BIG DRY CREEK WATERSHED

SUMMARY OF EXISTING CONDITIONS

Prepared for:
The Big Dry Creek Partnership

Prepared by:
Wright Water Engineers, Inc.
2490 West 26th Ave., Ste. 100A
Denver, CO 80211

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EXECUTIVE SUMMARY

The Big Dry Creek watershed originates in unincorporated Jefferson County at the mouth of Coal Creek Canyon at an elevation of approximately 8,000 feet above mean sea level. The watershed drains easterly from the headwaters area across Rocky Flats, where several tributaries form including Walnut Creek, Woman Creek and Upper Big Dry Creek. The flow in Big Dry Creek is heavily regulated by releases from Standley Lake reservoir, which exists in the center of the watershed, as well as releases from wastewater treatment plants. Below Standley Lake, Big Dry Creek flows in a northeasterly direction to its confluence with the South Platte River near Fort Lupton in Weld County. Significant portions of the watershed are currently undergoing rapid urban development, transitioning from predominantly agricultural uses to include a mixture of residential, commercial and industrial uses. The total drainage area at the confluence is approximately 110 square miles with a 42-mile length.

This report summarizes key characteristics of the Big Dry Creek watershed for the purpose of establishing a common base of information for watershed stakeholders. This information can be used to help identify and prioritize future measures to improve watershed conditions. In conjunction with this report, an electronic database of existing water quality data has been compiled that represents conditions over the last five to ten years. This report and database are an initial step toward understanding and communicating what is known (and unknown) about the Big Dry Creek watershed. This report should be viewed as a living, evolving document that will be updated as new and/or more accurate information becomes available. The information in this report has been derived from readily available information and previous studies that have been assumed to be reasonably accurate. Additional relevant information may exist which has not been included in this report.

This report has been prepared under U.S. Environmental Protection Agency (EPA) grant funding provided to the Big Dry Creek Partnership, which includes the Cities of Broomfield, Northglenn and Westminster and Rocky Flats Environmental Technology Site (Rocky Flats). These four entities discharge wastewater into Big Dry Creek and have been heavily involved in monitoring stream conditions for many years. The three cities have worked together since 1988 to monitor stream conditions in Big Dry Creek from Standley Lake to the confluence with the South Platte, while Rocky Flats has intensively monitored stream conditions in the reach of Big Dry Creek from its headwaters to Standley Lake.

Key conclusions and recommendations identified in the report include the following:

1. A significant number of studies pertinent to the Big Dry Creek watershed have been conducted on a wide variety of topics such as wildlife habitat, aquatic life, water quality, stormwater management, and open space planning. As the watershed group plans future monitoring and special watershed projects, care should be taken not to "reinvent the wheel" or restudy issues that have already been addressed.

2. A variety of efforts to protect water quality are currently in place in the watershed. The watershed group should seek to complement and stay abreast of these efforts. Key efforts currently in place include extensive water quality monitoring and protection programs at Rocky Flats and Standley Lake. Large amounts of water quality data are available through these efforts. The group should continue to include water quality data from these on-going efforts in the Big Dry Creek Water Quality Database.

3. The Big Dry Creek Monitoring Program conducted by the Cities of Broomfield, Northglenn and Westminster should continue because it provides useful data for stream characterization from Standley Lake to the South Platte. The data set obtained from this program is the primary source of water quality information in the watershed below Standley Lake.

4. Stormwater quality and quantity impacts to Big Dry Creek are not well-characterized although a variety of stormwater impacts such as streambank erosion can be reasonably inferred from field observations. As the Clean Water Act Phase II stormwater regulations are promulgated and implemented over the next few years, the cities will likely be impacted by Phase II requirements. It will be important for the cities to develop an understanding of stormwater impacts to receiving water quality and implement best management practices (BMPs) to minimize these impacts. Several master drainage plans have been completed in the watershed which identify existing and proposed patterns of stormwater flows (i.e., outfalls, flow volumes, etc.). This information can be helpful in designing stormwater quality monitoring programs and developing an overall understanding of stormwater issues in the watershed.

5. Documented pollutant sources in the watershed include discharges from municipal wastewater treatment plants and Rocky Flats and spills and releases from facilities regulated by the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA). Stormwater runoff from urbanized areas and overland flow from agricultural lands are also expected to be relevant sources of pollution, although studies of these sources are not known to have been conducted.

6. Groundwater quality and groundwater-surface water interactions are not well-characterized along the main stem of Big Dry Creek. These issues may be worthy of study in the future, particularly with regard to understanding the role that groundwater plays in the hydrology of Big Dry Creek.

7. Although the main stem of Big Dry Creek has not been identified on the 1998 303(d) list, which would trigger the total maximum daily load (TMDL) process for the creek, Big Dry Creek will be affected by the on-going TMDL process in Segment 15 of the South Platte River. The Big

Dry Creek group should monitor and participate in the activities of the South Platte Urban Watershed TMDL Advisory Committee.

8. Ecological studies along Big Dry Creek suggest that aquatic life in the stream is limited due to poor habitat conditions. Future projects in the watershed could consider areas of potential habitat improvement. In planning these efforts, hydrologic information in the various master drainage plans and flood hazard delineation areas should be taken into account.

9. In the area downstream of I-25, agriculture is the predominant land use. Cattle grazing and watering in the stream and runoff from adjacent croplands impact water quality. Quantitative studies are not known to have been conducted to correlate agricultural activities with water quality in this area; however, the Natural Resource Conservation Service (NRCS) indicates that these impacts are potentially present. In the event that a waste load allocation (WLA) for nitrate is developed for Big Dry Creek as a result of the TMDL process for Segment 15 of the South Platte, additional quantitative study of this issue may be needed. Similarly, the group should work with the NRCS and farmers in the area to determine what measures should be taken to minimize water quality impacts associated with agricultural practices through measures such as streambank stabilization and riparian buffer area preservation/restoration.

10. Most of the cities in the Big Dry Creek watershed have stormwater and construction ordinances in place for new development that address water quality. The group should work with the cities to encourage enforcement of ordinances requiring the implementation of BMPs at construction sites, since much of the watershed area is rapidly developing. Similarly, as the population within the watershed grows, water quality impacts associated with urbanized areas will increase. Public education would be a worthy effort of the group to promote proper handling and disposal of household waste, application of fertilizers and pesticides, and other practices that reduce pollutant loadings to the stream.

11. The City of Westminster and Jefferson County Open Space are actively pursuing preservation of open space, particularly along Big Dry Creek. The group should support these and other similar efforts because of the role that preserved riparian corridors play in protecting water quality, maintaining streambanks, enhancing aquatic habitat, etc.

12. Geographic Information Systems (GIS) mapping is available from various entities for a large portion of the watershed, excluding Weld County. Although Broomfield and Northglenn do not have GIS systems in place, the mapping is in electronic form that should interface with a GIS system. With some coordination, a good GIS map could be developed for the watershed as a tool for linking water quality and quantity with various geographic features.

1.0 INTRODUCTION

This report summarizes key characteristics of the Big Dry Creek watershed for the purpose of establishing a common base of information for watershed stakeholders. This information can be used to help identify and prioritize future measures to improve watershed conditions. In conjunction with this report, an electronic database of existing water quality data has been compiled that represents conditions over the last five to ten years and is summarized in Appendix A. This report and database are an initial step toward understanding and communicating what is known (and unknown) about the Big Dry Creek watershed. This report should be viewed as a living, evolving document that will be updated as new and/or more accurate information becomes available. The information in this report has been derived from readily available information and previous studies that have been assumed to be reasonably accurate. Additional relevant information may exist which has not been included in this report.

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The report describes the physical watershed characteristics, key features, wastewater discharges, stormwater information, pollutant sources, existing monitoring programs, special studies, water rights, water supply information, regulatory framework and issues, and recommendations and conclusions.

2.0 WATERSHED DESCRIPTION

General Setting

The Big Dry Creek watershed originates in unincorporated Jefferson County at the mouth of Coal Creek Canyon at an elevation of approximately 8,000 feet above mean sea level. The headwaters area is located approximately 5 miles west of Rocky Flats, 10 miles south of the City of Boulder, 20 miles northwest of the City of Denver, and 10 miles west of the City of Westminster. The watershed drains easterly from the headwaters area across Rocky Flats, where several tributaries form including Walnut Creek, Woman Creek, and Upper Big Dry Creek. The flow in the watershed is significantly influenced by the Standley Lake irrigation and water supply reservoir which exists in the upper watershed. Below Standley Lake, Big Dry Creek flows in a northeasterly direction approximately 33 miles to its confluence with the South Platte River near Fort Lupton in Weld County. The total drainage area at the confluence is approximately 110 square miles with a 42-mile length. The Big Dry Creek watershed is shown in Figure 1. Figure 2 shows the municipal and county boundaries in the watershed, and Figure 3 shows the percentage of each county and municipal area comprising the watershed.

Population

Estimating the population in the land area tributary to Big Dry Creek is somewhat complex because of the multiple municipalities and counties that are only partially included in the watershed area. The Denver Regional Council of Governments (DRCOG) develops regional statistical areas (RSAs) for the urbanized corridor of the DRCOG region for statistical and planning purposes. Four of these areas are useful in estimating the population in the urbanized portion of the Big Dry Creek watershed as shown in Table 1. Although these estimates do not include areas upstream of Highway 93 or downstream of Highway 7 (the Weld County area), these areas are still mostly open space or agricultural areas with low populations, so they should not significantly affect the population estimate. The Big Dry Creek watershed population estimate is approximately 260,000 people. Two of the areas, Adams-Northwest and Standley Lake, experienced high growth rates between 1990 and 1996 with 38 and 19 percent population increases, respectively (DRCOG 1997a).

Table 1
DRCOG Regional Statistical Area Populations Estimate (1996)

DRCOG Regional Statistical Area (RSA number and description)		Total Population Estimate 1996
202	Standley Lake (includes City of Westminster)	75,293
301	Adams-Northwest	37,149
304	Adams-West	80,896
306	Northglenn-Thornton	68,614
Total		261,952

Source: DRCOG 1997a.

Land Usage

Currently and in recent years, land usage in the watershed has been rapidly changing from predominantly agricultural/rangeland use to also include a mixture of residential, commercial, and industrial uses. This trend is expected to continue as Colorado's population grows.

The existing predominant land use pattern from the headwaters to the outlet of Standley Lake is rangeland, with the notable exception of the 10-square-mile Rocky Flats industrial complex. In the 12.8-mile reach from below Standley Lake to I-25, the land uses are rapidly changing from open space/rangeland to a mixture of uses that are increasingly residential and commercial; however, an open space riparian corridor has been preserved by Jefferson County Open Space and the City of Westminster along much of Big Dry Creek within this area. At full development, this area is expected to become up to 50 percent impervious (Greiner 1988).

Land use east of I-25 to the confluence with the South Platte is predominantly agricultural/cultivated land with some residential development in the area just east of I-25. The Natural Resources Conservation Service (NRCS) estimates that between 152nd Avenue northeast to the confluence with the South Platte River that there are approximately 4,200 acres of irrigated cropland in a strip one-mile wide along Big Dry Creek (NRCS 1997).

More detailed land use mapping and information can be found in local comprehensive plans for the cities and counties. Several of these plans, including the ones for Thornton, Broomfield and Adams County, are currently being updated with new information.

Hydrology

The hydrology of the Big Dry Creek watershed can generally be divided into two areas: 1) the headwaters and tributaries upstream of Standley Lake, which consists of the Woman Creek, Walnut Creek and Upper Big Dry Creek drainages; and 2) the main stem of Big Dry Creek, which begins below Standley Lake and continues to the South Platte River.

The main stem of Big Dry Creek has served as a water supply ditch to downstream irrigation users since the early 1900's when Standley Lake was constructed. Big Dry Creek has not been channelized, as many drainages along the Front Range have been, and is still allowed to meander. However, because of the upstream presence of Standley Lake, it is deprived of its natural sediment load that is deposited in Standley Lake. As a result, the creek actively erodes and downcuts to reach equilibrium with its sediment load. The results of this "load gathering" tendency are evidenced throughout the length of the creek by the presence of steep cliffs and vertical soils in many areas, primarily in the reaches between Standley Lake and I-25. These vertical soil cliffs are generally formed at the outside edge of a meander as the curve of the stream channel moves slowly outward (Chenowith and Associates 1995).

The Big Dry Creek channel below Standley Lake is a well-defined meandering channel with a flat, sandy bottom and highly erodible side slopes. The typical tributary channel is broad with native grasses and cattails in low-flow areas. The longer tributary streams, such as Walnut and Airport Creeks, which drain major areas of the watershed, have well-defined channels with trees along the channel banks (Greiner 1988). The slope of the stream from just below Standley Lake to just above the Broomfield wastewater treatment plant (WWTP) is approximately 0.41 percent, and the slope downstream to the South Platte River confluence is 0.33 percent (Brown and Caldwell 1992).

Key tributaries of the main stem of Big Dry Creek below Standley Lake and Great Western Reservoir include:

- Tanglewood Creek
- North Cotton Creek
- Middle Cotton Creek
- South Cotton Creek
- Airport Creek
- North Branch Airport Creek
- North City Park Creek
- South City Park Creek
- South Branch Hylands Creek
- Middle Branch Hylands Creek
- North Branch Hylands Creek
- Walnut Creek
- Countryside Creek
- North Branch Walnut Creek
- Wadley South Creek
- Wadley North Creek
- Short Run
- Elms Run
- Morris Creek
- Shay Ditch
- Mustang Run
- Sack Creek
- South Fork Preble Creek
- Preble Creek

Big Dry Creek's hydrology is significantly influenced by releases from Standley Lake, stormwater flows, treated wastewater discharges and diversions by irrigation ditches. Relatively little is known about groundwater-surface water interactions along the stream, with the exception of the tributaries upstream of Standley Lake where such interactions have been studied on the Rocky Flats site (Wright Water Engineers 1994). Seepage of water from Standley Lake is expected to influence surface and groundwater flows along Big Dry Creek. Similarly, seepage from Great Western Reservoir is expected to influence base flows in Walnut Creek, which in turn flows into Big Dry Creek.

Climate

The climate in the watershed is semi-arid, which is characterized by low relative humidity, low rainfall, moderate to high wind movement, and a large daily range in temperatures. The climate is characterized by dry, cool winters and warm summers. A wide range of temperature extremes exists in the area, ranging from -26 degrees to 102 degrees Fahrenheit, with a mean temperature of approximately 50 degrees Fahrenheit. While the average wind velocity is between 8 and 9 miles per hour, wind gusts up to 90 miles per hour have been reported. The number of sunny days averages over 250 annually. The average annual precipitation is 14 to 15 inches. An average of 69 percent of this precipitation falls during thunderstorms which occur from April through September. These storms are characterized by high rainfall intensities of relatively short duration that produce high peak flows and moderate volumes of runoff (Greiner 1988; Wright Water Engineers 1994).

Estimates of yearly evaporation vary depending on yearly precipitation and pan constants used. According to National Oceanic and Atmospheric Administration data for 1956 to 1970, gross shallow lake evaporation averages 40 inches per year. Net evaporation, which takes into account average precipitation, is approximately 26 inches per year (National Oceanic and Atmospheric Administration 1982). A more recent study estimated Rocky Flats total reservoir evaporation to be between 43.9 and 46.5 inches per year, with net annual evaporation between 28.8 and 31.3 inches per year depending on the pan evaporation coefficient used (Wright Water Engineers 1994).

Geology and Soils

The headwaters of the watershed in the vicinity of Rocky Flats are underlain by the Rocky Flats alluvium transitioning to the Dawson and Arapahoe formations south and east of the Rocky Flats site. Formations along the tributary drainages just upstream of Standley Lake consist of various alluvium and colluvium formations. Downstream of Standley Lake, the formations along Big Dry Creek are also alluvial, including the post-Piney Creek and Piney Creek alluvium and Broadway alluvium. The watershed area outside of the alluvium along the creek is primarily loess from the Upper Pleistocene period which consists of silt with lesser amounts of clay and sand deposited by wind. Some areas of Dawson and Arapahoe formations are also interspersed, primarily in the area north and east of Big Dry Creek below Standley Lake (Trimble and Machette 1979).

From the headwaters to Standley Lake, the soil associations transition from the Flatirons-Veldkamp association to the Denver-Kutch association. The Flatirons-Veldkamp is "nearly level to steep, deep, well-drained, cobbley and gravely soils that formed in mixed alluvium." On hillsides, these soils are "dominantly well-drained, stony, cobbley or clayey soils." The Denver-Kutch association is

"moderately sloping to steep, deep and moderately deep, well drained, clayey soils that formed in material derived from mudstone and shale."

From Standley Lake to the Adams County Line, the Alda-Torrifluvents association is present with "very gravely with nearly level, deep, somewhat excessively drained and somewhat poorly drained, loamy, very gravely and sandy soils that formed in mixed alluvium." These soils are dominantly "somewhat excessively drained and well-drained, sandy and loamy soils on high terraces and hill slopes" (USDA SCS 1980).

From the Adams County Line to the Weld County Line, the soils along the creek are primarily Arvada-Held-Nunn association which are "nearly level, well-drained, loamy and clayey soils formed in alluvium on terraces and fans." Adjacent soils to the north and west are Platner-Ulm-Renohill associations with "nearly level to strongly sloping, well-drained loamy soils formed in old alluvium on interbedded shale and sandstone on upland areas." To the south and east are Samsil-Shingle association that are "sloping to steep, excessively drained, clayey and loamy soils formed in material from soft shale and sandstone, also located on uplands" (USDA SCS 1974).

From the Weld County Line to the South Platte, the soils along the creek are Nunn-Haverson characterized by "deep, level and nearly level, well-drained loams and clay loams formed in alluvium." Outside of the soil band along the creek are the Wiley-Colby-Weld soils that are "deep, nearly level to moderately sloping, well-drained silt-loams and loams formed in calcareous eolian deposits" (USDA SCS 1979).

Ecology

Several ecological studies have been conducted in the watershed that address wildlife, aquatic life, habitat types and wetlands. Several of these studies address the impacts of ammonia in WWTP discharges on aquatic life. Known studies that provide insight into various ecological considerations in the watershed are briefly highlighted below, from upstream to downstream.

- *Baseline Biological Characterization of the Terrestrial and Aquatic Habitat at the Rocky Flats Plant* (EG&G 1992). This study involved the collection of water quality and biological samples in the spring and fall of 1991 along Woman Creek and Walnut Creek. Field parameters including pH, dissolved oxygen (DO), temperature, conductivity, and turbidity were measured concurrently with collection of the aquatic samples. General water quality indicators such as alkalinity, free and total acidity, total hardness, total suspended solids (TSS), sulfate, ammonia, nitrate, nitrite, and orthophosphate were measured. Macro-invertebrate metric values did not appear to vary as a result of ammonia levels (EG&G 1992).

- *Bioassessment and Physical/Chemical Characterization of Walnut Creek and Woman Creek, Rocky Flats Environmental Technology Site* (Wright Water Engineers 1995). This study assessed the physical characteristics, flow regime, and aquatic life of Woman and Walnut Creeks using the EPA Rapid Bioassessment Protocol III for stream impairment assessment (EPA 1989). The bioassessment found that lower Walnut Creek had significantly poorer habitat and an impaired macro-invertebrate community compared to Woman Creek. Operational practices at Rocky Flats detention ponds were determined to cause a lack of flow and long periods of dry

channel in lower Walnut Creek, having a major impact on aquatic life. However, habitat evaluations indicated that, even with a constant base flow, other characteristics such as riparian overstory and stream substrate conditions would prevent lower Walnut Creek from achieving the same biological health that currently exists in Woman Creek (Wright Water Engineers 1995).

The study also determined that flow and habitat conditions which limit the biological health of lower Walnut Creek also limit the potential impacts to aquatic life from un-ionized ammonia in discharges to this segment. Ammonia concentrations in the ponds fluctuate in response to operational practices and natural processes and can exceed current stream standards; however, the available data showed poor correlation between ammonia concentrations in pond water discharges and impairment of aquatic life in the ponds or in lower Walnut Creek below the ponds. Furthermore, sampling data indicated significant reductions in un-ionized ammonia concentrations as water discharged from Pond A-4 traveled through the reach, such that the Segment 4 un-ionized ammonia standard was achieved prior to reaching Indiana Street. Existing un-ionized ammonia concentrations appeared to have no detrimental impacts on the uses or biological health of the reach or downstream segments (Wright Water Engineers 1995).

- Fish studies in Great Western Reservoir. Between 1986 and 1992, three fish studies were independently conducted in the reservoir by the Colorado Department of Wildlife (CDOW), the City of Broomfield, and Rocky Flats. All three studies had similar results and are summarized together in the *Use Attainability Study for Great Western Reservoir* (City of Broomfield 1996a). The primary fish species captured included common carp, white suckers, and fathead minnows. Collectively, the fish studies indicated that diversity is poor. The predominant fish species tolerate a wide range of environmental conditions, and sensitive species are rare or absent.

- Standley Lake ecological studies. Aquatic Wetlands Consultants, Inc., as a subconsultant to CH2M Hill, mapped wetlands in the vicinity of the Standley Lake in 1991 as part of the Standley Lake Protection Project activities. They identified roughly 50 acres of wetlands including six general types of wetlands in the area: leadplant (false indigo-bush) shrubland, willow shrubland, wet meadow, emergent wetland, mixed shrubland and open water wetland areas. A biological assessment was also conducted to identify threatened and endangered species (as discussed in the next section) (CH2M Hill 1991).

From a water quality perspective, the aquatic ecology of the lake is regularly monitored to ensure that the lake does not become eutrophic. For example, chlorophyll-a and nutrient analyses are regularly conducted as an indicator of the concentrations of algae within the water (RBD 1994).

- *Big Dry Creek Corridor Preliminary Biological Characterization (Vegetation, Wildlife and Soils)* (Chenowith and Associates 1995). The purpose of this study was to provide a preliminary evaluation of existing biological resources within the Big Dry Creek corridor to provide the City of Westminster with a baseline inventory of natural resource values. The study covered the area from just west of Federal Boulevard to I-25. Vegetation mapping included the following mapping units: herbaceous wetland, shrubby wetland, Cottonwood or Peachleaf Willow, Russian Olive, native grasslands, Western wheat grass grassland, prairie cordgrass grassland, disturbed riparian area grasslands, weeds growing in recently disturbed areas, prairie dog communities (which suppress native species), noxious weed infestations, desurfaced bare areas,

and pasture. The 13 color maps in the report should be referenced for the distribution of these vegetation units. The study results showed the plant communities associated with Big Dry Creek were in surprisingly good condition given the historical agricultural and grazing use of the area. The study also noted that most of the upland vegetation associated with Big Dry Creek open space is disturbed and dominated by introduced and/or weedy plant species. Control of areas infested with noxious and other weeds was recommended.

The study concluded that the riparian corridor along Big Dry Creek provides habitat for a significant number of species. Appendix B provides a list of the wildlife species identified in the study area in 1995. The study also identified several factors that have or are influencing wildlife habitat in the Big Dry Creek Corridor in Westminster, including:

◊ Historical conversion of native short grass and mixed grass prairie to agricultural uses may have resulted in increased habitat suitability for prairie dogs, which in turn increased the seasonal abundance of birds of prey along the Front Range.

◊ Historical and current water storage and conveyance structures have altered the seasonal flow regimes of the creek. This has enabled more extensive distribution of riparian trees and shrubs as a result of increased flow volumes and year-round persistence of water in the creek. These trees and shrubs in-turn provide food and cover for a greater number of wildlife species. However, introduction of non-native vegetation has also affected the habitat, resulting in a decrease in foliage height diversity and associated food and cover values for wildlife.

◊ Historical trapping of beaver may have resulted in enhancement of riparian habitat quality for many fish and wildlife species because of the increased persistence of small trees and shrubs.

◊ Recent and current intensive development of agricultural land is resulting in habitat loss and range compression for wildlife species which formerly utilized uplands. Human use has and will continue to lead to avoidance or exclusion of some wildlife sensitive to disturbance from humans and pets.

- Environmental and aesthetic assessment of the watershed area between 144th and 168th Avenues as part of the *Outfall Systems Planning North Area Tributary Big Dry Creek (Adco)* (Wright Water Engineers 1989b). This involved a reconnaissance-level site survey of the tributaries between 144th and 168th Avenues to identify typical tributary units as defined by vegetation, land form, and water supply. Six typical tributary units were identified as described below and as shown on Figure 4. Although a similar study is not known to have been conducted downstream of this area, similar tributary units are expected to occur in other portions of the watershed. For the Weld County area east of 168th Avenue, the agricultural/cultivated tributary unit is likely to dominate.

  ◊ *Swale.* This channel type occurs toward the upper reaches of several tributaries. The unit is characterized by a poorly defined flat bottom with an indistinct low flow channel and somewhat distinct side slopes. The typical width of these swales is 80 to 100 feet.

Overbank flows are dispersed to adjacent agricultural fields. Vegetation is primarily dry land species with pockets of wetland vegetation in the bottom and near obstructions. The primary source of water is groundwater, with some water detained from storms.

◊ *Swale With Emergent Wetlands***.** This unit is a more well-developed variant of the swale channel type; it is similar in land form to the swale, but is characterized by a more consistent water source and obligate wetland species. This swale is somewhat deeper (approximately five feet) and has one to several defined low-flow channels. Adjacent areas are commonly agricultural fields. Channel width, from bank to bank, averages 100 feet. This unit is typically located below a pond and is fed by seepage from the pond. Mature, deciduous vegetation occurs along the pond edges. Wetland vegetation is more dense and more well-developed than that of the swale type. Wetland species tend to occur at greater density in low pockets and along meanders of the low-flow channel. Upland shrubs occur within the channel as well as along the outer banks.

◊ *Agricultural/Cultivated.* The tributaries in this unit have been modified for agricultural use, and riparian or wetland vegetation has been removed or not allowed to occur. This unit is typically tilled every year for agricultural use and is identified only by a slight depression in the land form. In areas where farming has stopped or at the edge of a property line, the channel has started to incise, and wetland vegetation begins to occur. In some agricultural areas, the drainage channels have been reduced to narrow ditches by cultivation. These ditches are the low-flow channel. High flows are dispersed to adjacent fields.

◊ *Modified Channel.* This unit is characterized by a channel that has been altered by development. The channel is usually a narrow, fairly deep ditch, and the water flow is generally perennial. These ditches tend to be relatively deep and contain the majority of high-flow regimes. Typical wetland vegetation (cattails, sedges, and rushes) grows along the embankments, and wetlands sometime occur in the high bank areas.

◊ *Backwater Wetland.* The backwater wetlands are characterized by an expanded wetland or water surface area. This condition usually results from a flow constriction or very shallow slope. Constrictions to flow occur upstream of road crossings and railroad embankments. They also occur naturally in some areas of the flat upper floodplain of Big Dry Creek. The unit includes multiple low-flow channels, with the high-flow channel poorly defined. This channel type is the most well-developed emergent wetland type occurring along the tributaries. Backwater wetlands can be relatively large, covering as much as several acres. These wetlands are significant songbird and small mammal habitats. They also function as natural filters for sediment and pollutants. Wetland vegetation is dense and relatively diverse. Standing water and saturated soils occur throughout the year. Vegetation varies from grasses on higher bars to cattails and sedges in lower flooded areas.

- CDOW (1996b). As part of the Colorado Water Quality Control Commission (CWQCC) December 1996 water quality standards hearing for Big Dry Creek, the CDOW suggested that the stream standard for un-ionized ammonia should be 0.06 mg/L because of the presence of

johnny darters in Big Dry Creek. The CDOW indicated that the largest decrease in fish species occurred in the stream reaches below the Broomfield and Westminster WWTPs. The CDOW stated that under normal conditions in Colorado rivers, fish species increase in a downstream manner, but in Big Dry Creek species diversity decreased downstream. The CDOW asserted that this decrease was due to nitrogen compounds in wastewater (Cities of Broomfield, Westminster and Northglenn 1997).

- Chadwick and Associates (1996) Bioassessment. In 1996, the Cities of Westminster, Broomfield, and Northglenn hired Chadwick and Associates to qualitatively evaluate Big Dry Creek from below Standley Lake to just above the confluence with the South Platte. The study was conducted in response to CDOW's assertion that a standard of 0.06 mg/L of un-ionized ammonia was warranted on Big Dry Creek (instead of the traditional 0.1 mg/L) because of the fish composition of the stream, specifically the johnny darter. Chadwick and Associates concluded that the habitat upstream of the WWTPs was of better quality than the lower reaches below the facilities and that this was probably the reason for the presence of johnny darters in that stream section. Chadwick and Associates also noted that Fathead Minnows were present downstream of the effluent and are comparably sensitive to un-ionized ammonia. They concluded that the presence of the Fathead Minnows indicated that the absence of the johnny darters must have been due to some reason other than the ammonia concentrations in the effluent. Further, the macro-invertebrate composition was uniformly distributed throughout the entire length of the creek, suggesting that water quality was not the key issue (Conklin 1996; Cities of Broomfield, Westminster and Northglenn 1997). The CWQCC maintained the 0.1 mg/L ammonia standard. It should be noted that CDOW continues to disagree with the findings of the Chadwick study (Woodling 1998).

- "Interim Report Results of the Aquatic Monitoring Program in Big Dry Creek 1997" prepared by Aquatics Associates for the Cities of Broomfield, Northglenn and Westminster, February 1998. This report provides the results of the aquatic monitoring program which began in October 1997 after the irrigation season. (Sampling was also conducted in the spring of 1998 prior to irrigation season; however, these results are not included in the report.) The program was conducted by the Cities of Broomfield, Northglenn and Westminster to document the abundance and distribution of fish and aquatic macroinvertebrate populations at select locations on Big Dry Creek. The objective of the sampling was to provide a database than could ultimately be used to determine appropriate surface water quality standards for Segment 1 of Big Dry Creek and document the effects of potential influences of water quality on the aquatic community. Seven sites were sampled for fish populations and macroinvertebrates. Macroinvertebrate data were summarized and evaluated following EPA's Rapid Bioassessment Protocol III. Key findings documented in the report include:

    ◊ The upper three sampling stations are located in transitional foothills-plains stream type, while the lower four stations are located in a plains stream type that has been channelized in the lower three stations. This shift in habitat type is a significant factor affecting the types of fish and macroinvertebrates found in the stream. The upper stations have riffle, run and pool habitat types, while the lower habitat type is primarily run habitat type. One confounding factor with regard to data interpretation is that the shift in habitat types

roughly corresponds to the location where discharges from the cities' wastewater treatment plants begin.

◊ Significant stream flow fluctuation was documented and identified as a significant factor affecting physical habitat conditions, which may negatively affect macroinvertebrate populations and natural reproduction of some fish species.

◊ Results of the fish surveys were comparable to previous surveys by CDOW (Woodling) in October 1992 and March 1993 and Propst in 1978-1980.

◊ Study results suggest that "the absence of johnny darters at sites in the downstream reaches of Big Dry Creek is most likely due to the lack of suitable habitat rather than water quality." (Aquatics Associates 1998, p.16). More specifically, the report identifies the lack of cobble substrate, increased deposition of silt and fine sand, and greater water depths in the channelized reaches of Big Dry Creek limiting the distribution of this species.

◊ Macroinvertebrate sampling showed 18 orders of macroinvertebrates and 113 taxa. Macroinvertebrate densities and number of taxa were generally high at all sites. Stoneflies were not present, probably due in part to increased stream temperatures associated with wastewater discharges. Other factors influencing the macroinvertebrate community include urban runoff, sedimentation, agricultural activities and diversions. Agricultural activities influence the aquatic community in areas downstream of the Westminster Big Dry Creek Wastewater Treatment Plant.

◊ The study reported that "Physical habitat and fluctuating stream flows most likely limit the macroinvertebrate community in Big Dry Creek, particularly in lower gradient areas downstream from the Broomfield Treatment Plant where riffle habitat with cobble substrate are sparse and much of the streambed is channelized." (Aquatics Associates 1998, p. 28).

◊ Selected recommendations of the report include continued monitoring of aquatic life in 1998 to document potential influences of treatment plant discharges. Additionally, because monitoring results indicate that physical habitat is a major factor influencing the distribution and abundance of the aquatic community, analysis and interpretation of habitat data is needed. (Habitat data were collected in 1997, but unable to be analyzed due to budget constraints.) Flow measurements were also recommended to be collected at all sample sites in order to develop a better understanding of how flow may influence the aquatic community.

Threatened and Endangered Species

Based on the *Biological Assessment for Standley Lake* (CH2M Hill 1994), Appendix B lists the potential federal and state listed species of concern that may occur along the Colorado Front Range in the vicinity of the Standley Lake. This list should reflect the threatened and endangered species potentially present in the Big Dry Creek watershed.

One species of particular interest to the Big Dry Creek watershed is the Preble's Meadow Jumping Mouse, which is found only in parts of Colorado and Wyoming. It has been listed as a threatened species on the federal Endangered Species List. These mice have been recorded in all the major drainages at Rocky Flats and are typically found along pond margins and wetland areas adjacent to stream channels, particularly in association with Coyote Willows. A special monitoring program is in place at Rocky Flats to determine the population centers and the prevalence of the mouse (Parker-Hall 1997).

Under a USGS grant, the CDOW is currently mapping riparian habitat from Boulder County through the Standley Lake area as well as areas where the mouse is known to occur. This mapping is expected to be completed in late spring of 1998. Potentially, a Phase II of the project could extend this mapping all the way to Brush, Colorado. The results of the mapping will be used to develop a habitat conservation plan for the mouse (Lovell 1998).

History/Historical Features

The Big Dry Creek area has historically been used for agricultural and grazing purposes. An evaluation of special historical features was not conducted for this report but may be included in future revisions of this document.

3.0 KEY FEATURES

Rocky Flats Environmental Technology Site

Rocky Flats is owned by the U.S. Department of Energy (DOE) and operated by Kaiser-Hill. The plant's historical mission was the development and fabrication of nuclear weapons components from radioactive and non-radioactive materials. In 1985, the site was placed on the national priorities list (Superfund) for cleanup of the site-wide radiological and chemical contamination that occurred during active operation of the plant. In January 1992, the decision to halt the production of nuclear weapons components was announced. Rocky Flats is currently in transition to decontamination and decommissioning (D&D) for site closure in 2010.

Rocky Flats covers almost 10 square miles, occupying Sections 1 through 4 and 9 through 15 of Township 2 South, Range 70 West of the 6th Principal Meridian in Jefferson County, Colorado. The developed plant site, or Industrial Area, comprises roughly 0.65 square miles in the center of the property and is surrounded by a buffer zone of approximately 9 square miles (Figure 5). The site is bounded on the north by the DOE NREL Wind Site and private mining land along State Highway 128, on the west by privately-owned land paralleling State Highway 93, on the east by Indiana Street, and on the south by privately-owned agricultural land. Most of the land immediately surrounding Rocky Flats is presently undeveloped.

The communities of Superior, Broomfield and Westminster to the east are the closest population centers to Rocky Flats. These communities have grown substantially in the last decade, and Indiana Street represents one of the current boundaries of the City of Broomfield.

The DOE has worked with the Colorado Department of Public Health and Environment (CDPHE) and EPA to develop a new, comprehensive cleanup agreement for the site. This agreement includes

a vision for the site's future, a commitment from DOE to remove the significant stockpile of nuclear materials from Rocky Flats by the year 2015, and an action level and standards framework that establishes numeric values that DOE, EPA, and CDPHE will use to determine whether remedial action is necessary and how extensive such action must be to protect human health and the environment. DOE, EPA, and CDPHE signed the final Rocky Flats Cleanup Agreement (RFCA) on July 19, 1996 (CDPHE 1996a).

The cleanup of Rocky Flats is expected to result in significant long-term improvements in the watershed of Big Dry Creek with respect to quantities and types of hazardous materials present. However, during cleanup and D&D there will be significant materials handling and removal activities with the potential to impact water quality. With respect to water quality, the vision requires that ultimately "water leaving [Rocky Flats] will be of acceptable quality for any use." During the active cleanup period, currently estimated to occur during the next 10 to 15 years, water quality should allow the attainment of all classified uses except drinking water supply (CDPHE 1996a).

Rocky Flats is a significant feature in the watershed because the headwaters of several tributaries to Big Dry Creek are located in the vicinity of Rocky Flats, including Woman Creek, Walnut Creek, and Upper Big Dry Creek. These drainage basins generally traverse the plant from west to east, as shown in Figure 5. The majority of the Industrial Area drains to Walnut Creek, and the majority of discharges from Rocky Flats have historically been made to Walnut Creek (Wright Water Engineers 1994). The estimated long-term average annual yields of Walnut Creek and Woman Creek at Indiana Avenue are 34.5 and 32.1 acre-feet, respectively. These yields are so low that the streams are considered essentially dry most of the year except for the summer months (May through August) (Wright Water Engineers 1994).

Standley Lake

Standley Lake is a terminal water storage reservoir located in northeastern Jefferson County that supplies drinking water to approximately 200,000 people in the Cities of Northglenn, Federal Heights, Thornton, and Westminster and their service areas. The lake covers approximately 1,200 acres and provides storage for approximately 43,000 acre-feet of water. The City of Westminster began using Standley Lake as a municipal water supply in 1965, while the Cities of Thornton and Northglenn began using Standley Lake as a water supply in 1980. The reservoir also provides irrigation water supply for farmers under the Standley Division of the Farmer's Reservoir and Irrigation Company (FRICO). The inflow and releases from the lake are dictated by water rights and demands for domestic, agricultural, and other water uses. RBD (1994) summarized the average annual ditch inflows by source to Standley Lake for the period between 1987 and 1993. These flows included 20,644 acre-feet from the Farmer's Highline Canal, 14,826 acre-feet from the Croke Canal, and 3,145 acre-feet from the Church Ditch. Since 1990, the flows from the Croke Canal have been close to those from the Farmer's Highline Canal (RBD 1994). The reservoir also receives flows from the Upper Big Dry Creek drainage and historically (but no longer) received flows from the Woman Creek drainage.

Standley Lake has been subject to water quality concerns over the years due to its importance as a municipal water supply. Most of the inflow to Standley Lake originates from Clear Creek in the

vicinity of Golden and is transported via the Church Ditch, the Farmer's Highline Canal, and the Croke Canal over 16 to 25 miles prior to reaching Standley Lake. Thus, water quality in Standley Lake is influenced by the large Clear Creek watershed. For example, in 1988, under the Clear Creek Water Quality Agreement, the Coors/Golden WWTP discharge was moved from upstream of the ditches to below the ditches in response to taste and odor water quality problems in Standley Lake that were attributed to the WWTP in the late 70's and early 80's.

In the Fall of 1988, a significant taste and odor problem was experienced by the cities. The problem occurred after the fall turnover when the lake water was completely mixed. The cities attributed the taste and odor problems to algae growth in Standley Lake. These types of issues led to the development of a lake water quality management and monitoring program. The *Standley Lake Management Plan* was completed in February 1995 by the Cities of Westminster and Northglenn. The plan addresses nutrient loading from in-lake processes, water supply operations, recreational activities, and other activities in the watershed. The plan also identifies the currently used and potential control measures which may result in the reduction of nutrient concentrations in the lake. Key control measures include removing storm flows from the canals carrying water from Clear Creek to Standley, negotiating with parties in the Clear Creek Basin to identify alternatives to reduce impacts from growth within that basin, evaluating nutrient control alternatives for the lake itself, and involvement in water rights augmentation and exchange applications (DRCOG 1998b). The monitoring program is described in Section 7.0.

One of the key water quality issues for Standley Lake has been its downstream location relative to Rocky Flats. Woman Creek, which flows through the Rocky Flats Buffer Zone, historically flowed directly into Standley Lake and caused concern that the cities' water supply could become contaminated from discharges to Woman Creek. As a result, in 1995, the Standley Lake Protection Project (SLPP) was completed as part of "Option B." This involved successfully isolating Standley Lake from the Woman Creek drainage. This was accomplished by construction of the Woman Creek Reservoir to collect stormwater flows from Rocky Flats (City of Broomfield 1997). The Woman Creek Reservoir captures and stores runoff from the Woman Creek watershed. Water is detained in the Woman Creek Reservoir until water quality test results from samples collected at Indiana Street demonstrate that water quality standards are met and then pumped to the Walnut Creek drainage below Great Western Reservoir. As part of this project, Kinnear Ditch water is routed to Standley Lake via pipeline prior to reaching Woman Creek (Wright Water Engineers 1994). A wetlands mitigation/wildlife enhancement project was also completed as part of the SLPP to offset losses of wetlands associated with construction activities (RBD 1994).

Another potential source of impacts to Standley Lake is the current and future development of the Standley Lake Park recreational area around the lake. In September 1994, the Cities of Westminster, Northglenn, and Thornton signed an intergovernmental agreement regarding recreation activities at the park, with the first priority being protection of water quality. Some of the provisions of this agreement included implementing measures to protect water quality, requiring regular water quality monitoring, and establishing initial baseline water quality conditions to assess impacts to the lake. The goal of the recreation plan for the lake is to have no impact on water quality. Sources of pollutants associated with recreational activities include pathogens from human and animal waste, solids and nutrients from erosion, and fuel oil from motorized sports (Wright Water Engineers

1996a&b). The recreational management plan identifies measures to control and minimize the impacts from such sources.

Great Western Reservoir

Great Western Reservoir is located in Sections 6 and 7, Township 2 South, Range 69 West in Jefferson County. At maximum storage capacity, the surface area is about 150 acres, and the maximum depth is 45 feet. The reservoir was constructed in 1904 on the Walnut Creek channel east of Indiana Street, about 1.5 miles from the eastern boundary of Rocky Flats. It was used as an irrigation reservoir until the 1950s, when it began being used as a water supply reservoir by the City of Broomfield. The reservoir was purchased by the city in 1962. The current storage capacity of Great Western is 3,250 acre-feet (City of Broomfield 1996a).

Great Western receives little inflow from its natural drainage area. Historically, the source for more than 90 percent of its water was diversions from Clear Creek delivered via the Church Ditch. Broomfield owns substantial water rights on Coal Creek, with water delivered via Church and/or McKay Ditches to Walnut Creek below Rocky Flats. Prior to 1989, the reservoir also received drainage from Rocky Flats via Walnut Creek. At that time, Broomfield constructed the Broomfield Diversion Ditch to route flow around the reservoir, returning flow to Walnut Creek below the dam (City of Broomfield 1996a).

From 1981 to 1997, strict water quality standards that involved "extra layers of protection" were adopted in various CWQCC hearings to protect the Broomfield drinking water supply stored in Great Western. These hearings were driven primarily by the upstream presence of Rocky Flats (CDPHE 1996a). In 1990, an agreement was negotiated between DOE and the City of Broomfield, wherein DOE would provide funds to allow Broomfield to abandon Great Western Reservoir as a drinking water supply and develop an alternative water source. This project, known as the Great Western Reservoir Replacement Project (GWRRP), involved construction of a pipeline to deliver water from Carter Lake to a new water treatment plant and permanently severed any physical connection between Rocky Flats and Broomfield's water supply. In order to help fund the construction of the new water treatment plant, Broomfield sold its Church Ditch water rights; therefore, the primary water source to the reservoir is no longer available. Remaining water rights of only about 700 acre-feet per year, minus seepage and evaporation, are available to serve the 3,250 acre-foot reservoir. It should be noted that one of the conditions of the DOE grant for the project is that Great Western can never be used as a drinking water supply (City of Broomfield 1996a).

Since August 1997, Great Western Reservoir has no longer been used for drinking water; instead, its intended use is to serve as a cost-effective way to store and reuse treated wastewater effluent for use as irrigation water for golf courses, city parks, and landscaped areas. Because Broomfield's replacement water is 100 percent consumable Windy Gap water diverted from the western slope, Broomfield's effluent can be reused. As part of the planned reuse project, approximately 1,650 acre-feet of secondary-treated effluent from the Broomfield WWTP will be stored in Great Western prior to treatment and irrigation reuse. The existing potable water treatment plant is planned to be modified for tertiary treatment to achieve water quality standards consistent with the Colorado Reuse Guidelines. Initially, Broomfield will deliver reuse water to irrigate a new golf course at the Interlocken Business Park. Reuse will continue to expanded to include city parks, open space, and

other property (Broomfield 1996a). The reuse system is not expected to be active until after 2002 (Mahan 1998).

In 1996, the City of Broomfield completed the *Use Attainability Analysis for Great Western Reservoir Big Dry Creek Segment 3 South Platte River Basin* (City of Broomfield 1996a). The study addressed issues such as future uses of the reservoir, management of contaminated sediments and water rights issues and summarized the physical, chemical, and biological characteristics of the reservoir. The study recommended modification of the Great Western (Segment 3) water quality standards to enable the proposed use of the reservoir to store reclaimed effluent. For this reason, the water quality standards in place for this reservoir have been reduced (CWQCC 1996a).

Open Space Areas

One key feature of the watershed area is that there is still a significant amount of preserved open space and undeveloped land. Both "ends" of the watershed are mostly agricultural, with the most developed portion of the watershed located primarily within the City of Westminster. In 1995, the City of Westminster and Jefferson County Parks released the *Big Dry Creek Trails Master Plan*. The goal of this plan is to provide a direct trails and open space connection from the Standley Lake Recreation Area to Westminster City Park (at Sheridan Boulevard) and ultimately to I-25. The alignment of the proposed trail and open space system is shown in Figure 6 (Wenk 1995). Open space areas, particularly riparian areas along the creek, are valuable for purposes of attenuating stormwater flows, filtering pollutants in stormwater, stabilizing streambanks, providing habitat for aquatic and terrestrial life, and other functions.

4.0 WASTEWATER TREATMENT PLANTS

The four municipal wastewater treatment plants that discharge treated effluent into the Big Dry Creek watershed include Rocky Flats, the City of Broomfield, the City of Westminster, and the City of Northglenn. These WWTPs are discussed in the following sections in order of upstream to downstream location.

A summary of the Colorado Discharge Permit System (CDPS) discharge limits for each of these WWTPs is provided in Table 2. The Cities of Westminster, Northglenn, and Broomfield have a combined discharge of 29.3 cfs, which is expected to increase to at least 32.7 cfs by the end of this permitting period. However, these flows may be reduced once wastewater reclamation and reuse plans are implemented (Mahan 1998). Big Dry Creek has a chronic and acute low flow of 1 cfs. Because the ratio of low-flow to permitted discharge to Big Dry Creek is so small, the CDPHE considers the effects of dilution to be negligible. For this reason, discharge limits are based on stream standards for Big Dry Creek (CDPHE 1996b). There are currently no ammonia limits in the discharge permits for these WWTPs.

Table 2

WWTP Discharge Permit Effluent Limits
Big Dry Creek Watershed

Effluent Parameter	**City of Broomfield** CO-0026409 (001A)	**City of Northglenn** CO-0036757 (004A)	**City of Westminster** CO-0024171 (002A, 003A, 0004A)	**Rocky Flats** CO-0001333 (STP1 & STP2)
Flow, MGD	5.4[a]	0.79-11.84[e] (tiered IWC)	7.0[a]	0.5
BOD, mg/L	25/40[b]	30/45[b]	30/45[b]	--
TSS, mg/L	30/45[b]	30/45[b]	30/45[b]	15/25[b]
Fecal Coliform Bacteria #/100 mL	2,404/4,808[b]	2,000/4,000[b]	2,000/4,000[b]	200/400[b]
Total Residual Chlorine, mg/L	0.5[c]	0.5[c]	0.5[c]	--
pH, su	6.5-9.0[c]	6.5-9.0[c]	6.5-9.0[c]	6.5-9.0[c]
Oil and Grease, mg/L	10[c]	10[c]	10[c]	10[c]
Dissolved Oxygen, mg/L	4.2 (min)[c]	5.0 (min)[c]	4.3 (min)[c]	--
Whole Effluent Toxicity, Acute	IWC=80.8%/ 50%[d]	tiered IWC, see Table 3		
Whole Effluent Toxicity, Chronic		No Statistical Difference	No Statistical Difference relative to IWC of 82%	
Other Parameters				see Appendix C

[a]30-day average.

[b]30-day average/7-day average.

[c]Daily maximum or range.

[d]WET testing is whole effluent toxicity testing. The standard is applied to individual toxicity tests showing toxicity at a concentration less than or equal to the identified In-stream Waste Concentration (IWC) or 50% species mortality in any sample.

[e]See Table 3 for specific IWCs according to month.

Rocky Flats

Rocky Flats has its own WWTP located on the plant site at Building 995 (B995). The WWTP discharges to Pond B-3 located in the South Walnut Creek drainage. Water subsequently flows to Ponds B-4 then B-5, prior to discharge off-site.

The design hydraulic capacity of the WWTP is 0.5 MGD. The WWTP treatment process consists of an activated-sludge system, tertiary treatment for phosphorus removal and sand filtration for solids removal. The plant normally removes over 90 percent of influent BOD and solids (Fiehweg 1998).

The Rocky Flats WWTP operations are strictly regulated under its NPDES permit, DOE orders, and other regulatory criteria. An internal waste stream (IWS) monitoring program is in place to regulate the types of waste discharged to the WWTP. Internal waste streams are non-process, non-domestic wastewaters compatible with the conventional treatment processes used at B995. The IWS program is similar to pretreatment programs found at most municipal wastewater facilities. Potential wastewater streams must be approved before discharge may begin and records are kept of volumes, dates of discharge and any pertinent information about the source of the water. In some cases, chemical analyses are required as part of the approval process (Fiehweg 1998).

In addition, fairly continuous influent monitoring is conducted at the influent to the WWTP to detect spills or discharges into the sanitary sewer system that could cause operational upsets of the WWTP. This monitoring includes real-time continuous measurements of pH and conductivity, lower explosive limit (LEL) monitoring of the atmosphere above the headworks and visual inspection for unusual conditions (Fiehweg 1998).

City of Broomfield

The City of Broomfield's Wastewater Reclamation Facility is located at 12380 Lowell Boulevard in Broomfield. The design hydraulic capacity of the Wastewater Reclamation Facility is 5.4 MGD, with an organic loading capacity of 10,300 pounds of BOD a day. The Wastewater Reclamation Facility currently discharges from outfall 001A to Big Dry Creek. The Wastewater Reclamation Facility treatment process consists of an aerated grit chamber, primary clarifiers, a flow-equalization basin, bio-tower, an activated-sludge system, and ultraviolet disinfection (CDPHE 1997d). Nutrient removal technologies are also being considered for the facility (RBD 1996). Broomfield has an approved industrial pretreatment program.

City of Westminster

The Westminster Water Reclamation Facility is located in the NW1/4, SW1/4 of Section 27, Township 1 South, Range 68 West in the 6th Principal Meridian at 13150 North Huron Street. The Water Reclamation Facility is called the "Big Dry Creek Reclamation Facility." The Water Reclamation Facility is an activated biosolids system consisting of primary clarifiers, aeration basins, final clarifiers, chlorine contact basins, dechlorination and effluent equalization ponds. The permitted capacity of the facility is 7.0 MGD, with an organic capacity of 14,500 pounds of BOD per day. The facility discharges to Big Dry Creek at discharge points 001A, 002A, and 003A and to the Farmer's Highline Canal at discharge point 004A. Approximately 13 percent of the flows treated at the Water Reclamation Facility are of industrial origin, with the remaining 87 percent being of domestic origin (CDPHE 1997). Westminster has an approved industrial pretreatment program.

In 1996, the City of Westminster determined the most cost-effective and best alternatives for development of a reclaimed water system. A large reuse system is planned to deliver up to 3,000

acre-feet of reclaimed water to irrigate large public turf areas such as golf courses and parks and provide water for lakes, ponds, and wetlands. Design of all system components began in May 1997 and an initial 1,100 acre-foot phase should be in place by the spring of 2000 (DRCOG 1998b). Currently, irrigation canal water is provided to Legacy Ridge Golf Course, Westminster City Park and Front Range Community College Pond. This water is monitored monthly for pH, nitrate-nitrogen, phosphorus, TSS, total coliform and *E. coli* bacteria for future comparison with the quality of reclaimed water (Quality-Water Biosystems 1997).

City of Northglenn

The City of Northglenn's WWTP is located in the West 1/2 of Section 36 in Township 1 North, Range 68 West of the 6th Principal Meridian at 5445 Weld County Road 2. The facility discharges to Bull Canal (001A), Big Dry Creek (004), and Thompson Ditch (005A). The hydraulic capacity is 6.5 MGD, with an organic capacity of 11,384 pounds of BOD a day. Approximately 10 percent of the wastewater treated at the WWTP is from commercial and industrial contributors. Northglenn has an approved industrial pretreatment program.

Chronic WET test requirements will be applied to this WWTP because WET testing data for the previous permit period indicated reoccurring toxicity to fathead minnows at approximately 50 percent effluent dilution. The city attributes the toxicity to ammonia. The chronic WET limit becomes effective January 1, 1999. In order to meet WET limits, the city selected a tiered in-stream wasteload concentration (IWC) approach that enables the city to vary its discharges to Big Dry Creek by using other discharge points and 4,000 acre-feet of effluent storage capacity. The formula for calculating the IWC is:

$$IWC = [Facility\ Flow/(Stream\ Chronic\ Low\ Flow+Facility\ Flow)] \times 100\%.$$

The IWC varies based on the flows in Big Dry Creek, as shown in Table 3.

Table 3
Permitted Northglenn Effluent Discharge (MGD) to Big Dry Creek Based On Instream Wasteload Concentrations (IWC)

Month	Chronic Low Flow 30E3, cfs	Outfall 04AX IWC = 55%	Outfall 04BX IWC = 40%	Outfall 04CX IWC = 20%
April	4	3.16	1.72	0.65
May through September	1	0.79	0.43	0.16
October	8	6.32	3.44	1.29
November	15	11.84	6.46	2.42
December through March	14	11.05	6.03	2.26

5.0 STORMWATER

Based on interviews with individuals involved with stream monitoring and farming along Big Dry Creek, the stream responds dramatically to stormwater events. However, with the exception of Rocky Flats, no data or studies were identified with regard to the impact of stormwater flows on water quality or stream habitat. However, stormwater outfall planning and flood hazard studies have been conducted from the headwaters of the watershed to approximately the Weld County line. These studies map existing and planned stormwater outfalls and should be referenced for more detail on this topic or when planning stormwater monitoring programs.

Master Drainage Plans

Several stormwater outfall systems plans and master drainage plans have been conducted in the watershed south of the Weld County line. The three most recent studies that are most relevant to current watershed conditions include: the *Rocky Flats Plant Drainage and Flood Control Master Plan for Woman Creek, Walnut Creek, Upper Big Dry Creek, and Rock Creek* ("Rocky Flats Master Drainage Plan"), which Wright Water Engineers prepared for EG&G Rocky Flats in 1992; the *Outfall Systems Planning, Big Dry Creek and Tributaries* ("Westminster Master Drainage Plan"), which Muller Engineering prepared for the Urban Drainage and Flood Control District, Adams County, Jefferson County, Jefferson County Airport, City of Broomfield, and City of Westminster in 1989 (as revised); and *Outfall Systems Planning North Area Tributaries (Adco)* (Wright Water Engineers 1989b).

The Rocky Flats report (Wright Water Engineers 1992) covers the watershed area from its headwaters to just below Great Western Reservoir and Standley Lake; the Muller (1989) study area reaches from this point to the Baseline Road, which is also the Weld County Line; and the Wright Water Engineers 1989 study covers the tributaries north of Big Dry Creek from 144th to the Weld County Line. The watershed area north and east of the Weld County line has not been studied in detail and remains primarily farm land. Highlights of each study are presented below, from upstream to downstream. It should be noted that these studies are now 5-10 years old and that some of the planned development at the time of these reports has been completed. The findings of these studies have not been updated to reflect current conditions.

Rocky Flats Master Drainage Plan

The Rocky Flats Master Drainage Plan (Wright Water Engineers 1992) focuses on five streams (all ephemeral) which drain across Rocky Flats including Walnut Creek, Woman Creek, Upper Big Dry Creek, Coal Creek, and Rock Creek, as shown in Figure 5. All of these streams are tributary to Big Dry Creek except Coal Creek and Rock Creek, which drains the northern portion of Rocky Flats to Coal Creek. Walnut and Woman Creeks drain most of the Rocky Flats site. Historically, Walnut Creek flowed into Great Western Reservoir, and Woman Creek flowed to Standley Lake. Flows from these two tributaries now bypass the reservoirs but ultimately discharge to Big Dry Creek. Upper Big Dry Creek still flows into Standley Lake. Six ditches also convey water across Rocky Flats.

The total area of the Walnut, Woman Creek and Upper Big Dry Creek basins, between their headwaters and Indiana Street, is 12.9 square miles. Characteristics of each of these basins are highlighted below:

- The Walnut Creek basin contains the "Industrial Area," or developed industrial portion, of Rocky Flats. This drainage slopes eastward at approximately 2.6 percent, draining towards Great Western Reservoir. Many detention and retention basins, including the A- and B-series ponds, exist in the Walnut Creek Basin. North and South Walnut Creeks flow to the east, joining together about 2,500 feet west of Indiana Street to form Walnut Creek.

The topographic and hydrologic characteristics of the basin vary considerably. The western portion of the basin from the mouth of Coal Creek Canyon to approximately the center of the site is relatively flat, sloping approximately 2 percent toward the east. There is no defined stream channel in this part of the basin. Most of the soil in the western portion of the site has a high infiltration rate. This area is presently undeveloped, with the exception of the highly developed Industrial Area at the eastern edge of the flat terrain.

The center portion of the basin consist of gullies with up to 20 percent side slopes and 4 percent channel slopes leading into the Walnut Creek tributaries. Most of the soils in this portion of the site have a low infiltration rate.

The eastern portion of the basin, including the northeastern portion of the Buffer Zone and the area east of the plant boundary to Great Western Reservoir, consists of broader valleys with about 5 percent side slopes and 2 percent channel slopes. The soil has low to medium infiltration characteristics. The eastern portion of the basin is presently undeveloped.

- The Woman Creek drainage basin extends eastward from the base of the foothills near the mouth of Coal Creek Canyon to Standley Lake. This basin includes the southern portion of the plant site. This basin is similar to the Walnut Creek basin, with relatively flat uplands followed by steep gullies draining to Woman Creek, followed by broader valleys adjacent to Woman Creek that drain towards Standley Lake. The north central part of the Woman Creek basin directly south of the Industrial Area has been removed from its historic pattern of drainage by the construction of the South Interceptor Ditch. This ditch routes runoff from the extreme southern part of the Industrial Area and the Buffer Zone between the South Interceptor Ditch and the Industrial Area to Pond C-2. The main channel of Woman Creek is routed to the north, around Pond C-2. The soil infiltration in this area varies according to topography, ranging from low to high.

- The Upper Big Dry Creek drainage basin extends eastward from the base of the foothills near the mouth of Coal Creek Canyon to Standley Lake. It also includes an area lying south of the Coal Creek tributary to Spring Creek that was historically tributary to Coal Creek instead of Big Dry Creek; this area is the "triangle" on the western boundary of the overall Big Dry Creek watershed. The Upper Big Dry Creek basin is similar to the Woman Creek and Walnut Creek basins, with gently sloping uplands followed by steep gullies draining to Upper Big Dry Creek and then broader valleys finally discharging to Standley Lake.

One significant aspect of the Rocky Flats site, from both hydrologic and regulatory perspectives, involves the 11 reservoirs that are used to contain surface water runoff, emergency spills and WWTP effluent to allow for sample collection and analysis prior to off-site discharge. The four A-series ponds (A-1, A-2, A-3, and A-4) lie northeast of the Industrial Area along North Walnut Creek, while the five B-series ponds (B-1, B-2, B-3, B-4, and B-5) lie just east of the Industrial Area along South Walnut Creek, as shown in Figure 5. There are two ponds in the C-series (Pond C-1 and C-2). Pond C-1 is a flow-through pond located on Woman Creek southeast of the plant. Pond C-2 is an off-channel pond which collects stormwater and other flows from the southern portion of Rocky Flats (Wright Water Engineers 1994).

Westminster Master Drainage Plan

The purpose of the Muller (1989) study was to present a comprehensive plan for the development of a drainage outfall system for the Big Dry Creek watershed in the northern portion of the Denver metropolitan region. The principal objectives were to propose solutions to existing drainage problems in developed areas and prevent the creation of drainage problems in areas of future development. The basin area evaluated in this study encompasses around 31 square miles located primarily in the City of Westminster and unincorporated Adams County (Figure 7). Key approaches to achieving the study goals recommended in the plan included regional detention ponding, improved channel conveyance, and floodplain preservation and regulation. The study area was divided into six study basins, the key characteristics of which are highlighted below.

- Standley Lake Basin. As of 1989, this area was less than 50 percent developed, with development actively continuing. The area was projected to be primarily residential, with open space limited to the areas along Big Dry Creek.

- Walnut Creek Basin. This area has a mixture of open space and large areas of industrial, commercial, and residential development.

- Hylands Hills Basin. This area was over 60 percent developed in 1989, with most development occurring in large tracts. The majority of this development is residential. The Hyland Hills Golf Course is located in this area in addition to several large parcels of land projected to remain as open space or park facilities. These include the Farmer's Highline Canal, the Westminster City Park at 104th and Sheridan Boulevard, and the floodplain land along Big Dry Creek. The north, middle, and south Branches of Hylands Creek are located in this basin.

- Airport Creek Basin: This basin includes the Jefferson County Airport and the Sheridan Green Subdivision, with the remaining area expected to be highly developed.

- Cozy Corner Basin. This basin includes middle and north Cotton Creeks, Ranch Creek, and several other unnamed outfall tributaries to Big Dry Creek. The majority of this basin lies under the jurisdiction of Westminster, with Jefferson County and Northglenn also having jurisdictional involvement. The area is primarily residential, with some industrial and commercial development in the eastern portion of the basin. The basin includes significant parcels of planned open space. These include the large Westminster Park north of the Front Range

Community College, the Ranch Golf Course, a Northglenn City park and open space adjacent to the Northglenn Water Treatment Plant, and floodplain land along Big Dry Creek.

- Lake Erie Basin. The southern third of the basin lies in Westminster; the middle third lies within Thornton, and the remainder is located in unincorporated Adams County. This basin is less developed than the others (less than 50 percent in 1989). Land use projections indicate that industrial and commercial development and multifamily housing will predominate in the southern half of the basin, with low- to mid-density single-family housing in the northern half. Examples of development in this basin include Park Centre, the AT&T complex, the Wexford Station apartment community, and Hunters Glen, North Star, Cherrywood Park, Spring Valley and Wadley Farms subdivisions. Tanglewood Creek discharges into Big Dry Creek near I-25.

The drainage plan discusses the Big Dry Creek channel, describing it as relatively similar in nature from below Standley Lake to the Weld County line. The channel includes a "normal flow channel" between 15 and 40 feet wide and between 3 and 10 feet deep. The banks of the "normal flow channel" are steep and sometimes vertical. Erosion of the banks is common and may be seen along the entire reach of Big Dry Creek. The "normal flow channel" meanders through a wide floodplain which is as much as a half mile wide at the Weld County line. The floodplain is generally uninhabited, except for a few homes and farm buildings. The channel appears to be in a relatively active meandering state, exhibiting numerous "horse-shoe" bends which appear to be migrating in typical stream fashion. Flood flows exceeding the "normal flow channel" can spread over pasture and croplands in the wide floodplain to depths varying from a few feet to as much as 20 feet, depending upon constrictions at the various road and railroad crossings.

Muller (1989) reported that the Greiner (1986 and 1988) flood hazard studies identified three general problems:

1. channel bank erosion and migration of channel meanders,

2. several homes or businesses located in the 100-year floodplain, and

3. a large number of street and highway crossing structures which have inadequate capacity to carry the fully developed 100-year flood (Greiner 1986, Greiner 1988, Muller 1989).

To address these problems, Muller (1989) recommended a floodplain regulation approach that relies on floodplain and floodway ordinances to control the location of development. In addition, improvements to crossing structures and erosion control structures within the channel and a levee around the Broomfield Wastewater Treatment Plant were also recommended. The study recommended that the channel of Big Dry Creek be maintained in its present and natural state, including maintenance of the meandering channel pattern. However, as development increases upstream, greater and more frequent flood flows and greater sustained low flows will be experienced, increasing the rate of channel bank erosion. The study indicated the general degradation of the channel bed will be relatively minor, because the channel is already at a very flat slope. Several figures in the Muller (1989) report identify proposed measures to help control erosion.

Outfall Systems Plan North Area Tributaries (Adco)

Continuing downstream, Wright Water Engineers (1989b) completed the *Outfall Systems Planning North Area Tributaries Big Dry Creek (Adco)* for the 18.7-square-mile area from 144th Avenue to the Weld County line (168th Avenue). The study area encompassed nine major tributaries, including: Wadley South Creek, Wadley North Creek, Short Run, Elms Run, Morris Creek, Shay Ditch, Mustang Run, Sack Creek, and Preble Creek. In 1989, the study area was essentially undeveloped cultivated land with only three low-density residential developments. The study showed that the existing culverts did not have adequate capacity to convey even the minor storm runoff without road overtopping. The 100-year floodplain is very wide, and increased velocity due to higher future peak flows will cause extensive channel erosion. The three major problems identified were lack of channel conveyance, potential for erosion and sedimentation, and road overtopping during minor floods (Wright Water Engineers 1989b).

To help solve these problems, the selected outfall systems included the use and/or expansion of existing inadvertent detention areas and channelization from the upstream to the downstream limit. Road crossings were designed to convey the 100-year flow without road overtopping. The open channels selected for the outfall system included engineered wetland bottom, engineered wetland bottom with bench, and engineered grass-lined channels (Wright Water Engineers 1989b).

Flood Hazard Area Delineations

Several floodplain studies have been conducted in the Big Dry Creek watershed; the two most recent of which include *Flood Hazard Delineation, Big Dry (ADCO)*, prepared by Greiner Engineering in December 1988, and *Flood Hazard Delineation, Big Dry (ADCO) North Area Tributaries*, prepared by Wright Water Engineers in July 1989. The Greiner (1988) study included the Big Dry Creek reach from the headwaters to I-25 followed by the Wright Water Engineers (1989a) study from I-25 to the Weld County line.

Greiner (1988) and Wright Water Engineers (1989a) indicated that, because of the historically undeveloped nature of the floodplain areas, relatively little flooding history was available. Two floods that were documented included the May 1973 flood in the vicinity of Huron Street and the June 1984 flood along the middle branch of Hylands Creek at Sheridan Boulevard. Damage was confined to the culvert crossings during these historic events (Greiner 1988). Further downstream, flooding was noted at 160th Avenue and 162nd Avenue where runoff overflowed from the stream channel, purportedly due to insufficient culvert capacity under the Union Pacific Railroad embankment (Wright Water Engineers 1989a). Greiner indicated that potential flood damage in its study area was due primarily to un-maintained channel areas with high roughness values, un-maintained culverts full of sediment, and undersized stream crossings. Standley Lake and Great Western Reservoir were identified as providing significant flood control benefits.

6.0 POLLUTANT SOURCES

Pollutant contributions to Big Dry Creek can occur through a wide range of sources. Several sources potentially applicable to the Big Dry Creek are described below.

Wastewater

As discussed in Section 4.0, four significant wastewater treatment facilities discharge to Big Dry Creek. Contaminants in these discharges are restricted under the NPDES/CDPS permit system.

Stormwater

As stormwater flows over land surfaces, it collects a wide range of pollutants. Urbanized areas often have increased pollutant loadings as impervious areas increase, decreasing the amount of infiltration of rainfall into the ground. Stormwater quality monitoring is not known to have been conducted in the watershed with the exception of Rocky Flats. As part of water quality monitoring in the Standley Lake area, stormwater monitoring has been recommended.

Construction Sites

One of the largest potential sources of pollution in the watershed is sediment-laden runoff from construction sites associated with the widespread land development in the watershed. It is important that best management practices (BMPs) be implemented on these sites to minimize adverse impacts to water quality due to pollutants contained in runoff from such sites. The CDPHE requires general stormwater permits for construction sites disturbing five or more acres. As a condition of these permits, a Stormwater Management Plan (SWMP) is required to be developed and implemented. City and county ordinances for construction sites may also apply as part of development approvals. It is important that stormwater ordinances and implementation of BMPs at construction sites be enforced. Participants in the Big Dry Creek Watershed Association generally agree that construction-related impacts to water quality are likely significant in the watershed and require attention (Big Dry Creek Watershed Association Meeting Minutes, March 20, 1998).

Non-point Pollution Sources

Non-point sources of pollution are areas of overland stormwater runoff that are not directed to storm sewer systems or wastewater treatment plants; in other words, there is no single "point" at which to control the discharges. Non-point sources of pollution are difficult to control and regulate. Key non-point sources of pollution in the Big Dry Creek watershed, particularly in the downstream reach in Weld County, may include agricultural areas where cattle drink water from the stream or where stormwater collects pollutants such as fertilizers and pesticides while running off of cultivated fields. Sediment from gravel county roads and bridges and road sanding/de-icing are other examples of non-point sources. Runoff from golf courses may also be a source of nutrient and pesticide loading.

Other Regulated Facilities

In addition to the previously discussed WWTPs, which are regulated under the NPDES/CDPS program, and Rocky Flats, which is regulated under RCRA, Comprehensive Environmental Response Compensation and Liability Act (CERCLA), the NPDES program and other regulations, there are also other facilities in the watershed that are regulated or listed under state and federal environmental regulations.

In order to obtain a general overview of these facilities in the Big Dry Creek watershed, queries were run on EPA's "Envirofacts" database system for the cities of Broomfield, Westminster, Northglenn, and Thornton. The west and east ends of the watershed, located in Jefferson and Weld Counties respectively, were only searched at a cursory level that was restricted to CERCLA and Toxic Release Inventory System (TRIS) sites because the majority of their land areas are not located within the watershed. The Envirofacts system provides a search of EPA's databases including: the Permit Compliance System (PCS) database for NPDES regulated facilities; CERCLIS (the CERCLA Information System) database for National Priorities List facilities regulated under CERCLA (Superfund); TRIS for facilities with toxic releases regulated under RCRA; the RCRA database which includes a variety of facilities that are permitted to handle hazardous wastes; and the air release database under the Clean Air Act.

To give an idea of the scope of businesses and industries within the watershed that are regulated in some way, the following numbers of facilities are regulated in each city within the watershed: Broomfield—138, Northglenn—55, Westminster—115, and Thornton--85. Most of these listings are for hazardous waste handling. With regard to the limited search conducted in Jefferson and Weld Counties, no toxic releases or Superfund sites were identified within the watershed boundaries in Weld County, although 32 toxic release sites were identified in Jefferson County. The Rocky Flats Superfund site is the only CERCLA facility located within the watershed boundaries in unincorporated Jefferson County. Given these numbers, it is reasonable to estimate around 400 regulated facilities in the watershed, taking into account that there are probably some additional facilities in the counties and that some areas within the cities are actually located outside of the watershed boundaries. These numbers are based on EPA data as of December 13, 1997.

The reasons why each facility is listed were not researched; however, this information can be obtained through EPA in the future, if needed. The summary information presented in Table 4 was retrieved directly from the EPA database (EPA 1997) and has not been field verified.

Table 4
CERCLIS and TRIS Facilities
Big Dry Creek Watershed

CERCLIS Facilities (Superfund)		
COD982598047	Chemwest Corp	11811 Upham St. Unit B; Broomfield, CO 80020
CO0000255224	Beryl Ore Co./ Westminster Beryllium	W. 100th Ave & Alkire St; Westminster, CO 80021
CO7890010526	Rocky Flats	Hwy 93 Between Golden and Boulder; Golden, CO 80402
CO0002015840	Grove Containers	9100 Grove St.; Westminster, CO 80030
COD981550692	FRICO	136th & Silverton St; Broomfield, CO 80020
CO0002014025	Generic Storage Site	7620 W. 116th Ave.; Broomfield, CO 80226
COD983793977	Sun Chemical Corp-GPI Div.	2135 Abbott Ave; Broomfield, CO 80020
TRIS Facilities (Toxic Spills)		
COD059256651	AT&T (Lucent Technologies)	1200 W. 120th Ave.; Westminster, CO 80234
COD982647570	Ball Aerospace Mfg.	9675 W. 108th Circle; Westminster, CO 80020
COD005387188	Cork Lab Inc.	2555 W. Midway Blvd.; Broomfield, CO 80038
COD983774910	Fusion Specialties, Inc.	11020 Leroy Dr.; Northglenn, CO 80233 & 2400 Industrial Ln # 500; Broomfield, CO 80020
COD078353901	Microsemi Corp Colorado	800 Hoyt St.; Broomfield, CO 80020
COD177307311	Velie Circuits, Inc.	555 Alter St. Ste 19; Broomfield, CO 80020

7.0 EXISTING MONITORING PROGRAMS

A variety of water-related monitoring programs exist in the watershed as described below. Available data from these monitoring programs have been included in the Big Dry Creek Water Quality Database, which was developed concurrently to this report. A summary of the database is provided in Appendix A.

Wastewater

Monitoring of wastewater discharges from the Broomfield, Northglenn, Westminster, and Rocky Flats WWTPs is required under the discharge permits for each facility. The permit limits imposed on these dischargers were previously presented in Table 2. Data for up to the last five years for each of these facilities has been included in the water quality database concurrently developed with this report.

Surface Water

A variety of surface water monitoring programs are in place including: the Rocky Flats surface water monitoring program; the Big Dry Creek in-stream water quality and aquatic life program

conducted by the cities of Broomfield, Northglenn and Westminster; the CDOW Riverwatch program; the Standley Lake program; and the Great Western Reservoir monitoring program.

Rocky Flats

The Rocky Flats Surface Water Monitoring Program encompasses five key areas: site-wide water quality, quality of waters within the Industrial Area, quality of discharges from the Industrial Area, quality of water leaving the site and off-site water quality. Appendix C contains a surface water monitoring matrix describing the extensive sampling conducted under this program (RFETS 1998). The program ensures that regulatory discharge limits and water quality requirements are met and that potential contaminant releases from the Industrial Area are detected. Figure 8 depicts the locations of the surface water monitoring stations. The *RFETS Integrated Monitoring Plan FY98/99* (RFETS 1998) should be referenced for more detail on the specifics of the extensive monitoring program.

For purposes of data inclusion in the Big Dry Creek water quality database, two automated gauging stations are of particular interest because they reflect the quality of water at the eastern-most points before it leaves the site. These are stations GS01 at Woman Creek and Indiana Street and GS03 at Walnut Creek and Indiana Street. These stations are monitored for various metals, radionuclides, and nutrients (Parker-Hall 1997).

Big Dry Creek In-stream Monitoring Program (Water Quality and Aquatic Life)

Since 1988, the cities of Broomfield, Northglenn, and Westminster have been conducting a combined water quality monitoring program on Big Dry Creek. These data are contained in the Big Dry Creek water quality database. Currently, the monitoring program is driven in part by the findings of the CWQCC December 1996 water quality hearings where there was conflict between the CDOW and the cities as to whether the un-ionized ammonia standard should be 0.06 mg/L or 0.1 mg/L. The CWQCC stated that "there was not enough evidence to justify adopting the more stringent standard at the present time." However, the CWQCC also encouraged the "cities discharging to this segment, the Division of Wildlife and the WQCD to work together to assess the future in-stream conditions in this segment resulting from anticipated effluent dechlorination efforts and municipal water supply/wastewater discharge operational changes."

As a result of CWQCC's statement, the cities decided to expand what had been a water quality monitoring program to also include biannual bioassessments. The list of water quality parameters was also expanded to include those that could adversely impact aquatic life. The goal of the expanded monitoring program is to help determine conditions and abundance of the aquatic life to provide insight for best management practices and habitat improvement, which should help protect and preserve the aquatic integrity of the stream. The water quality monitoring and analysis involved a documented quality assurance and quality control (QA/QC) protocol.

The bioassessment is based on EPA's Rapid Bioassessment Protocol (RBP) III for benthic macro invertebrates and RBP V for fish assessment. Habitat assessment is a part of these protocols. The intent of the fish surveys is to obtain a representative estimate of the fish species present and establish their abundance and condition. For more detail on these procedures, the EPA manual *Rapid Bioassessment Protocols for Use in Streams and Rivers* should be referenced (EPA 1989).

The monitoring sites for the program are provided in Table 5 below and shown on Figure 1. Changes may be made to the program in 1998 in response to the results of the 1997 program which have not yet been analyzed.

Table 5
Big Dry Creek In-stream Monitoring Program 1997

		Flow	Water Quality	Biological	Habitat
Site #	**Location**				
0.1	Below Standley Lake Dam		**X**	**X**	**X**
0.5	Old Wadsworth Boulevard	**X**	**X**	**X**	**X**
1.0	112th and Big Dry Creek	**X**	**X**	**X**	**X**
1.5	120th and Big Dry Creek		**X**		
Broom	Broomfield WWTP		**X**		
2.0	128th and Big Dry Creek	**X**	**X**	**X**	**X**
Westy	Westminster WWTP		**X**		
3.0	I-25 and Big Dry Creek	**X**	**X**	**X**	**X**
4.0	York St. and Big Dry Creek		**X**		
Northg	Weld County Road 15		**X**		
5.0	Weld County Road 4	**X**	**X**	**X**	**X**
6.0	Weld County Road 23	**X**	**X**	**X**	**X**

Rivers of Colorado Water Watch Network

In 1990, CDOW started the Rivers of Colorado Water Watch Network program to involve middle/ junior high and high school students and their teachers in protecting the quality of Colorado rivers (CDOW 19996a). In 1993, Broomfield and Northglenn High Schools began monitoring Big Dry Creek's in-stream water quality. Currently, only Standley Lake High School is involved in the program. Data collected by these schools, including basic water quality indicators and several metals, have been included in the water quality database. Barbara Horn, CDOW aquatic biologist, is the program director. Wayne Cowell, a science teacher at Standley Lake High school, is involved with the monitoring program on Big Dry Creek (Horn 1997).

Standley Lake

An extensive water quality monitoring program is conducted at Standley Lake because of its use as a major drinking water supply. The Cities of Westminster and Thornton began a long-term water quality monitoring program for Standley Lake and its tributaries in 1980. Northglenn began participating in the monitoring program in 1985. The monitoring program has been modified several times since 1980, with changes made in the sampling locations, the number of sampling parameters, and some field procedures. The USGS has also conducted monitoring of the lake and its tributaries from June 1989 to October 1990 (RBD 1994).

The cities' monitoring locations are shown in Figure 10. Parameters monitored included both field and laboratory measurements. Field measurement of dissolved oxygen, temperature, pH, turbidity,

and conductivity are conducted. Laboratory analysis of nutrients, metals, radionuclides, fecal coliform, chlorophyll-a, and algae are also conducted. Particular emphasis is placed on nutrients and algae in order to maintain the mesotrophic status of the lake (RBD 1994).

As part of the future Standley Lake Park, targeted water quality monitoring will also be conducted to measure recreational impacts. In addition to the parameters already included in the monitoring program, indicators of petroleum contamination, such as total volatile hydrocarbons (TVH) and total extractable hydrocarbons (TEH), are proposed to be included as part of this expanded program (Wright Water Engineers 1996b).

Great Western

Because the use of Great Western Reservoir changed significantly after the 1997 completion of the Great Western Reservoir Replacement Project, the historical monitoring program conducted by the City of Broomfield has recently been revised to reflect the current irrigation storage use. The current monitoring program includes collection of grab samples on a monthly basis which are analyzed for gross alpha/beta, total/fecal coliforms, and volatile organic compounds. Temperature/dissolved oxygen profiles are measured at least quarterly and depth-integrated composite samples are analyzed for metals, inorganic non-metals, raidonuclides, nutrients, chlorophyll and general water quality indicators. Although the CDPHE historically monitored Great Western, they no longer monitor this reservoir. Walnut Creek at Indiana and the Walnut Creek diversion outfall are monitored with results presented on a quarterly basis at the Exchange of Rocky Flats Environmental Information Meeting (Mahan 1998).

The City of Broomfield's Annual Water Quality Reports can be referenced for a description of the historical water quality monitoring program and data for Great Western Reservoir.

Stormwater

As previously mentioned, stormwater monitoring is not known to have been conducted within the Big Dry Creek watershed, with the exception of Rocky Flats. A brief summary of the stormwater program at Rocky Flats is provided below.

Stormwater quality has been monitored at Rocky Flats since 1989 as a part of a number of programs and, most notably, to support the revised NPDES permit application submitted to the EPA in 1992 and to provide data for RFCA compliance. The most recent and complete data regarding stormwater quality are contained in several reports including the "Event-Related Surface-Water Monitoring Reports" beginning in 1991 and continuing through 1994 (EG&G 1993a; RMRS 1995), the *Stormwater NPDES Permit Application Monitoring Program, Rocky Flats Plant Site* (Advanced Sciences, Inc. 1993), the actual NPDES permit application submitted to the EPA in October, 1992, the *Pond Water Interim Measures/Interim Remedial Action (IM/IRA) Plan* (Wright Water Engineers 1994) and the Annual Reports for the Industrial Area IM/IRA (Wetherbee 1998).

The purpose of the stormwater monitoring program at Rocky Flats is to collect, interpret, and disseminate available data on storm-related surface water hydrology and quality at Rocky Flats with an emphasis on the fate and transport of metals and radionuclides. Approximately 30 long-term gauging stations are present at the site, equipped with hardware to continuously monitor water levels

and collect water quality samples when stream stage increases in an effort to capture each runoff event (Wetherbee 1998). A full discussion of the stormwater monitoring program results is beyond the scope of this report; however, the reports identified above may be reviewed for specific conclusions, as needed.

Groundwater

General

Other than studies conducted at Rocky Flats, relatively little readily available information was identified with regard to groundwater in the watershed. However, most of the unincorporated areas within the watershed rely on groundwater drawn from private wells. These wells were not inventoried for the purposes of this report, but that could be accomplished relatively easily through the State Engineers' Office in subsequent revisions of this report. Several groundwater monitoring wells are located behind the Front Range Community College; however, these are infrequently monitored for a relatively small number of parameters such as water elevation, pH and conductivity. These wells could be used in the future if groundwater monitoring is identified as a priority for the watershed group (Barth 1997). In addition, several drinking water wells are known to be located in the vicinity of the Big Dry Creek In-stream Monitoring Program Site 6.

Rocky Flats

The groundwater at Rocky Flats has been contaminated with radionuclides, chemicals, metals, and other substances from past spills, leaks, former wastewater management, and disposal practices and releases from other activities. The contaminated areas have formed several groundwater contaminant plumes which are slowly migrating. Much of the groundwater discharges to the surface water and may impact surface water quality. In response, Rocky Flats maintains an extensive integrated network of monitoring wells to monitor the groundwater quality across the site. Currently, there are over 250 active monitoring wells as shown in Figure 9. Groundwater monitoring activities include analyses for chemical and radionuclide contamination, identification, and tracking the extent and movement of pollutant groundwater and measurement to interpret and define the groundwater hydrology. The wells are monitored according to the following schedule: 89 wells sampled for specific analytes on a semiannual basis, monthly measurement of water elevations at 72 wells, a quarterly measurement of water elevations at 68 additional wells, semiannual measurement of water elevations at another 100 wells, and real-time measurement of water elevations at 25 wells (Singer 1998). The *RFETS Integrated Monitoring Plan FY98/99* should be referenced for more detail on this program (RFETS 1998).

Of particular interest to the Big Dry Creek watershed are the six boundary wells located downgradient of the Industrial Area along the eastern site boundary. These wells are located within the major site drainages and sub-drainages. Samples collected from these wells are analyzed for plutonium, americium, uranium, tritium, nitrate, fluoride, and sulfate.

8.0 SPECIAL STUDIES

STREAMDO Modeling

In 1992, Brown and Caldwell completed modeling of Big Dry Creek using the "STREAMDO" model at the request of the City of Northglenn. The report provided a good start at characterization of water quality in Big Dry Creek. Data input into the model included pH, flow, temperature, dissolved oxygen (DO), carbonaceous biological oxygen demand (CBOD), organic nitrogen, ammonia, and nitrate/nitrite measured in the Westminster, Northglenn, and Broomfield WWTP discharges. Stream flow data were obtained from the USGS gage #06720820, and diversion records were obtained from the State Engineers' Office for relevant ditches including the Bull Canal, German Ditch, Thompson Ditch, Yoxall Ditch, and Lupton Bottoms Ditch. After calibrating the model to stream conditions, stream DO and un-ionized ammonia conditions were modeled over a range of Northglenn discharge conditions. The Brown and Caldwell (1992) report provides the results and plots of the model runs. Brown and Caldwell provided a number of recommendations for future monitoring, modeling options, and other issues. These recommendations are contained in Appendix D because of their importance in guiding future water quality efforts in the watershed.

USGS NAWQA

The USGS has conducted a National Water Quality Assessment (NAWQA) Program study in the South Platte River Basin. This extensive study was conducted throughout the entire South Platte River Basin including the three-state area of Wyoming, Nebraska, and Colorado. The NAWQA program summarizes and characterizes watersheds based on a variety of information including climatological data, land use, demographics, surface water quality, groundwater, and biology/habitat. Although the study is valuable and comprehensive in terms of the overall South Platte watershed, the monitoring stations used in the study are not located within the Big Dry Creek watershed; therefore, data specifically applicable to the Big Dry Creek watershed are not available (USGS 1997). The NAWQA study does, however, provide a larger framework in which to view the Big Dry Creek watershed.

Natural Resources Conservation Service (NRCS)

The NRCS (formerly the Soil Conservation Service) works with farmers and others to develop soil conservation plans and serves as an information resource for farmers. The NRCS has indicated that issues which concern farmers in the Big Dry Creek area include topics such as flooding, sediment loads, stream stability, and salinity (Rogers 1997).

The NRCS promotes creation of buffer zones along the creek bank and helps to provide cost-sharing for such efforts. The NRCS has developed a proposal for grant funding for stream stabilization measures in rural Adams and Weld counties between 152nd Avenue and the South Platte River. The proposal documents that over 100 years of livestock grazing with uncontrolled access to Big Dry Creek, coupled with the close proximity of cropland, has contributed to serious soil erosion and reduced water quality where the stream flows through agricultural lands. The report also documents that upstream urban growth has resulted in increased impervious area with rapid runoff conditions, which has caused more frequent flooding in these downstream rural areas. Objectives of the NRCS

are to implement conservation practices to reduce soil erosion, improve riparian wildlife habitat, improve water quality, and improve pasture, cropland and livestock health and productivity (Rogers 1997).

DRCOG

In 1989, DRCOG completed the Lower South Platte Water Quality and Wastewater Management Study. This study did not identify any serious water quality problems with Big Dry Creek below Standley Lake; however, limited water quality data were available for the evaluation. The study indicated that impacts of nonpoint sources on Big Dry Creek would need to be considered in a future nonpoint source program (DRCOG 1997b).

DRCOG also modeled the projected dissolved oxygen levels in Big Dry Creek over the next 20 years, but identified no potential problems at existing or proposed treatment levels. DRCOG recommended that Big Dry Creek water quality continue to be monitored (DRCOG 1997b).

DRCOG has taken a lead role in work related to the South Platte Urban Watershed Total Maximum Daily Load (TMDL) process. Big Dry Creek is included in this work, as discussed in more detail in Section 11.0. The Big Dry Creek Watershed was recently designated as a hydrologically distinct watershed relative to the Urban South Platte Watershed (DRCOG 1998b).

Upper Clear Creek Watershed Association

The activities of the Upper Clear Creek Watershed Association are of interest to the Big Dry Creek watershed because they influence the quality of water transported to Standley Lake, which is the primary drinking water supply for the cities of Westminster, Thornton, and Northglenn. Pollutants from the Clear Creek watershed transported to Standley Lake may originate from WWTP discharges, stormwater runoff, mine drainage and various non-point sources. The 1993 Upper Clear Creek Watershed Agreement contains provisions for implementation of BMPs and other measures to protect water quality in Clear Creek, the ditches that transport Clear Creek water and in the land areas adjacent to Standley Lake.

GIS Mapping

As part of future watershed efforts, it may be desirable to integrate water quality data, land use information, stormwater outfall and tributary locations, ditch diversions and other data through geographic information systems (GIS) mapping. GIS mapping for various parts of the watershed is available from Jefferson County, the City of Westminster, and the City of Thornton, Rocky Flats CDOW (Preble's Meadow Jumping Mouse habitat) and DRCOG. Adams County is in the process of developing its GIS mapping and currently has some land use mapping available in GIS. The City of Northglenn has various coverages available that can be accessed by ArcView (a GIS software) if desired. The City of Broomfield's mapping is currently in AutoCAD although funding has been obtained to complete some very limited "pilot" mapping in GIS. Weld County does not have GIS mapping available. EPA's Envirofacts database offers mapping of various regulated facilities.

9.0 WATER RIGHTS AND DITCH DIVERSIONS

As is the case in most of Colorado's streams, Big Dry Creek flows are significantly influenced by a complex system of water rights that controls ditch diversions, reservoir releases, and required return flows. Appendix E provides a tabular summary of the water rights decrees for Big Dry Creek. The figure in Appendix E provides a "straight-line diagram" for Big Dry Creek depicting over 70 water rights decrees. The majority of these water rights are owned by the cities of Westminster and Thornton, with the remainder primarily owned by private land owners. The majority of the decreed uses are for irrigation (or irrigation and recreation), with the remainder decreed for municipal uses.

Other water rights are also in place on the upstream tributaries including Walnut and Woman Creeks in the Rocky Flats area. For example, Mower Ditch diverts from Woman Creek in the eastern portion of Rocky Flats and supplies Mower Reservoir east of Indiana Street (Wright Water Engineers 1994).

A significant amount of water is diverted from Clear Creek and Coal Creek into the watershed. Coal Creek water is diverted into the watershed via the Upper Church Ditch, Kinnear Ditch No. 2, the Last Chance Ditch and Smart Ditch No. 2. The Farmer's Highline Canal, Church Ditch and the Croke Canal divert and transport water from Clear Creek near Golden to Standley Lake. The Cities of Thornton and Westminster own over 50 percent of the Farmer's Highline Canal water. As previously mentioned, from a water quality perspective, the Clear Creek water may be impacted from both point source and non-point source discharges into Clear Creek as well as into the ditches conveying the water to Standley Lake. For this reason, the Big Dry Creek Group should maintain involvement with the Upper Clear Creek Watershed Association.

The Farmer's Reservoir and Irrigation Company (FRICO) controls releases of water from Standley Lake to meet water rights obligations (not to sustain flows in Big Dry Creek) (Kimsey 1998). Water released to Big Dry Creek is later diverted from the stream by the Bull Canal (Whipple Ditch) from roughly between the Broomfield and Westminster WWTP discharges. Other significant downstream diversions include the German Ditch, which diverts water from Big Dry Creek below the Westminster discharge and east of I-25 and the Thompson Ditch (Big Dry Creek Ditch), which diverts water from Big Dry Creek north of 160th Avenue.

The ditches and canals in the Big Dry Creek drainage are earthen and require periodic maintenance to remove flow restrictions from vegetation and sediment deposition. Ditch cleaning operations can expose soil on ditch banks that can be later washed into the ditches during storm events. Dredged spoils from cleaning can also be washed into the ditches (Cities of Westminster and Northglenn 1994).

One of FRICO's key concerns in the watershed is the impact of increasing stormwater flows in the creek due to increased development. The various ditch headgates are not designed to withstand these increased flows and in some instances have nearly been washed out during storm events in the last few years (Montoya 1998).

10.0 WATER SUPPLIES

The cities and counties located within the Big Dry Creek watershed boundaries rely on a variety of water sources. The cities are primarily served by water stored in Carter Lake and Standley Lake. For the most part, farmers in the county areas rely on well water for domestic purposes and FRICO water released from Standley Lake for irrigation purposes.

Until August 1997, the City of Broomfield's primary water supply was based on Great Western Reservoir. Since then, under "Option B," a new $75-million water supply has been developed. The alternative water source is 4,300 acre-feet of water from the western slope of Colorado that is transported through the Colorado-Big Thompson/Windy Gap system under management of the Northern Colorado Water Conservancy District. The water is stored on the east slope in Carter Lake in Larimer County. The water is then conveyed in 32 miles of pipeline to the recently constructed Broomfield Water Treatment Facility. The facility's current capacity is 8 MGD, and this can be expanded to up to 20 MGD (City of Broomfield 1997).

Standley Lake is the sole source municipal water supply for the cities of Westminster and Northglenn and a major water supply source for the city of Thornton. See the discussion of the Standley Lake Protection Project in Section 3.0 for recent measures implemented to protect this water supply.

FRICO provides the primary source of irrigation water used by farmers in the watershed. This water is stored in Standley Lake and released to Big Dry Creek for delivery to the downstream farms. This water is then diverted and distributed via various canals and ditches (Montoya 1998; Kimsey 1998).

11.0 REGULATORY FRAMEWORK AND ISSUES

Stream Standards/CWQCC Hearings

The Colorado Water Quality Control Commission adopted the "Classifications and Numeric Standards South Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin 3.8.0" in April 1981. Since that time, the standards have been amended nearly 40 times, with the most recent being March 3, 1997. The Big Dry Creek watershed is regulated under these classifications and standards. Appendix F summarizes the stream segment descriptions, designations, classifications, numeric standards, and temporary modifications and qualifiers. Figure 11 illustrates the locations of these segments.

There are seven stream segments specified for the Big Dry Creek watershed in the regulations including:

- Segment 1. Main stem of Big Dry Creek, including all tributaries, lakes and reservoirs, from the source to the confluence with the South Platte River, except for specific listing in Segments 2, 3, 4a, 4b, 5, and 6.

- Segment 2. Standley Lake.

- Segment 3. Great Western Reservoir.

- Segment 4a. Main stem and all tributaries to Woman and Walnut Creeks from sources to Standley Lake and Great Western Reservoir except for specific listings in Segments 4b and 5.

- Segment 4b. North and South Walnut Creek and Walnut Creek, from the outlet of Ponds A-4 and B-5 to Indiana Street.

- Segment 5. Main stems of North and South Walnut Creek, including all tributaries, lakes, and reservoirs from their sources to the outlets of Ponds A-4 and B-5 on Walnut Creek and Pond C-2 on Woman Creek. All three ponds are located on Rocky Flats property.

- Segment 6. Upper Big Dry Creek and South Upper Big Dry Creek, from their source to Standley Lake.

It should be noted that a narrative standard is in place for Standley Lake (Segment 2), which requires that the reservoir be maintained in a mesotrophic state. This standard was negotiated by the cities in the Big Dry Creek and Upper Clear Creek watersheds and was adopted by the CWQCC in 1994 (DRCOG 1998b).

Wastewater Discharge Permits

The Cities of Westminster, Broomfield, and Northglenn and Rocky Flats discharge effluent to the watershed under NPDES/CDPS permits. See Section 4.0 for more detail on these WWTPs.

Total Maximum Daily Loads (TMDLs)

Overview

The TMDL process is designed by the Clean Water Act to ensure that all sources of pollutant loading are accounted for when devising strategies to meet water quality standards. The TMDL itself is an estimate of the greatest amount of a specific pollutant that a water body or stream segment can receive without violating water quality standards. This amount includes a "margin of safety," a waste load allocation for point sources, and a load allocation for non-point sources and natural background. The TMDL process is a method of analyzing pollution sources and allocating responsibility among those sources (CDPHE 1997c).

Section 303(d) of the Clean Water Act requires states to identify waters that do not, or are not expected to, meet applicable water quality standards with technology-based controls alone. These findings are identified in a biennial "303(d)" list. Once listed, the state is required to prioritize their waters, analyze the causes of the water quality problem, and allocate the responsibility for controlling the pollution (CDPHE 1997c).

Relevance to Big Dry Creek

The state has recently developed the 1998 303(d) list, and the main stem of Big Dry Creek is not on this list. The primary TMDL issue with regard to Big Dry Creek is that Segment 15 of the South

Platte River is identified on the 303(d) list. This is the segment of the river from Burlington Ditch to a point immediately below the confluence with Big Dry Creek. Because Big Dry Creek is tributary to the South Platte in the Segment 15 reach, it will be affected by the TMDL process. Prior to 1998, Big Dry Creek was not categorized as being unique or separate from the overall Urban South Platte Watershed; however, as part of the TMDL assessment process, Big Dry Creek was determined to be hydrologically distinctive from the remainder of the Urban South Platte Watershed (DRCOG 1998b). As a result, Big Dry Creek has been identified as a "work group" by the South Platte Urban Watershed TMDL Committee. Another tributary, Sand Creek, is also included as a work group (DRCOG and Camp Dresser and McKee 1998). Key wastewater dischargers to Segment 15 include the Metropolitan Wastewater Reclamation District, the South Adams County Water and Sanitation District, the City of Brighton, and the City of Wattenburg (DRCOG 1997b).

The South Platte Urban Watershed TMDL Advisory Group reports the constituents of concern for Segment 15 to include ammonia, metals (cadmium, copper, lead, mercury, selenium, manganese), and dissolved oxygen. The segment is currently identified as "not supporting" designated uses for ammonia and dissolved oxygen. Studies showed that municipal wastewater discharges to this segment were the greatest contributors of nitrogen, phosphorus, and organic carbon on an annual basis (DRCOG 1997b; DRCOG and Camp Dresser and McKee 1998). DRCOG also reports that urban runoff has been identified as producing a large portion of the annual load of total suspended solids and total lead with significant quantities of sediment, organic matter, trace metals, and bacteria. Although these loads can and often do exceed the quantities discharged from municipal sources, these loads are intermittent flows for short durations of time, and their effect on designated uses has not been demonstrated. DRCOG reports that groundwater quality in the Lower South Platte study area has been affected by previous waste disposal and agricultural practices. Contamination associated with urbanization including non-point source runoff has affected groundwater quality in the shallower aquifers (DRCOG 1997b).

Status of the Urban South Platte TMDL Process

The *Final Draft South Platte Urban Watershed Total Maximum Daily Load Process Phase II: Regulatory Processes, Model Development, Screening Criteria and Copper and Nitrate Evaluation* was released by the South Platte Urban Watershed TMDL Advisory Committee in January 1998. This 139-page report summarizes key information about the TMDL process. A few specific highlights include:

- Stormwater loading has been identified as a key area of concern by CDPHE and EPA.
- Nitrate and copper will be the first constituents to be modeled.
- Selected models for the TMDL process include the Watershed Management Model (WMM) for modeling stormwater and non-point source impacts and STREAMDO for the receiving water model. Data requirements for the WMM model include pollutant type, land use, average precipitation, annual base flow and average base flow pollutant concentrations. WMM uses Lotus 1-2-3 as the spreadsheet program shell.
- Modeling will include both low flow and storm flow conditions.

- Big Dry Creek beginning at the Standley Lake Dam is treated as a point source for the receiving water model.

- Recommended parameters for monitoring purposes are identified and contained in Appendix G.

Other important conclusions and recommendations are provided that have not been described in the above list. The DRCOG and Camp Dresser and McKee (19998) report should be referenced for more detail.

Municipal Stormwater Permits

At this time, none of the municipalities in the Big Dry Creek watershed are required to obtain NPDES stormwater permits because they are below the population thresholds of 100,000 and 250,000. (Note: Rocky Flats is required to have a stormwater NPDES permit.) However, this is expected to change as EPA's Phase II stormwater regulations are finalized. The draft regulations were released in the late fall of 1997 and are currently under public comment. As currently drafted, the municipalities in the Big Dry Creek watershed would be subject to regulation.

The proposed requirement of the Phase II stormwater program should be considered when designing BMPs and stormwater monitoring programs for Big Dry Creek.

Stormwater Ordinances

The 1993 Clear Creek Watershed Management Agreement committed all parties to the agreement to adopt both construction and permanent stormwater BMPs as stormwater ordinances. The intent of these BMPs is to help protect water quality in Clear Creek and Standley Lake. The Cities of Arvada, Golden, Northglenn, and Thornton and Jefferson County all agreed to adopt stormwater BMPs as part of the agreement; these requirements also apply to areas that do not drain to Standley Lake. The ordinances adopted by the cities incorporated the UDFCD's *Volume 3 of the Storm Drainage Criteria Manual Best Management Practices*, which is used throughout the Denver metropolitan area for management of stormwater. The timeline for the development of BMPs was December 1994, and the ordinances were required to be in place by July 1995.

In June 1995, the Westminster City Council passed a bill requiring the city to establish permanent stormwater quality management for future development within the City of Westminster. These BMPs were to maintain and enhance the quality of water discharged into the city's storm drainage by (1) requiring measures which prevent erosion and the loss of sediment and other pollutants from construction sites; (2) requiring protection of the soil surface before, during and after construction; (3) establishing stormwater quality design requirements for the development and redevelopment of property; and (4) promoting the use of temporary and permanent BMPs to achieve a reduction in the pollutant loading of stormwater runoff. The city also developed the *City of Westminster Storm Drainage Design and Technical Criteria Manual* (City of Westminster 1987).

The City of Northglenn adopted a soil erosion and sediment control ordinance in 1982 which provides for erosion and sediment control during initial grading and site development only (City of Northglenn 1982). Northglenn also has an urban runoff drainage ordinance adopted in 1979 which is intended to require new development to provide for control of increased storm flows associated

with development. Other measures include provision for an Urban Runoff Management Plan, detention facilities, development of a storm drainage and flood control board, and fees for storm drainage and flood control (City of Northglenn 1979).

The City of Thornton's stormwater ordinance includes provisions for stormwater detention, sedimentation and erosion control for new development, prohibitions on illicit discharges to the storm sewer system, and compliance with state and federal storm water control measures (City of Thornton 1996).

The City of Broomfield is in the process of developing a surface water management plan that addresses erosion and sediment control measures and water quality protection (Mahan 1998). Erosion and sediment control ordinances are needed because of the rapid development that is occurring in the city (Behlen 1998).

Adams and Jefferson Counties' land development and subdivision regulations devote chapters to storm drainage, design and technical criteria as well as to erosion control and sediment control design criteria. Weld County does not have specific regulations in place that address these issues.

Groundwater Standards

The CWQCC controls groundwater quality in Colorado under the "Basic Standards for Groundwater" 3.11.0 (5 CCR 1002-8) and the "Site-Specific Water Quality Classifications and Standards for Groundwater" 3.12.0 (5 CCR 1002-8). Groundwater in the Big Dry Creek watershed is controlled under both regulations.

The purpose of the "Basic Standards" is to establish state-wide standards and a system of classifying groundwater and adopting water quality standards for these classifications to protect existing and potential beneficial uses of groundwater. The regulations identify water quality standards applicable to groundwater in the state unless site-specific standards have been adopted. These standards include narrative and numeric standards for human health, secondary drinking water and agricultural uses (CDPHE 1997a).

In 1991, site-specific standards were adopted for the Rocky Flats area in Jefferson and Boulder counties, with more recent amendments in January 1997. The specified area in these standards is all unconfined groundwater within i) the Upper Hydrostratigraphic Unit (UHSU), including the unconsolidated quaternary and Rocky Flats alluvium, colluvium and valley fill alluvium and weathered claystone and hydraulically connected sandstone bedrock of the Arapahoe and Upper Laramie formations; ii) the Arapahoe and Upper Laramie aquifers not hydraulically connected to the UHSU; and iii) the Laramie-Fox Hills aquifer, within a specified area (CDPHE 1997b).

These waters of the Upper Hydrostratigraphic Unit were classified for surface water protection. Site-specific standards adopted for these waters included the statewide surface water radioactive materials standards, the statewide surface water interim organic pollutant standards and the site-specific stream standards for segments 4a, 4b and 5 of Big Dry Creek (CDPHE 1997b).

Site-specific groundwater standards were also adopted for the Federal Heights well field; however, only a small portion of the upper northwest corner of the well field is located within the Big Dry

Creek watershed. The specified area includes all confined and unconfined groundwaters within the saturated zone underlying the mapped well field area. The classification of these waters is for Domestic Use-Quality and Agricultural Use-Quality (CDPHE 1997b).

12.0 CONCLUSIONS AND RECOMMENDATIONS

1. A significant number of studies pertinent to the Big Dry Creek watershed have been conducted on a wide variety of topics such as wildlife habitat, aquatic life, water quality, stormwater management, and open space planning. As the watershed group plans future monitoring and special watershed projects, care should be taken not to "reinvent the wheel" or restudy issues that have already been addressed.

2. A variety of efforts to protect water quality are currently in place in the watershed. The watershed group should seek to complement and stay abreast of these efforts. Key efforts currently in place include extensive water quality monitoring and protection programs at Rocky Flats and Standley Lake. Large amounts of water quality data are available through these efforts. The group should continue to include water quality data from these on-going efforts in the Big Dry Creek Water Quality Database.

3. The Big Dry Creek Monitoring Program conducted by the Cities of Broomfield, Northglenn and Westminster should continue because it provides useful data for stream characterization from Standley Lake to the South Platte. The data set obtained from this program is the primary source of water quality information in the watershed below Standley Lake.

4. Stormwater quality and quantity impacts to Big Dry Creek are not well-characterized although a variety of stormwater impacts such as streambank erosion can be reasonably inferred from field observations. As the Clean Water Act Phase II stormwater regulations are promulgated and implemented over the next few years, the cities will likely be impacted by Phase II requirements. It will be important for the cities to develop an understanding of stormwater impacts to receiving water quality and implement best management practices (BMPs) to minimize these impacts. Several master drainage plans have been completed in the watershed which identify existing and proposed patterns of stormwater flows (i.e., outfalls, flow volumes, etc.). This information can be helpful in designing stormwater quality monitoring programs and developing an overall understanding of stormwater issues in the watershed.

5. Documented pollutant sources in the watershed include discharges from municipal wastewater treatment plants and Rocky Flats and spills and releases from facilities regulated by the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA). Stormwater runoff from urbanized areas and overland flow from agricultural lands are also expected to be relevant sources of pollution, although studies of these sources are not known to have been conducted.

6. Groundwater quality and groundwater-surface water interactions are not well-characterized along the main stem of Big Dry Creek. These issues may be worthy of study in the future, particularly with regard to understanding the role that groundwater plays in the hydrology of Big Dry Creek.

7. Although the main stem of Big Dry Creek has not been identified on the 1998 303(d) list, which would trigger the total maximum daily load (TMDL) process for the creek, Big Dry Creek will be affected by the on-going TMDL process in Segment 15 of the South Platte River. The Big Dry Creek group should monitor and participate in the activities of the South Platte Urban Watershed TMDL Advisory Committee.

8. Ecological studies along Big Dry Creek suggest that aquatic life in the stream is limited due to poor habitat conditions. Future projects in the watershed could consider areas of potential habitat improvement. In planning these efforts, hydrologic information in the various master drainage plans and flood hazard delineation areas should be taken into account.

9. In the area downstream of I-25, agriculture is the predominant land use. Cattle grazing and watering in the stream and runoff from adjacent croplands impact water quality. Quantitative studies are not known to have been conducted to correlate agricultural activities with water quality in this area; however, the Natural Resource Conservation Service (NRCS) indicates that these impacts are potentially present. In the event that a waste load allocation (WLA) for nitrate is developed for Big Dry Creek as a result of the TMDL process for Segment 15 of the South Platte, additional quantitative study of this issue may be needed. Similarly, the group should work with the NRCS and farmers in the area to determine what measures should be taken to minimize water quality impacts associated with agricultural practices through measures such as streambank stabilization and riparian buffer area preservation/restoration.

10. Most of the cities in the Big Dry Creek watershed have stormwater and construction ordinances in place for new development that address water quality. The group should work with the cities to encourage enforcement of ordinances requiring the implementation of BMPs at construction sites, since much of the watershed area is rapidly developing. Similarly, as the population within the watershed grows, water quality impacts associated with urbanized areas will increase. Public education would be a worthy effort of the group to promote proper handling and disposal of household waste, application of fertilizers and pesticides, and other practices that reduce pollutant loadings to the stream.

11. The City of Westminster and Jefferson County Open Space are actively pursuing preservation of open space, particularly along Big Dry Creek. The group should support these and other similar efforts because of the role that preserved riparian corridors play in protecting water quality, maintaining streambanks, enhancing aquatic habitat, etc.

12. Geographic Information Systems (GIS) mapping is available from various entities for a large portion of the watershed, excluding Weld County. Although Broomfield and Northglenn do not have GIS systems in place, the mapping is in electronic form that should interface with a GIS system. With some coordination, a good GIS map could be developed for the watershed as a tool for linking water quality and quantity with various geographic features.

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FIGURES

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APPENDICES

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