Barr Lake and Milton Reservoir Watershed Management Plan

Barr Lake & Milton Reservoir Watershed Association

water·shed plan (wố′tər-shēd′ plăn) *n.*
A watershed plan is a strategy that provides assessment and management information for a geographically defined watershed, including the analyses, actions, participants, and resources related to developing and implementing the plan that will lead to measurable results and an overall improvement in the water quality and watershed conditions. The watershed planning process is iterative, holistic, geographically defined, integrated, and collaborative (USEPA 2005).

BARR LAKE AND MILTON RESERVOIR WATERSHED MANAGEMENT PLAN

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LIST OF ACRONYMS AND ABBREVIATIONS

AFO	Animal Feeding Operation
amsl	above mean sea level
Authority	Cherry Creek Basin Authority
Arsenal refuge	Rocky Mountain Arsenal National Wildlife Refuge
Barr	Barr Lake
BCWA	Bear Creek Watershed Association
BDCWA	Big Dry Creek Watershed Association
BDMD	Beebe Draw Metropolitan District
BMW	Barr Lake and Milton Reservoir Watershed
Board	BMW Board of Directors
Burlington	Burlington Canal
CAFO	Concentrated Animal Feeding Operation
CDPHE	Colorado Department of Public Health and Environment
CDSS	Colorado Decision Support Systems
Chl-a	Chlorophyll-a
CWA	Clean Water Act
Database	BMW Association Water Quality Database
DIA	Denver International Airport
DO	Dissolved Oxygen
DRCOG	Denver Regional Council of Governments
DWR	Colorado Division of Water Resources
USEPA	U.S. Environmental Protection Agency
FRICO	Farmers Reservoir and Irrigation Company
Hydrosphere	Hydrosphere Resource Consultants
I/E	Information/Education
LA	Load Allocation (nonpoint source)
Metro	Metro Wastewater Reclamation District
Milton	Milton Reservoir (a.k.a. Pelican Lake)
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer System
N	Nitrogen
N:P	Nitrogen to Phosphorus ratio

NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
P	Phosphorus
PIP	Project Implementation Plan (2005 319(h) NPS Grant)
Plan	Barr/Milton Watershed Plan
Platte Valley	Platte Valley Canal
POTW	Publicly owned treatment work
QA/QC	Quality Assurance/Quality Control
RMBO	Rocky Mountain Bird Observatory
SACWSD	South Adams County Water and Sanitation District
SPCURE	South Platte Coalition for Urban River Evaluation
SWAT	Soil and Water Assessment Tool
TMDL	Total Maximum Daily Loading
TN	Total Nitrogen
TP	Total Phosphorus
UCCWA	Upper Clear Creek Watershed Association
UDFCD	Urban Drainage and Flood Control District
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WASP	Water Quality Analysis Simulation Program
WLA	Waste Load Allocation (point source)
WQCC	Water Quality Control Commission
WQCD	CDPHE Water Quality Control Division

INTRODUCTION

Located on the high plains of central Colorado, Barr Lake (Barr) and Milton Reservoir (Milton) are two warm-water reservoirs, each with a storage capacity of approximately 30,000 acre-feet. The upper South Platte River and its tributaries provide source water for both waterbodies through a series of controlled canals. The watershed includes diverse land and water uses that contribute to in-reservoir water quality impairment in the form of nutrient loading. Nutrients such as nitrogen (N) and phosphorus (P) are carried by rivers and canals to the reservoirs where the plant-growing elements are stored and used by algae and other aquatic plants. In 2002, the Colorado Department of Public Health and Environment (CDPHE) included both reservoirs on the State's 303(d) list of impaired waters for exceedance of the upper pH limit of 9.0, with a medium priority for completion of a Total Maximum Daily Load (TMDL).

The Barr Lake and Milton Reservoir Watershed (BMW) Association incorporated as a 501(c)6 nonprofit stakeholder group in May of 2005 with a focus on improving water quality in Barr and Milton. Through collaborative stakeholder efforts, the BMW Association has developed this Watershed Plan (Plan) to prescribe management guidelines for resolving water quality problems associated with human-induced reservoir eutrophication (i.e. lake/reservoir aging caused by excessive addition of nutrients). The Plan further outlines a course of action for fostering an information/education program designed to broaden stakeholder involvement while educating the public on how to effectively solve water quality issues.

This Plan was developed in part with funds provided through the Section 319 Nonpoint Source Program of the CDPHE Water Quality Control Division (WQCD). The format of the document generally follows the Colorado Uniform Watershed Plan Outline (Nonpoint Source Colorado 2005) provided by the WQCD to meet elemental requirements set forth by the United States Environmental Protection Agency (USEPA).

This Plan is a living, dynamic document that will serve as a reference and as a guide. This 2008 version represents the second full iteration of the Plan. Some portions of the Plan are well developed based upon current understanding of the watershed issues while other portions have yet to be produced. As more data gathering, technical analyses, and programmatic modifications are conducted, the BMW Association will further its understanding of watershed issues and improve this Plan. The BMW Association intends to issue annual updates of the Plan to incorporate new information as it develops. With each year of work, the roadmap for water quality improvement will become clearer.

This 2008 Barr Lake and Milton Reservoir Watershed Plan, contains management-related information on the following topics:

- Goals and objectives that support the water quality mission and vision for Barr, Milton, and the watershed
- Overviews of the history and key regulatory guidelines pertinent to the watershed and the BMW Association
- Current and potential future water quality concerns
- Reservoir data analyses and characterizations

- Strategies and timeline to quantify sources of water quality contaminants and to identify the best management measures available to mitigate water quality impacts through a pH *total maximum daily load (TMDL)*
- Association partners, as well as financial and technical resources, needed to develop a pH TMDL and implement management measures
- Information and education (I/E) program plans to broaden stakeholder involvement and encourage public awareness of watershed issues

WATERSHED ASSOCIATION GUIDELINES

In order to provide guidance and structure to the BMW Association, the stakeholders developed a mission and vision for the organization along with guiding value and goal statements. The mission, vision, and values provide the Plan's framework. Detailed water quality goals are described in Section 3.3.2 of this document.

Mission—The mission of the BMW Association is to encourage cooperation, involvement, and awareness by all interested parties in collaborative efforts to improve the water quality of Barr Lake and Milton Reservoir.

Vision—The vision of the BMW Association is to maintain appropriate water quality in Barr Lake and Milton Reservoir through the continuous implementation of a collaboratively-developed watershed management plan. Clear communication to all watershed stakeholders will be a major attribute.

Values—From the inception of the organization, members have emphasized a strong set of core values. These values have provided the mental framework that supported the development of the nonprofit organization, bylaws, and business operating policies, and that guides the day-to-day functioning of the stakeholder process. The BMW Association has developed the following values:

- **Consensus**—Agreement on major decisions
- **Broad & Active Stakeholder Participation**—All inclusive to encourage partnerships
- **Action & Measurable Results**—Continuous progress that can be seen and measured
- **Outreach & Education**—Information sharing to effect change in habits and perceptions
- **Objectivity & Sound Science**—Nonbiased, science-based decision-making process
- **Respect for Public Resources—**Visualizing the larger picture and connectivity
- **Proactive & Prevention—**Focus on cost-effective actions for the future

The BMW Association strives to serve as the lead organization to facilitate collaborative work by interested stakeholders towards this mission and vision. The future of Barr and Milton will depend on the success of this collaborative effort and the cyclical process of development-implementation-evaluation of integrated watershed management. It is important to remember that implementation of this Plan will be the responsibility of individual stakeholders.

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1 WATERSHED CHARACTERIZATION AND REGULATORY FRAMEWORK

This Section provides background of historical, geographic, environmental, and regulatory relevance for the Barr/Milton watershed. This background information describes the basic foundations for the BMW Association's current watershed management efforts and provides perspective on stakeholder interests and actions within the watershed.

1.1 HISTORY AND BACKGROUND

Barr and Milton are warm-water, plains reservoirs filled through surface water diversions from the South Platte River at the Burlington Canal (Burlington) headgate and the Platte Valley Canal (Platte Valley) headgate. The reservoirs are also interconnected through the Beebe Draw (Figures 1-1, 1-2, and 1-3a, and 1-3b). In the early 1900s, the Farmers Reservoir and Irrigation Company (FRICO) purchased and enhanced these two reservoirs to regulate and store water for agricultural use. FRICO has maintained ownership and management since that time. Water from Barr and Milton is decreed for domestic municipal uses, augmentation, livestock watering, and unrestricted agricultural use.

With the advent of centralized, wastewater collection systems in the early twentieth century, sewage generated in the Denver metropolitan area was collected, treated, and conveyed directly to Barr via the Burlington and indirectly to Milton twenty-six miles down river via the Platte Valley. Water quality issues and poor aesthetics in both reservoirs climaxed in the 1950s and early 1960s after years of primary-treated sewage and nonpoint source (NPS) pollution accumulation. In 1966, the Metro Wastewater Reclamation District (Metro) was built at its current location just downstream of the Burlington headgate. Since this time, water quality in both Milton and Barr has significantly improved due to advances in secondary wastewater treatment and changes in flow management. However, with continued upstream contributions of permitted point source (industrial, municipal, and stormwater) and NPS pollution (non-permitted stormwater, agricultural runoff, and other sources), Barr and Milton continue to exhibit undesirable water quality conditions related to excessive nutrient enrichment.

In 1978, FRICO granted the State of Colorado a perpetual recreation easement, adding Barr to the Colorado State Park system. Colorado State Parks has since acquired land surrounding Barr for incorporation into the park system. Park activities do not affect FRICO's operation of the water system.

Starting in 1994, FRICO implemented a routine water quality sampling program. Analysis of water quality data indicated that both reservoirs exceeded the State of Colorado's upper pH standard of 9.0. In 2004, the State of Colorado included both reservoirs on the 303(d) list of water quality-impaired segments for nonattainment of the Warmwater, Class 2 Aquatic Life use classification (CDPHE 2002a). In 2004, both reservoirs were designated for domestic water supply use, creating a higher priority for solving the water quality issues.

The initial stages of forming a watershed group began in 2002. Key stakeholders included FRICO, Metro, South Platte Coalition for Urban River Evaluation (SPCURE), Bromley Park Metropolitan District, and the cities of Littleton, Englewood, Thornton, and Brighton. This initial planning group collaborated with the WQCD to acquire an initial 319(h) NPS grant to fund the formation of a comprehensive water quality database and the services of a facilitator to organize stakeholder meetings. This process, completed in 2005, was Phase 1 of a four-phase project to improve water quality in the reservoirs (Figure 1-4). A second 319(h) NPS grant was awarded in 2005 for the next six years to fund completion of Phases 2 and 3. Phase 2 includes the development of this Plan and builds on Phase 1 by including the following activities:

- Providing funding to the watershed organization during its formative years to ensure it can accomplish the goals
- Assessing current water quality conditions in both reservoirs and calculating water quality and quantity budgets
- Building a model(s) to predict water quality improvements in the reservoirs under various alternative solutions and linking reservoir conditions to watershed sources
- Establishing initial water quality targets
- Investigating feasibility of control/management strategies
- Developing an information/education program

Phase 3, beginning in 2009, will involve the following items:

- Selecting water quality improvements for implementation
- Developing a third party pH TMDL
- Finalizing numeric water quality targets
- Assisting the State with developing nutrient standards
- Defining the implementation schedule

Phase 4 focuses on TMDL implementation and evaluation and is expected to occur from 2011 through 2022.

1.2 DEFINED WATERSHED

1.2.1 Watershed Boundary and Sub-basins

The Barr/Milton watershed lies within the U.S. Geological Survey (USGS) Hydrological Unit Code watershed delineation - Missouri Water Resource Region, 1019 South Platte Sub-region, 10190003 Middle South Platte-Cherry Creek Cataloging Unit (Figure 1-5). This is a large area with diverse land and water uses, management challenges, established watershed organizations, and multiple trans-basin diversions. To define the initial area of interest and focus efforts within this larger area, the BMW Association officially adopted a "datashed" boundary in 2004 as part of Phase 1. This datashed served to define the initial geographic focus area for BMW Association efforts. The BMW Association based the original datashed on data accessibility and management, in addition to recognizing the adjacent boundaries of active watershed organizations including the Big Dry Creek Watershed Association, the Upper Clear Creek Watershed Association, the Bear Creek Watershed Association, the Chatfield Water Authority, and the Cherry Creek Basin Authority. The off channel reservoirs of Barr and Milton defined the northern and eastern edges of the datashed, and the terminal dams for Bear Creek, Chatfield, and Cherry Creek reservoirs defined the southern edge. This boundary was slightly modified in August 2006 to better capture natural hydrologic sub-basins (Figure 1-2). The August 2006 boundary is used throughout this document and serves as the "working watershed" for the BMW Association. The BMW Association recognizes that watershed boundaries are subject to change as additional information is gathered, and will review the watershed boundary regularly. Note that, although the term "watershed" is used throughout the text, neither the initial "datashed" nor the current "working watershed" encompasses the entire hydrologic basin connected to Barr and Milton, and therefore is an incomplete representation of the entire hydrologic watershed.

The Barr/Milton watershed includes 42 sub-watersheds (Figure 1-6; Table 1-1). These basins were delineated based on watershed modeling output from the Soil and Water Assessment Tool (SWAT) which took into consideration topography and surface water drainage patterns. It is important to note that constructed ditches, canals, and connecting channels alter the natural movements of surface and groundwater. The scale and number of sub-watersheds was based on the appropriateness of modeling the watershed and the available water quality and quantity data (see Section 5.2.2).

1.3 WATERSHED FEATURES AND INVENTORIES

The Barr/Milton watershed covers over 850 square miles (2,200 square kilometers) on the central Colorado plains. The watershed encompasses portions of six counties (Table 1-2): Adams, Weld, Arapahoe, Denver, Jefferson, and Douglas. The large area of the Barr/Milton watershed supports a diversity of land and water uses, as well as wildlife habitats and population centers. The watershed runs generally south to north, paralleling the foothills of the Rocky Mountains to the west. Relatively flat, elevations in the watershed range from 4,724 ft (1.44 km) to 5,879 ft (1.79 km) above mean sea level (amsl), with a mean elevation of 5,174 ft (1.58 ft) amsl (Figure 1-7).

The watershed is characterized by a continental-type climate, with a wide annual temperature range (from approximately $^{-}30^{\circ}$ to 100°F) and irregular seasonal and annual precipitation. Annual precipitation in the watershed is less than 15 inches per year; however, snowmelt from the Rocky Mountains supplements the plains' water budget. Most of the precipitation on the plains occurs as brief, isolated thunderstorms during the summer months. December is the driest month for the watershed while May is the wettest (NOAA 2006).

1.3.1 Major Land Uses

Over 89% of the Barr/Milton watershed is privately owned (Figure 1-8; Table 1-3). Developed (residential/commercial/industrial) and agricultural areas dominate land-cover in the watershed (Figure 1-9; Table 1-4). The agricultural areas are concentrated in the northeastern portions of the watershed while most of the developed land coverage is concentrated in the southern half of the watershed. In between these two use areas is where rapid, suburban growth is occurring.

1.3.1.1 Agriculture

The northern part of the watershed is primarily agricultural land use and heavily relies on irrigation (Figure 1-10). Nearly 55% of the watershed supports agricultural uses, including grasslands, pasture, small grains, and row crops. According to the 2002 U.S. Census of agriculture (NASS 2006b), irrigated crops common to Adams, Weld, and Arapahoe counties, which make up 72% of the total watershed, include alfalfa, wheat, corn for grain, dry beans, sunflower seed, sugar beets, barley, and sorghum. Cattle and calves are the primary livestock raised in the watershed. In 2006, over 50,000 head of beef cattle were raised in Weld, Adams, and Arapahoe counties (Table 1-9). Over 85% of these beef cattle were raised in Weld County alone. Weld County also supports dairy farms, with over 60,000 head of dairy cattle in the county in 2006 (NASS 2006a). The rural, agricultural area of the watershed has many smaller communities which include: Lochbuie, Hudson, Platteville, Fort Lupton, Barr, and Wattenberg.

1.3.1.2 Urban

Residential and commercial/industrial areas (i.e. urban), including most of the Denver metropolitan area, cover 38% of the total watershed area and are located primarily in the southwestern section of the watershed and along the South Platte River corridor (Figure 1-9; Table 1-4). The Denver metropolitan area includes the City and County of Denver and the Cities of Aurora, Thornton, Brighton, Lakewood, Westminster, Arvada, Commerce City, Wheat Ridge, Northglenn, Littleton, Englewood, Sheridan, Federal Heights, Edgewater, and Broomfield.

1.3.1.3 Open Land

Public open lands cover less than 2% of the watershed (Figures 1-8 and 1-9). Barr Lake State Park protects over 600 acres (243 hectares) adjacent to Barr. At nearly 17,000 acres (6,880 hectares), the Rocky Mountain Arsenal National Wildlife Refuge (Arsenal Refuge), managed by the U.S. Fish and Wildlife Service (USFWS), is the largest contiguous open space in the Denver metropolitan area. The Arsenal Refuge is working to ensure that wildlife and habitat are considered in all of its ongoing restoration activities (USFWS 2006b). An important nature corridor exists between the Arsenal Refuge and Barr, connecting the two wildlife refuges.

1.3.1.4 Facilities of Note

Denver International Airport (DIA)—Half of DIA is within the Barr/Milton watershed, draining primarily into Third Creek, with some additional drainage into Second Creek (Figure 1-1). Both Second and Third Creek terminate at the Burlington, providing a hydrologic connection between DIA and Barr. Current and proposed airport operations and expansions, which will increase impervious surface area, pose increased stormwater runoff concerns. For instance, runoff events from DIA have introduced propylene glycol (de-icing fluid) into Third Creek (CDM 2003). DIA has an extensive stormwater detention/retention system in place to minimize stormwater runoff effects, as well as plans to improve stormwater management performance.

Rocky Mountain Arsenal National Wildlife Refuge—The Arsenal Refuge (Figure 1-1) presents another major area of special concern within the watershed. The Arsenal Refuge was purchased by the U.S. Army in 1942 to produce chemical weapons, mainly chlorine gas, Napalm, mustard gas, and white phosphorus. After the war, private companies acquired the facility to manufacture pesticides. In 1987, the Arsenal Refuge was listed on the USEPA National Priorities List as a Superfund Site. In 1992, the area was designated as a National Wildlife Refuge, home to some 330 animal species including wintering Bald eagles. USEPA-managed Superfund cleanup continues at the site. To date, more than $1.3 billion has been spent by the U.S. Army and Shell Oil Company to incinerate approximately 10.5 million gallons of liquid waste, clean up more than 2 million cubic yards of contaminated soil, and to construct and operate groundwater treatment systems that process 2.4 million gallons of water each day (USEPA 2006a).

1.3.2 Geology and Soils

The Barr/Milton watershed lies primarily over the Colorado Piedmont geologic area and the western edge of the High Plains. This area runs along the base of the foothills of the Rocky Mountains, consisting of a broad, hilly valley that stretches north and east from Denver through the South Platte River valley. This area is slightly lower in elevation, generally less than 5,000 feet (amsl), than both the foothills to the west and the High Plains to the east. The Piedmont was formed approximately 28 million years ago during a period of continental uplift. Pierre shale underlies the Piedmont area.

Primary surficial geology in the watershed consists of the Navarro Group - late Cretaceous (65 to 95 million years ago) sedimentary deposits made up of chalk, marl, and shale and the Paleocene Continental formation (56–65 million years ago) (Figure 1-11). A small portion of the watershed, near Dutch Creek in the southwest corner, is underlain by the late Cretaceous sedimentary Austin and Eagle Ford Groups and the much older Upper Paleozoic (250–550 million years ago) rocks that begin the transition to the Rocky Mountain foothills. Quaternary (1.6–1.8 million years ago) alluvial deposits line the South Platte River, which supports the gravel mining operations shown in Figure 1-11 (USGS 2006a).

Soils in the watershed include clay, loam, and sand on 0% to 9% slopes (NRCS 2006). In general, these soils are highly suitable for farming and residential land uses. Soil pH values (Figure 1-12) show little variability in soil acidity, ranging from pH 5.8 to 8.2 in the watershed, with an area-weighted mean pH of 7.18 (NRCS 2006). Saturated hydraulic conductivity (K_{sat}) describes the propensity of water to flow through the pore spaces of saturated soils. K_{sat} values range from 0.22 μm/s to 141 μm/s, with an area-weighted mean K_{sat} of 63 μm/s (NRCS 2006). In general, soil permeability is greatest in the northern portion of the watershed, near Milton (Figure 1-12).

1.3.3 Oil and Gas Wells

The Colorado Oil and Gas Commission regulate oil and gas extraction activities within the State. The Commission maintains a database containing location and permit information for each permitted well in the state (CO OGCC 2006). The vast majority of current oil and gas extraction activities within the watershed occur in Weld County (Figure 1-11). Weld County contains over 10,000 permitted well sites, representing 40% of all wells within the State of Colorado (CO OGCC 2006).

1.3.4 Permitted Dischargers

Forty-two major dischargers hold National Pollutant Discharge Elimination System (NPDES) permits in the watershed, including industrial, wastewater and drinking water treatment, and other facilities (Figure 1-13; Table 1-5). There are also three Municipal Separate Storm Sewer Systems (MS4) permits in place for municipalities that are greater than 100,000 in population: Denver, Aurora, and Lakewood (CDPHE 2004a). Phase II (population less than 100,000) stormwater permit holders in the watershed include Arvada, Brighton, Broomfield, Commerce City, Englewood, Federal Heights, Littleton, Northglenn, and Thornton, Westminster, Wheat Ridge, and all six counties. Stormwater discharges are discussed in more detail in Section 6. Permitted point source discharges from publicly owned treatment works (POTWs) constitute a significant portion of the flow in the mainstem of the South Platte River during much of the year. Because of this influence, the mainstem of the South Platte through the watershed is described as effluent-dominated.

1.3.5 Water Resources

Over 500 miles (805 kilometers) of streams and rivers flow through the watershed. These natural waterways are supplemented by over 550 miles (885 kilometers) of engineered canals, ditches, and pipelines (Figure 1-2; Table 1-6). Climate, land-use/land-cover, and environmental conditions including soils and geology all influence both the quantity and quality of waters in the Barr/Milton watershed. In addition to natural factors, Colorado's prior appropriation system of water allocations also controls the flow of water. Streams in the watershed tend to follow the typical flow patterns of a high plains area, showing monthly variability driven by precipitation and water use.

1.3.5.1 Streams and Rivers

The South Platte River forms the hydrologic backbone of the Barr/Milton watershed (Figure 1-2). In the transmontane (i.e., retains some of the characteristics of a high mountain stream) reach of the South Platte River, Chatfield Reservoir through Denver metropolitan area to the Fulton Ditch diversion, four urban streams flow into the South Platte River. These streams are Bear Creek, Cherry Creek, Sand Creek, and Clear Creek. Downstream of the Fulton Ditch diversion, the South Platte River is characterized as a high plains stream, flowing primarily through cropland and low-intensity residential areas. Big Dry Creek is the primary tributary to the South Platte River in this lower reach.

Wetlands

The USFWS conducted a nationwide inventory of existing wetland resources that has been electronically compiled for portions of the country. USFWS digital wetland maps are available for the upper portion of the watershed, but not for the lower reaches (USFWS 2006c). The BMW Association considers this dataset as incomplete and out-of-date (generated from 1980s and prior aerial photography), and therefore does not reproduce the USFWS wetlands data herein. Currently, the lack of accurate wetlands data presents a data gap.

The potential extent of wetlands is minimal in the upper portions of the watershed due to the effects of urbanization. Relative wetland extent increases in a downstream direction, although potential for wetlands is still limited due to historic and current agricultural practices.

Beebe Draw, the drainage that flows from Barr north to Milton, historically supported thousands of acres of wetland (Montoya 2006, pers. comm.). Much of this acreage was drained through channelization undertaken in the mid-part of the 20th century. Extensive wetland complexes still exist along the Beebe Draw from Barr downstream through the Mile High Lakes region, a section five miles in length. The Mile High Wetland Bank, a commercially operated mitigation bank, is located within the Mile High Lakes region.

1.3.5.2 Lakes and Reservoirs

Numerous small water storage impoundments occur within the watershed. No naturally occurring lakes are known to exist. Barr and Milton are the only two waterbodies of notable size. These two reservoirs are very similar in size, shape, and management. Barr, at full capacity of 30,057 acre-feet (3,707 hectare-meter), has a surface area of 1,835 acres (743 hectares) and a maximum depth of 37 feet (11.3 meters) (Figure 1-3a). Milton, at full capacity of 26,000 acre-feet (3,207 hectare-meter), has a surface area of 1,840 acres (745 hectares) and a maximum depth of 29 feet (12.5 meters) (Figure 1-3b). Both reservoirs are owned and operated by FRICO.

Barr is filled via surface water diverted from the South Platte River at the Burlington headgate and from Metro effluent that is pumped into the Burlington just downstream of the headgate (up to 100 cfs). Barr is filled through the winter and is generally topped off during the spring runoff. Releases typically begin in May and continue through the irrigation season until the end of September (Figure 1-14). The hydraulic residence time is roughly 225 days or 7.5 months for Barr (AMEC 2008a).

Milton is filled through surface water diverted from the South Platte River at the Platte Valley headgate, located north of Fort Lupton. Water is diverted into Milton at various times of the year depending upon the call on the South Platte River. It is not typically filled to capacity by the beginning of summer. Releases begin in May and continue through the irrigation season until the end of September (Figure 1-14). The hydraulic residence time is roughly 192 days or 6.4 months for Milton (AMEC 2008b).

1.3.5.3 Drinking Water Supply

As the population of the Denver metropolitan area increases, so does the need for more drinking water supplies. There are many drinking water projects operating, planned, or proposed in the Barr/Milton watershed, which would benefit from an improvement in water quality. The list below includes drinking water nitrate compliance points, all located along the mainstem of the South Platte River. These compliance points indicate current or anticipated future drinking water withdrawal locations (Lewis and Saunders 2005):

- South Platte River at 78th Avenue

- South Platte River at 88th Avenue
- Fulton Headgate
- Brantner Headgate
- United Diversion #3 at 124th Avenue
- Brighton Ditch Headgate
- South Platte River at 160th Avenue (i.e., Brighton and Aurora wells)
- South Platte River at Highway 52 (Fort Lupton wells)
- Platte Valley Canal Headgate (Evans Ditch #2)

Large projects such as Aurora's Prairie Waters Project and the East Cherry Creek Valley Water and Sanitation District's H2O6 Project have signaled the beginning of many potential water development projects within the Barr/Milton watershed. In addition, many completed gravel pits along the South Platte River corridor are being used as municipal water storage reservoirs.

1.3.5.4 Ditches and Canals

For over 125 years, Colorado has used a system of water allocation referred to as the prior appropriation doctrine. Per this doctrine, the first-in-time appropriator of water has a senior right to that water and that right must be satisfied before any subsequent junior rights can receive water. The prior appropriation doctrine creates a relatively clear but complex system of water administration. In 1991, the Colorado legislature established the Office of the State Irrigation Engineer, today known as the Colorado Division of Water Resources (DWR). The agency's primary responsibility is to administer the prior appropriation doctrine.

The Barr/Milton watershed falls entirely within DWR, Division 1, South Platte River, which is administered out of the Greeley office. Division 1 is subdivided into a number of water districts. Boundaries for Districts 2 and 8 overlap with the Barr/Milton watershed boundary (CO DWR 2006).

The Colorado Water Conservation Board and DWR have jointly developed the Colorado Decision Support Systems (CDSS). CDSS is a water management system designed as a tool for making informed decisions regarding historic and future use of water. One of the tools developed for the CDSS includes straight-line diagrams that graphically illustrate the movement and storage of water within a given District. A straight-line diagram has been developed for Division 1, District 2, but not yet for District 8 (CO DWR 2006). Another tool of relevance is the 2006 tabulation of water rights in Division 1 (Hall and Simpson 2006). This 2006 tabulation documents the current status of decreed water rights, in order of seniority, within the South Platte River basin. Information provided in the tabulation includes the structure type, water right type, source water, location, use type, absolute and conditional water right amount, alternate point of diversion and exchange, adjudication and appropriation dates, and administration number.

Per the straight-line diagram for Division 1, District 2, major water diversions that occur off the South Platte River, from the confluence with Cherry Creek downstream to the termination of the watershed, in order of occurrence, include:

- Farmer and Gardeners Ditch

- Gardeners Ditch
- Burlington Canal
- Fulton Ditch
- Brantner Ditch
- United Diversion #3
- Brighton Ditch
- McCanne Ditch
- Lupton Bottom Ditch
- Meadow Island #1
- Platte Valley Canal

These diversions collectively, and in some cases singularly, create significant flow modifications to the South Platte River under most flow conditions. Some diversions can sweep (i.e., completely empty) the South Platte River legally during certain times of the year, effectively drying up the riverbed (Montoya 2006, pers. comm.). Water diversions, combined with municipal and industrial wastewater return flows, result in a highly modified, human-controlled flow regime throughout the entire watershed.

The Burlington Ditch/O'Brian Canal (the Burlington), Platte Valley Canal, and Beebe Seep are key canals in the Barr/Milton watershed (Figure 1-2). The Burlington diverts water from the South Platte River upstream of 64th Avenue on the north side of Denver. Water is also supplied to the Burlington from treated effluent from the Metro Wastewater Reclamation District[1]. Approximately 81% of the flow in the Burlington comes from the South Platte River, 11% comes from treated effluent discharge, and 8% comes from stormwater runoff (AMEC 2008a). The Burlington conveys this water to Barr Lake, as well as to the Little Burlington Canal and the Denver Hudson Canal which both bifurcate from the Burlington upstream of Barr. The Burlington is approximately 17.5 miles (28 kilometers) in length, and ditch capacity is approximately 1,000 cfs. After diversions to the Little Burlington and Denver Hudson canals, and ditch loss to seepage and evaporation, only 31% of the average 124,000 acre-feet of water carried by the Burlington enters Barr Lake annually (AMEC 2008a). The Burlington typically flows from October through May and supplies 94% of the total annual volume of water in Barr (AMEC 2008a). The Burlington commonly sweeps the South Platte River, especially during the winter.

The Beebe Draw connects Barr and Milton and is approximately 19 miles (31 km) long. The Beebe Draw is fed by seepage from Barr and return flows from other canals delivering water out of Barr. Water is delivered from Barr to Milton during the non-irrigation season of October through April, delivering on average 37% of Milton's annual water budget (AMEC 2008b)

The Platte Valley Canal diverts water from the South Platte River five miles north of Fort Lupton at County Road 20. The Platte Valley is 26 miles (42 km) long with a capacity of 500 cfs.

[1] Denver Water, pursuant to legal agreements with FRICO, delivers replacement water to FRICO in the form of treated, municipal wastewater pumped directly from the Metro facility into the Burlington. Treated effluent is typically delivered between November 1st and the end of February at flows between 30 - 80 cfs (0.8 – 2.3 cubic meters per second) 24 hours per day.

This canal supplies 54% of the total annual inflow to Milton Reservoir at various times of the year depending upon the water rights calls on the South Platte River (AMEC 2008b).

1.3.6 Threatened and Endangered Species/Critical Habitat

A database search was conducted to develop a list of potential threatened and endangered plant and animal species occurring within the Barr/Milton watershed. An initial query was conducted using the Colorado Division of Wildlife Natural Diversity Information Source (CO DOW 2006) and the USFWS (USFWS 2006a) databases which report information on a county-wide basis (Table 1-7). For all six Barr/Milton watershed counties, seven wildlife species are included on the Federal or State list of endangered species. Federally endangered species include: southwestern willow flycatcher, least tern, pallid sturgeon, whooping crane, and black-footed ferret. State endangered species include the plains sharp-tailed grouse and the wolverine. An additional 11 plant and animal species have Federal or State threatened status. Federal threatened species include: bald eagle, Colorado butterfly plant, Mexican spotted owl, Pawnee montane skipper, piping plover, Preble's meadow jumping mouse, Ute Ladies-tresses orchid, Canada lynx, and greenback cutthroat trout. State threatened species are the northern river otter and the western burrowing owl.

A more detailed review of species-specific profiles provided within the database yielded better information for narrowing the potential list of species based upon habitat requirements (Table 1-7). The Barr/Milton watershed is below 6,000 feet within the high-plains ecoregion, eliminating a number of listed species that occur in portions of counties covering montane and subalpine ecoregions (i.e. wolverine, Mexican spotted owl, Pawnee montane skipper, Canada lynx, greenback cutthroat trout, and northern river otter). Other species have been extirpated from Colorado (i.e., black footed ferret) or were not known to occur here historically (i.e., pallid sturgeon) (USFWS 2006a).

After eliminating species based upon habitat requirement and other considerations, the refined list of nine potential species that could occur in the watershed includes:

- Least tern
- Whooping crane
- Southwestern willow flycatcher
- Plains sharp tailed grouse
- Bald eagle
- Piping plover
- Preble's meadow jumping mouse
- Ute ladies tresses orchid
- Western burrowing owl

The Preble's meadow jumping mouse is the only species on the refined list for which the USFWS has officially designated critical habitat within the watershed. This habitat occurs in the upper reaches of the watershed along the South Platte River, as well as along the Bear Creek and Ralston Creek drainages within Douglas and Jefferson County.

Populations of Ute Ladies Tresses orchid have been mapped in portions of the watershed, particularly on Clear Creek. Bald eagle use of the South Platte River drainage has been well documented with active nests occurring at Barr, Milton, and along the South Platte River downstream of Fort Lupton.

1.3.7 Outdoor Activities

Barr Lake—Nature enthusiasts visiting Barr Lake State Park enjoy a multitude of activities, from wildlife watching and educational programs to hunting and fishing. Over 350 species of birds have been identified at the park, which is home to the Rocky Mountain Bird Observatory (RMBO) and an important Colorado wildlife refuge. RMBO and the State Park host a number of educational experiences throughout the year. Barr Lake State Park allows non-motorized boating or motorboats with 10 horsepower or less. Barr Lake State Park is a day-use only park and does not offer camping or swimming. The park has a Conservation Area Plan that identifies parcels of land for future acquisition to expand the park boundaries (Conservation Fund 1996).

Milton Reservoir—Recreational use of Milton is currently leased to the Beebe Draw Metropolitan District (BDMD). The BDMD manages the recreational amenities on behalf of the Pelican Lake Ranch development, a privately-owned master-planned community adjacent to Milton. The BDMD allows members to boat, fish, hunt, and bird watch.

South Platte River Corridor—The South Platte River has garnered great attention over the last decade as an important and valuable recreational resource. Biking and walking trails and riverfront parks occur along the mainstem of the South Platte River from Cherry Creek and Chatfield reservoirs downstream to 136th Avenue. At the upstream end of the watershed, the mainstem of the South Platte River has been a focus area for the City of Englewood, which developed the South Platte River Open Space Plan (Wenk Associates 2003). The plan presents a framework for increasing recreational values within the corridor, preserving natural areas, protecting water quality, and encouraging compatible land uses. Similarly, former Denver Mayor Wellington Webb created a South Platte River Commission in 1996 charged with developing and implementing a South Platte River Initiative Plan (Denver, City and County of 2006). Many recreational improvements along the stretch of the South Platte River, flowing through the City and County of Denver, have been implemented as a result. It is now common to see people paddling and floating the South Platte River, as well as wading into the river water from urban riverfront parks. The City and County of Denver also prepared a South Platte River Corridor Long Range Management Framework (Denver, City and County of 2000). This plan seeks to improve the South Platte River for people, recreation, and wildlife. Further downstream along the South Platte River, Adams County has developed its own plan: the Adams County South Platte Heritage River Plan (ERO Resources Corporation 1997). This plan provides an outline for future county land acquisitions for trail connections, natural areas protection, and conservation.

In-stream recreational opportunities diminish downstream of Brighton because the South Platte River flows through privately-owned agricultural land. Several large diversion structures also inhibit water-based activities.

1.3.8 Population Characteristics and Demographic Information

Population density in the Barr/Milton watershed ranges from sparsely-populated, rural areas that are predominately agricultural to the densely-populated Denver metropolitan area, with population density in the watershed ranging from 0 to 29,510 people per square mile in 2005 (Figure 1-15). The Denver Regional Council of Governments (DRCOG) studied populations and modeled future population growths in the Metro Vision 2035 Plan (DRCOG 2008). This plan notes that, for the past 15 years, the Denver region has been one of the nation's fastest-growing areas. Currently, more than 2.7 million people live in the Denver metropolitan area. By 2035, models predict the population will increase to nearly 4.2 million.

Areas with highest housing growth and development are northeast, south, and southeast of Denver. Delineated urban growth boundaries identify areas of urban growth expansion in future years (Figure 1-16). Figures 1-15 and 1-16 both show that the Denver metropolitan area is expected to continue expanding into the northern and eastern portions of the watershed. This rapid growth drives a shift from traditional agricultural land and water uses to more urbanized land use and land cover, specifically an increase in impervious land cover (Figure 1-17) and a shift from irrigation to drinking water uses. A fast growing population, associated land use and land cover changes, and pressures related to the infrastructure necessary to accommodate these new residents will affect both water quality and quantity.

1.4 IMPACTS ON WATER QUALITY UPSTREAM OF THE BARR/MILTON WATERSHED

Five major drainages flow into the Barr/Milton watershed, all of which have established watershed associations (Figure 1-2). These neighboring organizations are: Cherry Creek Basin Water Quality Authority, Chatfield Watershed Authority (upper South Platte River), Bear Creek Watershed Association, Upper Clear Creek Watershed Association, and Big Dry Creek Watershed Association.

Cherry Creek Basin Water Quality Authority (Cherry Creek Authority)—The Cherry Creek Authority, a special district authorized by the Colorado legislature, is charged with managing water quality in the upper reaches of the Cherry Creek watershed to improve water quality in the Cherry Creek Reservoir. The outfall of Cherry Creek Reservoir enters the southeastern end of the Barr/Milton watershed. The WQCC adopted a site-specific water quality standard for chlorophyll a (chl-a) for Cherry Creek Reservoir. This chl-a standard replaced an earlier Total Phosphorus (TP) standard of 32 ug/L. A total maximum annual load (TMAL) is in place for TP of 14,270 lb/year. This TMAL was developed based on the 32 ug/L TP standard. The WQCC adopted Control Regulation 72 to implement the TMAL. To date, reservoir standards for chl-a (and previously TP) have not been achieved in the reservoir. Revisions to the TMAL and the control regulation are in progress. The Cherry Creek Authority's watershed management plan (CCBWQA 2003) outlines strategies to implement stream improvements, construct additional pollutant reduction facilities, encourage pollutant trading, adopt stormwater control measures, install in-reservoir mixing systems, and reducing non-point septic system loading. The Cherry Creek Stewardship Partners (CCSP) work with the Cherry Creek Authority and other stakeholders to encourage communication on watershed issues. For more information, see www.cherrycreekbasin.org or www.cherry-creek.org.

Chatfield Watershed Authority—The Chatfield Watershed Authority manages water quality in the upper South Platte River basin to Chatfield Reservoir. Its boundaries include Plum Creek, Deer Creek, and the portion of the South Platte River from the outlet of the Strontia Springs Reservoir to Chatfield Reservoir. The outfall of Chatfield Reservoir enters the south end of the Barr/Milton watershed. The WQCC adopted a site-specific standard of 27 ug/L TP for Chatfield Reservoir. A TMAL of 7,398 lbs/year was adopted to achieve this standard. The WQCC adopted Control Regulation 73 (CDPHE 1989) to implement the TMAL.

Large wildland fires have significantly impacted the upper South Platte River basin, including the 137,000 acre Hayman fire in 2002 and the 12,000 acre Buffalo Creek fire in 1996. The Chatfield Watershed Authority continues to collect water quality data to monitor effects of the fire. For more information, see www.chatfieldwatershed.org.

Bear Creek Watershed Association (BCWA)—The BCWA manages water quality in the Bear Creek watershed. Flow releases from Bear Creek Reservoir, the terminus of this watershed, enter the Barr/Milton watershed at its southwestern edge. The Bear Creek Reservoir Control Regulation #74 (CDPHE 1992) regulates a total maximum annual load (TMAL) to controls total phosphorus wasteload allocations for point sources, and the allowable nonpoint source load, for the Bear Creek watershed. Additionally, the WQCC adopted a narrative phosphorus standard for Bear Creek Reservoir:

> *Concentrations of total phosphorus in Bear Creek Reservoir shall be limited to the extent necessary to prevent stimulation of algal growth to protect beneficial uses. Sufficient dissolved oxygen shall be present in the upper half of the reservoir hypolimnion layer to provide for the survival and growth of cold-water aquatic life species. Attainment of this standard shall, at a minimum, require shifting the reservoir trophic state from a eutrophic and hypereutrophic condition to a eutrophic and mesotrophic condition, based on currently accepted limnological definitions of trophic states* (BCWA 2005).

While Bear Creek Reservoir is currently meeting this narrative goal, the BCWA reports potential water quality issues associated with low dissolved oxygen (DO), elevated pH, and high water temperatures. An aeration system was replaced and upgraded in 2005 to alleviate these issues with on-going monitoring to evaluate the effectiveness of the system. For more information, see www.bearcreekwatershed.org.

Clear Creek Watershed Foundation (CCWF)—The Clear Creek watershed extends from the Continental Divide to the eastern plains and flows into the east-central portion of the Barr/Milton watershed. Flows from this watershed influence only Milton and are not hydrologically connected to Barr. The CCWF manages mainly the upper portions of this watershed from the Continental Divide to just below the City of Golden. The CDPHE included stream segments within the Upper Clear Creek watershed on the Colorado 303(d) list for cadmium, copper, iron, lead, manganese, and zinc impairments related to historical mining activities (DRCOG 1998, 2006). Additionally, stormwater runoff and discharge from 11 POTWs in the Clear Creek watershed has raised concern over nutrient loading to Standley Lake. The cities of Northglenn, Thornton, and Westminster, with assistance from the cities of Arvada and Golden, administer an extensive water quality monitoring program in this watershed. The CCWF collects and evaluates water quality data in an ongoing effort to develop specific management recommendations. In accordance with the Clear Creek Watershed Management Agreement, the WQCC adopted a narrative standard for Standley Lake:

> *The trophic status of Standley Lake shall be maintained as mesotrophic as measured by a combination of common indicator parameters such as total phosphorus, chlorophyll a, Secchi*

> *depth, and dissolved oxygen. Implementation of this narrative standard shall only be by Best Management Practices and controls implemented on a voluntary basis (Clear Creek Watershed Management Agreement 2006 Annual Report).*

This narrative standard was adopted in lieu of a numeric standard and control regulation. For more information, see www.bearcreekwatershed.org.

Big Dry Creek Watershed Association (BDCWA)—The BDCWA manages water quality in the Big Dry Creek watershed, which originates at the base of the foothills just west of the former Department of Energy's Rocky Flats facility and drains easterly to the confluence with the South Platte River near Fort Lupton. The Big Dry Creek watershed has influence only on Milton, and is not hydrologically connected to Barr. Currently, waters in the Big Dry Creek watershed meet state water quality standards. The water quality focus of the BDCWA is currently on fecal coliform counts, selenium, and stormwater runoff. For more information, see www.bigdrycreek.org.

1.5 REGULATORY ISSUES AND PROCESSES

The following excerpt from USEPA Watershed Academy's online Clean Water Act (CWA) training provides a succinct overview of the federal regulatory issues and processes pertinent to the Barr/Milton watershed (USEPA 2006a):

> "The CWA is the cornerstone of surface water quality protection in the United States. The statute employs a variety of regulatory and non-regulatory tools to sharply reduce direct pollutant discharges into waterways, finance municipal POTWs, and manage polluted runoff. These tools are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters so that they can support 'the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water.'
>
> For many years following the passage of CWA in 1972, USEPA, states, and Indian tribes focused mainly on the chemical aspects of the 'integrity' goal. During the last decade, however, more attention has been given to physical and biological integrity. Also, in the early decades of the Act's implementation, efforts focused on regulating discharges from traditional 'point source' facilities, such as municipal sewage plants and industrial facilities, with little attention paid to runoff from streets, construction sites, farms, and other 'wet-weather' sources.
>
> Starting in the late 1980s, efforts to address polluted runoff have increased significantly. For 'nonpoint' runoff, voluntary programs, including cost-sharing with landowners, are the key tool. For 'wet weather point sources' like urban storm sewer systems and construction sites, a regulatory approach is being employed.
>
> Evolution of CWA programs over the last decade has also included something of a shift from a program-by-program, source-by-source, pollutant-by-pollutant approach to more holistic watershed-based strategies. Under the watershed approach equal emphasis is placed on protecting healthy waters and restoring impaired ones. A full array of issues are addressed, not just those subject to CWA regulatory authority. Involvement of stakeholder groups in the development and implementation of strategies for achieving

and maintaining state water quality and other environmental goals is another hallmark of this approach."

Colorado relies on regulation and guidance adopted by USEPA for formulating its own standards, procedures, and guidelines. The Colorado Water Quality Control Act (Colorado Revised Statutes 25-8-101 through 25-8-702) provides the policy direction to conserve, protect, maintain, and improve, where necessary and reasonable, the quality of state waters. The act authorizes water pollution prevention, abatement, and control programs. The Water Quality Control Commission (WQCC) is the rulemaking body responsible for regulating water quality and establishing classifications and standards to protect beneficial uses of streams, lakes, and groundwater in the state (Colorado Revised Statutes 25-8-201 through 25-8-406). The WQCC's nine members are appointed by the Governor for three-year terms and confirmed by the Colorado Senate. The WQCC is authorized to promulgate control regulations to describe limitations for the extent of specifically identified pollutants that any entity may discharge into any specified class of state waters.

The WQCC assigns use classifications to water bodies as well as numeric standards to protect these uses.

The following water quality use classifications are applied in the watershed (Figure 1-18), as defined by Regulation 31 of the WQCC (WQCC 2005)[2]:

- **Agriculture** — Waters suitable or intended to become suitable for irrigation of crops usually grown in Colorado and which are not hazardous as drinking water for livestock. A total of 480 miles (772 kilometers) of streams, located throughout the Barr/Milton watershed, are classified for agricultural use. Barr and Milton are also classified for agricultural use.
- **Aquatic Life Cold-Water Class 1 —** Waters that (1) currently are capable of sustaining a wide variety of cold-water biota, including sensitive species, or (2) could sustain such biota but for correctable water quality conditions. A total of 5.4 miles (8.7 kilometers), all located on the South Platte River directly downstream of Chatfield Reservoir, are classified as Class 1 cold-water aquatic life.
- **Aquatic Life Warm-Water Class 1** — Waters that (1) currently are capable of sustaining a wide variety of warm-water biota, including sensitive species, or (2) could sustain such biota but for correctable water quality conditions. A total of 30 miles (48 kilometers) of stream length on the South Platte River, Clear Creek, and Bear Creek are classified as Class 1 warm-water aquatic life.
- **Aquatic Life Cold- and Warm-Water Class 2** — Waters that are not capable of sustaining a wide variety of cold or warm water biota, including sensitive species, due to physical habitat, water flows or levels, or uncorrectable water quality conditions that result in substantial impairment of the abundance and diversity of species. A total of 3.7 miles (6 kilometers), all located directly northeast of Chatfield Reservoir, are classified as Class 2 cold-water aquatic life.

[2] Note that Figure 1-18 and the text included in this report are based on water quality use classifications reported in the December 31, 2005 version of Regulation 31. Water use classifications were updated in the May 31, 2008 version of Regulation 31. Updated figures and information will be presented in the final version of this Watershed Plan, expected in 2010.

- **Recreation Class E** (existing primary contact) — Surface waters used for primary contact recreation or have been used for such activities since 11/28/1975.
- **Recreation Class P** (potential primary contact) — Surface waters that have the potential to be used for primary contact recreation.
- **Recreation Class N** (not primary contact use) – Water that are not suitable or intended to become suitable for primary contact recreation uses.
- **Recreation Class U** (undetermined use) – Surface waters whose quality is to be protected at the same level as existing primary contact use waters, but for which there has not been a reasonable level of inquiry about existing recreational uses and no recreation use attainability has been completed.
- **Water Supply —** Waters are suitable or intended to become suitable for potable water supplies. After receiving standard treatment (coagulation, flocculation, sedimentation, filtration, and disinfection), these waters will meet Colorado primary drinking water regulations. A total of 100 miles (161 kilometers) of streams, including the Bear Creek, Cherry Creek, Clear Creek, Little Dry Creek, and the South Platte River, are classified for use as a water supply. Barr and Milton are also classified for water supply use.

The numeric standards are the allowable concentrations of various parameters that are determined to protect classified water uses. The WQCD, as staff to the WQCC, is responsible for monitoring and assessing water quality in Colorado and managing the discharge of pollutants into waters of the state from various facilities. The Act creates the Colorado pollutant discharge permit system (Colorado Revised Statutes 25-8-501 through 25-8-506) which requires any entity discharging pollutants into state waters to obtain a permit from the WQCD. Discharge permits are issued to comply with basic, narrative, numeric standards, and control regulations so that all discharges to waters of the state protect the classified uses.

1.5.1 CWA Section 303(d) Impaired Waters

Section 303(d) of the CWA requires that each state identify those waters for which existing technology based pollution controls are not stringent enough to meet the national goal of fishable/swimmable and attain or maintain state water quality standards. The WQCC adopted a 2008 303(d) list of impaired waterbodies for Colorado (CDPHE 2004 b,c). For these waters, Colorado establishes TMDLs according to a priority ranking. A TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards. In mathematical terms:

$$\text{TMDL} = \text{LA} + \text{WLA} + \text{MOS}$$

LA is the NPS load allocation, WLA is the point source waste load allocation, and MOS is the margin of safety.

There are a total of 20 state-defined waterbody segments included in the Barr/Milton watershed with assigned designations and classifications (Figure 1-19; Table 1-8) (CDPHE 1981). Basic water quality standards apply to each segment unless site-specific standards have been applied. Of the 20 segments contained in the Barr/Milton watershed, nine are impaired for one or more parameters. Pollutants of concern in the Barr/Milton watershed include: bacteria *Escherichia coli (E. coli)*, selenium, organic sediment (for impairment of Aquatic Life use classification), and pH. The pH impairments occur specifically in Barr and Milton. Each of the nine impaired segments has a TMDL priority ranking. The assigned priority for the Barr and Milton pH TMDL is medium.

> It is important to note that the BMW Association is focusing its TMDL efforts solely on the pH impairment for Barr and Milton (Segment 4 of the Middle South Platte basin). None of the other impairment listings in the watershed are related to nutrient loading which is the basis for the pH impairment in the two reservoirs. Additionally, other workgroups are currently focusing their efforts on the other impairments within the watershed.

The *E. coli* listing and TMDL for segment 15 of the Upper South Platte is being addressed by the WQCD. The WQCD is also working on TMDL plans for *E. coli* on segment 16a of the Upper South Platte, segments 15 and 18a of the Clear Creek basin, and Segment 2 of the Bear Creek basin. The selenium listing on segments 16a and 16c of the Upper South Platte is being addressed by a Selenium Stakeholders group. Impairment listings on segment 1 of Big Dry Creek are being addressed by the BDCWA. Aquatic Life use impairments by organic sediment on Clear Creek segments 15 and 14b are being addressed by the WQCD.

1.5.2 CWA Section 319 Nonpoint Source Management Program

Recognizing the need for greater federal leadership to help focus State and local NPS efforts, Congress amended the CWA in 1987 to establish the section 319(h) NPS Management Program. Under section 319, States, Territories, and Indian Tribes receive grant money to support a wide variety of activities including technical and financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the results of specific NPS implementation projects. Development of this Plan, as well as other activities of the BMW Association, is funded with a Section 319(h) grant by the CDPHE.

As with many federal programs, the Nonpoint Source program has grown and evolved over time. In 2005 the WQCD created the 2005 supplement to the Nonpoint Source Management Program. This document supersedes the major update to the program that was approved by EPA in 2000 and provides an updated action plan, program priorities and funding guidelines. The supplement outlines the program actions for the next five years. In particular it outlines how the NPS program will migrate from an individual pollutant category approach, such as agriculture, mining or construction, to a pollutant-integrated watershed approach, addressing the collective NPS needs of a specific geographic region of Colorado. In addition, USEPA has adopted new strategic targets and associated reporting requirements which will need to be implemented in the program. Because of this, the WQCD is prioritizing watersheds based on four main categories:

1. Water quality standards;
2. Watershed groups' level of readiness;
3. How ready the local community is to proceed; and
4. How well project implementation results can be monitored.

Using this prioritized watershed approach by the WQCD will result in a more structured approach in approving 319 projects. This should assist in focusing resources and producing more measurable results in regards to water quality improvements from nonpoint sources. This process also allows for the WQCD to allocate the majority of the NPS funds in the basins on a rotating basis that coordinate with the triennial regulation reviews in the basins.

1.5.3 CWA Section 304(a) Nutrient Criteria

Section 304(a) of the CWA directs USEPA to develop and publish criteria guidance to assist states and authorized tribes in developing water quality standards that are protective of designated uses. USEPA's section 304(a) nutrient criteria recommendations are intended to protect against the adverse effects of cultural eutrophication. Cultural (i.e. human-induced) eutrophication of surface waters is a long-standing problem. The problem is national in scope but specific levels of over-enrichment leading to these problems vary from one region of the country to another because of factors such as geographical variations in geology, vegetation, climate, and soil types. For these reasons, USEPA has developed its recommended nutrient water quality criteria on an ecoregion basis (USEPA 2001). The intent of USEPA's recommended ecoregion nutrient criteria is to represent water quality conditions that are minimally impacted by human activities and to provide for the protection and propagation of aquatic life and recreation. They provide guidance for states and authorized tribes in adopting water quality standards that ultimately provide a basis for controlling discharges or releases of pollutants.

In keeping with USEPA guidance, the WQCD has developed the Nutrient Criteria Development Plan for Colorado that presents a conceptual framework for development of criteria for streams and reservoirs (CDPHE 2002b). The plan outlines the use of a phased approach for developing nutrient criteria for lakes and reservoirs. Based on Colorado’s familiarity and experience in setting lake and reservoir nutrient standards, the WQCD strategy is to develop nutrient standards for selected targeted water bodies that have significant nutrient issues and are high on the list of priorities. Barr is listed in the Nutrient Criteria Development Plan as a high priority due to non-attainment of pH standards, 303(d) listing, public concern, and the availability of an existing dataset.

The Nutrient Criteria Development Plan offers an expected endpoint of 2009 for development of nutrient criteria for Barr, corresponding with the Triennial Rulemaking Hearing date for the South Platte River Basin. The BMW will cooperate in assisting the WQCD with criteria development for both Barr and Milton since the technical basis for their development is expected to be the same as that used for the pH TMDL determination.

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2 WATERSHED PARTNERSHIPS AND ORGANIZATIONAL STRUCTURE

This Section identifies the partners, organizational structure, and collaboration efforts of the BMW Association. Solid watershed partnerships and organizational structure are key elements to successful development and implementation of watershed management plans and activities associated with the TMDL process.

2.1 WATERSHED PARTNERS

Making substantive water quality changes in the Barr/Milton watershed has required the input of a variety of stakeholders. Gaining support and buy-in from all stakeholders will lead to thoughtful discussions and decision-making that will minimize future conflicts. The BMW Association will work as a partnership, with each member, sharing a set of resources that can be coordinated to meet the goals of the Watershed Plan.

The 2008 membership roster includes 22 dues paying entities and individuals, plus another ten or so active, non-dues paying members. Member entities include industry, recreation, municipalities, drinking water agencies, raw water providers, POTWs, homeowner associations, water quality agencies, and citizen groups (Table 2-1). Another 100 individuals and entities are notified of group activities via an e-mail distribution list.

As the BMW Association moves forward with watershed protection, other interested parties are expected to join the stakeholder base. Membership in the BMW Association is open to any party interested in improving water quality in the watershed. Members are encouraged to bring approaches and solutions to the table for discussion and action. As the watershed project develops and is promoted, it is expected that outreach efforts will result in additional interest and participation.

2.2 WATERSHED ORGANIZATIONAL STRUCTURE

The BMW Association is a consensus-driven, decision-making organization. Each member brings a different perspective to the group. By acknowledging and addressing issues proactively as a cohesive group, informed decision-making can occur in a collaborative fashion.

2.2.1 Watershed Organization Type

The BMW Association has filed Bylaws and Articles of Incorporation with the State of Colorado as a nonprofit 501(c)(6) corporation. A 501(c)(6) organization is a business league or an association of persons having some common business interest, the purpose of which is to promote such common interest and not to engage in a regular, for-profit business. The Internal Revenue Service has recognized the BMW Association for tax-exempt status.

2.2.2 Categories of Participation

Individuals, as well as agencies, are encouraged to become members of the BMW Association. Association members join at one of four membership levels: Sustaining, Active, Supporting, and Ex-officio. Fees and voting rights vary with each level of membership.

Sustaining Member—Sustaining members are entitled to appoint one representative to the Board of Directors (Board). Sustaining members are required to attend stakeholder meetings and to cast one vote upon any substantive decision submitted to the membership.

Active Member—Active members are eligible to serve as at-large members on the Board. Active members are entitled to participate in all meetings, to cast one vote upon any substantive decision submitted to the membership, and to cast their vote at each at-large Board election.

Supporting Member—Supporting members are eligible to serve as at-large members on the Board. Supporting members are entitled to participate in all meetings, to cast one vote upon any substantive decision submitted to the membership, and to cast their vote at each at-large Board election.

Ex-officio Member—Ex-officio members are entities that want to participate and stay involved but cannot vote or pay to be a member due to conflicts of interest.

While dues payment is encouraged, it is not required as a condition of general membership. Any member of the public is invited and encouraged to attend and participate.

2.2.3 Rules of Operation

One of the unique features of the BMW Association is the use of consensus-based decision making. The corporate Bylaws specify a procedure for attempting to achieve consensus on all substantive issues that require a decision by the group. Consensus-based decisions include all present from the general membership at the time the proposal is presented. This approach requires that proposals be well presented, thoroughly discussed, and modified as necessary to meet the needs of those engaged in the discussions. If consensus is not possible, the Bylaws contain provisions for official voting.

Day-to-day business operations of the BMW Association are governed by a board that is comprised of a representative from each Sustaining member, as well as a minimum of 3 At-large Directors. The Board also ratifies all substantive, consensus-based decisions made by the general membership. The terms are for one year, including those of the Executive Committee made up of the Chair, Vice-Chair, Secretary, and Treasurer.

The Board adopted a Business Operating Policies document (BMW Association 2005a). The document describes standards that guide actions of the directors, officers, members, clients, affiliates, employees, agents, consultants, vendors, and independent contractors. These policies set forth key guiding principles that represent the BMW Association policies.

2.2.4 Funding Mechanisms

Funding mechanisms for the BMW Association include grants and membership dues. In 2002, the initial planning group partnered with the WQCD to receive a $49,500 319(h) NPS grant and in 2005 was awarded a second 319(h) NPS grant for $301,000. Membership dues are used as cash match for the grant funds.

2.3 OUTREACH AND TECHNICAL ACTIVITIES

Expertise of the membership is utilized in various committees as authorized by the Board. Currently active committees include Technical, I/E, Watershed Plan, and Budget Committees. A great deal of hands-on work is accomplished at the committee level.

2.3.1 Outreach and Education

One of the key functions of the BMW Association is public outreach and education. This public process keeps the community up to date and informed of the Association's activities and successes in the watershed. This process is also designed to target entities, individuals, and programs that are affected by Association activities, in an on-going attempt to encourage and expand membership.

The BMW Association Information and Education (I/E) Committee developed and currently implements a plan for outreach and education activities and material development. Many of the I/E committee members have experience in this field and draw upon resources from their professional workplace. The opportunity exists for collaborating with many of the stakeholders that have existing I/E programs in place. Development and production of I/E materials is undertaken largely by Association members. Section 7.4 provides more information on the BMW Association's I/E program.

2.3.2 In House Technical Activities

The BMW Association draws upon the wealth of technical resources represented from within the organization's membership.

Water quality monitoring, including sampling and laboratory analysis, has been one of the foundational technical activities undertaken by Association members. Results of historical monitoring led to the determination of water quality impairment in the two reservoirs. Monitoring and data analysis has continued in recent years to supplement the historical record for water quality modeling purposes. Monitoring by member organizations will continue indefinitely as part of the on-going management plan to evaluate the effectiveness of watershed improvement activities.

The Watershed Plan Committee has been responsible for the writing and compilation of this Watershed Plan, which serves as the roadmap for Association activities. This effort seeks to synthesize the various pieces of work completed by committee, individuals, or entities from within or as advisors to the organization.

The Technical Committee serves as the planning, project management, and clearinghouse portion of the Association with regards to technical activities and outputs. All technical work is scoped by the Committee and delegated either within the Association or to qualified outside consultants. Work progress is managed by the Committee and all draft and final work products reviewed prior to distribution to the membership.

To assure the financial sustainability and stability of the BMW Association, a Budget Committee was formed to identify funding opportunities to augment with members' dues. The Committee develops budgets, reviews expenditures, and provides financial guidance for the Association.

2.3.3 Outside Technical Assistance

The BMW Association has also recognized the need for highly specialized technical services given the nature of the water quality issues at hand. The 6-year budget from the 2005 319(h) NPS grant Project Implementation Plan (PIP) reflects this recognition by accounting for expenditures for technical consultants in the fields of limnology, water quality modeling, and engineering (BMW Association 2005c). To date, technical consultants have been used in Phase 1 for meeting facilitation, association coordination, database development and updates, initial reservoir water quality characterization, spatial data manipulation and outputs, and website development and maintenance. Consultants are currently being used in Phase 2 for water quality model development and will continue to be used in Phases 2 and 3 for TMDL development, Best Management Practice (BMP) feasibility analyses, and cost/benefits analyses.

2.4 INTEGRATION WITH OTHER PLANNING EFFORTS

In an effort to leverage funding, maximize resources, and produce timely results, the BMW Association coordinates its efforts throughout the planning region. By reaching out to other watershed associations, providing feedback to local planning agencies, and gaining recognition in the community, the BMW Association anticipates a high degree of success resulting from watershed planning.

2.4.1 Integration Approach

Since one of the functions of the BMW Association is public outreach, the Association conducts its planning efforts in close coordination with other local water quality and watershed management efforts. This is accomplished, in part, by having BMW Association representatives act as liaisons for information exchange between the BMW Association and their represented organizations that have water quality plans in place. For example, in 2007-2008 this Watershed Plan was formally presented to approximately 20 audiences, reaching more than 300 individuals. Additional copies of the Plan have been distributed through other outreach activities.

This Plan is the overall document that will integrate with other programs and plans. Within the Barr/Milton watershed, other plans must be considered, referenced, and developed, such as: municipal stormwater management plans, the airport stormwater management plan, reservoir management plans, land development plans and guidelines, agricultural nutrient management plans, water quality management plans for concentrated animal feeding operations, water quality monitoring plans, and other documents that address water and land quality in the Barr/Milton watershed.

Identifying both similar and contradictory aspects of all these documents with this Plan will be important to integration. All stakeholders should be comfortable in the understanding that they are not alone in protecting and improving water quality in the watershed. This will not only have a positive effect in the Barr/Milton watershed but also in the neighboring watersheds.

2.4.2 Links to Water Quality, Environmental, or Other Relevant Regulatory Efforts and Programs

In the Denver metropolitan area, DRCOG has been designated as the Clean Water Act Section 208 planning agency. DRCOG is thus responsible under state and federal statutes for regional water quality planning. DRCOG developed the Clean Water Plan which describes wastewater management strategies, watershed water quality programs, wasteload allocations, stream standards, priority regional projects, NPS control strategies, and stormwater management programs within the planning area (DRCOG 1998, updates 2006). The Clean Water Plan provides a regional context for protecting and maintaining water quality through integrated, watershed management processes. This plan is an integrated part of Metro Vision, the region's long-range growth and development plan (DRCOG 2008).

The region's goal is to "restore and maintain the chemical and physical integrity, in order to assure a balanced ecological community, in waters associated with the region." The Clean Water Plan, as an integrated part of the Metro Vision 2035 Plan, supports a proactive bottom-up planning process with regional coordination. Integration with Metro Vision 2035 primarily comes from wastewater utility plans. This linkage allows the Clean Water Plan to be flexible, collaborative, and effective, while incorporating mechanisms to assist local governments in voluntarily meeting water resource goals.

The relationship between planning agencies, approved plans, and regulatory agencies is defined in the Continuing Planning Process for Water Quality Management in Colorado as maintained by the WQCC. It sets forth objectives and operational requirements of the state's water quality management program, its organizational structure, intergovernmental decision-making process, and timing relationships.

DRCOG's planning area overlaps with roughly the lower two-thirds of the Barr/Milton watershed.

North of the DRCOG planning area, and serving the remainder of the watershed, the North Front Range Water Quality Planning Association (NFRWQPA) is the 208 planning agency. As the designated agency, NFRWQPA has the responsibility of a 208 plan, the Areawide Water Quality Management Plan (NFRWQPA 2008). The 208 plan is the overriding planning document used to coordinate water quality planning in the area. As stated in the Clean Water Act, the plan shall include "the identification of treatment works necessary to meet the anticipated municipal and industrial waste treatment needs of the area" and "the identification of the measures necessary to carry out the plan." The Plan provides essential information to ensure that local water quality goals and objectives are considered in state and federal water quality decision making. NFRWQPA is also responsible for carrying out the tasks identified in the plan. The Association has policies that govern specific activities associated with these tasks. These policies are designed to steer the planning process.

Both organizations are members of the BMW Association and have taken an active role in the development of this Plan. It is the intent of the BMW Association to foster a close working relationship with both agencies as this Watershed Plan is developed, updated, and implemented.

At the state and federal level, all activities that result from implementation of the Watershed Plan will necessarily be coordinated with the CWA Section 303(d), Section 319(h), and Section 304(a) programs as detailed in Section 1.5.

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3 SCOPE OF WATERSHED EFFORTS

The scope of watershed efforts presented here defines the water quality and organizational goals of the BMW Association based on pollutants of possible concern and indicators of watershed conditions. The current scope is based on the 303(d) listing of Barr and Milton for pH, as well as known high levels of nutrient loading. This scope may expand as required by TMDL development efforts.

3.1 POLLUTANTS OF POSSIBLE CONCERN

Pollutants of concern include contaminants from many point, nonpoint, and stormwater sources. In Barr and Milton, elevated pH and algal overgrowth are a result of excessive concentrations of N and P (AMEC 2008 a,b). N and P are the primary pollutants of concern due to their overabundance in the system. As part of Phase 2, the BMW Association is facilitating a complete evaluation of the point and NPS contribution of these nutrients, as well as the annual, seasonal, and diurnal chemical interactions that control water pH.

3.1.1 Nutrient and pH Water Chemistry

Maintaining balanced nutrient and water chemistry depends on the acidity or alkalinity of the water. Eutrophication (Figure 3-1) is an ecological process where inputs of plant nutrients; primarily soluble P and N, result in the inordinate growth of aquatic plants (e.g., rooted macrophytes and planktonic algae).

Although eutrophication is a natural process, human activities can greatly accelerate eutrophication by increasing the rate that nutrients and organic substances enter aquatic ecosystems from surrounding watersheds. Agricultural runoff, urban runoff, leaking septic systems, sewage discharges, eroded streambanks, and other similar sources can increase the flow of nutrients and organic substances into aquatic systems. These substances can overstimulate the growth of algae, creating conditions that interfere with the recreational uses and the health and diversity of indigenous fish, plant, and animal populations.

Algal blooms impact the system in two ways. First, they cloud the water and block sunlight, causing desirable underwater macrophytes to die. Because these rooted, aquatic plants provide food and shelter for aquatic organisms, spawning, feeding, and nursery habitat is destroyed. Second, when the algae die and decompose, dissolved oxygen is consumed. Dissolved oxygen is essential to most aquatic organisms, especially fish.

The chemical reactions that take place in plants driven by sunlight are called photosynthesis, described in the equation below. During photosynthesis, algae and aquatic plants consume carbon dioxide (raising pH) and produce dissolved oxygen.

Photosynthesis

$$\underset{\text{carbon dioxide}}{CO_2} + H_2O + \text{Nutrients} \xrightarrow{\text{light}} \underset{\text{organic matter}}{CH_2O} + H_2O + \underset{\text{oxygen}}{O_2}$$

The above equation shows that photosynthesis causes an increase in DO and a decrease in carbon dioxide in the system. Carbon dioxide quickly dissolves in water to form carbonic acid, and ultimately bicarbonate and carbonate. Bicarbonate/carbonate increases the acidity of the waterbody (lowers pH). Carbon dioxide fuels photosynthesis, resulting in a reduction of carbonic acid, bicarbonate/carbonate, and fewer hydrogen ions; this process increases pH (i.e., the water becomes more basic).

Dissolved Inorganic Carbon Process

$$\underset{\text{carbon dioxide}}{CO_2} \xrightarrow[H_2O]{} \underset{\text{carbonic acid}}{H_2CO_3} \longrightarrow \underset{\text{bicarbonate}}{HCO_3^-} + H^+ \longrightarrow \underset{\text{carbonate}}{CO_3^{-2}} + H^+$$

Respiration is just the opposite. At night, the algae and plants respire (i.e., take in oxygen), depleting available DO, increasing carbon dioxide, and lowering the pH. The water increases in acidity. This can result in large, diurnal fluctuations of water chemistry that can be harmful to aquatic life.

Respiration

$$\underset{\text{detritus}}{CH_2O} + H_2O + O_2 \longrightarrow CO_2 + H_2O + \text{Nutrients} + \text{energy}$$

As long as the supply of nutrients is maintained, plants will grow until limited by the availability of light, water temperature, or some other micro-nutrient. Light availability often limits algal growth at depth in eutrophic waters because dense algal populations restrict light penetration. Although photosynthetic activity can increase DO concentrations in surface waters, the subsequent decomposition of plant material resulting from eutrophication can later strip bottom waters of DO, negatively affecting both nutrient dynamics and aquatic life.

Sampling conducted in both Barr and Milton reservoirs strongly suggests the reservoirs are currently eutrophic (AMEC 2008 a,b) to levels that undermine beneficial uses. Reservoir monitoring found consistent evidence of an overabundance of algal growth, surface scum, odors, blue-green algae blooms (including potentially toxic *Microcystis spp*.), and high pH levels—all undesirable consequences of high nutrient loads stimulating excessive plant growth.

3.1.2 Pollutant Sources

Nitrogen and phosphorus, the pollutants of primary concern come from numerous sources throughout the watershed; nutrients, alone, are not pollutants. N and P are vital elements to all living organisms. As discussed above they become problematic when overabundant in the aquatic system. N and P are generated within the watershed through both point and nonpoint sources of pollution, as described in the following subsections.

3.1.2.1 Point Sources

Industrial and Wastewater Point Sources—The USEPA defines **point source pollution** as "any single identifiable source of pollution from which pollutants are discharged, such as a pipe, ditch, ship or factory smokestack".

Factories and wastewater treatment plants are two common types of point sources. Factories, including oil refineries, pulp and paper mills, chemical, electronics, and automobile manufacturers, typically discharge one or more pollutants in their discharged waters (called effluents). Some factories discharge their effluents directly into a waterbody; others treat it at the facility before it is released, and still others send their wastes to sewage treatment plants for treatment. Wastewater treatment plants treat human wastes and send the treated effluent to a stream or river.

To control point source discharges, the Clean Water Act established the National Pollutant Discharge Elimination System (NPDES). Under the NPDES program, factories, sewage treatment plants and other point sources must obtain a permit from the state before they can discharge their waste or effluents into any body of water. Prior to discharge, the point source must use the latest technologies available to treat its effluents and reduce the level of pollutants. If necessary, a second, more stringent set of controls can be placed on a point source to protect a specific waterbody.

A total of 42 entities hold NPDES permits for point source discharges in the Barr/Milton watershed, including industrial, water treatment, wastewater, stormwater, sand and gravel operations, and Superfund facilities. Active major permit holders in the watershed are identified on Figure 1-13 and in Table 1-5. In addition to these major permit holders in the watershed, many other permitted dischargers located both in and upstream of the Barr/Milton watershed may impact watershed flow volumes and water quality. Table 3-1 lists additional permitted dischargers in and upstream of the Barr/Milton watershed.

Some wastewater point sources in the Barr/Milton watershed contribute large masses of N and P from their treated effluent to the watershed. Table 3-2 reports the nutrient loads generated annually by the major wastewater facilities from 2003 – 2004 (the years represented in the model).

Onsite Wastewater Systems—Onsite wastewater systems (also known as individual sewage disposal systems, or ISDS's) provide wastewater treatment and disposal, primarily for individual homes (as well as some commercial and business establishments), in areas not served by central wastewater treatment systems. From a regulatory perspective, onsite wastewater systems less than 2,000 gallons per day flow are the responsibility of state and local health departments rather than designated management agencies (i.e., cites, counties, wastewater authorities). These systems are to be designed, operated, inspected, and maintained according to existing local health department regulations and recommendations. Onsite wastewater systems are an acceptable means of waste disposal assuming they are designed and maintained properly.

In 2001, the CDPHE established the ISDS Steering Committee to bring together a wide range of expertise and interests related to onsite wastewater systems. According to the ISDS Steering Committee, water quality impacts related to onsite wastewater systems are known to occur in a number of specific areas in Colorado. However, the presence and nature of these problems often are not verified or rigorously documented, and few studies have been done in Colorado that directly link water quality or health risks with onsite wastewater systems. Recognized impacts include elevated nitrate and bacteria levels in groundwater used for drinking water, as well as nutrient load increases which adversely affect surface waters. The overall scope, extent, and type of water quality impacts from onsite wastewater systems in most areas of Colorado is unknown. Although few site-specific studies have been completed, it appears that substantial cumulative loadings of nutrients to state waters are likely occurring in some areas where there are a significant total number and density of onsite wastewater systems (ISDS 2002).

There are areas of known nitrate contamination and increased nitrate levels in groundwater in areas of high density onsite wastewater systems (lots less than one acre) and a significant number of homes. In some surface water basins, phosphorus loadings from onsite wastewater systems are a potentially significant water quality factor (ISDS 2002).

Stormwater Point Sources—To address the nationwide problem of stormwater pollution, in 1987 Congress broadened the CWA definition of "point source" to include industrial stormwater discharges and municipal separate storm sewer systems (MS4). Stormwater is a term used to describe water that originates during precipitation events. It may also be used to apply to water that originates with snowmelt or runoff water from overwatering that enters the stormwater system. Stormwater that does not soak into the ground becomes surface runoff, which either flows into surface waterways or is channeled into storm sewers. Stormwater is of concern for two main issues: one related to the volume and timing of runoff water (flood control and water supplies) and second related to the potential contaminants that the water is carrying, i.e. water pollution. Qualifying stormwater discharges are now regulated through NPDES permits.

This 1987 expansion was promulgated in two phases: Phase I and Phase II. Phase I required that all municipalities of 100,000 persons or more, industrial dischargers, and construction sites of 5 acres (20,000 m^2) or more have NPDES permits for their stormwater discharges. Phase I permits were issued in much of the U.S. in 1991. Phase II required that all municipalities, industrial dischargers, construction sites of 1-acre (4,000 m^2) or more, and other large property owners (such as school districts) have NPDES permits for their stormwater discharges. Phase II rules came into effect in 2003.

Other entities that require stormwater permits include the construction industry disturbing one or more acres of land, oil and gas construction, certain light and heavy industries (e.g., POTWs with treatment capacities over 1.0 mgd), transportation facilities, metal mining, and sand and gravel operations.

With the increase of impervious surfaces related to urbanization, debris or chemicals on streets, roofs, and sidewalks are washed into a stormwater collection system that eventually delivers those substances to a creek or canal. Weather determines the amount and rate at which precipitation falls on impervious surfaces. Although the Barr/Milton watershed receives less than 15 inches of rain per year, the rain typically comes in very short, intense, and isolated thunderstorms that can create temporary flash flooding. These first-flush, high volume events are a significant contaminant source within the watershed.

Stormwater "hotspot" areas are land use areas that produce higher concentrations of priority pollutants than normally found in urban runoff. Hotspot areas include commercial, industrial, institutional, municipal, or transport related operations that produce higher levels of stormwater pollutants, and present a higher potential risk for spills, leaks, or illicit discharges. Nutrient pollution is typically associated with most categories of hotspots. In contrast, pervious areas and residential, institutional, and office developments are not normally considered stormwater hotspots. However, a number of common residential practices can still result in pollution carried through stormwater, such as widespread use of non-porous paving materials, overuse of fertilizers, and poor maintenance of septic systems.

Other Point Sources—There are a few other sources of point source pollution that may have an impact on Barr and Milton. Operation of sand and gravel mining along the South Platte River corridor can be a source of pollution, mainly turbidity. Mining can also alter the flow regime of the rivers, as well as alter alluvial groundwater flows. There are a couple of USEPA superfund sites in the watershed that are worth noting. These designated areas are responsible for pollution containment and clean-up.

3.1.2.2 Nonpoint Source

NPS pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. Most NPS pollution occurs as a result of runoff as rainfall or snowmelt moving over and through the ground picks up natural and human-made pollutants, eventually depositing them into lakes, rivers, wetlands, coastal waters, or groundwater. The USEPA (1994) lists the following common NPS:

- Excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas;
- Oil, grease, and toxic chemicals from energy production and non-permitted urban runoff;
- Sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks;
- Salt from irrigation practices and acid drainage from abandoned mines; and
- Bacteria and nutrients from livestock, pet wastes, and faulty septic systems.

In recent years, the oil and gas drilling industry has experience a major boom in Weld County, in the northern end of the Barr/Milton watershed. Intensive drilling activities can be a serious source of nonpoint pollution if not properly regulated and managed. New access roads, footpads for each site, the use of water for fracturing substrate, the collection and disposal of brackish water from wells, and the on going long-term maintenance impacts all can provide a collective impact to downstream water quality conditions.

NPS contamination is more difficult to locate, calculate, and quantify than is point source contamination where you have a known source of pollution. The collective impact of NPS from a population of 2.7 million people cannot be ignored. 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 1980 (DRCOG). While this includes all land type uses, it suggests a residential pattern dominated by single-family residences. The average 1990 population density in the metropolitan service area was about 3,600 persons per square mile (DRCOG 1990). There are currently about 500 square miles of urban area.

In 1983, DRCOG 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. Since the DRURP, DRCOG has been involved in six watershed studies which were designed to assess the nature, severity, and impact of stormwater and/or NPS on water quality. These efforts characterized urban runoff in relation to development patterns. (NOTE: results of the study are likely influenced by permitted stormwater sources as well as unpermitted nonpoint sources).

The DRURP showed large-scale NPS that can impact receiving waters and it encourages certain control strategies. The DRURP not only assessed the effect of urban runoff on receiving water quality but 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, and mixed use) contribute significant and varying amounts of pollutants to stormwater runoff. In an urban context, construction runoff with associated erosional components and runoff associated with urban activity are the primary areas of concern. In relation to urban lake management, the major controllable NPS parameter is phosphorus. The DRURP study identified sediments, metals, nutrients, and specific metals as the parameters of concern. The long-term detrimental impact to receiving waters from NPS was not demonstrated (DRCOG 2006).

3.1.2.3 Environmental Sources

Natural sources of nutrients are also of concern. Typical natural sources of nutrients include streambank erosion, groundwater, internal sinks (e.g., reservoir or wetland sediments), wildlife waste, and bioturbation within the reservoirs from benthic bottom feeders (e.g. carp and catfish). There are also quasi-natural sources relating to how the reservoirs are managed. Re-suspension of nutrients occurs annually when the reservoirs are filled. Debris and nutrients also enter the reservoirs from the canals, especially after a canal has been dewatered for some time.

Both Barr and Milton exhibit similar pollution issues; however, the proportion of source contributions may be slightly different for each reservoir. The modeling task will further define the pollutant sources for both reservoirs (see Section 5.3.2).

3.2 SELECT INDICATORS TO MEASURE ENVIRONMENTAL CONDITIONS

3.2.1 Indicator Parameters by Category Type

For Barr and Milton, water quality parameters associated with high pH are the main focus for monitoring. In order to meet water quality standards, the reduction of pH levels is imperative.

It is important to understand that high pH levels are a symptom, not the problem. The high pH stems from excessive in-reservoir primary productivity resulting from high nutrient levels.

Two categories of parameters require full understanding: 1) symptom parameters and 2) problem parameters. Symptom parameters make good indicators because of the visual aspects and their familiarity to the public. These parameters include pH, Secchi depth, Chl-a, algae concentration and speciation, and DO. Problem parameters are difficult for the public to see and require more expensive testing. These parameters include both the N and P nutrients that exist in soluble, total, organic, and inorganic forms.

Tracking symptom parameters over time will assist in quantifying water quality conditions. Barr and Milton have been closely monitored for both the symptom and problem parameters since 1994 and 1997, respectively. See Section 4.3 for further discussion.

3.2.2 Monitoring Requirements

To fully understand the dynamic water quality issues in Barr and Milton, a monitoring plan must include all inlet and outlet conditions as well as all in-reservoir conditions from surface to bottom. The symptom and problem parameters should be monitored year round and specifically twice a month during the growing season from March to October (Mountain River Associates 2004a,b). Section 4.3 details existing monitoring programs in the Barr/Milton watershed.

3.2.3 Expected Outcomes and Measures of Success

Predictive modeling is being used to determine the allowable load of nutrients for maintaining pH levels within regulatory limits of 6.5 to 9.0 units (see Section 5.2.2). The allowable load along with a plan for meeting required load reductions will be explained in the form of a pH TMDL. The pH TMDL will clearly define the desired water quality endpoints in addition to the quantitative indicator parameters selected for determining compliance (e.g., chl-a, transparency, and P and N concentrations). As the pH TMDL is implemented, the expectation is that nutrient loading will be reduced to pre-determined conditions, late growing season chl-a concentrations (September–October) will decrease, overall primary productivity will decrease, less carbon dioxide will be consumed, and pH levels will decrease.

The ultimate measure of success will be the reduction in pH to within the regulatory limits of 6.5 to 9.0 units.

3.3 GOALS AND OBJECTIVES

An overall goal is to resolve water quality problems related to algae growth in Barr and Milton by developing and implementing a watershed plan and pH TMDL. To reach this final goal, the BMW Association identified near-term benchmarks to measure success towards meeting long-term water quality goals. These goals were developed at an annual Board retreat on May 23, 2006. Additionally, the BMW Association developed organizational goals related to the overall functions and business activities of the group itself. The BMW Association recognizes that these goals are dynamic and will change.

3.3.1 Near-term Benchmarks

Near-term benchmarks provide reachable, measurable milestones indicating progress. The following list includes significant near-term benchmarks for the BMW Association in the 2008/09 year:

- 2008 update of the Watershed Plan
- Development and calibration of a watershed and reservoir predictive water quality model
- Hosting of three technical workshops related to model development and preliminary results
- Continued hosting of bi-monthly Board and stakeholder meetings, monthly subcommittee meetings, and an annual watershed tour
- Outreach activities including:
  - Quarterly newsletter,
  - BMW Association website,
  - Participation in water quality-related events including a South Platte River Clean-Up and Lake Appreciation Month activities at Barr Lake.
  - Poster displays at regional conferences (South Platte Forum, Cherry Creek Forum, Colorado Watershed Assembly conference, Barr Lake Fall Birding Festival)
- Work towards a sustainable financial plan

3.3.2 Long-term Water Quality Goals

Although a variety of water quality issues exist throughout the watershed, the water quality of Barr and Milton, with respect to pH and nutrient levels, is the focus of BMW Association 319 and pH TMDL efforts. The most pressing water quality issues are related to cultural eutrophication, resulting in the following unbalanced extremes within the systems:

- High pH values
- Low DO near the reservoir bottoms
- High un-ionized ammonia concentrations
- Excessive algae growth
- Extensive blue-green algae populations during parts of the year
- Low transparency/reduced water clarity

High nutrient loads drive each of these water quality issues; thus, both natural and cultural eutrophication processes require consideration when developing specific, numeric water quality goals.

During Phase 1 of this project, the BMW Association developed lists of questions related to water quality and pH TMDL development during a brain-storming exercise (Hydrosphere Resource Consultants 2005b). The questions were intended to help guide the selection of the appropriate tools/models to analyze the water quality issues (Tables 3-3 and 3-4).

These questions were further refined following development of the BMW Association's Mission and Vision statements, which resulted in the following list of water quality goals for the organization:

- Attain, then maintain water quality so that Barr and Milton are not on the 303(d) list
- Develop water quality model(s) which will
  - Identify the mechanism that is driving excessive algal growth and high pH
  - Qualify water quality parameters driving excessive algal growth and high pH
  - Quantify water quality parameters driving excessive algal growth and high pH
  - Identify appropriate reservoir management to maximize water quality
  - Identify proper pollutant load allocations to achieve water quality targets
  -
- Ensure that all plans and actions will maintain or improve water quality & habitat
  - Develop and manage a Water Quality Monitoring Plan
  - Develop and manage a Reservoir Management Plan
  - Develop and manage a BMP Plan
- Define site-specific, numeric and narrative water quality targets
- Recommend to the State an appropriate wasteload and load allocation plan for a TMDL

During goal development, participants noted that the water quality goals needed to include numeric values; in particular, the final BMW Association water quality goals should set numerical targets for pH and nutrients. Future modifications to the BMW Association's water quality goals will include these specific numeric targets. These goals will supplement additional scientific questions driving the pH TMDL and nutrient development processes.

It is the intent of the Association to revisit the long-term water quality goals on an annual basis to make necessary modifications and additions based upon technical data and results as they become available.

3.3.3 Organizational Goals

The organizational goals listed here were compiled from the board retreat, the PIP document, and comments from stakeholders. BMW Association organizational goals are as follows:

- Maintain a stakeholder-driven, consensus-based watershed organization
- Procure funding sources to sustain the nonprofit watershed organization and its activities
- Continually expand the active membership of the organization and build partnerships

- Develop and implement a public information/education program
- Coordinate with the efforts of other watersheds, agencies, and related organizations
- Fulfill the requirements of 319 and other grants received
- Develop and adhere to agreements among stakeholders on all projects
- Develop and implement an iterative process to evaluate the effectiveness of actions taken and make further recommendations and adjustments

As with the long-term water quality goals, it is the intent of the Association to revisit the organizational goals on an annual basis to make necessary modifications as new information becomes available.

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4 WATERSHED INFORMATION SOURCES, MONITORING, AND DATA INVENTORIES

This section provides an overview of existing information sources, monitoring activities, and data inventories for the Barr/Milton watershed. This watershed data supports the data analysis and characterization presented in Section 5 and summarizes the key technical elements that are currently available for development of a pH TMDL.

4.1 INFORMATION SOURCES

A wealth of current water quality and flow data exists for the watershed. Entities that share water quality data in this region are listed below:

- Big Dry Creek Watershed Association
- Centennial Water and Sanitation District
- City of Thornton
- City and County of Denver
- Denver International Airport
- Farmer's Reservoir and Irrigation Company
- City of Glendale
- Colorado Division of Wildlife
- Colorado River Watch
- Colorado State Engineers Office
- City of Aurora
- Littleton/Englewood Wastewater Treatment Plant (L/E)
- Metro Wastewater Reclamation District
- South Adams County Water and Sanitation District
- South Platte Coalition for Urban River Evaluation
- Urban Drainage and Flood Control District (UDFCD)
- U.S. Geological Survey
- Colorado Department of Public Health and Environment - Water Quality Control Division

Various reports containing water quality-based information pertinent to the Barr/Milton watershed were documented in *The BMW Water-Quality Database and Monitoring Recommendation* (Database Report) (Hydrosphere 2005a) (Table 4-1). These reports describe previous studies and background information specific to Barr and Milton from 1963 to the present. Additionally, the recently completed reservoir assessments for Barr Lake (AMEC

2008a) and Milton Reservoir (AMEC 2008b) provide detailed data analyses and reservoir characterizations (see Section 5.2.1).

4.2 DATA INVENTORIES

4.2.1 Barr/Milton Database

The BMW Association contracted with Hydrosphere Resource Consultants (Hydrosphere; currently known as AMEC Earth & Environmental) to organize relevant water quality data into a user-friendly database. The initial BMW Water Quality Database (Database) was completed in 2005 with a report titled *The BMW Water-Quality Database and Monitoring Recommendation* (Database Report) (Hydrosphere Resource Consultants 2005a). This database was used for the reservoir assessments and as the basis for water quality modeling efforts.

The Association plans to update the Database as needed during the implementation and monitoring phases of the project. The Database currently consists of 513,102 records that represent data from 332 stations and 229 different parameters. Data collection dates range from 1975 through 2007. The most recent Database update was performed in July 2007.

The BMW Water Quality Database is compatible with EPA's national STORET water quality database. A utility exists within the database that allows the user to select data and export it to a format uploadable to STORET. This functionality satisfies conditions of the 319 Grant and allows water quality information to be made easily available to the public. Instructions for exporting data to STORET format can be found in the BMW WQ Database User's Guide (Hydrosphere Resource Consultants 2005a).

4.2.2 Other Data Inventories

Although the Database serves as the cornerstone of water quality modeling efforts, a library of other data that does not "fit" in the database has also been assembled by the Association. This data is also being used in the modeling and analysis efforts. Examples of data external to the database include surface water elevation data, elevation-capacity relationships of the reservoirs, sediment data, zooplankton and phytoplankton counts, diurnal datasets, and GIS-based watershed characterizations and analyses.

Aside from the extensive database and additional data libraries created by the BMW Association, other statewide data inventories may prove to be useful during project efforts:

- STORET – EPA maintains this data management system, which is actively populated with water quality data. Included is raw biological, chemical, and physical data on surface and groundwater collected by federal, state, and local agencies; volunteer groups, academics, and others. This national database includes large amounts of Colorado data.

- Colorado Data Sharing Network – The DSN was envisioned in 2004 as a collaborative approach to minimize barriers to effective sharing of water quality data. The project is currently in the midst of assembling an easy-to-use primary water quality data management system specific to Colorado.

The BMW Database has or will have a large amount of data as well as many data providers in common with both STORET and the DSN database. Many of the stakeholder organizations involved in the BMW are also involved in the effort to complete the DSN project and enter data into the DSN system. The BMW Association intends to work efficiently with the DSN efforts to help update the database and make the water quality data readily available to the public.

4.3 MONITORING

4.3.1 Monitoring Program Elements

All watershed-related monitoring is conducted by BMW Association members as in-kind contributions. Historic monitoring has been geographically extensive and highly varied between sampling locations, depending upon institutional requirements of the monitoring entity. Most of the entities that contributed data to the 2005 and 2007 Databases continue to implement their basic sampling programs today. In some cases, monitoring plans have been or will be modified to address gaps in the data.

The Database Report provides a thorough description of the technical details associated with the data, including sampling locations, parameters monitored, frequency of sampling, who conducted the sampling, and other metadata (Table 4-1, see also Hydrosphere Resource Consultants 2005a). In addition to this combined database and report, each of the 15 entities who contributed data maintain records to document their monitoring programs.

Figure 4-1 shows the locations of the 360 water quality sampling stations within the Barr/Milton watershed. These stations provide information about 39 different waterbodies within the watershed. The majority of sampling has occurred in streams located around and upstream of Denver, although fairly extensive in-reservoir data exist for both Barr and Milton. Water flow monitoring is also extensive within the watershed, and the components of the flow monitoring program are included in the Database (Figure 4-2 and Table 4-1; see also Hydrosphere Resource Consultants 2005a). Additional flow monitoring stations have recently been added and will be available in future updates of this Plan.

Upon completion of the modeling and TMDL efforts, specific recommendations for future watershed monitoring will be considered. The recommended monitoring program will be designed to support the following:

- pH TMDL tracking
- Determination of appropriate nutrient levels for Barr and Milton
- Ongoing modeling and analysis efforts
- Evaluation of management and implementation strategies.

In addition to chemical data, future monitoring efforts may also include qualitative indicators such as frequency/type of use, user surveys, opinion polls, or other non-analytic measurements of program status.

4.3.2 Quality Assurance Project Plans

Many of the sampling sites included as updates to the initial Database are sampled as part of ongoing, routine monitoring programs from accredited watershed groups and public agencies experienced in field data collection. Water quality monitoring and quality assurance project plans are designed by the organization or individual entity that collects the data. The Database Report includes a list of monitoring entities that have submitted monitoring plan documents. All data must follow typical quality assurance/quality control (QA/QC) procedures before being sent to the BMW Association for entry into the Database.

4.3.3 Sampling Analysis Plans

Laboratory analyses follow EPA-approved methods or the American Public HealthAssociation Standard Methods (Eaton et al. 1995). Sampling entities analyze samples in a manner consistent with their in-house established standards of laboratory quality management.

4.3.4 Data Management Plan

Data incorporated in the Database have and will be subjected to a thorough and consistent QA/QC review process that verifies station information, parameters, parameter units, and duplicate/replicate records and identifies out-of-range values.

A technical consultant will be contracted specifically for database maintenance and will enter available data on an as-needed basis. The Database Report contains a QA/QC Punch List that outlines recommended database management procedures. This list will be used to maintain uniformity among the various stations, parameters, and data to support reliable information analysis during modeling and assessment phases.

4.3.5 Reporting Requirements

Data reported to the BMW Association for incorporation into the Database and subsequent studies must be located within or near the Barr/Milton watershed. Data must be reviewed by the database administrator to resolve any discrepancies pertaining to station location, parameter metadata, and data validity.

4.3.6 Data Gaps

Flow and water quality data gaps have been identified for the Barr/Milton watershed (Hydrosphere Resource Consultants 2005a). Gauging Milton inflows for both the Platte Valley and the Beebe Draw were identified as a data gap in the 2006 Plan but have since been resolved by new gauges provided by FRICO. Other data gaps include sediment data, fish species and habitat surveys, aquatic nuisance species, algal bioassays, precipitation water quality data, agricultural data, agricultural return flows, stormwater data, and atmospheric deposition.

A lack of groundwater analytical and flow data may also represent a data gap. Future evaluations of the watershed, including modeling of flow and loading sources, will likely elucidate the magnitude of groundwater influence on Barr and Milton water quality. Additional groundwater data may be collected if future studies suggest that groundwater significantly influences water quality in the watershed.

Additional data gaps regarding assessment of public opinion may exist. Qualitative data including use surveys and opinion polls may help with understanding public perspectives of the condition of the reservoirs and watershed and how social norms impact water quality. If NPS education and policy decisions are made to improve water quality, the improvements need to be measureable.

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5 DATA ANALYSES AND CHARACTERIZATIONS

This section describes both completed and future work related to analysis and characterization of information and data identified in Section 4. Work completed thus far includes the development of baseline in-reservoir water quality assessments and computerized models to simulate in-lake and watershed chemistry. These tools have and will continue to be used to quantify existing pollutant loads and, in the near future, to determine needed load reductions. Results will be incorporated into a pH TMDL. A simplified flow diagram illustrating the process for developing the modeling phases and pH TMDL is shown in Figure 5-1.

In a report titled Evaluation of Approaches and Tools (Tools Report; Hydrosphere Resource Consultants 2005b), Hydrosphere provided recommendations to the BMW Association for moving forward with data analysis, characterization, and predictive modeling (Hydrosphere Resource Consultants 2005b). Ten recommendations from the Tools Report outlined a sequence of activities based on the USEPA TMDL development process:

1. Conduct detailed reservoir assessments for each reservoir that would include water balance, nutrient loading (internal and external), trend analysis, comparison between in-reservoir sites, and analysis of annual and seasonal patterns.
2. Adjust the current monitoring programs to account for the recommendations made in the Database Report (Hydrosphere Resource Consultants 2005a).
3. Develop separate water quality models for Barr and Milton.
4. Develop a river/canal and watershed water quality model to link to the reservoir models.
5. Determine initial numeric nutrient targets.
6. Identify and characterize point and nonpoint sources in the watershed.
7. Using the reservoir and watershed models, develop a watershed feasibility analysis to evaluate point and nonpoint source reductions and changes in reservoir operations.
8. Allocate total loading plus a margin of safety to the sources.
9. Develop an evaluation plan.
10. Develop an implementation plan.

The BMW Association contracted with AMEC Earth & Environmental (AMEC) to conduct the reservoir assessments (Assessments) described above in Activity 1. The Assessments were finalized in May 2008. These provide a definition of the current baseline water quality conditions, including nutrient balances, for each reservoir.

A number of adjustments in the monitoring program have been implemented per the recommendations provided in the Database Report (Hydrosphere Resource Consultants 2005a) (Activity 2). In particular, approximately five additional flow monitoring sites have been added to the FRICO monitoring plan to increase the amount of information available. Other monitoring plan modifications include the addition of total and dissolved organic carbon to the in-reservoir monitoring program.

The Association contracted with ENSR, an independent consulting firm, to develop a series of dynamic, mechanistic water quality models (Activities 3 and 4). ENSR began the process of model development in early 2007 and completed calibration of the watershed and in-reservoir models in July 2008. The models provide the basis upon which Activities 5 through 10 can proceed, beginning in late 2008.

5.1 APPLIED DATA SETS AND DATA MANAGEMENT

Watershed-specific water quality and quantity data inventories that were used to complete the reservoir assessments and computerized modeling are described in Section 4.2. Data utilized in model construction and calibration ranged from 2002 to 2005. The 2002 data was used primarily as a startup year for calibration whereas the primary datasets from 2003 and 2004 are representative of flood and drought years, respectively. Additional data were required to support construction of the water quality models. For example, topographic information, precipitation data, land-use information, and soil characteristics were used to build the NPS components of the watershed model. Much of this data already existed in federal and State-supported data sources.

5.2 ANALYSIS METHODOLOGIES

5.2.1 Reservoir Assessments

The purpose of the reservoir assessments (Assessments) is to document the current state of water quality and serve as a scientific starting point for future TMDL development. The focus of the Assessments is the period when intensive reservoir data was collected; between June 2002 and December 2005.

In the Assessments, the reservoirs are first described in terms of their physical characteristics as evaluated through morphometric and hydrologic data. In-lake water chemistry is then characterized, including the parameters of pH, chl-a, temperature, DO, Secchi depth, TP, orthophosphate, Total Nitrogen (TN), nitrate/nitrite, and ammonia. Magnitude, patterns, and trends in the chemical data are described. The analysis includes conclusions on the causes of high pH levels.

Where available, historic data (i.e., post-1975) is compared to the recent data to determine trends. Data from other reservoirs in the area (such as other "plains" reservoirs near the Lower South Platte River, such as Prewitt Reservoir and Jackson Reservoir) are also reviewed for comparison. Inflow and outflow patterns are graphed and examined for potential relationships with observed in-reservoir water-quality results. A water and nutrient balance was developed specific to the Burlington O'Brian Canal, the main diversion that feeds Barr Lake.

The Assessments include mass balances of both water and nutrients within the reservoirs and for the Burlington Ditch. These analyses help to determine if there are important data gaps and provide a sense of relative loadings (internal and external). Loading estimates are made for TP and TN. External loading is estimated using flow and nutrient concentrations. Internal TP loading is estimated using the following three methods: 1) comparing to similar reservoirs listed in the literature; 2) using an empirical relationship between TP sediment concentrations and TP release rates; and 3) making an estimate based upon changes in hypolimnetic concentrations. The results point at the relative loading contribution occurring from the recycling of internal sources. Further detailed sediment experiments may be warranted if internal loading appears to be a significant source.

5.2.2 Modeling

Models are generally used as a tool of analysis to accurately reflect, account for, and predict water quality processes occurring within a body of water. Models link water quality impairments to indicators and sources when they fulfill the following goals: 1) appropriately simulate physical, chemical, and biological processes; 2) appropriately incorporate relevant and available data; and 3) reasonably predict historic, current, and future water quality conditions.

Applied reservoir and watershed water quality models have been developed for the Barr/Milton watershed to determine: 1) eutrophication dynamics; 2) the relationship of eutrophication parameters to pH; 3) the spatial and temporal trends associated with nutrient loads; and 4) the sources of nutrient loads during critical times of the year.

The Association has contracted with ENSR to assist with model development and manipulation. ENSR was tasked with constructing a series of models, both watershed-based and in-reservoir. Basic modeling tasks that were scoped include the following:

1. Review existing technical data/reports and provide recommendations to Association stakeholders on selection of model(s) and process/schedule for model development.
2. Construct and calibrate water quality models to simulate current conditions.
3. Manipulate model(s) to predict outcome of various water quality improvement strategies within the watershed.
4. Provide output information that will allow the Association to refine water quality targets into numeric targets.
5. Determine expected/needed pollutant loading reductions to achieve pH standards.
6. Predict water clarity, chl-a, nutrient concentrations, and other relevant eutrophication parameters and their relationships to pH levels.
7. Provide technical information to assist CDPHE with nutrient standard development.
8. Utilize model(s) to determine load allocations within watershed that will be implemented to meet TMDL requirements and nutrient standards.

As of October 2008, scope tasks 1, 2, 5, and 6 have been completed.

5.2.2.1 Watershed Modeling

ENSR used the Soil and Water Assessment Tool (SWAT) for the first step in modeling. The SWAT model is a continuation of nearly 30 years of modeling efforts conducted by the USDA Agricultural Research Service (ARS). SWAT has gained international acceptance as a robust interdisciplinary watershed modeling tool. The model has been adopted as part of the EPA

Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) software package and is being used by many federal and state agencies (Gassman et al. 2007).

SWAT is a basin□scale, continuous□time model that operates on a daily time step and is designed to predict the impact of management on water, sediment, and agricultural chemical yields in watersheds. The model is physically based, computationally efficient, and capable of continuous simulation over long time periods. Major model components include weather, hydrology, soil temperature and properties, plant growth, nutrients, pesticides, bacteria and pathogens, and land management. In SWAT, a watershed is divided into multiple sub-watersheds, which are then further subdivided into hydrologic response units (HRU's) that consist of homogeneous land use, management, and soil characteristics. The HRU's represent percentages of the sub-watershed area and are not identified spatially within a SWAT simulation. Alternatively, a watershed can be subdivided into only sub-watersheds that are characterized by dominant land use, soil type, and management (Gassman et al. 2007).

ENSR has completed the process of SWAT model construction and calibration for specific application in the Barr/Milton watershed. The SWAT model developed for the watershed simulations has performed well, following a few computer code modifications to provide a better representation of the Barr/Milton watershed than would otherwise have been possible. The model has been demonstrated by ENSR to effectively predict water volumes in Barr and Milton and water quality at their inlets (i.e., the O'Brian Ditch just upstream of Barr Lake and the Platte Valley Canal just upstream of Milton Reservoir).

5.2.2.2 In-Lake Modeling

SWAT includes an in-lake component that, combined with simple empirical models, provided preliminary in-lake results. An issue for the Barr/Milton watershed is how well watershed events determine in-lake water quality at Barr and Milton and how much need exists for a separate in-lake model to address in-lake processes that may be important to in-lake water quality variation and resultant algal blooms and high pH. ENSR recommended that the EPA's Water Quality Analysis Simulation Program (WASP) model be used to simulate water quality in both Barr and Milton. The WASP model was chosen based on the following (ENSR 2008a):

- WASP is a public domain model with a long history of development and application and has excellent technical support available.
- WASP has been modified to provide a very user-friendly Windows® interface.
- WASP uses a hydrodynamic interface file that can easily be developed from the SWAT model output for a nearly seamless transition from the watershed modeling to the lake modeling.
- WASP is a fully dynamic, one-dimensional model that simulates the complex processes associated with eutrophication without over-complication of the hydrodynamics.

5.2.2.3 Model Manipulations

The models will be initially used to determine allowable nutrient loading that achieves and maintains the current pH standard of 6.5 to 9.0 for both reservoirs. Once the allowable loading is determined, preliminary work on the pH TMDL will be initiated.

ENSR will apply the combined watershed/in-lake models to existing conditions and to several scenarios representing expected changes in watershed features (e.g., increased urbanization, reallocation of water) or management approaches (e.g., point source reductions, implementation of BMPs, modifications in reservoir management). These scenarios will form the basis for explaining complete model function and constraints and for selecting and modifying additional scenarios for testing.

ENSR will run the models to determine the expected in-lake conditions associated with a variety of "what if" scenarios representing: 1) the limits of management (e.g., maximum practical BMPs); 2) potential "natural" conditions (e.g., no human development); 3) nutrient levels that result in acceptably low bloom frequency and any related pH compliance, water clarity, and chl-a levels that support desired uses; and 4) other alternatives linked to desired conditions. These scenarios will define water quality based on expected "background" or "optimal" conditions, although such conditions may not necessarily be readily achievable. These limits will be considered by the stakeholders when evaluating and refining management scenarios for further model testing. Model outputs will also form the basis for evaluating the feasibility of achieving water quality targets and eventually for demonstrating an effective load allocation strategy based upon watershed management techniques.

5.3 QUANTIFY POLLUTANT LOADS AND LOAD REDUCTIONS

Current pollutant loading has been quantified in the nutrient balances provided in the Assessments (AMEC 2008a,b). Necessary nutrient load reductions required to meet in-lake pH standards will be determined through application of the model.

5.3.1 Observations

The Assessments provide some general analysis of in-lake chemistry that is useful in understanding the larger picture of lake nutrient dynamics. (Material presented in subsection 5.3.1 is either quoted directly or paraphrased from the AMEC reports (2008a,b) unless otherwise noted.)

5.3.1.1 Barr Lake

The Barr Lake Reservoir Assessment concludes that Barr is a highly-enriched, hypereutrophic reservoir with high nutrient concentrations, low clarity, DO depletions at the bottom of the reservoir, high levels of chl-a, and high pH resulting from photosynthetically active algae (AMEC 2008a). The parameters of pH, chl-a, and Secchi depth exhibit annual and seasonal trends (Figure 5-2).

The upper standard for pH (9.0) was exceeded every year for the period analyzed (2002 to 2005), usually beginning and peaking in July-August, with exceedences occurring into the fall and early winter. Secchi depth averaged 1.7 meters for the same period with a range of 0.4 to 6.0 meters. The mean annual concentration of chl-a was 54 ug/l with a mean summer (June to September) concentration of 78 ug/l. The maximum recorded for the period was over 300 ug/l in August of 2002 (AMEC 2008a).

Extremely high concentrations of P create an N-limited condition for most of the growing season. Average TP for Barr from 2002 to 2005 was 652 □g/L, with a maximum concentration higher than 1,700 □g/L (Figure 5-3). P is present primarily in the bioavailable (orthophosphate) form and concentrations are generally highest in winter (AMEC 2008a).

Average TN from 2002 to 2005 was 4,800 ug/l with a maximum concentration of 15,000 ug/l (Figure 5-3). As with P, the N species (total, nitrite/nitrate, ammonia) concentrations increase in the winter (AMEC 2008a).

Biological analysis identifies distinct patterns in the water quality and biological data. The type of algae growing in Barr changes with the N to P ratio (N:P). When the N:P ratio increases (i.e., P is low), diatoms dominate. When the N:P ratio decreases (i.e., P is high), blue-green algae dominate. In November, there is an increase in nutrient loading to Barr from the Burlington, corresponding to a decrease in the N:P ratio. In the early summer, the N:P ratio again decreases slightly due to internal loading and biological uptake. Beginning in early July, the reservoir exceeds pH 9.0, simultaneous with the *Microcystis* (blue-green algae species) bloom. *Aphanizomenon*, a nitrogen-fixing blue-green algae, increases during September as inorganic nitrogen concentrations are very low (AMEC 2008a).

Lewis (2008a) offers additional explanation regarding changes in algal abundance from season to season. The dominance of diatoms in the cool months reflects low stability of the water column during the cool season. Diatoms are favored by such conditions, as they have high sinking rates that work against them when the water column is stable, and because they are adapted well to intermittent light exposure, which is characteristic of a moving water column. The blue-green algae, which grow more slowly and require more light, are suppressed until the water column becomes more stable, during the warm months. Both *Microcystis* and *Aphanozomenon* have gas pseudovacuoles that allow them to control buoyancy and remain near the surface when the water is calm, thus enhancing extended solar exposure (Lewis 2008a).

5.3.1.2 Milton Reservoir

The Milton Reservoir Assessment concludes that, similar to Barr, Milton is a highly-enriched, eutrophic to hypereutrophic reservoir with low clarity, DO depletions at the bottom of the reservoir, high levels of chl-a, and high pH resulting from photosynthetically active algae. Similar to Barr, the parameters of pH, chl-a, and Secchi depth exhibit annual and seasonal patterns (Figure 5-4) (AMEC 2008b).

Values for pH peak in summer around July of each year. The upper standard for pH (9.0) was exceeded every year for the period analyzed (2002 to 2005). Secchi depth averaged 2.1 meters with a range of 0.3 to 6.6 meters. The mean concentration of chl-a was 33.5 ug/l with a mean summer (June to September) concentration of 27 ug/l. The maximum recorded for the period was nearly 350 ug/l in October of 2005 (AMEC 2008b). Milton shows exceptionally long intervals of very low chl-a, attributing this to very low stability of layering in the reservoir, which causes light deprivation for algae (Lewis 2008b).

Average TP for Milton from 2002 to 2005 was 538 □g/L, with a maximum concentration of 1,230 □g/L (Figure 5-5). TP concentrations tend to peak in July and August. P is present primarily in the bioavailable (orthophosphate) form. Average TN for the period was 3,329 ug/l with a maximum of 7,130 ug/l (Figure 5-5). Concentrations of TN are typically higher in the spring (AMEC 2008b).

As in Barr, blue-green algae (*Microcystis, Aphanizomenon and Aphanocapsa*) dominate in Milton and influence reservoir pH. N-limiting conditions occur for much of the growing season.

5.3.1.3 Comparison of Barr and Milton to Other Colorado Urban and Plains Reservoirs

Both Assessments compare water quality variables for Barr and Milton with those of other urban and plains reservoirs along the Front Range, including pH, TP, TN, chl-a, and Secchi depth (Figure 5-6). The results are variable, but in general reservoirs occurring upstream of the Barr/Milton Watershed (i.e., the urban municipal water supply and/or recreation reservoirs) exhibit better water quality than the reservoirs that occur within the watershed (i.e., Barr, Milton, and Horse Creek reservoirs). Reservoirs that occur downstream of the watershed (i.e., the plains, agricultural water supply reservoirs) are generally of a similar water quality to the reservoirs found within the watershed.

5.3.2 Pollutant Load Estimates

5.3.2.1 Barr Lake

The Barr Lake Assessment included a nutrient balance analysis, which was conducted over a 3-year period (irrigation years 2003 to 2005) for Barr (AMEC 2008a). The Barr nutrient balance analysis found that P and N enter the reservoir via the Burlington canal, atmospheric deposition, internal loading, subsurface inflow, and runoff from the direct watershed. N can also be introduced to the reservoir via fixation by cyanobacteria (blue-green algae) and lost via denitrification. Nutrients leave the reservoir via the two outlets (east and west outfalls) and reservoir seepage.

General N and P sources that have been preliminarily identified within the watershed and that includes direct discharges from permitted wastewater treatment facilities (e.g., Metro, L/E, and Centennial) and municipal storm sewers (e.g., Denver, Aurora, Lakewood, Denver International Airport), and nonpermitted stormwater runoff from agriculture, interstates and highways, the Rocky Mountain Arsenal, and other yet unidentified sources.

Phosphorus

The total annual loading of P is about 157,000 lbs/yr, which translates to about 9.8 g P/m2-yr (Table 5-1 and Figure 5-7). For lakes with a mean depth similar to that of Barr, a permissible loading rate of 0.07 g P/m2-yr is suggested, while a rate of 0.13 g P/m2-yr and above is referred to as excessive (Vollenweider 1968). For the incoming P, 91% was from the Burlington-O'Brian Canal, <1 % was from precipitation, 3% from seepage, and the remaining 6% was from internal loading. The total annual mass of P leaving Barr is estimated at about 61,900 lbs/yr (Table 5-2). This means that Barr is a phosphorus sink (Figure 5-8).

It is important to know how much P leaves the reservoir and how much stays within (Table 5-3). Reservoir retention is the unaccounted for mass divided by the sum of the initial mass stored in the reservoir and the total inflow. The reservoir retained an average of 52% of the inflowing P. P retention occurs in reservoirs due to several factors including: 1) sedimentation of inflow P; 2) adsorption of P with inorganic compounds; and 3) sedimentation of P with algae and other organic matter (Wetzel 2001). The latter two mechanisms are most likely important for Barr Lake.

Nitrogen

The N balance was computed similarly to the P balance. The total annual loading of N is about 1,180,000 lbs/yr, which translates to about 80 g N/m2-yr (Table 5-4 and Figure 5-7). For lakes with a mean depth similar to that of Barr, a permissible loading rate of 1.0 g N/m2-yr is suggested while a rate of 2.0 g N/m2-yr and above is referred to as excessive (Vollenweider, 1968). For the incoming N, 96% was from the Burlington-O'Brian Canal, 1% was from precipitation, 3% from inflow seepage, and <1% was from internal loading. The mass of N leaving the reservoir was estimated at 423,700 lbs/yr (Table 5-5 and Figure 5-8).

Similar to P, it is important to understand the balance of N, where it comes from, and where it goes (Table 5-6). The reservoir retained an average of 59% of the inflowing N plus that initially stored. N retention is somewhat higher than P retention. N retention occurs in reservoirs due to biological uptake and deposition of particulate organic N (Sprague 2002). N retention is suspiciously high, possibly because of denitrification (Lewis 2008a).

5.3.2.2 Milton Reservoir

The Milton Reservoir Assessment included a nutrient balance analysis, which was conducted over a 2-year period (irrigation years 2003 to 2004) for Milton (AMEC 2008b). The Milton nutrient balance analysis found that P and N enter the reservoir via the Platte Valley Canal, the Beebe Canal, subsurface seepage, precipitation, internal loading from the bottom sediments, and direct runoff from the watershed. N can also be introduced to the reservoir via fixation by cyanobacteria (blue-green algae). Nutrients leave the reservoir via outlet releases (Gilmore Canal) and seepage. N can also be lost due to denitrification.

General N and P sources that have been preliminarily identified within the contributing watershed include direct discharges from permitted wastewater treatment facilities (e.g., South Adams, Lochbuie, and Brighton) and non-permitted stormwater runoff from agriculture, roads and highways, open pit gravel mining, residential development, and other yet unidentified sources.

Phosphorus

The total annual loading of P is about 89,300 lbs/yr, which translates to about 7.7 g P/m2-yr (Table 5-7 and Figure 5-9). For lakes with a mean depth similar to that of Milton, a permissible loading rate of 0.07 g P/m2-yr is suggested, while a rate of 0.13 g P/m2-yr and above is referred to as excessive (Vollenweider 1968). For the incoming P, 71% was from the Platte Valley Canal, <1 % was from precipitation, 28% from the Beebe Canal and subsurface inflow, and the remaining 1% was from internal loading. The total annual mass of P leaving Milton is estimated at about 39,800 lbs/yr. This means that Milton is a phosphorus sink (Table 5-8 and Figure 5-10). Releases to the Gilmore Canal account for approximately 68% of P leaving Milton.

It is important to also know how much P leaves the reservoir and how much stays within, so that the entire balance can be explained (Table 5-9). The reservoir retained an average of 44% of the inflowing P plus that initially stored. The two most important factors influencing P retention in Milton are adsorption of P with inorganic compounds and sedimentation of P with algae and other organic matter.

Nitrogen (N)

The total annual loading of N is about 532,000 lbs/yr, which translates to about 36 g N/m2-yr (Table 5-10 and Figure 5-9). For lakes with a mean depth similar to that of Milton, a permissible loading rate of 1.0 g N/m2-yr is suggested while a rate of 2.0 g N/m2-yr and above is referred to as excessive (Vollenweider 1968). For the incoming N, 76% was from the Platte Valley Canal, 22% was from the Beebe Canal and subsurface inflow, 2% from precipitation, and <1% was from internal loading. The mass of N leaving the reservoir was estimated at 188,800 lbs/yr (Table 5-11 and Figure 5-10).

Similar to P, it is important to understand the balance of N, where it comes from, and where it goes (Table 5-12). Releases to the Gilmore Canal account for approximately 60% of P leaving Milton Reservoir. The reservoir retained an average of 53% of the inflowing N plus that initially stored. Lewis (2008b) suggested that denitrification, rather than algal uptake, may be responsible for much of the disappearance of nitrate, given the presence of high levels of ammonia.

5.3.3 Allowable Load Estimates

As required for the pH TMDL, a site-specific allowable load of nutrients will be calculated for both Barr and Milton. The allowable load will be an expression of the maximum mass of nutrients that can enter the reservoir over a specified period of time without exceeding the upper limit for pH of 9.0 units. Model outputs are being refined in order to develop these predictions. Initial calculations made by ENSR suggest that the allowable P load required to ensure pH compliance in Barr Lake is on the order of ~5% of the current load entering the Barr, and the allowable P load in Milton Reservoir is on the order of ~10% of the current load entering Milton (ENSR 2008b). These preliminary allowable P load estimates indicated that major P loading reductions are needed to lower pH in the reservoirs.

5.3.4 Estimated Needed Load Reductions (by Source and Type) and Priorities

Load reductions for both nitrogen and phosphorus are needed to improve the water quality in both Barr and Milton. Such load reductions might change the algae community by reducing blue-green algae and decreasing the pH below 9.0 from July to October. The ongoing modeling efforts for the reservoirs and watershed will address load reduction scenarios. The BMW Association recognizes the excessiveness of the current nutrient loading and the need to significantly reduce loads from all potential sources. Table 3-2 lists the estimated load inputs to the watershed by major dischargers which were included in the watershed model. Needed nutrient load reductions will be determined based on these measured and estimated load inputs using the watershed and in-reservoir models.

5.4 RECOMMENDED PH TMDL STRATEGY

The CDPHE-recommended TMDL strategy has eight components (listed below). The BMW Association intends to follow this process as closely as possible in developing this third-party pH TMDL. Development of the pH TMDL will be initiated by the Association once the ENSR modeling exercise is substantially completed.

1. **Identify Objectives**—Develop a pH TMDL and assist with the development of nutrient standards. Status: objective as stated is still appropriate.
2. **Develop Initial Numeric Targets**—Determine appropriate nutrient limits to protect all the classified uses and to achieve pH levels below 9.0, using a calibrated reservoir model. Status: to be completed as part of reservoir modeling process in 2008 and 2009.
3. **Assess Watershed Sources**—Identify and quantify nutrient sources in the watershed by type, magnitude, and location. Status: in progress.
4. **Link Watershed Sources to Lake Inputs**—Develop a tool to link the watershed sources to the inflows (loadings) into the reservoirs. Status: in progress with tracked development of a watershed model and in-reservoir model(s) in 2008.
5. **Investigate Feasibility/Determine Final Numeric Target**—Link the watershed model and river model with the reservoir models. This linked system will be used to run "what if" scenarios using the additional watershed information along with assumptions regarding specific feasible point and NPS controls and alternative water management strategies. This step will be used to refine numeric targets set initially and to determine total loading capacities. Status: in progress with tracked development of a watershed model and in-reservoir model(s) in 2008 and model runs in 2009.
6. **Perform Allocation between Sources**—Allocate the total loading capacity and the margin of safety between current and future sources. Status: 2010 once model runs have been completed to determine effect of and feasibility of pollutant reduction options.
7. **Develop Evaluation Plan**—Develop a monitoring plan specifically designed to determine if the TMDL is being attained and to support any revisions that may be needed in the future. Status: future work post-2010.
8. **Develop Implementation Plan**—Develop a plan for implementing specific tasks to reduce sources to within the agreed-upon allocations along with a schedule for implementation. Status: future work 2010.

The Technical Committee will oversee the development process starting in January of 2009. The PIP schedule then allows two years for the Association to develop a third-party pH TMDL. The current strategy by the Technical Committee is to write and develop as much of the pH TMDL as possible with existing documents (e.g., reservoir assessments, database reports, and this watershed plan). The remaining information will be acquired by further contracts with consultants. CDPHE and the WQCD will be invited and closely involved with the entire process of writing the third-party pH TMDL.

6 WATERSHED MANAGEMENT ACTION STRATEGY, POLICIES AND PROGRAMS

This section summarizes existing management strategies, policies, and programs in the watershed that contribute to the maintenance and/or improvement of water quality conditions in Barr and Milton. Including further suggestions listing proposed management strategies that will be considered when evaluating alternatives for meeting required load reductions for nutrients. This section ends by describing the process for evaluating and choosing the most effective nutrient control and reduction alternatives for inclusion in the pH TMDL.

6.1 EXISTING MANAGEMENT STRATEGIES

6.1.1 Growth and Development

The watershed encompasses multiple municipalities and six counties. Growth and development are managed independently by the individual planning jurisdictions. Most areas do fall within the DRCOG 208 planning agency area. The portion of Weld County encompassed within the BMW watershed falls within the jurisdiction of the NFRWQPA as the 208 planning agency.

Adopted by DRCOG in 2005 and with 2035 as the planning goal, the Metro Vision 2035 is the regional plan for future growth and development (DRCOG 2007). In addition to exploring future growth scenarios and management, the Metro Vision 2035 integrates previous plans, transportation, and current water quality management plans. Although each jurisdiction makes independent decisions in terms of zoning and development, the participating areas are encouraged to cooperate in the Metro Vision 2035 plan.

The 2007 Update of the Area-wide Water Quality Management Plan is the water quality-specific planning tool used by NFRWQPA. Growth and development planning in the NFRWQPA is left to the authority of the land use and wastewater management agencies.

In addition to comprehensive development planning between communities through DRCOG, UDFCD also aids in planning drainage infrastructure across multiple, jurisdictional boundaries. UDFCD works with jurisdictions within its boundaries and participates in preparing comprehensive Outfall Systems Plans for growing areas. Drainage master planning is a critical component for every watershed.

Local jurisdictions determine how an area develops. While comprehensive low-impact development is becoming more prevalent, there is currently no strict continuity from jurisdiction to jurisdiction to influence how properties are developed. At times, financial relevance, rather than the impact to the watershed or environment, is the ultimate determining factor in how an area is developed.

6.1.2 Existing Regulatory Strategies

Quality of water within the watershed is controlled through the State regulated NPDES permit system. The regulatory permit system is used to control point source discharges of pollutants. Voluntary programs are currently in use to control NPS discharges of pollutants.

Effluent standards for point source discharges are determined by the basic standards applicable for the assigned beneficial uses, and NPDES permits are written accordingly. Most of the water bodies in the watershed are classified, with a few exceptions, for these beneficial uses: Recreation Class 1a, Aquatic Life Warmwater 1 or 2, Water Supply, and Agriculture (Table 1-8).

Basic water quality standards for the classified uses as established per Regulation #31 (CDPHE 2008a) provide numeric standards for radioactive materials, organics, inorganics, metals, and biological and physical parameters. Narrative water quality standards also apply. Basin or site-specific water quality standards that would apply to the water bodies found in the watershed are provided in Regulation #38 (CDPHE 1981, 2008b).

There have been no specific control regulations promulgated for the Barr/Milton watershed to date.

6.1.3 Existing Point Source Strategies

6.1.3.1 Wastewater

Wastewater management is designed to reduce the influent concentration of nutrients to the treatment plant, specifically nitrogen. There are nine wastewater treatment facilities in the watershed: of these, the five largest are Metro, L/E, SACWSD, Centennial, and Aurora. The remaining four facilities (Lochbuie, Hudson, Ft. Lupton, and Brighton) are relatively small in volume of effluent discharged daily (< 2 mgd). Wastewater treatment facilities are closely regulated through the NPDES program and conduct extensive effluent and downstream monitoring.

Nutrient reduction occurs through: 1) pretreatment programs, 2) physical, biological, and chemical treatment processes at the plant, and 3) proper management of biosolids. Treatment for nitrogenous compounds (e.g., total nitrogen, nitrate, and nitrite) is dictated by NPDES permit limits. Within the watershed, effluent limits for nitrogenous compounds are generally limited by in-stream standards of 10 mg/l nitrate (drinking water related standard) and site specific, calculated total ammonia concentrations (aquatic-life use protection). The discharge of phosphorus compounds is not currently addressed or limited in any way through NPDES permits, although phosphorus reduction may be incidental at certain treatment facilities through the treatment process. As of October 2008, the nine wastewater treatment facilities referenced here are not currently known to be equipped with specific phosphorus treatment capabilities.

Pretreatment—The USEPA administers the National Pretreatment Program under the General Pretreatment Regulations, first adopted in 1978. These regulations, amended in 1981 and again in 1988, set forth specific requirements that both wastewater treatment facilities and industries must comply with to reduce industrial pollutant discharges. The *General Pretreatment*

Regulations require that any wastewater treatment facility designed to treat over five million gallons a day of wastewater or receiving significant discharges from industrial sources, must develop a local pretreatment program that includes: 1) developing local limits for toxic and other pollutants as necessary to protect sewage treatment operations, 2) identifying all commercial and industrial dischargers that are significant industrial users, 3) issuing permits to all significant industrial users that require monitoring and reporting, 4) monitoring significant industrial user operations, discharges and reports to determine compliance with federal and local pretreatment standards and requirements, and 5) taking appropriate enforcement actions against industries found to be in violation of applicable requirements. Pretreatment programs can, but are not required, to include phosphorus in their list of pollutants to track and manage for. Metro started in 2008 to include phosphorus monitoring within their pretreatment program.

Treatment—Facilities with a capacity greater than 2,000 gallons/day are required to have a utility plan that documents their wastewater management strategy and the associated planning area. All utility plans must contain a defined set of minimum information (location, sizing, staging, service area, process system, effluent quality and financial arrangements). The primary goals for establishing the wastewater utility plans are to provide reasonable, feasible, and economical wastewater service to an area designated for urban development. A utility plan considers the water quality impact the treatment system will have on receiving waters and provides a strategy for meeting all applicable water quality standards and classifications, while quantifying the potential impact a discharger may have on other dischargers (Table 6-1).

Biosolids—The byproduct of removing nutrients and pollutants from wastewater is the generation of biosolids. Biosolids contain significant amounts of nutrients such as nitrogen, phosphorus, and potassium, as well as valuable micronutrients like zinc and iron. There are three main options in managing the use of biosolids: incinerate, take to a landfill, or land application. Since biosolids are rich in nutrients and organic matter, the best ecological use is land application. Biosolids can improve soil quality by improving waterholding capacity, structure development, and air and water transport. Proper use of biosolids can ultimately decrease topsoil erosion. The reuse of biosolids includes dryland farming, crop growing, nurseries, commercial landscapers, and soil amendment applications for forest fire areas. Proper land application is important to assure no negative impacts to local water bodies. There is no known biosolids application to any land within the BMW.

6.1.3.2 Industry

There are 14 active industries in the Barr/Milton watershed that have NPDES permits (Table 1-5). The major industries are oil refinery, coal-fire power plants, the Rocky Mountain Arsenal, and concrete producers. None of the industries are classified as having a high likelihood of contributing nutrients.

6.1.3.3 Permitted Stormwater

The Barr/Milton watershed includes both Phase I and Phase II permitted cities within its boundaries. The Phase I municipalities of Denver, Aurora, and Lakewood have been permitted since 1990 and are required to implement water quality BMPs as a part of their permits. These include:

- Storm water quality monitoring;
- Mapping of storm drain network;
- Outfall screening;
- Removal of illicit discharges;
- Source identification;
- Structural and source control measures to reduce pollutants;
- Erosion/sediment control programs;
- Demonstration of legal authority to control stormwater discharges; and
- Fiscal analysis.

No firm benchmarks for program performance are established. At this time there are no numeric standards applied to the end of the pipe in any of the state-issued Phase I MS4 permits.

Phase II municipalities and counties were permitted in 2003 and are in the process of implementing the six minimum control measures:

- Public education/outreach;
- Public participation/involvement;
- Illicit discharge detection;
- Construction site runoff control;
- Post-construction runoff control; and
- Pollution prevention.

Other secondary environmental programs promoted in urban areas that reduce downstream water quality impacts include: minimizing transportation impacts (commuter light rail and bussing), minimizing development impacts (Leadership in Energy and Environmental Design building, green rooftops, pervious paving, and watering with reuse water), and minimizing community impacts (recycling programs, LeafDrop and Treecycling programs, sustainable living programs, storm drain labeling, and education campaigns for picking up pet waste and lawn fertilization techniques).

Though much of the urban area in the watershed is managed by MS4 permits, other populated areas have not been required to obtain stormwater permits. Public education in nearby communities may provide some information to citizens who live or work in municipalities implementing stormwater programs.

DRCOG encourages that stormwater discharge monitoring be conducted on a regional basis with regional water quality assessments made on the effectiveness of management programs. DRCOG, in coordination with UDFCD, have established three major recommended objectives for stormwater discharge permitting programs:

1. Reduce pollutant loadings in municipal storm sewer discharges to the *maximum extent practicable*;
2. Eliminate illicit wastewater connections, illegal discharges and non-exempt non- stormwater discharges to municipal storm sewer systems; and

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

The structural and nonstructural BMPs listed in the UDFCD's *Criteria Manual Volume 3* are applicable to and widely used within the metropolitan region.

6.1.4 Existing NPS Strategies

There are individual practices and policies in place that are designed to minimize NPS, however, as of the time of this writing, there is no clearinghouse that inventories all the existing strategies. The BMW Association, as part of its watershed plan implementation, will document and track the success of specific strategies as they are identified.

The second largest land cover in the BMW is classified as "cultivated crops" (Figure 1-10). Along with crop production, dairy and poultry operations are also important when it comes to managing rural NPS pollution. Nonpoint source impacts from the farming community are less known and managed than in the urban setting. There are many educational opportunities for farmers to learn about minimizing runoff impacts from their fields, and concentrated animal feeding operations (CAFOs) are required to develop nutrient management plans according to USEPA guidelines. The challenges for existing nonpoint source strategies for agriculture are:

- lack of water quality data on ditch returns and the understanding of the actual impacts to water quality;
- having a good network of agencies, water rights owners, and farmers that can be reached with information and educational material; and
- lack of information on what management practices are being implemented and where they are located.

6.2 WATERSHED APPROACH FOR LOAD REDUCTION STRATEGIES

The watershed approach to water quality management involves a coordinated, environmental management effort to include both public and private sectors to address the highest priority problems within a watershed (USEPA 1996). By following a watershed approach, a management group may consider the complete watershed, just critical areas, or a combination of these approaches. In the case of the Barr/Milton watershed, the appropriate level for applying management strategies will be identified following water quality model analysis and evaluation of applicable management measures.

The BMW Association has developed current overarching concepts of applying a watershed approach particular to the Barr/Milton watershed. The Barr/Milton watershed is mainly dominated by urban use in the upper section and agricultural use in the lower section, with suburban sprawl marking the transition between these areas. Management strategies will need to address these diverse, and often opposing, land use regimes. The large population in the watershed also influences management strategies. Watershed management may need to be conducted at a sub-watershed scale due to the size, population, and complexity of the watershed's uses and involved local, state, and federal regulatory agencies.

As established previously in this document, N and P are the parameters of concern as they relate to controlling excessive cultural eutrophication in the reservoirs. Sources of nutrients must be reduced significantly to meet state water quality standards (i.e., pH) and to protect beneficial uses. Nutrients are contributed by a variety of sources, all of which must be addressed to some degree in order to meet water quality goals. Therein, both the problems and solutions are watershed-wide.

In order to achieve success on a watershed scale, nutrient source reduction in the watershed must be evaluated from a variety of angles, including:

- Point source reduction through regulatory controls;
- Nonpoint source reduction through regulatory controls (as possible) and voluntary processes; and
- Treatment of in-lake sources.

A number of management strategies exist that have the potential to, in combination, address the pending water quality issues. Those identified thus far are described in the following section. The Association has outlined a process for continued identification and technical evaluation of potential water quality management strategies that will occur as part of the water quality modeling exercise. Those alternatives that have technical merit will be further examined in terms of cost/benefit and implementation feasibility. Output from the analyses will be prioritized and formulated into a plan for implementation.

6.3 WATERSHED-APPROPRIATE POTENTIAL MANAGEMENT STRATEGIES

Since the BMW Association is currently in the preliminary stages of developing a pH TMDL, only a general description of potential practices and strategies is appropriate. Future updates to this Plan will specify applicable BMPs based on additional data, modeling results, and feasibility studies. Feasibility analysis of BMPs is planned as a final step of Phase 2 of the Barr/Milton four-phase project and is expected to begin in 2009 (Figure 1-4). Final selection and prioritization of strategies will occur following a thorough evaluation of all potentially applicable management practices.

6.3.1 Potential Growth and Development Strategies

Management action strategies for existing and future urbanized areas need to address impacts associated with old infrastructure as well as new and rapid development. Zoning laws, construction requirements, building permits, site inspections, and other development strategies need to be incorporating the prevention of water quality degradation.

Watershed management and land use choices should be viewed by land use managers as interactive components in their efforts at water quality enhancement. Since regional land use development can influence regional water quality trends, land use management must be considered in devising a water quality management strategy for a watershed. Conversely, water quality must be considered in zoning and planning processes of local governments.

DRCOG suggested that model ordinances for erosion control and stormwater quality are part of any management program. Model ordinances are intended to provide guidance to communities that may want to adopt such ordinances, or update their existing ones. Model ordinances have been developed by both DRCOG and UDFCD in concert with many local municipalities in the Denver region. Both of these model ordinances are applicable to urban areas throughout the DRCOG region. These ordinances should be reviewed and evaluated as to their ability in contributing to nutrient source control in the watershed. These ordinances, or some modification thereof, could be promoted for use in the watershed.

The BMW Association will continue its dialog with DRCOG and NFRWQPA as the 208 water quality planning agencies that cover the watershed area. It will also continue its work with the local land planning agencies that have jurisdiction over development in the area.

6.3.2 Potential Regulatory Strategies

The pH TMDL will contain an allowable load that represents the maximum loading possible before the pH standard is exceeded. This allowable load will likely be expressed in terms of nutrients. Once the pH TMDL is finalized, all NPDES permits that authorize discharges within the watershed will be reviewed (generally upon permit renewal that occurs on a 5-year cycle) and be modified as necessary by the WQCD such that load allocations to Barr and Milton will not be exceeded. Likely modifications to NPDES permits will be restrictions on P and N concentrations discharged at the end of pipe. These restrictions could affect wastewater, industrial, and stormwater point sources.

Other sources of nutrients contributed by unpermitted stormwater discharges and nonpoint sources may be determined through the modeling process to be of consequence. If these contributions are determined to be significant, it may be effective to consider implementation of a watershed-based control regulation, promulgated through the WQCC. Development of a control regulation, similar to those in effect for the Cherry Creek, Chatfield, Bear Creek, and Dillon watersheds, allow for the control and enforcement of water quality discharges stemming from all sources, including nonpoint.

6.3.3 Potential Point Source Strategies

Wastewater and industrial point sources may need to upgrade or install new facilities specific to nutrient treatment. Most all entities have or are in the process of upgrading their facilities for nitrogen treatment in order to meet in-stream nitrate and ammonia standards. Many have also anticipated upgrades to comply with in-stream and in-lake nutrient standards as required by USEPA and scheduled for adoption by the WQCC in 2010. Wastewater treatment plants that install partial or complete tertiary treatment will clearly benefit Barr and Milton. It is not yet clear if additional treatment (i.e., beyond that required to meet state in-stream and/or in-lake nutrient standards) will be required to comply with the BMW pH TMDL.

Wastewater facility upgrades alone are initially projected to be in the hundreds of millions dollar range. Besides the social cost reflected in increased utility rates, there is a significant environmental cost that needs to be considered. It will take considerable energy to upgrade point source treatments, possibly leading to more air pollution and more demand for non-renewable energy sources. Economies of scale will also play a large part in determining where it is economically feasible to install upgrades. Smaller treatment facilities may find it cost prohibitive to install required upgrades to meet treatment standards. Instead, it may make economic sense to pay for "nutrient credit offsets", whereby a regional facility is paid to provide an additional increment of nutrient treatment to offset that discharged at another facility without that treatment capacity.

6.3.4 Potential Permitted Stormwater Management Strategies

All of the individual MS4 stormwater management agencies have established practices that are implemented pursuant to their NPDES permits (Table 1-5). The MS4 program is arguably still in its early phases. There has been much learned about the efficacy of a number of management practices, thus providing opportunities for improving and upgrading those practices in place now as well as those required in the future. As described earlier, it is possible that additional controls will be written into these permits by the WQCD once the pH TMDL allowable load is established.

DRCOG has recognized the need for a more focused effort related to NPS controls in the region (DRCOG 2006). DRCOG suggests the following priorities (these apply to both permitted stormwater and unpermitted nonpoint):

1. Education of the general public in urban centers through source control or preventative programs which can include, but are not limited to, the following: use and disposal of household waste products; application of fertilizers, pesticides, and insecticides; landscape design and effective uses of vegetation to reduce small lot erosion; construction-related erosion control; and other urban runoff pollution prevention activities.
2. Education of the workforce related to NPS control and prevention programs which can include, but are not limited to, the following: develop BMP training programs, dissemination materials, classroom curriculum, and other teaching aids; develop BMP guidance documentation; landscape design and effective uses of vegetation to reduce construction related erosion; other construction-related erosion control and prevention programs.
3. Education of local governments and state decision makers in urban centers related to NPS problems with an emphasis on control and prevention programs which can include, but are not limited to, the following: regulatory programs directed at erosion control, zoning or other special regulations or ordinances; planning level identification of available control and prevention long-term and near term alternatives and cost-effectiveness of alternatives; and urban design and development prevention programs.
4. Demonstration and evaluation of BMP control and prevention practices and structures, including stormwater practices or structures, related to urban development or construction activities.

Three of the four priorities suggested by DRCOG involve education. With close to 70% of the population of Colorado living within the watershed, a public education campaign is important. If all 2.7 million people could reduce their impacts by a small amount, collectively it could make a major difference in the Barr/Milton watershed. A successful way to change people's behaviors is through community-based social marketing. It is a way to reduce the barriers and improve the benefits by using a community approach.

EPA has funded a series of studies related to stormwater source control and management that were conducted by the Center for Watershed Protection. Relevant publications include:

- *Illicit Discharge Detection and Elimination: A Guidance Manuel for Program Development and Technical Assessments* (2004)
- *Pollution Source Control Practices* (2005)
- *Urban Stormwater Retrofit Practices Manuel* (2007)
- *Municipal Pollution Prevention/Good Housekeeping Practices* (2008)

These references should be reviewed and their suggested practices evaluated for applicability to conditions in the Barr/Milton watershed. It is possible that new tools and practices exist beyond those currently integrated into MS4 permits and local/regional water quality management plans.

6.3.5 Potential Nonpoint Source Management Strategies

Agricultural pollution prevention practices are perhaps one of the more important strategies to focus on in the northern half of the watershed. Collectively, a more careful approach to how agricultural lands are managed can make a major difference, especially for Milton.

Agriculture BMPs can be grouped according to their functions. Suggested categories include the following (USEPA 1993):

- Managing sedimentation: measures to control the volume and flow rate of surface water runoff, keep the soil in place, and reduce soil transport.
- Managing nutrients: measures to help to keep the nutrients in the soil, minimizing their movement into water bodies.
- Managing pesticides: measures to reduce non-point source contamination from pesticides, by helping limiting pesticide use and managing its application.
- Managing confined animal facility: measures to reduce or limit the discharge from confined animal facilities.
- Managing livestock grazing: measures to reduce impacts of grazing on water quality.
- Managing irrigation: measures to help farmers to improve water use efficiency.

Those practices found to be most effective for managing nutrients in an example watershed in the Chesapeake Bay region include (USEPA 1993):

- Permanent vegetative cover;
- Animal waste management systems;
- Strip cropping systems;
- Terrace systems;
- Grazing land protection systems;
- Cropland protection systems;
- Conservation tillage systems;

- Tree planting; and
- Fertilizer management.

While there are a number of potential strategies for dealing with NPS control related to agricultural lands, the Association currently has minimal connection with or support from this stakeholder sector. Before embarking on solutions, it will be necessary to develop relationships with the Colorado Department of Agriculture, the Soil Conservation Districts, Colorado Farm Bureau, and other entities that represent agricultural interests in the watershed. These entities have various focuses, affiliations, and technical abilities and together should be able to assist with: 1) the generation of baseline data (e.g., how farmers in the watershed manage their fields, animals, and manure) to assess impacts, 2) identification and prioritization of effective solutions, 3) dissemination of information to affected parties, and 4) technical, on the ground implementation assistance.

6.3.6 Potential Regional Treatment Strategies

Consistent with a watershed approach to problem solving, there are a number of treatment-based strategies for reducing nutrient loading. These potential strategies are detailed within this section since nutrient problems often occur on a regional scale, crossing political boundaries from their point of origin to locations further downstream in different jurisdictions. In order to be effectively implemented, these strategies will necessitate the support of a number of entities, particularly those involved with the nutrient source, transport, accumulation and treatment.

Regional Stormwater Retention/Detention Basins—Capturing and controlling the movement of nutrients within the watershed is a method for alleviating downstream reservoir eutrophication. There may be concern with increased evaporation from these facilities, posing a water rights issue, thus the design and location of potential facilities need to be carefully considered. Potential location sites for a regional facility exist along the Burlington Canal near the junctions with 1st, 2nd, and 3rd Creeks, along the Beebe Draw between Barr and Milton, and along the Platte Valley Canal.

Regional Wetland Treatment Basins—Constructed wetlands are routinely used to capture and treat nutrients using chemical, physical, and biological processes. The Center for Watershed Protection has recently published *The Next Generation of Stormwater Wetlands* that details the most recent advancements in designs for optimal function (2008). Proper sizing is critical, and land availability as well as consumptive use issues will need to be addressed. Constructed wetlands are currently being used for passive water quality treatment purposes on the Beebe Draw between Barr and Milton. Wetland construction opportunities are extensive along the Beebe Draw.

In-Lake Modifications—There are a handful of tested in-lake treatment practices that could significantly benefit water quality. Aeration/destratification systems and alum treatments are two possible examples for Barr and Milton. In- lake modifications can produce immediate results due to their proximity. However, in-lake modifications may lead to expensive, short-term fixes that only address the symptoms and not the actual problem. Annual costs may be relatively inexpensive compared to other watershed projects but the long term costs may end up being just as expensive.

Reservoir Management Adjustments—Adjustments in the timing of inflows from the South Platte River and/or changes in the volume of water delivered from Metro could result in a significant difference in water quality. Reservoir management changes took place after 1965 when the Metro discharge point was relocated from upstream to downstream of the Burlington headgate. Historical data shows that significantly less direct wastewater entered the Burlington Ditch, and consequently Barr Lake, after 1965 as shown on Figure 6-1 (Metro 2008 and US Department of Health, Education, and Welfare 1965). This water quality improvement suggests that, by relying more on runoff from the South Platte River, rather than wastewater effluent, to fill Barr, water quality improvements may occur in a short amount of time. Strict water rights laws based on Colorado's prior appropriations doctrine represent constraints to this alternative. Creativity and collaboration within the established system of water rights and transfers will be needed to make this practice feasible.

6.4 COST-BENEFIT ANALYSIS

In order to evaluate the feasibility of applying specific water quality BMPs in the watershed, the BMW Association will evaluate the projected cost-benefit ratio of each potential BMP. This cost-benefit analysis will ensure that economically reasonable management measures will be applied in the watershed. As management strategies are implemented, their successes are evaluated, and as the cost of implementation changes with time, the cost-benefit analysis may need to be revisited over the multi-year course of the project.

6.4.1 Funding Options

The BMW Association will draw funding from both internal and external sources for developing and implementing the pH TMDL management strategies. Internal funding will be from general membership dues. External funding opportunities are currently being explored as part of the development of an organizational financial sustainability plan. More specific funding details will be provided as

6.4.2 Benefits

The BMW Association recognizes the uncertainty inherent in predicting water quality improvements and other benefits of proposed management strategies. Benefits of implementation measures will be estimated based on best-available science, engineering, and social information. In addition to contaminant load reductions, less-tangible benefits including increased usability, aesthetic improvements, and other positive changes will be considered when conducting cost-benefit analyses.

6.5 PROCESS FOR SELECTING MANAGEMENT STRATEGIES

6.5.1 Preferred/Prioritized Strategies and Programs

Following watershed modeling and potential BMW evaluation and comparison, the BMW Association will identify preferred management strategies as those that provide the greatest water quality improvement, are cost-effective, have scientific/engineering integrity, and are accepted by the public, stakeholders, and regulatory partners. These preferred strategies will then be prioritized for implementation according to time, cost, and regulatory constraints.

The BMW Association recognizes the dynamic nature of the complex hydrologic and ecologic systems, expanding database, and developing science driving water quality issues and solutions in the watershed; therefore, the organization notes that management priorities may change over the course of the project, in particular following the water quality modeling phase. Prioritization of management prescriptions will consider the magnitude of impact per pollutant, distance from the reservoirs, costs to implement, overall feasibility, time frame, and available technology. A prioritized list of programs and management strategies will be developed to . The BMW Association will be responsible for facilitating modifications, updates, and watershed plan implementation while individual stakeholders will be responsible for on-the-ground program implementation. A fair and balanced management approach will be critical to the success of the program, which requires public understanding that structural strategies, regulatory changes, and broad-scale behavior adjustments all require time and financial support to complete.

7 IMPLEMENTATION

This Section builds upon the existing management strategies, policies, and programs presented in Section 7 by presenting the BMW Association's plans for development and implementation of additional watershed management strategies to successfully complete the pH TMDL process and improve water quality in Barr and Milton. This Plan plants the seed for water quality improvements; however, actual implementation of programs and policies is required to eventually lead to measurable results. The watershed planning process is iterative, holistic, and integrated. Implementation of this Plan will take time, cover many issues, and require diverse entities coming together with focus on a common purpose.

7.1 IMPLEMENTATION STRATEGY

7.1.1 Elements and Tools

Successful implementation of this Plan includes four key elements:

1. **Science**—Decisions based on relevant, scientifically-sound information
2. **Financial**—Successful administration of grant monies and financial support
3. **Consensus**—Continued progress as related to the overall goals and mission
4. **Service**—Continued participation of active stakeholders

All final decisions, action items, and outcomes must be objective and based on sound science. Social, political, and regulatory influences may guide management priorities; however, scientific knowledge must remain the foundation of decisions.

Fiscal responsibility and financial stability are also important to implementation. This means cost-benefit analysis, systematic hiring procedures, fundraising, and regular audits may be a part of each step in implementing this Plan.

Cooperation and consensus is strongly valued by the BMW Association members. To implement this Plan, the common values and goals stated within the Plan must continue to drive the organizations' decisions and activities. Differing points of view among stakeholders are expected during the management process. In order to successfully implement this Plan, stakeholders must come to consensus on the overall goals, values, and substantive conclusions of the group.

Finally, the level of active participation is vital to implementing any type of activity. Organizations and individuals must be willing to contribute financial, technical, and particular labor resources to the project. The BMW Association is the umbrella organization that only manages the planning efforts; actual implementation of individual tasks is the responsibility of each stakeholder.

Identification and incorporation of essential tools needed to complete each BMP, management strategy, and I/E project or program is also necessary. Important tools may include monitoring programs, modeling, GIS maps, risk assessments, TMDL allocations, BMPs, local government management strategies, and regulations at all levels. The BMW Association is currently in the process of developing many of these tools for use in future implementation and will continue to update this Plan with new tools and related information. It is also important to recognize the significance of having a dedicated individual serving as a Watershed Coordinator. By having a paid watershed coordinator, the success rate and likelihood of completing action items are much higher.

7.1.2 Schedule

This project involves a long-range implementation schedule. The following major tasks are highlighted below, as well as in Figure 1-4 and the PIP (BMW Association 2005c):

- Modeling: 2006 – 2008
- pH TMDL Development: 2009–2010
- Adopt Nutrient Criteria by the State: 2010
- TMDL Implementation: 2011–2022
- TMDL Evaluation: 2015–2022.

This schedule is likely to be refined as this Plan is updated each year. The near-term implementation schedule for 2007-2010 includes approximately five I/E products, annual Plan updates, annual implementation lists, calibrated models, load estimates to achieve pH standards, and regularly scheduled board and stakeholder meetings and events (Table 7-1).

Once the BMW Association develops a pH TMDL and an implementation plan, then more detailed schedules will be created.

7.2 TECHNICAL ASSISTANCE

Much of this Plan is technically based. The BMW Association draws upon technical resources from both within and outside of the organization. In-house technical resources will include all the field sampling and laboratory analysis, GIS work, all legal counseling, website design and maintenance, and the development and production of I/E materials.

The watershed coordinator will also assist with technical duties and provide guidance to and review of the mentioned in-kind technical services.

The BMW Association will also draw upon outside specialized technical services given the nature of the water quality issues at hand. The 6-year budget for Phases 2 and 3 incorporate the use of technical consultants in the field of limnology, water quality modeling, and engineering. Consultants are and will continue to be used in Phases 2 and 3 for database updates, water quality model development, pH TMDL development, BMP feasibility analyses, and cost/benefits analyses. Additional technical needs for implementation measures in Phase 4 will be addressed both internally and externally.

7.3 FINANCIAL

As described in the PIP, the BMW Association has identified funding sources and developed an operating budget and financial plan to guide the organization and implementation of activities for Phases 2 and 3 (Tables 7-2 and 7-3). The Association created a budget committee in 2007 and is currently in the process of developing a sustainable financial plan that projects 10 years beyond the current 319 grant. This plan is expected to be available in 2009. A financial plan specific to implementation of activities under Phase 4 will be developed following BMP selection/prioritization and concurrent with development of the pH TMDL implementation plan.

7.4 INFORMATION AND EDUCATION

The I/E committee identified several annual events and products as important action items that the group will participate in or produce (Table 6-4).

- I/E Events
  - South Platte Forum
  - Colorado Watershed Assembly
  - Local water festivals
  - Lake Appreciation Month
  - Colorado Cares Day
  - Secchi Dip-In
  - Annual watershed tour
- I/E Products
  - Newsletter
  - Website
  - Brochures
  - Poster/booth display
  - Watershed recognition awards
  - Press releases and contact lists

The I/E committee participants have also identified the following list of distinct target audiences for the above I/E products and events:

- General public and community (e.g., resident and non-resident)
- BMW Association active participants (i.e., Board and General Membership)
- "In-reach" audiences (e.g., DRCOG, SPCURE, and Colorado Watershed Assembly)
- Special interest groups (e.g., Business, Agriculture, Developers, and Recreation)
- Municipalities

- Property owners (e.g., land and water)
- Adjacent watershed organizations
- Environmental advocacy groups (e.g. Sierra Club, League of Women Voters, Friends of Barr Lake, Rocky Mt. Bird Observatory, and Colorado State Parks)
- Regulatory Agencies (i.e., state and federal)

The BMW Association will strive to reach all these target audiences through one or more of the I/E programs. The group will continue to expand their list of I/E action items to best support the ongoing activities of Phases 2 and 3 of this project.

7.4.1 Measures of Progress and Success

Monitoring progress is a crucial component of the implementation process and the overall success of this iterative, management cycle. The BMW Association understands the importance to having clearly defined and measurable milestones, both near-term and long-term. Phase 4 (pH TMDL implementation) will include many on-the-ground activities and create opportunities to measure success in the watershed and reservoirs.

There are four general types of environmental indicators that can be measured. The BMW Association will select indicators for each of these types and then measure the changes over time. These milestones will be updated and may change from year to year.

- Programmatic and Regulatory Actions
  - Policy changes from municipalities and agencies that match the policies and intent of the BMW Association
  - Number of new regulations promulgated that are consistent with watershed plan
  - Number of businesses and households that have altered behaviors to reduce pollutants
  - Percentage of "green certified" businesses
- Actions Likely to Impact Water Quality
  - Number of targeted facilities/properties that have implemented BMPs
  - Number of land uses demonstrating features that are consistent with Plan
  - Number of de-listed 303(d) waters
  - Number of watershed plan activities completed and on time
  - Number of new and expanded industrial and wastewater dischargers
- Ambient Water Quality Change
  - Length of time blue-green algae dominate
  - Length of time exceeding upper pH limit of 9.0
  - Length of hypolimnium anoxic periods
  - Number of pounds of nutrients reduced

- Changes in reservoir pH, water clarity, chl-a, nutrient levels, and/or DO levels
- Direct Effect on Humans, Wildlife, Habitat, and Economy
  - Linear miles of protected corridors
  - Acres of protected land and restored habitat
  - Frequency and extent of reservoir user complaints
  - Increase income from State park attendance
  - Number of new members and organizations

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8 ADAPTIVE WATERSHED MANAGEMENT

To best meet the water quality goals described in this Plan, the BMW Association will apply an adaptive management strategy to the Barr/Milton watershed. As described by the USEPA, adaptive management of a watershed involves continuously incorporating new information about the health of a watershed into the watershed management plan (USEPA 2000).

This management approach supports bringing about desired changes in inherently complex, uncertain, and changing systems such as the Barr/Milton watershed. When successfully applied, adaptive management strategies bring together scientific research, monitoring, practical management, and stakeholder collaboration in a way that provides the opportunity to find the best solutions for a watershed. Adaptive management requires development and evaluation of hypotheses about ecosystem structure and function, defined management goals and actions, analysis of ecosystem changes, and careful management decisions in response to ecosystem changes.

8.1 REVIEW PROGRESS FOR ADAPTIVE MANAGEMENT

Since formation in 2005, the BMW Association has been laying the groundwork for facilitating successful adaptive management of the Barr/Milton watershed. Management progress includes the following activities:

- Forming and incorporating a nonprofit stakeholder organization dedicated to supporting water quality improvements
- Conducting monthly meetings of the watershed stakeholders
- Identifying and updating water quality and organizational goals
- Securing funding for continued functioning of the organization, development of specific water quality targets, and implementation plans
- Facilitating the design of and updates to a water quality database
- Conducting reservoir assessments for both Barr and Milton
- Compiling a basic environmental characterization of the watershed, including preliminary GIS work
- Producing watershed and in-reservoir water quality models
- Identifying and testing (through the models) initial scenarios for load reduction required to meet pH standards
- Developing an active and expanding information/education program

The 2008 Plan represents the second compilation and review of adaptive management steps and updates the 2006 Plan. Future updates to the Plan will provide detailed information on important steps including development of a pH TMDL and nutrient targets, BMP selection and prioritization, and future management strategies for re-evaluation and re-implementation.

8.2 REPORTING PROCESSES

In order to ensure that stakeholders, regulatory agencies, and other partners are fully informed of BMW Association activities, the BMW Association will continue to report on project progress and plans using the following methods:

- Host monthly meetings
- Update the BMW website
- Send out e-mail announcements
- Distribute quarterly newsletters
- Publicize semi-annual 319 NPS grant progress reports to the CDPHE
- Conduct annual updates to this Plan
- Celebrate the annual General Membership Meeting and Cookout

By providing these multiple methods of communication, every effort will be made to ensure full stakeholder participation, review, and consensus support for all steps in the adaptive management process. Stakeholders are encouraged to provide constructive comments about any of the BMW Association activities.

8.3 TOTAL MAXIMUM DAILY LOAD IMPLEMENTATION

Similar to adaptive management, adaptive implementation refers to a process that allows for the evaluation of the adequacy of the TMDL in achieving water quality goals. Following pH TMDL development, water quality monitoring will be used to evaluate water quality improvements resulting from implementation of management practices in the Barr/Milton Watershed. Staged or phased implementation may be employed in the watershed. This approach enables managers to observe water quality improvements as they are achieved. This provides a measure of quality control and ensures that the most cost-effective practices are implemented first.

8.4 CONCERNS AND ISSUES

The BMW Association strives to incorporate and respond to all stakeholder and regulator comments, concerns, and ideas related to the watershed adaptive management strategies. As participants review new data, model outputs, stakeholder feedback, and implementation results, new concerns and issues are expected to arise.

The BMW Association intends to maintain its current open, consensus-driven operating policy to ensure that the adaptive watershed management strategies take into account new concerns as they arise and result in the best management decisions possible. All concerns and issues raised in this Plan, along with the resolutions and outcomes to address them, will be included in future documents.

8.4.1 Past Concerns and Issues

Several concerns and issues were identified in the 2006 Management Plan. Where possible, these issues were addressed as follows:

8.4.1.1 Finalize Reservoir Assessments

The 2006 draft assessments were completed in May 2008. The final versions address comments and concerns submitted by the stakeholders from review of the initial drafts. The assessments also reflect the incorporation of updated reservoir inflow and outflow information. Results of the assessments are being compared to output from the water quality models to ensure general concurrence. Data analysis and results reported in the assessments are discussed in Section 5.3.

8.4.1.2 Update BMW Water Quality Database

The water quality database was updated to include data collected for the period of 2003 through 2005. This data has been used by ENSR to construct and calibrate the watershed and in-reservoir water quality models. The Association has taken on the task of performing a review of the database for quality assurance and control.

8.4.2 2007 – 2008 Concerns and Issues

8.4.2.1 Outreach to Parties Potentially Affected by the pH TMDL

Concern has been raised that not all of the parties potentially affected by a future TMDL are participating in the stakeholder process. The I/E Committee has recommended consideration of a special Forum and/or an informational mailing, designed to target the missing entities. The Board and I/E Committee are currently evaluating the questions of who to target, when, through what medium, and with what material.

8.4.2.2 Data Sharing Network

A new effort has been initiated to voluntarily standardize and consolidate all water quality data collected in the State of Colorado. The DSN is being developed and advocated by a consortium of interested entities, including the WQCD. The Association is currently addressing the questions of: 1) when to perform another updated of the BMW database, and 2) whether all future updates should be done through the DSN.

8.4.2.3 Organization Legal Structure

The BMW Association is currently organized through and recognized by the state as a 501c(6) not for profit corporation. A concern has arisen as to whether this structure is eligible for a variety of supplemental funding grants. This issue is currently under investigation through the Budget Committee.

9 CONCLUSIONS

The BMW Association considers this Plan a living, dynamic document. The BMW Association will update the Plan as needed to provide current watershed and management information to stakeholders and regulators. The USEPA identifies nine key elements that must be included in a watershed plan in order to restore waters impaired by NPS pollution. These nine elements, their location in this Plan, and their current status are listed below:

1. Identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in your watershed-based plan.
   - Section – 5
   - Status – Ongoing and future (2006 – 2009)
2. An estimate of the load reductions expected for the management measures described in Part 6 (Watershed Management Action Strategy, Policies and Program) of your watershed plan.
   - Section – 5
   - Status – Ongoing and future (2006 – 2009)
3. A description of the BMPs and techniques (NPS management measures) that are expected to be implemented to achieve the estimated load reductions.
   - Section – 6
   - Status – Ongoing and future (2006 – 2010)
4. An estimate of the amounts of technical and financial assistance needed for monitoring, I/E, administrative, and/ or the sources and authorities that will be relied upon to implement your watershed plan.
   - Section – 7
   - Status – Ongoing and future (2006 – 2022)
5. An information and education component that will be implemented to enhance public understanding of the project and enable their early and continued participation in selecting, designing, and implementing the NPS management measures.
   - Section – 7.4
   - Status – Ongoing and future (2006 – 2022)
6. A schedule for implementing the activities and NPS management measures identified in this plan.
   - Section – 7.1
   - Status – Future (2011 – 2022)
7. A description of interim measurable milestones for determining whether the NPS management measures or other control actions are being implemented and what will be done if the project is not meeting its milestones.
   - Section – 7.4

   - Status – Ongoing and future (2006 – 2022)

8. A set of environmental, social, and administrative criteria that will be used to determine whether the implementation schedule is being met, loading reductions are being achieved over time, and substantial progress is being made towards attaining water quality standards.
   - Section – 7.4
   - Status – Future (2011 – 2022)
9. The monitoring and evaluation component to track progress and evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under #7 and #8 elements.
   - Section – 4
   - Status – Ongoing and future (2006 – 2022)

This 2008 Barr Lake and Milton Reservoir Watershed Plan compiles important information related to the BMW Association's organizational scope including a presentation of the group's mission and water quality goals, a basic environmental characterization of the watershed, identification of associated regulatory frameworks and watershed partnerships, description of data collection and analysis activities, a presentation of watershed management plans and implementation strategies for those management measures, and a presentation of the BMW Association's approach to following an adaptive watershed management process. The topics presented herein are essential ingredients for developing an effective and efficient stakeholder-driven, adaptive, watershed management plan.

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GLOSSARY

Glossary definition sources (in order of number of definitions contributed):

- NALMS 2006
- Wikipedia 2006
- Water Quality Association 2006
- USEPA 2006c
- Two or fewer definitions were derived from the following sources:
  - Answers.com 2006
  - BMW Association 2005b
- Colorado Water Partnership 2006
- USGS 2006d
- Water Information Program 2006
- Wetzel 1983

Atmospheric deposition: Pollution from the atmosphere associated with dry deposition in the form of dust, wet deposition in the form of rain and snow, or as a result of vapor exchanges.

Augmentation: A way for junior appropriators to obtain water supplies through terms and conditions approved by a water court that protect senior water rights from the depletions caused by the new diversions. Typically will involve storing junior water when in priority and releasing that water when a call comes on, purchasing stored waters from federal entities or others to release when a river call comes on, or purchasing senior irrigation water rights and changing the use of those rights to off-set the new users injury to the stream.

Best management practice: Structural, nonstructural, and managerial techniques that are recognized to be the most effective and practical means to control nonpoint source pollutants yet are compatible with the productive use of the resource to which they are applied.

Bicarbonate: A compound containing the HCO3- group, for example, sodium bicarbonate (NaHCO3), which ionizes in solution (water) to produce HCO3-.

Biomass: The total quantity of plants and animals in a lake. Measured as organisms or dry matter per cubic meter, biomass indicates the degree of a lake system's eutrophication or productivity.

Biosolids: The byproduct of removing nutrients and pollutants from wastewater

Bioturbation: The displacement and mixing of sediment particles by benthic fauna (animals) or flora (plants).

Blue-green algae: A group of phytoplankton which often cause nuisance conditions in water, so called because they contain a blue pigment in addition to chlorophyll. Blue-green algae are often associated with problem blooms in lakes. Some produce chemicals toxic to other organisms, including humans. They often form floating scum as they die. Many can fix nitrogen (N2) from the air to provide their own nutrient.

Call: In times of water shortage, a senior right may place a "call" on a stream to obtain a full supply. The stream will then come under the administration of the Colorado Division of Water Resources and any junior water rights will be restricted.

Canal(s): A constructed open channel for transporting water.

Carbonate: The CO3-2 ion in the Carbonate Buffer System. Combined with one proton, it becomes bicarbonate, and with two protons, carbonic acid. The carbonate ion forms a solid precipitant when combined with dissolved ions of calcium or magnesium.

Carbonic acid: A weak, unstable acid, H2CO3, present in solutions of carbon dioxide and water. The carbonic acid content of natural, unpolluted rainfall lowers its pH to about 5.6.

Chlorophyll-a: The green pigments of plants. There are seven known types of chlorophyll, chlorophyll-a and chlorophyll-b are the two most common forms. A green photosynthetic coloring matter of plants found in chloroplasts and made up chiefly of a blue-black ester. Major light gathering pigment of all photosynthetic organisms and is essential for the process of photosynthesis. The amount present in lake water depends on the amount of algae and is therefore used as a common indicator of water quality.

Clay: A fine-grained, firm earth material that is plastic when wet and hardens when heated, consisting primarily of hydrated silicates of aluminum and widely used in making bricks, tiles, and pottery.

Community-based social marketing: The application of commercial marketing concepts and techniques to target populations to achieve the goal of positive social change.

Concentrated animal feeding operations (CAFO): A large-scale animal feeding operation

Consensus: An opinion or position reached by a group as a whole.

Critical habitat: The area of land, water, and airspace required for normal needs and survival (e.g., forage, reproduction, or cover) of a plant or animal species.

Cultural eutrophication: Human-induced eutrophication in which lake aging is greatly accelerated by increased inputs of nutrients and sediments into a lake, as a result of watershed disturbance by humans.

Datashed: A defined area of study that is not based solely on a watershed hydrologic boundary, but also incorporates political or other important areas.

Decision support system: A computerized system for helping to make decisions.

Detritus: Non-living particulate organic material.

Dissolved oxygen: Measure of water quality indicating free oxygen dissolved in water.

Ditch: A long narrow trench or furrow dug in the ground, as for irrigation, drainage, or a boundary line.

Diurnal: Daily.

Easement: A legal instrument enabling the giving, selling, or taking or certain land or water rights without transfer of title, such as for the passage of utility lines. An affirmative easement gives the owner of the easement the right to use the land for a stated purpose. A negative easement is an agreement with a private property owner to limit the development of his land in specific ways.

Effluent-dominated: Water bodies that would be intermittent or perennial without the presence of wastewater effluent whose flow for the majority of the time is primarily attributed to the discharge of treated water (i.e. >50% of the flow consists of treated wastewater for at least 183 days annually, for 8 out of 10 years).

Endangered species: Any plant or animal species likely to become an "endangered" species within the foreseeable future throughout all of a significant area of its range or natural habitat; identified by the Secretary of the Interior as "threatened", in accordance with the 1973 Endangered Species Act (ESA).

Eutrophication: The process of enrichment of water bodies by nutrients. Degrees of eutrophication typically range from oligotrophic water (maximum transparency, minimum chlorophyll-a, minimum phosphorus) through mesotrophic, eutrophic, to hypereutrophic water (minimum transparency, maximum chlorophyll-a, maximum phosphorus). Eutrophication of a lake normally contributes to its slow evolution into a bog or marsh and ultimately to dry land. Eutrophication may be accelerated by human activities and thereby speed up the aging process.

First in time, first in right: The first person to take a quantity of water and put it to beneficial use has a higher priority of right than a subsequent user. The rights can be lost through nonuse; they can also be sold or transferred apart from the land

Geographic information system (GIS): A computer information system that can input, store, manipulate, analyze, and display geographically referenced data to support the decision-making processes of an organization. A map based on a database or databases. System plots locations of information on maps using latitude and longitude.

Headgate: The gate that controls water flow into irrigation canals and ditches. A watermaster regulates the headgates during water distribution and posts headgate notices declaring official regulations. Headgate also refers to a diversion structure which controls the flow rate from a conveyance system (canals and laterals) into the farm conveyance system

Hydraulic conductivity (Ksat): A property of soil or rock that describes the ease with which water can move through pore spaces or fractures. It depends on the intrinsic permeability of the material and on the degree of saturation. Saturated hydraulic conductivity, Ksat, describes water movement through saturated media.

Load: The amount of material that a transporting agency, such as a stream, a glacier, or the wind, is actually carrying at a given time. Also, the amount of power delivered to a given point.

Loam: A soil consisting of a friable mixture of varying proportions of clay, silt, and sand.

Macrophytes: Macroscopic forms of aquatic vegetation.

Micro-nutrient: Essential elements needed by life in small quantities. They include microminerals and Vitamins.

Mitigation bank: Actions designed to lessen or reduce adverse impacts; frequently used in the context of environmental assessment.

Model: A simulation, by descriptive, conceptual, statistical, or other means, of a process or thing that is difficult or impossible to observe directly, as a river flow model. A descriptive or conceptual model is one which represents the structure or mechanisms of a model but does not specify the relationships in numerical form. The concept of a (simulation) quantitative model is to approximate reality by means of a quantifiable process such as a mathematical equation or series of equations. In this way the model may be used to simulate various changes in conditions in a "what if" or predictive framework. The fundamental premise of model building is that within some defined bounds of statistical probability a model may be constructed based upon the past behavior of some numeric quantity or variable, or a set of such variables, so as to be able to predict the future behavior of that variable. The actual structure of the model represents the underlying set of assumptions about a phenomenon based on the model builder's view of reality, theoretical underpinnings, proven or probable causal relationships, and deductions and inferences from past observations and experience. To be manageable and useful as a predictive tool, the model must sufficiently simplify the complexities of reality so as to lend itself to some quantifiable structure. However, this simplifying process must not be so extensive as to weaken the model's validity and negate its usefulness as an explanatory and predictive tool.

Nitrate: A chemical compound having the formula NO3-. Nitrate salts are used as fertilizers to supply a nitrogen source for plant growth.

Nitrogen: (1) (General) Chemical symbol N, the gaseous, essential element for plant growth, comprising 78 percent of the atmosphere, which is quite inert and unavailable to most plants in its natural form. (2) (Water Quality) A nutrient present in ammonia, nitrate or nitrite or elemental form in water.

Nonpoint source (NPS): Pollution sources which are diffuse and do not have a single point of origin or are not introduced into a receiving stream from a specific outlet. The pollutants are generally carried off the land by stormwater runoff. The commonly used categories for NPS are: agriculture, forestry, urban, mining, construction, dams and channels, land disposal, and saltwater intrusion.

Nutrient: An element or compound essential to life, including carbon, oxygen, nitrogen, phosphorus, and many others.

Open land: Lands that are preserved in a restored, or predominantly natural open or undeveloped condition and used for wildlife habitat, cultural or recreational use, watershed protection or other use consistent with the preservation of land or in restoration of land to a predominantly natural open and undeveloped condition. Open land does not include land for active recreational activities such as baseball, tennis, soccer, golf, or other similar activities. The presence or development of facilities, including trails, waterways, and grassy areas that enhance the qualities of the land or facilitate the public's access to or use of the land may be consistent with open land purposes.

Outfall: The place where a sewer, drain, or stream discharges; the outlet or structure through which reclaimed water or treated effluent is finally discharged to a receiving water body.

Periphyton: An assemblage of microorganisms (plants and animals) firmly attached to and growing upon solid surfaces, such as the bottom of a stream, rocks, logs, pilings, and other structures.

pH: (1) A convenient method of expressing the acidity or basicity of a solution in terms of the logarithm of the reciprocal (or negative logarithm) of the hydrogen ion concentration. The pH scale runs from 0 to 14; a pH value of 7.0 indicates a neutral solution. Values above 7.0 pH indicate basicity (basic solutions); those below 7.0 pH indicate acidity (acidic solutions). Natural waters usually have a pH between 6.5 and 8.5. Because the units are derived from common logarithms, a difference of one pH unit indicates a tenfold (101) difference in acidity; similarly, a difference of two units indicates a hundredfold (102) difference in acidity.

Phosphorus: The chemical element that has the symbol P and atomic number 15. A multivalent nonmetal of the nitrogen group. An element that is essential to plant life but contributes to an increased trophic level of water bodies.

Photosynthesis: The chemical process by which green plants make carbohydrates (which the plants use as food) from carbon dioxide and water in the presence of sunlight and chlorophyll. Oxygen is released as a byproduct of photosynthesis.

Planktonic algae: Microscopic forms of aquatic vegetation that is free floating in the open water (pelagic) areas of a lake or reservoir.

Point source: A stationary location or fixed facility from which pollutants are discharged or emitted. Also, any single identifiable source of pollution, e.g., a pipe, ditch, ship, ore pit, factory smokestack.

Pretreatment: Processes used in reducing or eliminating the contaminants in wastewater or in altering its nature, before discharging it into a waste treatment system.

Primary productivity: A measure of the rate at which new organic matter is formed and accumulated through photosynthesis and chemosynthesis activity of producer organisms (chiefly, green plants). The rate of primary production is estimated by measuring the amount of oxygen released (oxygen method) or the amount of carbon assimilated by the plant (carbon method).

Primary wastewater treatment: The removal of particulate materials from domestic wastewater, usually done by allowing the solid materials to settle as a result of gravity. Typically, the first major stage of treatment encountered by domestic wastewater as it enters a treatment facility. The wastewater is allowed to stand in large tanks, termed clarifiers or primary settling tanks. Primary treatment plants generally remove 25 to 35 percent of the biological oxygen demand (BOD) and 45 to 65 percent of the total suspended matter. Also, any process used for the decomposition, stabilization, or disposal of sludges produced by settling. The water from which solids have been removed is then subjected to secondary wastewater treatment and possibly tertiary wastewater treatment.

Prior appropriation doctrine: The system for allocating water to private individuals used in most Western states. The doctrine of prior appropriation was in common use throughout the arid West as early settlers and miners began to develop the land. The prior appropriation doctrine is based on the concept of "First in time, first in right."

Propylene glycol: An organic compound (a diol alcohol), commonly used as a base ingredient in aircraft deicing fluid and some automobile antifreezes.

Residence time: The average time a substance spends within a specified region of space, such as a reservoir.

Respiration: The oxidative process occurring within living cells by which the chemical energy of organic molecules (i.e., substances containing carbon, hydrogen, and oxygen) is released in a series of metabolic steps involving the consumption of oxygen (O2) and the liberation of carbon dioxide (CO2) and water (H2O).

Sand: Composed predominantly of coarse-grained mineral sediments with diameters larger than 0.074 mm (0.0029 inch) and smaller than 2 mm (0.079 inch) in diameter.

Secchi disk: A circular plate, generally about 10 to 12 inches (25.4 to30.5 cm) in diameter, used to measure the transparency or clarity of water by noting the greatest depth at which it can be visually detected. Its primary use is in the study of lakes.

Secondary wastewater treatment: Treatment (following primary wastewater treatment) involving the biological process of reducing suspended, colloidal, and dissolved organic matter in effluent from primary treatment systems and which generally removes 80 to 95 percent of the biochemical oxygen demand (BOD) and suspended matter. Secondary wastewater treatment may be accomplished by biological or chemical-physical methods. Activated sludge and trickling filters are two of the most common means of secondary treatment. It is accomplished by bringing together waste, bacteria, and oxygen in trickling filters or in the activated sludge process. This treatment removes floating and settleable solids and about 90 percent of the oxygen-demanding substances and suspended solids. Disinfection is the final stage of secondary treatment.

Soil and water assessment tool: A watershed scale model developed to predict the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land use and management conditions over long periods of time.

Stakeholder: A person or organization that has a legitimate interest in a project or entity.

Stormwater: Water from precipitation events that flows over non-permeable surfaces rather than being absorbed into the ground.

Substantive: The term "substantive decision" when used in these Bylaws is defined to mean: a) any decision, process or action that would alter, amend or change the Corporation's Articles of Incorporation, Bylaws or organizational structure; b) the adoption or use by the Corporation of any scientific, technical or systematic procedure, program, practice, process or formula which has not been previously generally accepted by the relevant scientific, technical or systemic community; c) the selection of a Watershed Coordinator for the Corporation; d) approval of long range strategies of the Corporation; or e) any decision of the Corporation's position regarding support for or against any federal, state or local statute, rule or regulation, including water quality guidelines, parameters and standards.

Sweep: Completely empty

Tertiary wastewater treatment: Selected biological, physical, and chemical separation processes to remove organic and inorganic substances that resist conventional treatment practices; the additional treatment of effluent beyond that of primary and secondary treatment methods to obtain a very high quality of effluent. The complete wastewater treatment process typically involves a three-phase process: (1) First, in the primary wastewater treatment process, which incorporates physical aspects, untreated water is passed through a series of screens to remove solid wastes; (2) Second, in the secondary wastewater treatment process, typically involving biological and chemical processes, screened wastewater is then passed a series of holding and aeration tanks and ponds; and (3) Third, the tertiary wastewater treatment process consists of flocculation basins, clarifiers, filters, and chlorine basins or ozone or ultraviolet radiation processes. Tertiary techniques may also involve the application of wastewater to land to allow the growth of plants to remove plant nutrients.

Threatened species: Any plant or animal species likely to become an "endangered" species within the foreseeable future throughout all of a significant area of its range or natural habitat; identified by the Secretary of the Interior as "threatened", in accordance with the 1973 Endangered Species Act.

Total maximum daily load (TMDL): The maximum quantity of a particular water pollutant that can be discharged into a body of water without violating a water quality standard. The amount of pollutant is set by the U.S. Environmental Protection Agency when it determines that existing, technology-based effluent standards on the water pollution sources in the area will not achieve one or more ambient water quality standards. The process results in the allocation of the TMDL to the various point and nonpoint sources of pollutants in the area.

Trans-basin diversions: The conveyance of water from its natural drainage basin into another basin for beneficial use.

Water budget: An accounting of the inflows to, the outflows from, and the storage changes of water in a hydrologic unit or system.

Water quality analysis simulation program: A model designed to simulate contaminant fate and transport in surface waters and lakes.

Water rights: The legal rights to the use of water. They consist of riparian water rights, appropriative water rights, prescribed water rights, and reserved water rights.

Water year: The 12-month period, October 1 through September 30. The water year is designated by the calendar year in which it ends. Therefore, the 1996 water year ends on September 30, 1996.

Watershed: (1) All lands enclosed by a continuous hydrologic drainage divide and lying upslope from a specified point on a stream. Also referred to as water basin or drainage basin.

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