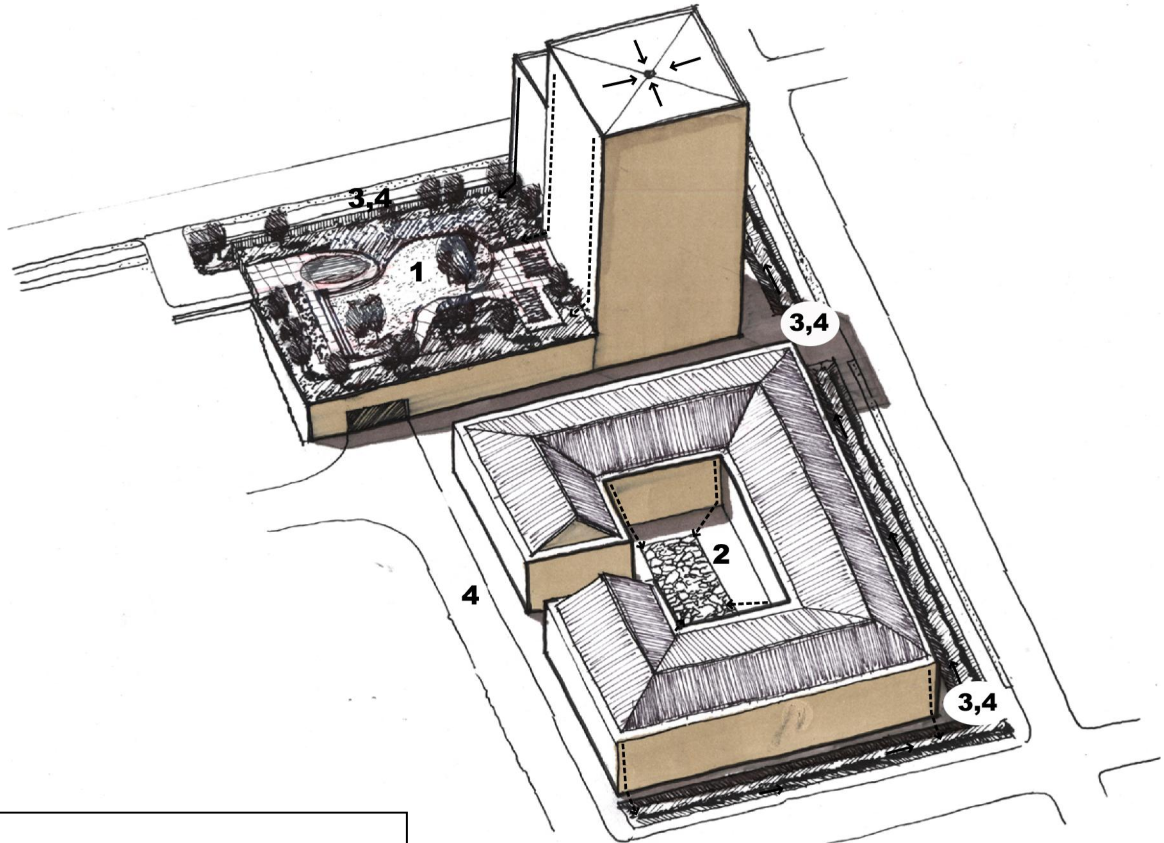
3. Flood Detention

- Flood water storage may be combined with stormwater quality treatment areas, provided in paved areas or roadways, or in below-grade vaults. (See note **4** opposite page)

4. Implementation Details

- **Roofs.** Route roof runoff through the building or through external downspouts. (See Implementation Detail)
- **Parking.** Include parking on the surface, in a structure, or in some combination of both. (See Implementation Detail)
- **Planting.** Provide plants with regular water and nutrients in urban settings where they are subject to the additional stresses of heat and restricted growing area. (See Implementation Detail)
- **Sediment removal.** Provide for removal of sediment loads, which are primarily from roofs, except where plaza areas and surface parking contribute pollutant loads and debris.

EXHIBIT 6.10
HIGH DENSITY MIXED USE DEVELOPMENT TYPE SKETCH



KEY

1 This green roof above the underground parking structure treats runoff from the structure itself as well as roof runoff from the adjacent high-rise building. At-grade vehicle access is provided to facilitate maintenance.

2 Porous pavement detention is provided on a sandstone patio in the courtyard that treats some of the WQCV from the roof.

3 Porous landscape detention treats roof runoff, and wraps around three sides of the building.

4 Flood storage for the 100-year storm is provided above the porous landscape detention areas in the landscape surrounding the building, and within the adjacent roadway.

EXHIBIT 6.11
GREEN ROOF PARKING STRUCTURE IN DENVER

The “green roof” water treatment and plantings on this at-grade and underground parking structure can be accessed easily for maintenance.

Campus

Characteristics: A campus site consists of multiple buildings with a related purpose or function, organized around pedestrian-oriented spaces. Emphasis on automobile circulation and parking can vary considerably.

Potential Stormwater Quality Treatment Sites: Runoff reduction techniques, infiltration techniques, and WQCV detention options can be integrated into the landscape to create site amenities where space permits. Strategies shown in the High Density Mixed Use Development Type Guidelines are also appropriate for confined spaces on campuses, including treatment in gardens, plazas, islands and buffers at surface parking, and roofs.

Design Recommendations:

1. Runoff Reduction

- Drain roofs, walks, drives and surface parking to **grass buffers** and **grass swales** throughout the landscape. Locate **grass swales** along paths and drives. (See note **1** opposite page, and BMP Fact Sheets)
- Develop **porous pavement** in areas with minimal traffic such as outer areas of parking and emergency access drives. (See note **2** opposite page, and BMP Fact Sheet)
- Develop **green roofs** on buildings and parking structures. (See Implementation Detail)

2. WQCV Treatment

- Drain surface parking to **porous landscape detention** at parking islands, medians, and buffers. (See BMP Fact Sheet)
- Develop **porous pavement detention** in pedestrian areas or areas with minimal traffic such as outer areas of parking and emergency access drives. (See BMP Fact Sheet)
- Develop detention basin BMPs that serve as site amenities including **extended detention basins, sand filter basins, constructed wetlands,** and **retention ponds.** (See note **3** opposite page, and BMP Fact Sheets)
- Develop **treatment roofs** on buildings and parking structures. (See Implementation Detail)

3. Flood Detention

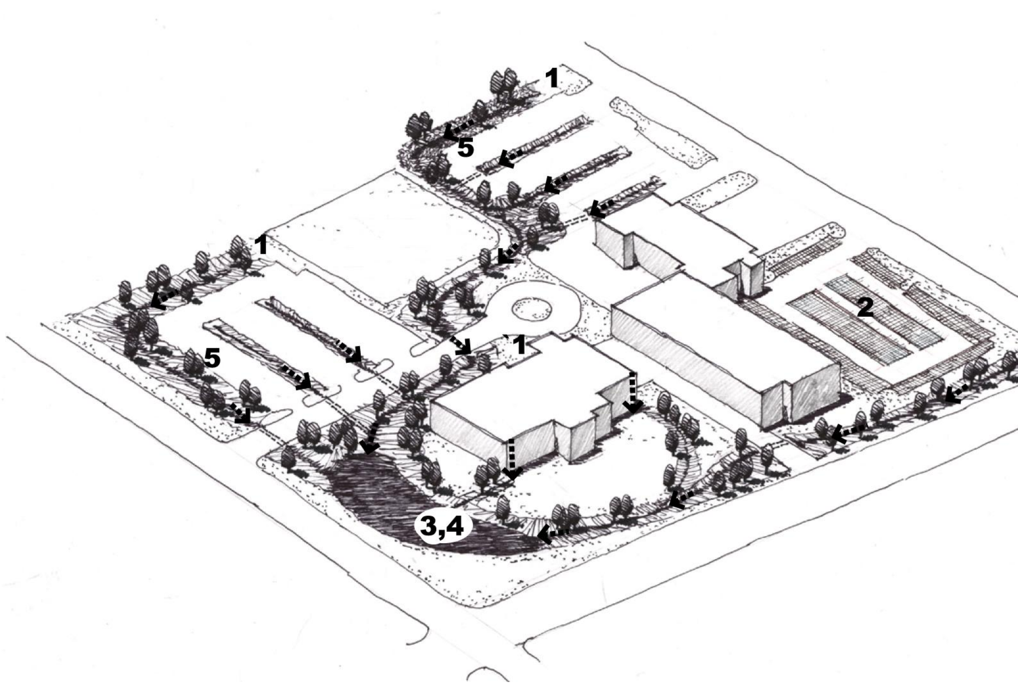
- Combine stormwater quality treatment with flood control in detention basins. (See note **4** opposite page)

4. Implementation Details

- **Roofs.** Include treatment and runoff reduction on campus roofs where density and land values make them viable. (See Implementation Detail)
- **Parking.** Design large parking areas with porous pavement and porous landscape detention in islands or medians where adjacent land cannot be employed for treatment. (See Implementation Detail)
- **Planting.** Consider foot traffic patterns when locating and selecting plantings for runoff reduction and WQCV treatment areas. (See Implementation Detail)

- **Sediment removal.** Provide for periodic removal of sediment that accumulates in detention basins. Include a concrete forebay or rock bench to provide equipment access. (See Implementation Detail)
- **Stormwater Distribution.** Include slots or interruptions in curbs that control traffic in parking areas to disperse runoff as it flows to adjacent grass swales and buffers. (See note **5** opposite page, and Implementation Detail)

EXHIBIT 6.12
CAMPUS DEVELOPMENT TYPE SKETCH



KEY
1 Grass buffers and swales receive runoff from parking and paving throughout campus, and direct it to detention pond.

2 Porous pavement detention in an overflow parking area treats runoff on the paved area.

3 This wet pond serves as a campus amenity, supporting a diverse ecology and treating runoff.

4 The wet pond also serves as flood storage for the100-year storm.

5 Slotted curbs disperse runoff flowing from parking areas.

EXHIBIT 6.13
NATURALISTIC WET POND AS A SITE AMENITY

The detention area adjacent to Goldsmith Gulch in southeast Denver is spanned by a boardwalk.

EXHIBIT 6.14
FORMAL WET POND AS A SITE AMENITY

This detention pond at a park in Aurora has a concrete edge and steps to allow visitors to access the water. The pond also serves as a water source for site irrigation.

Industrial

Characteristics: Industrial sites consist of one or more large structures surrounded by surface parking and truck access areas. Open area is predominantly paved and accounts for up to 90 percent of the site. Sites include manufacturing, gas stations, car dealerships, and warehouses. Point source pollution can be an issue on industrial sites.

Potential Stormwater Quality Treatment Sites: Treatment occurs in islands and perimeters at surface parking. Large buildings with flat roofs are potential sites for green roofs or treatment areas. Corner-of-the-site treatment options may include limited use of retaining walls that minimize the basin's footprint, but still provide for maintenance access. These sites require care to reduce the likelihood of commingling industrial chemicals with stormwater—stormwater contaminated by industrial chemicals manufactured or stored on site must be treated separately and cannot be infiltrated.

Design Recommendations:

1. Runoff Reduction

- Drain roofs to **grass buffers** at parking islands, medians, and buffers. (See BMP Fact Sheet)
- Sheet-drain parking to **grass buffers** and **grass swales.** (See note **1** opposite page, and BMP Fact Sheets)
- Develop **porous pavement** in low-traffic areas and places where trailers or equipment are stored. (See BMP Fact Sheet)
- Where structures do not create an edge at or near the property lines, develop continuous **grass buffers**. (See BMP Fact Sheet)

2. WQCV Treatment

- Drain runoff to **porous landscape detention** at parking islands, medians, and buffers. (Seen note **2** opposite page, and BMP Fact Sheet)
- Develop **porous pavement detention** in areas with minimal traffic such as outer areas of parking and emergency access drives. (See BMP Fact Sheet)
- Develop detention basin BMPs including **extended detention, sand filter basins, constructed wetlands, and retention ponds**. (See note **4** opposite page, and BMP Fact Sheets)
- Incorporate covering of storage, manufacturing and loading areas, spill containment, and prevention of groundwater contamination.

3. Flood Detention

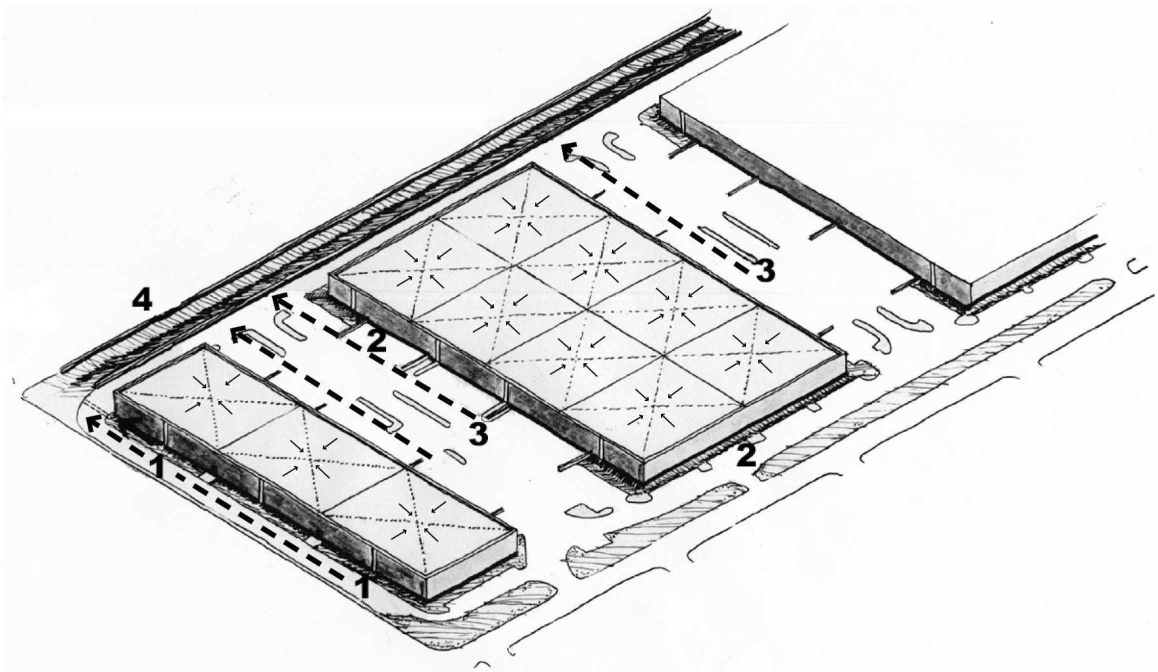
- Provide flood detention within parking areas without creating a hazard at loading areas. (See notes **3** and **4** opposite page)

4. Implementation Details

- **Parking.** Break up extensive parking areas with porous pavement detention or porous landscape detention without creating a hazard at loading docks. (See Implementation Detail)

- **Planting.** Where the site is contiguous with open space buffers, develop plantings that create a smooth transition between these spaces. (See Implementation Detail)
- **Stormwater Distribution.** Sheet-drain large areas of paving to landscape, or spread flows with slotted curbs or level spreaders. (See Implementation Detail)

EXHIBIT 6.15
INDUSTRIAL DEVELOPMENT TYPE SKETCH



KEY
1 Grass swales receive roof runoff from downspouts and direct it towards the detention basin at the back of the site, reducing runoff and removing large sediment.

2 Porous landscape detention receives and treats runoff from portions of the roof in the front and back of the building, and creates a landscape amenity.

3 Roof runoff in excess of the WQCV flows through roof downspouts directly to storm sewers and along to the detention basin.

4 A linear detention basin at the back of the site treats the WQCV and detains flood water.

5 Cover storage areas to prevent contaminated runoff. (not shown)

EXHIBIT 6.16
LINEAR DETENTION POND AT AN INDUSTRIAL SITE

The linear form of this detention pond at an industrial park in Denver follows the street edge, creating a significant landscape buffer.

Low Density Mixed Use

Characteristics: Low Density Mixed Use sites consist of commercial, office, event-oriented, or residential structures organized by automobile circulation and parking with some pedestrian-oriented spaces and walkways. This typical big-box pattern includes extensive parking areas that account for more than half the site.

Potential Stormwater Quality Treatment Sites: Treatment occurs in islands, buffers, and medians at surface parking lots, lawns, plazas, courtyards, and gardens. Parking areas can be designed to both treat the WQCV and store flood volumes for the runoff they generate. Corner-of-the-site treatment options can serve as an amenity along major roads, or be included in unobtrusive portions of the site. Greater area is available for runoff reduction and treatment landscapes when parking requirements are combined for multiple buildings.

Design Recommendations:

1. Runoff Reduction

- Drain roofs to **grass buffers** in gardens, planters, or parking islands, medians, and buffers. (See BMP Fact Sheet)
- Develop **porous pavement** in low traffic areas, including driveways and portions of parking lots. (See BMP Fact Sheet)
- Sheet drain parking to **grass buffers** and **grass swales**. (See BMP Fact Sheets)
- Where structures do not create an edge at or near the property lines, develop continuous **grass buffers**. (See BMP Fact Sheet)

2. WQCV Treatment

- Develop **porous pavement detention** in areas with minimal traffic, such as outer areas of parking and emergency access drives. (See note **1** opposite page, and BMP Fact Sheet)
- Drain surface parking to **porous landscape detention** at parking islands, medians, and buffers. (See notes **2, 3, 4** opposite page, and BMP Fact Sheet)
- Where space permits, develop detention basin BMPs at site low points to facilitate gravity flow to them. These include **extended detention basins, sand filter basins, constructed wetlands, and retention ponds**. (See note **5** opposite page, and BMP Fact Sheet)

3. Flood Detention

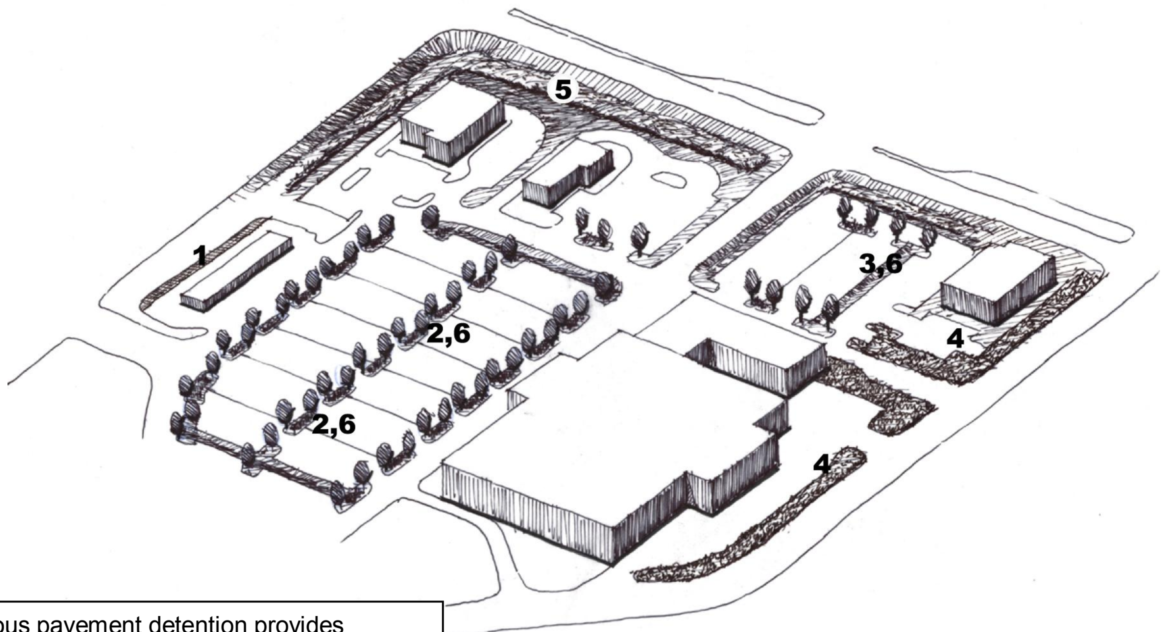
- Design parking areas and landscapes to accommodate their own treatment and flood detention requirements. Include shallow paving depressions of less than nine inches in parking lots to detain flood volumes. (See note **6** opposite page)

4. Implementation Details

- **Roofs.** Consider treatment roofs on the large roofs of big-box retail. (See Implementation Detail)
- **Parking.** Include treatment areas for the runoff parking areas generate. (See Implementation Detail)
- **Planting.** Separate trees from porous landscape detention areas so the planting medium may be periodically replaced without impacting tree roots. (See Implementation Detail)

- **Planters.** Provide raised or sunken contained planting spaces adjacent to buildings. (See Implementation Detail)
- **Stormwater Distribution.** Use slotted curbs or flush curbs and wheel stops to separate vehicles from landscape areas while allowing runoff to flow without concentrating. (See Implementation Detail)
- **Sediment Removal.** Provide for periodic removal of the sediment deposited by vehicles. (See Implementation Detail)

EXHIBIT 6.17
LOW DENSITY MIXED USE DEVELOPMENT TYPE SKETCH



1 Porous pavement detention provides treatment in a seldom-used area of parking.

2 Porous landscape detention in parking islands treats runoff from surrounding parking.

3 Porous landscape detention in parking medians treats runoff from surrounding parking.

4 Porous landscape detention adjacent to paved areas receives and treats runoff.

5 An extended detention basin at the low end of the site provides treatment for runoff from roofs and other paved surfaces.

6 Grading adjacent to and within parking and paved areas allows100-year storm to be stored within those areas.

EXHIBIT 6.18
PARKING MEDIAN IN DENVER, CO

A flush curb along this parking median allows stormwater to flow into this swale and move to an extended detention area.

Residential

Characteristics: The Residential development type is characterized by residential structures lining a roadway. Typical development patterns include open areas in the front and back of each structure, as well as communal open space.

Potential Stormwater Quality Treatment Sites: The focus in this development type is on reducing runoff from homes. Yards and gardens surrounding each structure or group of structures receive runoff from roofs as well as paved walks and drives.

Design Recommendations:

1. Runoff Reduction

- Drain roofs to **grass buffers** and **grass swales** in gardens and yards. (See note **1** opposite page, and BMP Fact Sheets)
- Drain driveways, walks and patios to adjacent **grass buffers** either directly or through slot drains or porous pavement. Provide sufficient slope and/or a ledge between the pavement and the landscape to accommodate future thatch buildup on lawns. (See note **2** opposite page, and BMP Fact Sheet)
- Construct driveways and parking aprons using **porous pavement**. (See note **3** opposite page, and BMP Fact Sheet)
- Public Space: In appropriate neighborhoods with rural character, develop roadside **grass swales** with or without curbs. Allow swales to drain frequently to open space areas or storm sewers to maintain shallow swales. (See BMP Fact Sheet)

2. WQCV Treatment

- In parks, greenways, or open space, develop **porous landscape detention** to treat runoff from adjacent areas. (See BMP Fact Sheet)
- In parks, greenways, or open space within residential areas, develop detention basin BMPs, including **extended detention**, **sand filter basins**, **constructed wetlands**, and **retention ponds** to serve larger tributary areas. (See BMP Fact Sheet)

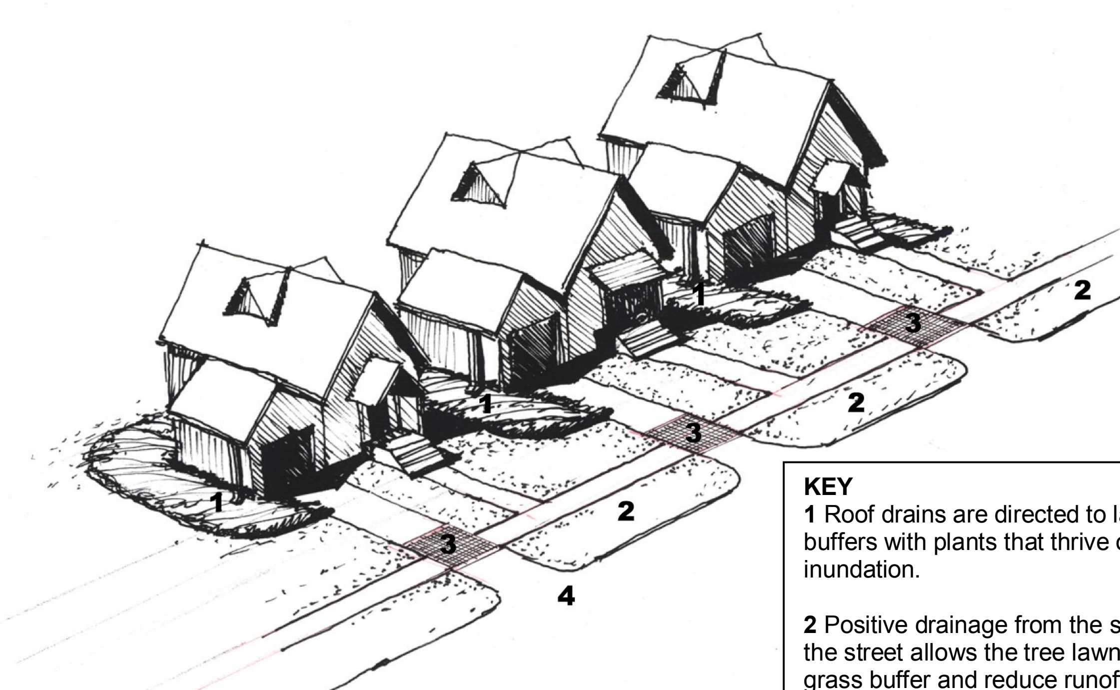
3. Flood Detention

- Locate residences at an elevation to accommodate the 100-year storm event within the adjacent roadway. (See note **4** opposite page)

4. Implementation Details

- **Roofs.** Drain roofs to adjacent landscape to reduce runoff. Avoid storing water on foundation soils at the building perimeter. (See Implementation Detail)
- **Planting.** Design gardens and planting beds to accommodate and thrive on runoff from roofs and paving. (See Implementation Detail)
- **Stormwater Distribution.** Direct runoff to roadside swales with curbless streets. (See Implementation Detail)

EXHIBIT 6.19
RESIDENTIAL DEVELOPMENT TYPE SKETCH



KEY

1 Roof drains are directed to landscape buffers with plants that thrive on periodic inundation.

2 Positive drainage from the sidewalk to the street allows the tree lawn to act as a grass buffer and reduce runoff.

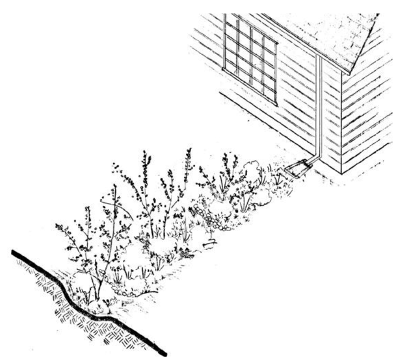
3 Porous pavement at the lower quarter of each driveway allows runoff to infiltrate.

4 Flood storage for the100-year storm is provided in downstream landscape areas. (not shown)

EXHIBIT 6.20
RESIDENTIAL AREA OF MINNEAPOLIS, MN

Roads and drives drain to an adjacent rain garden planted with species that thrive on the additional moisture while reducing runoff from the neighborhood.

EXHIBIT 6.21
SKETCH OF ROOF DRAIN PLANTINGS



The garden at the outlet from a house roof drain includes plants that thrive on the additional moisture flowing from the roof. Turfgrass is also a good recipient of roof runoff. Source: *City of Portland 2002 Stormwater Management Manual.*

Parks and Natural Areas Open Space

Characteristics: Due to the minimal amount of impervious area in parks, supplemental efforts to reduce runoff are rarely required. In fact, Denver Parks and Natural Areas Open Space may efficiently serve to treat runoff from surrounding areas if approved by the Parks Department; however, this practice must preserve the quality of park features and programmed uses. In particular, park lakes are of concern because they serve as both park amenities and receiving waters (see Chapter 4). Parks with high intensity use, like sports facilities, may have significant areas of surface parking runoff requiring treatment.

Potential Stormwater Quality Treatment Sites: The public nature of park spaces creates a tremendous opportunity for reducing and treating runoff at a regional level. Stormwater quality facilities are best included in parks larger than 10 acres, where they do not take up more than a third of the total park area, and can be combined with other park uses. Facilities should only be included in smaller parks when they are considered early in the public design process. Treatment facilities cannot be combined with active recreation areas like sports fields. Potential regional stormwater quality facilities within parks are identified in Chapter 8. There are more opportunities for integrating stormwater quality treatment in new parks whereas existing parks may not be able to accommodate these features.

Criteria for the Use of Parks as Stormwater Treatment Sites: Consider the following in determining a park's feasibility as a stormwater treatment site:

- Compatibility with design, historic designation or other protective constraints including wildlife habitat and protection. (e.g., Washington Park is a federal historic landmark. Because of this, significant changes to the shape or size of its two major lakes would not be permitted as that would impact the park's character.)
- Compatibility with recreational uses. The level of organized and informal activity in a park must be considered.
- Technical constraints and opportunities including soil characteristics, turf management, or terrain.
- Potential for new natural areas and wildlife corridors.
- Size and configuration of the park. A small neighborhood park under five acres would probably not be appropriate for a water quality facility.
- Maintenance and operations, funding resources, successful techniques for dealing with silt, debris, etc.
- The configuration and easements for underground utilities and their impact on the existing park land.
- Potential for total rehabilitation of existing sites to accommodate multi-purpose uses.
- Impacts on all aspects of the open space system: Highline Canal and trails, South Platte River Greenway, natural areas including potential areas such as along gulches, traditional parks, and other publicly owned lands.

Design Recommendations:

1. Runoff Reduction

- Sheet-drain parking and paving to **grass buffers** and **grass swales**.(See note **1** opposite page, and BMP Fact Sheets)
- Drain roofs to **grass buffers**, **grass swales,** and **porous pavement**. (See BMP Fact Sheets)
- Develop multi-purpose trails, maintenance routes, and parking areas to minimize directly connected impervious areas. Avoid concentrating runoff from roadways and parking lots by allowing runoff from those areas to sheet drain over landscape areas.
- Use **porous pavement** to the maximum extent practicable for parking areas, patios, trails, etc. (See BMP Fact Sheet)

2. WQCV Treatment

- Treat runoff from parking lots and roadways using **porous landscape detention** and **porous pavement detention** where practicable**.** (See BMP Fact Sheets)
- Develop regional stormwater quality treatment in detention basin BMPs, including **extended detention basins, sand filter basins, constructed wetlands,** and **retention ponds**. Construct all facilities as site amenities, with minimal variation in water levels during storm events, the ability to support diverse ecology, and the ability to be drawn down for clean out and maintenance. (See note **3** opposite page, and BMP Fact Sheet)
- Do not combine WQCV facilities with active recreation.
- Implement source control BMPs. Proper pesticide, herbicide, fertilizer and other chemical use is important. Use integrated pest management (IPM) and follow the Mayor's Executive Order 121 for pesticide use. Also see the *Denver Lake Management and Protection Plan* (Dudley 2004) for park lakes. (See note **2** opposite page)

3. Flood Detention

- Develop berms around existing ponds, lakes, and extended detention facilities to increase water storage capacities within the park. (See note **4**, opposite page)

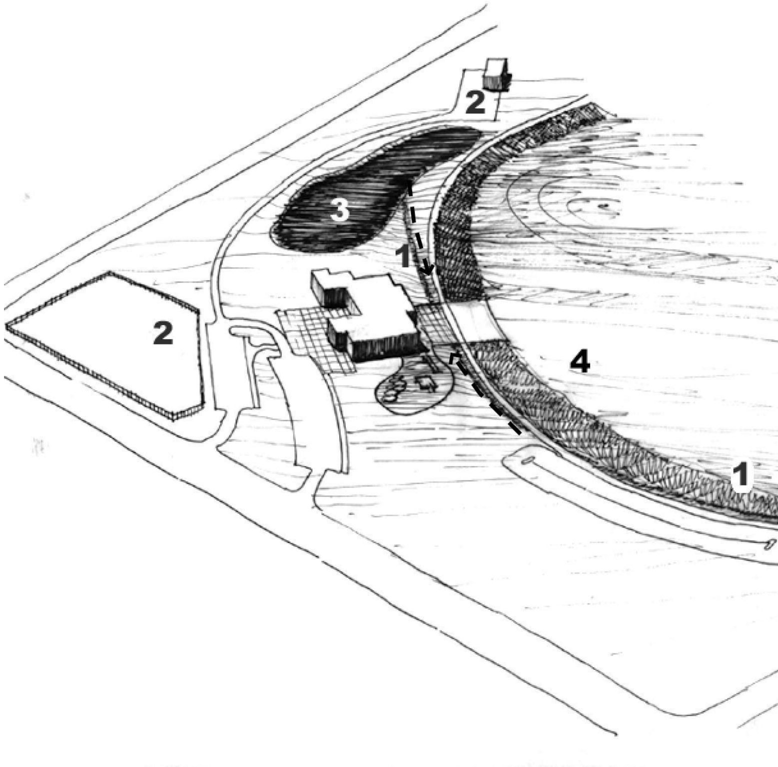
4. Implementation Details

- **Parking.** Direct runoff from parking to adjacent landscape areas. (See Implementation Detail)
- **Planting.** Parks present a tremendous opportunity to include diverse plantings in larger treatment areas in Natural Areas Open Space. (See Implementation Detail)

EXHIBIT 6.22
WET POND IN NEIGHBORHOOD PARK IN MINNEAPOLIS, MN

Shown here under construction, this park pond treats runoff from the surrounding neighborhoods, while creating an amenity for the community.

EXHIBIT 6.23
PARKS DEVELOPMENT TYPE SKETCH



KEY

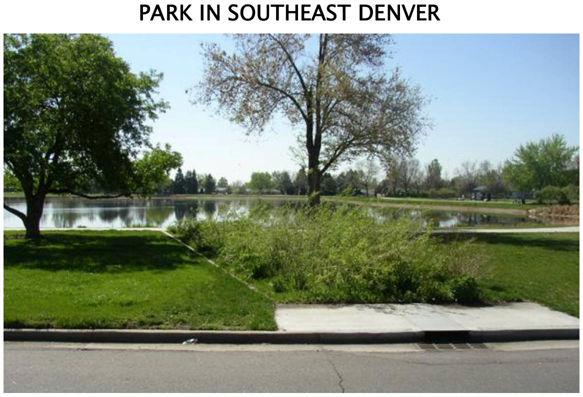
1 Swales and buffers that intercept runoff before entering the lake allow a diverse ecology to be maintained in park lakes.

2 On-site pollutant sources, including maintenance areas and dog parks, are isolated and runoff from those areas is treated. If possible, divert these flows from entering park ponds and lakes.

3 Detention basins may provide treatment of runoff from surrounding areas as long as this does not compromise park functions.

4 Denver Parks and Natural Areas Open Space may provide storage for the 100-year storm flood waters from surrounding areas in park lakes if the proposed flood storage improvements, especially for frequent storm events, do not significantly impact the integrity of the park's design and function.

EXHIBIT 6.24
POROUS LANDSCAPE DETENTION AT HUSTON LAKE PARK IN SOUTHEAST DENVER



Planted with diverse wetland vegetation, this treatment area collects and treats runoff from the adjacent neighborhood before it enters the park.

EXHIBIT 6.25
LAKE BUFFER IN DENVER

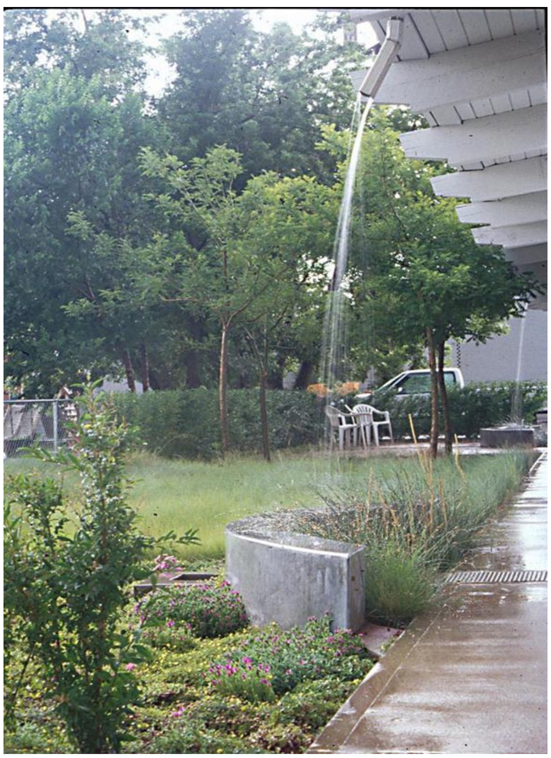
Native vegetation forms a buffer along this park lake shoreline. By separating open water from open turf, fertilizers are less likely to directly enter lake water, and geese habitat is minimized. Source: Dudley 2004.

IMPLEMENTATION DETAILS

Roofs

Runoff from roof surfaces contains urban pollutants primarily from atmospheric fallout (Urbonas and Doerfer 2004). This water requires treatment before being conveyed offsite. Although roof drains have often been tied directly to storm sewers, this practice is no longer acceptable. Several approaches to treating roof runoff are discussed below. For all of these treatment options, it is essential that the building foundation be protected from moisture. When properly designed, these features can remove pollutants and provide aesthetic appeal.

EXHIBIT 6.26
GARDEN SUPPORTED BY ROOF RUNOFF IN DENVER



Runoff drains through a spout from the roof to a splash basin and rain garden below, highlighting the flow of stormwater to garden visitors. Due to splashing, this type of detail should not be placed near major pathways.

EXHIBIT 6.27
PLANTER GARDEN SUPPORTED BY ROOF RUNOFF IN BOULDER

Runoff drains to a planter adjacent to, but separated from, the building. The planter contains a variety of plants that thrive with the additional moisture.

Primary approaches for treating roof runoff at ground level include:

1. Downspouts and scuppers at the building perimeter may be drained to a contained porous landscape detention facility or a porous pavement detention facility located adjacent to the structure. These closed systems drain away from building foundations.

2. Internal roof drain piping may be routed to an exterior wall and daylighted above grade to a contained porous landscape detention or porous pavement detention facility located adjacent to the structure.

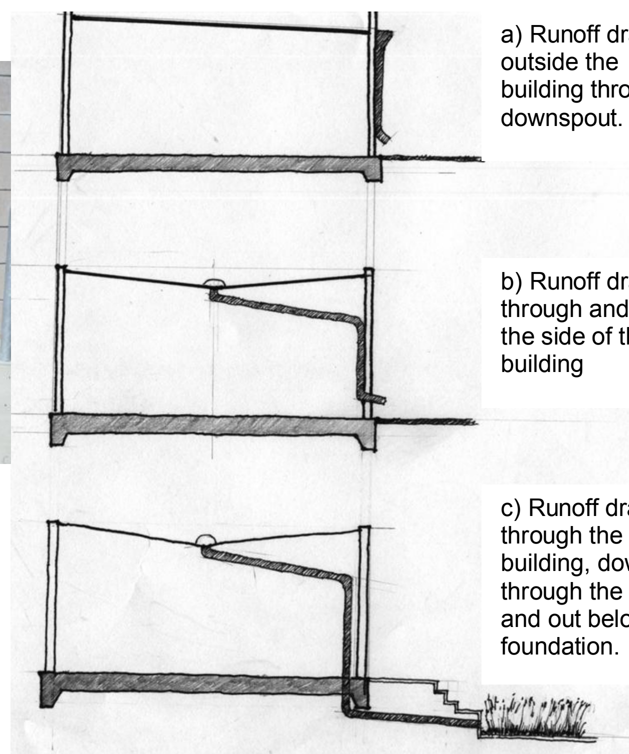
3. Internal roof drain piping may be routed under the first floor and directed to a contained below-grade porous landscape detention or other BMP adjacent to the structure. Although not as desirable as daylighting above grade, this is a viable technique in constrained sites. In this case, BMPs must be located down-slope from the building or in a sunken planter.

4. Internal drains may also be conveyed below grade in a pipe to a porous landscape detention area, extended detention basin, or other treatment BMP at the low end of site.

EXHIBIT 6.28
DOWNSPOUTS IN BOULDER

Rooftop runoff from an industrial facility splashes into rain gardens set in buried concrete pipe adjacent to the building, and then flows on a concrete pan out of the basin.

EXHIBIT 6.29
ROOF DRAINAGE SKETCHES



a) Runoff drains outside the building through a downspout.

b) Runoff drains through and out the side of the building

c) Runoff drains through the building, down through the slab, and out below the foundation.

Green Roofs/Treatment Roofs:

A green roof – a building roof or parking structure covered with soil and vegetation – reduces the impervious area of a site and provides filtering and stormwater quality treatment of rain falling on the roof. This concept requires careful planning, design, construction, and maintenance. Many proprietary green roof systems are available on the market. These roofs have the potential to provide significant runoff reduction and stormwater quality enhancement for a site, particularly when the roof area is large. Access for maintenance must be considered. This technique works particularly well when the structure is underground and at least a portion of the roof is at-grade.

Elements of green and treatment roofs include:

- Roof structure that supports soils, vegetation, and live loads associated with rainfall, snow, people, and equipment.
- Waterproof membrane.
- Root barrier.
- Drainage layer.
- Soil/growth medium. For treatment roofs, this includes a porous landscape detention or porous pavement detention type soil.
- Irrigation and plant materials. Native/naturalized, drought-tolerant grasses, perennials, and shrubs are preferred for roof plantings. However, even this low-water vegetation will require some supplemental irrigation in Denver.

Treatment roofs include all the elements of a green roof, as well as the detention component of porous landscape detention or porous pavement detention on the roof structure. Green roofs are not currently approved as a standard design for treatment; however, they will be considered on a case-by-case basis. See Exhibit 6.11 for a green roof in Denver.

EXHIBIT 6.30
INDUSTRIAL FACILITY "LIVING ROOF" IN DEARBORN, MI

This 10-acre Ford Motor Company facility has a green roof planted with sedum ground cover.
Source: http://www.ford.com

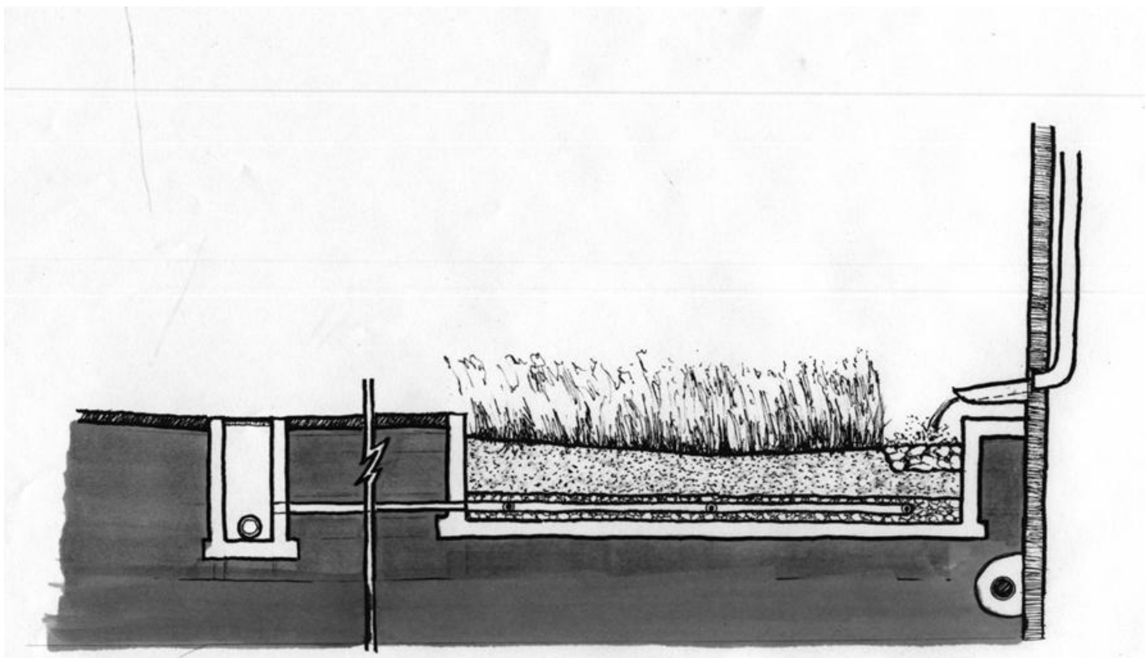
EXHIBIT 6.31
CHICAGO, IL CITY HALL GREEN ROOF

Roof garden plantings reduce the amount of runoff from this urban building with soils that absorb water and plantings that increase evapotranspiration.
Source: http://www.roofmeadow.com/

Infiltration Planters

Porous landscape detention can be implemented within planter boxes adjacent to buildings to treat roof runoff. Incorporating the standard porous landscape detention design into a planter box allows treatment to occur in constrained spaces while providing a landscape amenity. It is critical to consider soil types and ensure that building foundations are protected from subsurface water. The planter should be designed to dissipate energy from the downspout or water source, and will usually require irrigation for plant establishment.

EXHIBIT 6.32
PLANTER POROUS LANDSCAPE DETENTION



Any basin adjacent to a building must be completely separated from the building to address geotechnical concerns. Create a stable system that accounts for foundation differential movement by following the recommendations of a structural engineer and including adequate foundation drainage.

Parking Medians and Islands

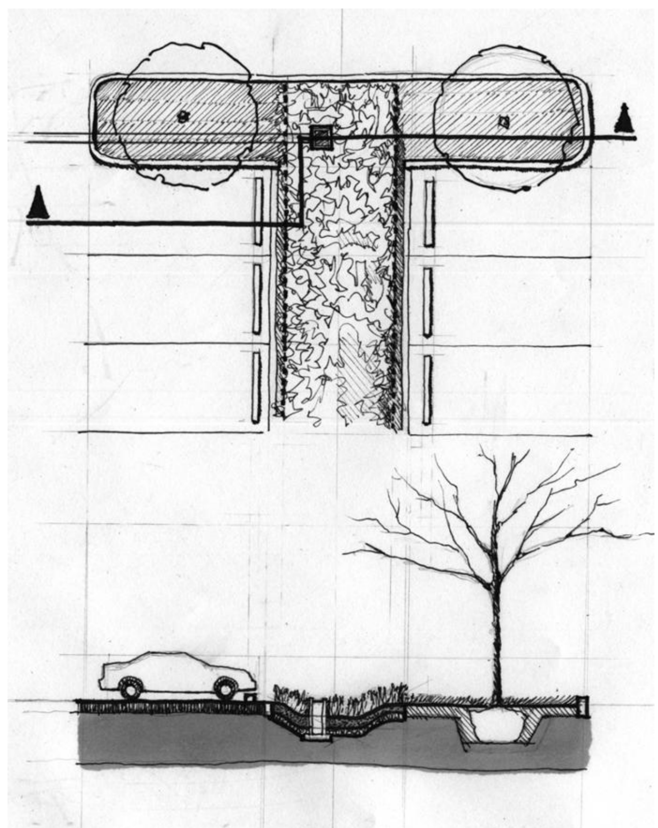
Parking lots contribute significant pollutant loading to urban runoff. Typical drainage approaches include inlets and storm sewers that capture runoff and convey it to perimeter detention basins. Although this facilitates efficient drainage, runoff volumes are not reduced, and the resulting detention basins are often forced into constrained “holes in the ground” that are difficult to maintain and add little value to a site.

The following techniques for parking medians, parking islands, and shallow parking lot detention incorporate both stormwater quality treatment and flood detention into parking areas to reduce or eliminate detention volumes required elsewhere on the site.

Parking Medians

Landscape medians between rows of cars can break up large expanses of pavement and provide a location for trees, plantings and turfgrass. Instead of raised medians with curbs, medians can be constructed as shallow depressions and protected with wheel stops or slotted curbs. A standard porous landscape detention design can be incorporated into the median. Exhibit 6.33 illustrates this concept in plan and section. These medians are designed to have a flat longitudinal grade so that the WQCV can have a level water surface (an average depth of 6 inches is recommended). Adjacent pavement should have a cross slope to drain runoff to the porous landscape detention. The flat longitudinal grade allows flood detention to be provided above the WQCV and the adjacent pavement at shallow depths (no more than nine inches above the pavement at the deepest point during the 100-year storm). An overflow inlet is provided in the porous landscape detention to control larger flood events and any porous landscape detention underdrains also tie into this inlet.

EXHIBIT 6.33
PARKING MEDIAN POROUS LANDSCAPE DETENTION



Medians can be included in every parking bay or in every other bay. If medians are oriented parallel with the flow of pedestrian traffic, access across the median does not present a significant design issue. When pedestrian access crosses the median, include intermittent walkways clearly designated by railings, tall shrubs, or mini-bridges. When trees are planted in the median, include a minimum 6-square-foot square planting area without underdrains that is not included in porous landscape detention volume calculations.

Parking Islands

Parking Islands are individual areas of porous landscape detention within a parking lot. The islands form less of a barrier to pedestrian traffic flow or snow removal than medians. They are best located at approximately 100-foot intervals. Exhibit 6.35 illustrates this concept.

Shallow Parking Lot Detention

Shallow Parking Lot Detention consists of a relatively flat section of parking lot with slight depressions draining to grated inlets. Flood control detention is provided at shallow depths above the pavement (no more than 9- inches deep during the 100-year storm) and stormwater quality detention is provided by porous landscape detention or, for large drainage areas, an extended detention basin located in the perimeter landscaping.

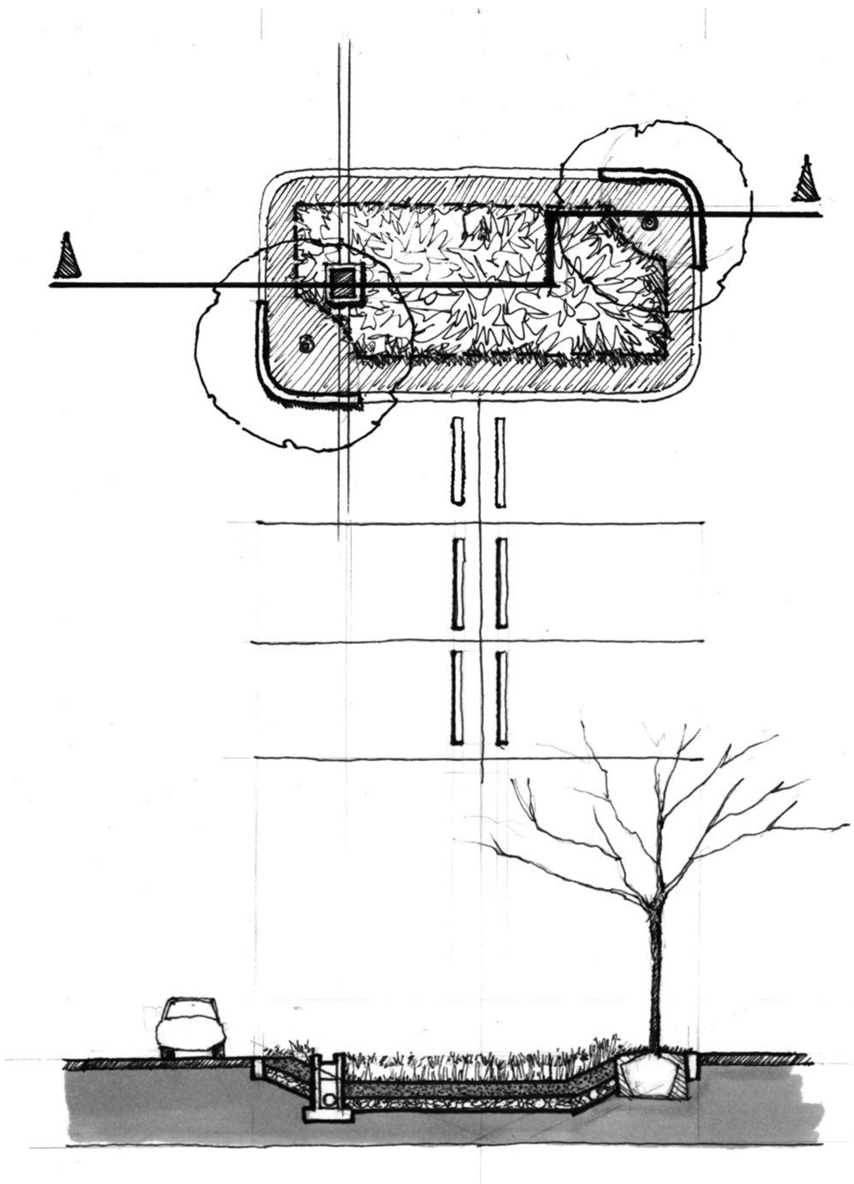
Porous pavement can be used in parking lots to reduce runoff and promote infiltration. If configured as porous pavement detention, WQCV treatment can be provided in a one- or two-inch layer above the pavement. (Size pavement with 10 to 15 percent open area with a WQCV design depth of one inch. Size pavement with a 40 percent open area with a two-inch depth.) Shallow flood control detention may also be provided with an overflow inlet to control larger storms.

EXHIBIT 6.34

PARKING MEDIAN POROUS LANDSCAPE DETENTION IN BOULDER

A narrow median strip receives runoff from two bays of parking. The runoff infiltrates and supports the native grasses, shrubs, and trees planted there. A stone crossing allows pedestrians to cross the median without trampling plantings. An impermeable liner extending three feet below each curb protects the pavement from water damage.

EXHIBIT 6.35
PARKING ISLAND POROUS LANDSCAPE DETENTION



Stormwater Distribution

Many of the BMPs described in this chapter require un-concentrated flows to function efficiently. Ideally, flows can sheet-drain to the BMP. A flush curb allows sheet flows to drain to the BMP landscape. However, both the pavement edge and the BMP landscape require protection from cars, which can be achieved by wheelstops, shrubs, or railings. When sheet-draining runoff is not possible, slotted curbs can minimize the amount of concentration, and level spreaders can allow concentrated flows to become re-dispersed. Variations on slotted curbs may be developed using closely spaced standard Colorado Department of Transportation (CDOT) curb inlets to drain paved areas into adjacent open space. This technique does concentrate flows somewhat, so care must be taken to provide adequate drainage in active areas and irrigated turfgrass.

EXHIBIT 6.36
SLOTTED CURB IN
CANYONLANDS NATIONAL PARK, UT

The slotted curb at this planted area has depressions between each parking space to allow runoff to flow to the interior landscape area without concentrating.

EXHIBIT 6.37
LEVEL SPREADER IN AURORA

A horizontal slotted pipe “level spreader” below the curb evenly distributes storm flows to avoid standing water and disperse concentrated flows.

Sediment Removal Traps and Forebays

Planning for sediment capture and periodic removal during maintenance operations is essential to ensure the long-term sustainability of stormwater BMPs. Particular attention to sediment control is necessary at inlets to all types of detention basins where waterborne sediments in stormwater reach slower velocities and tend to settle out and adjacent to parking lots and roadways where winter use of gravel creates heavy sediment loads. Sediment removal areas are an early step in the treatment train for stormwater, removing large sediments and trash from the runoff. A wide range of sizes and configurations for these areas is possible, from small rock mulch beds to large pre-sedimentation forebays in detention basins. Sediment traps at pipe outlets need to be designed to dissipate the energy of storm flows sufficiently to allow sediment to drop out and not become re-suspended. All types of sediment traps and forebays need to include access for maintenance equipment. Additional information on the design of pre-sedimentation forebays is provided in Volume 3.

EXHIBIT 6.38
FOREBAY AT STAPLETON IN DENVER

This forebay to a detention basin allows the energy in runoff to dissipate and drop out suspended particles and solids. Designed to the standards described in Volume 3, vehicles can access this area for periodic cleanout.

EXHIBIT 6.39
ROADSIDE SEDIMENT TRAP IN BOULDER

One-foot-wide rock mulch along this curbless road at an industrial facility traps sediment from runoff before it enters the swale below and can be replaced easily when clogged. An edger between the mulch and adjacent landscape would help contain the mulch and create a cleaner edge.

Soils

Soil characteristics are important to BMP performance because of their ability to 1) trap pollutants and 2) support vegetation that traps pollutants. Runoff that flows across and through the upper part of the soil profile comes in contact with the physical, chemical, and biological components of the soil. The organic material in the soil binds and removes phosphorous, metals, and salts.

Most of the BMPs described employ vegetation as an integral component in treating stormwater runoff. The medium in which the vegetation grows is critical to the growth and long-term health of that vegetation.

Grass buffers, grass swales, and basin BMPs use native soils, and the characteristics of these soils, including texture, impermeable soil layers, salinity, and the quantity of organic matter, are key considerations in making plant selections. Soils tests should be completed to determine soil characteristics and the type of soil amendments needed to support the desired plant types. For example, three to five cubic yards of organic matter incorporated into the top layers of soil is typically required for turfgrass planted in swales. Porous landscape detention requires an engineered soil—either a mix of 75 percent sand and 25 percent peat (Exhibit 6.40), or a sandy loam, (Exhibit 6.41). The soil must allow stormwater to infiltrate while still holding enough fine material and organics with nutrients and moisture to support vegetation and provide some adsorption capacity. The following tables describe these two types of soil.

EXHIBIT 6.40 SAND-PEAT MIX		
75% sand as defined below, and 25% sphagnum peat		
Textural class/USDA Designation	**Size in mm**	**Percent of total weight**
Gravel	>2 mm	Less than 5%
Sand	0.05-2 mm	95-100%
Silt	0.002-0.05 mm	Less than 5%
Clay	<0.002 mm	Less than 5%

EXHIBIT 6.41 SANDY LOAM		
100% sandy loam as defined below		
Textural class/USDA Designation	**Size in mm**	**Percent of total weight**
Gravel	>2 mm	Less than 5%
Sand	0.05-2 mm	70-80%
Silt	0.002-0.05 mm	15-20%
Clay	<0.002 mm	Less than 5%

Planting

When selecting plants for use in stormwater quality BMPs, select plants that can survive under the site conditions, perform the desired water quality function, are appropriate to the site context, and can be supported with a realistic maintenance schedule. Key aspects of each of these factors are described below.

1. Plants that can survive.

While typical plant choice considerations including site soils, slope, aspect, and exposure apply equally to BMPs, the most significant environmental consideration is water. Plants in BMPs are subject to inundation, prolonged localized saturation, and drought, so they must be selected to thrive in these widely varying conditions. These plants should also be supported with irrigation for establishment and during periods of drought.

Consider the typical amount of saturation in a BMP, site-specific conditions as described in Exhibit 6.42, and typical periods of inundation described in Exhibit 6.43 in choosing appropriate plantings.

EXHIBIT 6.42 BMP SITE-SPECIFIC CONDITIONS		
Wet	**Variable**	**Dry**
Detention pond basin bottoms	Porous landscape detention bottoms	Grass Buffers
Swale bottoms	Pond and basin margins	Upper slopes of ponds
Wherever irrigation flows concentrate		Side slopes of swales and porous landscape detention

EXHIBIT 6.43 TYPICAL BMP INUNDATION PERIODS	
BMP	**Inundation Period**
Porous landscape detention	6 hours
Sand filter extended detention basins	40 hours
Extended detention basins	40 hours
Retention ponds	Permanent: 12 hours in zone above pool
Constructed wetland basins	Permanent: 24 hours in zone above pool

Soil considerations include texture, compaction, nutrients, permeability of subgrade, salinity, and the quantity of organic matter. For porous landscape detention, employ engineered soils to achieve required permeability.

EXHIBIT 6.44
BASIN PLANTINGS IN DENVER

Plant trees and shrubs on the side slopes of basins rather than in the wet bottom area.

EXHIBIT 6.45
RUSHES IN A STORMWATER GARDEN IN DENVER

Rushes can withstand up to six months of drought and two months of inundation after establishment.

EXHIBIT 6.46
SWALE GRASSES SLOW RUNOFF IN AURORA

Both the bluegrass turf in the upper portions and the native grasses in the lower portions of this broad swale serve to slow down or attenuate the velocity of stormwater runoff.

EXHIBIT 6.47
DETENTION BASIN WETLAND MICROPOOL IN AURORA

Wetland grasses planted in the bottom of this detention basin remove nutrients and pollutants from stormwater runoff.

2. Plants that perform the desired stormwater quality function.

Plants are an integral aspect of most of the BMPs, performing a wide range of functions that improve the quality of stormwater runoff. Runoff typically enters a BMP with some velocity, and one function of the plants is to slow down that water to reduce erosion both within the BMP and downstream of it. The aboveground portions of a plant can reduce the velocity of runoff. For example, grasses and shrubs or groundcovers with stiff stems can filter sheet flows. Root systems serve to stabilize the soil, with fibrous roots systems providing greater stability. These issues are more critical on the sloping portions of BMPs than in flat or gently sloping bottoms.

Because some of the most common pollutants in urban runoff are actually excess nutrients, many plants can thrive in BMPs while removing the very nutrients that can cause problems downstream. Many plants also remove other pollutants from runoff, particularly wetland species that are included in basin micropools and wetlands. Slower and more evenly spread-out flow (sheet flow) will greatly improve the treatment effects of vegetation.

3. Plants that are appropriate to the context.

Many of the BMPs can perform multiple functions. In addition to providing stormwater quality functions, plants in BMPs can also provide shade and screening for parking lots, color and texture at building entrances, or grassy fields in unprogrammed park areas. The aesthetics of how and which plants are included in a BMP can make all the difference in creating a successful landscape.

4. Plants that can be supported with a realistic maintenance schedule.

All plants require some amount of ongoing maintenance. Ensure that the plantings can be cared for within a project budget and schedule, as well as in perpetuity.

Weed control in BMPs must be considered both with regard to the overall structure of the BMP, as well as with regard to access to areas for removal of both weeds and trash. Because these areas are intended to improve the quality of stormwater runoff, they are particularly poor choices for the use of herbicides, which pollute the very water being treated.

Mulch can provide an effective barrier against weeds. Rock mulch has greater stability than organic mulches, which float and can wash out of the system. Sedimentation on top of mulch, and subsequent plant growth in the sediments, should be considered. In choosing a mulch, consider that it may be necessary to mow these areas after several years of operation.

The planting strategy can have a tremendous impact on the requirements of weed control. Masses of dense shrubs or groundcover can often out-compete weeds without appearing overgrown, while more intricate planting patterns with many different plant species require larger spaces between plants that often become subject to weedy invasions. Consider also the ultimate size, growth rate, and other characteristics of all plantings included. Also, consider if the plants can easily be trimmed or mowed, especially on pond bottoms.

EXHIBIT 6.48
TREES IN GRASS BUFFER IN DENVER

Trees in this grass buffer serve to both screen and shade the adjacent parking.

EXHIBIT 6.49
SPLASH OF COLOR AT BUILDING ENTRANCE IN DENVER

The colorful plantings in this stormwater garden provide an attractive feature at the building entrance.

EXHIBIT 6.50
GRASS FIELD IN DENVER

The grass over this sand filter can serve as an informal play area during most of the year.

BMP FACT SHEETS

Grass Buffers

Function: Runoff Reduction

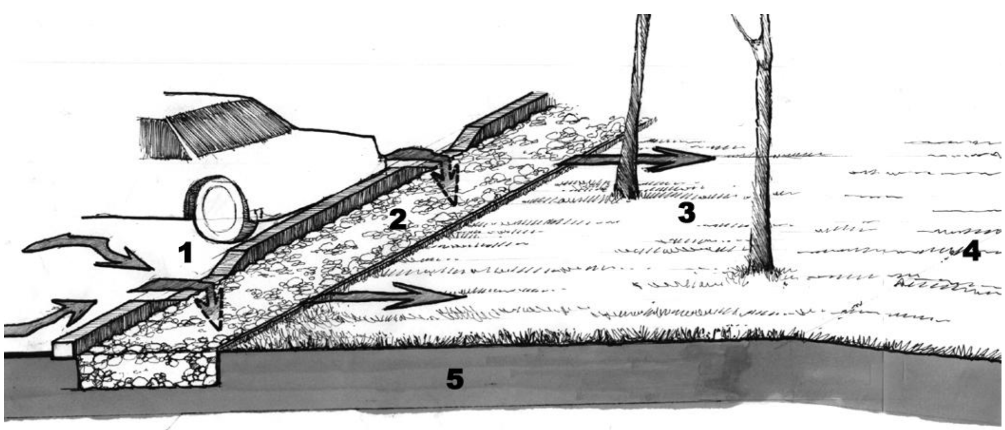
A grass buffer is a gently sloped turf area designed to disperse runoff over a broad area, promote infiltration, remove large sediment, and reduce the volume of runoff entering treatment facilities.

- **Typical Applications:** Landscape edges and transitions to paved areas, roads, and parking lots, and residential lawns.

- **Operation and Maintenance Considerations:** Turf should be approximately three inches lower than adjacent paving to provide positive drainage even when a moderate amount of sediment and thatch has accumulated. When used adjacent to parking lots, consider slotted curb, other vehicular controls, or reinforced turf at the edge of the pavement to reduce wheel rutting of the buffer. Avoid heavy use of fertilizers that will undermine stormwater quality goals. Provide sheet flows (unconcentrated flows) to grass buffers to reduce erosion. See Maintenance Guidelines at end of chapter.

- **Landscape Considerations**: Select turf or native grasses appropriate to the surrounding landscape. Supplemental irrigation is necessary to establish and maintain turf and should be applied based on water requirements of the selected plant species. When groundwater is close to the surface, use wetland grasses that can tolerate inundation. Dense groundcovers with fibrous root systems may also be considered.
- **Relative Cost**: Low
- **Governing Documents:** See Volume 3, page S-2

EXHIBIT 6.51
GRASS BUFFER SKETCH



1: Inlet: Slotted curbs or level spreaders promote uniform storm flows. Depress grade three inches below pavement to provide positive drainage even with moderate sediment accumulation.
2: Sediment Trap: In areas with high sediment loads, include a rock mulch strip contained by a landscape edger.
3: Vegetation: Irrigated dense turf or native grasses—may include other dense groundcovers.
4: Outlet/Overflow: Drain to a grass swale or a depression with inlet and storm sewer.
5: Infiltration Matrix: Native soils.

EXHIBIT 6.52
GRASS BUFFER AT STAPLETON IN DENVER

Stormwater flows directly from the road across the grass buffer planted with turf and trees into a sand filter treatment in a residential parkway.

EXHIBIT 6.53
LAWN IN DENVER

This urban lawn could easily be adapted to create a grass buffer for roof runoff in this area of dense development.

EXHIBIT 6.54
GRASS BUFFER IN DENVER

The native grasses of the buffer in this park reduce runoff from the alley, neighborhood, and irrigated turf above, reducing pollutants and protecting the adjacent drainageway.

Grass Swales

Function: Runoff Reduction

A grass swale is a gently depressed turf-lined channel that conveys stormwater slowly, promoting infiltration.

- **Typical Applications:** As a flow conveyance facility in lieu of a storm sewer. Use along curbless streets or to capture flow from grass buffers.

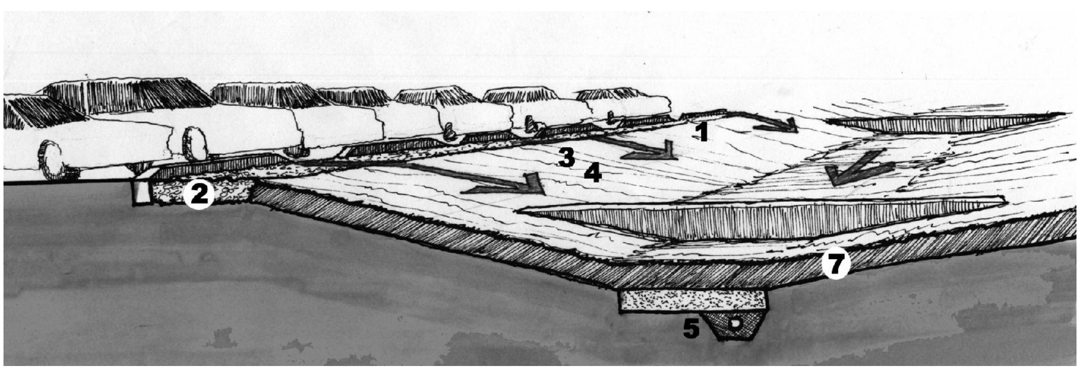
- **Operation and Maintenance Considerations:** In locations where routine mowing is planned, provide an underdrain, turf reinforcement, or rock mulch and avoid mowing following extended periods of precipitation. Maintain mowable side slopes in accordance with Volume 3. See Maintenance Guidelines at end of chapter.

- **Landscape Considerations**: Irrigated turfgrass provides a stable surface for storm flows, but requires regular mowing, which may be difficult when wet. Consider using native grasses that require less frequent mowing. Woody plant material should be avoided as it may trap trash and debris and become difficult to maintain.

- **Relative Cost**: Low

- **Governing Documents:** See Volume 3, page S-8

EXHIBIT 6.55
GRASS SWALE SKETCH



1: Inlet: Slotted curbs or curbless streets provide uniform flows. Control for sediment and erosion at inlets and wherever flows concentrate. Depress ground three inches below pavement to provide for positive drainage even with moderate sediment accumulation.
2: Sediment Removal: Grass may grow up through accumulated sediment, requiring periodic removal of vegetation.
3: Slopes: Provide slopes and check structures in accordance with Volume 3.
4: Vegetation: Dense turf or native grasses.
5: Underdrain/Liner: In accordance with Volume 3, sandy soils (Type A&B) do not require underdrains, while clay soils (Type C&D) do.
6: Outlet/Overflow: Flows are typically delivered to a BMP that treats the WQCV, or convey runoff from a WQCV facility. (not shown on sketch)
7: Infiltration Matrix: Consists of native soils.

EXHIBIT 6.56

GRASS SWALE IN DENVER

This roadside grass swale is planted with bluegrass turf along a curbless neighborhood street. A pipe culvert allows water to flow from one side of the driveway to the other.

EXHIBIT 6.57

GRASS SWALE IN BOULDER

This swale planted with native grasses conveys water from planter boxes close to the building around the site.

EXHIBIT 6.58

GRASS SWALE IN DENVER

This swale in a depressed parking median removes coarse sediment while conveying flows to an extended detention basin. Note the flush curb that provides a clean edge to the asphalt and allows sheet flows into the swale.

EXHIBIT 6.59

GRASS SWALE IN BOULDER

A swale between this industrial building and the entry drive collects runoff from downspouts and pavement then conveys it below the road to an adjacent stormwater quality treatment area.

Porous Pavement and Porous Pavement Detention

Function: Runoff Reduction (porous pavement) and Site WQCV (porous pavement detention)

Both porous pavement and porous pavement detention consist of paver blocks or other reinforcement with sufficient void space to allow stormwater to percolate. Porous pavement detention is flat and includes a shallow storage area above the surface for the water quality capture volume (WQCV). Volume 3 describes five types of porous pavement.

1. Modular Block Porous Pavement
2. Cobblestone Block Porous Pavement
3. Reinforced Grass Pavement
4. Poured Porous Concrete Pavement
5. Porous Gravel Pavement

Of these types, Modular Block Porous Pavement and Porous Gravel Pavement may be used in porous pavement detention installations.

- **Typical Applications:** Use Reinforced Grass Pavement or planted Modular Block Porous Pavement in landscape areas used for maintenance access, in infrequently used overflow parking lots, and adjacent to curbless streets where wheel rutting is a concern. In higher traffic and parking areas, use Cobblestone Block Porous Pavement or Poured Porous Concrete Pavement. Porous Gravel Pavement may be considered for industrial land uses where there is little likelihood of groundwater contamination.

- **Operation and Maintenance Considerations:** Void spaces can become clogged over time and require periodic maintenance to re-establish infiltration capacity. Blocks planted with turf cannot easily be plowed. See Maintenance Guidelines at end of chapter.

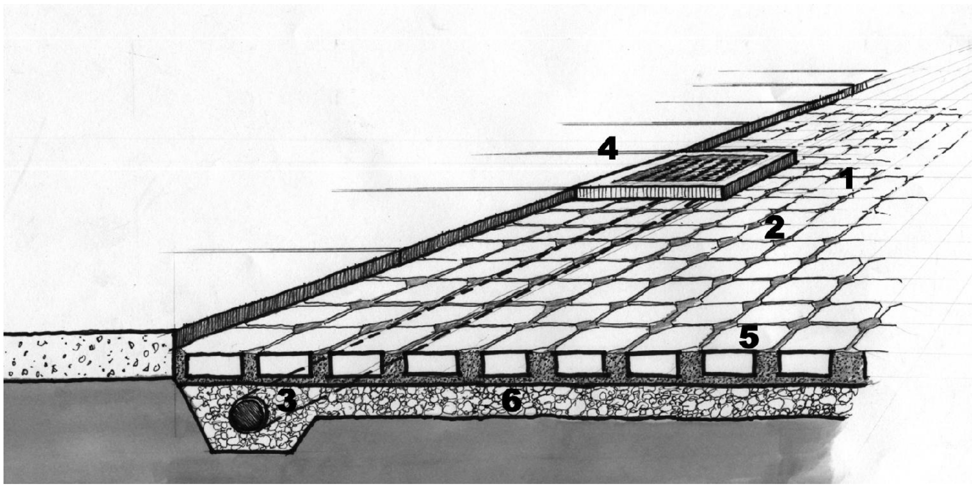
- **Landscape Considerations**: Turf grown in pavers is particularly susceptible to drought, and must be irrigated. Consider irrigation head locations when establishing vehicle routes. Vehicles tend to compact soils, making vegetation growth difficult. Consider Cobblestone Block Porous Pavement or Poured Porous Concrete Pavement for paved pedestrian areas and walkways to reduce tripping hazards.

- **Relative Cost**: Moderate to high

- **Governing Documents:** See Volume 3, pages S-13, S-22, and www.udfcd.org for updated information

EXHIBIT 6.60

POROUS PAVEMENT SKETCH
(COBBLESTONE BLOCK POROUS PAVEMENT SHOWN)



1: Vegetation: If turfgrass is desired, use Reinforced Grass Pavement or Modular Block Porous Pavement with supplemental irrigation.
2: Slopes: Flat with a shallow surcharge zone for porous pavement detention. Gradual slopes for porous pavement.
3: Underdrain/Liner: Underdrain is required when underlying soils have insufficient infiltration capacity. Underdrain and liner are recommended where geotechnical concerns exist. Porous pavement shall not be used if a likelihood of groundwater contamination exists due to the handling of chemicals or petroleum products.
4: Inlet: For porous pavement detention, inlet provided for runoff greater than the recommended WQCV, as specified in Volume 3.
5: Pavers: Install per manufacturer's directions when using proprietary products.
6: Infiltration Matrix: In accordance with design requirements shown in Volume 3.

EXHIBIT 6.61
POROUS PAVEMENT TURF BLOCK IN DENVER

Modular Block Porous Pavement is planted with bluegrass turf to create a driving surface for emergency access only. This installation receives very little traffic. (Blocks are located in area between garage door and street.)

EXHIBIT 6.62
POROUS PAVEMENT TURF RINGS IN HOUSTON, TX

Reinforced Grass Pavement stabilized by plastic rings is used for an occasional driving and parking surface outside this stadium. (Rings are located throughout turf area.)
Source: www.invisiblestructures.com

EXHIBIT 6.63
COBBLESTONE BLOCK POROUS PAVEMENT IN DENVER

Porous pavement in this small parking lot allows water to infiltrate from the adjacent building, as well as the parking lot itself. Monitoring tubes in the foreground allow visual access to the storage layers below grade.

EXHIBIT 6.64
REINFORCED GRASS PAVEMENT

Proprietary products on the market, installed in accordance with recommendations in Volume 3, stabilize turf enough to allow emergency and occasional vehicle use. Source: www.invisiblestructures.com

Porous Landscape Detention

Function: Site WQCV

Porous landscape detention is a depressed landscape area with sandy soil that promotes filtration and infiltration of runoff.

- **Typical Applications:** Parking islands, medians, and buffers, courtyards, planters, and green roofs. Excellent on sites with minimal space for detention where landscape and stormwater quality can be combined. Geotechnical and foundation issues must be carefully considered when selecting and locating porous landscape detention facilities and designing underdrains and linings.

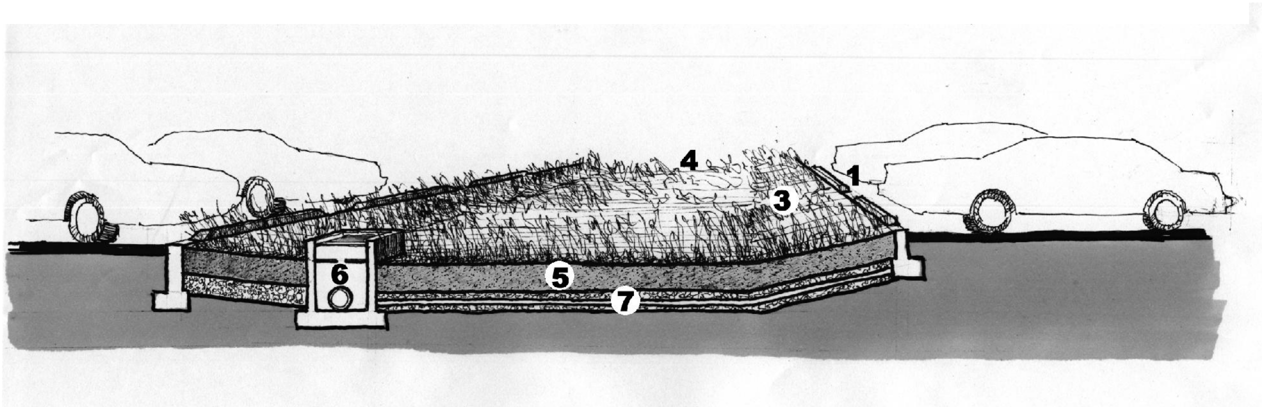
- **Operation and Maintenance Considerations:** Growing medium will have to be removed and replaced periodically to maintain performance when clogging reduces infiltration capacity to unacceptable levels. Access to facility must be provided to enable maintenance operations. See Maintenance Guidelines at end of chapter.

- **Landscape Considerations**: A wide variety of plant types is possible, ranging from irrigated bluegrass turf to native grasses, groundcovers, flowers, and shrubs. Trees should not be included in porous landscape detention areas because the infiltration matrix needs to be replaced periodically; however, trees may be included in oversized porous landscape detention, or outside of porous landscape detention. Dense shrub plantings may become difficult to maintain and must be removed for major maintenance requiring removal of growing medium. If planted with trees, a three-foot radius around each tree should not include underdrains or be counted as porous landscape detention volume. Consider stonework or pedestrian-oriented pavers within the installation. Consider the use of a non-floatable mulch as a water-retaining element of the BMP.

- **Relative Cost**: Moderate to high

- **Governing Documents:** See Volume 3, page S-27, and www.udfcd.org for updated information

EXHIBIT 6.65
POROUS LANDSCAPE DETENTION SKETCH



1: Inlet: Level spreader or slotted curbs supply uniform flows to porous landscape detention.
2: Erosion Protection: Include a rock rundown to reduce the likelihood of erosion from inlet flows. (Not shown in sketch)
3: Slopes: Relatively flat bottom with a 6-12 inch deep WQCV zone (six inches recommended). Sides may include up to a 3:1 slope.
4: Vegetation: Turf, native grasses, shrubs, and gardens. See Implementation Details.
5: Underdrain/Liner: Underdrain is required when underlying soils have insufficient infiltration capacity. Underdrain and liner are recommended where geotechnical concerns exist.
6: Outlet/Overflow: Provide overflow above WQCV for larger storm events.
7: Infiltration Matrix: Provide in accordance with design requirements shown in Volume 3.

EXHIBIT 6.66
POROUS LANDSCAPE DETENTION IN PORTLAND, OR

Porous landscape detention can be employed in the small spaces between buildings like the central planters in this residential courtyard.
Source: Murase Associates

EXHIBIT 6.67
POROUS LANDSCAPE DETENTION IN DENVER

Porous landscape detention adjacent to the roadway is planted with a variety of water-loving plants in a sandy loam soil matrix that filters runoff from the adjacent roadway.

EXHIBIT 6.68
POROUS LANDSCAPE DETENTION IN DENVER

This porous landscape detention area takes the form of a public garden in a townhouse development. The overflow inlet (not visible) prevents flooding of the courtyard. Rock mulch might require less maintenance than the wood chips seen here.

Detention Basins

Function: Site WQCV and Flood Control

Detention basins for stormwater quality include the following four types, each capturing the WQCV and slowly releasing it to provide long-term settling.

1. Extended detention basin
2. Sand filter extended detention basin
3. Constructed wetland basin
4. Retention pond

These basins are generally intended to serve watershed areas greater than one acre, with areas less than one acre served by WQCV facilities such as porous landscape detention and porous pavement detention. Constructed wetland basins and retention ponds are only suitable if the local hydrology will support viable wetlands or a permanent pool, and if water rights issues are considered and addressed. Flood control detention may be designed in a surcharge zone above any of the water quality detention basins identified above.

- **Typical Applications:** Watershed areas typically greater than one acre, generally located in landscape areas.

- **Operation and Maintenance Considerations:** Access to the basin by sediment cleanout equipment is required. Provide an all-weather driving surface designed in accordance with Volume 3 to the bottom of the basin near the pre-sedimentation forebay and outlet works. See Maintenance Guidelines at end of chapter.

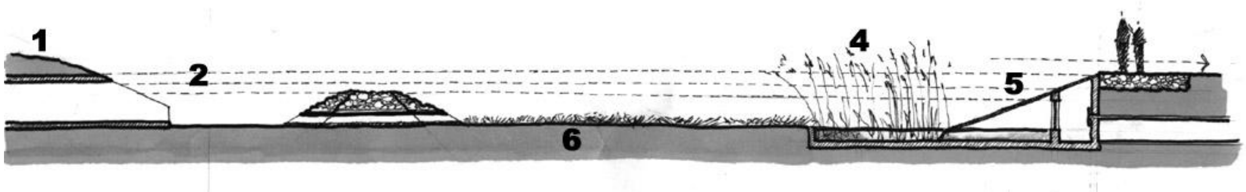
- **Landscape Considerations**: Locate basins along major roads when consistent with zoning and urban design requirements, and when basin can be designed as a site amenity; otherwise, locate in an unobtrusive part of the site. Exclude recreation facilities, bluegrass, and cobble from the bottom of the facility subject to frequent prolonged inundation. The shaping of the detention basin should focus on creating a subtle, attractive facility. Constructed wetland detention basins can create habitat and wildlife amenities while providing additional stormwater quality benefits.

- **Retaining Walls:** Attempt to design without the use of retaining walls, but if walls are unavoidable, plan at least one side of the basin perimeter without retaining walls to allow access. Walls over 30 inches in height require handrails designed in accordance with the Uniform Building Code. Locate walls away from main view points to and from the site.

- **Outlets**. Outlets must control the design release rates and be provided with micro-pools, oversized trash racks, and emergency spillways in accordance with Volume 3. Outlets that are flush with the vegetated side slope are less visually obtrusive.

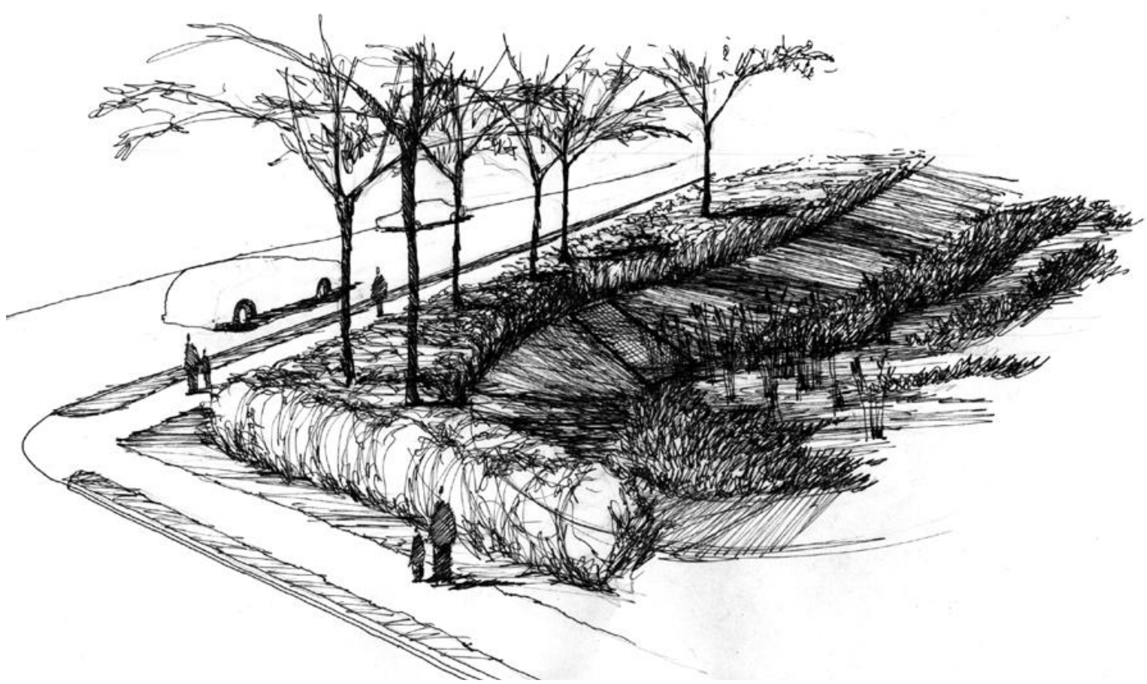
- **Governing Documents:** See Volume 3, pages S-35, S-47, S-53, and S-64.

EXHIBIT 6.69
EXTENDED DETENTION BASIN SKETCH



1: Inlet: Dissipate energy at inlets to prevent erosion and sediment re-suspension.
2: Sediment Trap: Provide forebay in accordance with Volume 3.
3: Slopes: Sideslopes are generally 4:1 or flatter for safety and maintenance. (Not shown on sketch)
4: Vegetation: Should consist of turfgrass supplemented by selected shrubs and trees. When high groundwater is present, include riparian vegetation.
5: Outlet/Overflow: Construct an outlet into the bank closest to most public areas to minimize visibility. Provide micro-pool, trash rack, and emergency spillway in accordance with Volume 3.
6: Infiltration Matrix: Native soils in all but sand filter basins, which are to be designed with a sand layer and underdrain system in accordance with Volume 3.

EXHIBIT 6.70
PLANTING CONCEPT FOR AN EXTENDED DETENTION BASIN



One planting concept for an extended detention basin includes wetlands adjacent to the micropool, trees and shrubs planted on the side slopes, the outlet structure flush with the slope on the more public side of the basin, and masses of shrubs screening the basin.

EXHIBIT 6.71

EXTENDED DETENTION BASIN AT STAPLETON REDEVELOPMENT IN DENVER

While attractive, the density of shrubs in the bottom of this basin may complicate maintenance. Native grasses that can easily be mowed would be a better choice.

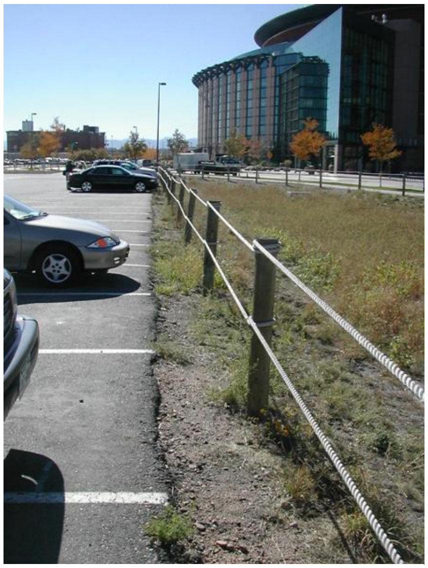
EXHIBIT 6.72

EXTENDED DETENTION BASIN IN LOWER DOWNTOWN DENVER

This is an excellent example of including a wide range of plant materials that screen and enhance the basin.

EXHIBIT 6.73

EXTENDED DETETION BASIN AT SPORTS ARENA IN DENVER



The fence along this basin prevents pedestrians from shortcutting across it, which is an important detail on high-use sites. Shrubs could provide a similar function, and a flush curb and rock mulch strip could create a cleaner edge.

EXHIBIT 6.74

EXTENDED DETENTION BASIN IN DENVER

Gravel in the frequently flooded portions of this new grass detention basin is difficult to maintain once vegetation moves in with deposited sediment. Use of riparian or wetland grasses would be a better long-term solution. Trees on the banks of the basin might help it to blend with the surrounding neighborhood landscape. The outlet structure would be less conspicuous if placed into the slope on the far end of the basin.

Treatment Wetlands

EXHIBIT 6.75
TREATMENT WETLANDS AT COTTONWOOD CREEK

Created wetlands adjacent to the creek provide areas for filtration of stormwater as well as habitat.

For sites with sufficient water to support wetlands, detention facilities can be developed as a constructed wetland basin, as described in Volume 3. The treatment wetland in the bottom of the basin utilizes physical, chemical, and biological processes in the water, soil, root zones, and vegetation to provide additional treatment of stormwater. Design guidance for treatment wetlands, which have been shown to reduce suspended solids, nutrients, and metals in stormwater runoff, is provided in Volume 3 for constructed wetland basins and in a variety of other references for other applications of treatment wetlands (Kadlek and Knight 1996; Hammer 1989).

Subsurface Treatment Devices

Over the last decade, many proprietary stormwater BMPs have been developed, many of these are subsurface, vault-type treatment devices. Examples of these devices include Stormcepter™, Vortechnics™, Bay Saver™, and Storm Filter™. As a class of treatment technologies, these devices have proven to be controversial for the following reasons:

- Unsubstantiated performance claims in some cases.
- In cases where the manufacturer does provide "performance data," such data were often not obtained using independent third parties and lacked appropriate quality assurance/quality control procedures.
- Because such facilities are normally located below the ground surface, they tend to be "out-of-sight, out-of-mind". Therefore, they do not receive regular maintenance, nor is their performance periodically monitored.
- Maintenance access is often poor, which can be a real deterrent to maintenance.
- To the extent that such devices work, their effectiveness is typically limited to the removal of larger-sized settleable pollutants. Dissolved pollutant removal and the removal of very small solids is typically very low, if at all.
- Few of these devices provide volume control, consequently, they fail to address perhaps the leading cause of receiving stream degradation from urban stormwater discharges—increased frequency, magnitude, and duration of runoff.

- Anaerobic (absence of dissolved oxygen) conditions in bottom sediments are more likely to develop in underground devices. This condition can release pollutants that were bound to the sediment and cause bad odors.

For all of these reasons, Denver strongly supports managing stormwater quality on the ground surface using the many kinds of BMPs described in this document and in Volume 3 of the *Urban Storm Drainage Criteria Manual* (UDFCD 2001). Under most circumstances, it should be feasible to manage the modest water quality capture volume (WQCV) on the surface, without having to utilize subsurface, proprietary devices. Nevertheless, Denver recognizes that there are some cases where the use of such facilities is necessary due to extreme space constraints in smaller redevelopment sites, such as ones located in the downtown area. Denver will consider the use of subsurface treatment techniques under certain circumstances; however, the applicant must comply with the following restrictions prior to receiving authorization for the use of such devices:

- Clear evidence must be provided on why the WQCV cannot be managed on the ground surface through capture, extended detention, filtration and/or infiltration and why the use of a subsurface proprietary device is the best choice for the site, considering factors such as initial installation, maintenance, and ability to assure long-term function.

- The proprietary device must provide volume control and be sized for the WQCV based on a drain time of no less than six hours.

- Independent, unbiased test data for the device must be provided to Denver for review. These data must demonstrate that the device is effective. Performance data should be gathered in general accordance with the recommendations of the International Stormwater BMP Database (www.bmpdatabase.org).

- A binding, long-term maintenance plan, including demonstration of adequate funding for such maintenance, must be provided.

- Because the performance of such devices has been shown to deteriorate over time without proper maintenance, the applicant must either annually submit proof of maintenance or must gather monitoring data to demonstrate that pollutant removals are not declining over an extended period of time (i.e., no less than five years). It is the responsibility of the applicant to submit a monitoring plan to Denver for review and approval. Again, Denver recommends that applicants utilize monitoring recommendations of the International Stormwater BMP Database (www.bmpdatabase.org).

Given that this field is rapidly changing, those considering alternative stormwater treatment technologies should periodically refer to Denver's website (http://www.denvergov.org/PublicWorks/) for updates and revisions to this policy.

Other Alternative Technologies

In keeping with the above policy statement on subsurface stormwater treatment, new alternative technology can be proposed for consideration with the following information submitted for reference:

- Description of technology including size, capital costs, design life, installation process and costs, and operating and maintenance requirements and costs.

- Data on effectiveness including lab testing and prior testing, pollutant removal rates, operational details on any existing installations, and monitoring information.

- Additional information including articles from peer-review, scientific or engineering journals, approvals or permits from other authorities, and references from other installations.

- General acceptance by UDFCD and DRCOG municipalities.

See Denver's website (http://www.denvergov.org/PublicWorks/) for updates and revisions to this policy and information on acceptable new technologies for implementation in Denver.

Industrial Source Controls

An important component of any stormwater management strategy involves BMPs to prevent pollution prevention by controlling it at its source. Examples include covering of storage/handling facilities and spill containment and control for sites that handle potential industrial or commercial contaminants, as described in Volume 3. These topics are discussed in more detail in Chapter 7.

Drainageway Stabilization

Sites that encompass or are adjacent to major drainageways will need to preserve and enhance natural stream functions, provide adequate flood capacity, and protect the channel from degradation. The *Urban Storm Drainage Criteria Manual, Volume 1* (UDFCD 2001) provides design criteria for major drainage improvements, and Volume 3 describes constructed wetland channels. "Soft" stream restoration techniques utilizing channel shaping and riparian vegetation, as well as natural-appearing grade control structures, are favored over more structural approaches to help enhance water quality and aesthetics.

Healthy streams and drainageways, if managed well, provide a number of important functions and values, including the following:

- Conveyance of baseflow and storm runoff
- Moderation of flood velocities and associated erosion
- Attenuation of peak flows though channel storage
- Support of riparian and wetland vegetation

- Creation of habitat for wildlife and aquatic species
- Promotion of infiltration and groundwater recharge
- Enhancement of water quality
- Reduction of ongoing maintenance requirements
- Provision of corridors for trails and open space
- Provision of favorable aesthetics
- Enhancement of property values and quality of life

Degradation of drainageways from increased urban runoff creates adverse water quality impacts by mobilizing significant quantities of sediment and associated pollutants and conveying them to downstream receiving waters. Stream degradation must be protected against, or, if significant erosion has already taken place, mitigated and repaired through appropriate stabilization improvements. These improvements, besides providing for adequate flood conveyance and a stable channel, should endeavor to provide all of the benefits listed above that are associated with healthy stream systems.

EXHIBIT 6.76
DRAINAGEWAY STABILIZATION AT WILLOW CREEK IN ARAPAHOE COUNTY

New channel section was stabilized using a combination of bioengineering and rip-rap reinforcement. Low-flow channel edges employed coir fiber rolls. The toe of an unstable slope (distant right on left photo) was stabilized using wrapped soil lifts. The photo on right shows revegetation after two years.

EXHIBIT 6.77
DRAINAGEWAY STABILIZATION AT GRANGE HALL CREEK IN NORTHGLENN

Urbanization had caused severe erosion on Grange Hall Creek in Northglenn. The stabilization plan called for creating a more stable channel through grade control and a raised channel invert. The new channel utilized a wider, more active flood plain, which allowed frequent flood flows to spread out over channel overbanks, creating a wider, more stable riparian zone and lower flow velocities. Drop structures were designed to fit the prairie context and be accessible and inviting places for public use.

MAINTENANCE POLICIES AND GUIDELINES

In order for stormwater BMPs to be effective, proper maintenance is essential. Maintenance includes both routinely scheduled activities, as well as non-routine repairs that may be required after heavy storm events or as a result of other unforeseen problems. Arrangements for BMP maintenance are the responsibility of the entity owning the BMP. More specifically, if Denver owns the BMP, then Denver maintains the BMP. If a private party owns the BMP, then the private party is responsible for arranging for maintenance of the BMP. BMPs should be designed with maintenance as one of the key design considerations, as discussed in the BMP Fact Sheets section of this chapter.

This section provides recommendations for Denver to ensure proper maintenance of BMPs, as well as specific guidelines for BMP maintenance. For BMPs currently widely used in the Denver Area, the maintenance guidelines build directly upon Volume 3 of the *Urban Storm Drainage Criteria Manual.* For BMPs that have been used less frequently in the Denver area, such as green roofs, recommendations for maintenance are provided based on experiences in other parts of the United States.

EXHIBIT 6.78 BMP MAINTENANCE POLICIES

PROPER LONG-TERM MAINTENANCE OF BMPS IS ESSENTIAL TO BMP EFFECTIVENESS

BMPS MUST BE DESIGNED WITH MAINTENANCE IN MIND

PRIVATELY-OWNED BMPS MUST BE PROPERLY MAINTAINED BY THEIR OWNER

DENVER-OWNED BMPS MUST BE PROPERLY MAINTAINED BY DENVER

BMP MAINTENANCE WILL BE ENFORCED UNDER DENVER'S CDPS STORMWATER PERMIT

Defining Maintenance Responsibility for Public and Private Facilities

Defining who is responsible for maintenance of BMPs and ensuring that adequate budget is allocated for maintenance is critical to the long-term success of BMPs. In Denver, maintenance responsibility may be assigned in four different ways:

1. Municipally owned BMPs are maintained by Denver, typically through the Wastewater Management Division, but occasionally by Parks and Recreation. Denver personnel responsible for maintenance are trained by Denver's Department of Environmental Health.

2. Regional drainage facilities located outside of Denver parks are maintained by UDFCD when specific criteria are met.

3. Privately owned BMPs are maintained by the property owner, Homeowner's Association or property manager.

4. Privately owned BMPs are maintained by Denver under a written agreement with the owner, with appropriate fees assessed for maintenance services.

Enforcement of BMP maintenance is required under Denver's Colorado Discharge Permit System (CDPS) stormwater permit and is accomplished through several full-time staff that conduct inspections of permanent BMPs. Additional legal enforcement may be accomplished by a variety of other mechanisms including: 1) agreements establishing legally binding BMP maintenance requirements and responsibilities; 2) permit obligations specifying BMP requirements; or 3) municipal legislative action or rulemaking authority. Examples of maintenance agreements from several communities throughout the country are provided in Appendix D. Examples of some of the specific requirements suggested for legal agreements by the Watershed Management Institute (1997) include:

- General Assurances: Identify requirements for proper operation and maintenance, conditions for modification of facilities, dedicated easements, binding covenants, operation and maintenance plans, and inspection requirements.
- Warranty Period: Require the original developer to be responsible for maintenance and operation during a defined short-term period, and identify the entity responsible for long-term operation. The party responsible for long-term maintenance must have appropriate legal authority to own, operate, maintain, and raise funds to complete needed maintenance.
- Proof of Legal Authority: Require that the entity meet certain conditions verifying its legal authority to ensure maintenance.
- Conditions for Phased Projects: Clearly specify how maintenance responsibilities are allocated over the long-term for a project that is phased in over time.
- Remedies: Clearly define remedies in the event that inspections determine that the facility is not being properly maintained.

EXHIBIT 6.79

SEDIMENT REMOVAL FROM A FOREBAY AT THE REGIONAL SHOP CREEK BMP SYSTEM

Source: Urban Drainage and Flood Control District.

For public facilities, one of the key issues for Denver is ensuring that adequate staff and budget are provided to the department responsible for maintenance. Ponds, lakes or wetland BMPs constructed in Denver Parks must be built with assurances that additional maintenance staff and resources are identified in advance. This is a particularly significant issue for multi-purpose pond or wetland BMPs located in Denver parks. These features require more trash, debris and sediment removal and surface maintenance to control erosion than is typically allocated in Parks and Recreation budgets (Murayama 2004).

For private facilities, such as those owned and maintained by homeowner's associations, there is often a lack of understanding of maintenance required for BMPs. Both Denver's internal staff and outside reviewers of this Plan identified maintenance of private facilities as a top priority. One proposed solution was to require a maintenance plan to be submitted as part of the development review/approval process. Recommendations for such maintenance plans are provided below. In addition to maintenance plans, another important step is educating the general public on the purpose and function of stormwater BMPs. This is critical in cases where Low Impact Development (LID) or landscape-based BMPs are implemented on multiple parcels in developments. In addition to legally binding maintenance agreements, it would also be helpful to have easy-to-understand informational brochures that describe the functions and maintenance requirements for these facilities.

Developing a Maintenance Plan

At the time that this Plan was completed, the Denver Public Works Rules and Regulations and *Stormwater Quality Control Plans, An Information Guide* (Denver 2000) did not contain explicit requirements for maintenance of stormwater BMPs. Based on the input of Denver staff and the importance of maintenance to the long-term success of BMPs, it is recommended that a simple maintenance plan be required as part of Stormwater Quality Control Plans. Such a plan (which need not exceed five pages) should include the following key components:

EXHIBIT 6.80
DIFFICULT BMP MAINTENANCE ACCESS

1. A simple sketch of the site showing the locations of all stormwater quality BMPs at the development site and key components such as forebays, inlets, outlets, low-flow channels or other components that require inspection or maintenance. The sketches should be in a form appropriate for easy use by inspectors (e.g., 8.5" x 11" or 11" x 17" paper if possible) and should be kept on site at the property or the property management office. Any changes to the facility over time should be noted on the sketch.

2. A brief description of the maintenance requirements and expected frequency of actions (which can be obtained from the Maintenance Requirements discussion below). It is important to not only identify maintenance requirements related directly to the water quality functions of the BMP, but also to identify public safety aspects of the BMP design and ensure that they are functioning as intended and in good repair (e.g., fences and guard rails, signage, lighting, safety racks, and submerged perimeter benches for BMPs with a permanent pool.).

3. An inspection form or checklist appropriate for the facilities in place at the site. An example inspection form used by the City of Portland, Oregon is provided in Exhibit

6.82. A log of inspection forms should be kept on-site or at the property management office to demonstrate that routine inspections and maintenance are occurring.

4. Identification of and contact information for the entity responsible for maintenance of the facility. For example, this could be a Homeowner's Association, Denver Public Works, Denver Parks and Recreation, UDFCD, or another entity.

5. Copies of legally binding agreements associated with the facility which show that the facility owner is aware of and will abide by its maintenance responsibilities. Denver's Storm Sewer Easement and Indemnity Agreement, as contained in Appendix D, is a good starting point. Alternative agreements used in other parts of the country are also provided in Appendix D.

Maintenance Requirements

EXHIBIT 6.81

PROPER MAINTENANCE IS ESSENTIAL TO PREVENT NUISANCE CONDITIONS

Specific maintenance guidelines for the BMPs included in this document are provided below building directly upon the *Urban Storm Drainage Criteria Manual, Volume 3* (UDFCD 1999) for BMPs commonly used in Denver. Additional guidelines for "new" BMPs included in this Plan, such as green roofs, are also provided based on experiences elsewhere. Although subsurface treatment devices are not preferred by Denver for reasons mentioned earlier in this chapter, basic maintenance guidelines for these facilities are also provided, in the event that they are approved on a limited basis under site-specific circumstances. BMP maintenance requirements should be posted on the Denver Public Works website for ready access by the public and be incorporated into updates to Denver's *Storm Drainage Design and Technical Criteria Manual*. Since some of the BMPs included in this Plan are relatively new to Denver, practical experience will likely provide more insight into maintenance needs. As a result, the Denver (www.denvergov.org) and UDFCD (www.udfcd.org) websites should be periodically checked for updates to maintenance recommendations. It is also important to note that the guidelines included in this Plan should always be combined with common sense and good judgment based on field observations and practical experiences of staff.

EXHIBIT 6.82

EXAMPLE BMP MAINTENANCE INSPECTION FORM FROM *MAINTAINING YOUR STORMWATER MANAGEMENT FACILITY: A HANDBOOK FOR PRIVATE PROPERTY OWNERS.* (CITY OF PORTLAND, OR 2002)

Facility Inspection and Maintenance Log (one sheet can be used per facility or for an entire site)

Facility Name: ______________________ Date __________ Inspector's Name ______________________

(Inapplicable fields shaded out) Fill in percentages or depth numbers when possible.

Facility Component	Trash/ Debris	Erosion/ Bank Failure/ Channel Formation	Sediment Accumulation	Vegetation	Structural Deficiency (list)	Ponding Water	Pests	Odors	Visible Sheen, etc.	Maintenance Action Taken
Access Road/ Structure										
Inlet										
Facility Structure										
Sedimentation Facility										
Treatment Media										
Vegetation										
Outlet Orifice										
Bypass Overflow										
Fence, Signs, Valves, etc.										

Other Observations

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In addition to the guidelines included in this Plan, other excellent supplemental references providing information on stormwater BMP maintenance include:

- Urban Drainage and Flood Control District. 1999. *Urban Storm Drainage Criteria Manual, Volume 3, Stormwater Best Management Practices*. Denver, CO: Urban Drainage and Flood Control District. Also see the UDFCD website for updates to Volume 3 BMP maintenance recommendations (www.udfcd.org).

- Watershed Management Institute. 1997. *Operation, Maintenance and Management of Stormwater Management Systems.* Ingleside, MD: Watershed Management Institute.

- Low Impact Development Center. 2003. Low Impact Development Urban Design Tools. http://www.lid-stormwater.net/.

- City of Portland, Oregon. 2002. *Maintaining Your Stormwater Management Facility: A Handbook for Private Property Owners.* Portland, OR: Bureau of Environmental Services.

On a general note with regard to BMPs that have a vegetation component or involve weed and pest control, the Mayor's Executive Order 121 establishes specific requirements for pesticide use in Denver (Denver 1997). UDFCD and Chapter 7 of this Plan strongly advocate use of Integrated Pest Management (IPM) practices that help to reduce the level of pesticide and herbicide use through a variety of practices.

Although water quality monitoring is not typically required as part of maintenance agreements, it is highly encouraged as an effective tool for determining if the BMP is functioning effectively. Stormwater quality monitoring guidelines can be downloaded from the International Stormwater BMP Database website (www.bmpdatabase.org).

Grass Buffers and Grass Swales

Grass buffers and swales require general maintenance of the turf grass cover and repair of any rill or gully development. Healthy vegetation can generally be maintained without using fertilizers because runoff from lawns and other areas contains the needed nutrients. Occasionally inspecting the vegetation over the first few years will help to determine if any problems are developing and to plan for long-term restorative maintenance needs. Exhibit 6.83 presents a summary of specific maintenance requirements and a suggested frequency of action.

EXHIBIT 6.83. GRASS BUFFER STRIP AND SWALE MAINTENANCE CONSIDERATIONS (ADAPTED FROM UDFCD 1999)		
Required Action	**Maintenance Objective**	**Frequency of Action**
Mowing	Maintain irrigated turfgrass at a recommended height of 2 to 4 inches tall. Non-irrigated native grass should be maintained at 6 to 8 inches tall.	Routine – As needed to maintain grass height or based on inspection. Will vary from as frequently as weekly during the summer, to no mowing during the winter.
Fertilizer, Herbicide and Pesticide Application	Use the minimum amount of biodegradable, nontoxic fertilizers and herbicides needed to maintain dense vegetation cover that is reasonably free of weeds. Hand pulling of weeds is preferred in areas with limited weed problems. Comply with Executive Order 121 (Denver 1997) regarding pesticide use and use integrated pest management (IPM) strategies.	Routine – On an as-needed basis only.
Irrigation	Adjust irrigation throughout the growing season to provide the proper irrigation application rate to maintain healthy vegetation. Less irrigation is typically needed in early summer and fall, with more irrigation needed during July and August. Check for broken sprinkler heads and repair them, as needed. Do not overwater. Signs of overwatering and/or broken sprinkler heads may include soggy areas and unevenly distributed areas of lush growth.	Routine—Adjust and maintain throughout growing season.
Reseeding/ Vegetation Replacement	Reseed and/or patch damaged areas in buffer, sideslopes and/or channel to maintain healthy vegetative cover.	Routine – As needed by inspection. Expect turf replacement for buffer strips once every 5 to 15 years.
Litter and Debris Removal	Remove litter and debris to prevent gully development, enhance aesthetics, and prevent floatables from being washed offsite.	Routine – As needed by inspection, but no less than two times per year.
Sediment Removal	For Grass Swales: Remove accumulated sediment near culverts and in channels to maintain flow capacity. Replace the grass areas damaged in the process.	Routine – As needed by inspection. Remove sediment from roughly 3 to 10 percent of the total length of the swale per year, as determined by annual inspection.
Inspections	Inspect vegetation for uniform cover and heavy traffic impacts, check for sediment accumulation and gully development.	Annually and after each major storm (more than 0.75 inches in precipitation). Repair as needed.

Porous Pavement and Porous Pavement Detention

The key maintenance objective for porous pavement and porous pavement detention is to know when runoff is no longer rapidly infiltrating into the surface, which is typically due to void spaces becoming clogged and requiring sediment removal. Exhibit 6.84 identifies key maintenance considerations for various types of porous pavement BMPs.

EXHIBIT 6.84. POROUS PAVEMENT MAINTENANCE CONSIDERATIONS (ADAPTED FROM UDFCD 1999, AS AMENDED BY UDFCD'S DRAFT POROUS PAVEMENT GUIDANCE, OCTOBER 2004)

Required Action	Maintenance Objective	Frequency of Action
Debris and Litter Removal	**For All Types:** Accumulated material should be removed as a source control measure.	Routine – As needed.
Sod Maintenance	**For Modular Block Pavement:** If sandy loam turf is used, provide lawn care, the irrigation system, and inlay depth maintenance as needed.	Routine – As dictated by inspection.
Vacuuming Pavement	**For Porous Concrete Pavement:** Vacuum the porous concrete pavement using high energy purging street vacuuming equipment to remove accumulating sediment from pavement pores.	Routine – Every year, but may be extended to every two or more years if routine inspections show the infiltration rates continue to be high. Very important to maintain infiltration flow through the full section of the concrete to extend it life during freeze-thaw cycles in colder climates.
Inspection	**For All Types:** Inspect representative surface areas for accumulation of sediment or poor infiltration. **For Reinforced Grass Pavement:** Inspect representative areas of surface for healthy grass growth, surface erosion, accumulation of sediment and poor infiltration.	Routine and during a storm event to ensure that water is not frequently bypassing these surfaces by not infiltrating into the pavement.
Replace Surface Filter Layer	**For Modular Block Pavement:** Remove, dispose, and replace surface filter media by pulling out turf plugs and by vacuuming out sand media from within the annular spaces of the blocks. Replace with fresh ASTM C-33 sand and, if appropriate, sandy loam turf plugs. **For Cobblestone Block Pavement:** Remove, dispose, and replace surface filter media by vacuuming out sand media from within the annular spaces of the blocks using scarifying high energy vacuum equipment. Replace with fresh ASTM C-33 sand.	Non-routine – when it becomes evident that runoff does not rapidly infiltrate into the surface. May be as often as every year or as little as every 5 to 10 years for modular block pavement or 2 to 5 years for Cobblestone Block Pavement.
Repair and Replacement of Sod Layer	**For Reinforced Grass Pavement:** Repair damaged sod. Remove and replace, as needed, the sod cover to maintain a healthy vegetative cover or when sod layer accumulates significant amount of silt (i.e., >1.5 inches) from atmospheric fallout and	Non-routine – when it becomes evident that runoff does not rapidly infiltrate into the surface. Repairs may be as often as every

EXHIBIT 6.84. POROUS PAVEMENT MAINTENANCE CONSIDERATIONS (ADAPTED FROM UDFCD 1999, AS AMENDED BY UDFCD'S DRAFT POROUS PAVEMENT GUIDANCE, OCTOBER 2004)		
	stormwater runoff.	year. Replacement of sod may be as little as every 10 to 25 years.
Replace Pavement	**For Modular Block Pavement**: Remove and replace the modular pavement blocks, the sand leveling course under the blocks, and the infill media when the pavement surface shows significant deterioration. **For Cobblestone Block Pavement**: Remove and replace the cobble pavement blocks, the sand leveling course under the blocks, and the infill media when the pavement's surface shows significant deterioration. **For Porous Concrete Pavement**: Remove, dispose, and replace porous concrete when it shows excessive surface deterioration and when it no longer infiltrates stormwater quickly. Inspect the full section of the pavement when the concrete layer is removed for accumulation of sediment in the base course and on top of the sand filter layer or sub-base. Remove and dispose accumulated sediment and replace base course, sand filter layer, and geotextile fabrics. **For Porous Gravel Pavement**: Remove, dispose, and replace surface gravel layer when it shows excessive surface deterioration and when it no longer infiltrates stormwater quickly. Inspect the full section of the pavement when replacing the surface gravel layer for accumulation of sediment in the base course and on top of the sand filter layer or sub-base. Remove and dispose accumulated sediment and replace base course, sand filter layer and geotextile fabrics.	Non-routine - when it becomes evident that the modular blocks have deteriorated significantly. Expect replacement every 10 to 25 years, dependent on use and traffic.
Repair of Structural Damage	**For All Types**: Structural damage due to improper construction, faulty materials or accidents should be repaired as needed.	Non-routine—Upon awareness that structural damage such as pavement unraveling has occurred.

Porous Landscape Detention

The primary maintenance objective for porous landscape detention is to keep vegetation healthy, remove sediment and trash, and ensure that the facility is draining properly. The growing medium for these BMPs will need to be replaced periodically to maintain performance. Exhibit 6.85 summarizes key maintenance considerations for porous landscape detention. Porous landscape detention is comparable to bioretention cell and rain garden practices used as part of Low Impact Development strategies.

EXHIBIT 6.85. POROUS LANDSCAPE DETENTION MAINTENANCE CONSIDERATIONS (Adapted from UDFCD 1999 and supplemented by Prince George's County Bioretention Manual and the City of Portland Environmental Services Homeowner Handbook)

Required Action	Maintenance Objectives	Frequency
Lawn mowing and turf care	Occasional mowing of grasses and weed removal to limit unwanted vegetation. Maintain irrigated turf grass at 2 to 4 inches tall and un-irrigated native grasses at 4 to 6 inches.	Routine—Depending on aesthetic requirements.
Debris and litter removal	Remove debris and litter from detention area to minimize clogging of the sand media; remove debris and litter from any overflow inlets.	Routine—depending on aesthetic requirements.
Sediment Removal	Remove sediment to maintain infiltration.	Routine —particularly in the inlet area.
Soil	Prevent erosion and provide healthy growing medium for plants.	Routine—Visually inspect and repair erosion following major storm events. Use small stones to stabilize erosion along drainage paths. Check the pH once or twice a year. Apply an alkaline product, such as limestone, if needed. Soil replacement may be required every 5 to 10 years, depending on pollutant loads.
Mulch	Conserve soil moisture and promote plant health.	Routine—Re-mulch any void areas by hand as needed. Every 6 months, in the spring and fall, add a fresh mulch layer. Once every 2 to 3 years, in the spring, remove old mulch layer before applying new one.
Plant Care	Maintain attractive, healthy vegetation.	Routine—Once a month (more frequently in the summer), visually inspect vegetation for disease or pest problems. If treatment is warranted, use Integrated Pest Management (IPM) approaches. In the early spring and late fall, remove and replace all dead and diseased vegetation. Provide adequate irrigation to promote healthy plant growth. During times of extended drought,

EXHIBIT 6.85. POROUS LANDSCAPE DETENTION MAINTENANCE CONSIDERATIONS (Adapted from UDFCD 1999 and supplemented by Prince George's County Bioretention Manual and the City of Portland Environmental Services Homeowner Handbook)		
		look for physical features of stress (unrevived wilting, yellow, spotted or brown leaves, loss of leaves, etc.). Weed on an as-needed basis. Prune excess growth annually or more often, if desired. Trimmed materials may be recycled back in with replenished mulch or land filled if there is a concern of heavy metals accumulation.
Drainage	Prevent extended ponding and mosquito reproduction.	Non-routine—After rainstorms, inspect the area and make sure that drainage paths are clear and that ponding water dissipates over 4-6 hours. (Water may pond for longer times during the winter and early spring.) It is important to note that these features are not ponds and should drain in a manner that does not promote mosquito breeding.
Chemical Spill Response	Remove soil and plants and replace with new material.	Non-routine—in the event of a chemical spill, the soils and plant material should be replaced.
Inspections	Inspect detention area to determine if the sandy loam media is allowing acceptable infiltration.	Routine—biannual inspection of hydraulic performance.

Extended Detention and Retention Basins

Extended detention basins and retention ponds have low to moderate maintenance requirements on a routine basis, but require significant maintenance about once every 10 to 20 years for sediment removal. Sediment removal frequency depends on the amount of construction activity within a basin, the erosion control measures implemented, the size of the basin and the design of the facility. When aggressive erosion control is practiced in the tributary watershed, it is estimated that accumulated sediment will need to be removed at 5- to 20-year intervals. Routine and non-routine maintenance is necessary to assure performance, enhance aesthetics, and protect structural integrity. Extended detention (dry) basins can result in nuisance complaints if not properly designed or maintained. If a shallow wetland or marshy area develops, mosquito breeding and nuisance odors could occur if the water becomes stagnant. Biodegradable pesticides may be required to limit insect problems. Frequent debris removal and mowing can reduce aesthetic complaints. Access to critical elements of both dry and wet ponds (inlet, outlet, spillway, and sediment collection areas) must be provided. The basic elements of the maintenance requirements are presented in Exhibit 6.87.

EXHIBIT 6.86
"MUCKING OUT" A MICROPOOL AT AN EXTENDED DETENTION BASIN

Source: Urban Drainage and Flood Control District.

EXHIBIT 6.87. EXTENDED DETENTION AND RETENTION BASIN MAINTENANCE CONSIDERATIONS (ADAPTED FROM UDFCD 1999)

Required Action	Maintenance Objective	Frequency of Action
Lawn Mowing and Lawn Care	Occasional mowing to limit unwanted vegetation. Maintain irrigated turf grass at 2 to 4 inches tall and un-irrigated native turf grasses at 4 to 6 inches.	Routine – Depending on aesthetic requirements.
Debris and Litter Removal	Remove debris and litter from the entire pond to minimize outlet clogging and improve aesthetics.	Routine – Including just before annual storm seasons (that is, April and May) and following significant rainfall events.
Erosion and Sediment Control	Repair and revegetate eroded areas in the basin and channels.	Non-routine – Periodic repair as necessary based on inspection.
Structural	Repair pond inlets, outlets, forebays, low-flow channel liners, and energy dissipaters whenever damage is discovered. Also stabilize banks and berms.	Non-routine – Repair as needed based on regular inspections.

EXHIBIT 6.87. EXTENDED DETENTION AND RETENTION BASIN MAINTENANCE CONSIDERATIONS (ADAPTED FROM UDFCD 1999)		
Inspections	Inspect basins to insure that the basin continues to function as initially intended. Examine the outlet for clogging, erosion, slumping, excessive sedimentation levels, overgrowth, embankment and spillway integrity, and damage to any structural element.	Routine – Annual inspection of hydraulic and structural facilities. Also check for obvious problems during routine maintenance visits, especially for plugging of outlets. Biannual performance and maintenance inspections.
Nuisance Control	Address odor, insects, and overgrowth issues. For dry ponds, check for stagnant or standing water in the bottom zone that may cause these problems.	Non-routine – Handle as necessary per inspection or local complaints.
Sediment Removal (for Dry Ponds)	Remove accumulated sediment from the forebay, micro-pool, and the bottom of the basin.	Non-routine – Performed when sediment accumulation occupies 20 percent of the WQCV. This may vary considerably, but expect to do this every 10 to 20 years, as necessary per inspection if no construction activities take place in the tributary watershed, but more often if construction is occurring. The forebay and the micropool will require more frequent cleanout than other areas of the basin, roughly every 1 or 2 years.
Sediment Removal (for Wet Ponds)	Empty the pond, divert the base flow, and dry out bottom sediment in fall and winter months to allow access with backhoe. Remove accumulated sediment along with overlying aquatic growth. Re-establish original design grades and volumes and replant aquatic vegetation.	Non-routine – As indicated per inspections and sediment accumulation. Expect to do this every 10 to 20 years if no construction activities take place in the tributary watershed. More often if they do. Expect to clean out the forebay every 1 to 5 years.
Aquatic Growth Harvesting (Primarily for Wet Ponds)	Remove aquatic plants such as cattails or reeds, thereby also permanently removes nutrients. Use an aquatic harvester and dispose of the material offsite.	Non-routine – Perform every 5 to 15 years or as needed to control accumulation.
Forebays	Ensure that measures described above (e.g., debris and sediment removal and aquatic harvesting) are also conducted for forebays to the ponds.	Routine and Non-routine – on an as needed basis, consistent with the practices described above.
Trash Racks	Regularly remove debris and ensure that trash rack is in good condition. This is important for proper function of the BMP, aesthetics and public safety.	Routine-Should be checked when mowing is conducted and after major storms.

Sand Filter Extended Detention Basin

Key maintenance considerations for sand filter extended detention basins involve ensuring that infiltration into the sand filter occurs as designed. Key maintenance practices are described in Exhibit 6.88.

Exhibit 6.88. Sand Filter Detention Basin Maintenance Considerations (Adapted from UDFCD 1999)		
Required Action	**Maintenance Objectives**	**Frequency**
Debris and Litter Removal	Remove debris and litter from detention area to minimize clogging of the sand media.	Routine – depending on aesthetic requirements.
Landscaping Removal and Replacement	If the sand filter is covered with rock mulch, bluegrass, or other landscaping covers, the cover must be removed to allow access to the sand media. Replace landscaping cover after maintenance of sand media is complete.	Every 2 to 5 years.
Scarify Filter Surface	Scarify top 3 to 5 inches by raking the filter's surface.	Once per year or when needed to promote drainage.
Sand Filter Removal	Remove the top 3 inches of sand from the sand filter. After a third removal, backfill with 9 inches of new sand to return the sand depth to 18 inches. Minimum sand depth is 12 inches.	If no construction activities take place in the tributary watershed, every 2 to 5 years depending on observed drain times (e.g., when it takes more than 24 hours to empty 3-foot-deep pool). Expect to clean out forebay every 1 to 5 years.
Flush-out Perforated Pipe Gallery	If a "clean-out" has been provided for the perforated pipe gallery, it can be used to flush out the pipes.	Routine- Once per year or when needed to promote drainage.
Inspections	Inspect detention area to determine if the sand media is allowing acceptable infiltration.	Routine – biannual inspection of hydraulic performance, with one after a significant rainfall.

Constructed Wetland Basins and Channels

To achieve and maintain a healthy wetland for water quality enhancement, the proper depth and spatial distribution of growth zones must be maintained. Exhibit 6.89 summarizes suggested activities and their frequencies to maintain an operational wetland.

EXHIBIT 6.89. CONSTRUCTED WETLAND CHANNEL AND BASIN MAINTENANCE CONSIDERATIONS (ADAPTED FROM UDFCD 1999)

Required Action	Maintenance Objective	Frequency of Action
Lawn Mowing and Lawn Care	Mow occasionally to limit unwanted vegetation. Maintain irrigated turf grass at 2 to 4 inches tall and non-irrigated native turf grasses at 4 to 6 inches.	Routine – Depending on aesthetic requirements.
Debris and Litter Removal	Remove debris and litter from entire pond and/or channel to minimize outlet clogging and aesthetics. Include removal of floatable material from the pond's surface.	Routine – Including just before annual storm seasons (that is, in April and May) and following significant rainfall events.
Sediment Removal	Remove accumulated sediment and muck along with much of the wetland growth. Re-establish growth zone depths and spatial distribution. Revegetate with original wetland species.	Non-routine – Every 10 to 20 years as needed by inspection if no construction activities take place in the tributary watershed. More often if they do. Expect to clean out forebay every 1 to 5 years.
Aquatic Plant Harvesting	Cut and remove plants growing in wetland (such as cattails and reeds) to permanently remove nutrients with manual work or specialized machinery.	Non-routine until further evidence indicates such action would provide significant nutrient removal. In the meantime, perform this task once every 5 years or less frequently as needed to clean the wetland zone out.
Inspections	Observe inlet and outlet works for operability. Verify the structural integrity of all structural elements, slopes, and embankments.	Routine – At least once a year, preferably once during one rainfall event resulting in runoff.

Green Roofs/Treatment Roofs

As discussed in the BMP Fact Sheets portion of this chapter, green roofs/treatment roofs have not been used extensively in the Denver area, but have been successfully used in other parts of the country and in Europe. If these roofs are selected for use in Denver, proper maintenance is critical for their success, as is the case with all BMPs. The Low Impact Development Center provides guidance on the maintenance requirements for green roofs (http://www.lid-stormwater.net/greenroofs/greenroofs_maintain.htm) and is reproduced below. The Low Impact Development Center states that once a properly installed green roof is well established, its maintenance requirements are usually minimal, with the extent of maintenance dependent on the type of green roof. Green roofing systems can vary in thickness from two to seven inches (5 to 18 centimeters). The term "extensive" is used to describe the lighter roofing systems, while the term "intensive" is used to describe the heavier roofing systems. While a roof's effectiveness in managing runoff generally increases with the thickness and weight of the roofing system, so do the maintenance requirements (www.lid-stormwater.net). Critical maintenance requirements include inspection of the roof membrane (the most crucial element of a green roof), routine inspection and maintenance of the drainage layer flow paths, and maintenance of the vegetation on the roof (www.lid-stormwater.net). Maintenance requirements for green roofs are reported to be the greatest during the first two years when plants are becoming established (Stormtech et al. 2003). Key maintenance activities are summarized in Exhibit 6.90 below and described in more detail in the remainder of this section.

EXHIBIT 6.90. GREEN ROOFS/TREATMENT ROOFS
(ADAPTED FROM THE LOW IMPACT DEVELOPMENT CENTER 2004)

Required Action	Maintenance Objectives	Frequency
Irrigation and Fertilizing	Maintain healthy plant growth. Use of native plants with a drip irrigation system will reduce maintenance efforts in arid environments. The irrigation system should be checked to ensure it is functioning properly.	Irrigation and fertilizer requirements are dependent on the plant species selected and the type of irrigation system installed. Drip irrigation system should be inspected monthly.
Trimming and Weeding	Maintain healthy plant growth. If properly designed and established, a typical green roof does not need to be mowed. A thin soil layer does not support tall vertical growth; therefore, the vegetation mat will tend to spread horizontally (Scholz-Barth 2001). Occasional weeding of the rooftop, especially in the establishment phase, will remain necessary.	As needed through growing season.
Inspection for Drainage	Ensure roof drainage is not blocked to prevent roof leakage and perpetually saturated soils. Because of the severe consequences of drainage backups, inspection of the drainage flow paths (or channels) is crucial, especially on extensive roofs. If drainage routes become blocked, green roofs can cause some flat roofs to leak due to continuous contact with water or wet soil. With insufficient drainage, the plants will also be susceptible to the impact of wide	Following major storm events.

EXHIBIT 6.90. GREEN ROOFS/TREATMENT ROOFS (ADAPTED FROM THE LOW IMPACT DEVELOPMENT CENTER 2004)		
	degrees of variability in the moisture content of the soil. If too much water is present, the soil will be adversely affected and the plants will drown or rot (Peck and Callaghan 1999; (www.lid-stormwater.net).	
Inspection for Leaks	Ensure roof is not leaking. Roofs can leak from drainage backups or root puncture, or if the correct waterproofing membrane system, root barrier, and/or drainage layer are not selected. Areas where occasional inspection for leaks is advisable include possible problem areas such as abutting vertical walls, roof vent pipes, outlets, air conditioning units, perimeter areas, etc. (www.greenroofs.com). Most roofing companies, including those that install green roofs, will provide a warranty for the waterproofing integrity of the roof membrane(s) they have installed, including green roof membranes (www.lid-stormwater.net).	Following major storm events.
Roof Replacement	Continue function of green roof. Green roofs are generally more effective than conventional roofing systems in protecting the roof membrane. This reduces regular maintenance costs and extends the life of the membrane itself. According to a study in Germany, a vegetated roof on average can be expected to prolong the service life of a conventional roof by at least 20 years (ZVG 1996; www.lid-stormwater.net). In some cases, green roof maintenance may involve re-waterproofing of the roof membrane. However, if designed and installed properly, the waterproof characteristic of a green roof will be maintained for at least as long as a conventional roof.	Variable, typically 20+ years.

Low Impact Development Designs

Low Impact Development (LID) and other BMPs based on minimizing directly connected impervious area present unique technical and administrative challenges in tracking the status and upkeep of these BMPs over time. The greatest challenge to the success of these practices is proper education on how these BMPs function and ensuring that they are properly maintained over the long-term. It is also critically important that these BMPs are understood by property owners as being permanent, legally required stormwater treatment facilities for the site and are not removed or regraded due to an owner's aesthetic preferences or site remodeling. Due to the localized, integrated nature of these BMPs, there is less likelihood of maintenance by a maintenance contractor or other professional entity. For this reason, very clear guidelines must be provided to homeowners, homeowners' associations, and others implementing LID techniques. The Low Impact Development Center website (www.lid-stormwater.net) provides maintenance guidelines for a variety of LID techniques. The key component of most LID designs is the bioretention cell, or rain garden. This technique is similar to porous landscape detention, as described in Volume 3 of the *Urban Storm Drainage Criteria Manual.* For this reason, the guidelines developed by UDFCD for porous landscape detention, as summarized in Exhibit 6.85, are recommended to be followed for landscape-based treatment approaches that have been termed bioretention cells or rain gardens in other parts of the country. Similarly, LID techniques that emphasize runoff reduction by disconnecting impervious area and grassy swales instead of pipes correspond to UDFCD's grass buffers and swales. Maintenance requirements for grass buffers and swales are summarized in Exhibit 6.83.

Subsurface Treatment Devices

Because subsurface treatment devices are normally located below the ground surface, they tend to be "out-of-site, out-of-mind." Therefore, they often do not receive regular maintenance, nor is their performance periodically monitored. This is one of the reasons that Denver strongly prefers above-ground treatment approaches. In the event that subsurface treatment is approved for a site, Exhibit 6.91 outlines maintenance requirements.

EXHIBIT 6.91. SUBSURFACE TREATMENT DEVICES

Required Action	Maintenance Objectives	Frequency
Accumulated Sediment and Debris Removal	Remove the accumulated sediment as recommended by the manufacturer, or when it has reached a depth of roughly half a foot, if not specified.	Frequency will vary based on device size and geometry. The approximate required removal frequencies should be calculated based on tributary watershed area, average annual precipitation, representative total suspended solids event mean concentration in runoff and the vault/device surface area. Manufacturer should be able to provide this information.
Inspections	Inspect device to determine whether it appears to be functioning as designed based on manufacturer's guidelines.	At least twice per year following major storm events. Water quality monitoring can help to determine if the device is functioning as intended.

Conclusions and Recommendations for Maintenance

1. A BMP maintenance plan requirement should become a part of Denver's Stormwater Quality Control Plans, as referenced in Denver's Rules and Regulations. The contents of these maintenance plans should be clearly outlined in *Stormwater Quality Control Plans, An Information Guide.*

2. A legally binding agreement describing BMP maintenance requirements and arrangements should be necessary for final approval of a development. Denver's existing Sanitary and Storm Sewer Easement and Indemnity Agreement is a good starting point for such an agreement. Examples of agreements used in other parts of the country, as contained in Appendix D, can be used to further develop this agreement with regard to BMP maintenance requirements.

3. Clearly defined maintenance requirements for BMPs should be included in updates to Denver's *Storm Drainage Criteria Manual*.

4. Clearly defined maintenance requirements for BMPs that represent new technologies or practices are essential. This is particularly relevant for low impact development or landscape-based practices that may be spread throughout multiple parcels in developments and that could be confused with ordinary landscaping. Though these techniques have many "natural" features, they still require intentional maintenance like any stormwater BMP.

5. A simple BMP maintenance brochure or handbook (that can stand-alone from this Plan) that explains the importance of BMP maintenance for stormwater quality management and directs relevant parties to the Denver website for detailed guidance should be developed. This could be jointly developed with the Joint Task Force (with Aurora, Lakewood and UDFCD) as a fourth brochure in the "Clear Choices for Clean Water" series that is currently posted on Denver's website.

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Chapter 7
POLLUTION SOURCE CONTROLS (NON-STRUCTURAL BMPS)

OVERVIEW OF POLLUTION SOURCE CONTROLS (NON-STRUCTURAL APPROACHES)

Pollution source controls, also commonly referred to as non-structural best management practices (BMPs), are a key component of any effective stormwater management strategy and should be integrated into plans for all development types. This set of BMPs can generally be described as a variety of practices intended to prevent or limit the entry of pollutants into stormwater runoff. In contrast to structural BMPs, which involve the construction of facilities such as ponds, wetlands, infiltration basins, etc., source controls or non-structural BMPs do not normally involve construction, but instead focus on measures to minimize pollution at its source, thereby reducing the amount of pollutants to be removed in downstream structural BMPs. Most source controls are dependent on behavioral change, which is in turn dependent on good education. Denver staff have a real opportunity to set the example for the public with regard to source controls. Non-structural approaches are particularly important in areas that have already been developed and are a key strategy in reducing pollution when new structural controls are not an option due to cost or space constraints. Many non-structural and structural practices are interrelated, but for purposes of this discussion, non-structural/source control BMPs have been grouped into the following general categories:

- **Public Outreach and Education**—Examples include educating citizens and business owners about topics such as automotive product disposal; good housekeeping practices at commercial, restaurant and retail sites; construction site training; industrial good housekeeping practices; inlet stenciling activities; proper pesticide/herbicide use; and educational programs at schools.

- **Illicit Discharge and Detection Programs**—This involves identification, detection and prevention of illicit discharges to storm sewers. This BMP relies on other non-structural BMPs such as public education and proper waste disposal programs. Examples of illicit discharges include illegal dumping, accidental chemical spills and illicit connections of sanitary sewers to storm sewers.

- **Source Controls**—Examples include minimizing exposure of pollutants to stormwater at facilities such as automobile maintenance sites, salvage facilities and service stations; commercial, restaurant and retail sites; construction sites; farming and agricultural sites; and industrial sites. Activities at such sites requiring particular attention include outside materials storage, above ground storage tanks, loading and unloading areas, vehicle washing, fueling, outside manufacturing, etc. It is also important to note that as stormwater management strategies evolve, the line between structural and non-structural controls is increasingly blurred. For example, soft, decentralized "natural" stormwater systems can also serve as source controls.

- **Recycling/Waste Disposal Programs**—Examples include household toxics collection and recycling programs and leaf and landscaping waste collection.
- **Good Housekeeping Practices/Spill Prevention and Response**—Examples include developing spill prevention measures, identifying spill areas, implementing material handling procedures, and spill plan development.
- **Municipal Maintenance Practices**—Examples include catch basin cleaning; maintenance of structural BMPs; parking lot and street sweeping; road and street pavement repair, sealing, overlay, etc.; road salting and sanding; roadside ditch cleaning and restoring.
- **Land Use Planning and Management (Programmatic) Strategies**—Examples include new development planning procedures; procedures for site planning at construction sites; protective covenants; riparian buffer zone setbacks; Low Impact Development, "green" development, and Smart Growth development strategies.

For more information on non-structural BMPs, including advantages/disadvantages, costs, and experiences, the following documents are particularly helpful and should be referenced for more detail:

- *Urban Storm Drainage Criteria Manual, Volume 3* (UDFCD 1999)
- *Urban Runoff Quality Management, Water Environment Federation Manual of Practice No. 23 and American Society of Civil Engineers Manual and Report on Engineering Practice No. 87* (WEF and ASCE 1998)
- Low Impact Development web site (http://www.lid-stormwater.net/)
- *California Stormwater Quality Association Stormwater Best Management Practice Handbook* (CASQA 2003)
- EPA Stormwater Web site (http://www.epa/gov/npdes/stormwater)
- *Green Industry Best Management Practices for the Conservation and Protection of Water Resources in Colorado* (GreenCO and Wright Water Engineers, Inc. 2004)

Denver's Stormwater Management Program, required under its Colorado Discharge Permit System (CDPS) permit, includes five major program components with specific structural and non-structural BMP requirements, as described in Chapter 3 and summarized in Exhibit 7.1. The vast majority of these practices are non-structural, and many of them are education-based. Denver completes an annual report itemizing how each of these BMPs has been implemented. Structural BMPs and site-planning type issues have already been discussed throughout this Plan. Construction-related BMPs are not included in this Plan since this Plan's scope focuses on post-construction, permanent development. Thus, the remainder of this section describes some of Denver's recent and on-going efforts to implement various non-structural BMPs according to the general categories of public education, illicit discharge and detection, source controls, recycling/waste disposal, and maintenance/good housekeeping and highlights some opportunities for better non-structural BMP implementation. For a detailed description of Denver's practices, see the annual reports completed by Denver and submitted to the Colorado Water Quality Control Division (CWQCD). (These reports can be obtained from Denver's Wastewater Management Division or the CWQCD.)

EXHIBIT 7.1 PRACTICES REQUIRED IN DENVER'S CDPS STORMWATER PERMIT	
Category	**Required Practice/Program**
Commercial/ Residential Management Program	▸ Maintenance of Structural Controls ▸ New Development Planning Procedures ▸ Public Street Maintenance ▸ Assessment of Impacts of Flood Management Projects ▸ Pesticide, Herbicide, and Fertilizer Application
Illicit Discharge Detection Program	▸ Prevention of Illicit Discharges and Improper Disposal ▸ Ongoing Field Screening ▸ Investigation of Suspected Illicit Discharges ▸ Procedures to Prevent, Contain, and Respond to Spills ▸ Educational Activities to Promote Public Reporting of Illicit Discharges and Improper Disposal ▸ Public Educational Activities to Promote Proper Management and Disposal of Potential Pollutants ▸ Used Motor Vehicle Fluid and Household Chemical Waste Collection Programs ▸ Control of Sanitary Sewer Seepage into the Municipal Storm Sewer System
Industrial Facilities Program	▸ Education and Outreach on Industrial Pollutant Source Control
Construction Sites Program	▸ Procedures for Site Planning ▸ Structural and Non-Structural BMPs ▸ Procedures for Site Inspection and Enforcement ▸ Training and Education for Construction Site Operators
Municipal Facility Runoff Control Program	Facilities addressed: ▸ Vehicle maintenance facilities ▸ Asphalt and concrete batch plants which are not already individually permitted ▸ Solid-waste transfer stations ▸ Exposed stockpiles of materials, including stockpiles of road deicing salt, salt and sand, sand, rotomill material ▸ Sites used for snow dumps, and/or for temporary storage of sweeper tailings or other waste piles

Applicability of Non-structural Approaches to Development Types

In keeping with the discussion of structural approaches to water quality, Exhibit 7.2 summarizes the applicability of various non-structural approaches to the development types discussed in Chapter 6 of this Plan. As a general principle, non-structural strategies should be broadly applied whenever possible to control sources of pollutants. Non-structural BMPs focus on routine day-to-day activities; therefore, public education and employee training regarding the importance of these activities must be on-going in order for many of these practices to be effective. Although it is much more difficult to quantify the effectiveness of non-structural BMPs relative to structural BMPs, common sense suggests that controlling pollution at its source is a sound approach to minimizing pollution and the costs of mitigating its impacts.

EXHIBIT 7.2
APPLICABILITY OF NON-STRUCTURAL APPROACHES TO DEVELOPMENT TYPES

	Development Type						
Non-Structural BMP	Ultra-Urban	High Density Mixed	Industrial	Low Density Mixed	Campus	Resi-dential	Park
Public Outreach/ Education	X	X	X	X	X	X	X
Source Controls	X	X	X	X	X	X	X
Industrial/ Commercial Hotspots	X	X	X	X	X		
Household Waste	X	X		X	X	X	
Pesticide/ Herbicide/ Fertilizer Management		X	X	X	X	X	X
Efficient Irrigation		X	X	X	X	X	X
Materials Storage Practices	X	X	X	X	X		X
Recycling/ Waste Disposal Programs	X	X	X	X	X	X	
Good Housekeeping	X	X	X	X	X		X
Spill Prevention/ Response	X	X	X	X	X	X	X
Municipal Maintenance Practices	X	X	X	X	X	X	X
Land Use Planning/Mgmt.	X	X	X	X	X	X	X

Public Outreach and Education and Illicit Discharge Controls

Public education addresses a multitude of pollutant sources by raising the general level of understanding of how individual actions can contaminate surface runoff and downstream waterbodies. Public education includes both educating the general public and Denver employees. Topics often addressed in public education programs include proper disposal of household and toxic waste; proper use of pesticides, herbicides, and fertilizers; and responsible disposal of spent materials. Representative mechanisms for public education may include brochures, posters, signs, and educational videos; utility bill inserts, flyers and handbills; newspaper articles and/or advertisements; public workshops, including field demonstrations; or developing school curricula. Another approach used in many municipalities is storm drain stenciling or signs on storm drains alerting the public that the drain leads to a downstream river or creek and that dumping to the drain is prohibited. Portland, Oregon (see Chapter 5) and Boulder, Colorado are examples of cities that have undertaken in-depth public education and training programs that target specific industry segments. For example, the City of Boulder has developed the Partners for a Clean Environment (PACE) program (see http://www.ci.boulder.co.us/environmentalaffairs/PACE/index.htm), which targets and provides educational information to specific industry segments including auto repair, auto body, green building, dental offices, dry cleaning, landscaping, manufacturing, printing, restaurant, and retail sectors.

Exhibit 7.4 summarizes the activities that Denver has implemented to promote public education regarding stormwater pollution. Public education is critical to all of Denver's stormwater program components (e.g., commercial/residential management program, illicit discharge detection program, etc.). Denver has recognized the importance of providing education and outreach at multiple levels: 1) public and elected officials, 2) schools, and 3) industrial and commercial facilities. In addition to the many educational activities involving schools listed in Exhibit 7.4, one of the important activities Denver has focused on is hands-on experience for public and elected officials. For example, Denver's municipal separate storm sewer system (MS4) compliance group and the Cherry Creek Stewardship Partners conducted two water quality bus tours to promote awareness and understanding of regional impacts to the Cherry Creek watershed.

EXHIBIT 7.3
DENVER PROACTIVELY WORKS TO ELIMINATE ILLEGAL DUMPING AND ILLICIT DISCHARGES

Source: Colorado Nonpoint Source Council 2001.

EXHIBIT 7.4
REPRESENTATIVE PUBLIC EDUCATION ACTIVITIES COMPLETED BY DENVER

Activity/Program Element	Completion Date
Establishment of a water quality web page (www.denvergov.org) featuring the stormwater hotline phone number and three educational brochures.	February 1999
Operation of a central phone number for the public reporting of illicit discharges.	On-going
Response to reports of illicit discharges from the public and other public agencies.	On-going
Placement of Stormwater Hotline phone number in the Metro Denver White Pages.	2000/2001
Updated Stormwater Hotline in the Metro Denver White Pages.	2003
Development of Pollution Prevention pamphlet.	May 1998
Posting of household waste and lawn and garden brochures on Denver's web pages (www.denvergov.org) under both the Wastewater Management and Denver Recycles sections.	February 1999
Distribution of brochures via Wastewater Management Division storm drainage fee billing to approximately 140,000 customers.	Began in May 1999, completed in April 2001
Placement of brochures at City Recreation Centers, Public Libraries, and City Permit Centers.	Began in February 1999, continued throughout 2003
Provided assistance to Denver Recycles on development of brochure promoting alternatives to household chemical use.	Fall 1999
Co-managed the program and provided funding for the collection operations of Denver's Household Hazardous Waste (HHW) Collection Program. Supplemented public education/marketing funding provided by Denver Recycles.	Began in November 1999, continued throughout 2003
Inclusion of flyer developed by Denver Recycles promoting the HHW collection program via Wastewater Management storm drainage fee billing to approximately 140,000 households.	Began in November 2000, completed in November 2001
Provided assistance to Denver's Department of Environmental Health in the development of a pet waste brochure and garden brochure for Denver residents.	Pet brochure completed in December 2000, distributed in 2001; landscape brochure issues to be discussed in next report
Assisted River Watch program for high school students. Provided Hach testing equipment, laboratory analysis, and program review.	March-April 2001
Purchased Enviroscape® NonPoint Source model for elementary and middle school education program.	December 2001

EXHIBIT 7.4 REPRESENTATIVE PUBLIC EDUCATION ACTIVITIES COMPLETED BY DENVER	
Activity/Program Element	**Completion Date**
Implemented Enviroscape® NonPoint Source outreach presentations as part of elementary and middle school education program.	2002, 2003
Assisted UDFCD in conducting a series of educational training modules to assist Phase II municipalities in preparation of CDPS applications.	July through December 2003, on a monthly meeting schedule
Presented nonpoint source model to Denver Public Schools 5th graders during Water Festival at Fishback Park, Denver.	September 2003
Provided personnel and fiscal support to the Cherry Creek Stewardship Partners to conduct a Project WET "Teach the Teacher" workshop. The workshop will continue to be supported by Denver in 2004.	October 2003
Provided personnel and fiscal support to the Cherry Creek Stewardship Partners to conduct the 5th Annual Partners Conference. The Conference will continue to be supported by Denver in 2004.	November 2003
Provided support to Front Range Earthforce middle school environmental steward groups for stenciling projects in the Cole, Highlands, and Park Hill Neighborhoods. 53 middle school age children participated in the three events.	Sept. 09 and 12, 2003
Stenciling support for 7th and 8th grade Cole Middle School teachers. Approximately 104 children participated in four separate activities.	Sept. 17, 2003
Nonpoint source presentations for 7th and 8th grade Cole Middle School teachers. Approximately 102 children participated in four separate activities.	Sept. 17, 2003
Development of a plan to support and encourage attendance at an education and training program for construction site operators.	January 1, 1999—July 1999 (full implementation), on-going program

In addition to educating the general public, Denver also works to educate and train Denver staff through a variety of mechanisms, with relevant examples summarized in Exhibit 7.5.

EXHIBIT 7.5
REPRESENTATIVE DENVER STAFF EDUCATION ACTIVITIES

Course/Training	Date	Description	Atten-dance	Audience
Colorado Contractors Association Workshop Titled "Construction Site Erosion Control"	February-03	NPDES compliance including construction activities and erosion control	2	Inspectors and program managers
System Maintenance and Response for Structural Controls	Throughout 2003	Spill response procedures, to minimize overall environmental impact during emergency conditions	170	Denver facility managers and personnel
Pollution Prevention	Throughout 2003	Pollution prevention practices and their relationship to protecting human health and the environment	209	Denver facility managers and personnel
Hazardous Material Management	Throughout 2003	Handling and managing hazardous materials, comprehension of Material Safety Data Sheets, and managing hazardous waste	443	Denver facility managers and personnel
GIS Workshop "GIS and Water Quality"	November-03	Incorporating of GIS technology and water quality data management	1	Engineer, program manager
Watershed Water Quality Tour	June-03	Awareness of the connection of water quality, planning, engineering, and non-point source pollution	10	Elected officials, regional planners, and Denver engineers and scientists
Open Space Water Quality Tour	October-03	Awareness of the connection of open space, water quality, planning, engineering, and non-point source pollution	8	Elected officials, regional planners, and Denver engineers and scientists
Colorado Water Congress "Water Quality Workshop"	October-03	Intensive one-day program on all aspects of water quality subjects	2	Engineer, program manager
Cherry Creek Stewardship Partners 5th Annual Conference	November-03	Awareness of the connection of open space, water quality, planning, engineering, and non-point source pollution in a single watershed	6	Elected officials, regional planners, and Denver engineers and scientists
Number of Training Efforts	**9**	**Denver Employees Trained**	**851**	

Source Controls

Source controls help prevent the disposal of or limit the application of constituents that may be potential pollutants in the urban landscape. Source controls also help to minimize the migration of constituents offsite from the point where they are being used, stored, or otherwise being exposed to stormwater. General categories of source controls discussed in more detail in this Plan include:

- Industrial and Commercial "Hot Spots" (Fueling Areas, Vehicle Washing, etc.)
- Household Waste (Litter, Pet Waste, Yard Waste, Used Oil and Automotive Fluids, etc.)
- Pesticide, Herbicide and Fertilizer Management (Including Integrated Pest Management)
- Efficient Irrigation
- Materials Storage Practices

Industrial and Commercial "Hot Spots"

The *Urban Storm Drainage Criteria Manual, Volume 3* (UDFCD 1999) provides a succinct description of industrial and commercial pollutant "hot spots" that should be considered and addressed throughout Denver in terms of both structural and non-structural BMPs. Design considerations for these hot spots include practices such as: providing overhead covering or roof; providing smooth impervious surfaces such as concrete beneath the activity; grading and contouring the site to prevent run-on of stormwater and run-off of pollutants; directing drainage to a structural BMP; strategically locating storm drains away from hot spot activities; and spill response procedures (CSQA 2003). Other practices may include zoning to keep these hot spots out of particularly sensitive areas. The *Urban Storm Drainage Criteria Manual, Volume 3* (UDFCD 1999) provides descriptions of these key hot spots:

- **Fueling Areas**. When stormwater mixes with fuel spilled or leaked onto the ground, it becomes polluted by petroleum-based materials that are harmful to humans, fish, and wildlife. Fuel overflows during storage tank filling can be a major source of contamination. This could occur at large industrial sites or at small commercial sites such as gas stations, convenience stores, strip malls, or garages. Sources of contaminants typically include: spills and leaks during fueling or oil delivery; spills caused by "topping off" fuel tanks; allowing rainfall to run onto the fuel area; hosing or washing down of the fuel area; or mobile fueling operations.

- **Vehicle and Equipment Maintenance and Storage**. Vehicle and equipment maintenance operations use materials and create wastes that can be harmful to humans and the environment if not property handled. Stormwater runoff from these areas can become polluted with a variety of contaminants including solvents and degreasing products, waste automotive fluids, oils and greases, acids, and caustic wastes. Sources of contaminants typically include: parts cleaning; shop cleanup; spilled fuel, oil, or other materials such as battery acid; replacement of fluids, such as oil, oil filters, hydraulic fluids, transmission fluid, and radiator fluids; dripping fluids from vehicles and equipment; and disposal of greasy rags, oil filters, air filters, batteries, battery fluids, spent coolant, degreasers, oils, etc.

- **Painting**. Many painting operations use materials or create wastes that are harmful to humans and the environment. Paint solvents used to remove or thin paint and dusts from sanding and grinding operations contain toxic metals like cadmium and mercury. These can pollute stormwater and create significant water quality impacts. Sources of contamination typically include: painting and chemical paint removal; sanding or paint stripping; spills of paint or paint thinner; sand blasting residue; or equipment painting.

- **Vehicle/Equipment Washing**. Washing vehicles and equipment outdoors or in areas where wash water flows onto the ground can pollute stormwater. Vehicle wash water is considered process water, not stormwater. Operators must have a CDPS permit to discharge vehicle wash water. Wash waters can contain high concentrations of oil and grease, solvents, phosphates, and high suspended solids loads. Sources of washing contamination typically include: outside equipment or vehicle cleaning (washing, degreasing, or steam cleaning); wash water discharges to the ground or directly to storm drain; mobile fleet washing, or pressure washing of buildings. Other types of washing include spraying down concrete and asphalt surfaces such as those outside of commercial sites where sales of products may have occurred, areas where dirt and mud have accumulated, loading dock areas, or parking and sidewalk areas that have accumulated wastes. These activities must have a CDPS permit. In some cases, these types of discharges are incorporated into the municipal stormwater permit. These areas also need to be taken into consideration with the possibility of potentially polluting stormwater.

- **Loading and Unloading**. Loading and unloading operations usually take place outside on docks, trucks, terminals, or outside storage or staging areas at both industrial and commercial sites. Materials spilled, leaked, or lost during loading and unloading may collect in the soil or other surfaces and be carried away by runoff, or when the area is cleaned. Rainfall may wash pollutants off machinery used to unload and load materials. Typically sources of contamination include: pumping of liquids or gases to or from a truck or rail car into a storage facility; pneumatic transfer of dry chemicals to or from the vehicles; transfer by mechanical conveyor systems; or transfer of bags, boxes, drums, or other containers by forklift, trucks, or other material handling equipment.

- **Above Ground Tanks—Liquid Storage**. Accidental releases of chemicals from above ground liquid storage tanks can contaminate stormwater with many different pollutants. Materials spilled, leaked, or lost from storage tanks may accumulate in soils or on other surfaces and be carried away by runoff. Typical causes of contamination from accidental releases include: external corrosion and structural failure; installation problems; spills and overfills due to operator error; failure of piping systems, including pipes, pumps, flanges, couplings, hoses, and valves; or leaks or spills during pumping of liquids or gases from trucks or rail cars to a storage facility or vice versa.

- **Outside Manufacturing**. Outside manufacturing activities can also contaminate stormwater runoff. Activities such as parts assembly, rock grinding or crushing, metals painting or coating, grinding or sanding, degreasing, parts cleaning or operations that use hazardous materials are of concern. Metal and wood shavings, excess lubricants, and other residuals resulting from outside manufacturing that are left on the ground can also be washed into the drainage system. Typical contaminant sources include: processes or equipment that generate dust, vapors or other emissions; outside storage of hazardous materials and raw materials; dripping or leaking fluids from equipment or processes; liquid wastes discharged directly onto the ground or into the storm sewer, or concrete manufacturing (pipes, inlets, etc.).

- **Industrial Site Waste Management**. Areas where industrial or chemical waste is stored, treated or disposed of can cause stormwater pollution. Wastes spilled, leached, or lost from management areas or outside manufacturing activities may build up in soils or on other surfaces and be carried away by rainfall runoff. There is also the potential for liquid wastes from lagoons or surface impoundments to overflow to surface waters or soak the soil where they can be picked up by runoff. Possible stormwater contaminants include toxic compounds, oil and grease, oxygen-demanding organics, paints and solvents, heavy metals, and high levels of suspended solids.

- **Commercial Site Waste Management**. Improper disposal of liquid wastes in a solid waste dumpster can result in the liquids draining out of the container and into the stormwater system. Lack of coverage of waste receptacles can result in rainwater seeping through the material and collecting contaminants or the material being blown around the site and into the stormwater collection system. Typical contaminant sources include: landfills; waste piles; wastewater and solid waste treatment and disposal sites; land application sites; dumpsters; or unlabeled 55-gallon drums.

- **Outside Storage of Materials**. Raw materials, by-products, finished products, containers, and materials storage areas exposed to rain and/or runoff can pollute stormwater. Stormwater can become contaminated by a wide range of contaminants (e.g. metals, oils and grease, sediment) when solid materials wash off or dissolve into water, or by spills or leaks. Typical contaminant sources include: fuels, raw materials, by-products, intermediates, final products, process residuals, or wind-blown debris.

- **Salt Storage**. Salt left exposed to rain or snow may migrate to the storm sewer or contaminate soils. Salt spilled or blown onto the ground during loading or unloading will dissolve in stormwater runoff. Stormwater contaminated with salt in high concentrations can be harmful to vegetation and aquatic life. Salty stormwater runoff soaking into the ground may contaminate groundwater, thus making the groundwater unsuitable as a drinking water supply. Typical contaminant sources include: salt stored outside in piles or bags that are exposed to rain or snow; salt loading and unloading areas located outside or in areas where spilled salt can contaminate stormwater; or salt/sand storage piles used for deicing operations.

- **Parking.** Customer parking areas can also be a source of contamination. Typical sources of contamination can include improper disposal of trash and leaky vehicles that can result in oils and other contaminants being deposited in the parking lot and then washed to the stream during a storm event.

- **Bare Soil**. Bare soil may be located on unpaved areas or areas under development at commercial and industrial sites. Trash and other contaminants such as vehicle leaks onto the soil can be washed away in stormwater runoff.

- **Landscaping Practices**. Chemicals used to maintain landscaping areas can have a significant impact on the water quality of stormwater runoff. Herbicides, pesticides, and fertilizers can create impacts if they are not applied correctly. Contaminant sources include: improper storage of chemicals, improper storage of cleaning equipment used to apply these chemicals, or improper application.

These hot spots can be addressed through a combination of non-structural practices that include public and employee education, materials storage practices, and thoughtful site designs (e.g., overhead cover and impervious underlying surfaces, etc.). In most cases, structural BMPs are also needed to treat runoff from these hot spots. See the "Spill Prevention and Response" discussion for additional supplemental information. As shown in Exhibit 7.1, Denver's vehicle maintenance facilities, asphalt and concrete batch plants, solid-waste transfer stations, exposed stockpile areas and snow dump sites, and other facilities require specific attention under Denver's CDPS permit.

Household Waste (Litter, Pet Waste, Yard Waste, Used Oil and Automotive Fluids, and Other Hazardous Waste)

Improperly disposed household waste materials can include household chemicals, pet waste, yard waste, litter, automotive maintenance waste, and others. These materials can enter storm runoff and pollute downstream water bodies when these wastes are placed on impervious surfaces such as streets, alleys, parking lots and sidewalks, and pervious structures such as ditches, drainageways, gulches, or discharged directly into the storm drainage system. The development of education programs and dissemination of information that promotes proper disposal of these materials is important. The passage of laws, rules, or ordinances prohibiting improper disposal of these materials, and their enforcement, is another step in this management practice.

The *Urban Storm Drainage Criteria Manual, Volume 3* (UDFCD 1999) provides this description of household waste that should be managed to minimize stormwater pollution:

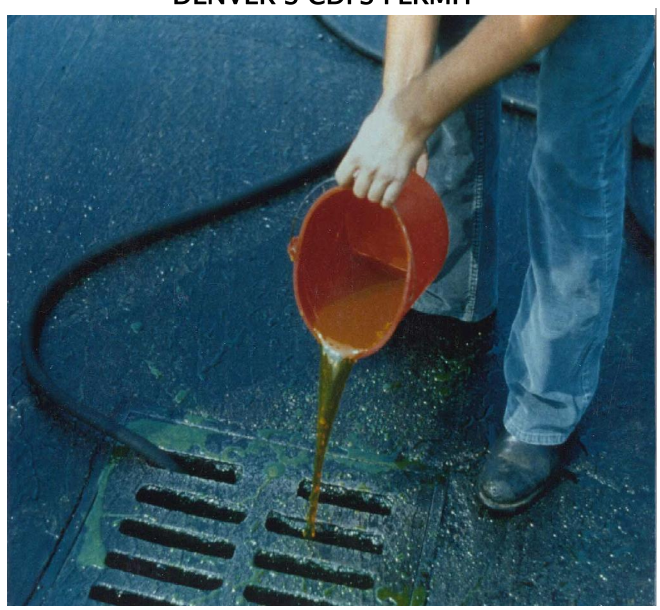
- **Litter**. Most litter is biodegradable and can create an oxygen demand in water as it decomposes. Examples of litter are paper products, used diapers, etc. Reduction of litter through proper disposal can reduce its accumulation on the urban landscape and its eventual entry into the stormwater system.

- **Pet Waste**. Pet waste deposited on impervious surfaces can be transported by the stormwater drainage system to receiving waters. Fecal matter potentially contains pathogenic viruses and bacteria and also creates an oxygen demand in water. The majority of improperly disposed pet waste occurs in public areas, such as streets and parks. Pet waste ordinances are common in municipalities; however, these are difficult to enforce, especially with limited municipal resources. Public education can help bring this problem to the public's attention and can thereby reduce deposition of pet waste on urban surfaces.

- **Yard Waste**. Yard waste is also a category of household waste. Examples of yard waste include leaves and grass clippings. It is distinguished from other categories of household waste in that it can be disposed of by composting. Fallen tree leaves, grass clippings, and garden debris can become water pollutants when they are disposed of in alleys, driveways, parking lots, streets, street gutters, irrigation ditches, and drainage channels. Public education efforts on the benefits of composting and on proper disposal of yard waste can help to reduce the volume of yard waste entering the stormwater system and receiving waters.

- **Used Oil and Automotive Fluids**. Used oil and automotive fluids including antifreeze, brake fluid, transmission fluid, grease, other lubricants, and petroleum-based cleaning solvents are wastes generated during automobile maintenance by residential households and commercial businesses. These can enter the storm drainage system if poured directly into storm inlets or from residue on concrete or asphalt exposed to precipitation. Improper disposal of used oil and automotive fluids causes receiving waters to become contaminated with hydrocarbons and residual metals that can be toxic to stream organisms. Used oil and other petroleum products can be recycled. A number of different recycling centers presently exist in the metropolitan area. Public education on the location of these centers, the benefits of recycling, prevention of fluid leaks, and the importance of proper disposal for improving stormwater quality can reduce the amounts of oil and used automotive fluids reaching receiving waters.

EXHIBIT 7.6
DISPOSAL OF USED AUTOMOTIVE PRODUCTS DOWN STORM DRAINS IS PROHIBITED UNDER DENVER'S CDPS PERMIT



Source: Colorado Nonpoint Source Council 2001.

- **Toxic Wastes**. Toxic wastes are generated by residential households and commercial businesses. These primarily consist of certain types of used and unused consumer products. Included among these are paint, solvents, putties, cleaners, waxes, polishes, oil products, aerosols, acids, caustics, pesticides, herbicides, and certain medicines or cosmetics. These products and their containers should always be disposed of properly. Some of these unused toxic materials can also be recycled. Improper disposal of toxic substances causes stormwater to become contaminated by these wastes. This occurs when toxic substances are dumped into street gutters or storm inlets. This also happens when stormwater comes in contact with toxic substances where they have been improperly disposed on land surfaces. There is no need for improper disposal of toxic substances because small amounts of toxic materials can legally be disposed of in landfills. Educational efforts to heighten public awareness of the environmental damage due to improper disposal and to encourage proper disposal and recycling, can reduce the amounts of these pollutants entering stormwater, provided the public as a whole actively participates.

Pesticide, Herbicide, and Fertilizer Management (Including Integrated Pest Management)

Pesticides, herbicides, and fertilizers are used by commercial applicators, Denver staff and the general public to maintain landscaping in residential, commercial and industrial areas. As stated in the *Urban Storm Drainage Criteria Manual, Volume* 3 (UDFCD 1999), these substances are usually toxic and can contaminate surface runoff if not properly used. While pesticides and herbicides are toxic to aquatic life at low concentrations, fertilizers are usually only toxic at high concentrations. Fertilizers, however, are more commonly a problem because of their nutrient-enrichment effect on receiving waterbodies. An oversupply of phosphorus and nitrogen will promote unsightly algal growth that can lead to a depletion of dissolved oxygen needed for fish and other aquatic organisms. These chemicals are applied on urban landscape areas and, when improperly applied or used, can be transported to receiving waters in surface runoff.

The rate and timing of application of pesticides, herbicides, and fertilizer are important to minimize transport by surface runoff, as well as to optimize their intended purpose in landscape maintenance. Over-application and over-spraying of pesticides, herbicides, and fertilizers onto impervious areas, such as streets and sidewalks, needs to be avoided, as well as excessive use of these chemicals. Use of these chemicals in accordance with manufacturer's recommendations can prevent most of the surface water contamination being attributed to their use.

In 1997, Mayor Webb issued Executive Order 121 on the topic of pesticide usage, identifying specific requirements for pesticide application, spill reporting, disposal practices, public notification, and other related issues. The Order emphasizes following label directions and using pesticides in a manner that does cause injury to humans, non-pest animals and non-pest vegetation, and in a manner that does not contaminate groundwater. Disposal of pesticides and tank rinse in sanitary sewers, storm sewers, ditches, streams, lakes, or in other illegal manners is prohibited (Denver 1997).

Public and landscaping industry education are particularly important to promoting proper landscaping chemical usage. Denver has already undertaken and continues to undertake public education efforts regarding usage of these chemicals, as described in Exhibit 7.4 under the public education discussion. In addition to these efforts, opportunities exist for Denver to target pollutants associated with the landscaping industry. As previously noted, the City of Boulder has developed the Partners for a Clean Environment (PACE) program (see http://www.ci.boulder.co.us/environmentalaffairs/PACE/index.htm) to provide training and recognition to landscaping professionals who undergo the city's landscaping program. Those completing the program are listed on the city's web site. Another existing opportunity with regard to landscaping BMPs is the recently developed Green Industries of Colorado (GreenCO) Water Conservation and Water Quality Protection Best Management Practices (BMP) training and certificate program, which has been completed under 319 grant funding to improve industry practices. Rather than develop a city-based training program, Denver could partner with GreenCO to support its on-going industry training efforts. (See www.greenco.org for more information.)

EXHIBIT 7.7
PROPER USE OF FERTILZER IS AN IMPORTANT SOURCE CONTROL

Source: Colorado Nonpoint Source Council 2001.

In addition to proper handling of pesticides, it is important to recognize a body of practices termed Integrated Pest Management (IPM). It uses biological, chemical, and genetic information to determine the best type of control, the timing and extent of chemical applications, and whether non-chemical means can attain an acceptable level of pest control.

IPM is a preventive measure aimed at knowing the exact pest(s) being targeted for control, the locations and times when pests will pose problems, the level of pest-induced damage that can be tolerated without taking action, the most vulnerable life stage, and control actions that are least damaging to the environment. The major components of IPM are as follows: monitoring and inventory of pest populations, determination of pest-induced injury and action levels, identification of priority pest problems, selection and timing of least toxic management tools, site-specific treatment with minimized chemical use, and evaluation and adjustment of pesticide applications. Monitoring of pest populations is key to successful IPM implementation. Pest problems are universally easier to control if the problem can be discovered early. With IPM, pesticides are used only as a last resort; maximization of natural controls, including biological controls and removal of pests by hand, is a guiding rule.

IPM encourages the use of less toxic or substitute methods of pest and weed control that, if followed, further reduce the amount of pesticides and herbicides in contact with surface runoff.

However, it is difficult to reach and influence all commercial and residential users of these chemicals and to present technical information in simplified form to all users.

Efficient Irrigation

In addition to providing water-conservation benefits, designing, installing and maintaining efficient irrigation systems helps to minimize excess irrigation water being conveyed into stormwater drainage systems (CSQA 2003). This helps to minimize pollutant loading associated with commonly used lawn chemicals and to keep dry weather flows out of the storm sewer. Detailed guidance and public education materials on efficient irrigation systems are available from GreenCO (www.greenco.org), Denver Water (www.denverwater.org), the Irrigation Association (www.irrigationassociation.org), EPA (www.epa.gov) and others. Efficient irrigation is an important topic for both public education and landscaping industry education. Given recent drought conditions in Colorado, opportunities exist to partner with water supply providers to encourage efficient irrigation.

Materials Storage Practices

Improper material storage on site can lead to the release of materials and chemicals that can cause stormwater runoff pollution. Having good materials storage and inventory practices is necessary for all commercial and industrial facilities.

Materials storage areas, including bulk solid materials, should be covered and should have adequate aisle space to facilitate material transfer and ease of access for inspection. Containers, drums, and bags should be stored away from direct traffic routes to prevent accidental spills. Manufacturer's instructions should be followed when stacking containers, and containers should be stored on pallets over a paved surface or similar surfaces to prevent corrosion of containers that results from containers coming in contact with moisture on the ground. Container labels should include the name and type of substance, stock number, expiration date, health hazards, handling suggestions, and first aid information. All storage areas should be designed to contain any spills, and procedures should be adopted to reduce the chance of spills or leaks during filling or transfer of materials.

An up-to-date inventory for all materials (both hazardous and non-hazardous) will help keep material costs down by reducing overstocking, track how materials are stored and handled onsite, and identify which materials and activities pose the most risk to the environment. Inventory of the site should include a site walk-through, review of purchase orders, listing of all chemical substances used, and obtaining Material Safety Data Sheets (MSDS) for all chemicals.

Hazardous materials must be stored according to federal, state, and local HazMat requirements. The responsibility of hazardous material inventory should be assigned to a limited number of people who are trained to handle such materials. Decisions on the amounts of hazardous materials that are stored on site should include an evaluation of any emergency control systems that are in place. Toxic or hazardous liquids should be stored within curbed areas or secondary containers, and the hazardous materials inventory should identify special handling, storage, use, and disposal considerations.

Recycling/Waste Disposal Programs

The purpose of recycling programs in the context of stormwater management is to keep toxic pollutants out of the storm sewer. As part of the public education efforts listed in Exhibit 7.4, several aspects of Denver's recycling program were noted, particularly with regard to Denver's used motor vehicle fluid and household chemical waste collection programs. Denver Recycles has developed numerous educational brochures to promote the proper management of household chemical waste. These brochures promote reduced use of toxic household products, substitution of acceptable alternatives, and proper storage, recycling or disposal of such chemicals. Denver Recycles also maintains a listing of privately operated drop-off facilities for items such as used motor oil, automotive batteries, antifreeze, and other household chemicals and materials. The list is updated regularly and made available to Denver residents to help them recycle or properly dispose of household hazardous waste (HHW) locally, whenever possible.

In certain instances, Denver Recycles refers citizens to Denver's Department of Environmental Health and/or the Fire Department. These agencies are equipped to assist residents with items that cannot be disposed of in Denver's HHW program. These items include flammable materials, medical waste, ammunition, radioactive sensors in smoke detectors, and other unusual wastes. Furthermore, Denver's Solid Waste Management Division works with these Denver agencies to manage abandoned or illegally dumped waste on residential and Denver property.

Since 1999, Denver Recycles and the Wastewater Management Division have managed and implemented a door-to-door HHW collection program for Denver residents. To operate the program, Denver contracted a private company, with services being provided by Curbside, Inc. The initial 13-month HHW pilot program was completed in December 2000. Denver is now into the fourth year of providing direct residential collection of HHW from Denver residents. This "turn-key" HHW program approach was chosen after careful evaluation of HHW collection options and the diverse service needs of the nearly 160,000 eligible Denver households.

Basic service (items collected at no charge) for this collection program includes residential pickup of lubricants, oil-based paint, latex paint (up to 10 gallons), cleaners and polishes, wood finishes, gasoline and other fuels, oil filters, solvents, thinners and removers, pesticides, insecticides, herbicides, swimming pool chemicals, hobby supplies, photography chemicals, household batteries, thermometers and thermostats, florescent tubes, and aerosol cans containing fluids. For a nominal fee, the contractor will also pick up additional quantities of latex paint over 10 gallons.

The Wastewater Management Division provides the funding for this collection program. In 2003, the Wastewater Management Division and Denver Recycles initiated a new contract for this service. The Wastewater Management Division will continue funding for this program as long as funds are available. However, the implementation of co-pays may also be evaluated.

It is believed that the HHW collection program has had a positive impact on Denver's stormwater quality as a source-control measure. Many residents have participated and have provided positive responses in written consumer surveys.

Good Housekeeping/Spill Prevention and Response/Preventative Maintenance

Good housekeeping, spill prevention and response, and preventative maintenance practices go hand-in-hand. Each of these groups of practices is described below based directly on the guidance provided in the *Urban Storm Drainage Criteria Manual, Volume 3* (UDFCD 1999).

Good Housekeeping

Good housekeeping practices are designed to maintain a clean and orderly work environment and can be applied to homeowners as well as commercial and industrial facilities. The most effective first steps towards preventing pollution in stormwater from work sites simply involves using good common sense to improve the facility's basic housekeeping methods. Poor housekeeping practices result in more waste being generated than necessary and an increased potential for stormwater contamination. A clean and orderly work site reduces the possibility of accidental spills caused by mishandling of chemicals and equipment and should reduce safety hazards to personnel. A well-maintained material and chemical storage area will reduce the possibility of stormwater mixing with pollutants.

Many aspects of good housekeeping are part of a strong pollution prevention plan, such as preventative maintenance of equipment, proper materials storage and inventory, and a spill prevention and response plan. Some additional simple procedures to promote good housekeeping are routine and regular clean-up schedules, maintaining well organized work areas, signage, and educational programs for employees and the general public about good housekeeping practices.

Examples of other practices include: maintaining dry and clean floors and ground surfaces by using brooms, shovels, vacuum cleaners or cleaning machines rather than wet clean-up methods; regular pickup and disposal of garbage and waste material; routine equipment maintenance and inspections; ensuring employees understand all spill cleanup procedures and that they receive appropriate training; designation of separate areas of the site for auto parking, vehicle refueling and routine maintenance; cleaning up leaks, drips and other spills immediately; and covering and maintaining dumpsters and waste receptacles.

Spill Prevention and Response

Spills and leaks are a large source of stormwater pollutants, and in most cases are avoidable. The storage, transport, and disposal of hazardous and toxic substances are regulated activities under state and federal laws, and many local police, fire, or other departments are equipped to respond to such spills. Nevertheless, most spills have the potential to contaminate receiving waters via transport by the storm sewer system. A good spill prevention and response plan will incorporate good housekeeping and preventative maintenance BMPs. Exhibit 7.8 provides examples of various BMPs to be considered in such a plan. A spill prevention and response plan identifies areas where spills can occur onsite, specifies materials handling procedures, storage requirements, and identifies spill cleanup procedures. Stormwater contamination assessment, flow diversion, record keeping, internal reporting, employee training, preventative maintenance, covering pollutants, and providing adequate security are associated BMPs that should be incorporated into a comprehensive plan.

Preparation of a spill prevention and response plan may include mapping of storm sewers. Such maps can then be used by the emergency response crews to help identify which inlets, areas, or sewers to protect or block off in the event of a spill. Training, updating of procedures, field exercises, proper equipment, and documentation are all part of a spill response program. Once a spill occurs, it should be monitored to determine when the area of the spill has been adequately cleaned up. Proper clean up procedures include:

- Wipe up small spills with a shop rag, store shop rags in covered rag containers, and dispose of properly (or take to professional cleaning service and inform them of the materials on the rag).
- Contain medium-sized spills with absorbents (kitty litter, sawdust, etc.) and use inflatable berms or absorbent "snakes" as temporary booms for the spill. Store and dispose of absorbents properly. Wet/dry vacuums may also be used, but not for volatile fluids.
- For large spills, first contain the spill and plug storm drain inlets where the liquid may migrate off-site, then clean up the spill.

A summary of the plan should be written and posted at appropriate points in the building (i.e., lunch rooms, cafeteria, and areas with a high spill potential), identifying the spill cleanup coordinators, location of cleanup kits, and phone numbers of regulatory agencies to be contacted in the event of a spill. Emergency spill containment and cleanup kits should also be located at the facility site. The contents of the kit should be appropriate to the type and quantities of chemicals or goods stored at the facility. Key personnel should receive formal training in plan execution for emergency spill cleanup and the appropriate agencies should be notified.

EXHIBIT 7.8
ADVANTAGES AND DISADVANTAGES OF BMPS FOR SPILL PREVENTION AND RESPONSE
(Source: *Urban Storm Drainage Criteria Manual, Volume 3* (UDFCD 1999)

Best Management Practice	Advantages	Disadvantages
Drip pans—pans used to contain small volumes of leaks	Inexpensive; simple installation and operation; possible reuse/recycle of material; empty/discarded containers can be used as drip pans	Small volumes; inspected and cleaned frequently; must be secured during poor weather conditions; personnel must be trained in proper disposal methods
Covering—enclosure of outdoor materials, equipment, containers, or processes	Simple and effective; usually inexpensive	Frequent inspection; possible health/ safety problems if built over certain activities; large structures can be expensive
Vehicle positioning—locating trucks or rail cars to prevent spills during transfer of materials	Inexpensive; easy; effective	May require redesign of loading and unloading areas; requires signage to designated areas
Loading/unloading by air pressure or vacuum—for transfer of dry chemicals or solids	Quick and simple; economical if materials can be recovered; minimize exposure of pollutants to stormwater	Costly to install and maintain; may be inappropriate for denser materials; site-specific design; dust collectors may need permit under Clean Air Act
Sweeping—with brooms to remove small quantities of dry chemicals/solids exposed to precipitation	Inexpensive; no special training; recycling opportunities	Labor-intensive; limited to small releases of dry materials; requires disposal to solid waste container
Shoveling—for removal of large quantities of dry materials, wet solids and sludge	Inexpensive; recycling opportunities; remediates larger releases	Labor-intensive; not appropriate for large spills; requires backfill of excavated areas to maintain grade
Excavation—by plow or backhoe for large releases of dry material and contaminated areas	Cost effective for cleaning up dry materials release; common and simple	Less precise; less recycling and reuse opportunities; may require imported material for backfill
Dust control (industrial)—water spraying, negative pressure systems, collector systems, filter systems, street sweeping	May reduce respiratory problems in employees around the site; may cause less loss of material and save money; efficient collection of larger dust particles	More expensive than manual systems; difficult to maintain by plant personnel; labor and equipment intensive; street sweepers may not be effective for all pollutants
Signs and labels	Inexpensive and easily used	Must be updated/maintained so they are legible, subject to vandalism and loss
Security—to prevent accidental or intentional release of materials	Preventative safeguard; easier detection of vandals, thieves, spills, leaks, releases; prevents spills with better lighting; no unauthorized access to facility	May not be feasible for smaller facilities; may be costly; may increase energy costs due to increased lighting; dispersed locations require individual enclosures; requires maintenance
Area control measures—good housekeeping measures, brushing off clothing before leaving area, etc.	Easy to implement; results in cleaner facility and improved work environment	May be seen as tedious by employees and may not be followed

EXHIBIT 7.8 ADVANTAGES AND DISADVANTAGES OF BMPS FOR SPILL PREVENTION AND RESPONSE (Source: *Urban Storm Drainage Criteria Manual, Volume 3* (UDFCD 1999)		
Best Management Practice	**Advantages**	**Disadvantages**
Preservation of natural vegetation	Can handle more stormwater runoff than newly seeded areas; effective immediately; increases filter capacity; enhances aesthetics; provides areas for infiltration; wildlife can remain undisturbed; provides noise buffers; less maintenance than new vegetation	Planning required to preserve and maintain existing vegetation; may not be cost effective with high land costs; may constrict area available for construction activities; may require signage or fencing; subject to disturbance
Temporary seeding—short-term vegetative cover on disturbed areas	Inexpensive and easy to do; establishes plant cover quickly in good conditions; stabilizes soils well; aesthetic; sedimentation controls for other site areas; helps reduce maintenance costs of other controls	Requires soil preparation; may require mulching or reseeding of failed areas; seasonally limited; may require signage or fencing; subject to disturbance

Preventative Maintenance

Preventative maintenance involves the regular inspection and testing of plant equipment and operational systems. The purpose of the preventative maintenance program should be to prevent breakdowns and failures by adjustment, repair, or replacement of equipment before a major breakdown or failure can occur. Preventative maintenance should be used selectively to eliminate or minimize the spill of contaminants to receiving waters. Maintenance activities will involve the use of chemicals and fluids, so spill response information and spill cleanup materials should be kept on the site and readily available.

For many industrial facilities, a preventative maintenance BMP would simply be an extension of the current plant preventative maintenance program to include items to prevent stormwater runoff contamination such as upkeep and maintenance of storage tanks, valves, pumps, pipes, and other process-water or chemical feed devices. Routine inspections and testing of equipment are required to identify maintenance needs. Typical equipment to inspect and test includes pipes, pumps, storage tanks and bins, pressure vessels, pressure release valves, process and material handling equipment, and stormwater management devices. Defective or severely worn equipment should be replaced or repaired promptly. Inspections, testing, and follow-up actions should be documented.

Similar to preventative maintenance for plants, a plan for vehicles and equipment maintenance includes routine inspections and testing. All equipment should be kept clean with no excessive amounts of oil and grease buildup, and equipment and parts should be stored under cover. Storage of solvents, greases, oils, hydraulic fluids, paints, thinners and hazardous materials should be consistent with the materials storage and inventory BMP, and used oil for recycling should be stored in self-contained labeled tanks. Used oil tanks and drums should be located away from the nearest inlet to the storm drainage system or flowing streams and preferably indoors, if possible.

Care must be taken during maintenance procedures to prevent pollutant releases by implementing measures such as drip pans; proper cleanup, disposal, and recycling; and removal of fluids and batteries from salvage vehicles and equipment. Cleanup from maintenance activities includes proper disposal or recycling of used oil, lubricants, and other fluids, and cleaning any catch basins that receive runoff from a maintenance area. Use of a mop or dry sweeping compound is preferable to hosing down work areas or using concrete cleaning products.

Proper maintenance activities associated with building and grounds include sweeping of paved surfaces rather than washing; routine cleaning of stormwater drainage systems; and proper disposal of wash water, sweepings and sediments.

Maintenance Practices

Denver implements a variety of municipal maintenance practices on a regular basis that provides opportunities for reduction of pollutant loading in stormwater. The Water Environment Federation and American Society of Civil Engineers (WEF and ASCE 1998) provide several examples of these practices:

- **Street Cleaning**. This involves regularly sweeping streets to physically remove pollutants from surfaces that drain to storm sewers. In Denver, streets are typically swept twice per year if debris has accumulated: once in the spring to remove deicing residuals and once in the fall to remove fallen leaves. Effectiveness of street sweeping has been shown to be highly variable in several national databases (see www.bmpdatabase.org). Studies suggest that vacuum-type sweepers are far more effective than rotary-brush type sweepers.

- **Catch Basin Cleaning**. This involves cleaning catch basins and stormwater inlets to remove pollutants, reduce high pollutant concentrations during the first-flush of storms, prevent clogging of the downstream conveyance systems and restore the catch basin's sediment-trapping capacity.

- **Storm Drain Flushing**. Storm drains can be flushed with water to suspend and remove deposited material. This helps to ensure that pipes convey design flows and removes pollutants from the storm drain systems. This practice is most effective when the storm drain daylights in a structural BMP area where sediment is trapped or otherwise able to be cost-effectively collected.

- **Roadway and Bridge Maintenance**. Methods to prevent or reduce the discharge of pollutants from roadway and bridge maintenance include paving as little area as possible (i.e., minimize urban sprawl), design bridges to collect and convey stormwater, using measures to prevent run-on and runoff, properly disposing of maintenance wastes, and training employees and subcontractors.

- **Structural BMP Maintenance**. Implementing routine maintenance for structural stormwater BMPs is critical to their proper functioning, as described in Chapter 6.

- **Storm Channel and Creek Maintenance**. Reduction in pollutant levels can be achieved by regularly removing dumped items and material from storm drainage channels and creeks. This can include identifying illegal dumping spots, posting "no littering" signs and providing significant penalties for doing so, etc. Stabilizing streambanks to enable them to withstand typical storm flows is also important in urbanized areas.

Under Denver's CDPS permit, Denver addresses six public street maintenance elements including snow and ice management; dry and liquid deicer storage; herbicide usage along roadways; sweeping litter and debris; sweeping streets following snow control (e.g., sanding/deicing); and disposal of sweeper waste (Denver 2002). Examples of the types of non-structural BMPs implemented include covered storage areas for stockpile areas, applying herbicides during "fair weather" conditions, and street sweeping in the spring and fall.

Land-Use Planning and Management Practices

Development of ordinances and land planning practices that protect streams and rivers are a key non-structural BMP. Site designs that maximize infiltration, provide on-site retention, slow runoff and minimize impervious land coverage provide a variety of stormwater management benefits. A variety of mechanisms exist, and only a few are discussed herein. The challenges to land-use planning practices are often political and require significant cooperation among multiple departments and agencies. Examples of land-use controls and practices that can provide significant water quality benefits, many of which are based on WEF and ASCE (1998) guidance, include:

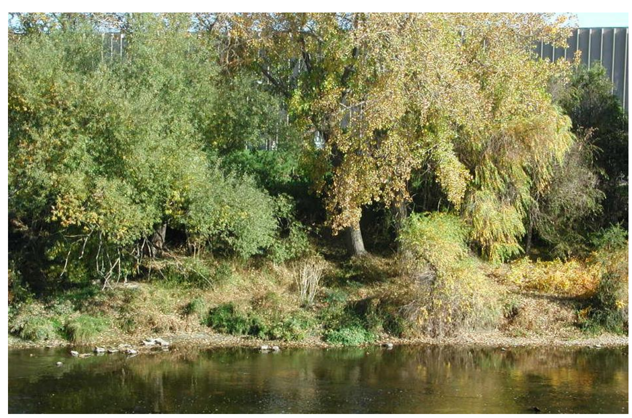
- Protective Covenants—provide restrictions on a variety of pollutant sources such as pesticide/fertilizer application, stream setbacks, vegetative cover requirements, etc.

- Stream buffer requirement/riparian zone protection—limit development directly adjacent to streams.

- Floodplain restrictions—limit development in the floodplain.

- Steep slope restrictions—limit clearing/grading on steep slopes.

EXHIBIT 7.9
WELL VEGETATED RIPARIAN BANK ALONG THE SOUTH PLATTE RIVER IN DENVER



- Wetland protection—limits development in wetland areas (also required under Section 404 of Clean Water Act).

- Specific protection for environmentally sensitive areas—limits development in certain habitat areas.
- Upland and riparian tree cover requirements—promote certain percentage of tree canopy, which helps to intercept rainfall and provide other benefits.
- Waterway disturbance permits—require roadways and utilities to cross streams in a manner to minimize their impact.
- Community open space requirements—provide additional open space and natural areas to infiltrate runoff and buffer the stream area.
- Cluster development strategies—reduce impervious area at developments by clustering development into centralized areas where stormwater can be effectively treated.
- Green Development and Smart Growth strategies—encourage developments with holistic design concepts that consider factors such as land-use issues, resource conservation, natural area and open space preservation, and community/cultural issues.

A key land-planning concept that has already been discussed in Chapter 5 is Low Impact Development (LID). As previously noted, the goal of LID is to mimic a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source. Instead of conveying and treating stormwater in facilities located at the bottom of drainage areas, LID addresses stormwater through small, landscape features located at the lot level. With regard to application and acceptance of LID in Denver, it is important to note that LID concepts can be integrated into the first step of the UDFCD BMP selection process, which is employing runoff reduction techniques. In Denver, structural BMPs are then required to treat the remaining Water Quality Capture Volume (UDFCD 1999).

Another key concept that has already been implemented in parts of Denver (e.g., Cherry Creek Basin, as discussed in Chapter 4) includes Green Development or Smart Growth strategies. These approaches are important in that they consider factors beyond the immediate development and redevelopment area, helping to minimize urban sprawl and its impacts, while recognizing the interconnectedness of the natural environment to development. Communities throughout the country have also moved toward these types of developments, including cities in Oregon, Maryland, Florida, California, Texas and others (See http://www.sustainable.doe.gov/greendev/). Zoning ordinances and municipal planning strategies are key components of Smart Growth and Green Development strategies and require cooperation across city departments and agencies. Denver should continue to pursue integration of these concepts due to their many benefits to both the community and the environment.

Protective covenants are also a particularly noteworthy example of an effective land management strategy to minimize pollution. As an example, in the Grant Ranch and Trailmark subdivisions in Littleton upstream of Bow Mar Lake, specific guidance and restrictions were detailed in protective covenants to minimize adverse impacts to the water quality of the lake. Water quality monitoring upstream of the lake has shown that these covenants have helped to minimize the concentrations of nutrients and pesticides in runoff tributary to the lake (WWE 2004).

SUMMARY AND CONCLUSIONS

Non-structural (pollutant source control) BMPs are critical to effective stormwater management in Denver and are foundational to many of Denver's CDPS permit requirements. Non-structural BMPs help to minimize the quantity of pollutants entering the storm drainage system, thereby reducing the treatment required at downstream structural BMPs. Non-structural BMPs are particularly important in areas that have already been developed. Denver has implemented many public education activities, which are necessary to the success of most non-structural BMPs. Specific opportunities for Denver that could be further developed in the future include:

1. Provide additional educational brochures and water pollution prevention resources on the Denver web site. For example, as discussed in Chapter 5, many of the national case studies provide extensive web-based resources.

2. Develop pollution prevention programs for specific industries that require further attention and/or partner with entities providing existing programs. For example, the City of Boulder's PACE program targets and provides educational information to specific industry segments including auto repair, auto body, green building, dental offices, dry cleaning, landscaping, manufacturing, printing, restaurant, and retail sectors. The City of Portland has a similar program—the "Eco-Logical Business Program." As an alternative to independently developing such programs, Denver can partner with professional organizations and industry groups to support their efforts in this type of training. For example, GreenCO is providing landscape BMP training for those in the landscaping industry in Colorado. Denver should support this effort and other similar efforts for other "hot spot" industry segments.

3. Educate developers and Denver staff on the benefits of land management strategies such as open space/natural areas preservation, riparian buffer zone protection, Smart Growth, Green Development, and Low Impact Development strategies. Many of these strategies are already practiced in the Denver area through stormwater management approaches that "Minimize Directly Connected Impervious Area" such as porous landscape detention, grassy swales and porous pavement.

4. Continue educational campaigns, both to the public and to Denver staff and elected officials.

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Chapter 8
Potential Regional Facilities

Stormwater management can be handled on-site, at regional facilities, or through a combination of both. A variety of factors determine which approach is most effective. Some factors include:

- Capital and operations/maintenance costs
- Right-of-way availability
- Property ownership
- Extent of existing development
- Extent of redevelopment
- Extent of on-site BMPs already in place
- Zoning
- Land development review practices
- Existing master drainage plans and their recommendations
- Local drainage criteria
- Special goals and objectives related to quantity and quality management
- Other factors

There are many benefits of larger, regional facilities such as their potential to serve as attractive, multi-purpose facilities that become true community assets. The following discussion identifies potential regional facility locations throughout Denver, especially in redevelopment areas identified in *Blueprint Denver: An Integrated Land Use and Transportation Plan* (Denver 2000), that could play a valuable role in protecting water quality, as well as fulfilling other objectives. All of the following discussion is provided at a conceptual level only. Considerable additional analysis will be necessary to determine if the following ideas are feasible.

The *Storm Drainage Master Plan – Phase I Final* (Matrix 2003) found the capacity of the drainage system within a majority of Denver correlates to between a 1- and 5-year system. Although this limited capacity results in periodic flooding, the current systems offer opportunities for regional water quality treatment. The extensive existing drainage networks discharging through only a few outfalls provide opportunities to treat the entire basin runoff at the end-of-pipe, rather than (or in addition to) attempting to treat the runoff in a myriad of small in-tract ponds within the basin. The existing drainage systems provide adequate capacity to treat the "first flush," or a storm of magnitude of ½-inch or less of runoff.

In keeping with the major drainageways information included in the *Storm Drainage Master Plan*, Exhibit 8.1 identifies the major Denver drainage basins. Exhibit 8.2 identifies potential opportunities for regional water quality facilities in these basins. Exhibit 2.3 in Chapter 2 should be referenced for more detailed basin locations by numeric code. A basin-by-basin discussion identifying the key drainage basin characteristics and regional water quality opportunities and constraints follows. These conceptual-level discussions will require additional follow-up work, as identified in Chapter 9, in order to make decisions regarding regional treatment.

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SOUTH PLATTE RIVER

Fourteen drainage basins tributary to the South Platter River are evaluated for regional stormwater treatment opportunities in this discussion, including:

- Prairie Gateway
- I-70 & Colorado Boulevard
- I-70 & York
- Lower Platte Valley
- Central Platte Valley
- 1st & Federal
- Valverde
- Ruby Hill
- Dartmouth
- College View
- West Belleview
- Sloan's Lake
- I-25
- West Harvard Gulch

Prairie Gateway (Basin 0058)

EXHIBIT 8.3 BACKGROUND DATA FOR PRAIRIE GATEWAY (BASIN 0058)	
Location Description:	56th and Quebec
Receiving Waterway:	South Platte River
General Land Use:	Commercial and Industrial (includes Denver Water Pump Station and Bulk Mail Facility)
Drainage Basin Area:	1.59 square miles
Basin Composite Imperviousness:	25%
Outfalls:	100-year retention – no outfall
Capacity of Outfalls:	100-year pipes and detention pond

Prairie Gateway is land along Quebec Street north of 56th Avenue that was previously part of the Rocky Mountain Arsenal. The *Prairie Gateway Outfall Systems Planning Preliminary Design Report* (UDFCD 2003) explored options to manage stormwater runoff and determined 100-year retention systems to be the most feasible option.

<u>Opportunities</u>

All development in the drainage basin must retain and treat water quality on-site or in regional ponds. The basin is being newly developed and must adhere to the current guidelines of the Urban Drainage and Flood Control District (UDFCD) for drainage criteria.

Constraints

Commerce City's storm outfalls do not have the capacity to handle additional runoff; therefore, development must incorporate stormwater ponds into the site planning.

I-70 & Colorado Boulevard (Basin 0060-01)

Exhibit 8.4 summarizes key background data for the I-70 & Colorado Boulevard basin (Basin 0060-01).

EXHIBIT 8.4 BACKGROUND DATA FOR I-70 & COLORADO BOULEVARD (BASIN 0060-01)	
Location Description:	North Denver and Commerce City 35th to 64th Avenues, and York to Dahlia Streets
Receiving Waterway:	South Platte River
General Land Use:	Mix of industrial and residential
Drainage Basin Area:	1,745 acres (2.73 square miles)
Basin Composite Imperviousness:	68.7%
Number of Outfalls and 2-Year Hydrology:	2 within Denver: 84" at 54th & Steele - 581 cfs 38" at 58th & York - 130 cfs
Capacity of Outfalls:	Generally less than 2-year

Opportunities

Basin 0060-01 is fully built-out with older neighborhood residential use in the upper reaches and commercial use in the lower reaches. *Blueprint Denver* shows the region downstream (northwest) of Vasquez Boulevard as an Area of Change, meaning that redevelopment is expected to occur in the area of the storm drain outfalls. This is an opportunity for installation of regional water quality treatment, especially since basin runoff is confined to only two outfalls within Denver.

A gravel pit between 54th and 56th Avenues and Brighton Boulevard and the Railroad is an opportunity for an on-line regional water quality pond at the discharge of the 84-inch outfall. However, this site is located within Commerce City, but would primarily treat runoff from Denver.

Vacant land is located northeast of Riverside Cemetery and would be an opportunity for off-line regional water quality treatment. Likewise, this site is located within Commerce City, but would primarily treat runoff from Denver.

Another location for regional water quality treatment within this basin is Swansea Park. This Denver Parks land may provide an opportunity for off-line regional water quality ponds.

An alternatives analysis for combined capital improvements for Basins 0060-01 & 4400-02 found the least-cost solution included regional detention in this basin. Areas identified for regional detention exist at the Park Hill Golf Course, 48th & Colorado, 38th and Grape Street, and the former Dahlia Square. These detention ponds could also be configured for regional water quality treatment.

Constraints

The main constraint to regional water quality treatment is the fact that the outfalls occur outside of Denver in Commerce City. Either land areas must be identified within Denver for regional treatment, or an agreement must be structured with Commerce City for operation and maintenance of regional facilities.

I-70 & York (Basin 0060-02)

Exhibit 8.5 summarizes key background data for the I-70 & York basin (Basin 0060-02).

EXHIBIT 8.5 BACKGROUND DATA FOR I-70 & YORK (BASIN 0060-02)	
Location Description:	North Denver and Commerce City 42nd to 52nd Avenues, and Brighton to Colorado Boulevards
Receiving Waterway:	South Platte River
General Land Use:	Mix of industrial and residential (includes National Western Stock Show Complex)
Drainage Basin Area:	936 acres (1.46 square miles)
Basin Composite Imperviousness:	71.8%
Number of Outfalls and 2-Year Hydrology:	12 within Denver Only large outfalls: 78” & parallel 42” at Race Court – 381 cfs
Capacity of Outfalls:	2-year

The only major (larger than 48 inch) outfall exists at Race Court just upstream of the Burlington Ditch headgate. This outfall drains 580 tributary acres discharging via a 78-inch pipe and parallel 42-inch pipe that have a total capacity of about 410 cfs. The existing system has about a 2-year level of service.

Opportunities

Basin 0060-02 is fully built-out with older neighborhood residential use in the upper reaches and commercial use in the lower reaches. *Blueprint Denver* shows the industrial sites as Areas of Change, meaning that redevelopment is expected to occur in the area of the storm drain outfalls. This is an opportunity for installation of regional water quality treatment, especially since most of the basin runoff is primarily confined to the one outfall north of the National Western Stock Show complex at Race Court.

Constraints

If the expected redevelopment does not occur, then land acquisition would be necessary for a regional facility. No Denver Parks or Open Space land is available in this basin for regional water quality treatment.

Lower Platte Valley (Basin 0062-01/4500-02)

Exhibit 8.6 summarizes key background data for the Lower Platte Valley basin (Basin 0062-01/4500-02).

EXHIBIT 8.6 BACKGROUND DATA FOR LOWER PLATTE VALLEY (BASIN 0062-01/4500-02)	
Location Description:	North of Downtown Denver 8th to 38th Avenues, and Grant to Williams Streets, Includes Coors Field
Receiving Waterway:	South Platte River
General Land Use:	Mix of industrial, commercial and residential
Drainage Basin Area:	2,858 acres (4.47 square miles)
Basin Composite Imperviousness:	77.5%
Number of Outfalls and 2-Year Hydrology:	16 outfalls 1 primary outfall captures 81% of the basin: 81" at 36th – 1,215 cfs
Capacity of Outfalls:	Less than 1-year

Basin 0062-01 is fully built-out with older neighborhood residential use in the upper reaches and commercial use in the lower reaches. This basin includes Lower Downtown, Coors Field, rail yards, and a number of existing residential neighborhoods. It is characterized by terrace topography in the upper portions of the basin and nearly flat outfalls near the South Platte River. This condition results in inadvertent detention near the basin headwaters and surcharge of storm sewers in lower reaches.

Opportunities

There are opportunities for regional end-of-pipe water quality treatment along the South Platte River. An off-line water quality pond could be constructed near the outfall of the existing 81-inch pipe in 36th Avenue. The existing pipe has capacity to convey a ½-inch rainfall event (i.e., water quality capture volume) and would capture runoff from 2,260 acres of a developed basin.

Another opportunity for regional end-of-pipe water quality treatment is at 29th and Broadway at an outfall to the South Platte River. An off-line water quality pond could be constructed off the existing 108-inch pipe through Coors Field. The pipe was recently constructed and receives runoff from 81 acres of the Coors Field parking lot. However, proposed improvements will extend the storm drain up 27th Avenue and will expand the tributary area.

Constraints

If the expected redevelopment does not occur, then land acquisition would be necessary for a regional facility. No Denver Parks or Open Space land is currently available in this basin for regional water quality treatment.

Central Platte Valley (Basin 0063-01)

Exhibit 8.7 summarizes key background data for the Central Platte Valley (Basin 0063-01).

EXHIBIT 8.7 BACKGROUND DATA FOR CENTRAL PLATTE VALLEY (BASIN 0063-01)	
Location Description:	Southwest of Downtown Denver Alameda to Cherry Creek, along the South Platte River, Includes Elitch Gardens
Receiving Waterway:	South Platte River
General Land Use:	Mix of industrial, commercial and residential
Drainage Basin Area:	1,342 acres (2.10 square miles)
Basin Composite Imperviousness:	83.2%
Number of Outfalls and 2-Year Hydrology:	32+ outfalls in total 6 primary outfalls
Capacity of Outfalls:	1-year to 5-year

This basin includes older neighborhood residential use in the upper reaches east of the railroad tracks and Santa Fe, and commercial use in the majority of the basin for the lower reaches. *Blueprint Denver* shows the majority of the basin (commercial areas) subject to change.

Intercepted stormwater is discharged via at least 32 storm drainage outfalls, which are comprised mainly of local storm drains from I-25 and adjacent properties. Some of the existing larger outfalls include:

- Bayaud Avenue outfall is 36-inch (54-inch upstream) with 351 tributary acres
- 3rd Avenue outfall is 54-inch with 104 tributary acres
- 6th Avenue outfall is 72-inch with 273 tributary acres
- 13th Avenue outfall is 42-inch with 119 tributary acres
- Colfax Avenue outfall is 36-inch with 53 tributary acres
- Elitch's outfall is 48-inch with 44 tributary acres

Opportunities

Redevelopment of the lower industrial areas will provide an opportunity for construction of regional water quality systems. In particular, end-of-pipe water quality ponds on the larger outfalls may be possible. The 72-inch storm drain in 6th and 7th Avenues could be constructed with a low-flow diverter to treat runoff from 273 acres.

Constraints

If the expected redevelopment does not occur, then land acquisition would be necessary for a regional facility. No Denver Parks or Open Space land is currently available in this basin for regional water quality treatment.

1st & Federal (Basin 0064-01)

Exhibit 8.8 summarizes key background data for the 1st & Federal basin (Basin 0064-01).

EXHIBIT 8.8 BACKGROUND DATA FOR 1ST AND FEDERAL BASIN (BASIN 0064-01)	
Location Description:	West of Downtown Denver Between Alameda and 8th Avenue, and Between Perry Street and Bryant Street
Receiving Waterway:	Weir Gulch and South Platte River
General Land Use:	Mix of industrial, commercial and residential
Drainage Basin Area:	610 acres (0.95 square mile)
Basin Composite Imperviousness:	66.6%
Number of Outfalls:	8 outfalls
Capacity of Outfalls:	1-year to 5-year

Blueprint Denver shows Federal Boulevard subject to change, along with some of the commercial/industrial area adjacent to the South Platte River.

Intercepted stormwater is discharged in eight storm drainage outfalls that include two to Weir Gulch and six directly to the South Platte River.

Opportunities

Redevelopment of the lower industrial areas may provide an opportunity for construction of regional water quality systems. An on-line water quality pond has been constructed and maintained on Weir Gulch at Barnum Park near 6th and Federal.

Constraints

Much of the industrial land is within the current South Platte River floodplain. No Denver parks or open space land is currently available in this basin for regional water quality treatment; therefore, land acquisition would be necessary to construct a regional facility.

Valverde (Basin 0064-02)

Exhibit 8.9 summarizes key background data for the Valverde basin (Basin 0064-02).

EXHIBIT 8.9 BACKGROUND DATA FOR VALVERDE (BASIN 0064-02)	
Location Description:	West of Downtown Denver Between Louisiana and 4th Avenue, and Between Wolffe Street and the South Platte River
Receiving Waterway:	South Platte River
General Land Use:	Mix of industrial and residential
Drainage Basin Area:	1,701 acres (2.66 square miles)
Basin Composite Imperviousness:	69.2%
Number of Outfalls and 2-Year Hydrology:	15 outfalls 1 outfall captures 55% of the basin: 54”x108” at Vallejo Street – 309 cfs
Capacity of Outfalls:	Generally 2-year

Basin 0064-02 is fully built-out with older neighborhood residential use in the upper reaches and commercial use in the lower reaches. *Blueprint Denver* shows Federal Boulevard, Alameda Avenue, and Morrison Road subject to change, along with some of the commercial/industrial areas adjacent to the South Platte River.

Intercepted stormwater is discharged in fifteen storm drainage outfalls.

Opportunities

A regional detention facility is located at West-Bar-Val-Wood Park, which serves the largest stormwater outfall system in the basin (Vallejo Street). The detention facility provides an opportunity for water quality treatment.

Blueprint Denver shows an area of expected redevelopment along the South Platte River. This area could provide an additional opportunity for regional water quality near the outfall of the Vallejo Street system.

An existing pond in Vanderbilt Park could provide water quality treatment for the storm drain system in the southern portion of the basin along Mississippi Avenue.

<u>Constraints</u>

This basin is fully built-out with dense development, and the high cost of real estate prohibits land acquisition for regional facilities.

Ruby Hill (Basin 0065-01)

Exhibit 8.10 summarizes key background data for the Ruby Hill basin (Basin 0065-01).

EXHIBIT 8.10 BACKGROUND DATA FOR SOUTH PLATTE – RUBY HILL (BASIN 0065-01)	
Location Description:	South Platte River Drive and West Evans Avenue in West Denver
Receiving Waterway:	South Platte River
General Land Use:	Mix of industrial and residential
Drainage Basin Area:	832 acres (1.3 square miles)
Basin Composite Imperviousness:	70.1%
Number of Outfalls:	5 existing to South Platte River
Capacity of Outfalls:	2-year to 5-year capacity for existing

Currently, there are only five known outfalls into the South Platte River within this basin:

- 48-inch from West Evans outfalls at Jewell Avenue
- 36-inch by 58-inch from West Evans outfalls at Jewell Avenue
- Direct flow from the southern basin
- Two 36-inch outfalls

This basin is fully built-out with neighborhood residential use in the upper reaches and commercial/light industrial in the lower reaches. *Blueprint Denver* shows the region along both sides of Federal Boulevard as an Area of Change. This is an opportunity for installation of regional water quality treatment. Two existing off-line detention and water quality ponds are located at Pacific Place and South Tejon Street.

<u>Opportunities</u>

A small portion of this basin will be redeveloped. The redevelopment area along Federal Boulevard at West Warren Avenue would be an excellent opportunity to provide water quality and detention.

Constraints

Redevelopment of the site must occur before regional water quality treatment could be constructed. Coordination with private property owners must occur.

Dartmouth (Basin 0065-02)

Exhibit 8.11 summarizes key background data for the Dartmouth basin (Basin 0065-02).

EXHIBIT 8.11 BACKGROUND DATA FOR SOUTH PLATTE-DARTMOUTH (BASIN 0065-02)	
Location Description:	South Platte River Drive and West Dartmouth Avenue in West Denver
Receiving Waterway:	South Platte River
General Land Use:	Mix of industrial and residential
Drainage Basin Area:	512 acres (0.8 square mile)
Basin Composite Imperviousness:	86.8%
Number of Outfalls:	1 existing to South Platte River
Capacity of Outfalls:	2-year to 5-year capacity for existing

Currently, there is only one known outfall into the South Platte River within this basin:

- 73-inch by 55-inch from West Dartmouth Avenue

This basin is fully built-out with light neighborhood residential and commercial/light industrial. Only a very small portion of this basin is within Denver.

Opportunities

No opportunities for regional water quality have been identified for this basin.

Constraints

The majority of the basin is outside of Denver city limits.

College View (Basin 0067-01)

Exhibit 8.12 summarizes key background data for the College View basin (Basin 0067-01).

EXHIBIT 8.12 BACKGROUND DATA FOR COLLEGE VIEW (BASIN 0067-01)	
Location Description:	South Platte River Drive and West Union Avenue
Receiving Waterway:	South Platte River through Arapahoe County
General Land Use:	Mix of industrial, commercial and residential
Drainage Basin Area:	960 acres (1.5 square miles)
Basin Composite Imperviousness:	45.5%
Number of Outfalls and 2-Year Hydrology:	2 existing to Park at Lowell and Quincy Avenue and South Federal and West Layton, 45 cfs and 166 cfs
Capacity of Outfalls:	2-year to 5-year capacity for existing

Outfalls include:

- 30-inch from West Quincy Avenue
- 42-inch from South Federal Boulevard

This basin is fully built-out with neighborhood residential and commercial/light industrial use. Only a very small portion of this basin is within Denver.

<u>Opportunities</u>

The park at South Irving and West Quincy Street is an excellent opportunity for water quality and on-line detention. It is located directly at the outfall across Lowell Boulevard and would benefit the upstream portion of the basin.

<u>Constraints</u>

The majority of the basin is outside of Denver. Discharge agreements with the City of Sheridan would need to be in place before constructing the facility.

West Belleview Avenue (Basin 0067-02)

Exhibit 8.13 summarizes key background data for the West Belleview Avenue basin (Basin 0067-02).

EXHIBIT 8.13 BACKGROUND DATA FOR WEST BELLEVIEW AVENUE (BASIN 0067-02)	
Location Description:	South Sheridan Boulevard, West Denver
Receiving Waterway:	South Platte River through Jefferson County
General Land Use:	Mix of industrial, commercial and residential
Drainage Basin Area:	3,520 acres (5.5 square miles)
Basin Composite Imperviousness:	52.0%
Number of Outfalls and 2-Year Hydrology:	4 existing to existing storm sewers within Jefferson County: 110 cfs, 30 cfs, 16 cfs (from Grant Ranch) and 191 cfs (from South Meade Street)
Capacity of Outfalls:	2-year to 5-year capacity for existing

Outfalls include:

- Future 48-inch from South Meade Street
- Existing 24-inch to 36-inch from Grant Ranch

This basin is fully developed with neighborhood residential and commercial/light industrial use. Only a very small portion of this basin is within Denver.

<u>Opportunities</u>

No new regional water quality facilities in Denver are needed for this basin because Grant Ranch has newly constructed water quality and detention facilities.

<u>Constraints</u>

The majority of the basin is outside of Denver. Existing discharge agreements with surrounding municipalities would need to be considered before any improvements could be constructed.

Sloan's Lake (Basin 4700-01)

Exhibit 8.14 summarizes key background data for Sloan's Lake basin (Basin 4700-01).

EXHIBIT 8.14 BACKGROUND DATA FOR SLOAN'S LAKE (BASIN 4700-01)	
Location Description:	West of Downtown Denver Between 33rd and Colfax Avenues, and Sheridan Boulevard and the South Platte River
Receiving Waterway:	South Platte River
General Land Use:	Mix of industrial and residential
Drainage Basin Area:	1,017 acres (1.59 square miles) within Denver
Basin Composite Imperviousness:	65.0%
Number of Outfalls:	1 outfall 54" along Colfax Avenue
Capacity of Outfalls:	Less than 2-year

Basin 4700-01 is fully built-out (within Denver) with older neighborhood residential use in the upper reaches and commercial use in the lower reaches and Colfax Avenue. This basin includes Sloan's Lake, which provides significant stormwater detention for a 3.7-square-mile tributary area from Lakewood, Edgewater, and Wheatridge.

Opportunities

Sloan's Lake could provide water quality opportunities for a large, urbanized drainage basin. The lake occupies 176.5 acres.

Redevelopment of the commercial areas along Colfax Avenue could provide an opportunity for construction of more localized water quality systems below Sloan's Lake.

Constraints

This basin is fully built-out with dense development, and real estate acquisition would be a constraint for regional facilities.

I-25 (Basin 5000-01)

Exhibit 8.15 summarizes key background data for the I-25 basin (Basin 5000-01).

EXHIBIT 8.15 BACKGROUND DATA FOR I-25 (BASIN 5000-01)	
Location Description:	Mississippi to Alameda Avenues, and I-25 to Downing Street
Receiving Waterway:	South Platte River across I-25
General Land Use:	Mix of commercial and residential
Drainage Basin Area:	802.6 acres (1.25 square miles)
Basin Composite Imperviousness:	71.9%
Number of Outfalls and 2-Year Hydrology:	13+ outfalls, primary outfall is a 54" at Center Street - 387 cfs
Capacity of Outfalls:	Approximately 1-year

Intercepted stormwater is discharged into the South Platte River. The outfalls include:

- 54-inch with 602 tributary acres, or 75% of Basin 5000-01
- 36-inch for the I-25 & Santa Fe intersection
- 30-inch for the Santa Fe & Alameda intersection
- 30-inch for the Alameda & I-25 intersection
- 2-24-inch for local I-25 drainage
- 2-18-inch for local I-25 drainage
- 5-15-inch for local I-25 drainage

Opportunities

Basin 5000-01 is fully built-out with older neighborhood residential use in the upper reaches and commercial use in the lower reaches. *Blueprint Denver* shows the commercial sites as "Areas of Change," meaning that redevelopment is expected to occur in the area of the storm drain outfalls. This is an opportunity for installation of regional water quality treatment, especially since most of the basin runoff is primarily confined to the one outfall in Center Avenue. The regional pond could be located near the Home Depot at Santa Fe and Alameda.

Smaller drain outfalls from the highway and adjacent industrial/commercial land along the Platte River Valley could be treated using ultra-urban retrofits. This may include mechanical treatment systems or other BMPs, and would require a regular maintenance program. The lack of existing BMPs on outfalls in this area may warrant these additional measures.

Constraints

If the expected redevelopment does not occur, then land acquisition would be necessary for a regional facility. No Denver Parks or Open Space land is currently available in this basin for regional water quality treatment.

West Harvard Gulch (Basin 5300-01)

Exhibit 8.16 summarizes key background data for the West Harvard Gulch basin (Basin 5300-01).

EXHIBIT 8.16 BACKGROUND DATA FOR WEST HARVARD GULCH (BASIN 5300-01)	
Location Description:	South Platte River Drive and West Yale Avenue Denver and Englewood
Receiving Waterway:	South Platte River
General Land Use:	Mix of industrial, commercial and residential
Drainage Basin Area:	896 acres (1.4 square miles)
Basin Composite Imperviousness:	57.1%
Number of Outfalls:	1 existing directly to South Platte River
Capacity of Outfalls:	2-year to 5-year capacity for existing

This basin is fully built-out with neighborhood residential and commercial/light industrial. A large portion of this basin is within Englewood and is an open channel.

Opportunities

The open parcel at Federal Boulevard and West Vassar Avenue provides an excellent opportunity for water quality and on-line detention. It is located directly at the 54-inch outfall that serves the entire upper portion of the highly developed upstream residential area.

The lower portion of the West Harvard Gulch provides a unique opportunity for water quality and detention. The gulch passes through a commercial gravel operation and is an excellent location for water quality.

Constraints

Discharge agreements with Englewood would need to be reviewed before constructing regional facilities. Land would have to be acquiredfor regional facilities.

FIRST CREEK

First Creek (Basin 3700)

Exhibit 8.17 summarizes key background data for the First Creek basin (Basin 3700).

EXHIBIT 8.17 BACKGROUND DATA FOR FIRST CREEK (BASIN 3700)	
Location Description:	Near DIA at Pena & 56th Avenue Flows through Aurora, Adams County, Denver, Rocky Mountain Arsenal and Commerce City
Receiving Waterway:	Outfalls to the South Platte River at approximately East 128th Avenue
General Land Use:	Commercial and residential in headwaters Open space through Rocky Mountain Arsenal Cultivated land in Commerce City
Drainage Basin Area:	47.2 square miles (About 9.62 square miles in Denver)
Basin Composite Imperviousness:	About 48% in upper reaches
Number of Outfalls:	Tributary “T” Blue Grama tributary Dogwood West tributary
Capacity of Outfalls:	100-year wetland channels, pipes and detention ponds

First Creek crosses Pena Boulevard just north of 56th Avenue and then flows through the northeastern portion of the Rocky Mountain Arsenal. The upper reaches of First Creek are being developed with regional detention and water quality ponds. Toward the center of the basin, First Creek bisects Green Valley Ranch, which consists of medium-density, single-family residences. First Creek then enters Rocky Mountain Arsenal with a more incised, low-flow channel and wider floodplain areas. The lower First Creek basin consists of irrigated farmland with pockets of light industrial and residential properties. In the lower reaches, First Creek flows across the O’Brian Canal and the Burlington Ditch, which intercept low flow runoff.

Opportunities

All development in the First Creek drainage basin must detain and treat water quality on-site or in regional ponds. The Rocky Mountain Arsenal has strict agreements for the quantity and quality of stormwater runoff into the federal property.

The main regional pond in the upper reaches is the Green Valley Ranch Golf Course pond, also known as the “Himalaya Pond.” There are also regional detention ponds adjacent to Pena Boulevard.

Constraints

Since this basin is recently developed, drainage master plans have required incorporation of regional water quality and detention into land planning. Developers must adhere to the current UDFCD drainage criteria guidelines.

IRONDALE GULCH

Irondale Gulch (Basins 3900 & 3901)

Exhibit 8.18 summarizes key background data for Irondale Gulch basins (Basins 3900 and 3901).

EXHIBIT 8.18
BACKGROUND DATA FOR IRONDALE GULCHES (BASINS 3900 & 3901)

Location Description:	North of I-70 and east of Quebec Flows through Aurora, Adams County, Denver, Rocky Mountain Arsenal, and Commerce City
Receiving Waterway:	Outfalls to the South Platte River at approximately East 96th Avenue
General Land Use:	Commercial/Industrial in headwaters Residential in upper reaches Open space through Rocky Mountain Arsenal Cultivated land in Commerce City
Drainage Basin Area:	26.7 square miles (about 12.48 square miles in Denver)
Basin Composite Imperviousness:	50% in upper reaches
Number of Outfalls:	Southern tributary to Havana Lateral at Havana & 56th Avenue Center tributary to Derby Lake in Rocky Mountain Arsenal Northern tributary to Highline Lateral for outfall to Parkfield II detention at Chambers and 56th Avenue
Capacity of Outfalls:	100-year pipes and detention ponds 10-year concrete open channels 100-year natural channels

Irondale Gulch drains through the areas of Aurora's Majestic Commerce Center, Green Valley Ranch residential area, Gateway commercial and multi-family area, Silverado Subdivision, Parkfield Subdivision, Montbello Subdivision, the Rocky Mountain Arsenal and Commerce City with an eventual outfall to the South Platte River at approximately East 96th Avenue. The drainageway throughout the basin and the Arsenal contains several lakes, ponds and detention areas. The drainage below the Arsenal is primarily storm sewer or roadside ditches, with capacity for only minor floods.

Opportunities

All development along Irondale Gulch must either detain or treat water quality on-site or in regional ponds. The Rocky Mountain Arsenal has strict agreements for the quantity and quality of stormwater runoff into the federal property.

Constraints

Since this basin is recently developed, drainage master plans have required incorporation of water quality and detention into land planning.

CLEAR CREEK

Clear Creek (Basins 4300-03 & 4309-01)

Exhibit 8.19 summarizes key background data for the Clear Creek basins (Basin 4300-03 and 4309-01).

EXHIBIT 8.19 BACKGROUND DATA FOR CLEAR CREEK (BASINS 4300-03 & 4309-01)	
Location Description:	Northwest Denver and Arvada Between I-76 and 32nd Avenue Between Harlan Street and Alcott Street
Receiving Waterway:	Clear Creek
General Land Use:	Mostly residential with some commercial including golf course and Regis University
Drainage Basin Area:	2,316 acres (3.62 square miles)
Basin Composite Imperviousness:	56.6%
Number of Outfalls:	4 (from Denver drainage systems) 66" outfall drains Berkeley Lake
Capacity of Outfalls:	2-year

The only major (larger than 48 inch) outfall exists at Sheridan Boulevard in Arvada. This outfall drains 1,343 tributary acres which includes the Berkeley Lake basin to the South. The outfall is a 66-inch pipe with a capacity of about 184 cfs (0.15% slope). The existing system further up in the basin and within Denver has a capacity of about 350 cfs (60" at 1.8%), which is approximately a 2-year capacity.

Opportunities

Berkeley Lake and Rocky Mountain Lake provide water quality treatment for the majority of tributary drainage area within Denver.

Constraints

With the exception of small outfalls at 52nd Avenue and 50th Avenue, the major outfalls occur outside of Denver in Arvada.

SAND CREEK

Four drainage basins tributary to Sand Creek are evaluated for regional stormwater treatment opportunities in this discussion, including:

- North Stapleton (Basin 4400-01)
- Quebec Corridor (Basin 4400-02)
- South Stapleton (Basin 4400-03)
- East Stapleton (Basin 4400-04)

North Stapleton (Basin 4400-01)

Exhibit 8.20 summarizes key background data for the North Stapleton basin (Basin 4400-01).

EXHIBIT 8.20 BACKGROUND DATA FOR NORTH STAPLETON (BASIN 4400-01)	
Location Description:	North Stapleton Quebec to Havana, and I-70 to 56th Avenue
Receiving Waterway:	Sand Creek
General Land Use:	Redevelopment of Stapleton Airport
Drainage Basin Area:	3,183 acres (4.97 square miles)
Basin Composite Imperviousness:	42.4%
Number of Outfalls:	1 existing to Sand Creek 3 new outfalls proposed
Capacity of Outfalls:	100-year capacity

Currently, drainage for areas north of I-70 flows to the north into the Rocky Mountain Arsenal. Only one formal major outfall currently exists to Sand Creek: the Colorado Department of Transportation (CDOT) storm pipe for the I-70 corridor, which flows in a storm pipe system parallel to I-70 into Sand Creek.

In the future, all drainage from the basin will discharge through only three outfall locations into Sand Creek. Regional water quality treatment is proposed at these three outfalls.

The Sand Creek floodplain significantly encumbers the site between Sand Creek and I-70 and will eventually become more confined via implementation of the Sand Creek Master Plan channel improvements.

Little drainage infrastructure currently exists in this undeveloped basin, except for the Catellus site, west of and adjacent to Havana. Since no major outfall exists today for the area, 100-year retention has been constructed. Water is metered-out through small storm drains to allow the ponds to dry between storms.

Opportunities

The *East Stapleton Development Plan: The Green Book* (Green Book) (Denver 1995) and *Outfall Systems Plan-Stapleton Area* (OSP) (Denver and UDFCD 1995) set the plan for future drainage. The current master planning document is the *Infrastructure Master Plan* (BRW 2000), which was approved by Denver Wastewater in April 2001 and generally adheres to the concepts in the OSP. One exception is that the OSP did not include a water quality component in the North Area regional detention basin. The OSP was predicated upon on-site MDCIA (Level 2), gross pollutant removal and water quality facilities (extended detention basins). The *Urban Storm Drainage Criteria Manual, Volume 3* (UDFCD 1999) included guidelines for water quality treatment within the detention basin, and this concept has been adopted in the new *Storm Drainage Master Plan* updates.

The land plan retains the Green Book concept of establishing a major drainageway called the "North Stapleton Outfall Channel." This major drainageway receives almost all runoff generated on the North Stapleton site. The conveyance is a large channel, where multiple uses are envisioned within the proposed drainage corridor. The proposed pond at the outfall is sized to store the 100-year hydrograph without overtopping, and includes a multi-stage outlet for water quality treatment.

Constraints

None were identified because regional water quality treatment of this basin is already planned for when the site is redeveloped.

Quebec Corridor (Basin 4400-02)

Exhibit 8.21 summarizes key background data for the Quebec Corridor (Basin 4400-02).

EXHIBIT 8.21 BACKGROUND DATA FOR QUEBEC CORRIDOR (BASIN 4400-02)	
Location Description:	North Denver and Commerce City 12th to 52nd Avenues, and Quebec to Dahlia Streets
Receiving Waterway:	Sand Creek
General Land Use:	Mix of industrial and residential
Drainage Basin Area:	3,206 acres (4.61 square miles)
Basin Composite Imperviousness:	65.0%
Number of Outfalls and 2-Year Hydrology:	1 primary within Denver: 90" & parallel 60" in Dahlia – 1,161 cfs
Capacity of Outfalls:	Less than 5-year

This basin is fully built-out with older neighborhood residential use in the upper reaches and commercial use in the lower reaches. *Blueprint Denver* shows the entire basin as an Area of Stability, inferring that Basin 4400-02 is not an area of future land use change. However, corridor studies are now being initiated for this segment of I-70 that will evaluate the need for highway and commuter rail improvements and identify related transit-oriented development (TOD) opportunities.

Opportunities

Redevelopment of land within these basins would generally require a 100-year drainage system and improvement of highway and rail drainage facilities for a 50-year conveyance system. It is assumed that additional locations for stormwater detention or related conveyance improvements would be planned and constructed as part of the improvement programs associated with any enhanced use within the area.

An alternatives analysis for combined capital improvements for Basins 0060-01 and 4400-02 found the least-cost solution included regional detention in this basin. Areas identified for regional detention exist at the Park Hill Golf Course, 48th and Colorado, future Denver Police Department site at 38th and Grape Street, and Dahlia Square. These detention ponds could also be configured for water quality treatment as well.

Since most of the basin is discharged though one outfall in Dahlia Street, there is an opportunity for an off-line regional water quality facility near the outfall. The pond could treat collected runoff regionally at the end of pipe before discharging into Sand Creek. However, end-of-pipe treatment would locate the pond in Commerce City.

Constraints

The main constraint to regional water quality treatment is the fact that the outfalls occur outside of Denver in Commerce City. Either land areas must be identified within Denver for regional treatment, or an agreement must be structured with Commerce City for operation and maintenance of regional facilities.

South Stapleton (Basin 4400-03)

Exhibit 8.22 summarizes key background data for the South Stapleton basin (Basin 4400-03).

EXHIBIT 8.22 BACKGROUND DATA FOR SOUTH STAPLETON (BASIN 4400-03)	
Location Description:	South Stapleton Quebec to Havana, and Montview to I-70
Receiving Waterway:	Sand Creek
General Land Use:	Redevelopment of Stapleton Airport
Drainage Basin Area:	1,016 acres (1.59 square miles)
Basin Composite Imperviousness:	70.8%
Number of Outfalls:	5 existing to Sand Creek
Capacity of Outfalls:	5-year capacity for existing 100-Year capacity for new systems

This basin will be almost completely redeveloped. South of I-70, only water quality detention is required, provided that the full 100-year storm is conveyed directly to the receiving major drainageway without impact to downstream properties. Therefore, all new Stapleton drainage systems are designed for 100-year capacity.

Opportunities

The Green Book and OSP (Denver and UDFCD 1995) set the plan for future drainage. The current document is the *Infrastructure Master Plan* (BRW 2000), which was approved by Denver Wastewater in April 2001 and which adheres to the concepts in the OSP.

Stapleton Filing No. 1 was recently developed to include in-tract water quality treatment. East of Filing 1 at Stapleton, stormwater will be directed easterly to the proposed regional outfall system discharging at Smith Road and Sand Creek (near RK Mechanical). Several proposed outfalls will be combined into one large regional water quality pond near Smith Road and Sand Creek. Approximately 285 tributary acres will be conveyed to this proposed regional water quality pond via three new storm drains.

Constraints

Redevelopment of the site must occur before regional water quality treatment can be constructed.

East Stapleton (Basin 4400-04)

Exhibit 8.23 summarizes key background data for the East Stapleton basin (Basin 4400-04).

EXHIBIT 8.23 BACKGROUND DATA FOR EAST STAPLETON (BASIN 4400-04)	
Location Description:	East Stapleton Havana to Peoria, and Montview to I-70
Receiving Waterway:	Sand Creek
General Land Use:	Redevelopment of Stapleton Airport
Drainage Basin Area:	1,806 acres (2.82 square miles)
Basin Composite Imperviousness:	73.3%
Number of Outfalls and 2-Year Hydrology:	4 existing to Sand Creek
Capacity of Outfalls:	2-year to 5-year capacity for existing 100-year capacity for new systems

Currently, there are only four known outfalls into Sand Creek within this basin:

- 72-inch from Aurora from the south through the Stapleton site
- 84-inch in Havana from the north, collecting drainage along Smith Road and Havana
- Open channel in Aurora from the north
- I-70 corridor in a parallel storm pipe system to Sand Creek

Drainage on the Stapleton site is currently informal with few storm drains, relying upon infiltration, evaporation and sheet flow to drain the site to Sand Creek. A 72-inch storm drain from Aurora currently flows north though the Stapleton site and discharges to Bluff Lake. This 72-inch pipe can convey runoff only up to the 5-year event. Drainage from the jail and other properties between Smith Road and I-70 is conveyed to Sand Creek in the 84-inch pipe. This pipe has approximate capacity for the 2-year discharge. The area south of Smith Road drains to open channels in Aurora and directly to Sand Creek.

<u>Opportunities</u>

This basin will be almost completely redeveloped. South of I-70, only water quality detention is required, provided that the full 100-year storm is conveyed directly to the receiving major drainageway without impact to downstream properties. Therefore, all new Stapleton drainage systems are designed for 100-year capacity.

Discussions with Denver Parks Department suggest interest in the development of Bluff Lake (in the southeastern portion of the Stapleton site) for limited use as a water quality pond. This lake was formerly fed by Sand Creek via an irrigation-style channel, but this water supply is no longer active. Management plans for Bluff Lake propose to enhance its use as a public amenity and to encourage wetlands restoration. Therefore, additional water supply is desired for the site. Proposed grading plans for the Stapleton site direct stormwater flows to Bluff Lake to enhance its water volume. A new 7-foot x 5-foot box culvert is proposed to discharge into Bluff Lake for regional water quality treatment. Storm drainage pipes in this area will be constructed commensurate with development.

Constraints

A portion of this basin is within Aurora. Redevelopment of the site must occur before regional water quality treatment could be constructed.

WESTERLY CREEK

Four drainage basins tributary to Westerly Creek are evaluated for regional stormwater treatment opportunities in this discussion, including:

- South Stapleton (Basin 4401-01)
- 11th Avenue to Montview (Basin 4401-02)
- Lowry (Basin 4401-03)
- Upper Westerly Creek (Basin 4401-04)

South Stapleton (Basin 4401-01)

Exhibit 8.24 summarizes key background data for the South Stapleton basin (Basin 4401-01).

EXHIBIT 8.24 BACKGROUND DATA FOR SOUTH STAPLETON (BASIN 4401-01)	
Location Description:	South Stapleton MLK to Montview, and Quebec to Peoria
Receiving Waterway:	Westerly Creek
General Land Use:	Redevelopment of Stapleton Airport Residential use in Aurora
Drainage Basin Area:	1,939 acres (3.03 square miles)
Basin Composite Imperviousness:	50.6%
Number of Outfalls:	8
Capacity of Outfalls:	100-year Capacity

The majority of this basin has been recently constructed or will be constructed soon as part of the Stapleton Redevelopment project. The portion south of 26th Avenue and east of Westerly Creek that lies within the City of Aurora is primarily residential.

Opportunities

Regional water quality has been recommended in the *Stapleton Infrastructure Master Plan*. Water quality ponds along Westerly Creek are to be installed as development progresses. No additional water quality is proposed for this basin.

Constraints

There are no constraints for implementation of the water quality ponds shown in the *Stapleton Infrastructure Master Plan*.

11th Avenue to Montview (Basin 4401-02)

Exhibit 8.25 summarizes key background data for Basin 4401-02.

EXHIBIT 8.25 BACKGROUND DATA FOR 11TH AVENUE TO MONTVIEW (BASIN 4401-02)	
Location Description:	South of Stapleton, north of Lowry Quebec to Peoria
Receiving Waterway:	Westerly Creek
General Land Use:	Residential with commercial along roadway corridors
Drainage Basin Area:	1,811 acres (2.83 square miles)
Basin Composite Imperviousness:	62.6%
Number of Outfalls:	3 existing to Westerly Creek, 1 additional proposed
Capacity of Outfalls:	2-year and 5-year capacity

This basin is fully built-out with older neighborhood residential and commercial uses throughout and is not an area of future land use change.

Opportunities

No opportunities have been identified for regional water quality treatment. Water quality will be treated in-tract commensurate with new development.

Constraints

This basin is fully built out with dense development, and acquisition of real estate is a constraint for regional facilities.

Lowry (Basin 4401-03)

Exhibit 8.26 summarizes key background data for the Lowry basin (Basin 4401-03).

EXHIBIT 8.26 BACKGROUND DATA FOR LOWRY (BASIN 4401-03)	
Location Description:	Lowry 11th Avenue to Alameda, Quebec to Havana
Receiving Waterway:	Westerly Creek
General Land Use:	Redevelopment of Lowry Air Force Base Mixed use of residential, commercial
Drainage Basin Area:	2,246 acres (3.51 square miles)
Basin Composite Imperviousness:	40.6%
Number of Outfalls:	5
Capacity of Outfalls:	100-year capacity

The majority of this basin has been recently constructed as part of the Lowry Redevelopment project.

Opportunities

Water quality has been provided as master planned in the *Lowry Master Drainage Plan* (BRW 1998) at two locations: Westerly Creek Pond Dam and Kelly Road Dam. All water flowing into Westerly Creek within the Lowry Redevelopment area is treated at Kelly Road Dam. No additional water quality is proposed for this basin.

Constraints

There are no constraints for implementation of the regional water quality ponds shown in the *Lowry Master Drainage Plan.*

Upper Westerly Creek (Basin 4401-04)

Exhibit 8.27 summarizes key background data for the Upper Westerly Creek basin (Basin 4401-04).

EXHIBIT 8.27 BACKGROUND DATA FOR UPPER WESTERLY CREEK (BASIN 4401-04)	
Location Description:	South of Lowry Alameda to Jewell, west of Havana
Receiving Waterway:	Westerly Creek
General Land Use:	Residential and commercial mix
Drainage Basin Area:	1,824 acres (2.85 square miles)
Basin Composite Imperviousness:	55.6%
Number of Outfalls:	5 existing
Capacity of Outfalls:	2-year and 5-year capacity

This basin is mostly built-out with neighborhood residential and commercial uses throughout, and major redevelopment within the basin is not anticipated.

Opportunities

All runoff flows north to the Westerly Creek Pond Dam where it is treated for water quality.

No additional water quality facilities have been proposed within the basin.

Constraints

This basin is fully built out with dense development, and acquisition of land is required for regional facilities.

CHERRY CREEK

Four drainage basins tributary to Cherry Creek are evaluated for regional stormwater treatment opportunities in this discussion, including:

- Central Business District (Basin 4600-01)
- Cherry Creek Mall (Basin 4600-02)
- Upper Cherry Creek (Basin 4600-03)
- Upper Cherry Creek (Basin 4600-04)

Central Business District (Basin 4600-01)

Exhibit 8.28 summarizes key background data for the Central Business District basin (Basin 4600-01).

EXHIBIT 8.28 BACKGROUND DATA FOR CENTRAL BUSINESS DISTRICT (BASIN 4600-01)	
Location Description:	Downtown Denver 6th Avenue to the South Platte River along the lower Cherry Creek corridor
Receiving Waterway:	Cherry Creek
General Land Use:	Commercial
Drainage Basin Area:	1,392 acres (2.17 square miles)
Basin Composite Imperviousness:	83.2%
Number of Outfalls:	42 outfalls
Capacity of Outfalls:	2-year to 5-year

Intercepted stormwater is discharged into Cherry Creek. Some of the major outfalls include:

- 16-foot x 4-foot box culvert from the Pepsi Center
- 10-foot x 5-foot box culvert recently constructed for the Convention Center up to 14th and Stout Street
- 96-inch pipe outfalling at 14th and Market Street draining large pipe in Larimer Street
- 54-inch pipe from Delgany Street

<u>Opportunities</u>

No opportunities have been identified for regional water quality treatment. Water quality will be treated in-tract commensurate with new development.

<u>Constraints</u>

This basin is fully built out with dense development, and the high cost of downtown real estate is a constraint for acquisition for regional stormwater facilities.

Cherry Creek Mall (Basin 4600-02)

Exhibit 8.29 summarizes key background data for the Cherry Creek Mall basin (Basin 4600-02).

EXHIBIT 8.29 BACKGROUND DATA FOR CHERRY CREEK MALL (BASIN 4600-02)	
Location Description:	6th Avenue to Colorado Boulevard Along the Cherry Creek corridor Includes the Denver Country Club and Cherry Creek Mall
Receiving Waterway:	Cherry Creek
General Land Use:	Commercial and residential
Drainage Basin Area:	2,952 acres (4.61 square miles)
Basin Composite Imperviousness:	57.7%
Number of Outfalls:	24 outfalls
Capacity of Outfalls:	2-year to 5-year

Intercepted stormwater is discharged into Cherry Creek. Some of the major outfalls include:

- 56-inch pipe at 1st and Marion Street
- 66-inch pipe from Cherry Creek Mall at University Boulevard and Cherry Creek
- 60-inch pipe from the east side of the Cherry Creek Mall near Steele Street
- 3-foot x 8-foot box culvert in Steele Street
- 48-inch x 76-inch elliptical pipe in Colorado Boulevard north of Cherry Creek
- 66-inch pipe at Garfield Street and Cherry Creek
- 42-inch pipe from University Boulevard south of Cherry Creek
- 72-inch pipe from Washington Street south of Cherry Creek draining 618 acres

Opportunities

No easy opportunities have been identified for regional water quality treatment. Water quality will generally be treated in-tract commensurate with new development. However, there may be an opportunity on the existing 66-inch pipe at University Boulevard that captures runoff from 44 acres of dense commercial development and parking at the mall. This storm sewer could be daylighted and detention constructed if some peripheral parking area were sacrificed.

Constraints

This basin is fully built-out with dense development, and the high cost of real estate prohibits acquisition for regional facilities. The many outfalls preclude construction of a few regional facilities. There are no opportunities for on-line water quality treatment within Cherry Creek.

Upper Cherry Creek (Basin 4600-03)

Exhibit 8.30 summarizes key background data for the Upper Cherry Creek basin (Basin 4600-03).

EXHIBIT 8.30 BACKGROUND DATA FOR UPPER CHERRY CREEK (BASIN 4600-03)	
Location Description:	Denver, Glendale, and Aurora Colorado Boulevard to Quebec Along the Cherry Creek corridor
Receiving Waterway:	Cherry Creek
General Land Use:	Commercial and residential
Drainage Basin Area:	3,597 acres (5.62 square miles)
Basin Composite Imperviousness:	68.9%
Number of Outfalls:	19 Outfalls
Capacity of Outfalls:	2-year to 5-year

The lower reach of this basin is outside Denver limits in the City of Glendale. The upper reaches of the basin are in Aurora. Most of this basin has been developed into neighborhood residential use and parks. *Blueprint Denver* shows the entire basin as an Area of Stability. No areas have been identified as Areas of Change.

This basin is characterized by smaller tributaries to Cherry Creek with travel paths generally less than one mile to each outfall. This reach of the Cherry Creek basin includes the Goldsmith Gulch outfall.

<u>Opportunities</u>

No opportunities have been identified for regional water quality treatment. Water quality will be treated in-tract commensurate with new development.

<u>Constraints</u>

This basin is fully built-out with dense development, and land acquisition is necessary for regional facilities. No opportunities for regional detention were identified in this basin. The many outfalls preclude construction of only a few regional facilities. There are no opportunities for on-line water quality treatment within Cherry Creek.

Upper Cherry Creek (Basin 4600-04)

Exhibit 8.31 summarizes key background data for the Upper Cherry Creek basin (Basin 4600-04).

EXHIBIT 8.31 BACKGROUND DATA FOR UPPER CHERRY CREEK (BASIN 4600-04)	
Location Description:	Denver and Aurora Parker Road, I-225, Yosemite Street Along the Cherry Creek corridor
Receiving Waterway:	Cherry Creek
General Land Use:	Commercial and residential
Drainage Basin Area:	3,693 acres (5.77 square miles)
Basin Composite Imperviousness:	51.3%
Number of Outfalls:	14 outfalls
Capacity of Outfalls:	2-year to 5-year

The lower reach of this basin is outside Denver limits in the City of Aurora. Most of this basin has been developed into neighborhood residential use and parks, with commercial use along major roadway corridors.

This basin is characterized by smaller tributaries to Cherry Creek with travel paths generally less than 1 mile to each outfall. There are three major outfalls in the basin, all located near the point where Cherry Creek passes under Hampden Avenue.

<u>Opportunities</u>

A new stormwater detention pond is proposed in the undeveloped parcel of land owned by Denver Parks west of the intersection of Parker Road and Dartmouth Avenue, just north of the baseball fields. The parcel of land is approximately 4.6 acres in area. Incorporating water quality into a detention pond in this location would treat runoff from approximately 478 acres of land east of Parker Road prior to discharging into Cherry Creek.

Two major storm sewer outfalls discharge into Cherry Creek within 1,200 feet of each other on the west side of Cherry Creek near Hampden Avenue and Dartmouth Avenue. An undeveloped parcel of land approximately 300 ft x 1,100 ft (7.6 acres) in area stretches between the two outfalls. A water quality feature in this location would treat runoff from approximately 728 acres of land to the west before it enters Cherry Creek.

<u>Constraints</u>

It is unclear if Denver Parks has plans for developing either parcels of land or if a water quality feature could be incorporated into whatever development plans they may have. Discussions with Denver Parks need to take place before either of these potential water quality treatment locations could be seriously considered.

GOLDSMITH GULCH

Goldsmith Gulch (Basin 4601-01)

Exhibit 8.32 summarizes key background data for the Goldsmith Gulch basin (Basin 4601-01).

EXHIBIT 8.32 BACKGROUND DATA FOR GOLDSMITH GULCH (BASIN 4601-01)	
Location Description:	I-225 and I-25 Interchange
Receiving Waterway:	Cherry Creek
General Land Use:	Mix of commercial and residential
Drainage Basin Area:	4,992 acres (7.8 square miles)
Basin Composite Imperviousness:	56.6%
Number of Outfalls:	2 existing to Cherry Creek
Capacity of Outfalls:	2-year to 5-year capacity for existing

Outfalls include:

- Open channel to Cherry Creek
- 72-inch by 120-inch from South Monaco Parkway

This basin is fully built-out with neighborhood residential and commercial/light industrial. Only a very small portion of this basin is within Denver. The newly constructed I-25 and I-225 interchange includes off-line detention and water quality ponds as part of the storm sewer system.

Opportunities

Several existing parks and detention facilities located along Goldsmith Gulch provide an opportunity for water quality. Each park's detention facility could potentially be modified to meet the requirements for water quality. The locations of these facilities are Wallace Park, Rosamond Park, Bible Park, Iliff and Monaco, and Cherry Creek and Monaco.

Constraints

Each detention facility will have to be analyzed to determine the effect of modifying the facility with respect to flood attenuation. Agreements between Denver, Greenwood Village, and UDFCD would need to be in place before constructing any facilities.

DRY GULCH AND LAKEWOOD GULCH

The Dry Gulch and Lakewood Gulch basins are evaluated for regional stormwater treatment opportunities together in the following discussion. Dry Gulch is tributary to Lakewood Gulch, which is tributary to the South Platte River.

Lakewood & Dry Gulches (Basins 4800-01 & 4801-01)

Exhibit 8.33 summarizes key background data for the Lakewood Gulch and Dry Gulch basins (Basins 4800-01 & 4801-01).

EXHIBIT 8.33 BACKGROUND DATA FOR LAKEWOOD & DRY GULCHES (BASINS 4800-01 & 4801-01)	
Location Description:	6th to Colfax Avenues, and Sheridan to Federal
Receiving Waterway:	Lakewood Gulch and Dry Gulch, a tributary of Lakewood Gulch All tributary to the South Platte River
General Land Use:	Primarily residential
Drainage Basin Area:	Lakewood Gulch: 750 acres (1.17 square miles) Dry Gulch: 248 acres (0.39 square mile)
Basin Composite Imperviousness:	Lakewood Gulch: 59.6% Dry Gulch: 62.0%
Number of Outfalls and 2-Year Hydrology:	1 pipe outfall larger than 24”: 39” at Lowell Boulevard - 106 cfs
Capacity of Outfalls:	About 2-year

Lakewood Gulch is a major drainageway with a 16-square-mile watershed, and Dry Gulch is a north bank tributary to Lakewood Gulch. Lakewood and Dry Gulch both discharge to the South Platte River. The gulches begin in Lakewood and terminate into the South Platte River at 14th Avenue. Only about 10 percent of the total tributary area is within Denver. The basins are long and narrow, running west to east.

The basins within Denver are fully built-out primarily with neighborhood residential use, except for commercial use along arterial transportation corridors. *Blueprint Denver* shows linear corridors along Dry Gulch and Colfax subject to change. There are proposed light rail and other transit-oriented improvements that may occur in these basins in the future.

Runoff generally flows down the relatively steep roadways into these major drainageways. Relatively little storm pipe is necessary in these basins due to the capacity of the streets to convey stormwater. Intercepted stormwater in the pipes is discharged in small, local storm drainage outfalls to the drainageways.

Opportunities

An on-line water quality pond could be constructed on Dry Gulch or Lakewood Gulch. However, due to the high peak flows, configuring a water quality pond to retain trapped sediment and trash would be a design challenge.

Constraints

There are no opportunities to construct a regional water quality pond at the end-of-pipe. No land has been identified within the gulches for on-line water quality ponds.

WEIR GULCH

Weir Gulch (Basin 4900-01)

Exhibit 8.34 summarizes key background data for the Weir Gulch basin (Basin 4900-01).

EXHIBIT 8.34 BACKGROUND DATA FOR WEIR GULCH (BASIN 4900-01)	
Location Description:	West of Downtown Denver Between 9th and Kentucky Avenues, and Sheridan Boulevard and the South Platte River
Receiving Waterway:	Weir Gulch
General Land Use:	Mix of residential, commercial, and industrial
Drainage Basin Area:	1,473 acres (2.30 square miles) within Denver
Basin Composite Imperviousness:	58.3%
Number of Outfalls and 2-Year Hydrology:	16 outfalls
Capacity of Outfalls:	2-year

Basin 4900-01 tributary to Weir Gulch is fully built-out (within Denver) with older neighborhood residential use in the upper reaches and commercial use in the lower reaches. Two major tributaries outfall into Weir Gulch: 1st Avenue and Dakota Avenue Tributaries.

Opportunities

An existing on-line water quality facility exists on Weir Gulch at Barnum South Park. Strip parks have been developed by the Denver Parks and Recreation Department from 1st Avenue to Alameda Avenue along the gulch, which could be reconfigured to be utilized for regional stormwater management.

Constraints

This basin is fully built-out with dense development, and land acquisition is necessary for regional facilities.

SANDERSON GULCH

Sanderson Gulch (Basin 5100-01)

Exhibit 8.35 summarizes key background data for the Sanderson Gulch basin (Basin 5100-01).

EXHIBIT 8.35 BACKGROUND DATA FOR SANDERSON GULCH (BASIN 5100-01)	
Location Description:	West Denver and Jefferson County South Platte River to South Pierce Street
Receiving Waterway:	South Platte River
General Land Use:	Mix of industrial and residential
Drainage Basin Area:	4,864 acres (7.6 square miles)
Basin Composite Imperviousness:	54.6%
Number of Outfalls and 2-Year Hydrology:	1 within Denver: Open Channel at Platte River Drive - See FHAD
Capacity of Outfalls:	100-Year

- Much of the Sanderson Gulch basin is tributary to Mississippi Avenue and the associated outfall.

Opportunities

Basin 5100-01 is fully built-out with older neighborhood residential use in the upper reaches and commercial use in the lower reaches. *Blueprint Denver* shows the region along both sides of Federal Boulevard as an Area of Change, meaning that redevelopment is expected to occur in the area of the storm drain outfalls. This is an opportunity for installation of regional water quality treatment, especially since basin runoff is confined to one major outfall.

An undeveloped open channel section along Mississippi Avenue at Quivas Street is an opportunity for an on-line regional water quality pond at the discharge of the 4 ft x 8 ft CBC. This site is an ideal location for water quality treatment.

Other locations for regional water quality treatment within this basin are Huston Lake, Garfield Lake, Ward Reservoir No. 5, and Harvey Park. These Denver Parks lands may provide an opportunity for off-line regional water quality ponds.

Constraints

The main constraint to regional water quality treatment is the fact that the outfall at Mississippi Gulch requires coordination with Public Service Company and private landowners. Either land areas must be identified within Denver for regional treatment, or an agreement must be structured with Public Service Company for operation and maintenance of regional facilities.

GREENWOOD GULCH

Greenwood Gulch (Basin 5401-01)

Exhibit 8.36 summarizes key background data for the Greenwood Gulch basin (Basin 5401-01).

EXHIBIT 8.36 BACKGROUND DATA FOR GREENWOOD GULCH (BASIN 5401-01)	
Location Description:	East Belleview Avenue and South Monaco Street, Southeast Denver
Receiving Waterway:	Greenwood Gulch
General Land Use:	Mix of industrial, commercial, and residential
Drainage Basin Area:	93 acres (0.15 square mile)
Basin Composite Imperviousness:	84.0%
Number of Outfalls:	3 existing leaves Denver and discharge to Greenwood Gulch
Capacity of Outfalls:	2-year to 5-year capacity for existing

Outfalls include:

- 30-inch from West Quincy Avenue
- 42-inch from South Federal Boulevard

This basin has several future developments planned. The majority of the basin is composed of residential, commercial and light industrial. The entire basin is within Denver.

Opportunities

Existing detention and water quality facilities are servicing this basin. No new facilities are required at this time.

Constraints

Any modifications to existing facilities must conform to the existing developer agreements.

BEAR CREEK

Six drainage basins tributary to Bear Creek are evaluated for regional stormwater treatment opportunities in this discussion, including:

- Fort Logan (Basin 5500-01)
- Upper Bear Creek (Basin 5500-02)
- Academy Park Tributary (Basin 5500-03)
- Marston Lake North (Basin 5500-04)
- Pinehurst Tributary (Basin 5500-05)
- Henry's Lake Tributary (Basin 5501-01)

Fort Logan (Basin 5500-01)

Exhibit 8.37 summarizes key background data for the Fort Logan basin (Basin 5500-01).

EXHIBIT 8.37 BACKGROUND DATA FOR FORT LOGAN (BASIN 5500-01)	
Location Description:	Southwest of Downtown Denver Between Yale and Union Avenues, and Between Sheridan and Federal Boulevards
Receiving Waterway:	Bear Creek
General Land Use:	Mix of residential and commercial
Drainage Basin Area:	1,997 acres (3.12 square miles)
Basin Composite Imperviousness:	52.8%
Number of Outfalls:	9 outfalls
Capacity of Outfalls:	1- to 2-year

Basin 5500-01 is primarily residential use on the north side of Bear Creek and a mixture of residential with Fort Logan National Cemetery and Mullen High School on the south side. Wolcott Lake, located on the northern end of the basin, does not receive enough stormwater runoff to be effective for water quality purposes.

Opportunities

The 2003 Fort Logan Cemetery development plan proposes two detention ponds which would provide water quality benefits for the south side of the basin.

No opportunities have been identified for regional water quality treatment on the north side of Bear Creek. Water quality will be treated in-tract commensurate with new development.

Constraints

No Denver Parks or Open Space land is available in this basin on the north side of Bear Creek. Land acquisition would be necessary to provide regional water quality systems to this area.

Upper Bear Creek (Basin 5500-02)

Exhibit 8.38 summarizes key background data for the Upper Bear Creek basin (Basin 5500-02).

EXHIBIT 8.38 BACKGROUND DATA FOR UPPER BEAR CREEK (BASIN 5500-02)	
Location Description:	Southwest of Downtown Denver Between Lakeridge Road and Lehigh Avenue, and Between Wadsworth and Sheridan Boulevards
Receiving Waterway:	Bear Creek
General Land Use:	Mix of residential, commercial, and industrial
Drainage Basin Area:	1,178 acres (1.84 square miles)
Basin Composite Imperviousness:	45.5%
Number of Outfalls:	15 outfalls
Capacity of Outfalls:	2-year

Intercepted stormwater is discharged into Bear Creek. Some of the major outfalls include:

- 30-inch to an open channel at Webster Street
- 30-inch at Reed Street
- 30-inch at Newland Street
- 42-inch at Lamar Street
- 42-inch at Joslin Court
- 48-inch at Golden Way
- 30-inch at the north side of Sheridan Boulevard
- 48-inch at the south side of Sheridan Boulevard

Opportunities

No opportunities have been identified for regional water quality treatment. Water quality will be treated in-tract commensurate with new development.

Constraints

This basin is fully built-out with dense development, and acquisition of real estate is a constraint for regional facilities. The many outfalls preclude construction of only a few isolated regional facilities.

Academy Park Tributary (Basin 5500-03)

Exhibit 8.39 summarizes key background data for the Academy Park Tributary basin (Basin 5500-03).

EXHIBIT 8.39 BACKGROUND DATA FOR ACADEMY PARK TRIBUTARY (BASIN 5500-03)	
Location Description:	Southwest of Downtown Denver Between Bear Creek and Quincy Avenue, and Between Wadsworth Boulevard and Ingall Street
Receiving Waterway:	Bear Creek
General Land Use:	Mostly commercial with some residential
Drainage Basin Area:	384 acres (0.60 square mile)
Basin Composite Imperviousness:	67.2%
Number of Outfalls:	3 outfalls Including 54" at Marshall Street
Capacity of Outfalls:	2-year

The majority of this basin (88%) is located within Jefferson County. Only the downstream outfall portion of the basin is located in Denver.

Opportunities

No opportunities have been identified for regional water quality treatment within Denver. Several small facilities associated with individual development have been constructed in the upstream (Jefferson County) portion of the basin.

Constraints

The basin is almost entirely located within Jefferson County.

Marston Lake North (Basin 5500-04)

Exhibit 8.40 summarizes key background data for the Marston Lake North basin (Basin 5500-04).

EXHIBIT 8.40 BACKGROUND DATA FOR MARSTON LAKE NORTH (BASIN 5500-04)	
Location Description:	Quincy to Belleview, Kipling to Wadsworth Wadsworth to Sheridan north of Quincy
Receiving Waterway:	Bear Creek
General Land Use:	Residential and commercial mix
Drainage Basin Area:	1,894 acres (2.96 square miles)
Basin Composite Imperviousness:	45.0%
Number of Outfalls:	1 existing to Bear Creek
Capacity of Outfalls:	5-year capacity

There are over 15 minor storm sewer outfalls to the Marston Lake North channel from its beginning at Lakes Lake to the channel's outfall into Bear Creek. The channel drains approximately 2.96 square miles. There is an existing detention pond called Lakes Lake located between Stanford Avenue and Balsam Way, north of Union Avenue

Opportunities

It is assumed that Lakes Lake was constructed with the intention of providing water quality. If that is not the case, incorporating water quality into the pond would provide treatment for the 453 acres flowing to it.

There is a series of ponds in line with the Marston Lake North channel located east and west of Sheridan near the Oxford Avenue intersection. Any of these ponds could be used for water quality treatment in the lower portion of the basin.

Constraints

Land acquisition may be necessary for the ponds in the lower reach of the basin.

Pinehurst Tributary (Basin 5500-05)

Exhibit 8.41 summarizes key background data for the Pinehurst Tributary basin (Basin 5500-05).

EXHIBIT 8.41 BACKGROUND DATA FOR PINEHURST TRIBUTARY (BASIN 5500-05)	
Location Description:	Southwest of downtown Denver Between Bear Creek and Quincy Avenue, and Between Wadsworth and Sheridan Boulevards
Receiving Waterway:	Bear Creek
General Land Use:	Residential and commercial
Drainage Basin Area:	461 acres (0.72 square mile)
Basin Composite Imperviousness:	42.2%
Number of Outfalls:	2 outfalls Primary outfall is 42”
Capacity of Outfalls:	50-year

Basin 5500-05 is primarily residential use in the lower reaches, and golf course/residential in the upper reaches. Colorado Academy is located in the central portion of the basin.

Opportunities

There are several existing and proposed detention/water quality systems throughout the basin. Newly constructed detention and water quality ponds exist on the Colorado Academy site. There is good opportunity for on-line water quality facilities to be constructed in the lower reaches of the channel, just south of Hampden Avenue.

Constraints

Land acquisition costs could be prohibitive.

Henry's Lake (Basin 5501-01)

Exhibit 8.42 summarizes key background data for the Henry's Lake basin (Basin 5501-01).

EXHIBIT 8.42 BACKGROUND DATA FOR HENRY'S LAKE (BASIN 5501-01)	
Location Description:	Southwest of Downtown Denver Between Bear Creek and Stanford Avenue Between Kipling Avenue and Pierce Way
Receiving Waterway:	Bear Creek
General Land Use:	Residential, commercial, golf course, undeveloped
Drainage Basin Area:	864 acres (1.35 square miles)
Basin Composite Imperviousness:	35.0%
Number of Outfalls:	1 outfall (located in Jefferson County)
Capacity of Outfalls:	Not quantified

The majority of this basin (95%) and the outfall are located within Jefferson County. Only 40 acres at the upstream end of the basin are located within Denver. Little Henry's Lake is located on Denver property.

Opportunities

A regional detention pond, Little Henry's Lake, is located just south of Henry's Lake and could provide regional water quality for Denver's 40 tributary acres. The pond is maintained by Denver's Parks and Recreation Department.

RTD owns land adjacent to the existing Park–N-Ride facility near Wadsworth Boulevard and Hampden Avenue in Jefferson County. RTD has expressed some interest in using the land for stormwater detention/water quality purposes.

A series of on-line ponds are located in the lower portion of the drainageway (Jefferson County).

Constraints

The basin is almost entirely located within Jefferson County. A maintenance agreement is required for use of Little Henry's Lake as a regional water quality facility.

DUTCH CREEK

Coon Creek (Basin 5901-01)

Exhibit 8.43 summarizes key background data for the Coon Creek basin (Basin 5901-01).

EXHIBIT 8.43 BACKGROUND DATA FOR COON CREEK (BASIN 5901-01)	
Location Description:	Belleview to Bowles, Kipling to Sheridan
Receiving Waterway:	Coon Creek
General Land Use:	Mixed use of residential, commercial
Drainage Basin Area:	1,984 acres (3.10 square miles)
Basin Composite Imperviousness:	53.2%
Number of Outfalls:	2 to Coon Creek within Denver
Capacity of Outfalls:	5-year capacity

The majority of this basin is relatively new construction and includes on-site detention and water quality facilities. Denver's jurisdiction consists of only a narrow strip of land cutting across Coon Creek and a small tributary basin at the upstream end of the basin. The majority of this basin is located outside of Denver, including the outfall to Dutch Creek.

Opportunities

No opportunities have been identified within Denver for regional water quality treatment.

Constraints

This basin is located almost entirely within Jefferson County.

SUMMARY

Multiple opportunities exist for regional stormwater quality treatment facilities. Chapter 9 identifies work that needs to be completed to further evaluate and plan for regional stormwater treatment at these potential sites.

Chapter 9
RECOMMENDATIONS AND IMPLEMENTATION PLAN

As is the case with cities throughout the country, Denver is faced with complex regulatory requirements with regard to water quality. Denver's Phase I CDPS permit specifies stringent requirements with which it must comply or face significant penalties. Fortunately, Denver already has many sound water quality requirements in place in the form of policies and regulations. This chapter provides a summary of recommendations for future water quality protection efforts, along with a proposed implementation plan for these recommendations.

RECOMMENDATIONS

1. All new and redevelopment projects must address water quality in their development plans, complying with the stormwater policies and design criteria specified in the *Urban Storm Drainage Criteria Manual, Volumes 1-3* (UDFCD 1999, 2001) and in Denver's CDPS permit. Particularly critical is the four-step BMP planning process that requires:

    - Implementing stormwater runoff reduction practices.
    - Providing treatment of the Water Quality Capture Volume.
    - Implementing streambank and channel stabilization techniques for any drainageways within or adjacent to a project site.
    - Providing additional treatment for pollution "hot spots."

2. Under Denver's CDPS permit, adverse impacts to receiving waters posed by urban stormwater discharges must be minimized to the "maximum extent practicable." Examples of these adverse impacts can include increased pollutant loading, increased runoff rates and volumes, channel instability, modification of aquatic habitat and increased sediment loading, both during and after construction. It is essential to recognize that, despite the best efforts to control stormwater runoff, there will be some change in receiving water characteristics due to development; therefore, a "zero impact" policy is not realistic or attainable. As a result, Denver advocates management of stormwater through the implementation of BMPs designed in accordance with the guidelines established by UDFCD (UDFCD 1999, 2001), as summarized in #1, above.

3. Denver will continue to advocate the use of multiple BMPs, including non-structural measures, source controls, and structural BMPs, to reduce stormwater pollution. Whenever practicable, combining BMPs in series can be very effective in reducing stormwater pollution.

4. The stormwater quality BMP implementation guidelines provided in Chapter 6 of this Plan will be shared with developers and city staff alike to promote better integration of water quality into site designs, including more substantial use of runoff reduction techniques.

5. Denver will work to ensure that water quality is addressed in the very beginning of the site development process so that stormwater quality BMPs are better and more cost effectively integrated into site designs. Various Denver departments (e.g., Public Works, Planning, Parks, Environmental Health) must work together with a shared vision of stormwater quality management to accomplish this goal.

6. Urban stormwater management must be an integral part of site design and take into consideration multiple objectives. As stated in the *Urban Storm Drainage Criteria Manual, Volume 1* (UDFCD 2001), the many competing demands placed on space and resources require that stormwater management strategies take into account water quality enhancement, groundwater recharge, recreation, wildlife habitat, wetland protection, protection of landmarks/amenities, control of erosion and sediment deposition, and creation of open space. In addition, the appearance of BMPs is particularly important; Denver will expect to receive site development plans that feature attractive BMPs that will be viewed as assets by the community. Denver will encourage multi-purpose usage of BMPs; however, compatibility among uses must be demonstrated (e.g., compatibility between recreational areas and detention areas).

7. Planning for water quality must proceed hand-in-hand with drainage planning for quantity (rate and volume). In urban areas, these two planning efforts are inseparable. When these issues are addressed together and early in the site planning process, more efficient, economical and attractive land uses generally result.

8. Denver will continue to review BMP designs for pubic safety and maintenance accessibility, maintainability, documentation of maintenance requirements and schedule, and assured long-term funding for maintenance. Proper maintenance is fundamental to public safety and long-term effectiveness of stormwater BMPs; therefore, Denver will take these steps to promote better long-term maintenance of BMPs:

    - Require inclusion of a simple BMP maintenance plan as part of Denver's Stormwater Quality Control Plan submittal requirements.

    - Require a legally binding description of BMP maintenance requirements and arrangements as part of development plan approval.

    - Clearly identify BMP maintenance requirements in forthcoming updates to Denver's *Storm Drainage Criteria Manual*.

    - Prepare easy-to-understand maintenance guidance documents and brochures for both pubic and private facility owners. These documents will be based on maintenance recommendations of UDFCD and the guidelines provided in Chapter 6 of this Plan.

9. The same stormwater quality management expectations and practices that apply to projects in the private sector also apply to projects that are the responsibility of Denver, such as buildings, parks, streets, utilities, etc. When Denver is preparing plans for any such

projects or managing, maintaining and/or upgrading existing facilities, potential adverse stormwater quality effects must be evaluated and suitably mitigated.

10. Denver will continue to actively participate in regional water quality management efforts such as those being conducted by South Platte Cooperative for Urban River Evaluation (CURE), the Cherry Creek Basin Stewardship Partners, and the Barr Lake-Milton Reservoir Watershed Group. These on-going efforts emphasize the importance of Denver partnering with neighboring communities to tackle difficult water quality issues. Denver must also stay abreast of forthcoming regulatory changes that affect management of the many lakes and streams within its boundaries.

11. Denver's stormwater management strategies must be consistent with the principles, criteria, and priorities in its multiple planning and technical criteria documents, as described in Chapter 4.

12. Denver will work to remove obstacles to innovative stormwater management approaches by reviewing regulations and codes and, where practical, modifying requirements that conflict with the principles of this Plan. For example, such conflicts may arise with regard to parking lot and curb and gutter design requirements relative to some Low Impact Development approaches.

13. Denver will continue to promote managing and treating stormwater quality using aboveground facilities, rather than in subsurface, "vault-type" treatment devices. Nevertheless, Denver recognizes that there are some cases where the use of such facilities is necessary due to extreme space constraints in smaller redevelopment sites, such as those located in the downtown area.

14. Denver will evaluate the feasibility of collaborating with UDFCD, a university, other local governments, and other organizations to pilot-test innovative BMPs. Denver will continue to actively partner with UDFCD to develop design guidance for "new" BMPs for the Denver area.

15. Denver will continue to educate the public on stormwater quality issues. Additional opportunities for Denver's existing public education program include:

    - Provide additional educational brochures and water pollution prevention resources on the Denver web site. For example, as discussed in Chapter 5, many of the national case studies provide extensive web resources.

    - Develop pollution prevention programs for specific industries that require further attention and/or partner with entities providing existing programs. For example, the City of Boulder's Partners for a Clean Environment (PACE) program targets and provides educational information to specific industry segments including auto repair, auto body, green building, dental offices, dry cleaning, landscaping, manufacturing, printing, restaurant, and retail sectors. The City of Portland has a similar program. As an alternative to independently developing such programs, Denver can partner with professional organizations and industry groups to support their efforts in this type of training.

- Educate developers and Denver staff on the benefits of land management strategies such as open space/natural areas preservation and/or restoration, riparian buffer zone protection, Smart Growth, Green Development, and Low Impact Development strategies.

- Continue educational campaigns on specific measures to minimize pollution at its source. These efforts will include a multi-faceted approach directed to the public, Denver staff and elected officials, and neighboring communities.

16. Based on an initial reconnaissance level evaluation (as described in Chapter 8), there are promising opportunities for regional water quality BMPs, including large retention basins and wetlands, that could reduce impacts to downstream receiving waters. Methods to finance the development and maintenance of these facilities are urgently needed. In addition, Denver will proceed with more detailed citywide planning to identify and prioritize regional BMP alternatives. As a part of any regional facility evaluation, it will be important to clearly define under what circumstances a developer can have their requirement for onsite water quality treatment waived (e.g., paying a fee-in-lieu-of treatment) due to regional treatment facilities.

17. Closely related to regional water quality facilities is the need to conduct a watershed-by-watershed evaluation of current stream and lake conditions, including steps that are necessary to improve the status quo. The purpose of such an evaluation is to identify watershed-specific goals, priorities, data gaps and practicable mitigation measures that could be developed to strategically improve conditions. It is logical to focus initially on 303(d)-listed streams (i.e., those that are considered by to be "impaired" for one or more pollutants) and to work closely with existing efforts such as those of South Platte CURE, the Barr-Milton Watershed Group, and Denver Public Works and Environmental Health.

18. Denver will continue to monitor approaches used throughout the country related to stormwater and watershed management. Lessons learned from case studies evaluated in this Plan will be kept in mind during decision-making and planning for Denver. Examples of common themes from communities with advanced stormwater programs include:

    - Comprehensive approaches are being used to address drainage, flooding, erosion, aquatic life, native habitat, and water quality in an integrated manner.

    - Watershed-based approaches are being used for planning and problem solving.

    - Geographic Information System (GIS) tools are being used effectively to prioritize stormwater improvements and to more effectively communicate to citizens, staff, and developers.

    - Storm runoff volume reduction practices are being used in many of these communities. These practices include a variety of runoff reduction techniques such as grass buffers and swales, green roofs, and other landscape-based approaches.

- The importance of sound long-term maintenance of BMPs is widely recognized, as is the need to provide pubic safety at drainage facilities.

- Strong public education and outreach campaigns in combination with extensive web sites are substantive components of these programs. Education is being aggressively used as a key strategy to improve runoff quality.

- Significant financial investments, often measured in millions of dollars, have been required for many communities to conduct their stormwater quality planning efforts. These communities recognize that comparable future expenditures will be required to implement their plans, and are implementing suitable methods of financing.

19. Because the water quality challenges facing Denver will require significant funding, new and potentially innovative financing strategies that capitalize on public/private partnerships will be investigated.

Although this Plan provides a solid framework and foundation for effective stormwater quality management in Denver, a follow-up implementation plan and schedule are needed to ensure that the principles and practices set forth in this Plan are implemented throughout Denver. An initial Implementation Plan is outlined in the following section.

IMPLEMENTATION PLAN

As a result of extensive review of this Plan by both the Denver Advisory Committee and an Outside Review Committee, the need for an implementation plan identifying how the recommendations of this Plan would be implemented was identified as a top priority. In Exhibit 9.1, recommendations from this Plan have been tabulated along with identification of responsible party, timeframe, and level of financial investment by Denver. This implementation plan can be considered a "road map" for Denver to manage stormwater quality in the future. It is anticipated that this initial framework will be revised periodically.

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EXHIBIT 9.1
IMPLEMENTATION PLAN FOR DENVER WATER QUALITY MANAGEMENT PLAN ACTION ITEMS

ACTION ITEM	DESCRIPTION	TIMEFRAME	LEAD DEPARTMENT	APPROXIMATE FUNDING LEVEL
1. Update Denver's *Storm Drainage Criteria Manual* to reflect the policies and guidelines of this Plan.	Integrate the policies and strategies identified in this Plan into the Denver *Storm Drainage Criteria Manual*. Representative topics include integration of water quality/quantity management, BMP maintenance, consideration of regional facilities, and policies regarding multiple use facilities and new BMPs.	2005	Public Works Engineering Division	$80-100,000 (Contract)
2. Update Denver's *Stormwater Quality Control Plans, An Information Guide* to reflect the policies of this Plan with specific emphasis on maintenance plans for BMPs.	Currently, the Information Guide has no requirements for long-term maintenance plans for BMPs. The guide should be expanded to require the developer to clearly outline maintenance requirements for the facility.	2005	Public Works: Engineering and Wastewater Management	$15-30,000 (Contract)
3. Update or expand Denver's Easement and Indemnity Agreement to provide specific language regarding maintenance of BMPs.	Denver's current agreement should be revised to provide specific legally binding provisions with regard to BMP maintenance in accordance with the recommendations of Chapter 6 and Appendix D. Alternatively, a separate agreement can be developed focusing solely on maintenance.	2005	Public Works and City Attorney's Office	To Be Determined
4. Update Denver's web site to enable easier public access to stormwater and water-quality-related information.	Currently, Denver's web site provides only limited information to the public on stormwater quality and water quality management. The web site could be updated to contain more information already developed by Denver and to consolidate drainage and water-quality-related planning documents.	2005	Public Works and Communications Department	To Be Determined

EXHIBIT 9.1 IMPLEMENTATION PLAN FOR DENVER WATER QUALITY MANAGEMENT PLAN ACTION ITEMS				
ACTION ITEM	DESCRIPTION	TIMEFRAME	LEAD DEPARTMENT	APPROXIMATE FUNDING LEVEL
5. Increase interdepartmental awareness of the policies and strategies in this Plan.	This can be accomplished by two avenues: 1) presenting the information to related departments such as Community Planning and Development and Parks and Recreation through PowerPoint presentations; and/or 2) developing a condensed, full-color, graphically appealing version of the document for broader distribution. These presentations would emphasize the importance of planning for stormwater management early in the development review process and the necessity of these policies applying to Denver's internal projects.	2005	Public Works Wastewater Management Division	To Be Determined
6.1 Evaluate regional BMP facility opportunities in more detail with regard to cost and practicality.	This Plan identifies multiple potential opportunities for regional BMPs; however, it was beyond to the scope of this document to systematically evaluate these in detail. Regional facilities have significant potential for stormwater quality management, but require detailed and thorough planning and financial arrangements to be effective.	2005-2006	Public Works Wastewater Management Division and Community Planning and Development	$50-100,000 (Contract)
6.2 Evaluate and develop acceptable funding strategies for regional BMPs, including the feasibility of public-private partnerships.	In the event that regional facilities are deemed feasible for various locations in Denver, Denver needs to have a policy and financing strategy in place for these facilities. Basic research of how other communities have financed these facilities would be beneficial, followed by adaptation of these strategies to fit Denver. An example is the "fee-in-lieu-of" approach.		Public Works Wastewater Management Division and Community Planning and Development	To Be Determined

EXHIBIT 9.1 IMPLEMENTATION PLAN FOR DENVER WATER QUALITY MANAGEMENT PLAN ACTION ITEMS				
ACTION ITEM	**DESCRIPTION**	**TIMEFRAME**	**LEAD DEPARTMENT**	**APPROXIMATE FUNDING LEVEL**
7. Conduct watershed-by-watershed assessments to better characterize the water quality issues facing Denver for the purpose of tailoring specific mitigation strategies to actual watershed issues.	Building upon and integrating with efforts already underway by regional watershed groups, Denver's Department of Environmental Health, Public Works Wastewater Management Division, the Joint Stormwater Task Force, Urban Drainage and Flood Control District and others, inventory available instream biological, chemical and physical data to better target watershed priorities and solutions. A considerable database already exists, but would benefit from integration into a GIS-based system. This type of assessment would form the basis of developing specific watershed goals where none have been developed, and promote better understanding in areas where goals have already been developed. This task should interface with Task 6.1 relating to identification of regional facilities. A three-phase program is envisioned that 1) inventories available information; 2) develops targeted strategies to address specific watershed concerns and/or fills data gaps; and 3) implements recommended strategies.	2005-Phase 1 2006-Phase 2 2007-Phase 3 (and into the future)	Public Works Wastewater Management Division and Environmental Health Coordination with existing watershed groups and Urban Drainage and Flood Control District will be essential.	To Be Determined
8. Continue to educate the general public and specific industry groups on stormwater quality issues.	This is an on-going program under Denver's stormwater permit and the Wastewater Management Division. It is important that these activities continue and that Denver integrate with independent industry training programs where appropriate (e.g., builders).	On-going	Public Works Wastewater Management Division	On-going Denver Program

EXHIBIT 9.1 IMPLEMENTATION PLAN FOR DENVER WATER QUALITY MANAGEMENT PLAN ACTION ITEMS				
ACTION ITEM	DESCRIPTION	TIMEFRAME	LEAD DEPARTMENT	APPROXIMATE FUNDING LEVEL
9. Pilot testing of innovative BMPs.	This Plan describes several innovative stormwater quality management strategies including green roofs, porous landscape detention, Low Impact Development strategies and others. Denver should partner with Urban Drainage and Flood Control District in pilot tests of these BMPs, as the opportunity arises.		Public Works Wastewater Management Division and Urban Drainage and Flood Control District	Variable
10. Provide additional education on BMP maintenance requirements to private owners of stormwater BMPs.	Given the many BMPs already in place in Denver, owners of privately owned facilities would benefit from easy-to-understand guidance regarding maintenance of BMPs. A brochure or short manual based on the maintenance guidelines in the Plan could be distributed to facilitate improved BMP maintenance. For example, a brochure could be developed for the Clear Choices for Clean Water series through the Joint Task Force with the reader directed to Denver's web site for more detailed guidance.	2005	Public Works Wastewater Management Division and Joint Stormwater Task Force	To Be Determined
11. Implement recommendations of comprehensive utility review.	A URS-led team of consultants will complete a four-report comprehensive utility review. Report 1 will be a utility assessment program and definition study. Report 2 will be a utility management, administration and organizational study. Report 3 will be a cost of service study, and Report 4 will be an integrated waste management feasibility study.	2005	Public Works Wastewater Management Division	To Be Determined

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GLOSSARY[1]

Antidegradation Requirements: Requirements that ensure protection of water quality for a particular water body where the water quality exceeds levels necessary to protect fish and wildlife propagation, and recreation on and in the water. This also includes special protection of waters designated as outstanding natural resource waters. Antidegradation plans are adopted by each state to minimize adverse effects on water.

Basin: A hydrologic unit consisting of a part of the surface of the earth covered by a drainage system consisting of a surface stream or body of impounded surface water plus all tributaries.

Best Available Technology Economically Achievable (BAT): Technology-based standard established by the Clean Water Act (CWA) as the most appropriate means available on a national basis for controlling the direct discharge of toxic and non-conventional pollutants to navigable waters. BAT effluent limitation guidelines, in general, represent the best existing performance of treatment technologies that are economically achievable within an industrial point source category or subcategory.

Best Available Technology/Best Control Technology (BAT/BCT): A level of technology based on the very best (state-of-the-art) control and treatment measures that have been developed or are capable of being developed and that are economically achievable within the appropriate industrial category.

Best Conventional Pollutant Control Technology (BCT): Technology-based standard for discharges from existing industrial point sources of conventional pollutants including BOD, TSS, fecal coliform, pH, oil and grease. The BCT is established in light of a two-part "cost reasonableness" test which compares the cost for an industry to reduce its pollutant discharge with the cost to a POTW for similar levels of reduction of a pollutant loading. The second test examines the cost-effectiveness of additional industrial treatment beyond BPT. EPA must find limits which are reasonable under both tests before establishing them as BCT.

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[1] Definitions in this glossary have been compiled from several key references and websites including: Denver Wastewater Management Division Rules and Regulations http://www.denvergov.org/admin/template3/forms/Sewer%20charges.PDF, Urban Drainage and Flood Control District, Volume 3 http://www.udfcd.org/usdcm/vol3.htm, Blueprint Denver Glossary http://www.denvergov.org/admin/template3/forms/BD_glossary.pdf, CWQCD http://www.cdphe.state.co.us/wq/, Utah APWA http://www.ulct.org/apwa/Glossary.htm, USGS website, Stormwater Magazine Glossary: http://www.forester.net/sw_glossary.html, EPA website glossaries http://www.epa.gov/ednnrmrl/main/gloss.htm and http://cfpub.epa.gov/npdes/glossary.cfm?program_id=0, the Low Impact Development website: http://www.lowimpactdevelopment.org/school/glossary.html, the Maryland website http://www.mde.state.md.us/assets/document/sedimentstormwater/Glossary.pdf, and the NRDC website http://www.nrdc.org/water/pollution/storm/gloss.asp.

Best Management Practices (BMPs): Schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States. BMPs also include but are not limited to treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or wastewater disposal, or drainage from raw material storage.

Better Site Design: A collection of site planning, design, and development strategies that help reduce adverse impacts to the natural environment by recreating, to a certain extent, the original hydrology and plant community of the predevelopment site.

Biofilter: Dense vegetation designed to filter stormwater runoff as it passes through. (Also see definition of Grass Buffer and Grass Swale.)

Bioretention: Also known as Rain Garden, Bio-Filter and a LID BMP. On-lot retention of stormwater through the use of vegetated depressions engineered to collect, store, and infiltrate runoff.

BMP: Best Management Practice. (See definition above.)

Brownfield: According to the Environmental Protection Agency, a brownfield is an abandoned, idled, or under-used industrial or commercial facility where expansion or redevelopment is complicated by real or perceived environmental contamination.

Buffer Strip: Strips of grass or other erosion resistant vegetation located between a waterway and an area of more intensive land use. (Also see definition of Grass Buffer.)

Buffer Zone: A designated transitional area around a stream, lake, or wetland left in a natural, usually vegetated state so as to protect the waterbody from runoff pollution. Development is often restricted or prohibited in a buffer zone.

Catch Basin: An entryway to the storm drain system, usually located at a street corner.

CDPS: See Colorado Discharge Permit System.

Channel Stabilization: Erosion prevention and stabilization of velocity distribution in channel using jetties, drops, revetments, structural linings, vegetation, and other measures.

Clean Water Act: Legislation that provides statutory authority for the NPDES program; Public law 92-500; 33 U.S.C. 1251 et seq. Also known as the Federal Water Pollution Control Act.

Cluster Development: Buildings concentrated in specific areas to minimize infrastructure and development costs while achieving the allowable density. This approach allows the preservation of natural open space for recreation, common open space, and preservation of environmentally sensitive features.

Colorado Discharge Permit System: The State of Colorado's system of permitting discharges (e.g., stormwater, wastewater) to Waters of the State that corresponds to the federal

National Pollutant Discharge Elimination System (NPDES) permits under the federal Clean Water Law.

Combined Detention Basin: A detention basin that performs both water quality and flood control functions.

Constructed Wetland Basin: A constructed wetland basin is appropriate for large catchments and is a shallow retention pond which requires a perennial supply of water to permit the growth of rushes, willows, cattails, and reeds. It treats runoff by slowing it down to allow time for settling and biological uptake.

Cubic Feet Per Second (cfs): A rate of flow that is equal to a volume of water one foot high and one foot wide flowing a distance of one foot in one second. One "cfs" is equal to 7.48 gallons of water flowing each second. As an example, if a car's gas tank is 2 feet by 1 foot by 1 foot (2 cubic feet), then gas flowing at a rate of 1 cubic foot/second would fill the tank in two seconds.

Culvert: A short, closed (covered) conduit or pipe that passes stormwater runoff under an embankment, usually a roadway.

Design Storm: A rainfall event of specific size, intensity, and return frequency (e.g., the 1-year storm) that is used to calculate runoff volume and peak discharge rate.

Detention: The storage and slow release of stormwater from an excavated pond, enclosed depression, or tank. Detention is used for pollutant removal, stormwater storage, and peak flow reduction. Both wet and dry detention methods can be applied.

Effective Imperviousness: The total imperviousness of a site is the weighted average of individual areas of like imperviousness. For instance, paved streets (and parking lots) have an imperviousness of 100 percent; drives and walks have an imperviousness of 96 percent; roofs have an imperviousness of 90 percent; and lawn areas have an imperviousness of 0 percent. The total imperviousness of a site can be determined taking an area-weighted average of the imperviousness of the street, walk, roof, and lawn areas.

End-of-Pipe System: Any device and/or treatment system applied to stormwater, combined wastewater, municipal wastewater and/or industrial wastewater at the outlet of a collection system prior to a receiving water body. The majority of wastewater treatment systems including sanitary and combined wastewater treatment plants and many stormwater treatment schemes such as detention basins are end-of-pipe systems.

Erosion: When land is diminished or worn away due to wind, water, or glacial ice. Often the eroded debris (silt or sediment) becomes a pollutant via stormwater runoff. Erosion occurs naturally, but can be intensified by land clearing activities that remove established vegetation such as farming, development, road building, and timber harvesting.

Eutrophication: Excessive levels of phosphorous, nitrogen, and nutrients in the water, which leads to a decrease in oxygen levels. Often characterized by excessive growth of algae and aquatic vegetation, often resulting in deteriorated water quality and beach closings.

Event Mean Concentration (EMC): A method for characterizing pollutant concentrations in a receiving water from a runoff event often chosen for its practicality. The value is determined by compositing (in proportion to flow rate) a set of samples, taken at various points in time during a runoff event, into a single sample for analysis.

Extended Detention Basin: An extended detention basin is appropriate for larger sites and is designed to totally empty out sometime after stormwater runoff ends. The extended basin uses a much smaller outlet than a flood control detention basin which extends the emptying time for the more frequently occurring runoff events to facilitate pollutant removal.

Fecal Coliform: Bacteria found only in the intestinal tracts of humans and animals. The major sources are animal waste, waste treatment plants, and failing septic systems. The presence of these bacteria typically indicates pollution that may pose a potential health risk.

Filter Strip: Grassed strips situated along roads or parking areas that remove pollutants from runoff as it passes through, allowing some infiltration and reduction of velocity.

First Flush: The condition, often occurring in storm-sewer discharges, in which a disproportionately high pollutant load is carried in the first portion of the discharge or overflow.

Flow Control Structure: A structure, such as an outlet of a detention basin, that is designed to produce a specific rate of runoff in the outflow of a stormwater management facility, generally with the intent of reducing peak runoff rates from developed areas, and, for treatment BMPs, to provide an extended drain time for settling of particulates.

Forebay: Storage space located near a stormwater BMP inlet that serves to trap incoming coarse sediments before they accumulate in the main treatment area.

Geographic Information System (GIS): A database of digital information and data on land-use, land cover, ecological characteristics, and other geographic attributes that can be overlaid, statistically analyzed, mathematically manipulated, and graphically displayed using maps, charts, and graphs.

Grading: Stripping, excavating, filling and/or stockpiling soil to shape land area for development or other purposes.

Grass Buffer: Uniformly graded and densely vegetated area of turf grass. This BMP requires sheet flow to promote filtration, infiltration, and settling to reduce runoff pollutants.

Grass Swale: Densely vegetated drainageway with low-pitched side slopes that collects and slowly conveys runoff. Design of longitudinal slope and cross-section size forces the flow to be slow and shallow, thereby facilitating sedimentation while limiting erosion.

Green Roof: A vegetated roof that can be used to treat precipitation and/or provide detention. Green roofs require an engineered structure that can support soils, vegetation and loads associated with rainfall, snow, people and equipment. Key components include a waterproof membrane, root barrier, drainage layer, soil/growing medium, irrigation system and plants.

Greenway: A linear open space or corridor composed of native vegetation. Greenways can be used to create connected networks of open space that include traditional parks and natural areas.

Hot Spot: Area where land use or activities generate highly contaminated runoff with concentrations of pollutants in excess of those typically found in stormwater.

Household Hazardous Waste: Common everyday products that people use in and around their homes—including paint, paint thinner and pesticides—that, due to their chemical nature, can be hazardous if not properly disposed.

Hydrodynamic Structure: An engineered structure using gravitational separation and/or hydraulic flow to separate sediments and oils from stormwater runoff.

Hydrology: The science addressing the properties, distribution, and circulation of water across the landscape, through the ground, and in the atmosphere.

Illicit Connection: Any discharge to a municipal separate storm sewer that is not composed entirely of stormwater and is not authorized by an NPDES permit, with some exceptions (e.g., discharges due to fire-fighting activities).

Integrated Management Practice (IMP): A Low Impact Development (LID) practice or combination of practices that are the most effective and practicable (including technological, economic, and institutional considerations) means of controlling the predevelopment site hydrology.

Impervious Area: A hard surface area (e.g., parking lot or rooftop) that prevents or retards the entry of water into the soil, thus causing water to run off the surface in greater quantities and at an increased rate of flow.

Infill Development: Development of vacant lots or enhancement of existing urban properties.

Infiltration: The process or rate at which water percolates from the land surface into the ground. Infiltration is also a general category of BMP designed to collect runoff and allow it to flow through the ground for treatment.

Inlet: An entrance into a ditch, storm sewer, or other waterway.

In-Line Storage: The use of a portion of the volume of a storm sewer or drain, combined sewer and/or interceptor sewer system that is not being used to transport combined wastewater or stormwater to accommodate the storage of additional stormwater runoff or combined wastewater. This term also applies to a storage facility, such as a tank, basin, or other reservoir, which is connected to a sewer system in such a way that all flow in the system passes through the storage facility. In the latter usage, inline storage is differentiated from offline storage which is connected in such a way that excess flow can be diverted to the storage facility, but normal flows bypass the facility. (Also see Off-Line Storage.)

Integrated Pest Management (IPM): The practice of using biological, chemical, cultural, and physical measures to manage pests while minimizing or eliminating the use of chemical pesticides.

Level Spreader: An outlet designed to convert concentrated runoff to sheet flow and disperse it uniformly across a slope, thereby preventing/minimizing erosion.

Low Impact Development: The integration of a site's ecological and environmental goals and requirements into all phases of urban planning and design from the individual residential lot level to the entire watershed. Also see Smart Growth, Minimizing Directly Connected Impervious Area, Sustainable Urban Drainage Systems.

Macroinvertebrate: An organism is visible without magnification and that lacks a backbone. Examples include snails, worms, fly larvae, and crayfish.

Maximum Extent Practicable (MEP): A standard for water quality that applies to all MS4 operators regulated under the NPDES program. Since no precise definition of MEP exists, it allows for maximum flexibility on the part of MS4 operators as they develop and implement their programs.

Media Filter: A filter containing sand, compost, sand peat, or perlite and zeolite designed to filter constituents (particulates, oil, bacteria, or dissolved metals) out of stormwater runoff as it passes through the filter. (Also see Sand Filter Extended Detention Basin.)

Micropool: A smaller permanent pool incorporated into the design of larger stormwater ponds to avoid resuspension of particles and minimize impacts to adjacent natural features.

Milligrams Per Liter (mg/L): A unit of concentration of a constituent in water or wastewater. It represents 0.001 gram of a constituent in 1 liter of water and is approximately equal to one part per million (PPM).

Minimizing Directly Connected Impervious Areas (MDCIA): A variety of runoff reduction strategies based on reducing impervious areas and routing runoff from impervious surfaces over grassy areas to slow down runoff and promote infiltration. The benefits are less runoff, less stormwater pollution, and less cost for drainage infrastructure. Also see Smart Growth and Low Impact Development.

Minimum Measures: Stormwater management programs required under the CDPS MS4 permit. They include public education and outreach, public participation/involvement, illicit discharge detection and elimination, construction site stormwater runoff control, post-construction stormwater management, and pollution prevention/good housekeeping for municipal operations.

Modular Block Porous Pavement: Modular block porous pavement consists of open void concrete slab units underlain with gravel. The surface voids are filled with sand. This BMP is intended to be used in low traffic areas to accommodate vehicles while facilitating stormwater infiltration near its source. A variation of this BMP is termed stabilized-grass porous pavement, consisting of plastic rings affixed to filter fabric underlain with gravel. The surface voids are filled with sand and grass sod or seed.

MS4: Municipal Separate Storm Sewer System, see below.

Municipal Separate Storm Sewer System (MS4): A publicly owned conveyance or system of conveyances that discharges to waters of the United States and is designed or used for collecting or conveying stormwater, is not a combined sewer, and is not part of a publicly owned treatment works (POTW).

Municipal Stormwater Permit: An NPDES permit issued to municipalities to regulate discharges from municipal separate storm sewers for compliance with EPA regulations.

National Pollutant Discharge Elimination System (NPDES): The national program under Section 402 of the Clean Water Act for regulation of discharges of pollutants from point sources to waters of the United States. Discharges are illegal unless authorized by an NPDES permit.

NPDES: National Pollutant Discharge Elimination System, as described above.

Non-Point Source (NPS) Pollution: Pollution discharged over a wide land area, not from one specific location. These are forms of diffuse pollution caused by sediment, nutrients, organic and toxic substances originating from land-use activities and carried to lakes and streams by surface runoff. Non-point source pollution is contamination that occurs when rainwater, snowmelt, or irrigation washes off plowed fields, city streets, or suburban backyards. As this runoff moves across the land surface, it picks up soil particles and pollutants, such as nutrients and pesticides.

Non-Structural BMPs: Stormwater runoff treatment techniques which use natural measures to reduce pollution levels, and do not require extensive construction efforts and/or promote pollutant reduction by eliminating the pollutant source.

Off-Line: A management system designed to control a storm event by diverting a percentage of stormwater events from a stream or storm drainage system.

Oil/Water Separator: A device installed (usually at the entrance to a drain) which removes oil and grease from water entering the drain.

On-Line: A management system designed to control stormwater in its original stream or drainage channel.

Open Space: Land set aside for public or private use within a development that is not built upon.

Open-Channel Flow: Fluid flow where the bottom and sides of the flow are confined by solid surfaces and the upper surface is in contact with the atmosphere and is at atmospheric pressure. Open-channel flow occurs in rivers, streams, canals, channels, swales, and ditches, and in pipes, sewers, and culverts that are less than completely full.

Outfall: The point where wastewater or drainage discharges from a sewer pipe, ditch, or other conveyance to a receiving body of water.

Peak Flow: The maximum instantaneous discharge of a stream or river at a given location. It usually occurs at or near the time of maximum stage.

Peak Runoff Rate: The highest actual or predicted flow rate (measured in cubic feet per second) for runoff from a site.

Permeability: The ability of a material to allow the passage of a liquid, such as water through rocks or soil. Permeable materials, such as gravel and sand, allow water to move quickly through them, whereas impermeable material, such as clay, does not allow water to flow freely.

Point Source Pollutant: Pollutants from a single, identifiable source such as a factory, refinery, or place of business.

Pollutant (as defined by CDPS Regulation 6.3.0 [51]): Dredged spoil, dirt, slurry, solid waste, incinerator residue, sewage, sewage sludge, garbage, trash, chemical waste, biological nutrient, biological material, radioactive material, heat, wrecked or discarded equipment, rock, sand, or any industrial, municipal or agriculture waste.

Pollutant Load: The quantity of pollutants carried in stormwater.

Porous Landscape Detention: Porous landscape detention consists of a low lying vegetated area underlain by a sand bed with an underdrain. A shallow surcharge zone exists above the porous landscape detention for temporary storage of the WQCV. This BMP allows small amounts of WQCV to be provided on parking lots or adjacent to buildings without requiring the set-aside of significant developable land areas. Also see Rain Garden.

Porous Pavement and Pavers: Alternatives to conventional asphalt that utilize a variety of porous media, often supported by a structural matrix, concrete grid, or modular pavement, which allow water to percolate though to a sub-base for gradual infiltration. See definition for Modular Block Porous Pavement.

Porous Pavement Detention: Porous pavement detention consists of modular block porous pavement that is installed flat and is provided with a two-inch-deep detention zone above its surface to temporarily store the WQCV from the tributary drainage area including its own surface. Runoff infiltrates the void spaces of the gravel base course through the sand filter and slowly exits through an underdrain.

Rain Garden: See bioretention and porous landscape detention.

Receiving Waters: Natural or man-made water systems into which materials are discharged.

Regional Transportation District (RTD): The regional public transportation agency for the six county Denver metropolitan area.

Restoration: Human activity that results in the return of an ecosystem to a close approximation of its condition prior to disturbance.

Retention Pond: A BMP consisting of a permanent pool of water designed to treat runoff by detaining water long enough for settling, filtering, and biological uptake. Wet ponds may also be designed to have an aesthetic and/or recreational value. These BMPs have a permanent pool of water that is replaced with stormwater, in part or in total, during storm runoff events. In addition, a temporary extended detention volume is provided above this permanent pool to capture storm runoff and enhance sedimentation. It requires a perennial supply of water to maintain the pool. A retention pond is appropriate for larger catchments.

Retrofit: The creation or modification of a stormwater management practice, usually in a developed area, that improves or combines treatment with existing stormwater infrastructure.

Riparian Area: Vegetated ecosystems along a waterbody through which energy, materials, and water pass. Riparian areas characteristically have a high water table and are subject to periodic flooding.

Riparian Zone: The border or banks of a stream. Although this term is sometimes used interchangeably with flood plain, the riparian zone is generally regarded as relatively narrow compared to a flood plain. The duration of flooding is generally much shorter, and the timing less predictable, in a riparian zone than in a river flood plain.

Runoff Reduction Practices: Strategies to reduce runoff peaks and volumes from urbanizing areas, employing a practice generally termed “minimizing directly connected impervious areas” (MDCIA).

Runoff: Water from rain, melted snow, or irrigation that flows over the land surface.

Sand Filter Extended Detention Basin: A sand filter extended detention basin consists of a sand bed and underdrain system. Above the vegetated sand bed is an extended detention basin sized to capture the WQCV. A sand filter extended detention basin provides pollutant removal through settling and filtering and is generally suited to off-line, on-site configurations where there is no base flow and the sediment load is relatively low.

Sanitary Sewer: A system of underground pipes that carries sanitary waste or process wastewater to a treatment plant.

Scupper: An opening in a wall through which water can drain (i.e., from the roof of a building or a landscape area)

Sediment: Soil, sand, and materials washed from land into water, usually after rain. Sediment can destroy fish-nesting areas, clog animal habitats, and cloud water so that sunlight does not reach aquatic plants.

Sheet Flow: The portion of precipitation that moves initially as overland flow in very shallow depths before eventually reaching a stream channel.

Slope: Angle of land measured in horizontal distance necessary for the land to fall or rise one foot, expressed by horizontal distance in feet to one vertical foot.

Slotted Curbs: Curbs with slots or cut-out areas that allow stormwater to flow away from the curbed pavement into an adjacent landscape or turf area. These can reduce excessive concentration of flows and associated erosion problems.

Smart Growth: Development that uses a variety of strategies to enhance existing communities and protect community character in a way that is compatible with the natural environment, as well as attracts economic development. It encourages more town-oriented, transit-focused, and pedestrian-friendly new development while restoring vitality to existing developed areas. Also see Low Impact Development.

Source Control: A method of abating storm-generated or CSO pollution at the upstream, upland source where the pollutants originate and/or accumulate.

Spill Prevention Control and Countermeasure Plan (SPCC): A plan prepared by a facility to minimize the likelihood of a spill and to expedite control and cleanup activities should a spill occur.

Storage Capacity: The volume of fluid that can be stored in a system. For storm drainage and sewerage systems, storage capacity refers to the volume available for the temporary storage of excess storm flow or wastewater flow in a pipe, channel, basin, tank, or other facility, or in the system as a whole.

Storm Drain: A slotted opening leading to an underground pipe or an open ditch from carrying surface runoff.

Storm Sewer: A sewer that carries intercepted surface runoff, street wash, and other wash waters, or drainage, but excludes domestic sewage and industrial wastes except for unauthorized cross-connections.

Stormwater Facilities: Systems such as watercourses, constructed channels, storm drains, culverts, and detention/retention facilities that are used for the conveyance and/or storage of stormwater runoff.

Stormwater Management: Functions associated with planning, designing, constructing, maintaining, financing, and regulating the facilities (both constructed and natural) that collect, store, control, and/or convey stormwater.

Stormwater Ponds: A land depression or impoundment created for the detention or retention of stormwater runoff. See definition for Retention Pond and Extended Detention Basin.

Stormwater Quality Control Plan (identified in *Stormwater Quality Control Plan, An Information Guide*): The Wastewater Management Division's guidebook which identifies the submittal requirements relating to erosion, sedimentation, and water quality issues for all development, redevelopment, and other construction projects.

Stormwater Quality Detention: The temporary storage of stormwater to provide stormwater quality treatment through the settlement of suspended solids.

Stormwater Quantity Detention: The temporary storage of stormwater on a site to provide downstream flood control through the reduction of the runoff rate to pre-development levels.

Stormwater: Precipitation that accumulates in natural and/or constructed storage and stormwater systems during and immediately following a storm event.

Streetscaping: Physical amenities added to the roadway and intersections, including lighting, trees, landscaping, art, surface textures and colors, and street furniture.

Structural BMPs: Devices that are constructed to provide temporary storage and treatment of stormwater runoff.

Sustainable Urban Drainage Systems (SUDS): A series of techniques that are designed to manage surface water runoff as close to the source as possible in a more sustainable manner than traditional drainage systems. Typical techniques include porous surfacing, permeable paving systems, infiltration/attenuation trenches and swales. Also see Low Impact Development, Smart Growth, and Minimizing Directly Connected Impervious Area.

Surface Conveyance: A means of conducting stormwater runoff aboveground rather than in underground pipes, usually involving curb and gutter, concrete V-pan, or channel.

Surface Water: Water that remains on the surface of the ground, including rivers, lakes, reservoirs, streams, wetlands, impoundments, seas, estuaries, etc.

Suspended Sediment: Very fine soil particles that remain in suspension in water for a considerable period of time without contact with the solid fluid boundary at or near the bottom. They are maintained in suspension by the upward components of turbulent currents.

Sustainable Development: Development that meets the needs of the present without compromising the ability of the future to meet its own needs. Also: Development that maximizes efficiency and functionality of systems while minimizing the consumption of precious resources.

Swale: See definition of Grass Swale.

Technology-Based Effluent Limit: Permit limit for a pollutant that is based on the capability of a treatment method to reduce the pollutant to a certain concentration.

Total Maximum Daily Load (TMDL): The maximum allowable loading of a pollutant that a designated water body can assimilate and still meet numeric and narrative water quality standards. TMDLs were established by the 1972 Clean Water Act. Section 303(d) of the US Water Quality Act requires states to identify water bodies that do not meet federal water quality standards. In 1996 the states developed (with EPA approval) a list of water bodies that failed to meet section 303(d) standards. These are the focus of TMDLs. Allocation of named pollutants is on percentage basis.

Transit-Oriented Development: Form of development that maximizes investment in transit infrastructure by concentrating the most intense types of development around transit stations to promote increased transit use.

Trash Rack: Grill, grate or other device installed at the intake of a channel, pipe, drain, or spillway for the purpose of preventing oversized debris from entering the structure.

Treatment Roof: A green roof that provides stormwater quality treatment.

Treatment Train: Best Management Practices that work together in series to provide stormwater quality treatment.

Treatment Volume: The volume of stormwater runoff from a site requiring stormwater quality treatment.

Underdrain: A perforated pipe, typically 4-6" in diameter placed longitudinally at the invert of a bioretention facility for the purposes of achieving a desired discharge rate.

Urban Design: Involves the social, economic, functional, environmental, and aesthetic objectives that result in the plan or structure of a city, in whole or in part.

Water Quality Capture Volume: The quantity of stormwater runoff that must be treated in stormwater quality BMPs in Denver. This volume is equivalent to the runoff from an 80th percentile storm, meaning that 80 percent of the most frequently occurring storms are fully captured and treated and larger events are partially treated. In simple terms, this quantity is about half of the runoff from a 2-year storm.

Waters of the State: Any and all surface and subsurface waters which are contained in or flow in or through this State, but does not include waters in sewage systems, waters in treatment works of disposal systems, and all water withdrawn for use until use and treatment have been completed.

Waters of the United States: All waters that are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters subject to the ebb and flow of the tide. Waters of the United States include all interstate waters and intrastate lakes, rivers, streams (including intermittent streams), mudflats, sand flats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds. [See 40 CFR 122.2 for the complete definition.]

Watershed: That geographical area which drains to a specified point on a water course, usually a confluence of streams or rivers (also known as drainage area, catchment, or river basin).

Wet Pond: See definition of Retention Pond.

Wet Weather Flows: Water entering storm drains during rainstorms.

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

WQCV: Water Quality Capture Volume (see definition above).

Zero-Lot-Line Development: A development option in which side yard restrictions are reduced and the building abuts a side lot line. Overall unit-lot densities are therefore increased. Zero-lot-line development can result in increased protection of natural resources, as well as reduction in requirements for roads and sidewalks.

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Appendices

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Appendix A
Colorado Water Quality Control Commission Stream Classifications and Water Quality Standards Relevant to Denver

Effective November 1, 2004

(Includes Stream Segments Either in or Adjacent to Denver's Boundaries)

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STREAM CLASSIFICATIONS and WATER QUALITY STANDARDS

REGION: 2,3 & 4 BASIN: UPPER SOUTH PLATTE RIVER Stream Segment Description	DESIG	CLASSIFICATIONS	NUMERIC STANDARDS PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS ug/l			TEMPORARY MODIFICATIONS AND QUALIFIERS
10b. Mainstem of West Plum Creek including all tributaries, lakes, reservoirs, and wetlands from its source to Perry Park Pond.		Aq Life Cold 1 Recreation 1a Water Supply Agriculture	D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E. Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 $S0_4$=WS	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
11a. All tributaries to the East Plum Creek system, including all lakes, reservoirs and wetlands which are not on national forest lands.	UP	Aq Life Warm 2 Recreation 1a Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E. Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.06 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5	As(ch)=100(Trec) Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	
11b. All tributaries to the West Plum Creek system, including all lakes, reservoirs and wetlands, which are not on national forest lands, except for specific listings in Segments 9 and 12.	UP	Aq Life Warm 2 Recreation 1a Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E. Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.06 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5	As(ch)=100(Trec) Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	
12. Mainstem of Garber Creek and Jackson Creek from the boundary of National Forest lands to the confluence with West Plum Creek.		Aq Life Cold 1 Recreation 1a Water Supply Agriculture	D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E. Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 $S0_4$=WS	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
13. Mainstem of Deer Creek, including the North and South Forks, from the source to Chatfield Reservoir.		Aq Life Cold 1 Recreation 1a Water Supply Agriculture	D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E. Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 $S0_4$=WS	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
14. Mainstem of the South Platte River from Bowles Avenue in Littleton, Colorado, to the Burlington Ditch diversion in Denver, Colorado.		Aq Life Warm 1 Recreation 1a Water Supply Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E. Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.06 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5 NO_3=10 Cl=250 $S0_4$=WS	As(ac)=50(Trec) Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS*2.8 Fe(ch)=WS(dis)	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=190(dis) Mn(ac/ch)=TVS Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	
15. Mainstem of the South Platte River from the Burlington Ditch diversion in Denver, Colorado, to a point immediately below the confluence with Big Dry Creek.	UP	Aq Life Warm 2 Recreation 1a Water Supply Agriculture	D.O.* pH = 6.5-9.0** F.Coli=200/100ml E. Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.10 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=1.0 NO_3=10 Cl=250 $S0_4$=WS	As(ac)=50(Trec) Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS*2.3 Fe(ch)=WS(dis)	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=400(dis) Mn(ac/ch)=TVS Hg(ac)=2.4(dis) Hg(ch)=0.4(dis)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	*See attached table for site-specific Dissolved Oxygen standards. **pH=6.0-9.0 from 64th Ave. downstream 2 miles. Temporary modifications: F. Coli=existing quality; E.Coli=existing quality. Expiration date of 2/28/10.
16a. Mainstem of Sand Creek from the source to the confluence with the South Platte River.	UP	Aq Life Warm 2 Recreation 1a Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E. Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.1 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5	As(ch)=100(Trec) Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS*	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac)=TVS Se(ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	Temporary modifications: Se(ch)= 19.3 μg/l Se(ac)=no acute standard. Expiration date of 2/28/10. *Cu (ac/ch) = TVS *2.6 below the Sand Creek Water Reuse Facility outfall.

STREAM CLASSIFICATIONS and WATER QUALITY STANDARDS

REGION: 2,3 & 4 BASIN: UPPER SOUTH PLATTE RIVER	DESIG	CLASSIFICATIONS	NUMERIC STANDARDS						TEMPORARY MODIFICATIONS AND QUALIFIERS
			PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS ug/l			
16b. Aurora Reservoir.		Aq Life Warm 1 Recreation 1a Water Supply Agriculture	D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 F.Coli=200/100m E. Coli=126l/100ml	NH_3(ac)=TVS NH_3(ch)=0.06 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
16c. All tributaries to the South Platte River, including all lakes, reservoirs and wetlands, from the outlet of Chatfield Reservoir, to a point immediately below the confluence with Big Dry Creek, except for specific listings in the subbasins of the South Platte River, and in Segments 16a, 16b, 16d, 16e, 16f, 16g, 17a, 17b, and 17c.	UP	Aq Life Warm 2 Recreation 1a Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E. Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.06 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5	As(ch)=100(Trec) Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	Fish Ingestion Organics Temporary modifications: East & West Toll Gate Creeks, Toll Gate Creek Se(ch)=18μg/l(dis), Se(ac)=no acute standard. Expiration date of 2/28/10.
16d. Second Creek from the source to the O'Brian Canal.	UP	Aq Life Warm 2 Recreation 1a Agriculture	D.O. (ch)=3.3 mg/l[1] pH=6.5-9.0 F.Coli=200/100ml E. Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.06 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5	As(ch)=100(Trec) Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	1 15th percentile of D.O. measurements collected between 6:30 a.m. and 6:30 p.m.
16e. Third Creek from the source to the O'Brian Canal.	UP	Aq Life Warm 2 Recreation 1a Agriculture	D.O. (ch)=4.0 mg/l[1] pH=6.5-9.0 F.Coli=200/100ml E. Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.06 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5	As(ch)=100(Trec) Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	1 15th percentile of D.O. measurements collected between 6:30 a.m. and 6:30 p.m.
16f. Barr Lake Tributary from the source to the Denver Hudson Canal.	UP	Aq Life Warm 2 Recreation 1a Agriculture	D.O. (ch)= [1] pH=6.5-9.0 F.Coli=200/100ml E. Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.06 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5	As(ch)=100(Trec) Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	1 When water is present, D.O. concentrations shall be maintained at levels that protect classified uses.
16g. Marcy Gulch from, including all lakes, reservoirs, and wetlands from the source to the confluence with the South Platte.	UP	Aq Life Warm 2 Recreation 1a Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E. Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.06 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5	As(ch)=100(Trec) Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS*	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	*Cu (ac/ch) = TVS *2.4 below the Centennial Wastewater Treatment Facility outfall
17a. Washington Park Lakes, City Park Lake, Rocky Mountain Lake, Berkely Lake.	UP	Aq Life Warm 1 Recreation 1a Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E.Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.06 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5	As(ch)=100(Trec) Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	
17b. Sloan's Lake.		Aq Life Warm 1 Recreation 1a Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E.Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.06 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5	As(ch)=100(Trec) Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	
17c. Bowles Lake, a.k.a. Patrick Reservoir or Bow Mar Lake.		Aq Life Warm 1 Recreation 1a Agriculture	D.O.=5.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E.Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.06 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5	Al(ac/ch)=TVS As(ch)=100(Trec) Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	

UPPER SOUTH PLATTE RIVER SEGMENT 15
Site-Specific Minimum Dissolved Oxygen Standards

UNDERLYING STANDARDS

Early Life Stage Protection Period (April 1 through July 31)

1-Day[1,5,6]	3.0 mg/L (acute)
7-Day Average [1.2.,4]	5.0 mg/L

Older Life Stage Protection Period (August 1 through March 31)

1-Day [1,5]	2.0 mg/L (acute)
7-Day Mean of Minimums[1,3]	2.5 mg/L
30-Day Average [1.2.]	4.5 mg/L

TEMPORARY MODIFICATION

During the period until October 31, 2001, the Segment 15 dissolved oxygen standards from 88th Avenue north to the end of the Segment shall be the currently existing ambient conditions as monitored in 1992, 1993, and 1994 by the Division and by the Metro District. Beginning November 1, 2001, the standards shall apply to all sections of Segment 15 south of the Brighton Ditch diversion. The standards north of the Brighton Ditch diversion shall continue to be the ambient conditions existing in 1992, 1993, and 1994. Beginning November 1, 2004, the standards shall apply to all sections of Segment 15.

Footnotes

1. For the purposes of determining compliance with the standards, dissolved oxygen measurements shall only be taken in the flowing portion of the stream at mid-depth, and at least six inches above the bottom of the channel. All sampling protocols and test procedures shall be in accordance with procedures and protocols approved by the Division.

2. A minimum of four independent daily means must be used to calculate the average for the 7-Day Average standard. A minimum of eight independent daily means must be used to calculate the average for the 30-Day Average standard. The four days and the eight days must be representative of the 7-Day and the 30-Day periods respectively. The daily means shall be the mean of the daily high and low values. In calculating the mean values, the dissolved oxygen saturation value shall be used in place of any dissolved oxygen measurements which exceed saturation.

3. The 7-Day Mean minimum is the average of the daily minimums measured at the location on each day during any 7-Day period.

[4] North of the Lupton Bottoms Ditch diversion, the ELS 7-Day average standards for the period July 1 – June 31 shall be 4.6 mg/L.

[5.] During a 24 hour day dissolved oxygen levels are likely to be lower during the nighttime when there is no photosynthesis. The dissolved oxygen levels should not drop below the acute standard (ELS acute standard of 3.0 mg/L or the OLS standards of 2.0 mg/L). However, if during the ELS period multiple measurements are below 3.0 mg/L during the same nighttime period, the multiple measurements shall be considered a single exceedance of the acute standard. For measurements below 2.0 mg/L during either the ELS or the OLS periods, each hourly measurement below 2.0 mg/L shall be considered an exceedance of the acute standards.

[6.] In July, the dissolved oxygen level in Segment 15 may be lower than the 3.0 mg/L acute standard for up to 14 exceedances in any one year and up to a total of 21 exceedances in three years before there is a determination that the acute dissolved oxygen standards is not being met. Exceedances shall be counted as described in Footnote 5.

STREAM CLASSIFICATIONS and WATER QUALITY STANDARDS

REGION: 3 AND 4 BASIN: CHERRY CREEK	DESIG	CLASSIFICATIONS	NUMERIC STANDARDS						TEMPORARY MODIFICATIONS AND QUALIFIERS
Stream Segment Description			PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS ug/l			
1. Mainstem of Cherry Creek from the source of East and West Cherry Creek to the inlet of Cherry Creek Reservoir.	UP	Aq Life Warm 2 Recreation 1a Water Supply Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E.Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.06 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5 NO_3=10 Cl=250 SO_4=WS	As(ac)=50(Trec) Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS Fe(ch)=WS(dis)	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	
2. Cherry Creek Reservoir.		Aq Life Warm 1 Recreation 1a Water Supply Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E.Coli=126/100ml Season mean chlorophyll a = 15 μg/l measured in the upper three meters of the water column for the months of July through September	NH_3(ac)=TVS NH_3(ch)=0.06 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5 NO_3=10 Cl=250 SO_4=WS	As(ac)=50(Trec) Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	
3. Mainstem of Cherry Creek from the outlet of Cherry Creek Reservoir to the confluence with the South Platte River.	UP	Aq Life Warm 2 Recreation 1a Water Supply Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E.Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.10 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5 NO_3=10 Cl=250 SO_4=WS	As(ac)=50(Trec) Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS Fe(ch)=WS(dis)	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	
4. All tributaries to Cherry Creek, including all lakes, reservoirs and wetlands, from the source of East and West Cherry Creeks to the confluence with the South Platte River, except for specific listings in Segment 2.	UP	Aq Life Warm 2 Recreation 1a Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E.Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.10 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5	As(ch)=100(Trec) Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	

STREAM CLASSIFICATIONS and WATER QUALITY STANDARDS

REGION: 3 BASIN: CLEAR CREEK Stream Segment Description	DESIG	CLASSIFICATIONS	NUMERIC STANDARDS PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS ug/l			TEMPORARY MODIFICATIONS AND QUALIFIERS
15. Mainstem of Clear Creek from Youngfield Street in Wheat Ridge, Colorado, to the confluence with the South Platte River.	UP	Aq Life Warm 1 Recreation 1a Water Supply Agriculture	D.O.=5.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml E.Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.06 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5 NO_3=10 Cl=250 SO_4=WS	As(ac)=50(Trec) Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVSx3.66*	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Trec)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVSx1.57*	Aquatic life warm 1 goal qualifier. Temporary modification: E.Coli=261/100 ml. Expiration date of 2/28/10.
16a. Mainstem of Lena Gulch including all tributaries, lakes, reservoirs and wetlands from its source to the outlet of Maple Grove Reservoir.	UP	Aq Life Warm 2 Recreation 1a Water Supply Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E.Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.10 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS	As(ac)=50(Trec) Cd(ac)=TVS Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	
16b. All tributaries to Clear Creek from the Farmers Highline Canal diversion in Golden, Colorado to the confluence with the South Platte River, except for specific listings in Segments 16a, 17a, 17b, 18a and 18b.	UP	Aq Life Warm 2 Recreation 2 Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=2000/100ml E.Coli=630/100ml	NH_3(ac)=TVS NH_3(ch)=0.10 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5	As(ch)=100(Trec) Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	
17a. Arvada Reservoir.	UP	Aq Life Cold 2 Recreation 2 Water Supply Agriculture	D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E.Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	Water + Fish Organics
17b. Mainstem of Ralston Creek from the source to the inlet of Arvada Reservoir, including Ralston Reservoir, and Upper Long Lake.	UP	Aq Life Cold 2 Recreation 1a Water Supply Agriculture	D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 F.Coli-200/100ml E.Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	Water + Fish Organics
18a. Mainstem of Ralston Creek, including all lakes and reservoirs, from the outlet of Arvada Reservoir to the confluence with Clear Creek.	UP	Aq Life Warm 2 Recreation 1a Water Supply Agriculture	D.O. = 5.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml E.Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.10 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5 NO_3=10 Cl=250 SO_4=WS	As(ac)=50(Trec) Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	
18b. Mainstem of Leyden Creek and Van Bibber Creek from their source to their confluence with Ralston Creek. Mainstem of Little Dry Creek from its source to its confluence with Clear Creek.	UP	Aq Life Warm 2 Recreation 2 Water Supply Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=2000/100ml E.Coli=630/100ml	NH_3(ac)=TVS NH_3(ch)=0.10 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5 NO_3=10 Cl=250 SO_4=WS	As(ac)=50(Trec) Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	
19. All tributaries to Clear Creek, including lakes, reservoirs and wetlands, within the Mt. Evans Wilderness Area.	OW	Aq Life Cold 1 Recreation 1a Water Supply Agriculture	D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E.Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	

* TVS x (times) the FWER (final water effect ratio) = site-specific standard.

REGION: 2	DESIG	CLASSIFICATIONS	NUMERIC STANDARDS						TEMPORARY MODIFICATIONS AND QUALIFIERS
BASIN: MIDDLE SOUTH PLATTE RIVER			PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS Ug/l			
Stream Segment Description									
1a. Mainstem of the South Platte River from a point immediately below the confluence with Big Dry Creek to the confluence with St. Vrain Creek.	UP	Aq Life Warm 2 Recreation 1a Water Supply Agriculture	D.O.* pH=6.5-9.0 F.Coli=200/100ml E.Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.10 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5 NO_3=10 Cl=250 SO_4=WS	As(ac)=50(Trec) Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS*2.2	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	*See attached table for site-specific Dissolved Oxygen standards. Fish Ingestion Organics
1b. Mainstem of the South Platte River from a point immediately below the confluence with St. Vrain Creek to the Weld/Morgan County Line.	UP	Aq Life Warm 2 Recreation 1a Water Supply Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E.Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.10 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5 NO_3=10 Cl=250 SO_4=WS	As(ac)=50(Trec) Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	Fish Ingestion Organics Temporary modification: NH_3(ch)=0.12 mg/l below confluence with Cache La Poudre River. Expiration date of 2/28/10.
2. Deleted.									
3a. All tributaries to the South Platte River, including all lakes, reservoirs and wetlands, from a point immediately below the confluence with Big Dry Creek to the Weld/Morgan County line, except for specific listings in the subbasins of the South Platte River, and in Segments 3b, 4, 5a, 5b, 5c, and 6.	UP	Aq Life Warm 2 Recreation 1a Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E.Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.10 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5	As(ch)=100(Trec) Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	Fish Ingestion Organics
3b. Hayesmount Tributaries including the Upper Hayesmount Tributary from the source to the confluence with Box Elder Creek and the Lower Hayesmount Tributaries from the source to the Denver Hudson Canal.	UP	Aq Life Warm 2 Recreation 1a Agriculture	D.O. (ch)=[1] pH=6.5-9.0 F.Coli=200/100ml E.Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.10 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5	As(ch)=100(Trec) Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	[1] When water is present, D.O. concentrations shall be maintained at levels that protect classified uses.
4. Barr Lake and Milton Reservoir.	UP	Aq Life Warm 2 Recreation 1a Water Supply Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E.Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.10 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5 NO_3=10 Cl=250 SO_4=WS	As(ac)=50(Trec) Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	Fish Ingestion Organics
5a. Mainstems of Lone Tree Creek, Crow Creek and Boxelder Creek from their sources to their confluences with the South Platte River, except for specific listings in Segment 5b.	UP	Aq Life Warm 2 Recreation 2 Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=2000/100ml E.Coli=630/100ml	NH_3(ac)=TVS NH_3(ch)=0.10 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5	As(ch)=100(Trec) Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	Temporary modification: Lone Tree Creek NH_3(ch)=0.26 mg/l. Expiration date of 2/28/10.
5b. Mainstem of Boxelder Creek from the confluence with Coyote Run to the Denver Hudson Canal.	UP	Aq Life Warm 2 Recreation 2 Agriculture	D.O. (ch)=4.7 mg/l[1] pH=6.5-9.0 F.Coli=2000/100ml E.Coli=630/100ml	NH_3(ac)=TVS NH_3(ch)=0.10 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=10 NO_3=100	As(ch)=100(Trec) Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	[1] 15^{th} percentile of D.O. measurements collected between 6:30 a.m. and 6:30 p.m.

REGION: 2 BASIN: MIDDLE SOUTH PLATTE RIVER Stream Segment Description	DESIG	CLASSIFICATIONS	NUMERIC STANDARDS PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS Ug/l			TEMPORARY MODIFICATIONS AND QUALIFIERS
6. Lost Creek from Interstate 76 south, including all its tributaries, stock ponds and wetlands.	UP	Aq Life Warm 2 Recreation 2 Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=2000/100ml E. Coli=630/100ml	NO_3=100 $N0_2$=10 CN=0.2	S=0.002 B=0.75	As=100(Trec) Be(ch)=100(Trec) Cd=10(Trec) CrIII=100(Trec) CrVI=100(Trec) Cu=200(Trec)	Pb=100(Trec) Mn=200(Trec) Ni=200(Trec) Se=20(Trec)	Zn=2000(Trec)	

Site-Specific Minimum Dissolved Oxygen Standards for Middle South Platte segment 1a

STANDARDS

Early Life Stage Protection Period (April 1 through July 31)

1-Day [1.4,5] 3.0 mg/L (acute)

7-Day Average [1.2] 5.0 mg/L

Older Life Stage Protection Period (August 1 through March 31)

1-Day [1.4] 2.0 mg/L (acute)

7-Day Mean of Minimums [1.3.] 2.5 mg/L

30-Day Average [1.2.] 4.5 mg/L

Footnotes

1. For the purpose of determining compliance with the standards, dissolved oxygen measurements shall only be taken in the flowing portion of the stream at mid-depth, and at least six inches above the bottom of the channel. All sampling protocols and test procedures shall be in accordance with procedures and protocols approved by the Division.

2. A minimum of four independent daily means must be used to calculate the average for the 7-Day Average standard. A minimum of eight independent daily means must be used to calculate the average for the 30-Day Average standard. The four days and the eight days must be representative of the 7-Day and the 30-Day periods respectively. The daily mean shall be the mean of the daily high and low values. In calculating the mean values, the dissolved oxygen saturation value shall be used in place of any dissolved oxygen measurements which exceed saturation.

3. The 7-Day Mean Minimum is the average of the daily minimums measured at a location on each day during any 7-Day period.

4. During a 24 hour day, dissolved oxygen levels are likely to be lower during the nighttime when there is no photosynthesis. The dissolved oxygen levels should not drop below the acute standard (ELS acute standard of 3.0 mg/L or the OLS standard of 2.0 mg/L). However, if during the ELS period multiple measurements are below 3.0 mg/L during the same nighttime period, the multiple measurements shall be considered a single exceedance of the acute standard. For measurements below 2.0 mg/L during either the ELS or the OLS periods, each hourly measurement below 2.0 mg/L shall be considered an exceedance of the acute standard.

5. In July, the dissolved oxygen level in Segment 1a may be lower than the 3.0 mg/L acute standard for up to 14 exceedances in any one year and up to a total of 21 exceedances in three years before there is a determination that the acute dissolved oxygen standards is not being met. Exceedances shall be counted as described in Footnote 4.

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Appendix B
Denver's Response to April 2004 EPA Audit of Stormwater Program

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CITY AND COUNTY OF DENVER

JOHN W. HICKENLOOPER
Mayor

DEPARTMENT OF PUBLIC WORKS

WASTEWATER MANAGEMENT DIVISION
2000 WEST THIRD AVENUE
DENVER, COLORADO 80223
PHONE: 303-446-3400

October 18, 2004

U.S. Environmental Protection Agency
Region 8 (8ENF-W-NP)
999 18th Street, Suite 300
Denver, CO 80202-2466

Attention: Ms. Lee Hanley

Subject: Submittal of City and County of Denver Municipal Separate Storm Sewer System CPDS Permit No. COS 000001 Response to EPA Evaluation Conducted April 19 – 22, 2004.

Enclosed please find two (2) copies of the City and County of Denver's (City) response to EPA Municipal Separate Storm Sewer System comprehensive program evaluation conducted April 19 - 22, 2004. This response is limited to addressing the required and recommended actions identified in the report received by the City on August 20, 2004.

If you have questions or require additional information regarding this submittal, please contact me at 303-446-3603.

Sincerely,

Terry R. Baus

Terry R. Baus, P.E.
Program Manager

TRB/dmm

Enclosure

cc: Colorado Department of Public Health and Environment
WQCD-PE-B2
4300 Cherry Creek Drive South
Denver, CO 80222-1530

Commercial/Residential Management [PermitI.B.1]

Public Street Maintenance

Requirements: Under Section I.B.1 (a) (3) of Permit No. COS-000001, CCD shall continue to operate and maintain public streets, roads and municipal parking lots in a manner so as to reduce the discharge of pollutants in this area.

Findings: See text beginning on page 3 of the report.

Required Action: Section I.B.1 (a) (3) requires that sweeping be conducted at least twice per year in fall and in spring. If CCD is changing its sweeping schedule such that some areas will be swept less than twice per year, CCD must coordinate with CDPHE regarding changing its program condition as appropriate.

Recommended Actions: None

CCD Response to Required and Recommended Actions: *CCD is committed to maintaining its street sweeping schedule and will not be reducing the frequency of this maintenance activity in any area. The CDPHE Water Quality Control Division will be notified prior to implementing any proposed sweeping schedule changes that reduce the frequency or number of street sweeping events in Denver and will coordinate with CDPHE regarding any program changes. A copy of our commitment to maintaining this minimum level sweeping has been added as Attachment A of this response.*

Pesticide, Herbicide, and Fertilizer (PHF) Application

Requirements: Under Section I.B.1 (a) (5) of Permit No. COS-000001, CCD shall continue to implement controls to reduce the discharge of pollutants related to application of pesticides, herbicides, and fertilizers. CCD shall continue to implement a plan to promote the proper use, application, and disposal of PHF by the public and CCD staff.

Findings: See text beginning on page 5 of the report.

Required Action: CCD must reconcile the issue of Mr. Stachowski not appearing on the State list of licensed applicators.

Recommended Actions: None

CCD Response to Required and Recommended Actions: *See attached copy of Mr. Stachowski's "QUALIFIED SUPERVISOR LICENSE" issued by the Colorado Department of Agriculture. Mr. Stachowski is licensed, and therefore certified to purchase and use restricted use pesticides in Turf Pest Control.*

Illicit Discharge Management Program [PermitI.B.1 (b)]

Ongoing Field Screening

Requirements: Under Section I.B.1 (b) (2) of Permit No. COS-000001, CCD shall continue to implement an ongoing program to screen the MS4 for illicit discharges, illegal dumping, and illicit connections.

Findings: See text beginning on page 7 of the report.

Required Action: None

Recommended Actions: CCD should develop SOPs for responding to dry weather flows from known outfalls. Specific training on the identification of illicit discharges, illicit connections, and illegal dumping should be provided to the various individuals responsible for the identification.

CCD Response to Required and Recommended Actions: *CCD WMD proposes to develop a standardized procedure for analyzing and identifying dry-weather flow from outfalls. The procedure will include approved instructions for collecting/containing samples, chemical analysis, source investigation techniques (including television survey), and recordkeeping by the end of the 1st quarter of 2005. Also, CCD WMD is currently updating and re-distributing educational materials and providing training to key CCD personnel from other departments and agencies on how to identify a dry-weather flow and whom to contact when one is encountered.*

Investigation of Suspected Illicit Discharges

Requirements: Under Section I.B.1 (b) (3) of Permit No. COS-000001, CCD shall continue to implement this program to locate and eliminate suspected sources of illicit connections and improper disposal.

Findings: See text beginning on page 7 of the report.

Required Action: None

Recommended Actions: (1) CCD should develop SOPs for investigating illicit discharges. (2) Specific training on the identification of illicit discharges, illegal connections, and illegal dumping should be provided to the various individuals responsible for the identification.

CCD Response to Required and Recommended Actions: *CCD WMD proposes to develop a standardized procedure for analyzing and identifying dry-weather flow from*

outfalls. The procedure will include approved instructions for collecting and containing samples, chemical analysis, source investigation techniques (including television survey), and recordkeeping by the end of the 1st quarter of 2005.
Also, CCD WMD is currently updating, re-distributing, and providing training to key CCD personnel from other departments and agencies on how to identify a dry-weather flow, and whom to contact when one is encountered.

Procedure to Prevent, Contain and Respond to Spills

Requirements: Under Section I.B.1 (b) (4) of Permit No. COS-000001, CCD shall continue to implement a program to prevent, contain, and respond to spills that discharge into the MS4.

Findings: See text beginning on page 8 of the report.

Required Action: None

Recommended Actions: CCD WMD should improve its coordination with other CCD entities responsible for responding to spills.

CCD Response to Required and Recommended Actions: *CCD WMD will work with the Denver Fire Department's Hazardous Materials Response Team specifically, CCD WMD will require copies of each complete incident report generated by DFD within a reasonable time-frame (24 to 48 hours after the report is generated). The WMD investigator will review each report to determine if the incident involved a possible code violation, or if the incident was a result of a systemic problem that requires further attention. The WMD investigator will issue a summons to the responsible party, when deemed justified.*

Industrial Facilities Program [Permit I.B.1(c)]

Requirements: Under Section I.B.1 (c) of Permit No. COS-000001, CCD shall develop and implement a program to promote proper management of industrial sites regarding stormwater quality and industrial best management practices. The program shall provide education and outreach on pollutants in stormwater discharges to municipal systems from industrial facilities that the permittee determines are contributing or have the potential to contribute a substantial pollutant loading to the municipal storm sewer system.

Findings: See text beginning on page 10 of the report.

Required Action: 40 C.FR § 122.26(d)(2)(i)(F) requires that the application for a large MS4 include a demonstration of adequate legal authority to carry out all inspection, surveillance, and monitoring procedures necessary to determine compliance and noncompliance with permit conditions including the prohibition on illicit discharges to the MS4. CCD's requirement that inspections cannot be conducted at industrial facilities without probable cause of violations may not meet this statutory requirement. CCD must ensure that it retains adequate legal authority to fully implement the MS4 program.

Recommended Actions: (1) CCD should pursue improved coordination and an exchange of information with the State of Colorado regarding its Industrial Facilities Program. CCD should request and obtain an annual update of the State permitted industries list; an annual list of state-permitted industrial facilities inspected by the State, and an exchange of information on the compliance status of state-permitted industries that may be contributing to CCD's MS4. (2) Based on information from CDPHE and CCD, there appears to be a lack of industrial facility inspections within CCD. With the transition of CCD's program to compliance assistance, in accordance with Section I.B.1(c) of CCD's renewed permit, compliance monitoring of industrial facilities may be inadequate to monitor and control discharges from industrial facilities contributing substantial pollutant loading to the MS4. Therefore, to adequately control discharges from industrial facilities within the CCD, CCD should consider taking into account field monitoring of industrial facilities during development of the industrial facilities program, which is due to CDPHE by January 20, 2006. (3) A master list of all industrial facilities located in the CCD should be developed and maintained. (4) All inspection field notes should be retained even though the information is placed in a database. Retention of field notes is vital should an enforcement action occur or in the event the database is compromised through a computer virus or failure. (5) While Section I.B.1(c) 2 of CCD's permit sets a deadline of January 20, 2006 for coordination with other Denver personnel on industrial inspections, the EPA recommends that training and SOPs be completed more quickly if CCD plans to rely on the Fire Department to screen industrial sites for possible storm water violations, (6) CCD should develop an industrial facility inspection SOP and inspection checklist. Development of inspection procedures and a standardized checklist will ease the transition from Mr. Morris to his replacement. (7) CCD should consult with CDPHE and revisit the requirement to inspect industrial facilities to ensure inspection coverage and compliance of industrial facilities within CCD.

CCD Response to Required and Recommended Actions: *CCD will review the legal authority to carry out inspection, surveillance, and monitoring procedures to assure compliance with 40 C.FR § 122.26(d)(2)(i)(F) regarding adequate legal authority to conduct industrial stormwater inspections and enforcement actions for state- permitted industries located in the boundary of the City and County of Denver. Furthermore, CCD will develop a Standard Operation Procedures (SOP) plan to conduct CCD initiated industrial stormwater inspections. This SOP will be designed to standardize inspection triggers, inspection protocols, enforcement actions, and details of information to be collected during the inspections. The SOP shall provide education, outreach and enforcement on pollutants in stormwater discharges to municipal systems from industrial facilities that are contributing or have the potential to contribute a substantial pollutant loading to the MS4. A copy of the Industrial Stormwater Inspection SOP will be included in CCD's revised Industrial Stormwater Program submittal due to the CDPHE by*

January 20, 2006. In the interim, CCD will continue to proceed with compliance activities covered under our existing permit, will take the EPA program recommendations into consideration as the program develops further, and will take action as needed for industrial site runoff that may be having a negative impact on the MS4. Additionally, CCD will forward a copy of this submittal to the EPA.

Construction Sites Program [Permit I.B.1.d]

Procedures for Site Planning

Requirements: Under Section I.B.1 (d) (1) of Permit No. COS-000001, CCD shall continue to implement procedures for site planning that incorporate considerations of potential water quality impacts from construction sites in Denver.

Findings: See text beginning on page 12 of the report.

Required Action: None

Recommended Actions: Although CCD conducts a very thorough review of submitted SWMPs based on its checklist, this is not consistently documented. CCD should ensure that all reviews are consistently documented, and the documentation is kept in the file.

CCD Response to Required and Recommended Actions: *CCD has revised the checklist currently used for Construction Activities Stormwater Management Plan review. The checklist will also be used as a record of project review status. The checklist will be signed and maintained in CCD WMD files for future project compliance review. A copy of our revised checklist has been included as Attachment B to this response document.*

Procedures for Site Inspection and Enforcement

Requirements: Section I.B.1 (d) (3) of Permit No. COS-000001, CCD shall continue to implement procedures for inspection and enforcement of control measures at construction sites.

Findings: See text beginning on page 14 of the report.

Required Actions: Enforcement procedures have primarily been verbal warnings and issuance of warning notices of noncompliance for failure to notify CCD for an initial inspection. CCD must implement appropriate enforcement response to ensure that BMPs are being installed and maintained according to the approved site plan, and that significant sources of pollution have been addressed. Although CCD may determine the best methods to address construction site compliance using a variety of methods, including inspections, enforcement, and education at some construction sites, the current procedures as implemented are not adequately ensuring to the Maximum Extent Practicable that BMPs are installed and maintained. CCD's revisions to its construction site program, due to CDPHE by October 20, 2005, must include additional measures that will be taken by CCD to address sites that routinely fail to install and maintain adequate BMPs during the period between inspections performed by CCD.

Recommended Actions: See text beginning on page 17 of the report.

CCD Response to Required and Recommended Actions: *CCD will revise its Construction Sites Program Plan (CSPP) on or before October 20, 2005. The revised CSPP will include an amended inspection and enforcement section. The proposed inspection and enforcement section will outline construction site inspection protocol and a phased enforcement schedule that covers written notices of non-compliance, remedy date, and enforcement follow-up procedures. CCD will also review and address the recommended program changes in the upcoming October 20, 2005 CSPP submittal to the CDPHE. Additionally, CCD will forward a copy of this submittal to the EPA.*

Municipal Facility Runoff Control Program [Permit I.B.1. (e)]

Requirements: Under Section I.B.1 (d) (1) of Permit No. COS-000001, CCD shall continue to implement a Municipal Facility Runoff Control Program.

Findings: See text beginning on page 19 of the report.

Required Action: (1) All municipal facility runoff control plans and maps must be amended to include current site conditions. (2) All municipal facility runoff control plans must include a facility site map. (3) CCD must ensure that process wastewater is not discharged to the MS4, unless a separate NPDES permit is obtained for discharge of the process wastewater.

Recommended Actions: (1) CCD should implement better coordination between the Fire Department Hazardous Materials Response Team and the WMD. All spills at municipal facilities should be reported to WMD immediately, so that they can also respond to the scene as necessary. Following the spill containment and cleanup, WMD should, in a timely manner, receive a report that at a minimum provides the incident date and time, cause, material spilled, quantity spilled, and outcome. (2) Each municipal facility should have a designated contact whose duties include storm water responsibility for the site. The designated contact should be knowledgeable and readily available for inspections by the municipal facility runoff control inspector. (3) The designated contact should be required to provide written documentation to the municipal facility runoff control inspector in response to recommendations made during each site inspection. (4) All field notes, including sticky pad notes, should be retained as part of the permanent record. (5) All appropriate municipal facility staff should receive training on the individual runoff control plans.

CCD Response to Required and Recommended Actions:

The Fleet Maintenance Bulk Storage Facility plan and site map have been updated to include the hazardous materials storage area. The Cherry Creek Transfer Facility runoff control plan has been updated to include the empty pesticide storage shed for Neighborhood Services as well as the site plan.

All site files were reviewed to ensure that all contained a site map of that facility. Three site files were found to be incomplete. Site maps were created prior to this submittal for missing maps, and any others will be updated as necessary to reflect current site conditions.

CCD WMD will propose to increase its involvement with the Denver Fire Department's Hazardous Materials Response Team by being provided copies of full incident reports within a reasonable time-frame (24 to 48 hours after the report is generated). The WMD investigator will review the report to determine if the incident involved a possible code violation, or if the incident was a result of a systemic problem that required further attention.

The WMD investigator would issue a summons to the responsible party, when deemed justified.

Separate files will be created and maintained for all field notes, including sticky pad notes, pertaining to Municipal Facility Inspections as well as Detention Pond Inspections.

WMD will identify a contact specifically in each facility who is knowledgeable of the facility and has the authority to effect changes or recommendations prescribed by the municipal facility runoff control inspector. This individual shall be provided training on the Municipal Facility Runoff Control Plan by the WMD staff.

All handwritten field notes shall be retained in the file after the written report is formally documented by the end of the 1st quarter of 2005. All appropriate municipal facility staff shall be provided training on the runoff control plan as deemed necessary by the designated municipal facility storm water contact.

CCD is currently evaluating all municipal facilities and activities for potential process water permitting considerations and will rectify observed conditions by the end of 2nd quarter 2005. This evaluation is currently underway and began with the CCD sites identified during the EPA MS4 review. Findings identified for the municipal sites reviewed by the EPA will be corrected by the end of the 4th quarter of 2004.

WET WEATHER MONITORING

Requirements: Under Section I.D.1 of Permit No. COS-000001, CCD shall continue to implement a Wet Weather Monitoring Program to assess wet weather conditions, particularly urban storm water effects on state waters.

Findings: See text beginning on page 21 of the report.

Required Action: None.

Recommended Actions: (1) As the additional data are collected and analyzed, CCD should continue to reevaluate the land use base data and whether these data have changed, considering the coverage area and the impacts from storm water associated with industrial activities (including construction).
(2) Since the monitoring program may be limited in scope (i.e., insufficient coverage of areas where industrial facility sites and construction sites are located based on selected sampling sites), it is important that CCD re-evaluate its industrial facilities program (as recommended in the Industrial Facilities Program section of this report) to ensure that it is adequate to monitor and control the impact of industrial facilities on its MS4.
(3) To the extent possible, CCD should also (a) assess surrogate parameters/variables such as effect of urbanization, effect of imperviousness, and the extent to which BMPs have been applied and (b) consider expanding the biomonitor network.

CCD Response to Required and Recommended Actions:

(1) Land-use data was gathered as part of the original NPDES permit application by CCD. This data included the extent of land area in 1990 for the five categories of residential, commercial, industrial, agricultural and open space (undeveloped). Over time, it is likely that undeveloped land will diminish in extent as urbanization continues.

No direct correlation between land use and stormwater quality were found in the Nationwide Urban Runoff Program reported by EPA in 1983. The trend analysis that is a permit requirement is not dependent on land-use information, and can be completed with the data currently being collected as a part of the program. However, the changes in land use and changes in stormwater quality are both of interest, and CCD will continue to reevaluate the land-use database over longer periods of time.

(2) The purpose of the wet-weather monitoring program, as agreed on by Denver, The Phase I Joint Taskforce, Water Quality Control Division, and EPA, is to determine long-term trends, and was not intended to discriminate between the various land uses, but rather to look at the watershed as a whole.

(3) The trend analysis that is a permit requirement is not dependent on land-use information. However, the extent to which BMPs have been applied is a factor that will be considered to the extent feasible in the analysis.

Biomonitoring was considered at the time of the original wet-weather monitoring plan development as were other monitoring methods; however, these were not included for the reasons stated in the work plan. UDFCD and the USGS continue to evaluate and make adjustments to the wet-weather monitoring program as needed, and these are reported in the annual reports.

Attachment A

Commitment to Maintaining Minimum Level Street Sweeping

CITY AND COUNTY OF DENVER

John W. Hickenlooper
Mayor

DEPARTMENT OF PUBLIC WORKS

OFFICE OF THE MANAGER
Wellington Webb Municipal Office Building
201 WEST COLFAX, Dept. 608
DENVER, COLORADO 80202
PHONE: (720) 865-8630
www.denvergov.org/publicworks

October 13, 2004

Jennifer Schaufele
Executive Director
Denver Regional Council of Governments
4500 Cherry Creek Drive South, Suite 800
Denver, CO 80246-1531

RE: Additional PM_{10} Emission Reduction Commitments by Denver

Dear Ms. Schaufele:

The City and County of Denver is very committed to a regional approach to improving air quality in the metropolitan area. We have reviewed our operations and are willing to commit to the levels of PM_{10} emission reductions attained in the 2003 calendar year, as noted on the attached form. In committing to these levels which exceed the requirements of the SIP, we anticipate that DRCOG will continue supporting the City and County of Denver in the acquisition of alternative materials purchase and storage and distribution equipment, as well as pursuing new street sweeping technology and operations management systems.

These commitments will continue effective September 1, 2004.

Please call me at 720-865-8711 if you have any questions.

Sincerely,

Guillermo V. Vidal
Deputy Mayor

Cc: Dennis Royer, Public Works
Dan Roberts, Street Maintenance
File

DRCOG
DENVER REGIONAL COUNCIL OF GOVERNMENTS

Board Officers
Lorraine M. Anderson, Chairman
Will Toor, Vice Chairman
Richard M. Sheehan, Secretary
Nancy Sharpe, Treasurer
Melanie A. Worley, Immediate Past Chairman
Jennifer Schaufele, Executive Director

August 18, 2004

The Honorable John Hickenlooper
Mayor
City and County of Denver
1437 Bannock Street, Room 350
Denver, Colorado 80202

Dear Mayor Hickenlooper:

The Denver Regional Council of Governments (DRCOG) is preparing an air quality conformity finding for the proposed 2030 Regional Transportation Plan (RTP). Critical to a positive conformity finding is meeting the fine particulate matter (PM_{10}) emissions budget of 51 tons per day for mobile sources for 2030. DRCOG estimates that 2030 PM_{10} emissions will be about 57 tons per day if the 2002 commitments made for the 2025 RTP are applied to the 2030 RTP. Local and state agency agreement to road sand reduction and sweeping actions is absolutely necessary for a positive conformity finding. The region must have a positive conformity finding on the 2030 RTP to permit new road and transit capacity projects to receive federal funds.

Denver is to be congratulated as one of the local governments and agencies that have exceeded the minimum requirement for street sanding and sweeping reductions in current practice. In winter 2003-2004, it maintained emission reductions of 71.9 percent in the Central Business District, 63.2 percent in the Sweepbox, and 41.4 percent in the remainder of its jurisdiction over the 1989 base. Its actions have been instrumental in ensuring that the region has not had any PM_{10} violations. The enclosed PM_{10} emission reduction report includes your current practice.

Denver's continued assistance is needed. DRCOG asks that Denver commit to continue its current practice for years 2015, 2020, and 2030 for the roadways it maintains. The methods used to achieve the stated emissions do not need to be specified at this time; only the resulting percentage of emissions reduction needs to be specified.

To prevent delays in project funding, please complete and return the enclosed PM_{10} Emission Reduction Commitment Form to Marcy Miller at DRCOG by October 1, 2004. For your information, a map indicating the various geographies referenced in the form is enclosed. You may also contact Marcy with questions at 303-480-6737.

Sincerely,

Jennifer Schaufele
Executive Director

Enclosures
c: The Honorable Rick Garcia, Denver DRCOG Board Representative
Dennis Royer, Ellen Ittelson, City and County of Denver
Dan Roberts, City and County of Denver

Enhancing and protecting the quality of life in our region

4500 CHERRY CREEK DRIVE SOUTH SUITE 800 DENVER, COLORADO 80246-1531 TEL 303-455-1000 FAX 303-480-6790
E-MAIL: DRCOG@DRCOG.ORG WEBSITE: WWW.DRCOG.ORG

2030 Regional Transportation Plan Conformity
PM10 Emission Reduction Commitments

Denver

PM10 Emission Reduction Conformity Commitments

Geographic Area of Commitment	for Staging Years	Emission Reduction Commitment
Denver in SIP Sweep Box (outside CBD)	2015	64 %
	2020	64 %
	2030	64 %
Denver Central Business District	2015	72 %
	2020	72 %
	2030	72 %
Denver remainder (except state freeways)	2015	42 %
	2020	42 %
	2030	42 %

It is our intention to pursue the above goals as a percentage of emission reductions.

Guillermo Vidal
Name

10/13/04
Date

Deputy Mayor/Manager/Public Works
Title

Signature needed from Chairman, County Board of Commissioners, Mayor/City Manager of Municipality, or Agency Executive Director.

DRCOG

PM10 Emission Reduction Status Report

Denver

1989 Base Sand Application Rate: 576 (pounds per lane mile per pass)

Road network Sanding Lane Miles: 2,136 (not the entire jurisdiction road system)

PM10 Street Sanding and Sweeping Current Practice Emission Reduction

Year	Area of Operation	Current Practice Reduction
2004	Denver in SIP Sweep Box (outside CBD)	63.2%
2004	Denver Central Business District	71.9%
2004	Denver remainder (except state freeways)	41.4%

Source: Regional Air Quality Council derived from the annual Colorado Regulation 16 Reports.

☐ Made commitment in previous conformity cycle (if not, SIP requirements used)

Previous PM10 Emission Reduction Conformity Commitments

Conformity Analysis Year	Geographic Area of Commitment	for Staging Years	Committed Emission Reduction
2002	Denver in SIP Sweep Box (outside CBD)	2010	50.0%
		2020	50.0%
		2025	50.0%
2002	Denver Central Business District	2010	72.0%
		2020	72.0%
		2025	72.0%
2002	Denver remainder (except state freeways)	2010	30.0%
		2020	30.0%
		2025	30.0%

Colorado SIP Maintenance Requirements

CBD	72%	Area bounded by and including Colfax Avenue, Broadway, 20th Street, Wynkoop Street and Speer Boulevard.
Sweep Box	50%	Area bounded by 38th Avenue, Federal Boulevard, Louisiana Avenue and Downing Street and outside the CBD.
Foothills Area	20%	Portions of Douglas, Jefferson and Boulder Counties with elevation of 6,000 feet or higher (west of C-470 and SH-93) in the PM10 modeling domain.
All Others in PM10 Model	30%	The PM10 Modeling Domain: A rectangular area generally bounded by 160th Avenue (north), SH-79 (east), Lincoln Avenue/Highland Ranch Boulevard (south) and a north-south line at the western edge of Golden (west). This group starts with the PM10 modeling domain and exclude the CBD, Sweep Box and Foothills areas as described above.

August 17, 2004

Attachment B

Revised Checklist for Construction Activities Stormwater Management Plan

Project Name: ______________________

Address ______________________

Point of Contact ______________________

____

CASDP SUBMITTAL REVIEW

GENERAL REVIEW

Y	N	
☐	☐	**CASMP Narrative (5-6 copies)**
☐	☐	a. Certification Note signed by property owner (NPDES Standard Note #2)
☐	☐	b. Professional Engineer's Statement and stamp.
☐	☐	**CASMP Plan Set (5-6 sets)**
☐	☐	a. Certification Note signed by property owner (NPDES Standard Note #2)
☐	☐	b. Professional Engineer's Statement and stamp.
☐	☐	**Permit Application**
☐	☐	a. Address Assignment Slip
☐	☐	b. Letter verifying status of an Authorized Agent
☐	☐	c. Application Fee
		Misc. Technical Information (1 copy)
☐	☐	a. Drainage Report/SQCP (approved copy not required)
☐	☐	b. Soils/Geotechnical Studies
☐	☐	c. Environmental Audits
☐	☐	d. CDPHE Permit Application
		Status of Related Projects

Y	N		ID Number	Submitted	Approved
☐	☐	a. SP			
☐	☐	b. PR			
☐	☐	c. SUDP			
☐	☐	d. FDR			

DETAIL REVIEW

Narrative

Y	N	
☐	☐	**1. Name, Address, and Phone Number of Applicant.**
☐	☐	**2. Name, Address, and Phone Number of Local Contact/Project Manager.**
☐	☐	**3. Name, Address, and Phone Number of Consultant.**
		4. Project location including
☐	☐	a. Name of Project or Development
☐	☐	b. Street Address
☐	☐	c. Township, Range, Section, Quarter Section
☐	☐	d. Latitude (+/- 15") and Longitude (+/- 15)
☐	☐	e. Metropolitan District
		5. Site description including;
☐	☐	a. Site acreage
☐	☐	b. Area of disturbance (in acres)
☐	☐	c. Site description (legal description)
		6. Current site conditions including:
☐	☐	a. Past Land Use
☐	☐	b. Possible Site Contamination
☐	☐	c. Current Land Use
☐	☐	d. Existing Topography
☐	☐	e. Vegetation
☐	☐	f. Drainage including:
☐	☐	1.) Identification of impacted State "Receiving Waters".
☐	☐	2.)Flow routing from the site to the Receiving Waters.

Y	N	Narrative Cont.
		6. Current Site Conditions cont.
☐	☐	g. Wetlands
☐	☐	h. Soils
☐	☐	i. Erosion Potential
☐	☐	**7. Description of adjacent areas**
☐	☐	**8. Description of erosion and sediment control "BMPs".**
☐	☐	a. Required Minimum BMP's
☐	☐	(1). Vehicle tracking Control VTC
☐	☐	(2). Inlet Protection
☐	☐	(3). Site Stabilization
☐	☐	(4). Spill Prevention/Containment
☐	☐	(5). Chute Washout Containment
☐	☐	(6). Street Sweeping
☐	☐	b. Site Conditions requiring Specific BMPs
☐	☐	(1). Proposed On-site Storm Runoff Detention Facility
☐	☐	(2). Potential for High Flow Conditions
☐	☐	(3). Steep Slopes
☐	☐	(4). On Site Drainageway
☐	☐	(5). Contaminated Site
		9. Project Description
☐	☐	a. Proposed Construction
☐	☐	(1). Grading Operations
☐	☐	(2). Utility/Infrastructure Construction
☐	☐	(3). Building Construction
☐	☐	(4). Landscaping/Site Stabilization
☐	☐	b. Construction Scheduling
☐	☐	(1).. Detailed Construction Schedule
☐	☐	(2). Construction Phasing
☐	☐	(a). Site Preparation/Grading
☐	☐	(b). Infrastructure/Building Construction
☐	☐	(c). Site Stabilization/landscaping
		10. Proposed Post Construction Water Quality "BMPs".
☐	☐	a. Grass Buffer
☐	☐	b. Grass Swale Modular Block Porous Pavement
☐	☐	c. Modular Block Porous Pavement
☐	☐	d. Porous Pavement Detention
☐	☐	e. Porous Landscape Detention
☐	☐	f. Extended Detention Basin
☐	☐	g. Sand Filter Extended Detention Basin
☐	☐	h. Constructed Wetlands Basin
☐	☐	i. Retention Pond
☐	☐	j. Constructed Wetlands Channel
☐	☐	k. Innovative Technology
☐	☐	**11. Permanent Stabilization, including:**
☐	☐	a. Site specific seed table
☐	☐	b. Seed bed preparation specifications
☐	☐	**12. BMP Maintenance Schedule**

Appendix C
Water Quality Improvement in the South Platte River, Report to the Mayor

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DRAFT
FOR INTERNAL REVIEW ONLY

24 JUNE 2004

WATER QUALITY IMPROVEMENT IN THE SOUTH PLATTE RIVER
REPORT TO THE MAYOR

AMY BERGSTEDT
999 18TH STREET, SUITE 300
DENVER, COLORADO 80202
303-312-6647

EXECUTIVE SUMMARY OF RECOMMENDATIONS

1. Increase communication and streamline procedures between Denver's Department of Environmental Health/ Environmental Services Division, Denver's Department of Public Works/ Wastewater Management Division, and DPW's Infrastructure, Planning and Programming engineers. ("Procedures" include achieving clarity on monitoring, response, roles, responsibilities, and follow through.)

2. Since the decreasing SPR water quality is the response of both watershed-wide, stormwater inputs as well as possibly from sewer system infrastructure, both long-range regional initiatives as well as near-term programmatic support are necessary to adequately protect our water.

3. In order to deal with the regional stormwater quality issues:

a. Promote a Denver-inspired, regional watershed initiative, uniting behind the work that is already completed in the DPW-WMD Water Quality Management Plan and USGS/Joint Task Force project and possibly using the same stakeholder initiative model as the original South Platte River Coalition.

b. Enforce the existing stormwater quality ordinances and regulations requiring all new and reconstructed developments over one acre to install and maintain stormwater quality Best Management Practices.

c. Fund and empower the CCD Natural Areas Program so that, regardless of the sources, contamination from this Urban setting is naturally, cheaply, and effectively dealt with before it gets to the River.

4. In order to deal with sewerage infrastructure and contamination issues:

a. Pursue storage in Chatfield Reservoir for additional base flow that will insure continued dilution even in drought conditions.

b. Continue to support/ acknowledge wastewater treatment plants in their efforts to improve effluent water quality.

c. Continue diligent monitoring, improvement and coordination efforts for the sanitary sewer system, especially in NW Denver. (See #1 above.)

WATER QUALITY IMPROVEMENT IN THE SOUTH PLATTE RIVER

This report synthesizes information regarding water quality in the South Platte River (SPR) as it courses through the urban Denver watershed. Presented below is a summary of: a) the City and County of Denver's Agency structure and responsibilities to the SPR, b) available, quality data sources for the 10.5 mile City reach, c) short descriptions of working groups that either focus, are tangentially aware of SPR issues, or have related water quality missions, and d) an overview of the pollutants, potential pollutant sources, and suggestions for remediation.

The following conclusions were gathered over twenty days of research which generally included interviews and follow up meetings with approximately thirty-five different stakeholders (Attachment 1: Stakeholder List) and review of various city documents (Attachment 2: Relevant Documents). This is by no means meant to be an exhaustive, conclusive review with absolute recommendations, but rather is intended as a starting point for this administration to familiarize itself with the issues, culture, and potential solutions.

This report has been researched and authored by an employee of the U.S. Environmental Protection Agency on detail to the City and County of Denver Mayor's Office. Be advised that the conclusions within are not official EPA opinions, but are intended to be helpful beginnings from an unbiased, third-party associate with relevant technical background.

I. Who Does What?

A. Available Data/ Agency (Platte-Related) Responsibilities

Denver Environmental Health, Environmental Protection Division (DEH-EPD) has the most extensive dry weather data set in the SPR system, including over 25 years of sampling programs. In dry weather conditions, surface water, biotic and sediment samples are retrieved from rivers, tributaries and lakes within the greater Denver watershed. DEH-EPD's specific mission is to collect quality data in support of Colorado Department of Public Health and Environment (CDPHE) and Clean Water Act objectives[1]. In addition to the instream sampling efforts and in coordination with DPW-WMD, they are also compiling a GIS database of stormwater outfalls to model watershed drainage areas. <u>DEH-EPD can provide characterization of a waterbody in the Denver Metro area relative to regulated contaminants.</u>

South Platte River Cooperative for Urban River Evaluation (SP CURE) has been collecting dry weather data for 8 years from fixed, mostly point-source discharge

[1] Specific Clean Water Act objectives include 1) determining water quality standards attainment (Section 305(b)); 2) identifying impaired waters (Section 303(d)); and 3) identifying causes and sources of water quality impairments (Sections 303(d) and 305(b)).

associated monitoring locations. This group is made up of local Platte River permitted dischargers and acts as a water quality data clearinghouse for all relevant (public and private) stakeholders. Their mission is to facilitate watershed pollutant modeling for discharge permits and TMDL negotiation, through the self-reporting/ self-monitoring of its members. All data is maintained on EPA's STORET system and inquiries are routed here rather than to a specific report. SP CURE and DEH-EPD coordinate sampling programs and share data to help with stream characterization, but SP CURE focuses on participating member, point-source discharges.

Denver Public Works, Wastewater Management Division (DPW-WMD, stormwater group) has also done some dry weather outfall monitoring as part of the Municipal Separate Storm Sewer System (MS4) permit and Section 402 of the Clean Water Act. Outfalls were initially surveyed in 1989 and then over 20% of the system was reviewed annually from 1996-2001 (but not consistently since because nothing was found). A comprehensive GIS water quality layer is being established which shall map point-source discharges, impervious surfaces, and locations of post-construction BMPs such as water quality ponds and constructed wetlands for both public and private lands. Currently, problematic outfalls are monitored as they are reported or discovered; response and monitoring responsibilities are shared with DEH and to some extent the DPW-City Engineer's office. Most monitoring data is case-by-case and related to MS4 outfalls in dry weather, but the GIS data will be extremely useful for watershed planning.

Denver Public Works, Wastewater Management Division (DPW-WMD, operations) has surveyed the entire Northwest Denver neighborhood sewer system. This effort cost nearly $1 million and occurred intensively over four months. Every foot of the system was reviewed to confirm structural integrity, including the stability of sewer connections and potential locations of illicit cross-connections with the separate stormwater conveyance system. It was also pressurized to locate any leaks and lined to prevent new ones. The operations group has concluded that there is no correlation between the sanitary sewer system and elevated bacterial contamination in the NW Denver watershed; they hypothesize that increased bacterial contamination is the result of pet and wildlife waste in the watershed's MS4.

The Joint Task Force (JTF), is a self-directed stormwater group including MS4 officials from Lakewood, Aurora and Denver. The group shares costs and collaborates on policy, technical, and programmatic issues when negotiating with the State. The Urban Drainage and Flood Control District (UDFCD) is the fourth partner and is responsible for technical assistance and pooling money to contract USGS for third-party, independent wet weather water quality assessment. The USGS has nearly completed 4 years of baseline data collection and is finalizing recommendations to the cities on how to improve and coordinate water quality responsibilities. This will add greater legitimacy to watershed planning when organized and published because it specifically focuses on storm-event generated pollution relative to the regional MS4 system.

**** IMMEDIATE NEED **** There exists institutional confusion regarding the coordination between EPD-DEH and DPW-WMD when it comes to water quality issues, and the Mayor's office needs to facilitate communication between the departments to ameliorate inefficiencies in workload management and in public responsiveness, i.e. when a citizen sees something that looks illegal or polluted, they do not know who to call, and what's worse, neither department really knows who should respond when something is found. An MOA was created between the departments in 2001 that was to define their relative roles and responsibilities. Pursuant to the Clean Water Act (CWA) Section 402, WMD assures that the MS4 system is compliant with State standards. DEH is specifically responsible to CWA sections 303 and 305 for assisting the State in assuring federal stream standards are met for target contaminants. Because the current water quality issues differ from the historical focus of point-source discharges, sources of pollution are watershed-wide, both missions overlap, and the sources of pollution are often unknown, the complexity of each program results in rising operational inefficiencies and a lack of clarity regarding authority, ability and responsibility.

**** IMMEDIATE NEED **** CCD water quality monitoring programs need to be coordinated and communicated across departments if each department lacks funding to have a completely self-reliant, thorough sampling program on its own. EPA is in the process of completing its audit of the DPW-WMD MS4 permit, and preliminary discussions reveal concerns regarding 1) monitoring, 2) communication, and 3) runoff/ discharges from industrial sites. The WMD monitoring program was found to be insufficient; adequate monitoring exists collectively throughout CCD, but again, is not well coordinated and communicated between DEH-EPD, DPW-WMD and the USGS contractor completing the wet weather studies. Additionally, there is *no* CCD program that does on-site inspections of industrial areas stormwater management systems; therefore, the impacts industrial sites have on water quality are unknown.

*** Potential Need *** More investigation is required to understand how the Public Works City Engineer's office (WMD responsible for the sewer system infrastructure), the Public Works stormwater division (WMD responsible for water quality from stormwater runoff) and Environmental Health- Environmental Protection staff (the ones that actually do the monitoring and can tell you where bacteria and nutrients are the highest) all work together. According to the Water Quality Report (DEH, p. 3-6) once trends or problematic outfalls are discovered they are referred to WMD. But the sense is that there is a disconnect when it comes to follow up- whether this is related to procedure, personalities, lack of funding, or simply not knowing what the source of the contamination problems are- I could not find a clear answer.

Opportunity EPD-DEH, DPW-WMD, and CCD GIS are not coordinating their GIS landscape water quality characterization efforts, and perhaps they should be. (The City GIS and Assessors offices also have created GIS parcel by parcel landuse maps.) Communication and coordination between all these parties on these projects could be quite powerful when CCD decides to undertake regional, watershed planning activities.

B. Communication/ Focus Groups

City and County of Denver, Water Quality Management Plan. DPW-WMD has released the final draft and will publish the Water Quality Management Plan this summer. The creation of this document has included participation across CCD departments and public stakeholders[2]. At publication, all members should be on the same page regarding required water quality protection regulations and the technical specifics of implementing these stormwater Best Management Practices (BMPs). I recommend that this document not be filed away in document never-neverland and instead that it, coupled with the data from the JTF-USGS study, is highlighted as a tool to unify the City on how our watershed will be protected.

The Water Quality Committee is made up of mostly CCD staff from across various departments[3]. This group meets quarterly and often forms sub-committees based on target issues (e.g. West Nile Virus). While the group is effective when it has an issue to focus around, currently has sporadic attendance and lack of vigor.

Denver Regional Council Of Governments (DRCOG)- Water and Environmental Planning Committee is responsible under state and federal statutes[4] to facilitate regional water quality planning for the Denver area. They review, debate and make recommendations to the DRCOG Board regarding action on water and environmental issues. They published the Metro Vision 2020: Clean Water Plan (DRCOG 1998) to provide guidance to regulatory agencies making water quality decisions. While DRCOG is generally effective for transportation issues, the Water Planning Committee currently has sporadic attendance and lack of focus.

Cherry Creek Stewardship Partners is a local watershed group for the Cherry Creek section of the Platte watershed. The Cherry Creek Watershed "Smart Growth for Clean Water" Report (December 2003) unifies the watershed around the vision of water quality. This group would be helpful partners on a water quality initiative, especially based on their experience, expertise, and proximity in the greater watershed.

The Greenway Foundation was instrumental in the first round of cleaning up the Platte (see SPRC Annual Report: South Platte River Denver (March 1998)). At this time they would like to gain support from the Mayor's office to lead a new effort that concentrates on water quality specifically, beyond the mainstem corridor structural

[2] Internal advisory committee includes: DPW-WMD, P&R Planning, P&R Natural Areas, Community Planning and Development Department (CPD), DPW-Development and Engineering Services (DES), DEH-EPD, UDFCD and the Mayor's Office. External Review Committee (fatal flaw analysis) includes: Village Homes, John Laing Homes, McStain Homes, Engle Homes, Cherry Creek Basin Authority, Urban Ventures, AMEC Earth and Environmental (Facilitator for Developers/Basin Authority/Land-use Agencies), Denver Housing Authority, Carroll and Lange (development engineer).

[3] Including DEH-EPD, DEH-Environmental Services (EVS), DEH- Animal Control, Community Planning and Development Department- Neighborhood Inspection Services, Parks and Recreation Department, DPW-WMD, Denver Water Board, UDFCD and Denver International Airport (DIA)

[4] Specifically, Clean Water Act, Section 208

improvements that were completed in the 1990's. This group would be helpful partners on a water quality initiative due to their historical connection to the Platte; however, they have very little understanding of the highly technical aspects of water quality, are not well connected to the management agencies that implement water quality control regulation, and are very recreation-focused.

The River Reach Use Initiative is a local non-profit youth organization that attempts to spark environmental education and recreation opportunities mainly for inner-city children. In the summertime they organize rafting expeditions through the SPR Denver reach. They do not hold activities on the River after a storm due to the poor water quality they observe and would immediately suspend activities if any portion of the water they contact was deemed unsafe. (They were specifically concerned that the amount of money spent on another gazebo in the parks could easily fund weed-pulling and volunteer outreach that could help the riparian corridor function properly.)

Opportunity (Please see solutions/ communication section below)

II. Water Quality

This section discusses the scope of the water quality issues in the mainstem SPR, traces the pollutants back through the watershed to their sources, and then recommends fixes to these problems.

A. Pollution (see 2002 Water Quality Assessment Report, City and County of Denver, Volume I: Rivers.)

The consensus amongst the data-gathering entities and regulatory agencies is that the major pollutants of concern and water quality standard exceedances within the SPR mainstem are nitrate and bacteria (fecal coloform and *E. coli*). Ammonia, nitrite, total kjeldahl nitrogen (TKN), and phosphorous are also increasing. The pH is decreasing, and selenium is being watched as it is increasingly found in high concentrations in all surface waterbodies across the Denver Metro area. Chloride increases after storm events in winter months. Despite the regulatory compliance of permitted point-source dischargers and sanitary sewer outfalls, SPR water quality appears to be decreasing over time.

The tributary systems in the watershed have similar issues. In Westerly and Sand Creeks dissolved and suspended solids are increasing, and ammonia, chloride, sulfate and selenium frequently exceed state standards. Cherry Creek has elevated levels of ammonia, nitrite, nitrate, TKN, phosphorous, sulfate, alkalinity and water hardness. Both show increases in Fecal Coliforms and *E. coli.*

B. Sources

In the approximately 35 interviews that were conducted for this project, all stakeholders and technical experts agreed that the biggest threat to Denver's SPR water quality was stormwater from within the greater watershed. Based on this research, I agree with this conclusion; unfortunately, no WET weather data yet exists that helps target specific areas to begin concentrating watershed rehabilitation, and the ensuing recommendations are generally big-picture oriented. Meanwhile, some immediate fixes relevant to the sanitary sewer system may improve water quality in the short-term and could be supported based on initial DRY weather monitoring data.

Point-source pollution is regulated and is an ongoing enforcement, maintenance and oversight responsibility of City, State and Federal agencies. *Industrial point discharges* and the *sanitary sewer* system certainly impact the river; but those that aren't up to the regulated standard become part of the end of pipe assistance, permitting and/or enforcement process. Where the MS4 and sanitary sewer system needs repair, established procedures make repairs as promptly as possible following discovery. Discharges add up, and where the River still exceeds pollution limits, TMDL standards are being created. These programs include the expertise and attention of DPW-Infrastructure Engineering, DPW-WMD, and DEH-EPD.

Every raindrop in Denver flows eventually into the Platte, which contributes to nonpoint source pollution. This is an urban drainage- abounding in concrete- so all stormwater is conveyed to the SPR system as quickly as possible after washing off streets, buildings, and industries. Elevated levels of nitrate and bacteria are side-effects of sanitary sewer systems, but are likewise washed into the watershed from nutrient sources (fertilizers) and other activities on individual land parcels. Water quality will improve if current regulatory programs remain diligent, functional, and proactive, and as stormwater and nonpoint sources are controlled throughout the basin.

Based on dry-weather data, ammonia, nitrate, nitrite, TKN and phosphorous are generally associated with wastewater treatment plants (WWTP), although these nutrients can also be traced to fertilization activities, vegetation debris and stormwater runoff throughout the watershed. The Glendale WWTP is a known cause for the State standard exceedances in Cherry Creek. The Littleton/Englewood WWTP is suspected as the cause for nitrate exceedances on the SPR because contamination is highest before other waters flow into the SPR downstream. These aquatic systems are especially susceptible to exceedances in low-flow or drought conditions where a large portion of the River's discharge is from the WWTP, not diluted by other hydrologic inputs. In anticipation of the nitrate TMDL Littleton/Englewood WWTP is installing new systems that will attempt to reduce its nitrate effluent to near zero. In a drought, most of the River's water is wastewater discharge and whatever is allowed through the WWTP equals the water quality in the River. Increasing base flows (perhaps through Chatfield Reservoir) and improving the quality of the WWTP effluent are likely to improve water quality for these parameters in the SPR.

Although bacterial contamination and State Water Quality Standard exceedances for *E. colli* are present and elevated throughout the mainstem and tributary systems, levels are highest in the more downstream SPR segments that drain older neighborhoods. Studies have been done to speciate the bacterial contamination, and they have all been inconclusive regarding a specific source of pollution. Likewise, the entire sanitary sewer system has been surveyed for breaks, leaks and illicit connections and found to be stable. Therefore, it is likely that there is more than one source throughout the watershed, including but not limited to waste from domestic animals and wildlife, a high population of homeless people that reside in the SPR parks, unknown cross-connections between the sanitary sewer system and the MS4, ongoing sanitary sewer line breaks and maintenance operations, and sanitary sewer WWTP outfalls.

The chloride increases seen after winter storm events across the region are specifically linked to de-icing chemicals used on roads and washed through the MS4 directly into the waterways.

The sediment increases in Westerley and Sand Creeks are linked to land-disturbing, reconstruction activities at Stapleton.

Selenium sources are relatively unknown, but may be a product of the high salt content in our soils and erosion or agriculture activities in the region.

The TREX project is consistently out of compliance for trichloroethene, sediment, metals and other aspects of their construction permits. The Coliseum's Western Stock Show is suspected of contributing large illicit bacterial discharges during the event. As far as I can tell, CCD monitors these non-compliances and has elevated them to the State, but no enforcement or remedial action has occurred.

C. Solutions and Opportunities

Communication/ Focus Group. If there is serious intent to improve the water quality of the SPR, serious effort must be extended to bring the right people together to accomplish this goal.

Illumination and support from the Webb administration to engage and empower appropriate players resulted in meeting nearly all of the goals originally outlined for the SPR (see Imperative 2000: A Vision for the South Platte River). The only two goals they were not able to accomplish with the group they assembled in the time it was convened were 1) to create a centralized database and 2) significant water quality improvement. Although a legacy for continual improvement was created (see Long Range Management Framework, South Platte River Denver), it was not carried out. Momentum was lost as the result of three factors: a) the coordinating responsibility for continued action was put into Parks and Recreation, which is not a water quality-focused Department; b) water quality at this day and age is a watershed-wide issue, and the players for this issue were now different than those already at the table; and c) loss of support and inspiration for this unique coordination effort from the Mayor's office.

The SPRC was extremely successful in the improvements it did accomplish, and since this previous structure was effective, there is no reason to create an *entirely* new model. At the top, coordinating, facilitating and focusing specifically on improving the SPR sat a charismatic, third-party, unbiased and unattached personality with relevant background in river systems and community involvement. The SPRC members were empowered representatives of every entity that had a stake in seeing improvement in the SPR, and they eventually united around a realistic set of goals and activities- that were funded.

At this time there are several different activities occurring mostly independent of each other but all trying to get their hands and minds around how to improve our watershed's water quality (see Communication/ Focus Groups, above). The data, regulations, and visions already exist (see References section, below) around which unity can occur, and many departments are already on notice about these common issues. At this point, <u>leadership is the missing link for action</u>.

* **Opportunity** * Get another charismatic leader from outside the CCD system, without history in the previous SPRC or bias. Extend a stakeholder group from DPW-WMD's Water Quality Plan and Advisory Committee (start with Terry Baus), but also include the Community Planning and Development Departments for the crucial Sustainable Development aspect of such an initiative. The new group can focus unity around existing agreement in pollutants and non-point pollutant sources and start from the solutions proposed in the Water Quality Plan. *Pitfalls*- this should be coordinated by an outsider/ someone new to the SPR as there is quite a bit of history, leftover emotion, and agenda-promotion in that history. Due to the extreme complexity of watershed issues, this type of effort needs, again, support and illumination from the top and a thorough grouping of empowered stakeholders. Specifically, this is why such responsibility should not rest within the Water Quality Committee or the Greenway Foundation. The DRCOG- Water and Environmental Planning Committee is a possible forum for such a "watershed" group, but would need restructuring and focus on this specific issue.

* **Opportunity** * An additional recommendation was for the formation of a "Watershed Utility." Such an entity is being reorganized or formed by other local governments adjacent to CCD. (See Terry Baus for further explanation.)

Landscape Scale Fixes- The Watershed Mayor

While ongoing education programs, a regional-wide stakeholder initiative and increased focus and enforcement of existing programs and regulations (described below) will all help to improve water quality in the SPR, nothing can clean water like Mother Nature can. The most cost-effective and efficient way to deal with water quality is to preserve wide, intact and functional riparian corridors as well as natural areas across the watershed. <u>Natural systems can "clean" infinitely greater amounts of water and</u>

contamination *regardless of the source* than an expensive, human-engineered system can handle.

The Natural Areas Program (see Reference section for enabling ordinance) currently sits deeply buried in the Parks and Recreation Department. It is comprised of one staff person and has barely any funding. Through creative partnerships and collaboration across the region, the Program has managed to identify over 3,000 acres of land that are currently or could be restored to a natural state- and they even have already gotten some of those acres restored and maintained despite programmatic hardship. The tragedy here is that none of these areas have been officially designated as Natural Areas and are in a very vulnerable place as development across the City continues to encroach. Natural Areas need to be officially designated immediately to protect from continuing development pressures.

Additionally, these areas do require special maintenance for the first 2-3 years that they are newly established. This maintenance is different from the usual way of doing business (requires selective mowing or the use of goat grazing programs), and at this time the maintenance crews in Parks and Rec are too busy or are otherwise reluctant to consistently provide the support the Natural Areas program needs. While initial investment to start a 'natural area' is generally greater than for traditional turf lawns, after the first few years, maintenance requirements (including mowing, fertilization and pesticide application) for natural areas falls nearly to zero. Reorganization, empowerment, staffing, and funding of the Natural Areas program will be crucial to its success, and the success of stormwater and water quality management is linked to success of the Natural Areas program.

One potential funding source for improving the Natural Areas program could be found in the stormwater BMP program. A "payment in lieu of" system has been requested by the public as the last option if constructing BMPs on a development site is an impossibility (such as may be on the 16th Street mall, for example). Using the same model as is used across the country for regional wetland mitigation banks[5], it might be possible to create a mechanism where as a last resort a developer could pay to meet his stormwater BMP requirements and the monies specifically channeled to promote the Natural Areas Program. (This suggestion may be read as a "regional stormwater quality bank"; however, do not confuse this recommendation with the desire to channel water away from one site and into another. While Natural Areas will accept and filter great amounts of stormwater, using them specifically for detention or retention of conveyed storm flows is absolutely inappropriate.)

[5] See Clean Water Act Section 404 (b)(1) Guidelines regarding avoidance, minimization and lastly offsite mitigation for disturbances to wetland systems as a regulatory model to avoid increasing stormwater impacts, minimizing them through onsite BMPs, and then, as a last resort, mitigating them through increasing stormwater mitigation balanced across the watershed.

Site- and Program-Specific Fixes

Current water quality-related programs (DPW- Infrastructure Engineering, DPW-WMD, and DEH-EPD), are, as expected, under-funded, understaffed, and could communicate between each other better, but they seem to be functioning and have very competent staff. The programs that handle specific problems are ongoing, (e.g., there are procedures to identify and repair a sewer break when one is found, but new ones occur periodically due to the reality of aged infrastructure). <u>Make sure there is open communication between the wastewater operations group, the infrastructure engineers, stormwater and environmental protection people for ongoing studies into the sources of contamination and potential fixes.</u>

1. Stormwater Quality BMPs: In 2002, implementation and maintenance of post-construction stormwater BMPs became regulation for all new and reconstruction developments greater than one acre. While it would be cost prohibitive to immediately retrofit the City to deal with these stormwater issues, it is extremely important that these regulations hold the line and begin the incremental steps to achieving stormwater control for the future. Currently there is a programmatic disconnect; the DPW- Infrastructure engineers "encourage" rather than "enforce" the BMPs due to protest from developers. <u>Implementation and maintenance of post-construction stormwater retention and detention water quality BMPs needs to be enforced such as a building code standard rather than as a discretionary option.</u>

In order to make these requirements more palatable to developers, the regulatory agencies have already brainstormed incentive systems. CCD charges an impervious surface/ stormwater tax, but onsite BMP implementation is already factored into the final tax charge. Additional financial incentives may be found through reviewing the new Rate Studies Report. However, the most promising incentives include a) DPW-WMD, stormwater eagerly seeks early project partnerships with developers to plan for BMPs as soon as possible in project design (although these efforts may be undermined by the infrastructure engineering programs); and b) as has been shown repeatedly throughout the Country and our City, vegetated BMPs always increase property value of the land parcel. (I also heard reluctance to install constructed wetlands or water retention/ detention facilities because "they become West Nile Virus habitat." Part of the regulation is to keep the structures maintained, which (as will a healthy wetland ecosystem) will prevent water stagnation, mosquito breeding and risk of WNV proliferation.)

2. The US Army Corps of Engineers is considering increasing the water storage capacity in Chatfield Reservoir. <u>The Denver Water Board (see Mark Waage) would like to help CCD obtain a storage right in the new portion if the project continues (Beth, they are expecting you to be the follow-up person on this issue).</u> They believe that, because the Corps will be compelled through NEPA to review base-flow requirements as they pertain to the SPR's ecological needs, CCD may be able to secure this right at no or reduced cost if CCD also intends to designate this extra flow to ecological needs. This extra water in the system will help dilute the effects of the

Littleton/ Englewood WWTP, especially during drought years. As part of the original SPRC, a base-flow of 150 CFS *in non-drought years* was negotiated. The prospect of consistent, additional flow becomes crucial within the jurisdiction of CCD to dilute the ecological and water quality issues associated with the (non-CCD) WWTP and contaminated watershed specifically *in drought years*.

To obtain the actual water right to be stored in the potential reservoir expansion would require regional partnerships and negotiation (assuming CCD did not have the funds to purchase a new one outright.) These partnerships could potentially be with Littleton/ Englewood to reduce some of their perceived responsibility for decreased low-flow discharge water quality. Additionally, the cities downstream of Denver that use the SPR for their main drinking water resource also have a stake in improving SPR water quality. It might be more cost-effective for them to assure minimum flows through the Denver reaches rather than investing in expensive and complicated treatment plants as they use the water.

3. To respond to the fecal coliform and *E. coli* contamination, many groups participate in an egg aldering program (currently quietly in progress at Sloan's Lake). By shaking eggs and thereby destroying the next goose generation, this program reduces the unnatural resident geese population. It is not recommended that the Mayor's office specifically support such efforts, but be aware that this is an option that is currently used in some places to reduce fecal inputs at the source.

4. Sign the Confluence: Because the Confluence of Cherry Creek and the SPR is notoriously high in bacterial contamination, the issue of providing the public some kind of warning is passionately and repeatedly voiced across CCD departments. The action of signing the risk of danger in this area was approved through a memo by Mayor Webb, but it was never implemented as he left office.

Parks and Recreation and the Greenway Foundation are vehemently opposed to signing anything as a health hazardous due to the high popularity of the SPR park system. However, children and other recreationists play here in summer months when the fecals and *E. coli* concentrations are extremely high. This is a danger to public health and safety, and there are consistent anecdotal accounts of people getting sick or having rashes after coming into contact with SPR water. A negotiation could be reached through at least singing the area with a warning (not necessarily a prohibition) so that people will have enough information to choose for themselves whether a risk is warranted. (Keep in mind that much of the use is by inner-city, low income families that may not speak English or have access to CCD to report health issues.)

ATTACHMENT 1: SOUTH PLATTE RIVER STAKEHOLDERS[6] CONTACT INFORMATION

Mayor's Office
Beth Conover
Andrew Wallach, Contractor- Mayor's Office & Denver Water Department: awallden@aol.com

Denver Environmental Health
Celia Vanderloop, Deputy Manager
Alan Polonsky, Aquatic Biologist
Janet Burgesser, Water Quality Committee
Jon S. Novick, Sampling and Reporting

Denver Public Works
(Bill Vidal, Manager PW)
(Nick Skifalides, Wastewater Management)
Reza Kazemian, Wastewater Management, TV Program
Terry Baus, Wastewater Management
(Darren Wallander, WW public education/ outreach)

Lesley Thomas, City Engineer –Stormwater: 5-3021
Jim Wiseman, Stormwater
Mike Anderson, Stormwater

Denver Parks and Recreation
Bar Chadwick: 3-0645
(Kim Bailey)
Jude O'Connor: 3-0648
Gail Weinstein, Natural areas: 303-341-0115
Susan Baird

Denver Water Board: 303-628-6000, main
Ed Pokorney
Mark Waage

Colorado Department of Public Health and the Environment (CDPHE)
Cathy Dolan, Stormwater: 303-692-3596
(Susan Nachtrieb, Unit Manager- Permitting)
(Bob McConnell, Unit Manager- Monitoring: 303-692-3578)
Dick Parachini, Unit Manager; former S. Platte Watershed Coordinator: 303-692-3516
(Phil Hedgemen, TMDLs: 303-692-3518)

Urban Drainage and Flood Control District (UDFCD): 303-455-6277, main
(Scott Tucker, District Director)
Ben Urbonas, Chief Master Planning/ SPR Programs

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[6] Individuals in parenthesis are relevant contacts, but were not consulted for this report.

(John Doerfer, Project Hydrologist: 303-455-6277)

Other Agencies

EPA: 800-227-9441 Environmental Stewardship- Marc Alston; Gene Reetz,
NPDES Enforcement - Lee Hanley; Darcy O'Connor
TMDL/ Stormwater- Bruce Zander; Greg Davis; Sarah Fowler

Metro Wastewater: Barbara Biggs, 303-286-3000

(Colorado Department of Transportation)

(US Army Corps of Engineers)

(US Geological Survey)

(Denver Regional Council of Governments/ Water & Environmental Planning Committee, DRCOG)

(CO Department of Wildlife)

Public Stakeholders

Jeff Shoemaker, Greenway Foundation: 303-818-8078

Carmie McClain, Clean Water Action: 303-839-9866

Myrna Poticha, Sierra Club: 303-771-9866

Jonathan Kahn, Confluence Kayaks: 303-433-3676

(Peter Heller, Outside Magazine)

Casey Davenhill, Cherry Creek Stewardship Partners: casey@cherry-creek.org, Ph. 303-744-0613; Cell 303-507-1284

Maureen Dudley, former C&CD WQ: 303-755-5476

Greg Pratt, River Reach Use Initiative: 303-477-7238; www.riverreach.org

(Barr Lake Working Group)

Trout Unlmited

South Platte Coalition for Urban River Evaluation (SP CURE), Kathy Shugarts: 303-286-3084

ATTACHMENT 2: RELEVANT DOCUMENTS

Water Quality Data

- Environmental Protection Division, Denver Department of Environmental Health (EPD). May, 2004 (*draft*). 2002 Water Quality Assessment Report, City and County of Denver, Volume I: Rivers.

- City and County of Denver, Public Works Division, Department of Wastewater Management. March 2004. NPDES Stormwater Permit Annual Report for 2003 (CDPS Permit Number COS-000001).

Legal Documents

- Colorado Department of Health and the Environment (CDPHE). May 2002. Colorado Discharge Permit System, Municipal Stormwater Discharge City and County of Denver, Permit No. COS-000001.

- City Ordinance No. 764, November 1997. Regarding the Designation and Preservation of Natural Areas.

Previous Planning Efforts/ SPR Vision Documents

- Mayor Wellington Webb and The South Platte River Working Group. January 1995. Imperative 2000: A Vision for the South Platte River

- Denver Regional Council of Governments (DRCOG). April 1998. Metro Vision 2020: Clean Water Plan. Policies, Assessments and Management Programs.

- The Mayor's South Platte River Commission. March 1998. Annual Report: South Platte River Denver.

- The Mayor's South Platte River Commission. November 2000. Long Range Management Framework, South Platte River Denver.

- Baus, Terry- City and County of Denver, Public Works Division, Department of Wastewater Management. Spring 1996. South Platte River Water Quality Issues and Initiatives (Summary).

Ongoing Projects & Proposals

- City and County of Denver, Public Works Division, Department of Wastewater Management. January 2004. Denver Stormwater Quality Management Plan Framework.

- Urban Drainage and Flood Control District (UDFCD). December 1998. Preliminary Design Report for the Upper Central Platte Valley South Platte River

Restoration.

- Cherry Creek Stewardship Partners. December 2003. Cherry Creek Watershed "Smart Growth for Clean Water" Report.

- The Greenway Foundation, Jeff Shoemaker. June 2004. Letter Announcing Proposal for Water Quality Action Plan.

Outreach Efforts

- DEH/EPD & DPW/WMD Brochure: Pets and Water Pollution: The Scoop on Poop

- Joint Task Force Brochure Series: Clean Choices for Clean Water
    - Managing Your Construction Site
    - Caring For Your Lawn and Garden
    - Managing Your Household Wastes

General Background Resources

- Denver Urban Drainage and Flood Control District (UDFCD). 1999-2002. Urban Storm Drainage Criteria Manual, Volume 3.

- Otto, B., McCormick, K and M. Leccese. March 2004. Ecological Riverfront Design: Restoring Rivers, Connecting Communities.

- Schueler, T. and H. K. Holland, *eds*. 2002. The Practice of Watershed Protection: Techniques for protecting our nation's streams, lakes, rivers, and estuaries.

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Appendix D
Representative Stormwater BMP Maintenance Agreements

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SANITARY AND STORM SEWER EASEMENT AND INDEMNITY AGREEMENT

THIS EASEMENT AND INDEMNITY AGREEMENT ("Agreement") is made and entered into this ________ day of ____________, 20___, by and between the CITY AND COUNTY OF DENVER, a municipal corporation of the State of Colorado, hereinafter referred to as the "City", and ______________________________, a ______________________________, whose address is ______________________________________, hereinafter referred to as the "Owner".

WITNESSETH:

WHEREAS, the Owner is the owner of the property known as ____________________________ (the "Property"), described in EXHIBIT "A", attached hereto, and by this reference made a part hereof; and

WHEREAS, the Owner is constructing the project (the "Project") known as "_______________" on the Property in the location as shown on EXHIBIT "B", attached hereto, and by this reference made a part hereof. The Project will contain buildings located within the legal description set forth on Exhibit "A" which will be served by one or more privately owned sewer facilities, which will render the Owner responsible for the maintenance and service of such privately owned sewer facilities, or in the event of Owner's failure to do so, by the City at its option; and

WHEREAS, the City is a municipal corporation within which the Property is located and which currently provides emergency and other municipal services to premises within the City using the publicly owned sewer facilities; and

WHEREAS, the Owner is desirous of providing ingress and egress to the City to enable the City to provide emergency and other municipal services in, to, and over the said Property and to assure the access of any other owner within the Property to the privately owned sewer facilities as necessary; and

WHEREAS, the Owner desires to provide that the Owner and the future owners of any interest in the Property (collectively, the "Owner(s)"), shall be bound to perform the obligations set forth herein, on the conditions set forth herein; and

WHEREAS, the Owner will cause this Agreement to be recorded.

NOW, THEREFORE, in consideration of the premises and in consideration of the Owner(s): (1) being excused from the lawful requirement to construct separate connections to publicly owned sewer facilities for each individual property, and (2) receiving the benefits of emergency and other municipal services from the City, the Parties hereto agree as follows:

SECTION ONE – CONVEYANCE OF EASEMENT.

1. The Owner(s) hereby grant(s) and convey(s) a non-exclusive easement to each of the Owner(s) and to the City, for ingress and egress over private property contained within

the Project, above referred to, for purposes of providing in the Project emergency privately owned sewer facility repairs, together with any and all rights-of-way, easements or rights of ingress and egress, necessary or convenient to the Owner(s) and/or the City to accomplish such purposes. PROVIDED, HOWEVER, that in non-dedicated driveways or privately maintained systems existing within the Project, the City shall not be obligated or expected to perform any construction, re-construction, maintenance, repair, cleaning, snow removal, street lighting, traffic control or regulation or any other services on property contained within the Project which it does not or can not perform on any other private property within the City and County of Denver.

2. It is the desire of the Owner(s) that the Owners and/or the City have the use of these private driveways, to provide emergency privately owned sewer facility repairs within the Project.

3. The term Owner(s) as used herein shall be deemed to include heirs, successors, and assigns of the original Owner(s). All duties and liabilities of the Owner(s) hereunder shall be joint and several among original Owner(s), their successors, and assigns; provided that if an occurrence giving rise to a claim hereunder is proven to be proximately caused by defined action or omission by Owner(s), its agents, servants or employees which occurred during a specific period of time, then only those Owner(s) holding fee title to the Project, or any portion thereof, during such specific period of time shall be jointly and severally liable hereunder.

SECTION TWO – CONSTRUCTION AND MAINTENANCE.

4. It shall be the duty of the Owner(s) to construct, reconstruct, repair and maintain all private driveways and privately owned sewer facilities contained within the Project in such condition so as to be usable by the other Owner(s) and/or the City for provisions of services as set out herein.

5. If, in the sole opinion of the City, the private driveways or privately owned sewer facilities are not properly maintained or are closed, blocked or vacated, the City shall give notice to the Owner(s) and if repairs or corrections are not made within the time designated in such notice, the City is authorized to make or have made repairs or corrections and will charge and collect the cost thereof from the Owner(s).

6. The Owner(s) shall in no way consider or hold the City or its personnel guilty of trespass in the performance of any of the municipal services, duties or responsibilities referred to herein.

7. The Owner(s) shall neither (a) alter the Project nor (b) close, block or vacate the private driveways or privately owned sewer facilities contained within the Project so that as a result of (a) or (b) the provision of the above-stated services to the Project is rendered impassible or materially impaired.

8. The Owner(s) shall pay for and be responsible for all costs of installation and maintenance of the privately owned sewer facilities and their access fittings and associated facilities contained within the Project as determined necessary by and according to the specifications of the Department of Public Works of the City and County of Denver. While the City assumes no obligation for the maintenance or operation of such privately owned sewer facilities, in the event of a malfunction of such privately owned sewer facilities and the failure of the Owner(s) to correct the malfunction, the Owners(s) authorizes the City to make or have made the corrections or repairs and to charge and collect the cost thereof from the Owner(s), jointly and severally pursuant to Section Two, Article 5 hereof.

SECTION THREE – INDEMNITY AGREEMENT.

9. The Owner(s) agree to: defend, indemnify, and hold harmless the City, its officers, agents, and employees against any and all claims for damage to property or injuries to or death of any person or persons which may result from the City service operations at the Project, provided, however that Owner(s) need not indemnify, defend, or hold harmless the City, its officers, agents, and employees from their own negligence, recklessness, or willful misconduct. By all claims for damages this Agreement specifically includes, but it is not limited to:

   (A) Any driveway deterioration or damage on the Project.
   (B) Any structural damage to buildings contained within the Project caused by City vehicle weight or size, by vibrations generated by City vehicles, or by any other cause not specifically described.
   (C) Any damage to utilities such as water pipes, sewer pipes, gas pipes, electrical power lines, and any other communication lines, conduits, or cables.
   (D) Any damage to landscaping including but not limited to shrubbery, trees and lawn.
   (E) Any bodily injury to any person except a City employee, which is caused directly or indirectly by City service operations at the Project, or by delays or complication or prevention of provision of such services due to closure, blocking, vacation, disrepair of the private driveways or privately owned sewer facilities referred to herein.

10. The Owner(s) further agrees jointly and severally to reimburse the City for any bodily injury to City personnel, or damages to the City property caused by defective and dangerous condition of the Project.

11. It is understood that the Owner(s) intends to cause the formation of one or more Property Owner's Associations to hold title to and/or administer the use and maintenance of the private roads and streets and other common facilities contained within the Project. IT IS FURTHER UNDERSTOOD THAT THE "DECLARATION OF COVENANTS, CONDITIONS AND RESTRICTIONS" OR ANY SIMILAR INSTRUMENT FOR ANY SUCH PROPERTY OWNER'S ASSOCIATION SHALL CLEARLY STATE THAT THE PROPERTY OWNER'S HAVE JOINT AND SEVERAL FINANCIAL

RESPONSIBILITY FOR THE MAINTENANCE AND REPAIR OF SUCH PRIVATE ROADS, STREETS, SEWERS, OR OTHER DRAINAGE FACILITIES, AND THE INDEMNITY PROVISIONS OF THIS AGREEMENT. THE OWNER(S) SHALL HAVE A COPY OF SUCH DECLARATION READILY AVAILABLE IN ITS SALES FACILITY AND SHALL PROVIDE A COPY TO EACH PURCHASER AT THE TIME OF EXECUTION OF EACH SALES AGREEMENT. THE OWNER(S) SHALL ALSO RECORD THE PROPERTY OWNER'S DECLARATION WITH THE CLERK AND RECORDER OF THE CITY AND COUNTY OF DENVER, AND PROVIDE SATISFACTORY EVIDENCE OF SUCH RECORDATION TO THE CITY.

SECTION FOUR – DISPUTES.

12. Disputes regarding any aspect of this Agreement shall be resolved by administrative hearing pursuant to D.R.M.C. Section 56-106.

SECTION FIVE – AGREEMENT TO RUN WITH THE LAND.

13. The grant of easement and duties contained herein shall run with the land and shall be binding upon, jointly and severally, and shall inure to the benefit of, the parties hereto, their heirs, successors, or assigns, and the Owner(s) agrees to that upon sale of any portion of the above-described Property a copy of this Agreement will be given to the purchaser.

14. The Owner(s) agrees to the terms of this Agreement and gives evidence of its voluntary agreement by having the individual(s) below sign their name to this Agreement. The person or persons signing and executing this Agreement on behalf of the Owner(s) do hereby warrant and guarantee that he, she or they have been fully authorized by the Owner(s) to execute this Agreement on behalf of the Owner(s) and to validly and legally bind the Owner(s) to all terms, performances, provisions and conditions herein set forth.

15. This Agreement shall become effective upon its execution by the parties hereto.

16. This Agreement shall be binding upon any and all heirs, successors, assigns, or transferees of the Parties hereto and shall be considered a covenant running with the land.

SECTION SIX – NO DISCRIMINATION IN EMPLOYMENT: NO THIRD PARTY BENEFICIARIES.

17. In connection with the performance of work under this Agreement, the Owner(s) agrees not to refuse to hire, discharge, promote or demote, or to discriminate in matters of compensation against any person otherwise qualified, solely because of race, color, religion, national origin, gender, age, military status, sexual orientation, marital status, or physical or mental disability, and further agrees to insert the foregoing provision in all subcontracts hereunder.

18. It is expressly understood and agreed upon 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 City and the Owner(s), and nothing contained in this Agreement shall give or allow any such claim or right of action by any other or third person on such Agreement, including but not limited to subcontractors, sub-consultants, and suppliers. It is the express intention of the City and Owner(s) that any person other than the City or the Owners receiving services or benefits under this Agreement shall be deemed to be an incidental beneficiary only.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement as of the day and year first above written.

ATTEST:

By: ______________________________
WAYNE E. VADEN, Clerk and Recorder, Ex-Official Clerk of the City and County of Denver

CITY AND COUNTY OF DENVER

By: ______________________________
Mayor

APPROVED AS TO FORM:

COLE FINEGAN, Attorney for the City and County of Denver

By: ______________________________
Assistant City Attorney

RECOMMENDED AND APPROVED:

By: ______________________________
Manager of Public Works

REGISTERED AND COUNTERSIGNED:

By: ______________________________
Auditor

Contract Control No. ________________

"OWNER(S)"

____

By: _________________________________

____

STATE OF ________________)

CITY OF ________________)

COUNTY OF ________________)

The foregoing instrument was acknowledged before me this ________ day of ____________,

20___, by ____, as "Owner(s)".

Witness my hand and official seal.

My commission expires: ________________ ______________________________________

Notary Public

____

Address

EXHIBIT “A”
Property Legal Description

[*INSERT LEGAL DESCRIPTION FROM ENGINEER OR SURVEYOR*]

EXHIBIT "B"
Project Site Plan

[*INSERT SITE PLAN FROM ENGINEER OR SURVEYOR*]

Operation, Maintenance, and Management of Stormwater Management Systems

Produced by the:

Watershed Management Institute, Inc.
"Creating Practical Solutions for Complex Resource Challenges"

in cooperation with

Office of Water
U. S. Environmental Protection Agency
Washington D.C.

August 1997

APPENDIX 4-2

Residential Agreement to Maintain Stormwater Management Facilities and to Implement a Pollution Prevention Plan

Olympia, Washington

Drainage Design and Erosion Control Manual for Olympia, Washington

Residential Agreement to Maintain
Stormwater Management Facilities and to Implement
a Pollution Prevention Plan

The upkeep and maintenance of stormwater management facilities and the implementation of pollution prevention best management practices is essential to the protection of aquatic resources. All property owners are expected to conduct business in a manner that promotes resource protection. This Agreement contains specific provisions with respect to maintenance of stormwater management facilities and use of pollution prevention practices.

LEGAL DESCRIPTION

Whereas, the ____________ have constructed improvements, including but not limited to buildings, pavement, and stormwater management facilities on the property described above. In order to further the goals of the Jurisdiction to ensure the protection and enhancement of aquatic resources, the Jurisdiction and the ______________ hereby enter into this Agreement. The responsibilities of each party to this Agreement are identified below.

_________________________ SHALL

1. Implement the stormwater management facility maintenance program included herein as Attachment "A". (maintenance checklist similar to that developed in Chapter 7)

2. Implement the pollution prevention plan included herein as Attachment "B". (homeowner responsibilities such as disposal of household wastes, lawn care, etc.)

3. Maintain a record (in the form of a log book) of steps taken to implement the programs referenced in (1) and (2) above. The log book shall be available for inspection by appointment at ______________________________. The log book shall catalog any action taken, who took the action, when it was taken, how it was done, and any problems encountered or follow-on actions recommended. Maintenance items ("problems") listed in Attachment "A" shall be inspected as specified in the attached instructions or more often if necessary. The ___________ are encouraged to photocopy the individual checklists in Attachment "A" and use them to complete its inspections. These completed checklists would then, in combination, comprise the logbook.

4. Submit an annual report to the Jurisdiction regarding implementation of the programs referenced in (1) and (2) above. The report must be submitted on or before ______, 199_ and each calendar year and shall contain, at a minimum, the following items:

   A. Name, address, and telephone number of the businesses, the persons, or firms responsible for plan implementation, and the persons completing the report.
   B. Time period covered by the report.
   C. A chronological summary of activities conducted to implement the programs referenced in (1) and (2) above. A photocopy of the applicable sections of the logbook,

with any additional explanations needed, shall normally suffice. For any activities conducted by paid parties, include a copy of the invoice for services.

D. An outline of planned activities for the next year.

THE JURISDICTION SHALL:

1. Execute the following periodic major maintenance on the subdivision's stormwater management facilities: sediment removal from facilities, managing vegetation in wet ponds, resetting orifice sizes and elevations, and adding baffles.

2. Maintain all stormwater management facility elements in the public rights-of-way, such as catch basins, oil-water separators, and pipes.

3. Provide technical assistance to the ______________ in support of its operation and maintenance activities conducted pursuant to its maintenance and source control programs. Said assistance shall be provided upon request and as Jurisdictions time and resources permit.

4. Review the annual report and conduct a minimum of one (1) site visit per year to discuss performance and problems with the ____________.

5. Review the agreement with the ______________ and modify it as necessary at least once every three (3) years.

REMEDIES

1. If the Jurisdiction determines that maintenance or repair work is required to be done to the stormwater management facilities located in the subdivision, the Jurisdiction shall give the ___________ notice of the specific maintenance and/or repair required. The Jurisdiction shall set a reasonable time in which such work is to be completed by the persons who were given notice. If the above required maintenance and/or repair is not completed within the time set by the Jurisdiction, written notice will be sent to the ____________ stating the Jurisdiction's intention to perform such maintenance and bill the ____________ for all incurred expenses.

2. If, at any time, the Jurisdiction determines that the existing facility creates any imminent threat to public health or welfare, the Jurisdiction may take immediate measures to remedy said threat. No notice to the persons listed in Remedies (1), above, shall be required under such circumstances. All other _____________ responsibilities shall remain in effect.

3. The _______________ grant unrestricted authority to the Jurisdiction for access to any and all stormwater management facilities for the purpose of performing maintenance or repair as may become necessary under Remedies (1) and/or (2).

4. The ________________ shall assume responsibility for the cost of maintenance and repairs to the stormwater management facilities, except for those maintenance actions

explicitly assumed by the Jurisdiction in the preceding section. Such responsibility shall include reimbursement to the Jurisdiction within 90 days of the receipt of the invoice for any such work performed. Overdue payments will require payment of interest at the current legal rate for liquidated judgements. If legal action ensues, any costs or fees incurred by the Jurisdiction will be borne by the parties responsible for said reimbursements.

This Agreement is intended to protect the value and desirability of the real property described above and to benefit all the citizens of the Jurisdiction. It shall run with the land and be binding on all parties having or acquiring any right, title, or interest, or any part thereof, of real property in the subdivision. They shall inure to the benefit of each present or future successor in interest of said property or any part thereof or interest therein, and to the benefit of all citizens of the Jurisdiction.

Agreed to and signed by:

____

Owner Date

STATE OF WASHINGTON, COUNTY OF THURSTON

On this day and year, the above personally appeared before me and provided photo identification, and who executed the foregoing instrument and acknowledge that they signed the same as their free and voluntary act and deed for the uses and purposes therein mentioned.

Given under my hand and official seal this _____ day of _____________, 199__

Notary Public in and for the State of
Washington, residing in ________________
My commission expires ________________

Dated in Olympia, Washington, this _______ day of _____________, 199__

STATE OF WASHINGTON, COUNTY OF THURSTON

On this day and year, personally appearing before me, ______________________ and ______________________, who executed the foregoing instrument and acknowledge the said instrument to be the free and voluntary act and deed of said Municipal Corporation for the uses and purposes therein mentioned and on oath states he is authorized to execute said instrument.

Given under my hand and official seal this _____ day of _____________, 199__

Notary Public in and for the State of
Washington, residing in ________________
My commission expires ________________

Dated in Olympia, Washington, this _______ day of _____________, 199__

APPENDIX 4-3

Commercial, Industrial Agreement to Maintain Stormwater Management Facilities and to Implement A Pollution Prevention Plan

Olympia, Washington

Drainage Design and Erosion Control Manual for Olympia, Washington

Commercial, Industrial Agreement to Maintain Stormwater Management Facilities and to Implement A Pollution Prevention Plan

The upkeep and maintenance of stormwater management facilities and the implementation of pollution prevention plans is essential to the protection of aquatic resources. All property owners are expected to conduct business in a manner that promotes resource protection. This Agreement contains specific provisions with respect to maintenance of stormwater management facilities and use of pollution prevention practices.

LEGAL DESCRIPTION:

Whereas, Business Name, has constructed improvements, including but not limited to, buildings, pavement, and stormwater management facilities on the property described above. In order to further the goals of the Jurisdiction to ensure the protection and enhancement of Jurisdiction's aquatic resources, the Jurisdiction and Business Name hereby enter into this Agreement. The responsibilities of each party to this Agreement are identified below.

BUSINESS NAME SHALL:

1. Implement the stormwater management facility maintenance program included herein as Attachment "A". (maintenance checklist similar to that developed in Chapter 7)

2. Implement the pollution prevention plan included herein as Attachment "B". (parking lot maintenance, covering outdoor storage areas, etc.)

3. Maintain a record (in the form of a logbook) of steps taken to implement the programs referenced in (1) and (2) above. The logbook shall be available for inspection by Jurisdiction staff at ________________ during normal business hours. The logbook shall catalog the action taken, who took it, when the action was done, how it was done, and any problems encountered or follow-on actions recommended. Maintenance items ("problems") listed in Attachment "A" shall be inspected on a monthly or more frequent basis as necessary. Business Name is encouraged to photocopy the individual checklists in Attachment "A" and use them to complete its monthly inspections. These completed checklists would then, in combination, comprise the monthly logbook.

4. Submit an annual report to the Jurisdiction regarding implementation of the programs referenced in (1) and (2) above. The report must be submitted on or before ________ of each calendar year and shall contain, at a minimum, the following items:

   A. Name, address, and telephone number of the business, the person, or the firm responsible for plan implementation, and the person completing the report.
   B. Time period covered by the report.
   C. A chronological summary of activities conducted to implement the program referenced in (1) and (2) above. A photocopy of the applicable sections of the logbook, with any

additional explanation needed, shall normally suffice. For any activities conducted by paid parties not affiliated with Business Name include a copy of the invoice for services.

D. An outline of planned activities for the next year.

THE JURISDICTION SHALL:

1. Provide technical assistance to Business Name in support of its operation and maintenance activities conducted pursuant to its maintenance and pollution prevention control programs. Said assistance shall be provided upon request, and as Jurisdiction time and resources permit, at no charge to Business Name.

2. Review the annual report and conduct a minimum of one (1) site visit per year to discuss performance and problems with Business Name.

3. Review this agreement with Business Name and modify it as necessary at least once every three (3) years.

REMEDIES

1. If the jurisdiction determines that maintenance or repair work is required to be done to the stormwater management facility existing on the Business Name property, the Jurisdiction shall give the owner of the property within which the facility is located, and the person or agent in control of said property, notice of the specific maintenance and/or repair required. The Jurisdiction shall set a reasonable time in which such work is to be completed by the persons who were given notice. If the above required maintenance and/or repair is not completed within the time set by the Jurisdiction, written notice will be sent to the persons who were given notice stating the Jurisdiction's intention to perform such maintenance and bill the owner for all incurred expenses. The Jurisdiction may also revoke stormwater runoff utility rate credits for the quality component or invoke surcharges to the quantity component of the Business Name bill if required maintenance is not performed.

2. If at any time the Jurisdiction determines that the existing facility creates any imminent threat to public health or welfare, the Jurisdiction may take immediate measures to remedy said threat. No notice to the persons, listed in (1) above, shall be required under such circumstances.

3. The owner grants unrestricted authority to the Jurisdiction for access to any and all stormwater management facility features for the purpose of performing maintenance or repair as may become necessary under Remedies (1) and (2).

4. The persons, listed in (1) above, shall assume all responsibility for the cost of any maintenance and for repairs to the stormwater management facility. Such responsibility shall include reimbursement to the Jurisdiction within 30 days of the receipt of the invoice for any such work performed. Overdue payments will require payment of interest at the current legal rate for liquidated judgments. If legal action ensues, any costs or fees incurred by the Jurisdiction will be borne by the parties responsible for said reimbursements.

5. The owner hereby grants to the Jurisdiction a lien against the above-described property in an amount equal to the cost incurred by the Jurisdiction to perform the maintenance or repair work described herein.

This Agreement is intended to protect the value and desirability of the real property described above and to benefit all the citizens of the Jurisdiction. It shall run with the land and be binding on all parties having or acquiring from Business Name or their successors any right, title, or interest in the property or any part thereof, as well as their title, or interest in the property or any part thereof, as well as their heirs, successors, and assigns. They shall inure to the benefit of each present or future successor in interest of said property or any part thereof, or interest therein, and to the benefit of all citizens of the Jurisdiction.

Agreed to and signed by:

____

Owner   Date

STATE OF WASHINGTON, COUNTY OF THURSTON

On this day and year, the above personally appeared before me and provided photo identification, and who executed the foregoing instrument and acknowledge that they signed the same as their free and voluntary act and deed for the uses and purposes therein mentioned.

Given under my hand and official seal this _____ day of _____________, 199__

Notary Public in and for the State of
Washington, residing in ________________
My commission expires ________________

Dated in Olympia, Washington, this _______ day of _____________, 199__

STATE OF WASHINGTON, COUNTY OF THURSTON

On this day and year, personally appearing before me, ______________________ and ______________________, who executed the foregoing instrument and acknowledge the said instrument to be the free and voluntary act and deed of said Municipal Corporation for the uses and purposes therein mentioned and on oath states he is authorized to execute said instrument.

Given under my hand and official seal this _____ day of _____________, 199__

Notary Public in and for the State of
Washington, residing in ________________
My commission expires ________________

Dated in Olympia, Washington, this _______ day of _____________, 199__

APPENDIX 4-4

Standard Maintenance and Monitoring Agreement

BMP Facilities Maintenance/Monitoring Agreement

City of Alexandria, Virginia

City of Alexandria, Virginia

Standard Maintenance and Monitoring Agreement
BMP Facilities Maintenance/Monitoring Agreement

THIS AGREEMENT, made and entered into this ___________ day of ____________, 19__, by and between ________________________________, herein called the "Landowner" and the City of Alexandria, Virginia (the "City")

WITNESSETH

WHEREAS the Landowner is the owner of certain real property described ________________ as acquired by deed in the land records of the City of Alexandria, Virginia, Deed Book _______ at Page __________, hereinafter called the "Property".

WHEREAS, the Landowner is proceeding to build on and develop the property; and

WHEREAS, Plan of Development/Site Plan/Subdivision Plan ________________, hereinafter called the "Plan" which is expressly made a part hereof, as approved or to be approved by the City, provides for detention on-site treatment of stormwater runoff within the confines of the property; and

WHEREAS, the City and the Landowner, its successors and assigns agree that the health, safety, and welfare of the residents of the City of Alexandria, Virginia, require that on-site stormwater management facilities be constructed and maintained on the property; and

WHEREAS, the City requires that on-site stormwater management facilities as shown on the Plan be constructed and adequately maintained by the Landowner, its successors and assigns.

NOW, THEREFORE, in consideration of the foregoing premises, the mutual covenants contained herein, and the following terms and conditions, the parties hereto agree as follows:

1. The on-site stormwater management facilities shall be constructed by the Landowner, its successors and assigns, in accordance with the plans and specifications identified in the plans.

2. The Landowner, its successors and assigns, shall maintain the stormwater management facilities in good working condition, acceptable to the City, so that they are performing their design functions.

3. The Landowner, its successors and assigns, hereby grants permission to the City, its authorized agents and employees, to enter upon the property, and to inspect the stormwater management facilities whenever the City deems necessary. The purpose of the inspection is to assure safe and proper functioning of the facilities. The inspection shall cover the entire facilities, berms, outlet structures, pond areas, access roads, etc.

When deficiencies are noted, the City shall give the Landowner, its successors and assigns, copies of the inspection report with findings and evaluations.

4. In the event the Landowner, its successors and assigns, fails to maintain the stormwater management facilities in good working condition acceptable to the City, the City may enter upon the Property and take whatever steps it deems necessary to maintain said stormwater management facilities and to charge the costs of the repairs to the Landowner, its successors and assigns. This provision shall not be construed to allow the City of Alexandria to erect any structure of a permanent nature on the land of the Landowner, outside of an easement belonging to the City. It is expressly understood and agreed that the City is under no obligation to maintain or repair said facilities, and in no event shall this Agreement be construed to impose any such obligation on the City.

5. The Landowner, its successors and assigns, will perform maintenance in accordance with the maintenance schedule for the stormwater management facilities including sediment removal as outlined on the approved plans and the following specific requirements:

   For extended dry detention facilities, wet ponds, or infiltration facilities, insert the following:

   Maintenance of the (Insert type of facility) shall conform to the maintenance requirements contained in the Northern Virginia BMP Handbook published by the Northern Virginia Planning District Commission.

   For unconventional BMPs for which design criteria is provided in the Design Manual, insert the following:

   Maintenance of the (insert type of facility) shall conform to the maintenance requirements contained in Chapter 2 of the Alexandria Supplement to the Northern Virginia BMP Handbook.

   For unconventional BMP's not detailed in Chapter 2 of this manual and for experimental BMP's, insert specific maintenance requirements as approved by the Director of Transportation and Environmental Services prior to release of the Final Site Plan.

6. In the event the City, pursuant to this Agreement, performs work of any nature, or expends any funds in performance of said work for labor, use of equipment, supplies, materials, and the like on account of the Landowner's or its successors' and assigns, shall reimburse the City upon demand, within ______ days of receipt thereof for all costs incurred by the City hereunder. If not paid within such ______ day period, the City shall have a lien against the property in the amount of such costs, plus interest at the Judgment Rate, and may enforce same in the same manner as a lien for real property taxes may be enforced.

7. The Landowner, its successors and assigns, shall indemnify and hold harmless the City and its agents and employees for any and all damages, accidents, casualties, occurrences or claims which might arise or be asserted against the City for the construction, presence, existence or maintenance of the stormwater management facilities by the Landowner, its successors and assigns.

   In the event a claim is asserted against the City, its agents or employees, the City shall promptly notify the Landowners, their successors and assigns, and they shall defend, at their own expense, any suit based on such claim. If any judgment or claims against the City, its agents or employees shall be allowed, the Landowner, its successors and assigns shall pay all costs and expenses in connection therewith.

   The following additional paragraph shall be added for all agreements covering non-conventional or experimental BMP's.

8. The Landowner, its successors and assigns, hereby grants permission to the City, its authorized agents and employees, and to the Northern Virginia Planning District Commission, its authorized agents, employees and consultants, to enter upon the property, and to install, operate and maintain equipment to monitor the flow rate and pollutant content of the input flow, the effluent, and at intermediate points in the BMP. The Landowner further agrees to design and construct the facility to provide access for monitoring. The Landowner further agrees to a contribution of (as established during the Site Plan approval process ______ in the case of experimental BMP's) the entire cost of the monitoring program, payable prior to the release of the Final Site Plan, towards the cost of the monitoring program.

8\. or 9. This Agreement shall be recorded among the land records of the City of Alexandria, Virginia, and shall constitute a covenant running with the land and/or equitable servitude, and shall be binding on the Landowner, its administrators, executors, assigns, heirs and any other successors in interests.

WITNESS the following signatures and seals:

____

(Landowner) (Seal)

By:____

____

Type Name

____

Type Name

ATTEST:

____

STATE OF ______________

CITY OF ______________

I, ____________________________, a Notary Public in and for the City and State aforesaid, whose commission expires on the ______ day of ______________, 19___, do hereby certify that ____________________________ whose name(s) is/are signed to the foregoing Agreement bearing date of the ______ day of ____________, 19___, has acknowledged the same before me in my said City and State.

GIVEN UNDER MY HAND THIS _____ day of _______________, 19___.

____
NOTARY PUBLIC

WITNESS the following signatures and seals:

____

Director, Department of T & ES (Seal)

By: ______________________________________

____
Type Name

____
Type Name

ATTEST:

____

STATE OF ______________

CITY OF ______________

I, ____________________________, a Notary Public in and for the City and State aforesaid, whose commission expires on the ______ day of ______________, 19___, do hereby certify that ____________________________ whose name(s) is/are signed to the foregoing Agreement bearing date of the ______ day of ____________, 19___, has acknowledged the same before me in my said City and State.

GIVEN UNDER MY HAND THIS _____ day of _______________, 19___.

____
NOTARY PUBLIC

KENT WASHINGTON	CITY OF KENT DEVELOPMENT ASSISTANCE BROCHURE	5-17

DECLARATION OF STORMWATER FACILITY MAINTENANCE COVENANT

This *City Of Kent Development Assistance Brochure* (hereinafter *DAB*) contains a sample of the above-referenced document for the perusal of the reader. The actual document will be prepared by the Property Management Section of the Department of Public Works upon receipt of a recent title report and a copy of the deed for all parcels within the development.

DECLARATION OF STORMWATER FACILITY MAINTENANCE COVENANT

IN CONSIDERATION OF the City of Kent ("City") approval for: ____________________________ relating to real property legally described on Exhibit A, which is attached hereto and incorporated by this reference, the undersigned Grantor(s) declares that the above-described property is subject to a privately maintained stormwater drainage, detention, and/or stormwater treatment system (the, "Stormwater Facilities"), and also covenants and agrees as follows:

DUTIES OF GRANTOR(S):

1. Grantor(s) shall regularly inspect and maintain/repair the private Stormwater Facilities on the said-described property in accordance with the standards specified in the City's Construction Standards, specifically including Appendix D ("Maintenance Requirements for Privately Maintained Drainage Facilities"), as now collectively enacted or hereafter amended, which are incorporated by this reference as if fully set forth herein (the, "City Construction Standards").

2. Grantor(s) shall inspect the Stormwater Facilities as often as conditions require, but in any event at least once each year. Grantor(s) shall, within four weeks after each inspection, maintain / repair the Stormwater Facilities as required by the City Construction Standards.

3. Grantor(s) shall inspect each element of the Stormwater Facilities whenever the City's Public Works Director ("Director"), in his/her sole discretion, determines that unacceptable conditions exist within or adjoining to the Stormwater Facilities. Similarly, the Director, in his/her sole discretion, may require the Grantor(s) to complete the maintenance / repair of the Stormwater Facilities within a shorter time period than allowed in Section 2, above.

4. Grantor(s), in effecting this maintenance/repair, shall restore the Stormwater Facilities to like new condition, or if that is not practical, to an acceptable condition to the extent listed and/or described in the City Construction Standards.

5. Grantor(s) is hereby required to obtain written approval from the Director prior to grading, filling, piping, cutting or removing vegetation (except for routine and minor landscape maintenance) in open vegetated drainage facilities (such as biofiltration swales, channels, ditches, ponds, etc.) or performing any alterations or modifications to the Stormwater Facilities. Grantor(s) shall obtain all necessary permits and provide all required land surveys as required by the City Construction Standards.

6. Grantor(s) shall assume all responsibility for the implementation and cost of any maintenance and/or repairs to the Stormwater Facilities.

RIGHTS OF THE CITY:

1. The City shall have ingress and egress rights to the said-described property for inspection and monitoring of the Stormwater Facilities in order to determine performance, operational flows or defects in the Stormwater Facilities, all in accord with the City Construction Standards.

2. If the City determines that, pursuant to the City Construction Standards, the Stormwater Facilities require maintenance and/or repair work, the Director shall deliver written notice to the Grantor specifically describing the required maintenance and/or repair. The notice shall also set a reasonable time in which Grantor must complete the described work. The notice shall also state that the City or its authorized agent may perform the authorized maintenance and/or repair if the Grantor(s) fails to complete the maintenance and/or repair within the time allowed.

3. If the Grantor(s) does not complete the required maintenance and/or repair within the time allowed as set forth in the Director's notice, the City or its authorized agent will not commence the maintenance and/or repair work described in the Director's notice until at least seven (7) calendar days after the expiration of the time allotted to Grantor to make the maintenance and/or repair. However, if the Director determines, at his or her sole discretion, that an imminent danger exists, the City's obligation to provide written notice shall be deemed waived, and the City or its authorized agent may immediately begin the required maintenance and/or repair work.

4. If the City or its authorized agent performs the required maintenance and/or repairs to the Stormwater Facilities, Grantor(s) shall reimburse the City all its costs incurred in completing the maintenance and/or repairs within thirty (30) calendar days of Grantor's receipt of the City's invoice for that work. Overdue payments shall accrue interest at the rate of twelve percent (12%) per annum.

5. If the Director determines, in his/her sole discretion, that the Stormwater Facilities, if originally constructed in accordance with the City's approved design, need further modifications, Grantor(s) authorizes the City to enter the Stormwater Facilities property in order to make these modifications.

Any notice or consent required to be given or otherwise provided for by the provisions of this agreement shall be effective either upon personal delivery or three (3) calendar days after mailing by Certified Mail, return receipt requested.

This Covenant is intended to protect the value and desirability of the property described above, including the larger parcel(s), if any, benefited by the Stormwater Facilities. Further, this Covenant shall inure to the benefit of all the citizens of the City and shall bind Grantor(s), and its heirs, successors and assigns.

STATE OF GEORGIA **CITY OF GRIFFIN**

Maintenance Agreement

WHEREAS, the Property Owner ____
recognizes that the wet or extended detention facility or facilities (hereinafter referred to as "the facility" or "facilities") must be maintained for the development called, ________________________, located in Land Lot(s) ______,District(s) _______ , of the City of Griffin, Spalding County, Georgia; and,

WHEREAS, the Property Owner is the owner of real property more particularly described on the attached Exhibit A as recorded by deed in the records of the Clerk of Superior Court of Spalding County in Deed Book _____________ at Page(s) _________ (hereinafter referred to as "the Property"), and,

WHEREAS, The City of Griffin (hereinafter referred to as "the City") and the Property Owner, or its administrators, executors, successors, heirs, or assigns, agree that the health, safety and welfare of the citizens of the City require that the facilities be constructed and maintained on the property, and,

WHEREAS, the Development Regulations require that facility or facilities as shown on the approved development plans and specifications be constructed and maintained by the Property Owner, its administrators, executors, successors, heirs, or assigns.

NOW, THEREFORE, in consideration of the foregoing premises, the mutual covenants contained herein, and the following terms and conditions, the parties hereto agree as follows:

SECTION 1.

The facility or facilities shah be constructed by the Property Owner in accordance with the plans and specifications for the development.

SECTION 2.

The Property Owner, its administrators, executors, successors, heirs or assigns shah maintain the facility or facilities in good working condition acceptable to the City and in accordance with the schedule of long term maintenance activities agreed hereto and attached as Exhibit B.

SECTION 3.

The Property Owner, its administrators, executors, successors, heirs or assigns hereby grants permission to the City, its authorized agents and employees, to enter upon the property and to inspect the facilities whenever the City deems necessary. Whenever possible, the City shall provide notice prior to entry. The Property Owner shall execute a twenty five (25) foot public access easement in favor of the City of Griffin to allow the City to inspect, observe, maintain, and repair the facility as deemed necessary. A fully executed original easement is attached to this Agreement as Exhibit C and by reference made a part hereof.

SECTION 4.

In the event the Property Owner, its administrators, executors, successors, heirs or assigns fails to maintain the facility or facilities as shown on the approved plans and specifications in good working order acceptable to the City and in accordance with the maintenance schedule incorporated in this Agreement, the City, with due notice, may enter the property and take whatever steps it deems necessary to return the facility or facilities to good working order. This provision shall not be construed to allow the City to erect any structure of a permanent nature on the property. It is expressly understood and agreed that the City is under no obligation to maintain or repair the facility or facilities and in no event shall this Agreement be construed to impose any such obligation on the City.

SECTION 5.

In the event the City, pursuant to the Agreement, performs work of any nature, or' expends any funds in the performance of said work for labor, use of equipment, supplies, materials, and the like, the Property Owner shall reimburse the City, or shall forfeit any required bond upon demand within thirty (30) days of receipt thereof for all the costs incurred by the City hereunder. If not paid within the prescribed time period, the City shall secure a lien against the real property in the amount of such costs. The actions described in this section are in addition to and not in lieu of any and all legal remedies available to the City as a result of the Property Owner's failure to maintain the facility or facilities.

SECTION 6.

It is the intent of this agreement to insure the proper maintenance of the facility or facilities by the Property Owner; provided, however, that this Agreement shall not be deemed to create or effect any additional liability of any party for damage alleged to result from or caused by stormwater runoff.

SECTION 7.

Sediment accumulation resulting from the normal operation of the facility or facilities will be catered for. The Property Owner will make accommodation for the removal and disposal of all accumulated sediments. Disposal will be provided onsite in a reserved area(s) or will be removed from the site. Reserved area(s) shall be sufficient to accommodate for a minimum of two dredging cycles.

SECTION 8.

The Property Owner shall provide the City with a bond or a letter of credit providing for the maintenance of the facility or facilities for a period of not less than ten years from the date of execution of this Agreement. The bond or letter of credit shall be in the amount of fifty percent (50%) of the construction costs of the facility or facilities pursuant to Section 8.7.5 of the City's Development Regulations concerning Maintenance Agreements-A copy of the bond or letter of credit is attached to this Agreement as Exhibit D and by reference made a part thereof.

SECTION 9.

The Property Owner shall use the standard SMP Operation and Maintenance Inspection Report attached to this agreement as Exhibit E and by this reference made a part hereof for the purpose of a minimal annual inspection of the facility or facilities by a qualified inspector.

SECTION 10.

The Property Owner, its administrators, executors, successors, heirs and assigns hereby indemnifies and holds harmless the City and its authorized agents and employees for any and all damages, accidents, casualties, occurrences or claims which might arise or be asserted against the City from the construction, presence, existence or maintenance of the facility or facilities by the Property Owner or the City. In the event a claim is asserted against the City, its authorized agents or employees, the City shall promptly notify the Property Owner and the Property Owner shall defend at its own expense any suit based on such claim. If any judgment or claims against the City, its authorized agents or employees shall be allowed, the Property Owner shall pay for all costs and expenses in connection herewith.

SECTION 11.

This Agreement shall be recorded among the deed records of the Clerk of Superior Court of Spalding County and shall constitute a covenant running with the land and shall be binding on the Property Owner, its administrators, executors, heirs, assigns and any other successors in interest.

SECTION 12.

This Agreement may be enforced by proceedings at law or in equity by or against the parties hereto and their respective successors in interest.

SECTION 13.

Invalidation of any one of the provisions of this Agreement shall in no way effect any other provisions and all other provisions shall remain in full force and effect.

MAINTENANCE AGREEMENT

SO AGREED this ______________ day of ________________19_________.

PROPERTY OWNER

____

BY: ______________________________ Attest:____________________________

Title: _____________________________ Title: ____________________________

Approved as to form:

By: _______________________________ Date: ____________________________
Assistant City Attorney

GRIFFIN, GEORGIA

Attest: ____________________________ By: ______________________________
Deputy County Clerk Chairman, Board of Commissioners

(SEAL)

Attachments: Exhibit A (Plat and Legal Description)
Exhibit B (Maintenance and Inspection Schedule)
Exhibit C (Access Easement)
Exhibit D (Standard SMP Operation and Maintenance Inspection Report)

CITY OF GRIFFIN

SMP Facility Operation and Maintenance Inspection Report for Pond Facilities
(THIS MAY BE USED AS A TEMPLATE FOR OTHER SMPs)

Inspector Name____________________ Community____________________

Inspection Date ____________________ Address ____________________

Type of SMP ____

Watershed ____________________ Tax Map____________________

ITEM INSPECTED	CHECKED		MAINTENANCE		OBSERVATIONS & REMARKS
	Yes	No	Reqd.	Not Regd.	
I. Pond Facilities A. Pond Dam Embankments and Emergency Spillways					
1. Vegetation and Ground Cover Adequate					
2. Surface Erosion					
3. Animal Burrows					
4. Unauthorized Planting					
5. Cracking, Bulging, or Sliding of Dam					
a. Upstream Face					
a. Downstream Face					
b. At or Beyond Toe Upstream Downstream					
c. Emergency Spillway					
6. Pond, Toe,& Chimney Drains Clear & Funct.					
7.					
8. Seeps/Leaks on Downstream Face					
9. Slope Protection or Riprap Failures					
10. Vertical and Horizontal Alignment of Top of Dam as Per "As-built" Plans.					

11. Emergency Spillway Clear of Obstructions and Debris.					
12. Other (Specify)					
B. Riser and Principal Spillway Type: Reinforced Concrete __ Corrugated Pipe _____ Masonry ___________ * Indicates Dry Ponds Only 1. *Low Flow Orifice Obstructed					
2. *Low Flow Trash Rack					
a. Debris Removal Necessary b. Corrosion Control					
3. Weir Trash Rack Maintenance					
a. Debris Removal Necessary b. Corrosion Control					
4. Excessive Sediment Accumulation Inside Rider					
5. Concrete/Masonry Condition Riser & Barrels					
a. Cracks or Displacement b. Minor Spalling (<1*) c. Major Spalling (Rebars Exposed) d. Joint Failures e. Water Tightness					
6. Metal Pipe Condition					
7. Control Valve					
a. Operational/Exercised b. Chained and Locked					
8. Pond Drain Valve					
a. Operational/Exercised b. Chained and Locked					
9. Outfall channels					
10. Functioning					
11. Other (Specify)					

C. Permanent Poll – Wet Ponds 1. Undesirable Vegetative Growth 2. Floating or Floatable Debris Removal Required 3. Visible Pollution 4.					

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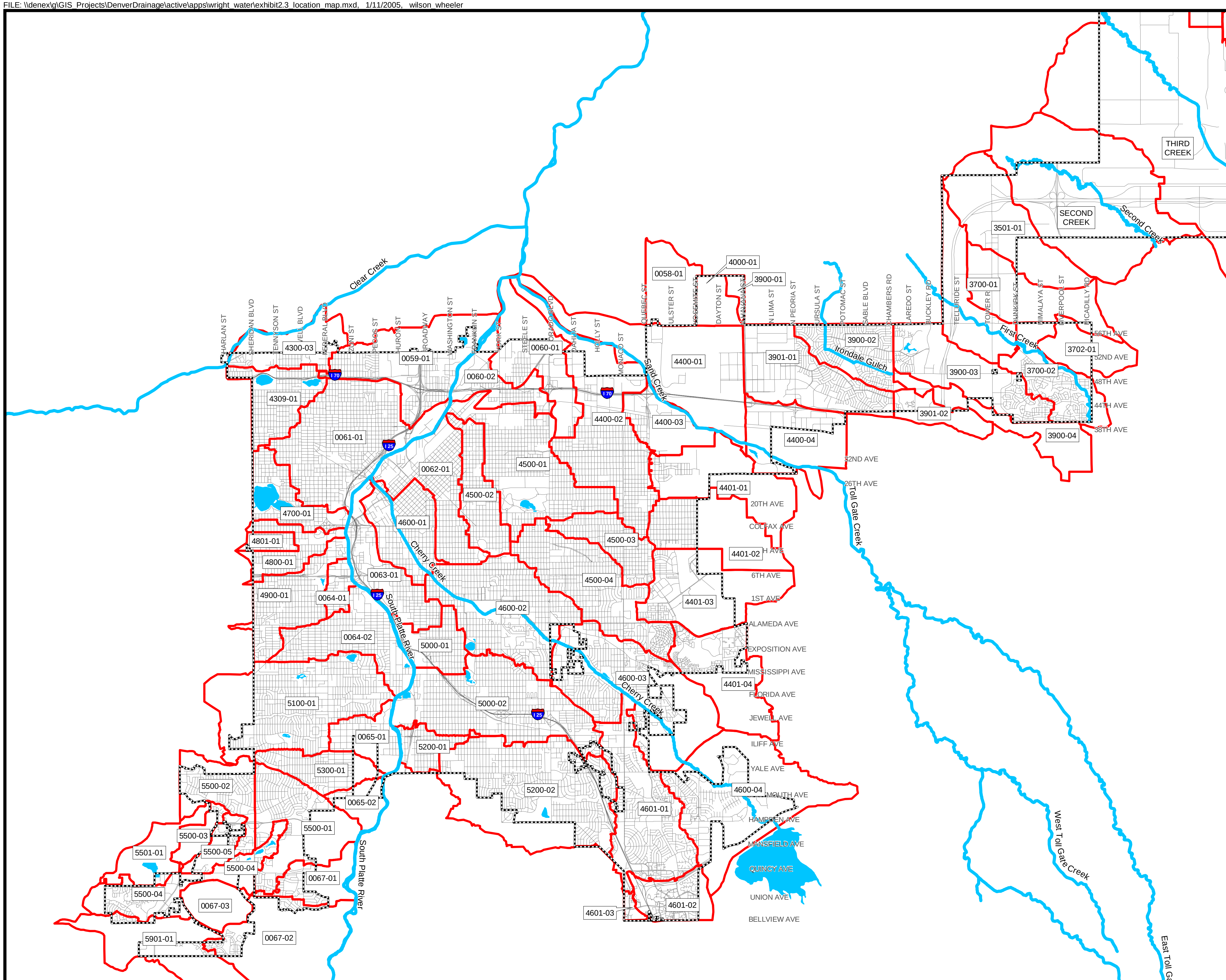

Exhibit 2.3
Drainage Basins Location Map

Legend

- Lake
- Streets-Interstates
- Rivers/Creeks
- City & County of Denver Storm Basins
- County Boundary

0 1 2 Miles

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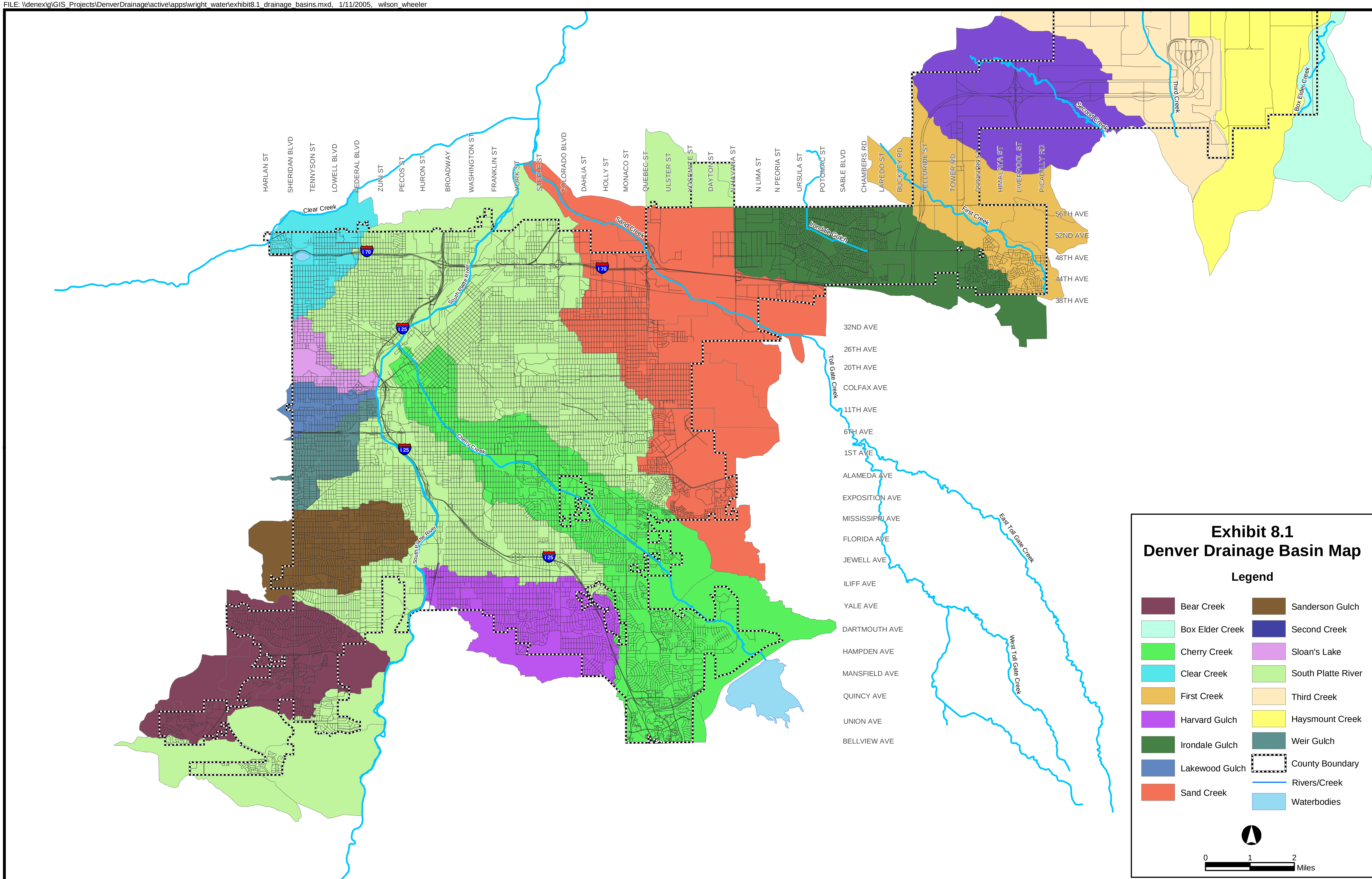

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