Chapter 6

URBAN AND CONSTRUCTION Management Program

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Water Quality Control Division

Prepared in Cooperation with the
Colorado Nonpoint Source Council
Urban and Construction Committee

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The urban and construction elements of Colorado's nonpoint source management program are contained in this chapter of the *Colorado Nonpoint Source Management Program*. Urban development, associated construction activities and highway construction throughout Colorado contribute nonpoint source pollutants and cause nonpoint source pollution.

The State of Colorado is facing significant challenges due to the pressures of increased employment and population. Colorado has experienced in-ward migration over the last several decades, and this pattern is forecasted to continue into the short- and medium-term future. In addition, the past migrant populations will play a continued role in the population growth of Colorado, especially in the Denver metropolitan region. The in-ward migration pattern is projected to remain constant during the next two decades (approximately 50,000 person per year). At the same time natural population growth (births minus deaths) continues to increase.

Specifically, the Colorado population was estimated to be 4,016,300 in July 1998. The Denver metropolitan region population was estimated at 2,259,800 during the same time period. The Colorado population is projected to reach over 5,547,600 person in the year 2020 with over 3.2 million people in the Denver metropolitan region. Based on an average household size of 2.5 person, 1.3 million more housing units (66,000 housing units per year) will be needed for this population increase.

About 80 percent of Colorado's population lives in or around major urban centers, with 56 percent of the state's population living in the Denver Metropolitan region. This development pattern has concentrated the construction activities into these discrete areas, and also increased the nonpoint source and stormwater loading potential within the urban centers. The Colorado urban and construction nonpoint source management program has been developed by the Water Quality Control Division in cooperation with the Colorado Nonpoint Source Council to address the growth expectations and development patterns in Colorado.

II. URBAN AND CONSTRUCTION PROBLEM IDENTIFICATION

Urban Hydrology

Land use patterns are changed with the introduction of urbanization. Residential, commercial and industrial uses replace open space with various structures and associated infrastructures. These types of land use can severely disrupt the natural landscape, replacing it with impervious surfaces and altering the hydrologic flow regimes. Runoff from storm events flows more rapidly from these surfaces, much less infiltration occurs. Altering infiltration changes baseflow; in some cases baseflow is increased by lawn irrigation practices or other forms of dry weather discharge. The South Platte River through the Denver region is a good example of these changes. Prior to the major urbanization of the late 1800's, the river was intermittent and went dry during the fall. The South Platte River now has year-round flows, due in part to the increased baseflow from urbanized areas.

Hydrologic impacts due to urbanization may also cause water quality problems such as nutrient enrichment, chemical pollutants, turbidity and increased temperatures and sedimentation, which in turn may cause loss of fish populations or reduced recreational opportunities. Widespread water quality data has demonstrated that these problems are associated with increased runoff volumes and velocities from urbanization because of increased watershed imperviousness. Changes in flow regimes can cause increased frequency of flooding and peak flow volumes, increased sediment loading, loss of aquatic/riparian habitat, changes in stream physical characteristics (channel width and depth) and decreased base flow.

Urbanization causes increased stormwater runoff, which is more intense, has a higher volume and has less residual runoff than natural runoff regimes. This change in the runoff hydrology requires urban areas to develop stormwater drainage systems to avoid flood damage. These systems are designed to accumulate runoff from certain larger, less frequent storms (i.e., 5-year, 10-year) and transmit the flows away from the urban area. The quality of this runoff was not an issue in the design criteria until recently. In many cases, the stormwater systems were used as a convenient method of disposing of undesirable materials.

It is important to remember that not all urban runoff is polluted. The severity of pollution in receiving water is related to the beneficial uses assigned to the waterbody by the regulating agencies within Colorado. The beneficial uses of water in Colorado are classified as Water Supply, Agriculture, Aquatic Life (Warm and Cold Water) and Recreation. Urban runoff quality is assessed against established standards and classifications. Many stream segments in urban areas of Colorado have site-specific water quality standards and classifications. Consequently, streams or rivers flowing through urban centers (e.g., the South Platte River in the Denver metropolitan region or Fountain Creek in Colorado Springs) with multiple segmentation will have differing sets of standards and classifications. Water quality parameters can be identified as

pollutants in one segment, but they are not pollutants in the next contiguous downstream segment. This factor also makes pollutant characterization in urban areas more difficult.

National Urban Runoff Program

The National Urban Runoff Program (USEPA 1983), which included the Denver Regional Urban Runoff Program (DRCOG 1983) showed urbanization can produce high concentrations and loads of potential urban runoff and construction related pollutants and pollution. These studies showed runoff discharged from residential and urban streets, roofs, lawns, open space, impervious surfaces and other areas during storm events and under dry weather conditions carried a wide variety of chemical and biological components. The chemical and biological constituent loads increased with passage through urban drainage systems and excessive accumulated amounts caused pollution of selected receiving waters, including streams, rivers, lakes, reservoirs and aquifers. The national program concluded that a major pollutant source to rivers, streams, reservoirs and lakes was derived from non-storm loading (dry weather flow) from drainage systems within major urban regions.

In 1983, the Denver Regional Council of Governments completed the Denver Regional Urban Runoff Program (DRURP), which studied the nature of urban runoff, its influence on receiving waters and possibilities for control in the Denver region. These study results are generally applicable to urban centers throughout Colorado. The study showed nonpoint source urban runoff, resulting from storm events and dry weather flow conditions, produced a large portion of the annual load of total suspended solids and total lead with significant quantities of sediment, organic matter, trace metals and bacteria also introduced into metropolitan waterbodies.

Quantities of these pollutants often exceeded quantities discharged into streams and rivers from municipal point sources. Pollutant loads and concentrations transported in urban runoff have the potential to effect receiving water quality to various degrees. However, these loads are associated with intermittent flows for short durations of time and their affect on designated beneficial uses is not fully demonstrated.

The DRURP also described the quality and loading of urban runoff from several representative land uses in the region. This study found various land uses (commercial, single-family residential, multifamily residential, mixed-use) contribute significant and varying amounts of pollutants to stormwater runoff. Consequently, land uses are characterized by pollutant specific event mean concentrations (EMCs). In an urban context, construction runoff with associated erosion components and runoff associated with urban activity was and has remained as the primary area of concern. In relation to urban lake management, the major controllable nonpoint source parameter is phosphorus. Nitrate is a growing parameter of concern in lake and reservoir management programs.

There are two general types of impacts to receiving water quality: acute and accumulative. Acute affects are generally caused by single runoff events of short duration. Accumulative or chronic effects are associated with long-term accumulations of mass pollutants and concentrations under persistent or chronic loading conditions, which can be associated with non-storm event urban runoff during dry weather periods. To deal with these types of impacts the Colorado Water Quality Control Commission (WQCC) has adopted water quality criteria based acute and chronic standards.

Urban runoff pollution and its control have received a considerable amount of investigation and evaluation since the 1983 NURP and DRURP studies. In Colorado, new procedures have been devised for estimating urban runoff pollutant loads. Control programs have been adopted in the major urban areas of Colorado. Best management practices (BMPs) for urban runoff have focused on improving stormwater quality, while meeting storm drainage criteria. Many BMPs in use in Colorado have been adjusted to accommodate western hydrologic and geographic conditions.

Urban runoff pollution and pollutants

Heavy metals (especially copper, lead and zinc) are by far the most prevalent priority pollutant constituents found in urban runoff. Copper, lead and zinc appear to pose a significant threat to aquatic life uses in some areas of Colorado. Copper is suggested to be the most significant of the three metals. The removal of leaded gasoline has reduced the risk of lead as a significant threat to aquatic life uses.

Some of the metals are present in high enough concentrations and at a frequency to be potential threats to beneficial uses assigned to waters flowing through the urban centers of Colorado. Although a significant number of problem situations could result from heavy metals in urban runoff, levels of freshwater aquatic life use impairment suggested by the magnitude and frequency of ambient criteria exceedances were not observed. Metals can be generated within the urban environment or transported by waterways into the area. Past mining activities associated with urban areas remain a significant source of metals. Some metals like lead, which was measured in the past at high concentrations, have been significantly reduced in urban runoff due to human induced activities (e.g., elimination of leaded gasoline).

The organic priority pollutants are detected less frequently and at lower concentrations than the heavy metals. Organic priority pollutants in urban runoff do not appear to pose a general threat to freshwater aquatic life.

Coliform bacteria are present at high levels in urban runoff and can be expected to exceed United States Environmental Protection Agency (USEPA) water quality criteria during and immediately after storm events in many surface waters, even those providing high degrees of dilution. Coliform bacteria discharges in urban runoff can have a significant negative impact on the recreational uses of lakes and reservoirs. Generally, microorganisms in urban stormwater are a common nonpoint source

pollutant. There appears to be little relationship between pathogen recovery and season of the year, amount of rainfall, period of the antecedent rainfall, and stream flow. Bacterial studies are beginning to focus on E. Coli, which has been demonstrated to be a problem at some swim beaches in urban lakes and reservoirs.

Oxygen demanding substances can be present in urban runoff at concentrations approximating those in secondary wastewater treatment plant discharges. If dissolved oxygen problems are present in receiving waters of interest, consideration of urban runoff controls as well as advanced waste treatment has been required. Changes to river and stream physical configurations have been demonstrated to exacerbate dissolved oxygen problems.

Total suspended solids concentrations in urban runoff are fairly high in comparison with point source discharges. Urban runoff control is strongly indicated where water quality problems associated with total suspended solids (TSS), including build-up of contaminated sediments from bed-load transport. The physical aspects of urban runoff (e.g., erosion and scour) can be a significant cause of habitat disruption and can affect fisheries and other wildlife habitats.

Groundwater aquifers that receive deliberate recharge of urban runoff do not appear to be imminently threatened by this practice. However, little data is available to verify this conclusion. In the Denver region, both the shallow alluvial and deeper aquifers have been affected by waste disposal, mine drainage, mineral processing, urbanization, nonpoint source runoff and agriculture. Waste disposal and agriculture have been the primary sources of groundwater contamination.

Table 1 lists some commonly identified urban and construction pollution types and pollutants of concern associated urban centers in Colorado or related to major construction activities. The list is not intended to be complete or suggest any degree of pollution associated with any of the parameters. Excessive concentrations or loads of pollutant parameters and significant ecological disruption from major pollution types can pose a threat to the beneficial uses of the receiving water.

Table 1 Potential urban and construction pollution/pollutants in Colorado

General Pollutants	Parameters
Chemical	Nutrients (Total Phosphorus, Ortho-Phosphorus, Nitrite, Nitrate, Ammonia)
	Chemical Oxygen Demand
	Total Organic Carbon
Biological	Biological Oxygen Demand
	Coliform Bacteria (total and fecal)
	E. Coli Bacteria
	Chlorophyll (Measure of Phytoplankton)
Physical	Solids (Total Suspended Solids, Total Dissolved Solids, Settable Solids
	Sediment
	Temperature
	Dissolved Oxygen
	pH
Metals	Aluminum, Arsenic, Boron, Barium, Cadmium, Chromium, Chromium VI, Chlorine, Copper, Cyanide, Iron, Lead, Manganese, Magnesium, Mercury, Nickel, Radium, Selenium, Silver, Sulfate, Zinc, Uranium
Toxics	Phenols, BTEX, Benzene, Xylene, MTBE, Organics, Inorganics
	Herbicides and Other Pesticides
General Pollution	Parameters
Biological	Bio-accumulation
	Bio-diversity
Physical	Flow (velocity)
	Temperature (Riparian shading)
	Habitat
	Hydrologic modification
	Sediment and bed-load transport
	Impervious surfaces
	In-stream gravel operations that exacerbate dissolved oxygen problems

Stormwater rule

The final rule change to the National Permit Discharge Elimination System Application Regulation for inclusion of a stormwater discharge regulation was issued on November 16, 1990 (Federal Register, Volume 55, No. 222). The stormwater rule regulates

stormwater discharges associated with specific industrial discharges, discharges from separate large and medium municipal stormwater systems serving populations over 100,000. The stormwater regulation initially affects the cities of Aurora, Colorado Springs, Denver, and Lakewood. Arapahoe County also met the population requirements as a result of the 1990 census. Many Colorado counties are expected to meet the population requirements based on the 2000 census.

Additionally, other smaller municipalities of less than 100,000 population that lie within the census bureau defined *urbanized area* will be included in phase II of the stormwater permit process by January 29, 2003. The proposed rule requires six minimum stormwater management programs be developed by each community: public education, public participation, illicit discharge elimination, construction site runoff control, post construction stormwater management, and pollution prevention for municipal operations.

Previously, the definition of stormwater discharge associated with nonpoint source runoff and watershed management plans did not distinguish between nonpoint source or stormwater runoff. Future watershed management plans or updates should address permitted stormwater management separate from nonpoint sources. Stormwater quality (wet weather and dry weather runoff) in relation to receiving water quality requires additional research and model evaluation.

Stormwater discharge monitoring should be done on a regional basis with regional water quality assessments made on the effectiveness of management programs. There are three major objectives of the stormwater discharge-permitting program:

1. Reduce pollutant loading in municipal storm sewer discharges to the *maximum extent practicable* (MEP).

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

3. Implementation of 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.

The structural and nonstructural best management practices listed in the Urban Drainage and Flood Control District *Criteria Manual Volume 3* are widely applicable to Colorado. The *Water Quality Control Division* supports these best management practices, along with several additional practices listed in this management program, for stormwater and nonpoint source management throughout Colorado. The Division is actively involved in the stormwater permitting process in Colorado and will work proactively with those communities who will be required to obtain phase II stormwater permits.

In the Denver metropolitan region, permitted cities, the Urban Drainage and Flood Control District, Denver Regional Council of Governments and interested agencies will work cooperatively with the *Water Quality Control Division* to establish a well coordinated and effective stormwater management program. The working committee established by the Urban Drainage and Flood Control District will continue to provide a local focus for phase II stormwater management in the Denver metropolitan region.

The Division is planning to provide education and interpretation of the new stormwater regulation, beginning with a series of public meetings for all affected communities throughout Colorado. The Division will also be requesting input from the regulated communities on various aspects of the program, such as state regulations, application requirements and permit content. If there is sufficient statewide interest, the Division will form a special limited term task force, to help shape the new program. Low interest loans from the Division's State Revolving Fund are already available for stormwater projects.

Future application of the stormwater rule to small towns and cities may create an economic hardship and many of these communities may not be able to comply. Options for small communities need to be made available. The *Water Quality Control Division,* as recommended by the *Nonpoint Source Council,* encourages the development of a best management practices manual that can be used by small communities to control urban runoff in a cost effective and efficient manner. This manual needs to target those best management practices that economically and effectively control stormwater runoff under small community development patterns.

Construction practices

Construction practices associated with development have the potential to cause sediment erosion beyond natural conditions. Runoff from construction sites also has the potential to carry other chemical pollutants and biological pollution. The deposition of sediments in receiving waters in Colorado is a major nonpoint source problem. Construction debris carried in runoff water has also been identified as a potentially significant nonpoint pollutant source. In relation to potential water quality degradation, there are two levels of construction activity occurring in Colorado that can produce varying degrees of nonpoint source pollution and specific runoff pollutants:

1. Site development that disturbs over five acres of land area (medium to high potential for runoff pollutant generation); and

2. Site development on less than five acres of land (low potential for runoff pollutant generation).

Major site development projects affecting five acres or more of land area requires a National Pollutant Discharge Elimination System (NPDES) stormwater permit. These larger scale construction activities have the greatest potential to cause nonpoint source pollution. Both structural and nonstructural best management practices are used to reduce water quality degradation from construction sites. Construction activities on sites with less than five acres of disturbance are not currently regulated; however, these small construction activities have generally posed a limited threat to receiving water quality in Colorado. The phase II stormwater regulation is proposing to regulate construction activities on lots between one and five acres.

Highway and road construction

The Colorado Department of Transportation (CDOT) has adopted an erosion control manual for contractors to use on all state highway and road construction projects. Major highway or road construction projects affecting five acres or more of disturbed land area requires a NPDES stormwater permit.

Runoff controls are important mechanisms to prevent potentially polluted runoff associated with roads, highways and bridges from reaching surface waters in Colorado. Erosion during and after construction of highway infrastructure can contribute large amounts of runoff pollutants. Metals, oils and other potentially toxic materials, along with construction debris, can be transported with runoff waters and deposited in adjacent waterways.

The use of best management practices during and after construction of highway infrastructure is essential to prevent highway related nonpoint source pollution. Table 2 lists some typical pollutants associated with highway runoff. Highway construction and maintenance practices can contribute a variety of other runoff pollutants not listed in Table 2.

Table 2 Typical pollution from highway runoff

Category	Pollutant	Source
Sedimentation	Sediment, particulate, dust	Pavement wear, vehicles, atmospheric deposition, maintenance activities, sanding operations, construction activities
Nutrients	Nitrogen	Fertilizer application, atmospheric deposition, construction activities
	Phosphorus	Fertilizer application, atmospheric deposition
Pesticides & Insecticides	Accumulations of pesticides & insecticides	Applications along roadways
Metals and Major Cations	Lead	Auto exhausts, gasoline and tire wear
	Zinc	Tire wear, motor oil and grease

Category	Pollutant	Source
	Iron	Auto body rust, steel highway structures and moving engine parts
	Copper	Metal plating, moving engine parts and brake lining wear, bushing wear, fungicides and insecticides
	Cadmium	Tire wear and insecticide application
	Chromium	Metal plating, moving engine parts and brake lining wear
	Nickel	Diesel fuel and gasoline, lubricating oil, metal plating, bushing wear, brake lining wear and asphalt paving
	Manganese	Moving engine parts
	Cyanide	Anti-cake compounds used to keep deicing salts granular
	Sodium, Calcium & Chloride	Deicing salts
	Sulfates	Roadway beds, fuel and deicing salts
Hydrocarbons	Petroleum	Spills, leaks, antifreeze and hydraulic fluids, asphalt surface leachate
	Rubber	Tire wear from vehicles

Septic Systems

A documented source of nonpoint source water pollution within some Colorado watersheds are individual sewage disposal systems (ISDS) where these systems are sited at or near urban densities, or where multiple systems have failed. The primary issue is not the effectiveness of individual septic systems, which can remove up to 95 percent of the phosphorus and up to 50 percent of the nitrogen from wastewater flows, but the cumulative amount of nutrients and other chemicals reaching surface or ground water. Moreover, only a small percentage of failed systems can significantly increase nutrient, bacteria or other chemical loading within a watershed.

Based on conservative 1988 estimates of the rural and unincorporated population distributions, about 725,000 people in Colorado use ISDSs to meet their daily wastewater treatment needs. Growth in Colorado through the year 2020 should result in an additional 112,000 people using individual septic systems (about 1/2 million individual systems). In the year 2020, wastewater flowing from septic tanks into leach fields is projected to exceed 100 million gallons per day statewide. This volume is roughly equivalent to the average flow in the South Platte River at Denver, Colorado.

Based on average measured concentrations of nitrogen and phosphorus typically found in septic tanks, ISDSs in use by 2020 could produce 38,000 pounds per day of total nitrogen (7,000 tons per year) and 13,000 pounds per day of total phosphorus (2,300 tons per year). Even assuming highly efficient soil sorption systems, there would be enough residual nutrients to degrade water quality in numerous waterways throughout Colorado.

Lakes and Reservoirs

Nutrients (nitrogen and phosphorus) are generally present in urban runoff and have impaired water quality in lakes and reservoirs in the Denver metropolitan region and other locations in Colorado. Nutrient loading of lakes and reservoirs is a water quality concern throughout Colorado. Nutrient loading to lakes or reservoirs caused by urban development is included in the Colorado urban and construction management program. Consequently, clean lake studies will be considered as part of the urban and construction management program with the nonpoint source remediation portions also considered for project funding.

Generally across the nation nutrient concentrations do not appear to be high in comparison with other possible discharges to receiving waterbodies. However, nutrients in urban runoff may accelerate eutrophication problems and severely limit recreational uses, especially in lakes and reservoirs. NURP lake projects indicate that the degree of beneficial use impairment varies widely, as does the significance of the urban runoff component. This has required site specific investigations. To a lesser extent, a hydrologic watershed approach has been used in many Colorado locations (e.g., Bear Creek Watershed, Big Thompson River, Clear Creek, Chatfield Watershed, Cherry Creek Watershed, Dillon Reservoir, and Fountain Creek).

Reservoir and some altered lakes are hydrologic modifications of historic flow patterns. Reservoirs have been constructed in Colorado for agricultural and flood control purposes. Many flood control reservoirs and altered natural lakes upstream of urban areas are used for recreational purposes. Consequently, reservoirs can have use classifications ranging from agricultural use alone to a mix of aquatic life, recreation, water supply and agricultural use.

Hydrologic modifications and structures may produce unique water quality problems when associated with reservoirs. Three reservoir systems in the Denver metropolitan region (Bear Creek Reservoir, Cherry Creek Reservoir and Chatfield Reservoir) have water quality control regulations adopted by the Colorado Water Quality Control Commission, and a fourth reservoir (Standley Lake) requires a specialized monitoring program. Hydrologic modifications of waterways associated with urban areas or affected by construction and development projects can be addressed through the urban and construction management program.

Water quality limited lakes and reservoirs and those waterbodies with control regulations or that require monitoring in Colorado are listed in Table 3. The water quality status of lakes and reservoirs in Colorado are listed in Table 4. The pollutant parameters of concerns associated with lakes and reservoirs in Colorado are listed in Table 5.

Table 3 Water quality limited lakes and reservoirs in the Colorado

Major River Basin	Water Quality Limited Lake or Reservoir
Colorado and North Platte River Basin	Dillon Reservoir (Control Regulation)
	Stagecoach Reservoir (monitor only)
Arkansas River Basin	Teller Reservoir
Rio Grande River Basin	Terrace Reservoir
	Sanchez Reservoir
San Juan and Dolores River Basin	Narraguinnep, Puett and Totten Reservoirs
Gunnison and Lower Dolores River Basins	Fruit Grower Reservoir
	Sweitzer Lake
South Platte River Basin	Mary Lake
	Ladora Lake
	Lower Derby Lake
	Barr Lake (monitor only)
	Bear Creek Reservoir (Control Regulation)
	Cherry Creek Reservoir (Control Regulation)
	Chatfield Reservoir (Control Regulation)
	Standley Lake (Special Monitoring Program)

Table 4 Status of lakes and reservoirs in the 1998 Colorado 305(b) report

	Number of Lakes or Reservoirs
Publicly Owned Lakes/Reservoirs	3,258 (143,019 surface acres)
WQCD Monitored Lakes/Reservoirs (1989-1997)	56 (2 percent)
Lakes/Reservoirs Routinely Monitored for Trophic State	13 (<1 percent)
Trophic Assessment for Monitored Lakes/Reservoirs (49 total)	
Oligotrophic/Mesotrophic	19
Eutrophic	21 (23,557 surface acres)
Hypertrophic	9 (12,069 surface acres)

Table 5 Parameters of concern and associated lake/reservoir problems

Watershed Related	**Lake or Reservoir Problem**
Nutrients (Phosphorus, nitrate and ammonia-nitrogen)	Reduced Dissolved Oxygen
	High Chlorophyll-a or increased Algal Productivity
	Species composition and reduced diversity
Bacteria	Impaired recreational uses
Sediment	Transparency, in-filling of waterbody
Metals (zinc, lead, mercury, iron, cadmium, copper, selenium, arsenic)	Fish Consumption, Acidity, Toxicity
Pesticides	Toxicity

III. PROGRAM PLANNING ELEMENTS

Mission of the urban and construction management program

Water quality in some stream segments, lakes and reservoirs within Colorado are impaired or threatened because of runoff from urban areas, caused by construction activities or caused by other development practices. The Colorado urban and construction management program identifies appropriate urban runoff and construction related best management practices, implementation strategies and control programs. Consequently, the mission of the urban and construction management program in Colorado is to:

> ***Significantly reduce the pollution potential from urbanized regions of the state and at major construction sites***.

The program provides mechanisms to educate a broad range of groups, test the effectiveness of best management practices under Colorado hydrologic conditions, update these practices as appropriate and encourage implementation of urban and/or watershed control programs.

Urban and construction program goals, objectives and actions

Colorado long-term goals and short-term actions

There are five long-term goals with subsets of short-term objectives, expressed as needed actions in Colorado, identified by the *Water Quality Control Division* for the Colorado urban and construction program. These goals and actions are applicable statewide. Although these long-term goals are not currently watershed specific, they can be applied to high priority watersheds as identified in the Colorado unified watershed process or as part of a watershed management effort.

Actions can be watershed specific or oriented toward urban centers and the construction industry. The Colorado goals, objectives and actions must remain flexible with the addition of action steps taken to meet state water quality goals. The *Water Quality Control Division* will continue working with the Colorado Nonpoint Source Council to review and update as appropriate long-term goals, major objectives of the program and specific short-term actions.

The urban and construction actions allow a broad spectrum of qualified projects related to urban and construction activities to be eligible for project funding, as appropriate. The five long-term state goals and specific actions listed below are *high priority* and anything else would be considered a low to medium priority.

1. GOAL - **Education of the general public in urban centers through source control, pollutant reduction, pollution prevention or other nonpoint source or stormwater preventative programs, which should include, but are not limited to, the following specific actions**:

   Action 1.1. Programs targeting the use and disposal of household waste products;

   Action 1.2. Programs targeting application of fertilizers, pesticides (i.e., herbicides and insecticides) and similar products in urban centers;

   Action 1.3. Programs targeting demonstration of landscape design and effective uses of vegetation to reduce small lot erosion, pesticide use and/or nutrient management;

   Action 1.4. Programs targeting demonstration of innovative construction related erosion control; and

   Action 1.5. Programs targeting other urban runoff pollution prevention activities that can be applied statewide.

2. GOAL - **Education of the work force related to nonpoint and stormwater source control, pollutant reduction, pollution prevention or other preventative programs, which can include, but are not limited to, the following specific actions**:

   Action 2.1. Best management practice training programs, dissemination materials, classroom curriculum and development of other specialized teaching aids;

   Action 2.2. Establishment of best management practice guidance documentation and training manuals;

   Action 2.3. Training programs that target landscape design and effective uses of vegetation to reduce construction-related erosion, pesticide use and/or nutrient management; and

   Action 2.4. Other construction related erosion control and prevention programs, including watershed and urban center erosion control inspection processes and programs.

3. GOAL - **Education of local governments and state decision makers in urban centers related to nonpoint source and stormwater problems with an emphasis on source control, pollutant reduction, pollution prevention or other**

preventative programs, which can include, but are not limited to, the following specific actions:

Action 3.1. Adoption of regulatory programs directed at erosion control, zoning or development of other special regulations or ordinances;

Action 3.2. Planning level identification of available control and prevention long-term and near-term alternatives and cost effectiveness of alternatives incorporated into water quality management plans or other appropriate local management plans; and

Action 3.3. Establishment of long-term urban design and development prevention programs.

4. GOAL - **Demonstration and evaluation of best management practice source control, pollutant reduction, pollution prevention or other preventative programs practices and structures, including stormwater practices or structures, related to urban development, highway construction or other development site construction activities, which can include, but are not limited to, the following specific actions**:

Action 4.1. Establish appropriate runoff models for land use types (e.g., mountain and forested land uses) in different regions of Colorado;

Action 4.2. Apply sets of best management practices to restore or prevent nonpoint sources at a watershed level or for a specific area, including stormwater management in non-permitted areas;

Action 4.3. Apply sets of best management practices to watersheds and urban centers associated with a Clean Lake Study in an urban setting or affected by urban runoff;

Action 4.4. Support Clean Lake Studies including Phase I Diagnostic-Feasibility Studies and Phase II Restoration-Protection Implementation Projects;

Action 4.5. Support demonstration of innovative highway construction and development site construction practices that target water quality improvements in receiving waters, provided practices are not required through a permitting process; and

Action 4.6. Demonstrate effectiveness, efficiency and economic suitability of non-traditional best management practices (not in frequent use in Colorado) that may be appropriate for wide-spread application in urban centers, at development or construction sites, associated with

highway construction activities or caused by hydrologic modification of waterways (e.g., diversions, ditches, channels, dams or reservoirs).

5. GOAL - **Development of categorical urban and construction best management practice guidance documents and manuals, which can include, but are not limited to, the following specific manuals and guidance documents**:

   Action 5.1. Specialized development type manuals (e.g., golf courses, large lot subdivisions, recreational facilities, mountain driveways, parks and open space buffers, landscape designs or high altitude);

   Action 5.2. Riparian corridors through urban centers, riparian corridors along highway systems and habitat conservation plan practices;

   Action 5.3. 401 certification practices;

   Action 5.4. High altitude best management practice manual;

   Action 5.5. Best management practices suitable for use in pollution and pollutant preservation or preventative programs that target high quality watersheds;

   Action 5.6. Pollution reduction guidance manual;

   Action 5.7. Small community stormwater management and selected best management practices manual; and

   Action 5.8. Small lot construction practices guidance and manual.

Local goals and objectives

Over the last few years, interest has increased in Colorado and across the country in a more holistic, integrated approach to environmental and natural resource management. Efforts to take into account the importance of ecological integrity consider the development of biological criteria or management of pollutants and pollution based on drainage systems are examples of this trend. These efforts are most logically rooted in a determination of the overall water quality uses and values to be protected or achieved in a particular watershed.

Federal water quality program initiatives have an increased emphasis on watershed protection. The USEPA is currently encouraging state water quality management efforts to move more in the direction of watershed protection. Moreover, some form of watershed planning and management is likely to be mandated or encouraged by

federal Clean Water Act reauthorization. Federal agencies such as the Forest Service, the Bureau of Land Management and the Fish and Wildlife Service have shifted their efforts toward an ecosystem management approach organized on a watershed basis. For example, the Colorado offices of these federal agencies have initiated a Colorado Ecosystem Partnership to coordinate ecosystem-planning activities among relevant federal, state and local agencies.

In recent years, concerns have increased in Colorado regarding the appropriate approach for integrating water quantity and water quality management. Watersheds are an appropriate and practical scale on which this integration can occur, particularly when a bottom-up approach (i.e., one that relies on local initiatives and a cooperative approach) to watershed protection is undertaken. Consequently, nonpoint source control programs initiated at a watershed level by local stakeholder groups can become an effective state strategy. In recent years, the number of local stakeholders groups willing to address nonpoint source pollution issues within their watersheds has increased dramatically. Those watersheds with urban development and major construction activities will be a high priority for implementation of nonpoint source programs or demonstration projects.

A critical short-term objective of the *Water Quality Control Division* is to identify by 2001 all of the urban and construction high priority watersheds, along with an appropriate watershed stakeholder group and appropriate watershed restoration action and implementation strategies. In some instances, this will require encouragement to establish local watershed associations. This institutional framework is required before urban and construction problems can be resolved on a watershed basis.

Colorado program framework

Geographical framework

The geographical framework for urban and construction nonpoint source management in Colorado must utilize a multiple approach:

- Project-specific;
- Site-specific;
- Urban-specific;
- Priority portion of watershed;
- Watershed; and
- River basin or statewide.

Construction activities are primarily site-specific, however some larger scale activities can be addressed at a watershed level. For example, the affect of large highway projects on water quality or nonpoint source contributions could generally be viewed from a watershed perspective. Major educational efforts can be directed at a river basin or statewide level. Large-scale site-specific or urban developments often require unique approaches to nonpoint source control and management.

Assessments of nonpoint source pollution in Colorado can be characterized on a watershed basis, provided the urban centers are recognized as potentially significant sources of urban pollutants. The NURP and DRURP demonstrated that nonpoint source runoff has a characteristic signature which is not geographically distributed. Consequently, the runoff from urban areas and construction sites are not a function of the associated watershed, but rather the magnitude of the activity or development. Implementation of nonpoint source management programs has been more effective on a site-specific basis. The application of river basin or ecoregion geographies to urban and construction nonpoint source programs in Colorado will be very limited.

River basin targeting

The *Water Quality Control Division* in cooperation with the *Nonpoint Source Council* will identify urban or construction related nonpoint source problems grouped by major river basins in Colorado: South Platte, Republican, Arkansas, Colorado, Rio Grande, White-Yampa and San Juan. Potential preventative activities related to known problems should be identified and listed by watershed (e.g. urban runoff in the South Platte River Basin, salinity in the Colorado River Basin). The Division's watershed coordinators will promote nonpoint management activities, identify stakeholders and support project sponsors within their designated river basins (South Platte, Upper Colorado, Lower Colorado and Arkansas).

Project and site-specific targeting

Proposed projects directed at an activity identified as a watershed priority could be given a higher rating by the *Urban and Construction Committee, Nonpoint Source Council* or *Water Quality Control Division* in the project evaluation and ranking process. In addition, proposed projects with widespread application in multiple watersheds could receive a higher rating. A proposed project directed at an activity not listed in the watershed priorities would still be considered and rated. Existing data sources, including state, regional and local government's reports and the nonpoint source assessment and management reports, and information directly obtained from representatives in each urban center will be used to develop the watershed priority list.

The *Water Quality Control Division* in cooperation with *Nonpoint Source Council* will develop a questionnaire and distribution list for each river basin and use this information as part of detailed watershed targeting and problem identification. The

South Platte River Basin evaluation is scheduled for completion in the year 2000. The questionnaire will be directed toward the general public, construction industry and public works departments in urbanized watersheds by major river basins in Colorado. Questionnaires should be distributed in all urban centers. A similar questionnaire directed to the construction industry should also be developed and distributed as part of this evaluation process.

Questionnaire information will be used, in part, to update a priority watershed list, provide detailed problem identification characterizations and create a need evaluation list. Watershed Priority lists will be reviewed and updated bi-annually by *Water Quality Control Division*. Appropriate urban center contacts will be added to the *Water Quality Control Division* distribution list and maintained in an appropriate database.

Hydrologic modification targeting

Proposed projects directed at reservoirs and hydrologically altered lakes, including associated diversion structures and channels and are affiliated with urban centers can be given a higher priority if they are:

- Proposed as a Phase I Clean Lakes Diagnostic-Feasibility study;
- Targeted on the Colorado Water Quality Control Division 303(d) list or included in the Colorado status of water quality in the state 305(b) report;
- Subject to a total maximum daily load process or study; or
- Supported by a local or watershed designated water quality management agency who has a management plan accepted by the Water Quality Control Division that will protect the designated beneficial uses of a reservoir or lake.

Priority watershed designation process

The *Water Quality Control Division* through the *Urban and Construction Committee* will work with a wide variety of partnerships and stakeholders through a continuing process to identify priority watersheds. Table 6 represents a partial list of watersheds, derived from both local or state processes and associated by major river basins, that have a higher priority for urban or construction management planning. Many of the listed watersheds are Unified Watershed Assessment category 1 watersheds that have potentially degraded water quality from a combination of point and nonpoint sources.

Assigning priorities can be a difficult and controversial process. Local and state priorities often are not identical, and criteria for prioritization may vary between interests. Consequently, assigning priority watersheds should be done on a case-by-case basis through a public process.

By 2001, the *Water Quality Control Division* through the *Nonpoint Source Council* expects to have completed a new prioritized list of watersheds in Colorado specifically affected by urban runoff and/or major construction activities. The urban areas and areas of higher construction activities will be compared to the category 1 watersheds and the prioritization adjusted accordingly.

The Colorado *Status of Water Quality in Colorado 1998* (WQCD 1998) also known as the 305(b) report and the 303(d) List of Impaired Waters will be used as sources for identifying priority stream segments. The Colorado 305(b) report characterizes nonpoint sources in Colorado. Priority stream segments and those segments requiring a total maximum daily load (TMDL) will be factored into the watershed prioritization process. The Table 6 list of priority urban and construction watersheds is not intended to replace or modify any list in the Colorado 305(b) report or 303(d) list

Table 6 Priority urban and construction watersheds within river basins

Colorado River Basins	Watersheds (Agency, Program or Watershed Number)
South Platte and Republican	Big Thompson (NFRWQPA)
	Bear Creek (DRCOG)
	Big Dry Creek (DRCOG)
	Boulder (DRCOG)
	Box Elder (DRCOG)
	Chatfield (DRCOG)
	Cherry Creek (DRCOG)
	East Plains (DRCOG)
	South Platte Urban (DRCOG)
	St. Vrain (DRCOG)
	Upper Clear Creek (DRCOG)
	Upper South Platte River (DRCOG & PPACG)
	Cache La Poudre (10190007)
	North Fork Republican (10250002)
	South Platte Headwaters (1019001)
Arkansas	Fountain Creek (PPACG)
	Headwaters Arkansas (11020001)
	Upper Arkansas (11020002)
	Upper Arkansas – Lake Meredith (11020004)
	Upper Arkansas – John Martin (11020009)
Upper Colorado (Colorado, White-Yampa)	Dillon Reservoir
	Seven Castles Creek
	Blue (14010002)

Colorado River Basins	Watersheds (Agency, Program or Watershed Number)
	Eagle (14010003)
	Colorado Headwaters Plateau (14010005)
	Lower Gunnison (14020005)
	Uncompahgre (14020006)
	Upper Dolores (1403002)
	San Miguel (14030003)
	Lower Dolores (14030004)
	Little Snake (14050003)
	Lower White (14050007)
Lower Colorado (Colorado, San Juan and Rio Grande)	Lake San Cristobal
	Rio Grande Headwaters (13010001)
	Alamosa -Trinchera (13010002)
	San Luis (13010003)
	Saguache (13010004)
	Conejos (13020101)
	Rio Chama (13020102)
	Animas (14080104)
	Mancos (14080107)
	McElmo (14080202)

Relationship to nine key elements

Table 7 summaries the nine key elements required by the Environmental Protection Agency and the linkages with the Colorado urban and construction management program. All of the nine key element components are addressed through the urban and construction portion of the Colorado nonpoint source management program.

The only element not being fully addressed by the Colorado nonpoint source management program is related to an identification of federal lands impacted by construction activities and management actions. Sediment runoff from federal lands has been identified as both a measurable problem with listing in the Colorado 305(b) report and as a potential nonpoint source issue in many watersheds throughout the state. One of the management program linkages is through road construction practices.

The Bureau of Land Management and the United States Forest Service have separate management programs that are being linked with the Colorado nonpoint source management program. The *Forest Service Handbook* (FSH 2509.25 and as amended) lists standard practices to protect the riparian zone, construct stream crossings, and reduce sediment loading from roads and disturbed site construction activities. The

Forest Service road construction and maintenance practices are incorporated by reference into the urban and construction management program. The *Water Quality Control Division* will work with these federal land managers and others to fully integrate their appropriate management practices into the Colorado program by 2001.

In the interim time period, road construction practices adopted by the Colorado Department of Transportation (CDOT) are applicable to road construction activities on federal lands. Since the federal land agencies have not indicated to the *Water Quality Control Division* through the *Colorado Nonpoint Source Management Program* a preference on road construction best management practices, those practices adopted by CDOT are recognized as appropriate road construction practices for use on federal lands in Colorado.

Table 7 Key elements and program linkage

Key Elements	Urban and Construction Linkage
1. Explicit short and long-term goals, objectives, strategies and actions	Five long-term goals with associated objectives or activities; ongoing development and updating of best management practices and strategies; developed short-term process of using a watershed approach to address urban development and construction priorities, while still addressing issues specific to urban centers; extensive use of local stakeholder groups and area-wide planning agencies
2. Strong working partnerships and collaboration	The *Water Quality Control Division* through the *Nonpoint Source Council* and *Urban and Construction Committee* have representatives from major urban areas; active involvement of four areawide planning agencies and over 20 local watershed associations; local governments; permitted dischargers (point and stormwater); Colorado Department of Transportation; building industry; state agencies (e.g., Division of Wildlife, Parks and Recreation); federal agencies (e.g., USGS, NRCS, BLM); and environmental community.
3. A balanced approach to management of impaired or threatened waters	Best management practices are adapted to urban runoff during storms and dry weather periods. Stormwater permit programs and construction activities (site development and road construction) utilize similar best management practices. Statewide education has been identified as a significant requirement of management and control programs. Management programs developed through watershed initiatives are oriented toward meeting water quality standards and classified uses in context with local management opportunities. The urban and construction management program blends regulatory requirements with a

Key Elements	Urban and Construction Linkage
	flexible, voluntary and collaborative approach that encourages local, regional, state and federal involvement through a watershed approach.
4. Abate known water quality impairments and prevent significant threats	Nonpoint source and stormwater control programs in problem urban stream segments are undergoing total maximum daily load allocation studies and implementation programs to abate known problems. The urban and construction management program encourages source controls using established BMPs. Prevention processes are currently being applied in over eight watersheds.
5. Identify waters and watersheds impaired or threatened and a process to address these waters	Various state programs (e.g., Unified Watershed Assessment and 305(b) Report) have targeted watersheds impaired or threatened by urban development and major construction activities. An important mechanism to encourage implementation programs has been education of elected officials, the work force, associated agencies and the general public. The total maximum daily load process will be applied by the state on appropriate stream segments.
6. Review, upgrade and implement program components	The *Water Quality Control Division* in cooperation with the *Nonpoint Source Council* reviews, upgrades and recommends implementation programs. The watershed coordinators with the division are also involvement in program implementation at the river basin and watershed levels. The division supports appropriate local implementation efforts.
7. Identify federal lands and objectives	The Unified Watershed Assessment process identifies federal lands and appropriate watershed action strategies identified by federal land managers is incorporated in the urban and construction management program. Road construction activities on federal lands need to be further addressed by the Water Quality Control Division.
8. Efficient and effective management and implementation program	The awareness among various stakeholders on urban and construction practices and management requirements has been enhanced by efforts of the *Water Quality Control Division* in cooperation with the *Nonpoint Source Council,* particularly through educational projects. Through continued education and demonstration on the effectiveness of best management practices, the effectiveness of the state nonpoint source program will increase. Developing new watershed approaches should make the state program more efficient. However, funding constraints severely limit the effectiveness of large urban implementation programs.
9. Five-year feedback	The *Water Quality Control Division* review and upgrade

Key Elements	Urban and Construction Linkage
loop	processes (unified watersheds, 305(b) report, total maximum daily load development, and watershed management) has been established as a feedback loop using the *Nonpoint Source Council* and watershed associations

Stormwater project eligibility criteria

A NPDES permit is required for stormwater discharges from all construction activities disturbing five or more acres of land, and for discharges from municipal separate storm sewer systems in incorporated and unincorporated areas with populations of 100,000 or more and other counties and cities under 100,000 that are designated by permit authorities.

Final Clean Water Act section 319 Grants Guidance issued by the USEPA states the following five urban runoff management activities are activities eligible for section 319(h) funding:

1. Technical assistance to state and local stormwater programs that address stormwater runoff not covered by NPDES Permit Program;

2. Source and runoff control BMP implementation (except discharges covered by the NPDES Permit Program);

3. Information and education programs;

4. Technology transfer and training; and

5. Development and implementation of regulations, policies, and local ordinances to address stormwater runoff not covered by the NPDES Permit Program.

The use of section 319 funds for stormwater/urban runoff education and information programs, training and technology transfer should be restricted to activities not subject to NPDES Phase I municipal stormwater permit program requirements unless such activities are part of a statewide, regional or watershed effort. Funding of activities where consistent statewide, regional or watershed coverage is intended, would be permissible. Training and information activities oriented for the community at large may include audiences or participants in municipalities subject to Phase I permit requirements. Technology transfer activities are eligible for section 319(h) funding. Monitoring studies designed to evaluate the effectiveness of BMPs or systems of BMPs that have national or regional applicability are also appropriate.

Sources that are located in an NPDES Phase I MS4 permit jurisdiction and are not subject to municipal controls could be eligible for section 319(h) funding. For example, projects to reduce and control nonpoint source impacts to groundwater would be eligible for funding. An innovative technology project outside of a NPDES Phase I area can be funded using section 319(h) monies.

Statewide, regional, or watershed public education/outreach programs to address urban runoff can be implemented using section 319(h) funding if such activities are disseminated or implemented uniformly across state, regional or watershed areas. [Note - Appropriate regional water quality management plans approved by the Colorado Water Quality Control Commission should identify the need for these regional or watershed educational/outreach programs].

NPDES Phase I municipal permittees, however, can benefit indirectly from watershed, regional or statewide education or outreach activities. NPDES Phase II permits issued to appropriate local governments could impose further requirements for section 319(h) funding eligibility. Permit requirements will require case-by-case evaluations.

Funding of projects which implement approved state nonpoint source management programs or portions thereof, e.g., general permits for small communities, would be appropriate if the development of such mechanisms does not fulfill NPDES Permit requirements and conditions. Section 319(h) funds may be used to develop regulations and policies for non-NPDES communities that apply as well to NPDES communities; regulations and policies to fulfill specific NPDES Permit requirements and conditions are ineligible to be conducted with section 319(h) funds.

Clean Lakes study eligibility (Section 314)

The Clean Lakes Program was established in 1972 as Section 314 of the Federal Clean Water Act, to provide financial and technical assistance to states in restoring publicly owned lakes. The early focus of the program was on research, development of lake restoration techniques, and evaluation of lakes. The Clean Lakes Program regulations (40 CFR 35 Subpart H), promulgated in 1980, redirected program activities to diagnose the current condition of individual lakes and their watersheds, determine the extent and sources of pollution, develop feasible lake restoration and protection plans (Phase I Diagnostic-Feasibility Studies), and to implement these plans (Phase II Restoration & Protection Implementation Projects).

The strategic approach to protecting and restoring water resources addresses the major issues, which pollute, degrade and threaten lakes. Pollution types include: sedimentation; nutrient over-enrichment; pathogens from septage, sewage and animal waste; air deposition; agriculture; and poorly planned development and urbanization that alters hydrology and sweeps pollutants to storm drains, through rivers and streams and into natural sinks.

The Environmental Protection Agency has not requested funds for the Clean Lakes Program in recent years, but rather has encouraged States in its Nonpoint Source Program guidance to use Section 319 funds for "*eligible activities that might have been funded in previous years under Section 314*." The Environmental Protection Agency has encouraged Colorado to use these funds to develop the institutional and administrative capabilities to carryout Colorado lakes programs.

Lake protection and restoration activities are eligible for funding under Section 319(h) to the same extent, and subject to the same criteria, as activities to protect and restore other types of waterbodies from nonpoint source pollution. Colorado will use Section 319 funding for eligible activities that might have been funded in previous years under Section 314 of the Clean Water Act. However, Section 319 funds will not be used for in-lake work such as aquatic macrophyte harvesting or dredging, unless the sources of pollution have been addressed sufficiently to assure that the pollution being remediated will not recur.

The Environmental Protection Agency (May 1996) guidance allows Colorado to use up to 20 percent of its Section 319 allocation for assessment activities, which may include Clean Lakes assessments. Lakes assessments will be considered along with all other assessment requests to determine which requests best fulfill needs of the state NPS program.

Response to growth and development

Colorado is experiencing rapid growth and development in both the urban centers and the rural portions of the state. Urban runoff is confined to those areas where development is at urban densities, including communities, towns, cities and some special districts. While most large-lot subdivisions in Colorado do not meet the urban criteria, these areas generate stormwater runoff that is characteristic of urbanized areas.

Urban and construction activities are a function of land uses. In large urban areas, land use patterns can be associated with watersheds to provide a broader framework for nonpoint source management. Smaller urban centers or large lot developments will need to be addressed on a site-specific basis, without reference to specific watersheds. The accumulative affects of individual sewage disposal systems (ISDS) within some areas or watersheds have produced pollution characteristic of urban areas. Consequently, the Colorado urban and construction management program will address water quality issues associated with ISDSs at the watershed or large-lot level. The urban and construction management program does not imply that all ISDSs cause water quality problems, but rather large accumulation of systems have the potential to degrade water quality.

The Denver metropolitan region is the largest urbanized center in Colorado. The metropolitan area is composed of over 40 communities in eight counties with a combined population in excess of 2.2 million. An additional million people are predicted to reside in the Denver metropolitan region within the next 25 years. This growth rate requires the construction of over 16,000 new homes each year and the associated commercial developments to support this new population. The Denver metropolitan region has over 65,000 miles of major roadways that require ongoing maintenance and are under construction for expanded capacity. The rapid growth and development throughout Colorado drives road construction activities.

Urbanization in the Denver region has proceeded at an average growth rate of one square mile per every additional 2,000 persons for the period 1960 to 1990. While this includes all land type uses, it suggests a residential pattern dominated by single-family residences. There are currently about 570 square miles of urban area with a predicted urban area of 750 square miles by 2020. The future population density patterns and distribution trends will affect regional nonpoint source and stormwater water quality.

The Denver region uses both a watershed approach and an urban center orientation to address nonpoint source and stormwater management. The cities of Denver, Lakewood and Aurora and Arapahoe County have stormwater permits. Stormwater management in these permitted areas can not be managed on a watershed basis. The phase II stormwater regulations will also exclude many other smaller communities and counties from using a watershed approach. Similar watershed approaches and urban center focus processes are also applied to urban development in other river basins in Colorado (e.g., Colorado Springs, Loveland, and Summit County).

Development patterns and nonpoint source management

The two major development patterns affecting nonpoint source management in Colorado are:

- Urban center expansion (cities, towns and communities); and
- Rural large lot developments.

Cities, towns and small community centers are experiencing growth rates up to 6 percent per year. The need for additional single and multi-family housing has placed the construction industry in a building boom, which is expected to continue through 2020. Generally, developments associated with urban areas rely on linking to existing infrastructure (e.g., roads, water supplies, and wastewater service). Rural large-lot developments generally rely on individual wells and septic systems or at least, community water supplies. Large-lot developments require additional nonpoint source management strategies related to sediment and nutrient management.

Land use patterns have a strong influence on surface water quality. Since land use development can influence water quality trends, land use management must be considered in devising water quality management strategies for watersheds or hydrologic systems.

Land use types and development patterns must be identified for existing conditions and future growth projections in watershed studies. The general categories recognized are single-family residential, multi-family residential, commercial, large lot and open space. Runoff from these land use types can be modeled to assess effects to nonpoint source water quality. Watershed management and land use choices are viewed by local and state officials as interactive components in their efforts at water quality management. Water quality must be considered in zoning and platting processes of local governments.

Individual Sewage Disposal Systems

An estimated 5,300 new home sites each year will require individual septic systems. A growing trend in Colorado is toward rural large lot developments that are dependent on individuals sewage disposal systems with either on-site wells or community water supplies. A large lot development with 200 housing units on septic systems generates an equivalent amount of wastewater as a major wastewater treatment plant that requires a Colorado permit to discharge. Many smaller watersheds throughout Colorado have experienced tremendous growth with over 50 percent increase in the number of houses built in the last decade. The increased density and magnitude of total housing units utilizing on-site systems can create an accumulative water quality risk at the watershed level, particularly in the more mountainous counties.

On-site wastewater treatment and disposal systems are regulated by the Individual Sewage Disposal Systems Act (CRS 25-10-101). The State Board of Health is responsible for the adoption of statewide guidelines and rules governing individual sewage disposal systems. County and district boards of health have the power to adopt rules and regulate individual sewage disposal systems within their jurisdictions (CRS 25-1-507 (1) (d)). The Individual Sewage Disposal Systems Act (CRS 25-10-104(2)) requires that *every local board of health in the state shall develop and adopt rules for individual sewage disposal systems within their respective areas of jurisdiction*. Generally, local health departments within the mountainous counties of Colorado have adopted individual sewage disposal regulations.

The Water Quality Control Commission is designated as the state water pollution control agency for all purposes of the federal Clean Water Act (CRS 25-8-202(K)(6). Systems with a design capacity of greater than 2000 gallons per day capacity that discharge into state waters are required to obtain site approval and a discharge permit from the Water Quality Control Division within the Colorado Department of Public Health and Environment.

Septic system or individual sewage disposal system failures have been documented by counties, local health departments, regional planning commissions, planning organizations and the Colorado Department of Public Health and Environment since 1971. Numerous reports have shown groundwater contamination and potential health risks from *failed systems* (a broadly defined and used term), particularly at the subdivision level of development.

Researchers from Colorado State University previously identified many mountain homes to be potentially using bacterial-laden well water caused by misplacement of leach fields. Based on nationwide research and published reports, the most serious threat to groundwater drinking supplies is caused by the movement of pathogenic bacteria and/or viruses from on-site systems. Most of the research has focused on bacterial contamination. Recent surveys conducted by the Environmental Protection Agency indicate viral contamination may be a significant problem.

The movement of nitrate into groundwater from on-site systems also poses a potential health risk. Nitrogen removal in soil infiltration systems has been extensively researched and the processes are well established in numerous published reports and studies. A wide variation in nitrogen removal efficiency occurs among and between different system designs. However, typical soil filtration systems achieve about 20 percent nitrogen removal with removal rates in the 25-50 percent range for mound or cyclic loading/resting systems.

While phosphorus is generally bound by soil systems, some fractured bedrock, sand and gravel areas transport phosphorus from on-site systems into surface or groundwater. The thin soils found in many mountainous regions of the state may allow greater phosphorus transport than suggested by studies from other parts of the country. Research in other portions of the country shows that the greater the distance a septic system is from a waterbody, the greater the potential for phosphorus removal by aquifer materials.

The problems associated with on-site treatment and disposal systems in Colorado range from the failure of individual systems to function as designed, groundwater quality degradation or contamination, health risks, potential degradation or contamination of surface waters, and odor complaints. Over the last 25 years, 30 Colorado counties have attributed elevated nitrate-nitrogen in groundwater to on-site systems.

Calculations of accumulative phosphorus and nitrogen loading from ISDSs, based on general literature data, show these systems could be a major nonpoint source nutrient contributor in urbanized watersheds. However, there is considerable disagreement from ISDS users and some professionals on the general literature values and load calculations. Nutrient management BMPs related to ISDSs should be established for Colorado. Pollutant discharges from unidentifiable sources in urbanized watersheds

have been identified by local, state and federal agencies as an area of concern. There is also a potential for other chemical discharges (i.e., hazardous wastes) into ISDSs to cause an accumulative nonpoint source problem in urbanized watersheds.

IV. AUTHORITIES AND RELATIONSHIPS

Authorities for NPS Management

Chapter I, Overview of the NPS Program contains a discussion of the legal authorities, both federal and state, for implementing the nonpoint source program. Recognizing that the NPS program is implemented through voluntary partnerships, there is also a discussion of other institutions such as local governments and health departments and areawide planning agencies.

Relationship to other state programs and targeting tools

Standards are the underlying framework for water quality management in Colorado. Targeting tools that must be considered in the urban and construction nonpoint source management program include high quality stream segment designations. The state 303(d) list, 305(b) report, Unified Watershed Assessment, nonpoint source assessment report and other Water Quality Control Division policy or guidance documents are examples of targeting tools.

State water quality limited waters

State water quality standards are the *yardstick* used by the WQCD and WQCC to assess the status of a waterbody or stream segment. The state compares recent information regarding the physical, chemical and biological condition of a stream segment with the associated water quality standards. Where technology-based effluent limits in discharge permits alone are not stringent enough to assure that water quality standards are met, these stream segments are designated *water quality limited* and added to the 303(d) list. This list of impaired waters f the state is updated every two years.

The 303(d) list includes the identification of the specific component (e.g., nitrate, copper, sediment or habitat) that further identifies the specific water quality problem for a given segment. Total maximum daily loads (TMDL) are required for all components on all stream segments in the 303(d) list. The TMDL process must quantify the pollutant sources and allocate allowable loads to the contributing sources.

Evaluation of nonpoint sources is an essential component of the TMDL process. Therefore, stream segments on the 303(d) list will be given a high priority for nonpoint source controls. The 303(d) list can be used as a targeting tool for prioritizing urban and construction projects or programs.

Source water protection program

The Colorado source water protection program uses a holistic watershed approach that begins with the seven major River Basins (Arkansas, Colorado, Rio Grande, Republican, San Juan, South Platte, and Yampa and White). Colorado is a headwater state with heavy reliance on surface water as potable water supplies. Over 80 percent of the states surface water supplies originate in the upper portions of the mountainous river basins. Nonpoint source pollution is a major factor that will be addressed in the assessment and implementation portion phases of the source water program.

Therefore, the Colorado delineation process begins in the headwaters of these river basins and progresses downstream. A number of factors are used to define source water protection areas. The program is not intended to create a burden for water providers or other stakeholders. Rather, it provides a context for establishing stakeholder involvement, responsibility, while maintaining a public process.

The Colorado process defines a number of special case areas that are the responsibility of specific agencies, regulated community or other groups. Some of these special case areas are already subjected to clean-up activities or programs and the source water protection program will be supportive but not additive.

Unified Watershed Assessment

The Clean Water Action Plan required states to identify priority watersheds through a broad process. Category 1 watersheds are those larger eight-digit watersheds (as mapped by the U.S. Geological Survey) identified as needing restoration. Most of the category 1 watersheds in Colorado have identifiable nonpoint sources, which could potentially cause water quality degradation. Consequently, these watersheds are targeted for funding programs and implementation of restoration activities. The larger urban centers in Colorado are located in category 1 watersheds. The Colorado urban and construction management program in Colorado will consider category 1 watersheds in the prioritization and funding of nonpoint source projects.

Public involvement

The public involvement process for the urban and construction management program relies extensively on the involvement of various local governments, watershed associations and authorities, water quality forums and other local initiative processes. The management program has explored mechanisms to increase public involvement with the primary focus on education programs. The watershed coordinators with the Water Quality Control Division outreach to specific river basins (South Platte, Arkansas, Upper Colorado, and Lower Colorado) and those partnerships within the four watersheds. The watershed coordinators will establish partnerships and other local watershed associations as appropriate.

The Colorado urban and construction program through the *Urban and Construction Committee* has held a series of out-reach meetings (1995-1998) in various urban centers for the explicit purpose of identifying local and public issues associated with nonpoint source problems. The long-term goal and specific program objectives or activities were adjusted based on this public input process. Education was and continues to be the critical public issue. The public involvement tools and targeted audiences are characterized in Table 8.

The educational efforts of the urban and construction program have been aimed at selected targets including, but not limited to, elected officials, boards and commissions, work force, public works departments, schools, learning centers and the general public through media campaigns. Additional education efforts are required and the milestones established by the *Water Quality Control Division* as part of the Colorado urban and construction management program for the *Urban and Construction Committee* of the *Nonpoint Source Council* include specialized education efforts.

Major media campaigns are required to inform large sections of the urban population. These educational efforts target source controls through preventative measures. The education efforts of the state are coordinated with the stormwater permitted cities. Citizens also need better mechanisms to obtain information or get answers to questions.

The establishment of a web site dedicated to nonpoint source information with specific information directed at the urbanized population could increase public awareness and result in significant water quality improvements. The web site can be associated with the existing Water Quality Control Division site with linkages to other appropriate sites. Major recommended public involvement efforts are listed in the Colorado urban and construction management program implementation milestones.

Table 8 Public involvement tools used in Colorado

Involvement Type	Tool	Target Audience
Public Meetings and Hearings	Nonpoint Source Council meetings	Interested agencies and public
	Water Quality Control Commission meetings/hearings	Interested agencies and public
	Watershed Coordinators	Watershed Associations
	Water Quality Forum	Interested agencies and public
	Continuing Planning Process	Interested agencies and public
General Media	Newsletters, bulletins and brochures	Public and targeted audiences
	Newspaper articles and press releases	Public statewide and localized public
	Television and radio	Public statewide, selected urban centers and localized public
	Web site with state	Interested agencies and public statewide
Major Media Campaigns	Television	Public statewide
	Advertising on sides of buses	Public statewide
	Web site with selected agencies	Public statewide
Education Efforts	Conferences, workshops and other special meeting presentations	Targeted audience
	Children's water festivals	School children
	Exhibits, learning centers and displays	Interested agencies, School children and public
	Training center	Regulated community

V. PROGRAM IMPLEMENTATION

Milestones for urban and construction program

The Colorado urban and construction management program milestone schedule is outlined in Table 9. Table 10 is a list of potentially responsible stakeholders, partnerships and agencies who can assist the *Water Quality Control Division* with implementation of the milestones listed in Table 9. Additional stakeholders and partnerships will be identified and added to Table 10 as appropriate.

While the Water Quality Control Division is administratively responsible for the NPS Program, the intent is to encourage implementation by appropriate stakeholders or partnerships. Generally, stakeholders or partnerships are not assigned to the implementation actions for 2000 or beyond. Many of the existing stakeholders and partnerships involved in nonpoint source management are anticipated to take leads in implementing the targeted milestones.

The targeted milestones are supported by the *Water Quality Control Division* as the highest priority actions within the urban and construction component for annual funding. A funding mechanism will be investigated within the Colorado nonpoint source program to allow members of the committee (e.g., *Urban and Construction Committee)* in cooperation with other partners to complete appropriate milestone objectives. The *Water Quality Control Division* will proactively encourage stakeholders and partnerships to support the key implementation actions.

Table 9 Implementation milestones for urban and construction program

Milestone	Years						
	1998	1999	2000	2002	2005	2010	2020
BMP Manuals & Review	Golf-course BMPs (completed]	Driveway BMPs [completed]	Small Community/ small lot BMPs	Large-lot Subdivision & Riparian BMPs	Review all Colorado Practices	Stormwater BMPs	Review all Colorado Practices
Education Workforce	BMP training Video [completed]		Inspection management program	Stormwater BMP Training	Web Site	Highway BMP Training	
Education Elected Officials			Web Site	Local Official Guides, new officials			
Education Citizens			League of Women Voters Program	Web Site	Major Media Campaign	Major Media Campaign	Major Media Campaign

Milestone	Years						
	1998	1999	2000	2002	2005	2010	2020
Watershed Targeting & Problem Identification			South Platte	Arkansas	Upper Colorado	Lower Colorado	South Platte
Urban Center Contacts		Working List	Review and Update Process		Review and Update Process	Review and Update Process	Review and Update Process
Program Review	Review	Updated Program		Integrate BLM & Forest Service BMPs into program	Review & update as appropriate	Review & update as appropriate	Review
Highway Construction priority Watersheds		Review	Recommend	Review & revise	Review & revise	Review & revise	Review & revise
Urban & construction priority watersheds		Review	Recommend	Review & revise	Review & revise	Review & revise	Review & revise
Sediment update and strategies	WQCD policy		Review policy	Recommend	Review & revise	Review & revise	Review & revise

Table 10 Urban or construction partnerships and stakeholders

Regional/Areawide/State	Local Associations & Authorities	Forums, Initiatives & Project Groups
Statewide		
Water Quality Control Division	General Purpose Governments (utilities & health departments]	Water Quality Forum
Colorado Department of Transportation	Special Districts	Colorado Environmental Coalition
Natural Resources Conservation Services	League of Women Voters	EcoRisk Reduction, Inc.
U.S. Geological Survey	Sierra Club	Red Rocks Community College
Forest Service		Children's Museum, Denver
Colorado of Division of Wildlife		
South Platte and Republican		
Denver Regional Council of Governments	Bear Creek Watershed Association	Clear Creek Forum
North Front Range Water Quality Planning Association	Big Dry Creek Watershed Association	Upper South Platte River Protection Association
Urban Drainage and Flood Control District	Chatfield Watershed Authority	Tri-Watershed Planning Group Initiative
	Cherry Creek Watershed	Upper Big Thompson Watershed

Regional/Areawide/State	Local Associations & Authorities	Forums, Initiatives & Project Groups
	Authority	Forum
	Clear Creek Watershed Association	South Platte River Restoration Committee
	Northern Conservancy District	
	Central Conservancy District	
Arkansas		
Pikes Peak Area Council of Governments	Fountain Creek Watershed Committee	Upper Arkansas Watershed Council
Pueblo Area Council of Governments		
Upper Colorado (Colorado, White-Yampa)		
Northwest Colorado Council of Governments	Summit Water Quality Committee	Roaring Fork Watershed Coalition
	Eagle River Watershed Plan Committee	East Grand Water Quality Board
	Routt County Water Quality Committee	
Lower Colorado (Colorado, San Juan and Rio Grande)		
	San Miguel Watershed Coalition	Rio Grande Alliance
		Gunnison River/Rio Grande Valley Water Quality Forum

Program updating steps

The *Urban and Construction Committee* of the *Nonpoint Source Council* will assist the WQCD with periodic updating of the management program. The recommended urban and construction best management practices are undergoing constant evaluation through various application processes. On a bi-annual basis, members of the *Urban and Construction Committee* will review and update practices as appropriate. Steps in the bi-annual updating process include:

- Review of water quality documents produced by the WQCD (e.g., 305(b) report, 303(d) list, Unified Watershed List);
- Review water quality information from local sources (e.g., areawide planning agencies, watershed associations, water quality initiatives, River Watch);
- Review water quality information from other state and federal sources (e.g., Forest Service, Division of Wildlife, U.S. Army Corp of Engineers);
- Identify and confirm priority nonpoint source watersheds;
- Identify potential implementation and restoration strategies;

- Review and confirm best management practices;
- Recommend education strategies for incorporation into the management plan;
- Establish a public review process that maximizes feed-back to the *Water Quality Control Division*;
- *Urban and Construction Committee* will report update recommendations to the *Nonpoint Source Council*; and
- The council will forward recommendations to the Water Quality Control Division.

Partnerships and stakeholders

The *Urban and Construction Committee* has involved a variety of partnerships and stakeholders throughout Colorado. Table 10 lists potential partnerships and stakeholders related to urban or construction activities. The number of stakeholders and partnerships is expected to increase each year with the implementation of urban or construction programs.

The *Water Quality Control Division* will continue to identify and invite new stakeholders into the Colorado management program. The watershed and pollution targeting program listed in the milestone schedule (Table 9) for the urban and construction program begins with the South Platte and Republic River Basin, with a target completion date of 2000. Other river basin targeting process will either follow this evaluation or they could occur concurrently.

Since 80 percent of the state's population is located within the jurisdiction of areawide planning agencies (208 agencies), these planning organizations and their collection of local governments are an important element in managing urban runoff and construction activities. The development community and particularly the construction industry are an important stakeholder needed to manage nonpoint sources. Except for the Colorado Department of Transportation (CDOT), the construction industry has not been a significant stakeholder in the Colorado nonpoint source program.

Other local stakeholders that must remain actively involved in the urban and construction portion of the Colorado nonpoint source program include, but are not limited to, general purpose governments, special districts, stormwater utilities, environmental community, watershed associations, and public health departments.

Local resources

Resource utilization is a critical issue in managing urban and construction programs and projects. Scarce local resources have limited many nonpoint source efforts in Colorado. However, local resources are being used to monitor water quality, establish control regulations, develop implementation strategies, fund site-specific restoration efforts and for a broad spectrum of education efforts. A resource catalog should be incorporated into the proposed urban and construction database.

Monitoring and evaluation plan

The monitoring and evaluation of the urban and construction management program is a three step process:

- Development and application of information exchange and tracking tools for use at local and state levels directed at the overall management program;

- Establishing partnerships that address the resource limitations and voluntary nature of the program; and

- Monitoring and evaluating the success of specific nonpoint source projects, activities or programs.

The information exchange resources will provide a mechanism to monitor the effectiveness and efficiency of the management program. Implementation tools include the establishment of a web site or several sites that can be used for information exchange, educating the work force, officials and public, priority watersheds, problem identification, lists of partnerships and stakeholders and management practices. Another tracking mechanism is a public access database.

The utilization of the various information exchange mechanisms will provide a measure of the success of the management program. The major challenge facing the *Nonpoint Source Council* and the *Water Quality Control Division* is the limitation on financial resources needed to establish appropriate information exchange mechanisms and processes. While the *Urban and Construction Committee* will be responsible for promoting and monitoring the long-range milestone schedule, other partnerships will be required to develop and maintain the information exchange programs.

The use of general-purpose governments, special associations, watershed associations, areawide agencies, and other local initiative programs will be critical to the management of urban and construction nonpoint sources in Colorado. A number of partnerships are actively involved in nonpoint source management in the major urban areas. However, most smaller urban areas have not established the necessary partnerships. The Colorado management program has a key focus of identifying potential stakeholders and recommending partnerships. Local partnerships can allow for better utilization of scarce local resources.

Monitoring and evaluation of specific nonpoint source projects has been a difficult task for the *Urban and Construction Committee, Nonpoint Source Council* and the *Water Quality Control Division.* Since most of the efforts of the Colorado urban and construction management program have been directed at education efforts, evaluations have been qualitative and involve best professional judgement. While there is clearly increased awareness among professional water resources staff in Colorado, the general public is largely uninformed about nonpoint source pollution and the steps being taken to abate the problem. The *Water Quality Control Division* intends to explore alternative approaches to monitoring and evaluating the success of nonpoint source management programs in Colorado.

Information and education program strategy

There is a growing need to develop educational programs for all age groups on nonpoint source runoff and potentials for pollution, along with urban or construction stormwater management. These educational efforts will be greatly expanded in the near future. The cities in Colorado permitted through the NPDES stormwater permit have developed and begun implementation of educational programs.

There are two general approaches to educating the general public about nonpoint source pollution, urban runoff and stormwater management:

- School curriculum and special presentations focused at youth; and

- Adult based information programs.

The youth programs are attempting to modify future behavior patterns. These types of youth educational programs should provide more long-term solutions to areas such as source control by preventing the problem from occurring. The adult programs tend to be more short-term and control oriented. Changing adult behavior patterns is generally a very costly and difficult task and therefore not the preferred educational tactic.

Generally, federal and state agencies in Colorado have a good understanding of the magnitude of nonpoint source pollution and impacts on state water quality. Local agencies do not have this same level of understanding, and do not have a clear understanding of what constitutes nonpoint source pollution. Many of these local officials are not aware of the occurrence of nonpoint source problems in their jurisdictions, let alone the magnitude of this problem. These officials must be educated before Colorado will be able to effect a long-term control strategy. Effective educational programs need to focus on specific nonpoint issues of interest to local officials that will provide general management strategies.

In the Denver metropolitan region and in other medium to large cities in Colorado, there is a significant nonpoint source effect on receiving waters related to urban runoff. The

nature of urban runoff, its influence on receiving waters and control strategies are defined for these metropolitan areas. BMPs that are applicable to urban and construction runoff are listed in the Denver Regional Council of Governments *Metro Vision 2020 Clean Water Plan*, the Urban Drainage and Flood Control District *Drainage Criteria Manual, Volume 3*, and they have been updated by permitted cities and the Urban Drainage and Flood Control District through the stormwater permit program.

A large number of communities do not have grading, erosion or sedimentation ordinances, and they do not perceive the need to adopt these types of ordinances. Enforcement of these types of ordinances is a major problem among municipalities and counties who have adopted them. This lack of enforcement is related to the local officials' misunderstanding of the magnitude of the construction and urban runoff problems and the effect to local or regional waterbodies.

The stormwater rule has made it difficult to distinguish between nonpoint source runoff and stormwater runoff in an urban setting. The educational efforts needed for stormwater management are the same as those used for nonpoint source control. The major difference is a matter of regulation. There is a concern about funding educational efforts and the transfer of education programs between permitted cities covered by the stormwater rule and those urban areas that still technically produce nonpoint source runoff. Grant funded projects that develop educational programs applicable to both stormwater and nonpoint source runoff can not directly benefit permitted cities.

The use of section 319 funds for stormwater/urban runoff education and information programs, training and technology transfer should be restricted to activities not subject to NPDES phase I or future phase II municipal stormwater permit program requirements (once enacted) unless such activities are part of a statewide, regional or watershed effort. Funding of activities where consistent statewide, regional or watershed coverage is intended, would be appropriate. Training and information activities oriented for the community at large may include audiences or participants in municipalities that are subject to phase I or future phase II permit requirements.

Statewide, regional, or watershed public education/outreach programs to address urban runoff can be implemented using section 319(h) funding if such activities are disseminated or implemented uniformly across state, regional or watershed areas. Permitted local governments can benefit indirectly from watershed, regional or statewide education or outreach activities.

Project selection criteria

The following criteria will be considered by the *Urban and Construction Committee*, *Nonpoint Source Council* and the *Water Quality Control Division* in selecting urban and construction NPS projects.

- Activities listed in Table 9 milestones are highest priority for funding;
- Provides a targeted education component;
- Provides increases understanding or improved application of best management practices related to urban development, including ISDSs, and construction activities;
- Provides targeted training program(s);
- Maximizes utilization of scarce resources through partnerships and by encouraging local resource applications;
- Can produce site-specific manuals;
- Targets urban restoration projects, major highway construction activities or watershed efforts designed to reduce affects of major development or construction activities; and
- Increases the level of understanding about managing urban runoff and reducing sediment and erosion problems in Colorado.

The *Urban and Construction Committee* in conjunction with the *Nonpoint Source Council* and the Water Quality Control Division will continue to review and refine selection criteria. A major focus of any selection criteria will be to retain flexibility in the program and increase local involvement in nonpoint source management implementation programs or projects.

VI. RECOMMENDED COLORADO BEST MANAGEMENT PRACTICES

National Urban Runoff Program recommended practices

In the National Urban Runoff Program (USEPA 1983) there was a strong preference for detention devices, street sweeping, and recharge devices as reflected by the control measures selected at the local level for detailed investigation. Interest was also shown in grass swales and wetlands. Detention basins were determined to provide very effective removal of pollutants in urban runoff. Both the design concept and the size of the drainage area in relation to the urban area served had a critical influence on performance capability.

Recharge devices were capable of providing very effective control of urban runoff pollutant discharges to surface waters. Although continued attention is warranted, present evidence does not indicate that significant groundwater contamination will result from this practice. Street sweeping was generally found ineffective as a technique for improving the quality of urban runoff. Grass swales provided moderate improvements in urban runoff quality. Wetlands were considered a promising technique, but required further research and application. However, neither performance characteristics nor design characteristics in relation to performance were developed by NURP.

Both structural and nonstructural control programs use best management practices (BMPs). The nonstructural BMPs are directed at prevention and source control. An erosion control ordinance is an example of a nonstructural BMP. Structural facilities are constructed to treat urban runoff before it enters the receiving water. The primary structural include minimizing directly connected impervious areas; grass buffer strips (irrigated); grass-lined swales; extended-detention ponds (dry); retention ponds (wet); constructed wetlands; and modular block porous pavement.

Other types of structural BMPs under consideration in Colorado, but not yet proven technology in a semi-arid climate include sand filters, infiltration basins and percolation trenches. The experience in structural BMP design, construction and maintenance, along with determining the resulting cost per pound of pollutant removal is generally limited under semi-arid conditions.

Best management practice categories

The best management practices (BMPs) in the Urban and Construction Nonpoint Source Management Program directed toward improving water quality fall into two categories:

1) erosion control BMPs intended to prevent discharge of pollutants or provide improved water quality in runoff from construction sites; and

2) Urban stormwater BMPs intended to reduce loads after the construction phase is complete (e.g. phosphorus and nitrate which stimulate aquatic weeds and algae.) Stormwater BMPs supplement existing urban runoff and flood control practices.

Model ordinances for erosion control and stormwater quality are also part of the management program. These model ordinances, developed by the Denver Regional Council of Governments and Urban Drainage and Flood Control District in concert with many local municipalities in the Denver region, are intended to provide guidance to communities that may want to adopt such an ordinance, or update their existing ordinance. Either model is applicable to urban areas in Colorado.

The recommended BMP list requires periodic updating, since demonstration or application of BMPs under Colorado conditions can prove the merit, or conversely prove the flaws of various BMPs. Many of the urban or long-term practices recommended in this management program are generally untested in Colorado. Additionally, emerging technologies could be added to the management program. For these reasons, it is recommended that this management program and the BMPs be reviewed on an annual basis.

The impact of the recommended BMPs on groundwater still requires research and further evaluation. A concern about the impact of these practices, particularly the structural practices, to groundwater has been noted by many agencies. Any demonstration of these practices must take into consideration design features and monitoring programs to determine groundwater impacts, if any caused by the practice. This information, as it is generated, may then be used to update the structural practices.

Other BMP management concepts, which require further refinement under Colorado conditions through the demonstration process, include:

- environmentally safe alternative de-icer application;
- rural urban development nutrient management (i.e., cumulative loading from individual sewage disposal systems);
- urban pollutant discharges from unidentifiable sources;
- toxic sediments;
- air quality management programs producing nonpoint source pollutants; and
- Urban biocriteria.

Implementation of BMPs to correct nonpoint source water quality problems, where such BMPs are identified solely as part of the state Section 319 program, is voluntary in Colorado. Thus, in the absence of independent statutory or regulatory authority, reference in other state and federal enactment's to Colorado's Section 319 program, including BMPs developed thereunder, shall not establish an enforceable requirement that BMPs be implemented other than voluntarily.

BMPs require careful planning, design, and construction as well as a long-term financial commitment to operation, maintenance and replacement. A planning process, which insures selection of the proper BMPs, is also essential. Recognition of the financial commitment involved not only in construction, but also in the long-term operation, maintenance and replacement is critical. Without a commitment to the long-term operation and maintenance requirements of BMPs, the initial capital investment and resulting water quality improvements could be lost. Agencies, municipalities or private organizations that have the ability to raise funds must be involved in the long-term maintenance of constructed BMPs.

Event mean concentrations found in urban runoff

Table 11 provides event mean concentration (EMC) of pollutants found in runoff from various land uses in the Denver region. These data include EMC data collected during the DRURP and more recently as part of the stormwater permit application process for the cities of Aurora and Lakewood and the City and county of Denver. The results in the Denver region parallel, in many respects, the findings of similar studies across the country as shown in the Nation Urban Runoff Report (NURP).

While these results are representative of general conditions, site specific data from watershed studies should be used when available. In general, constituents such as lead, zinc, copper, fecal coliform bacteria and total suspended solids were identified as significant pollutants in urban runoff. Establishing event mean concentration data for other portions of Colorado in important toward managing urban runoff in developing areas.

Table 11 Event mean concentrations (EMC) in mg/l of constituents

Constituent	Natural Grassland	Commercial	Residential	Industrial
Total Phosphorus	0.4	0.42	0.65	0.43
Dissolved or Ortho-Phosphorus	01.	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	0.1	0.059	0.053	0.13
Zinc	0.1	0.24	0.18	0.52
Copper	0.04	0.043	0.029	0.084
Cadmium	0.0	0.001	0.0	0.003
COD	72	173	95	232
Total Organic Carbon	26	40	72	22-26
Suspended Sediments	400	225	240	399
Dissolved Carbon	16	30	41	12

Category-specific BMP manuals

Golf course best management practices

The development of a golf course can affect the hydrologic and water quality characteristics of an area, alter the historic stormwater patterns and impact habitat, groundwater, soil conditions, and other aspects. Surface and groundwater quality can also be changed by the different operation practices used on a golf course. Guidelines were developed to help the golf industry incorporate best management practices (BMPs) in the planning, design, construction, and operation of a golf course (Wright Water Engineers, Inc. and DRCOG 1996). The golf course practice manual is titled *Guidelines for Water Quality Enhancement at Golf Courses Through the Use of Best Management Practices*, December 1996, is available through the Denver Regional Council of Governments.

The selected set of BMPs can minimize potential adverse nonpoint source impacts associated with golf courses. If these relatively straightforward, proven BMPs are implemented, golf courses can be designed and operated to enhance the environment. Some key water quality improvement or prevention issues associated with golf course design, construction and maintenance include:

- ongoing conflict between the public and the golf course industry over environmental issues related to water resources degradation;

- a lack of customized BMPs appropriate for western states for use in design and operation of golf courses;

- the need for fundamental industry requirements for prevention of water quality or environmental degradation; and

- past unsuccessful public-private partnerships due to communication problems.

Stakeholders included the American Society of Golf Course Architects, metropolitan golf course owners and superintendents, environmental coalitions, various consultants, and state and federal governmental agencies. Stakeholders provided input on potential BMPs they perceived as effective, modifications to BMPs, and practices that do not work with golf course design.

If golf courses are properly designed, constructed and operated, they are compatible with a healthy environment. The set of 28 key BMPs recommended for consideration in the design, construction and maintenance of golf courses are environmentally friendly. Many of these practices are adapted from the standard practices already identified as applicable for Colorado in the urban and construction management portion of the Colorado Nonpoint Source Management Program, and by the Urban Drainage and Flood Control District.

The *Guidelines for Water Quality Enhancement at Golf Courses Through the Use of Best Management Practices* (Wright Water Engineers, Inc. and DRCOG 1996) is a publicly available reference that provides descriptions of key BMPs for use with golf courses. Key practices defined in the manual include:

- Pre-design Natural Resources Inventory and Evaluation

- Pre-design Planning and Golf Superintendent Design Input

- Identify Applicable Source Controls

- Retention Ponds (Wet Ponds) and Detention Basins (Dry Ponds)

- Edge Treatment Along Ponds, Waterways, Riparian Corridors, and Wetlands

- Irrigated Grass Buffer Strips

- Grass-Lined Swales

- Off-site Velocity Controls

- Stream Crossing Design

- Man-made Wetlands
- Conservation Easements
- Incorporation of Wildlife Habitat Features
- Advanced Irrigation Design
- Erosion and Sediment Control
- Minimizing Disturbance of Areas Designated for Native Species
- Re-seeding with Desirable Golf Course Mixes
- Topsoil Preservation
- Integrated Pest Management (IPM) and Use of Biological Treatments
- Irrigation Management
- Proper Use of Turf Grass Fertilizers
- Landscaping and Vegetative Practices
- Turf Management Plan
- Golf Course Lake Management
- Monitoring
- Record keeping
- Regular Maintenance

Mountain driveway best management practices

Driveways in mountainous areas can be a significant source of sediment and erosion products that reach streams and other waterbodies. While BMPs appropriate for secondary roads and highways exist, BMPs appropriate for driveways are not specifically defined. The mountain driveway BMP manual includes a limited number of BMPs appropriate for driveways compiled in a concise manner with engineering sketches (Wright Water Engineers, Inc. and DRCOG 1999). The manual titled *Mountain Driveway Best Management Practices*, June 1999, is available from the Denver Regional Council of Governments.

Selected practices can be printed as individual information sheets for general distribution. This manual and accompanying information sheets can be used by county planning agencies as a checklist during development plan review and as guidelines for landowners, developers, and consultants during the planning and construction processes or by other appropriate agencies as needed. The availability of a driveway BMP manual, designed to reduce nonpoint source loading to waterbodies, is a valuable watershed management tool.

A substantial amount of information on the top 20 potential BMPs for use in roadway design and construction of water quality retrofitting already exists. In many cases, these BMPs were streamlined to those applicable to driveway design and construction. This project included building stakeholder involvement (primarily at the county level), researching, compiling, customizing the BMPs, and developing and distributing the information. The guidance material emphasizes practices appropriate for western state mountainous conditions. Enhanced industry knowledge on what can be done to improve efficiency of runoff from driveways and incorporation of these changes in the design and construction of driveways should succeed in improving the quality of water resources in Colorado.

High altitude best management practices

Erosion control specialists face challenges when revegetating and restoring land high in the Rock Mountains where construction of roads, mines, pipelines, and ski areas have left earth bare. Vegetation may not mature until the third growing season, requiring additional time in the implementation of best management practices. In addition to a short construction and growing season high-altitude erosion control projects must contend with realities such as:

- Less availability of nutrients. Plant roots can take up food only when the soil is free of frost.

- Less soil microbial activity. Cold temperatures reduce activity of microorganisms that convert organic debris and inorganic matter to soil.

- Less photosynthesis. The thinner atmosphere at high-elevation sites filters out less ultraviolet radiation from the sun. These rays can damage leaf surfaces, disrupting photosynthesis and even killing plants.

Fall is the best time to seed high-altitude sites. Species adapted to high places produce seed in late summer. These seeds remain dormant over the winter until conditions are suitable for germination and growth in the spring. Fall also is the best time to transplant live, but dormant, high altitude-adapted plants. Live planting is

expensive, but on small, critical sites where seeding might be difficult, it's a good alternative.

Large-lot subdivisions

The growth and development in Colorado has resulted in the proliferation of large-lot subdivisions. While many of these subdivisions are located near urban centers, many are found in rural portions of the state. It is not uncommon to have over 100 houses built within these subdivisions. The development densities in large-lot subdivision are less than urban densities. However, the amount of infrastructure and increased impervious surfaces causes runoff from these types of development to have water quality characteristics similar to urban areas.

The nonpoint source runoff from construction of large-lot developments and subsequent runoff after development has the potential to alter water quality in the associated watersheds. A large lot sub-division with 250 houses on septic systems could produce up to 4.4 tons of total nitrogen and 1.5 tons of total phosphorus per year. Assuming all these septic systems exceed design criteria, there are still over 2 tons of nitrogen and over 300 pounds of phosphorus reaching underlying drinking water supplies or nearby surface waters. County officials in mountainous counties are concerned about these types of development impacts on the quality of life. Consequently, a set of best management practices directed at minimizing water quality degradation from large-lot developments is needed as part of the nonpoint source management program.

Keeping Soil on Site

The Denver Regional Council of Governments, in cooperation with the Urban Drainage and Flood Control District and the Colorado Department of Transportation developed a training video (*Keeping Soil on Site: Construction Best Management Practices*) and companion notebook on construction best management practices (DRCOG 1998). The video details current practices used during construction to control erosion and sediments.

The notebook contains an outline of the video, 35 fact sheets on main points discussed in the video, pages designed to reinforce important points, and contacts for other information sources. The video provides motivation for doing erosion and sediment control, provides important definitions, outlines pre-construction activities, details overlot grading, utility installation, practices for final stabilization and discusses economic incentives. Copies of the video and notebook are available from the Denver Regional Council of Governments (303-455-1000).

Checklist of Colorado urban and construction practices

Table 12 lists best management practices used in Colorado under various application categories. Design or guidance documentation is available for these practices. More detailed descriptions of these practices are included in this management program or referenced as being available in other source documents. Listed practices can have multiple design features and most have numerous variations, which are necessary to fit site-specific conditions.

Table 12 Checklist of urban and construction best management practices

Colorado Urban and Construction Best Management Practices	
Structural Practices	
1.	Minimizing Directly Connected Impervious Areas
2.	Irrigated Grass Buffer Strips
3.	Grass-lined Swales
4.	Extended Detention Basins (dry basins)
5.	Retention Ponds (12-hr wet ponds)
6.	Long-term Retention Ponds (>12-hr wet ponds)
7.	Sand Filter Extended Detention Basin
8.	Infiltration Trenches
9.	Constructed Wetlands/Basins/Channels
10.	Modular Block Porous Pavement
11.	Porous Pavement Detention
12.	Porous Landscape Detention
13.	Sediment Vaults, Water Quality Vaults & Inlets
14.	Porous Pavement Detention
15.	Porous Landscape Detention
16.	Covered Storage & Handling Areas
17.	Spill Containment & Control Barriers
Nonstructural Practices	
1.	Adoption of Criteria and Standards
2.	Disposal of Household Waste and Toxics
3.	Stormwater Quality Control Planning
4.	Stream Buffer Setbacks
5.	Landscaping and Vegetative Practices
6.	Use of Pesticides, Herbicides and Fertilizer
7.	Good Housekeeping & Maintenance
8.	Spill Prevention & Response Practices
9.	Painting Operations
10.	Above Ground Storage Tanks Operations
11.	Loading and Unloading Operations
12.	Fueling Operations
13.	Minimization of Exposure

Colorado Urban and Construction Best Management Practices
14. Mitigation of losses and Preservation of Native Species
15. Public Education & Participation
16. Outside Material Storage
17. Storm Drain System Signs
18. Dust Control
19. Illicit Discharge Controls
20. Outside manufacturing
21. Vehicle & Equipment Washing
22. Materials Inventory
Construction and /or Temporary Practices
Erosion Control Practices
1. Surface roughening
2. Mulching
3. Revegetation
4. Interim ground stabilization
5. Roads and soil stockpiles
Sediment Control Practices
1. Vehicle tracking
2. Slope-length & runoff considerations
3. Slope diversion dikes
4. Swales
5. Sediment barriers
6. Sediment entrapment facilities
Drainageway Protection Practices
1. Waterway crossing practices
2. Temporary crossing & diversions
3. Stability practices
4. Conveyance controls
5. Outlet Protection
6. Inlet Protection

Other Construction Site Practices
1. Topsoil Preservation and Reuse
2. Material Storage and Petroleum Products
3. Underground Utility Construction
4. Maintenance & Housekeeping
5. Disposition of Temporary Measures

Colorado Department of Transportation	
Erosion and Sediment	
1.	Seeding And Mulching
2.	Surface Roughening
3.	Erosion Bales And Silt Fence
4.	Berms, Diversions And Check Dams
5.	Inlet And Outlet Protection,
6.	Slope Drains
7.	Erosion Control Blankets
8.	Channel Linings
9.	Sediment Traps
10.	Sediment Basins
Stormwater Quality Control BMPs	
1.	Grass Swales
2.	Grass Buffer Strips
3.	Constructed Wetlands
4.	Extended Dry Ponds
5.	Wet Detention Ponds
6.	Infiltration Basins
Permanent Best Management Practices	
1.	Minimizing Directly Connected Impervious Areas
2.	Irrigated Grass Buffer Strips
3.	Grass-lined Swales
4.	Extended Detention Basins (dry basins)
5.	Retention Ponds (12-hr wet ponds)
6.	Sand Filter Extended Detention Basin
7.	Infiltration Trenches
8.	Constructed Wetlands/Basins/Channels
9.	Modular Block Porous Pavement
10.	Porous Pavement Detention
11.	Porous Landscape Detention
12.	Sediment Vaults, Water Quality Vaults & Inlets
13.	Porous Pavement Detention
14.	Porous Landscape Detention
15.	Stream Buffer Setbacks
16.	Adopted Criteria and/or Standards
17.	Landscaping and Vegetative Practices
18.	Use of Pesticides, Herbicides and Fertilizer
19.	Public Education & Participation
Mountain Driveway Best Management Practices	
Pre-construction planning	
1.	Site constraints (e.g., slope stability, drainage aspect and constructability)
2.	Emergency access
3.	Construction timing

4.	Local permitting
	Design
1.	Minimize Disturbance of Vegetation/Wetlands
2.	Winter Maintenance – Driveway Orientation, Sanding and Snow Removal
	Construction
1.	Stormwater Diversion During Construction
2.	Vehicle Tracking Pad
3.	Straw Bales
4.	Sand bags
5.	Silt Fence
6.	Sediment Traps
7.	Sediment Basins
8.	Brush Barriers
9.	Check Dams
10.	Vegetation Buffers
11.	Grass-lined Swales
12.	Revegetation (Special Seed Mixtures)
13.	Mulching
14.	Erosion Control Blankets
15.	Slope Stabilization
16.	Slope Drains
17.	Road Drainage
18.	Drainageway Protection
19.	Outlet Protection
20.	Infiltration Practices
21.	Stream Crossings
22.	Source Controls
	Golf Course Best Management Practices
	Design
1.	Pre-design natural Resources Inventory and Evaluation
2.	Pre-design Planning and Golf Superintendent Input
3.	Identify Applicable Source Controls
4.	Special Golf Course Drainage Design Considerations
5.	Wet retention Ponds and Dry Ponds
6.	Edge Treatment Along Ponds and Waterways
7.	Grass Buffer Strips
8.	Grass-lined Swales
9.	Off-site Velocity Control Practices
10.	Stream Crossing Design
11.	Man-mage Wetlands
12.	Conservation Easements
13.	Incorporation of Wildlife Habitat Features
14.	Advanced Irrigation Design
	Construction Practices
1.	Erosion and Sediment Control
2.	Minimize Disturbance of Areas Designated for native Species

3.	Re-seeding with Desirable Gold Course Mixes
4.	Topsoil Preservation
	Maintenance Practices
1.	Integrated Pest Management and Use of Biological Treatments
2.	Irrigation Management
3.	Proper Use of Turf Grass Fertilizers
4.	Landscape and Vegetative Practices
5.	Turf Management Plan
6.	Golf Course Lake Management
7.	Source Controls and Spill Prevention
8.	Monitoring Plan
9.	Record Keeping
10.	Regular Maintenance
	Forest Services Watershed Conservation Construction Practices
1.	Standard 3 – Restrictions on Heavy Equipment Operations in Waters of the State
2.	Standard 4 – Design and Construction of Stream Crossings and Instream Structures
3.	Standard 6 – Management of Water-use Facilities including diversions and dams
4.	Standard 9 – Limit Roads and Disturbed Sites (Sediment Controls for Roads)
5.	Standard 10 – Construction of Roads and Development Sites
6.	Standard 11 – Stabilize and Maintain Roads and Other Disturbed Sites During and After Construction to Control Erosion
7.	Standard 12 – Reclaim Roads and Other Disturbed Sites When Use Ends

General objectives used to select structural practices

The general objectives used by local governments and other agencies to select structural BMPs for an urban area include:

- Having an effective level of urban pollutant removal;
- Selecting an appropriate BMP for the site, given the site's physical constraints;
- Keeping selected BMPs cost-effective compared with urban runoff controls;
- Minimize the future maintenance burden;
- Minimize, to the maximum extent practical, impacts on receiving waters; and
- Provide opportunities for multi-use benefits (parks, green spaces and landscaping features).

Colorado structural, nonstructural, industrial and commercial practices

The structural, nonstructural, industrial and commercial best management practices are based to a large extent on those described in the *Urban Drainage and Flood Control District Drainage Criteria Manual*, Volume 3. This set of best management practices contains most of the control methods used in Colorado for stormwater and nonpoint source runoff management and construction activities. The Denver Regional Council of Governments has also adopted these practices for the eight-county metropolitan region. Table 13 lists structural, non-structural, industrial & commercial best management practices recommended by the *Water Quality Control Division* for use in the Colorado Nonpoint Source Management Program, as updated in 1999.

All of the nonstructural best management practices have an educational component. There is also a need for general education programs related to construction nonpoint source runoff, stormwater discharge and other urban runoff. Specific education programs need to be directed toward the construction industry in Colorado. The *Urban and Construction Committee* in a future program update will update specific information sources for each practice. General information sources are included in this recommended guidance document.

Table 13 Updated structural, non-structural, industrial & commercial BMPs

Best Management Practice	Planning Considerations
Structural Best Management Practices	
Minimizing Directly Connected Impervious Areas	1. Site drainage flow path to maximize flow over vegetated area; 2. minimize ground slopes to limit erosion and slow down flow; 3. select vegetation for survival values and water quality benefit
Irrigated Grass Buffer Strips	Design is based on maintaining sheet-flow conditions across a uniformly graded, irrigated, dense grass cover strip
Grass-lined Swales	Minimize Direct Connected Impervious Areas to decrease runoff peaks, volumes and pollutant loads; design is based on maintaining sheet-flow conditions across a uniformly graded, irrigated, dense grass cover strip
Extended Detention Basins (dry basins)	Rely on an outlet designed to extend the emptying time of the basin's capture volume; design embankment-spillway-outlet system to prevent catastrophic failure; design to empty capture volume over a 40-hour period
Retention Ponds (12-hour maximum wet ponds)	Requires a base flow to maintain and to flush a permanent pool; designed to empty capture volume over a 12-hour period; design embankment-spillway-outlet system to prevent catastrophic failure
Retention Ponds (>12 hour wet ponds)	Requires a base flow to maintain and to flush a permanent pool; Site specific use and design criteria not fully established for Colorado; designed to empty capture volume over a period greater than 12-hours; design embankment-spillway-outlet system to prevent catastrophic failure
Sand Filter Extended Detention Basin	A runoff storage zone is underlain by a vegetated sand bed with an underlying sand bed as an under-drain system. Runoff ponds in the surcharge zone and gradually infiltrates into sand bed filling the void spaces. Pollutant removal is provided through settling and filtering, and

Best Management Practice	Planning Considerations
	is suited where there is no base flow or the sediment load is relatively low.
Infiltration Trenches	This practice shows promise but needs further demonstration to determine pollutant removal effectiveness, develop design criteria that insures proper design, construction and maintenance.
Stream Buffer Setbacks	Buffer setbacks are used to protect water quality. No minimum buffer setback distances have been established in Colorado and should be determined on site-specific bases. This practice shows promise but needs further demonstration to determine pollutant removal effectiveness and to develop design criteria. This practice may be used with appropriate stream crossing practices.
Constructed Wetlands, Basins and wetland channels	1. Can be constructed as a wetland basin or set into a drainageway to form a wetland bottom channel; 2. Requires a base flow to maintain wetland vegetation; 3. Pollutant removal efficiencies of constructed wetlands vary significantly; 4. Removal efficiency design factors include influent concentrations, hydrology, soils, climate, vegetative type, growth zonation, maintenance and harvesting
Modular Block Porous Pavement	Design for even flow distribution over the entire porous surface; assume permeable pavement area are 30 percent impervious with subsoil infiltration and 60 percent impervious with no subsoil infiltration
Sediment Vaults, Water Quality Vaults and Inlets	Sediment or water quality vaults and specialized inlet vaults show promise but need further independent demonstration to determine pollutant removal effectiveness in semiarid climates or in mountainous areas and to develop cost-effective design criteria that insures proper design, construction and maintenance. Site-specific application of sediment vaults should be demonstrated where space limitations control types of applicable structural practices.
Porous Pavement Detention	A modular porous pavement that is flat and provides a 2-inch deep surcharge zone above its surface to temporarily store capture volume draining from adjacent tributary area, including its own surface. Runoff infiltrates into void spaces of gravel base course through sand filter and slowly exists through an underdrain. This practice is designed to improve water quality.
Porous Landscape Detention	A low-lying vegetated area underlain by a sand bed with an underdrain pipe. A shallow surcharge zone exists above the porous landscape detention for temporary storage of capture volume. Runoff ponds in the vegetated zone and gradually infiltrates into the underlying sand bed filling the void spaces. The underdrain slowly dewaters the sand bed and provides a water quality benefit.
Stormwater Quality Control Planning	1. The implementation of this BMP is in the form of adoption or promulgation of ordinances, resolutions or executive orders granting authority to local government staff to review stormwater quality control plans and to either approve or present recommendations to elected officials for their approval; 2. Requires a commitment of staff and fiscal resources of the local government to follow through with review, approval and enforcement of site-specific plans; 3. Regulations must be adopted specifying the content of stormwater quality control plans

Best Management Practice	Planning Considerations
Covering of Storage & Handling Areas	Covering of storage & handling facilities will reduce the likelihood of stormwater contamination and will prevent loss of material from wind or rainfall erosion. Covering can be permanent or temporary using tarpaulins, plastic sheeting, roofing, enclosed structures, or any other device that prevent rain, snow melt or wind from spreading possible contamination
Material Storage and Staging Areas	Spill containment and control at material storage site or staging area should include lined areas, diked areas, berming or gates to prevent extensive soil contamination. Berms may be made of concrete, earthen material, metal, synthetic liners, or any material that will safely contain a spill. Spill material is any material not allowed into surface waters or storm sewer systems according to local, state or federal regulation. Spill control devices include valves, slide gates, or any other device, which can contain spill material when required.
Nonstructural Best Management Practices	
Adoption of Criteria and Standards	The adoption by local governments of criteria and standards for the selection, planning and design of stormwater facilities
Disposal of Household Waste and Toxics	The goal of household waste disposal is to contain all refuse, reduce litter and encourage proper waste disposal practices through public education programs; develop and encourage recycling and resource recovery programs
Use of Pesticides, Herbicides and Fertilizer	The development of an ongoing educational program is the basis of this BMP; develop and encourage alternate application technologies, composting and resource recovery programs
Illicit Discharge Controls	Activities designed to reduce entry of pollutants into municipal stormwater systems during dry-weather periods; programs which address illegal dumping, accidental spill response and illicit connections
Landscaping and Vegetative Practices	Development and distribution of guidelines and educational materials on landscaping and vegetative utilization for urban development area; fugitive dust and bare-ground re-vegetative local ordinances
Stormwater Public Education and Participation	Storm drain system signs are means of raising public awareness. A wide variety of educational efforts using multi-media are needed to educate specific groups and general public. Systematic media campaigns conducted over multiple years.

Good Housekeeping, Preventative Maintenance & Inspections	Good housekeeping requires keeping potential areas where pollutants and pollution exist clean and orderly. Use of common sense to improve and maintain basic housekeeping methods: accidental spill response, well-maintained machinery and processes, improved operations, material storage practices, material inventory controls, routine or regular clean-up schedules, well organized work areas, educational programs and method to prevent mixing of runoff into environment from stormwater runoff. Preventative maintenance involves regular inspection and testing of equipment and operational systems to prevent break downs and failures that cause potential runoff contamination.
Light Industrial and Commercial Best Management Practices (Activities that Pose a Potential Stormwater Threat and Basic Structural or Nonstructural Practices that can be Applied to Activity)	
Spill Prevention and Responses, Minimization of Exposure, Mitigation Plan, Materials Inventory	Spill containment practices, storage handling area practices and a prevention response plan and mitigation plan should be utilized. Maintaining a material inventory should be incorporated in a mitigation plan. Generally, minimization of exposure can reduce potential contamination and promote good housekeeping practices.
Painting Operations	Paint solvents used to remove or thin paint and dust from sanding and grinding operations can contain toxic metals like cadmium and mercury. Sources of contamination can be pint and chemical paint removal, sanding blasting or equipment painting. Spill containment practices, materials storage and handling practices, and good housekeeping/ preventative maintenance practices should be utilized.
Above Ground Storage Tanks Operations	Storage tank potential leak must be contained using dikes and berms. Spill containment practices and storage handling area practices should be utilized.
Loading and Unloading Operations	Loading and unloading operations taking place at docks, truck terminals or outside storage and handling areas can have material spills, leaks or other potential material contamination. Spill containment practices, materials storage and handling practices, and good housekeeping/ preventative maintenance practices should be utilized.
Fueling Operations	Fuel overflows during storage tank filling can be a major source of contamination. Spills can occur during fueling or oil delivery, topping of tanks, allowing rainfall into fueling areas, hosing or wash-down operations or mobile fueling operations. Spill containment practices and storage handling area practices should be utilized.
Outside Manufacturing	Activities include parts assembly, rock grinding or crushing, metal painting or coating, grinding or sanding, degreasing, parts cleaning or operations that use hazardous materials. Spill containment practices, materials storage and handling practices, dust control, runoff prevention practices, education and good housekeeping/ preventative maintenance practices should be utilized.
Outside Material Storage	Covering of materials and storage area practices, spill containment practices, materials storage and handling practices, and good housekeeping/ preventative maintenance practices should be utilized.

Vehicle and Equipment Washing	Runoff control practices, spill containment practices, materials storage and handling practices, and good housekeeping/ preventative maintenance practices should be utilized.
Dust Control	Cover or wet down areas or materials subject to wind erosion or blowing dust.

Descriptions of selected structural and nonstructural practices

Minimizing directly connected impervious areas

Minimizing directly connected impervious areas (DCIAs) is a structural BMP strategy that requires a basic change in drainage design philosophy. This change in drainage strategy directs stormwater runoff to landscaped areas, grass buffer strips, and grass-lined swales to slow down the rate of runoff, reduce runoff volumes, attenuate peak flows, and encourage filtering and infiltration of stormwater. Traditional land development practices that do not focus on water quality enhancement promote runoff from rooftops, parking lots, driveways, and roads to quickly flow to a curb and gutter and to a formalized stormwater conveyance system. This practice concentrates runoff quickly, which results in a fast responding system and relatively large peak runoff rates. Minimizing DCIAs can reduce the size of on-site and regional water quality enhancement facilities and the size of downstream conveyance systems. When integrated into new landscaping plans, minimizing DCIAs can divert some of the rainwater to irrigate vegetation by using the runoff from impervious areas.

Irrigated grass buffer strips

Grass buffer strips are uniformly graded and densely vegetated areas of irrigated turf grass. They require sheet flow to promote filtration, infiltration and settling to reduce runoff pollutants. Grass buffer strips differ from grass-lined swales as they are designed to accommodate overland sheet flow rather than concentrated or channelized flow. They can be used to remove larger sediment from sheet flow runoff flowing off impervious areas.

Whenever concentrated runoff occurs, it should be evenly distributed across the width of the buffer strip via a porous pavement strip or another type of structure to achieve sheet-flow conditions. Buffer strips may also be located adjacent to major drainageways and receiving waters. Buffer strips can be interspersed with shrubs and trees that can take up nutrients and provide shading. In a semiarid climate, irrigation is required to maintain a healthy and dense grass on the grass buffer strip to withstand runoff from impervious areas.

Grass-lined swales

Grass-lined swales are densely vegetated drainageways with low-pitched side-slopes that collect and slowly convey runoff. Design of their longitudinal slope and cross-section size forces the flow to be slow and shallow, thereby facilitating sedimentation while limiting erosion. Berms or check dams should be installed perpendicular to the flow as needed to slow it down and to encourage settling and infiltration.

Extended detention basins (dry)

Extended detention basins are designed to totally empty out after stormwater runoff ends. They are similar to detention basins used for flood control. The primary difference is in the outlet design. The extended basin uses a much smaller outlet that extends the emptying time of the more frequently occurring runoff events to facilitate pollutant removal. A drain time of the brim-full capture volume of 40 hours is recommended to remove a significant portion of fine particulate pollutants found in urban stormwater runoff. Soluble pollutant removal can be somewhat enhanced by providing a small wetland marsh or ponding area in the basin's bottom to promote biological uptake. The basins are considered to be *dry* because they are designed not to have a significant permanent pool of water.

Retention ponds (ponds with a permanent pool)

A retention pond has a permanent pool of water that is replaced with stormwater, in part or in total, during storm runoff events. Temporary detention is provided above this permanent pool to allow more sedimentation. Retention ponds are similar to extended detention basins because they are designed to capture in total and detain a volume of runoff from frequently occurring storms. However, detention ponds differ from extended detention basins because the influent water mixes with the permanent pool water as it rises above the permanent pool. The captured volume above the permanent pool is then released over 12 hours. Retention pools require a dry-weather base flow to maintain the permanent pool. They can be very effective in removing pollutants, and, under the proper conditions, can satisfy multiple objectives.

Constructed wetlands

Two types of constructed wetlands are described in this section-very shallow retention ponds and wetland-bottomed channels. Both configurations require a perennial base flow to permit the growth of rushes, willows, cattails, and needs to slow down runoff and allow time for settling and biological uptake.

Constructed wetlands differ from *natural* wetlands as they are artificial and are built to enhance stormwater quality. Sometimes small wetlands that exist along ephemeral drainage-ways on Colorado's high plains could be enlarged and incorporated into the

constructed wetland system. Such action, however, requires the approval of federal and state regulators.

Regulations intended to protect natural wetlands recognize a separate classification of wetlands constructed for a water quality treatment. Such wetlands generally are not used to mitigate the loss of natural wetlands but can be disturbed by maintenance activities. Therefore, the legal and regulatory status of maintaining a wetland constructed for the primary purpose of water quality enhancement is separate from the disturbance of a natural wetland.

Modular block porous pavement

Modular block porous pavement consists of perforated concrete slab units underlain with gravel. The surface perforations are filled with coarse sand, or sandy turf. This BMP is used in low traffic areas to accommodate vehicles while facilitating stormwater infiltration near its source. Modular block porous pavement has been in use since the mid-1970s.

Although it lacks field data that quantify its long-term performance as an infiltration device, the episodal record indicates it is reliable and has experienced few problems. Modular-block porous pavement should be placed in a poured-in-place concrete grid that restricts horizontal movement of infiltrated water through the underlying gravel.

Stormwater quality control planning

Stormwater management planning is an established practice with a long history of use by municipalities in Colorado. Its primary focus prior to the end of the 1980s was the prevention and mitigation of flood damages and loss of life. Emphasis in planning was on storm runoff events with return periods of 2-years through 100-years with very little attention paid to stormwater quality enhancement.

As a result of the 1987 Clean Water Act (CWA) requirements, stormwater quality planning is a required practice. These requirements extend to planning for water quality enhancement whenever conducting flood control and floodplain management planning activities.

Planning for stormwater quality can take several forms such as planning for an individual site, a new subdivision, overall planning for an urban watershed or a portion thereof, or overall planning for an entire municipality. As the planning area expands, less specific detail can be addressed and the plans become more conceptual in scope. A well developed citywide or watershed conceptual plan is useful because it provides guidance on how to deal with stormwater runoff and its quality as changes occur in land use. On the other hand, site-specific plans can clearly describe the types of BMPs, the phasing for their installation, and the type of long-term maintenance that will be required to keep them operational.

This nonstructural BMP identifies the stormwater planning needs for individual developments and the general nature of the review and approval process of local governments. Municipalities should consider development and adoption of a stormwater quality planning process. It is recommended that the proponent of any new development or redevelopment contact the local government of jurisdiction to determine the exact steps to be taken to obtain final approval of their site plans. The process begins with the preparation and submittal of a stormwater management plan by the proponent to the local government as a part of local zoning, subdivision, or other applicable development review process.

Adoption of criteria and standards

The adoption by a municipality of criteria and standards for the selection, planning, and design of stormwater quality facilities can be considered a nonstructural Best Management Practice (BMP). Criteria and standards establish the requirements for the design, construction, operation and maintenance of structural stormwater quality BMP facilities that the municipality considers being the minimum acceptable. Their formal adoption or promulgation must occur before these minimum standards have a legal basis within the community. Since the criteria set forth the minimum standard, their use should not preclude innovation, or the use of detail other than presented in the criteria as long as the basic technology and sound engineering practice are not violated and the goals are being met.

When combined with the municipality's legislative authority and its comprehensive planning process, the adoption of criteria and standards supports the review and approval of zoning, plat filing, and construction actions for land development and redevelopment. This also ensures that the structural BMPs being used are based on sound technical and engineering design principles that should provide the intended stormwater quality enhancement.

Source reduction and disposal of household waste and toxics

Improperly disposed waste materials are a source of stormwater pollution. This is especially true when wastes are placed on impervious surfaces directly connected to the storm drainage system, such as streets, alleys, parking lots and sidewalks. The development of educational programs and similar efforts, which can lead to source reduction or alternative product selection, is a type of pollution prevention practice. This type of program can reduce the amount and type of material potential available at households.

The development of public education programs and dissemination of information that promotes proper disposal of household waste, litter, pet waste, yard waste, used oil, and toxic waste is also a nonstructural best management practice (BMP) that can be employed by the state, municipalities, civic groups and industry. The passage of

municipal ordinances prohibiting improper disposal of these materials, and their enforcement, is another step in this management practice; however, an on-going education program, along with facilities for such disposal, has been judged to be most effective at this time.

Use of pesticides, fertilizer and alternative pest control practices

Pesticides and fertilizers are used to maintain landscaping in residential and commercial areas. These substances are toxic and can contaminate surface runoff if not properly used. This nonstructural BMP consists of the development and dissemination of public information that encourages proper use and application of pesticides and fertilizers.

There are alternative pest control practices, which lead to less use of pesticides. Additionally, integrated landscape management can reduce pesticide and herbicide application and more efficient use of fertilizers. Yard-waste composting products can be used to replace commercial fertilizers and local governments should be encouraged to promote this activity.

Illicit discharge controls

Activities and education programs that reduce the entry of pollutants into the municipal storm sewer system during dry-weather periods can enhance the quality of receiving waters. These include controls on illegal dumping of toxic substances and petroleum products, responses to contain accidental spills, measures to locate and disconnect illicit connections of wastewater sewers from storm sewers and measures to prevent additional illicit wastewater sewer connections in the future.

To their credit, many municipalities already have programs in place to address all of these concerns. Measures that limit these types of illicit discharges to the storm drainage system are considered nonstructural best management practices (BMPs).

Landscaping and vegetative practices

Establishment and maintenance of landscaping and vegetation in existing urban areas can assist in reducing stormwater runoff rates and volumes, sediment loads, and pollution associated with sediment from entering streams and lakes.

In any urban area, many areas of land exist that are devoid of vegetation for long periods of time. Efforts to re-vegetate these areas and those experiencing soil disturbance activities, or otherwise provide stabilization from erosion during storm runoff, will improve the quality of stormwater runoff entering receiving waters. This nonstructural BMP encourages the establishment and maintenance of urban landscaping, integrated landscape management practices and vegetation or re-

vegetation through the development of public education programs, dissemination of information, and the adoption of erosion control ordinances.

One of the significant elements of this BMP is the appropriate use of plant material in the landscape design. Good site design and plant selection results in healthier plants and landscapes that are better able to withstand the natural and unnatural stresses placed on them without chemical support (e.g., source control). The principles of xeriscaping should be applied to landscape designs in the semi-arid portion of Colorado. This BMP relates to pesticides and fertilizers as used to maintain landscaping in residential and commercial areas.

General education programs

All of the nonstructural best management practices have an educational focus and recognize the need for general education programs related to construction related nonpoint sources, stormwater discharge and urban runoff. Educational programs in metropolitan or urban areas and directed toward the construction industry should target a wide variety of audiences including, but not limited to: schools (3rd through 12th grade levels); University, college or trade school courses; general public; specialty groups (e.g. special districts, municipal governments, homeowners associations, architects, engineers, contractors, and public works personnel); distribution stores (e.g. greenhouses, home supply stores).

General education programs in urban areas could include the compilation, development and distribution of information on how oil, antifreeze, pesticides, paints, solvents, or other potentially harmful chemicals affect waterways after being dumped into storm sewers or drainage channels; information on the effective use of "housekeeping" practices, including the use of adsorbents, cleaning compounds, and oil/grease traps for controlling oil and grease in gas stations, automotive repair shops, parking areas, commercial/industrial facilities, and food service facilities; information on the environmental impacts which can result from leaks and spills from gasoline, fuel oil, and chemical tanks (above and below ground).

Other programs could distribute information on how to keep rainfall and runoff from contacting potential contaminants; how to minimize both the total volume of runoff and the peak rate of runoff from a given area; or information on the need to minimize the total runoff volume that roof drains contribute directly to storm sewers and drainage channels.

Air Quality and transportation related education programs are needed which identify the relationship between air pollution and nonpoint source water quality problems. These education programs should coordinate information with Colorado agencies responsible for transportation, air quality and water quality planning and management. Other types of transportation related education programs could include distribution of information on the need to intensify vehicle inspection; maintain efforts to reduce

leakage of oil, antifreeze, hydraulic fluid; promote cooperative programs which seek to reduce particulate atmospheric emissions of pollutants from individual, public, commercial, and industrial sources; promote cooperative programs which seek to reduce automobile use by various means (e.g., ride sharing, car-pooling, public transportation); promote programs which intensify vehicle inspection and maintenance efforts to reduce atmospheric emissions.

Educational programs can also be directed at erosion and sediment control practices and the need to have these types of programs including distribution of information on need for and practical methods for erosion control and sediment control for open-space lands; distribute information to managers and users of park lands and open-space lands on the need to restrict off-trail activities; the need to establish and enforce practical, site-specific regulations to control off-trail activities.

Colorado erosion and sediment control practices

Sediment is one of the most prevalent nonpoint source runoff components associated with urban development and construction activities. Similar best management practices are applicable to both stormwater runoff in urban areas and construction site runoff (Table 14).

Erosion and sediment control practices were summarized from the Urban Drainage and Flood Control District Drainage *Criteria Manual, Volume 3*. These practices are designed for use with urban development and other construction activities and they are applicable to all urban areas and construction activities in Colorado. These practices are recommended for use in the Colorado Nonpoint Source Management Program. The *Urban and Construction Committee* will update specific information sources for each practice, as appropriate. General information sources are included in this management program (e.g., *Keeping Soil on Site*, DRCOG 1998).

Table 14 Erosion and sediment control practices

Control Type	Summary Of Practice Criteria
1. Sediment / Erosion Control Plan	Erosion and sediment control planning should occur early in the site development process and be adjusted throughout site development as needed; These plans should define the erosion and sediment control practices and include a drainage-way protection plan, if necessary
2. Erosion Control	Surface roughening provides temporary stabilization of disturbed areas from wind and water erosion; surface roughening should be performed after final grading to create depressions 2 to 4 inches deep and 4 to 6 inches apart
	Mulching of all disturbed areas should occur within 14 days after final grade is reached on all portions of site not permanently stabilized
	Revegetation of a viable vegetative cover should occur within one year on all disturbed areas and stockpiles not permanently stabilized; Temporary vegetation is required on all disturbed areas having a period of exposure to final stabilization of one to two years; permanent vegetation is required on all disturbed areas having an exposure period longer than two years; perennial grasses should be considered for all revegetation efforts
	Roads and soil stockpiles should be covered as early as possible with the appropriate aggregate base; all non-paved road portions should be seeded and mulched within 14 days after final grading; stockpiles in place over 60 days should have temporary vegetation; stockpiles within 100 feet of drainageways need additional erosion and sediment control measures
3. Sediment Control	Vehicle tracking of mud and dirt onto paved surfaces should result in cleaning of paved surfaces at the end of each day; for sites greater than two acres, a rock pad should be built at points of ingress and egress
	Slope diversion dikes located above disturbed areas may discharge to a permanent or temporary channel; diversion dikes located mid-slope on a disturbed area must discharge to temporary slope drains or other appropriate structure; diversion dikes located at the base of a disturbed area must discharge to a sediment trap or basin
	Roads and roadside swales should be provided for when road areas are not paved within 30-days of final grading; terracing and slope drains can be used in steep slope areas
	Sediment entrapment facilities include terracing, slope drains, straw bale barriers, silt fences, filter strips, sediment traps and sediment basins; at least one entrapment facility should capture run-off leaving a disturbed area
4. Topsoil Preservation and Reuse	As a minimum, topsoil preservation and reuse involves the removal, stockpiling, and re-spreading of the surface six to eight inches of natural soil.
5. Drainage-way Protection	Waterway crossing practices should limit construction vehicles in waterways to the maximum extent practicable
	Temporary crossing or diversions are needed for actively-flowing water courses with regular crossing of construction vehicles
	Outlet protection temporary slope drains, culverts, sediment traps and sediment basins must be protected from erosion and scour; check dams can be used in swales and ditches to protect these from down-cutting
	Inlet protection all stormwater sewer inlets made operable during construction must have sediment entrapment facilities installed to prevent sediment-laden water from entering the inlet
6. Material Storage	Chemicals, petroleum products and waste storage practices should be designed to

Control Type	Summary Of Practice Criteria
Practices	prevent discharge of any stored material into the runoff from a construction site
7. Underground Utility Construction	Trench dewatering devices must discharge in a manner not to adversely affect flowing streams, wetlands, drainage systems or off-site property; limit the amount of open trench to 200 feet
8. Disposition of Temporary Measures	All temporary erosion and sediment control measures must be removed within 30-days after final stabilization
9. Maintenance	All temporary BMPs shall be maintained and repaired as needed to assure continued performance during the construction phase of a project

Erosion and sediment control plan

The objective of erosion control is to limit the amount and rate of erosion occurring on disturbed areas. The objective of sediment control is to capture the soil that has been eroded before it leaves the construction site. Despite the use of both erosion control and sediment control measures, it is recognized that some amount of sediment will remain in runoff leaving the construction site.

An erosion and sediment control plan is comprised of three major elements.

1. The erosion control measures that will be used to limit erosion of soil from disturbed areas at a construction site;

2. The sediment control measures that will be used to limit transport of sediment to off-site properties and downstream receiving waters; and,

3. The drainage-way protection and runoff management measures that will be used to protect streams and other drainageways located on the construction site from erosion and sediment damages.

Erosion control planning should occur early in the site development process. The planning process can be divided into five separate steps:

1. Gather information on topography, soils, drainage, vegetation and other predominant site features.

2. Analyze the information in order to anticipate erosion and sedimentation problems.

3. Devise a plan, which schedules construction activities and minimizes the amount of erosion created by development.

4. Develop an *Erosion and Sediment Control Plan* which specifies effective erosion and sediment control measures

5. Follow the *Erosion and Sediment Control Plan* and revise it when necessary.

Erosion control

The planning for the installation of permanent or temporary soil erosion controls needs to begin in advance of all major soil disturbance activities on the construction site. After construction begins, soil surface stabilization shall be applied within 14 days to all disturbed areas that may not be at final grade but will remain dormant (undisturbed) for periods longer than an additional 30 calendar days. Soil surface stabilization protects soil from the erosive forces of raindrop impact, flowing water, and wind. Erosion control practices include surface roughening, mulching, establishment of vegetative cover, and the early application of gravel base on areas to be paved. Stabilization measures to be used should be appropriate for the time of year, site conditions and estimated duration of use. Phased grading and the protection of existing vegetation should also be considered in the erosion control plan.

Surface roughening provides temporary stabilization of disturbed areas from wind and water erosion. It is particularly useful where temporary revegetation cannot be immediately established due to seasonal planting limitations. Surface roughening helps surface soils resist erosion by wind and/or water while improving infiltration, overland flow and snowmelt, which all results in less erosion and runoff. All disturbed areas must be mulched, or seeded and mulched, within 14 days after final grade is reached on any portion of the site not otherwise permanently stabilized. Areas that will remain in an interim condition for more than one year should be seeded. In wind prone areas, roughened surfaces should include ridges oriented perpendicular to prevailing erosive winds in approximately a 1:4 ridge height to ridge width ratio. On slopes, or where water erosion is a principal hazard, surface roughening should be performed on the contour. Surface roughening only provides temporary protection and must be used in combination with other BMPs, such as mulching and temporary cover.

A viable vegetative cover should be established within on year on all disturbed areas and soil stockpiles not otherwise permanently stabilized. Vegetation is not considered established until a ground cover is achieved which, in the opinion of the city or county of jurisdiction, is sufficiently mature to control soil erosion and can survive severe weather conditions. Areas to be re-vegetated should have soil conditions capable of supporting vegetation. Over-lot grading will oftentimes surface subsoils that have low nutrient value, little organic matter content, few soil microorganisms, and conditions less conducive to infiltration of precipitation. Under certain conditions, soil amendments and treatments may be necessary to provide an adequate growth medium to sustain vegetation.

Temporary revegetation is required on all disturbed areas having a period of exposure prior to final stabilization of one year or longer. Temporary seeding shall be protected

with mulch. To provide vegetative cover on disturbed areas not paved or built upon for a period of two years or longer, or for an indeterminate length of time, a perennial grass should be planted. Each site will have different characteristics, and a landscape professional should be contacted to determine the most suitable seed mix for a specific site.

Road cuts, road fills, and parking lot areas should be covered with the appropriate aggregate base course on the surfaces to be paved in lieu of mulching. Early application of road base is suitable where a layer of course aggregate is specified for final road or parking lot construction. This practice may not be desirable in all instances, and is not needed when final pavement construction will take place within 30 days of grading to final contours. All non-paved portions of road cut, fill, and parking lot areas should be seeded and mulched as soon as possible after final grading has occurred, but in no case later than 14 days after grading has been completed.

Sediment control

Sediment control will be site specific and can include vehicle tracking controls; sod buffer strips around the lower perimeter of the land disturbance; sediment barriers, filters, dikes, traps or sediment basins; or a combination of any or all of these measures. Sediment controls must be constructed before land disturbance takes place. Earthen structures such as dams, dikes, and diversions should be mulched, as a minimum, within 14 days of installation. Earthen structures that are expected to remain in place for more than one year must be seeded and mulched.

Wherever construction vehicles enter onto paved public roads, provisions must be made to prevent the transport of sediment (mud and dirt) by runoff or by vehicles tracking onto the paved surface. Cut-and-fill slopes must be designed and constructed to minimize erosion. This requires consideration of the length and steepness of the slope, the soil type, up-slope drainage area, groundwater conditions and other applicable factors. Slopes that are found to be eroding excessively will require additional slope stabilization until the problem is corrected. A temporary diversion dike is a horizontal ridge of soil placed perpendicular to the slope and angled slightly to provide drainage along the contour. Temporary diversion dikes can be constructed by excavation of a V-shaped trench or ditch and placement of the fill on the down-slope side of the cut.

The drainage system provided for roads will define to some extent the length and area of individual slope segments within the disturbed area. A number of smaller hill-slope segments will be created by construction of roads. Sediment can be controlled on slopes that are particularly steep by the use of terracing. During grading, relatively flat sections, or terraces, are created and separated at intervals by steep slope segments. The steep slope segments are prone to erosion, however, and must be stabilized in some manner. Retaining walls, gabions, cribbing, deadman anchors, rock-filled slope

mattresses and other types of soil retention systems are available for use. These should be specified in the plan and installed according to manufacturer's instructions.

There are certain instances when runoff must be directed down a slope within the disturbed area. A temporary slope drain can be used to protect these hill-slope areas from scour and additional erosion. A number of alternative designs and materials can be used for a slope drain. Sediment entrapment facilities are necessary to reduce sediment discharges to downstream properties and receiving waters. Sediment entrapment facilities include straw bale barriers (low preference), silt fences, sod filter strips, sediment traps and sediment basins. The type of sediment entrapment facility to be used depends on the tributary area, basin slope and slope length of the upstream area.

Straw bales can be placed at the base of a hill-slope to act as a sediment barrier. The use of straw bales for sediment control is one of the most used practices in Colorado; however, this BMP also has proven to be one of the least effective practices. Straw bale installation is not recommended for use within a swale or channel. Straw bales are temporary in nature and may only perform for a period of weeks or months. Proper installation and maintenance is necessary to ensure their performance. A silt fence is made of a woven synthetic material and acts to filter runoff. Silt fence can be placed as a temporary barrier at the base of a disturbed area but is not recommended for use in a channel or swale.

Vegetated filter strips act to cause deposition of sediment within the area of vegetation. Buffer strips of natural vegetation can be left at the time of site grading, or can be created by using sod. A dense ground cover is necessary or runoff can channelize within the area. A width of 20 feet or more is recommended. A sediment trap is a temporary structure that is designed to fill with sediment. A sediment trap can be constructed by either excavating below grade or building an embankment across a swale. Excavated traps are less prone to failure than embankments. No pipe is used at the outlet, as in a sediment basin, and an open-channel spillway must be included in the design. A minimum of 900 cubic feet of storage volume must be provided for each tributary acre.

Areas draining more than five acres must be routed through a sediment basin. If the site is to include a stormwater quality or flood detention basin, the permanent detention facility may be used as the temporary sediment basin, provided the outlets are modified upon completion for this purpose. Such permanent detention facilities shall be restored to design grades, volumes, and configurations after site development is completed and the project is finalized.

Topsoil preservation and reuse

Topsoil preservation and reuse involves the preservation of a scarce and irreplaceable natural resource. Topsoil is invaluable for the establishment and maintenance of protective vegetation and ornamental landscaping. Topsoil is the uppermost, usually darker colored, horizon of a natural soil, possessing the most favorable characteristics for plant growth, including a good supply of organic matter, nutrients, biological activity, and good structure which promotes the infiltration and circulation of water and air and the development of healthy root systems in plants.

As a minimum, topsoil preservation and reuse involves the removal, stockpiling, and re-spreading of the surface six to eight inches of natural soil. Salvaged topsoil is stockpiled in an area where it is protected from off-site surface drainage, wind and water erosion, and weed invasion. The stockpile is located and protected so that unavoidable erosion does not pose a threat to off-site property or water quality. Man-altered landscapes (i.e., fills, cuts, dumps, etc.) may possess surface soils that are inferior to natural soils and undesirable for plant growth. These sites must be individually evaluated for physical and chemical properties that influence plant growth.

Topsoil is re-spread on sites that are being prepared to receive permanent vegetative stabilization or landscaping. On large areas graded for residential development, topsoil re-spreading should be performed for each individual homesite after the basement is excavated and spoils are removed or re-spread. If basement excavation spoils will be hauled away, then topsoil can be re-spread over the entire site after final grading and before home construction.

Topsoil in many parts of Colorado is thin compared to other regions of the United States, which have rainfall that is more plentiful. Yet topsoil is arguably more valuable here, because our subsoil, with their accumulations of clay, slow permeability rates, high pH, and concentrations of salts, tend to be much more hostile to plant growth compare with subsoil of other regions. Our subsoil, amended with fertilizers and conditioners, cannot be easily transformed into good plant growth media.

Topsoil preservation and reuse has important implications for the *conservation of water supplies,* as well as for protecting water quality. Water efficient, sustainable landscaping depends on good soil. Good soil enables efficient irrigation water management. Poor soil produces unhealthy plants and undermines attempts at efficient landscape and irrigation water management.

Drainage-way protection

At times construction activities must occur adjacent to or within a drainage-way. Whenever this occurs, bottom sediments will be disturbed and transported downstream. The goal of these criteria is to minimize the movement of sediments

resulting from construction activities that take place within any drainage-way. Temporary facilities can be installed to divert flowing water around such sediment-generating construction activities within drainageways.

Limiting construction activities within actively flowing water will significantly reduce sediment movement downstream from these activities. This can be done by using a temporary diversion facility that carries water around construction activities taking place within a waterway. To protect adjacent downstream properties from erosion due to concentrated flows, a stable outlet or channel is necessary. If there is no stable outlet, one may have to be constructed. In lieu of constructing a temporary or permanent outlet to the storm drainage-way system, temporary total retention of the runoff from a 24-hour, 100-year storm may be provided. All storm sewer inlets which are made operable during construction must be protected to prevent sediment-laden runoff from entering the conveyance system without first being filtered or otherwise treated to remove sediment.

Material storage practices

Materials are sometimes used at a construction site that present a contamination potential. These include fuel, oil, lubricants, paints, solvents, concrete-curing compounds and other liquid chemicals such as fertilizers and pesticides.

Areas at the construction site used for storage of toxic materials and petroleum products should be designed with an enclosure, container, or dike located around the perimeter of the storage area to prevent discharge of these materials in runoff from the construction site. These barriers will also function to contain spilled materials from contact with surface runoff. Areas used for collection and temporary storage of solid or liquid waste should be designed to prevent discharge of these materials in runoff from the construction site. Collection sites should be located away from the storm drainage system. Consideration should be given to covering waste storage areas, fencing these areas, if necessary, to contain windblown materials, and construction of a perimeter dike to exclude runoff.

Underground utility construction

The construction of most underground utility lines shall be subject to the following criteria:

1. No more than 200 feet of trench are to be opened at one time (local criteria may be more restrictive).

2. Where consistent with safety and space considerations, excavated material is to be placed on the uphill side of trenches.

3. Trench dewatering devices must discharge in a manner that will not adversely affect flowing streams, wetlands, drainage systems, or off-site property.

4. Provide storm sewer inlet protection whenever soil erosion from the excavated material has the potential for entering the storm drainage system.

Disposition of temporary measures

All temporary erosion and sediment control measures shall be removed and disposed within 30 days after final site stabilization is achieved, or after the temporary measures are no longer needed, whichever occurs earliest, or as authorized by the city or county of local jurisdiction. For example, a site containing only one building will have temporary erosion control measures removed after building construction is complete and final landscaping is in place. Temporary erosion control measures may be removed from a commercial construction site or residential subdivision only after streets are paved and all areas have achieved final stabilization. Trapped sediment and disturbed soil areas resulting from the disposal of temporary measures must be returned to final plan grades and permanently stabilized to prevent further soil erosion.

Maintenance

All temporary and permanent erosion and sediment control practices shall be maintained and repaired by the owner during the construction phase as needed to assure continued performance of their intended function. Straw bale barriers or silt fences may require periodic replacement and all sediment accumulated behind them must be removed and disposed of properly. Sediment traps and basins will require periodic sediment removal when the design storage level is one-half full. All facilities must be inspected by the owner or owner's representative following each heavy precipitation or snowmelt event that results in runoff.

Road or highway construction sediment and erosion control practices

Roads, highways, and bridges are a potential source of nonpoint pollutants to waters of the state. Contaminants from vehicles and activities associated with road and highway construction and maintenance are washed from roads and roadsides when it rains or snow melts. A large amount of this runoff pollution is carried directly to water bodies.

Common contaminants in runoff pollution from roads, highways, and bridges include:

- Sediment
- Oils and Grease
- Heavy Metals

- Debris
- Road Salts
- Fertilizers, Pesticides, and Herbicides

Road projects should incorporate pollution prevention, preferably by reducing the amount of pollutants released, through effective runoff pollution control plans. Best management practices such as permanent storm water retention/detention ponds, slope protection, or grass strips, and temporary sediment traps, silt fences, diversion trenches, and provisions for washing vehicles before they leave the construction site are all means to reduce runoff pollution. Key management measures for roads, highways, and bridges include the following:

- Protect areas that provide important water quality benefits or are particularly susceptible to erosion or sediment loss.
- Limit land disturbance such as clearing and grading and cut fill to reduce erosion and sediment loss.
- Limit disturbance of natural drainage features and vegetation.
- Place bridge structures so those sensitive and valuable aquatic ecosystems are protected.
- Prepare and implement an approved erosion control plan.
- Ensure proper storage and disposal of toxic materials.
- Incorporate pollution prevention into operation and maintenance procedures to reduce pollutant loading to surface runoff.
- Develop and implement runoff pollution control for existing road systems to reduce pollutant concentrations and volumes.

<u>Inspection and general maintenance</u>

- Road, highway, and bridge operation and maintenance involve inspection, routine and season-specific maintenance, and repairs of not only highways and bridges but also the rights-of-way where drainage control facilities are located.
- Develop an inspection program and schedule to ensure that general maintenance is performed. Inspect erosion and sediment control devices regularly.

- Maintain retaining walls and pavements to minimize cracks and leakage.
- Repair potholes.
- Maintain energy dissipaters and velocity controls to minimize runoff velocity and erosion.
- Properly dispose of accumulated sediment collected from detention ponds, drainage systems, and pollution control structures, and any wastes generated during maintenance operations, in accordance with appropriate local, state and federal regulations.
- Use techniques such as suspended tarps, vacuums or booms to prevent paint, solvents and scrapings from becoming pollutants during bridge maintenance.
- When blading gravel roads, take care to maintain a structurally sound surface while providing an adequate crown and drainage so that erosion or scattering of gravel are avoided.
- Develop an infrastructure safety inspection program in conjunction with general maintenance.
- Keep drainage ditches free of debris.

Snow and ice control

Deicing agents for removal of ice and snow from highways and streets are essential to wintertime road maintenance in most areas of Colorado. Due to the ever-increasing use of highway deicing materials, there has been growing concern as to environmental effects resulting from these practices. Highway deicing can cause injury and damage across a wide environmental spectrum.

Salt storage facilities often become a major contributing source of local groundwater and surface water contamination and vegetation damage. Coverage and proper drainage of salt piles is becoming more prevalent, but there has not been an adequate acceptance of approved practices and a proper recognition of pollution problems associated with this material storage. Widespread damage of roadside soils and vegetation has been observed in areas of liberal salt usage. Snow removal and de-icing best management practices include:

Cover salt storage piles and other deicing materials to reduce contamination of surface waters. Locate them outside the 100-year floodplain.

Regulate the application of deicing salts to prevent oversalting the pavement.

Use trucks equipped with salt spreading calibration devices.

Use alternative deicing materials, such as sand or salt substitutes, where sensitive ecosystems should be protected.

Prevent dumping of accumulated snow into surface waters or onto frozen water bodies.

Right-of-way maintenance

Right-a-way best management practices include:

- Seed and fertilize, seed and mulch, and/or sod damaged vegetated areas and slopes.
- Establish pesticide/herbicide use and nutrient management programs.
- Restrict herbicide and pesticide use in highway rights-of-way to applicators certified under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) to ensure safe and effective application.
- Limit the use of chemicals such as soil stabilizers, dust palliatives, sterilants, and growth inhibitors to the best estimate of optimum application rates. Try to avoid excess application and consequent intrusion of such chemicals into surface runoff.
- Regularly clean, reshape, and re-vegetate drainage ditches to ensure they perform as desired. Keep ditch slopes covered with vegetation or other material.
- Maintain shoulders, slopes and swales to assure their function and operation.

Road cleaning and debris removal

Road clean and debris best management practices include:

- Sweep, vacuum and wash residential streets and parking lots.
- Collect and remove road debris.
- Encourage litter and debris control management.
- Encourage development of Adopt-a-Highway programs.

Colorado Department of Transportation practices

The Colorado Department of Transportation (CDOT) has adopted a series of best management practices (Table 15), which include erosion and sediment control, stormwater quality, maintenance and management measures. This set of BMPs will be used by CDOT for all highway construction projects in Colorado. The CDOT erosion control program includes, as a main component, the preparation of a Stormwater Management Plan (SWMP) for most CDOT construction projects.

The SWMP includes BMPs for erosion and sediment control and for stormwater quality management. Following is a table that shows some of the most common BMPs adopted and considered by CDOT for use at CDOT construction projects.

In addition, CDOT has adopted four general management practices that include:

1. Limiting the size and time of exposure of areas that are disturbed by clearing and grubbing and earthwork operations.

2. Requiring spill containment measures at materials and equipment storage areas.

3. Requiring contractors to assign *an Erosion Control Supervisor* (ECS) to CDOT construction projects and requiring the ECS to have gone through a CDOT approved ECS training program.

4. Limiting the distance between state waters and storage or waste disposal areas.

Table 15 Colorado Department of Transportation best management practices

Erosion And Sediment Control BMPs	Stormwater Quality Management BMPs
1. Seeding and Mulching 2. Surface Roughening 3. Erosion Bales and Silt Fence 4. Berms, Diversions and Check Dams 5. Inlet And Outlet Protection, 6. Slope Drains 7. Erosion Control Blankets 8. Channel Linings 9. Sediment Traps 10. Sediment Basins	11. Grass Swales 12. Grass Buffer Strips 13. Constructed Wetlands 14. Extended Dry Ponds 15. Wet Detention Ponds 16. Infiltration Basins

Detailed descriptions of the above BMPs are contained in *CDOTs Erosion Control and Stormwater Quality Guide* and in CDOTs *Standard Specifications for Road and Bridge Construction*, sections 107.25 (Water Quality) and 208 (Erosion Control). Copies of the above documents can be obtained through CDOTs Staff Design branch at (303) 757-9343 or (303) 757-9474. These highway construction practices are recommended for use in the Colorado Nonpoint Source Management Program.

The highway construction best management practices used by CDOT are applicable to all highway and road construction projects in Colorado. The *Water Quality Control Division* recommends adopting these practices for all highway or road construction projects in Colorado.

Urban and construction concepts for demonstration

Seven best management practice topics are under evaluation by various agencies (Table 16). These practices need further refinement through the demonstration process. Research studies are not needed for these practices, but rather a demonstration on the application with development of specific water quality enhancement criteria. The *Urban and Construction Committee* will continue evaluation of these topics.

When specific best management practice criteria is developed for an evaluation topic, the *Water Quality Control Division* would be willing to recommend these practices for inclusion in the urban and construction management program. The evaluation topics and water quality enhancement components are listed in the following table:

Table 116 Seven practices for demonstration or evaluation projects

BMP Evaluation Topic	Evaluation Components
Alternative De-icers	A sand/salt mixture is the general material applied to roadways for snow and ice conditions. This sand/salt mixture has been identified as an air quality contaminant in the metropolitan area and as a nonpoint water quality degradation parameter in the Colorado Nonpoint Assessment Report. The environmentally safe application of alternative de-icing compounds needs to be established for Colorado.
Urban Groundwater Protection	Contamination of alluvial groundwater associated with urban developments has been identified as a potential water quality problem in Colorado. Urban or prolonged large-scale construction runoff can alter shallow alluvial aquifer geochemistry. Groundwater protection BMPs need to be established for Colorado.
Rural Urban Development Nutrient Management	An identified potential source of nonpoint source nutrients within some watersheds is derived from individual sewage disposal systems (ISDSs) where these systems are sited at or near urban densities. Calculations of accumulative phosphorus and nitrogen loading from ISDSs, based on general literature data, shows these systems could be a major nonpoint source nutrient contributor in urbanized watersheds. However, there is considerable disagreement from ISDS users and some professionals on the general literature values and load calculations. Nutrient management BMPs related to ISDSs needs to be established for Colorado.
Urban Pollutant Discharges from Unidentifiable Sources	Pollutant discharges from unidentifiable sources in urbanized watershed has been identified by local, state and federal agencies as an area of concern. There is also a potential for other chemical discharges (i.e., hazardous wastes) into ISDSs to cause an accumulative nonpoint source problem in urbanized watersheds.
Air Quality Relationship to Water Quality	Air quality management programs have the potential to produce nonpoint source water quality pollutants. Gasoline additives needed to reduce motor vehicle emissions are measurable in alluvial urban groundwater.
Toxic Sediment	Sediments in some reservoirs and lakes associated with urban development can have relatively high concentrations of inorganic and organic compounds, metals and nutrients. Sediment toxicity reduction BMPs need to be established for Colorado.
Urban Biocriteria	Biological indicators can be used as a measure of urban water quality and to measure the effectiveness of urban BMPs. Urban BMPs that incorporate biocriteria components need to be established for Colorado.

Control measures from other western states for consideration

Other potential regulatory related and public agency urban control measures as adopted or considered by other arid and semi-arid western states are included in Table 17. Some of these control measures may be of benefit to Colorado in the future when more information is available on applicability to Colorado hydrologic conditions. There are no specific best management descriptions available for these control measures. However, many of concepts contained in these control measures are similar to those already recommended by the *Water Quality Control Division*.

The *Water Quality Control Division* is not recommending specific adoption of these control practices at this time. The table is provided for information and discussion purposes. The *Urban and Construction Committee* will continue evaluation of these control measures.

Table 17 Urban control measures used in other western states

Program	Potential Urban Control Measures
Regulatory Programs With Metropolitan Or Urban Applicability	
Research, Strengthen (if necessary), and Enforce Regulations	Which give local jurisdictions legal authority to control littering and improper disposal of potentially harmful wastes.
	Which give local jurisdictions the legal authority to prevent the improper disposal of soil, debris, refuse, or other pollutants into storm sewers and drainage channels.
	Which require landowners and/or tenants to provide covers (e.g., roofs, tarps) to keep rain off of areas which contain contaminants (e.g., chemical storage areas, waste storage areas, contaminated industrial areas); and to keep runoff from draining through areas which contain contaminants.
	Which give local jurisdictions the authority to require oil and grease controls in areas that are significant sources (e.g., gas stations, automotive shops, wrecking yards, machine shops, commercial/industrial facilities, parking areas and food service).
Hydraulic Regulatory Controls	Require new public and private sector developments to make significant use of permeable surfaces in new landscaping, recreation areas, walkways and parking areas to maximize infiltration (e.g., bark, gravel, other ground-cover, brick, cobblestone, porous pavement). Use planted areas and/or grassy swales, where appropriate, to maximize retention and infiltration.
	Require new commercial, industrial, institutional and major multi-family residential building complexes to have drainage facilities that incorporate on-site retention and/or infiltration - to assure that neither the total volume of runoff nor the peak rate of runoff exceeds pre-project conditions.
	Require site drainage designs and systems that minimize the total volume of runoff and the peak rate of runoff from new construction, where local conditions permit.
Public Agency Control and Implementation Programs	
Implementation Programs	Label storm drainage inlets and provide signs along the banks of drainage channels and creeks explaining the environmental impacts of dumping wastes.
	Provide, collect, and maintain more litter receptacles in strategic public areas and/or during major public events.

Development and Implementation Programs	Develop and implement regional collection programs that provide convenient means for people to properly dispose of oil, antifreeze, pesticides, paints, solvents, and other potentially harmful chemicals (recycle if possible).
	Develop and implement field programs to search for, test, remove and properly dispose of sediment deposits (in drainage channels and streams) which contain pollutants.
	Develop and implement a statewide program that provides a means of recording observations of field inspection and maintenance personnel.
	Implement field programs to search for, detect and correct situations where rainfall and/or runoff presently contact potential contaminants.
	Implement field programs to search for, detect and correct situations where rainfall or snowmelt causes air pollutants to contaminate surface or groundwater.
	Develop and implement frequent clean-up days and corresponding curbside collection for trash and debris.
	Implement programs to actively search for, identify, evaluate and prioritize erosion problems on previous construction areas (e.g., highways), undeveloped lands, parks, riparian corridors or urban open-spaces.
	Develop and implement programs for re-vegetating and otherwise restoring urban or construction caused eroding areas (e.g., road cuts, fires, landslides and off-road vehicle use).
	Develop and implement programs to work with landowners, tenants, and/or private agencies to apply practical erosion control and sediment control practices.
Research and Effectiveness Programs	Document the effectiveness of increasing the frequency of cleaning out storm sewer inlets, catch basins, storm sewers, and drainage channels in areas where sediments and/or debris tend to accumulate.
	Determine the effectiveness of retrofitting existing stormwater retention or infiltration basins to function as detention basins.
	Determine the effectiveness of building, maintaining, and testing regional detention basins in the lower reaches of watersheds.
	Determine the effectiveness of man-made wetlands and riparian vegetation in retrofitted and/or new drainage channels.
	Determine the effectiveness of building, establishing, and maintaining relatively large man-made wetlands in watersheds.
	Determine the effectiveness of developing in-line infiltration facilities within selected reaches of large capacity drainage channels to accept and treat storm runoff.

VII. BEST MANAGEMENT PRACTICE INFORMATION SOURCES

Best management practice database

The *Urban and Construction Committee* in cooperation with the Nonpoint Source Council and the Water Quality Control Division will establish an urban and construction database. Beginning in 1999, the structure and content of the database needs to be developed by the committee.

Reference material

The following list of information sources include those listed in the Colorado Nonpoint Source Management Program (Colorado Department of Health, 1989) and other more recent applicable sources. The *Water Quality Control Division* has not updated the list. Future updates to the management program will expand the list of information sources directly related to best management practices. Additionally, the *Urban and Construction Committee* will identify specific information sources with specific best management practices.

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VIII. URBAN AND CONSTRUCTION NONPOINT SOURCE PROJECTS

Education

- Children's Museum of Denver Educational Display (We all Live Downstream)
- Denver Health and Hospitals Nonpoint Source Targeting Study
- Erosion Control Training Video
- Jefferson Soil Conservation District Fact Sheet Education
- Outdoor Classrooms Urban Watershed Education
- Urban Runoff Education Video
- Statewide Urban Polluted Runoff Media Campaign

Demonstration

- Cherry Creek Urban Runoff Wetland Enhancement
- Chatfield LEMNA System Nutrient Removal Evaluation
- Individual Sewage Disposal System Nutrient Contributions
- Improved Nutrient and Irrigation Urban Turf Management

Restoration

- Boulder Creek Riparian Restoration (Three Phases)
- Straight Creek Highway Runoff Containment
- Frisco Alleyway Urban Runoff Containment
- Soda Creek Restoration
- Brush Creek at Snowmass Village Restoration