COLORADO
Department of Public Health & Environment

Total Maximum Daily Load Assessment

Big Dry Creek – COSPBD01, Broomfield, Jefferson, Adams, and Weld Counties, Colorado

Big Dry Creek north of 128th Ave (Westminster, 2016)

USGS Westminster gage on Big Dry Creek (USGS 2015)

EXECUTIVE SUMMARY

Information fundamental to Big Dry Creek TMDL development is summarized in Table 1. The results of TMDL development are provided in Table 2-4.

Table 1. TMDL Development Summary		
TMDL Impairment Information/Methodology	**Description**	
Waterbody ID	COSPBD01	
Segment Description	Mainstem of Big Dry Creek, including all tributaries, lakes, reservoirs and wetlands, from the source to the confluence with the South Platte River, except for specific listing in Segment 2, 3, 4a, 4b, 5 and 6.	
Pollutants Addressed	*Escherichia coli* (*E. coli*)	
Description of Segment 1 Reaches	Upper Reach: lake/reservoir outlet to sample location BDC 1.5 Middle Reach: BDC 1.5 to 152nd Avenue Lower Reach: 152nd Avenue to confluence with South Platte River	
Assessment Locations (Critical conditions)	Upper Reach: BDC 1.5 (downstream of 120th Ave.) Middle Reach: BDC 2.0 (Upstream of 128th Ave., 0.5 miles West of Huron, downstream of Broomfield WWTP discharge) Lower Reach: BDC 6.0 (Upstream from bridge on Weld County Road 8, Near Wattenberg & Weld County Rd 23)	
Designated Uses and Impairment Status for *E. coli*	Agriculture Aquatic Life Warm 2 Recreation P	Not Impaired Not Impaired **Impaired**
HUC12	101900030406 (Upper Big Dry Creek), 101900030407 (Middle Big Dry Creek), 101900030408 (Lower Big Dry Creek)	
Size of Watershed	Approximately 108 square miles, drains to the South Platte River	
Land use	Mixture of developed urban, ranch/rural and open space/river corridor.	
Source Identification	Permitted (municipal wastewater and MS4) and non-point sources (wildlife)	
Water Quality Goal	Protection of designated public health and recreational uses	
Water Quality Target	Attainment of *E. coli* water quality standard (205 cfu/100 mL) throughout segment.	
Analysis/ Methodology	Load Duration Curves were used to determine loading for varying flow regimes.	
Load Duration Curve	A duration curve is a cumulative frequency graph that represents the percentage of time during which the value of a given parameter is equaled or exceeded. Load duration curves are developed from flow duration curves and can illustrate existing water quality conditions (as represented by loads calculated from monitoring data), how these conditions compare to desired targets, and the portion of the water body flow regime represented by these existing loads. Load duration curves were used to determine the load reductions required to meet the target maximum concentrations for *E. coli.*	

Table 1 (continued) – TMDL Development Summary	
TMDL Impairment Information/Methodology	**Description**
Critical Conditions	The stream flow data period of record used (2003-2015) represent a range of hydrologic and meteorological flow conditions for the flow duration curve. Flow estimates were determined based on nearby stream gaging stations USGS 06720820 Big Dry Creek at Westminster, CO and USGS 06720990 Big Dry Creek at mouth near Ft Lupton, CO. The entire water quality data period of record extends over 14 years, and determined 2002 to be an anomalous year, and the critical period was defined as (2003-2014).
Seasonal Variation	Load duration calculations are based on varying flow conditions, using multiple years of flow data, to ensure the TMDL accounts for seasonal variation in the stream.
Margin of Safety (MOS)	A 10% explicit margin of safety was included in this TMDL. Implicit conservative assumptions were also used, such as using the sampling location with the highest rate of impairment to determine load reductions.

Segment 1 of the Big Dry Creek Basin in the South Platte River Basin in Colorado is defined as the mainstem of Big Dry Creek, including all tributaries, lakes, reservoirs and wetlands, from the source to the confluence with the South Platte River, except for specific listings in Segments 2, 3, 4a, 4b, 5 and 6. Segment 1 includes approximately 48 stream miles within the watershed. Approximately 21% of the watershed area lies in Jefferson County, 41 % in Adams County, 11% in City and County of Broomfield, and the remaining 27% in Weld County.

In 2004, the Recreation classification for Segment 1 of Big Dry Creek was changed from a Recreation Class 2 (Rec N, or no primary contact recreation) to a Recreation Class 1b (Rec P, or potential primary contact recreation) standard with a corresponding change in the *Escherichia coli* ("*E. coli*") standard from 630 cfu/100 mL to 205 cfu/100 mL. (WQCC, 2016b) As a result of the change in standard, Segment 1 has been on the State's 303(d) list of water quality impaired waterbodies since 2006 for exceeding the Recreation P *E. coli* standard of 205 colony forming units per one hundred milliliters (cfu/100mL). (WQCC, 2016a)

Fecal coliform and *Escherichia coli* (*E. coli*) are indicators of the possible presence of pathogenic organisms that may cause illness in those who come in contact with or ingest contaminated waters. Segment 1 routinely exceeds current *E. coli* standards. The goal of this Total Maximum Daily Load (TMDL) assessment is the protection of recreational uses and public health.

The sources of *E. coli* in Segment 1 are presently unconfirmed but may include regulated stormwater, human-made nonpoint sources such agricultural return flows and failing septic systems and naturally occurring nonpoint sources such as wildlife, naturalized sources of bacteria and resuspension of sediment in the stream. Several observed sources were documented by BDCWA (WWE, 2008). These included cattle grazing along the creek in the lower watershed and significant wildlife presence along the entire creek (geese, birds, beavers, coyotes and raccoons, among others).

E. coli levels are measured as a density-based unit, i.e. a number of bacteria colony forming units (cfu) per 100 milliliters (mL) of water. *E. coli* sources are presumed to be non-additive due to death, reproduction, and diurnal fluctuations. In addition to the non-additive nature of indicator bacteria, flows in Big Dry Creek Segment 1 fluctuate on a non-seasonal basis due to intensive water management. Therefore, the Colorado Water Quality Control Division (the division) has adopted a density-based approach for this TMDL assessment, which allocates pollutant loads to sources based upon the *E. coli* water quality standard.

The segment was divided into three distinct reaches to account for changes in land use, influences in river flow (diversions, reservoir releases, WWTF contributions, etc.), and location of permitted point sources. TMDLs were developed for each reach: Upper Reach (from outlet of Standley Lake and Great Western Reservoir to sample location BDC 1.5); Middle Reach (from BDC 1.5 to 152nd Avenue); and Lower Reach (from 152nd Avenue to the confluence with the South Platte River). Allowable loads and wasteloads for *E. coli* were developed for varying flow conditions at a representative assessment location in each reach (Tables 2-4).

Table 2. Upper Reach *E. coli* TMDL: allowable loading and pollutant reductions necessary to meet the recreation based *E. coli* standard in Big Dry Creek.

Loading Calculations (Giga cfu/day)	High Flow	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flow
TMDL	290.90	80.25	20.06	10.03	6.02
MOS (10%)	29.09	8.02	2.01	1.00	0.60
Allowable Load	261.81	72.22	18.06	9.03	5.42
Existing Load	234.61	124.74	16.69	10.18	12.56
Required Reductions	0%	42%	0%	11%	57%
WLA					
MS4s	201.59	55.61	13.90	6.95	4.17
Reserve Capacity	10.08	2.78	0.70	0.35	0.21
LA					
Nonpoint Source	50.14	13.83	3.46	1.73	1.04

Table 3. Middle Reach *E. coli* TMDL: allowable loading and pollutant reductions necessary to meet the recreation based *E. coli* standard in Big Dry Creek.					
Loading Calculations (Giga-cfu/day)	**High Flow**	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flow**
TMDL	423.34	198.56	129.18	73.58	27.94
MOS (10%)	42.33	19.86	12.92	7.36	2.79
Allowable Load	381.01	178.71	116.26	66.22	25.14
Existing Load	1119.13	425.48	244.05	114.49	94.98
Required Reductions	66%	58%	52%	42%	74%
WLA					
Westminster WWTF	58.24	54.32	51.49	31.97	16.99
Broomfield WWTF	74.20	64.00	57.63	31.58	4.92
MS4s	149.14	36.23	4.29	1.60	1.94
Reserve Capacity	7.46	1.81	0.21	0.08	0.10
LA					
Nonpoint Source	91.97	22.34	2.64	0.99	1.19

Table 4. Lower Reach *E. coli* TMDL: allowable loading and pollutant reductions necessary to meet the recreation based *E. coli* standard in Big Dry Creek.					
Loading Calculations (Giga cfu/day)	**High Flow**	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flow**
TMDL	461.43	225.70	150.47	115.36	65.20
MOS (10%)	46.14	22.57	15.05	11.54	6.52
Allowable Load	415.28	203.13	135.42	103.82	58.68
Existing Load	1682.14	619.55	256.30	134.65	140.81
Required Reductions	75%	67%	47%	23%	58%
WLA					
Northglenn WWTF	50.44	50.44	50.44	50.44	50.44
MS4s	43.78	18.32	10.20	6.41	0.99
Reserve Capacity	4.38	1.83	1.02	0.64	0.10
LA					
Nonpoint Source	316.68	132.53	73.76	46.33	7.15

1.0 Introduction

Section 303(d) of the federal Clean Water Act (CWA) requires States to periodically submit to the U. S. Environmental Protection Agency (EPA) a list of water bodies that are water quality impaired. A water quality impaired segment does not meet the standards for its designated use classification. This list of impaired water bodies is referred to as the "303(d) List". In Colorado, the agency responsible for developing the 303(d) List is the Water Quality Control

Division (WQCD). The List is adopted by the Water Quality Control Commission (the commission) as Regulation No. 93.

For water bodies and streams on the 303(d) list a Total Maximum Daily Load (TMDL) is used to determine the maximum amount of a pollutant that a water body may receive and still maintain water quality standards. The TMDL is the sum of the Waste Load Allocation (WLA), which is the load from permitted point source discharges, Load Allocation (LA) which is the load attributed to natural background and/or non-point sources, and a Margin of Safety (MOS) (Equation 1).

(Equation 1) TMDL=WLA+LA+MOS

A segment or pollutant may be removed from the List if the applicable standard is attained, if implementation of clean-up activities via an alternate means will result in attainment of standards, if the original listing decision is shown to be in error, or if the standards have been changed as the result of a Use Attainability Analysis (UAA) or other EPA approved recalculation method.

Big Dry Creek Segment 1, designated as COSPBD01, is located in Adams, Broomfield, Jefferson, and Weld Counties, within the South Platte Watershed. Approximately 10.1 stream miles of Segment 1 lies within Jefferson County, 19.8 miles in Adams County, 5.4 miles in Broomfield and approximately 12.8 stream miles lies within Weld County. The mainstem of Big Dry Creek, including all tributaries, lakes, reservoirs and wetlands, from the source to the confluence with the South Platte River, (except for specific listings in Segments 2, 3, 4a, 4b, 5 and 6) first appeared on the Colorado 2006 303(d) List for non-attainment of the *E. coli* standard with a high priority for TMDL development and remains on the 2016 303(d) list (WQCC, 2016a) with a low priority for TMDL development. The assignment of priority for TMDL development is based on prioritization criteria in the listing methodology which is updated every two years.

1.1 Land Use

The Big Dry Creek drainage basin (Figure 1-1) lies north of the city of Denver and the listed segment (COSPBD01) accounts for approximately 48 miles of river in the basin. The segment begins in Jefferson County at Standley Lake, just north of the City of Arvada and south of Highway 128. It then flows north and east through Adams County, a small portion flows through City and County of Broomfield, back to Adams County and into Weld County until its confluence with the South Platte River near the town of Fort Lupton. Big Dry Creek is a highly managed stream segment based on the exercise and beneficial uses of water rights. Several ditches receive flow from Big Dry Creek and tributary and reservoir releases supplement flow into the Big Dry Creek stream segment.

Recreational use of the open space in the upper portion of Big Dry Creek occurs frequently. A 10-mile trail along Big Dry Creek is managed by the City of Westminster, and is used by a variety of outdoor enthusiasts. Westminster began preservation of the Big Dry Creek Open Space and Trail Corridor in 1989 with the acquisition of four acres. Since then, almost 700 acres have been acquired along this 9.5-mile corridor, which travels through the middle of the City. The City acquired this corridor for open space, trails, natural areas, and view preservation. Abundant wildlife and native vegetation thrive along the trail corridor, bringing tranquility to this otherwise urban center. The Big Dry Creek Trail is a regional trail and ultimately this corridor will allow connections to be made to the South Platte River Corridor and to the communities of Broomfield, Thornton, and Northglenn to the east.

In addition to the Big Dry Creek trail, the Big Dry Creek watershed is home to an 18-acre community park that houses baseball and soccer fields, picnic shelters, a playground, and a dog park. 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 48 total stream miles. The watershed area includes three twelve digit Hydrologic Unit Code (HUC12) subwatersheds; upper, middle, and lower Big Dry Creek (Table 1.1-1).

Table 1.1-1. Big Dry Creek Watershed HUC12

HUC12	HUC12 Name	Size (Acres)
101900030406	Upper Big Dry Creek	22675.58
101900030407	Middle Big Dry Creek	23985.66
101900030408	Lower Big Dry Creek	22643.8

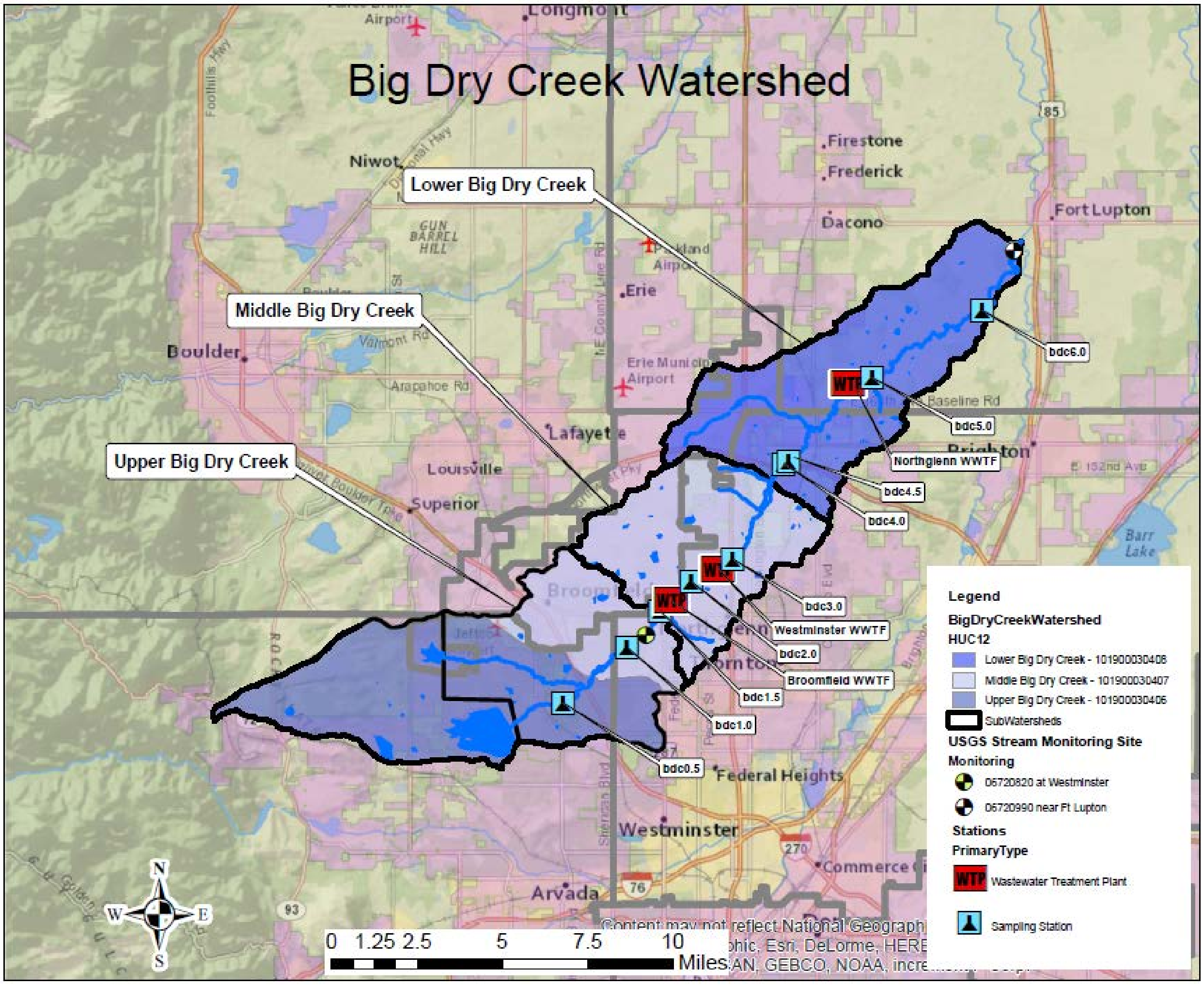

Figure 1.1-1. Map of Big Dry Creek watershed area and associated HUC12

The TMDL reaches are also divided into upper, middle and lower portions, with slightly different boundaries than the HUC12 breaks in the upper and middle portions (Figure 1.1-1). The portioning was decided based on factors such as land use, key hydrologic influences (e.g., WWTF discharges) and E. coli results at BDCWA's long-term monitoring locations. Changes in use are illustrated in the national land cover dataset (NLCD 2006) for the watershed (Figure 1.1-2). Three TMDL reaches were identified as follows: Upper Reach (from outlet of Standley Lake and Great Western Reservoir to sample location BDC 1.5); Middle Reach (from below BDC 1.5 to 152nd Avenue); and Lower Reach (from 152nd Avenue to the confluence with the South Platte River). For the remainder of this document, the terms Upper Reach, Middle Reach and Lower Reach refer to the TMDL reaches, as opposed to the HUC12 subwatersheds shown in Table 1.1-1 and Figure 1.1-1.

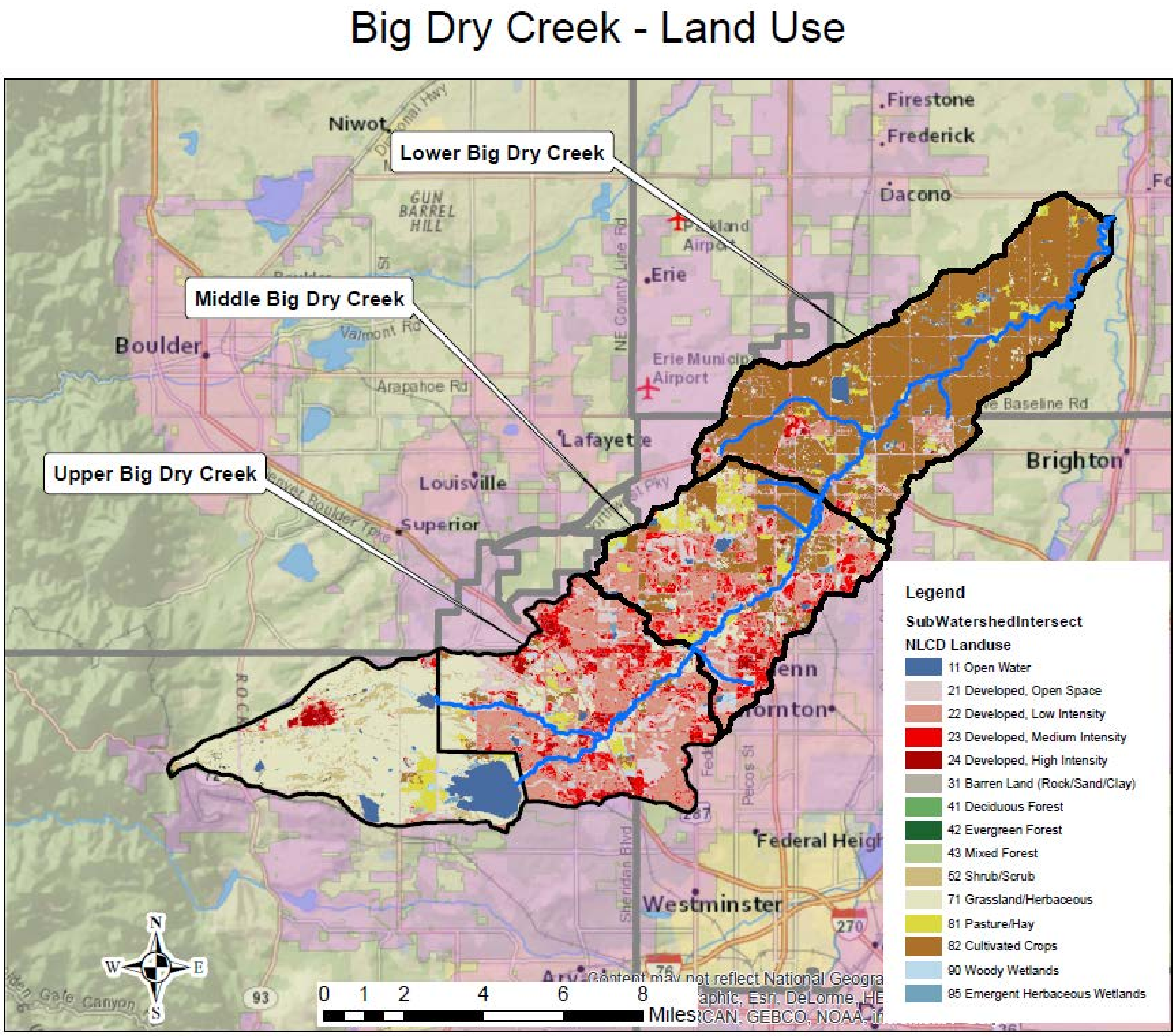

Figure 1.1-2- Map of Reach boundaries and land use

The upper and middle reaches are predominately urban, with 77% and 60% developed land use, respectively (Figures 1.1-2). The developed land use group consists of four classifications; open space, low intensity, medium intensity and high intensity. Descriptions are below (Table 1.1-2).

Table 1.1-2. Descriptions of NLCD developed land use classifications
Developed, Open Space - areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
Developed, Low Intensity - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units.
Developed, Medium Intensity – areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units.
Developed High Intensity -highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover.

The lower reach, is predominately rural/agriculture, with 79% of the land use classified as cultivated crops, and only 12% urban/developed. This is where the watershed transitions to private agricultural land. The area in acres per reach is shown in Table 1.1-3. As well as showing the relative size of each reach, with the upper and middle reaches being comparable in size (29-31% of the TMDL watershed area) and the largest area being the lower portion (41%). Figures 1.1-3 through 1.1-5 illustrate the dominant land use classifications in each reach.

Table 1.1-3. Land use classification for all three reaches

NLCD Land use Group	Upper Reach		Middle Reach		Lower Reach	
	Area (acres)	% of watershed	Area (acres)	% of watershed	Area (acres)	% of watershed
Water	102.2	1%	204.3	1%	297.5	1%
Developed	13160.1	**77%**	9575.6	**60%**	2629.2	**12%**
Barren	23.4	0%	15.8	0%	65.2	0%
Forest	10.0	0%	16.0	0%	75.1	0%
Shrubland	295.8	2%	12.6	0%	8.5	0%
Herbaceous	2146.7	12%	1187.1	7%	800.1	4%
Planted/Cultivated	850.2	5%	4378.3	27%	17841.6	79%
Wetlands	599.4	3%	639.0	4%	903.6	4%
Total	***17187.7***	***31%***	***16028.8***	***29%***	***22620.9***	***41%***

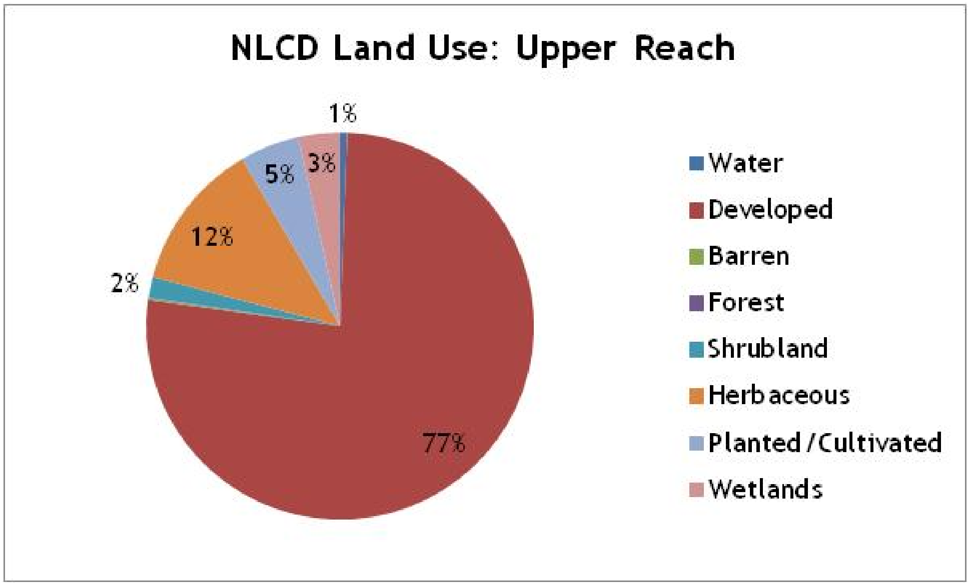

Figure 1.1-3. Land use percentages for the upper reach; Standley lake outlet toBDC1.5.

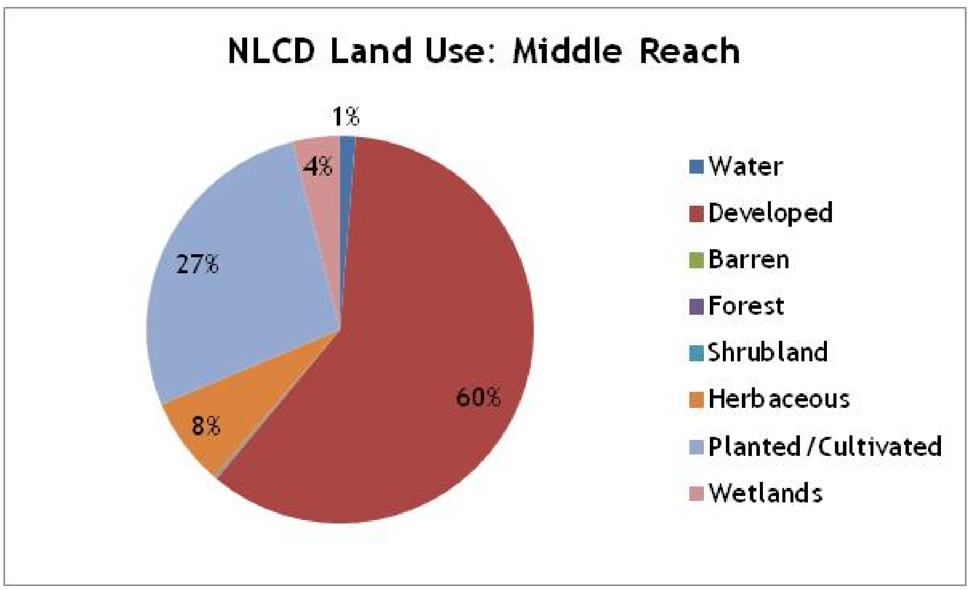

Figure 1.1-4. Land use percentages for the middle reach; BDC 1.5 to 152nd Ave.

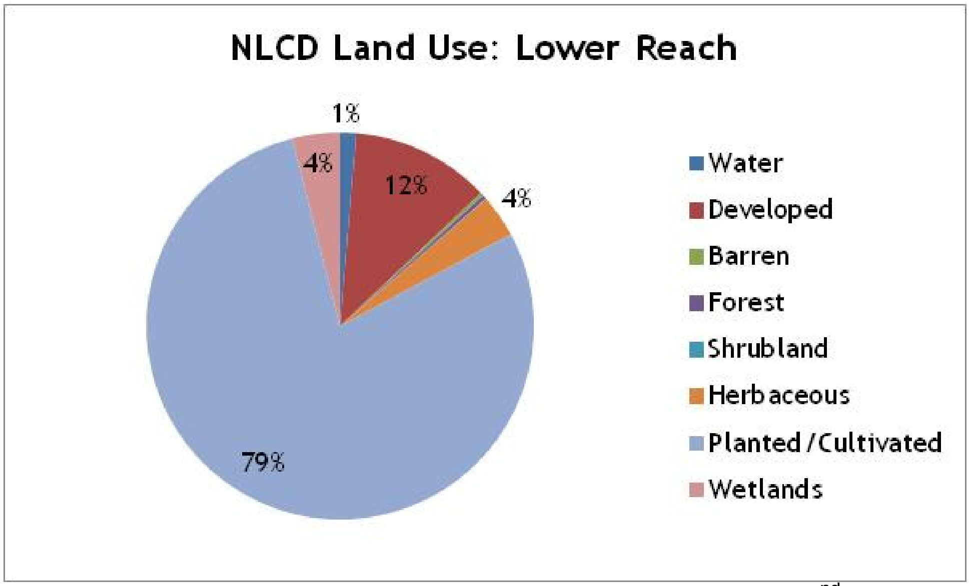

Figure 1.1-5 Land use percentages for the lower reach; 152nd Ave. to the confluence.

1.2 Discharge Permits and Property Ownership

The National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. Currently, there are several active Colorado Discharge Permit System (CDPS) permitted discharges into Segment 1 of Big Dry Creek. Segment 1 currently has three active CDPS individual dischargers with *E. coli* as a pollutant of concern. The City and County of Broomfield is the first in a series of wastewater treatment facilities to discharge to Big Dry Creek. The City of Westminster discharges approximately 2.4 miles downstream of Broomfield's discharge and the City of Northglenn discharges approximately 6.7 miles further downstream.

Table 1.2-1 Permitted discharges to Big Dry Creek Segment 1.

Permitted Facility	CDPS ID	SIC DESC	Design Capacity (MGD)
City of Westminster (Big Dry Creek) WWTF	CO0024171	sewer systems	11.9
City of Broomfield WWTF	CO0026409	sewer systems	12.0
City of Northglenn WWTF	CO0036757	sewer systems	6.5

A water quality assessment (WQA) is prepared upon each individual permit renewal to facilitate issuance of the CDPS permits. The WQA is done on a watershed scale, and determines the assimilative capacities available to the facilities for pollutants of concern. The *E. coli* permit limits changed from 630 cfu/100 mL to 205 cfu/100 mL with the 2010 permit renewal. The new limits were consistent with the change in water quality standards along Big Dry Creek. In order to meet the anticipated change in permit limits, the facilities had to undergo some upgrades in treatment. Currently, all three facilities have ultraviolet (UV) disinfection, and discharge concentrations of *E. coli* well below the 205 cfu/100 mL water quality standard. The facilities are in compliance with their permits regarding *E. coli*, as reported in their monthly discharge monitoring reports (DMRs). The permit includes a 30-day average as well as a 7-day maximum, at 410 cfu/100 mL. All DMR *E. coli* values are reported as geomeans. A summary of the most recent 5 years of DMR data for Broomfield, Westminster and Northglenn WWTFs can be seen in Table 7.2-1.

1.3 Hydrologic Influence

Big Dry Creek is a highly managed stream, with reservoir releases, diversion ditches, tributaries, and WWTF discharges. All of which impact flow fluctuations along the creek. Figure 1.3-1 is a simple representation of the system. The BDCWA included a diagram (Figure 1.3-1) in their annual report(s)(WWE, 2015) which illustrate the hydrologic influences along segment 1. While the data are in acre feet per year (2005-2009), and does not include seasonal variation, it does help illustrate the impact of flow management in the watershed. The impact of the WWTF discharges on the middle reach are accounted for in determining the TMDL.

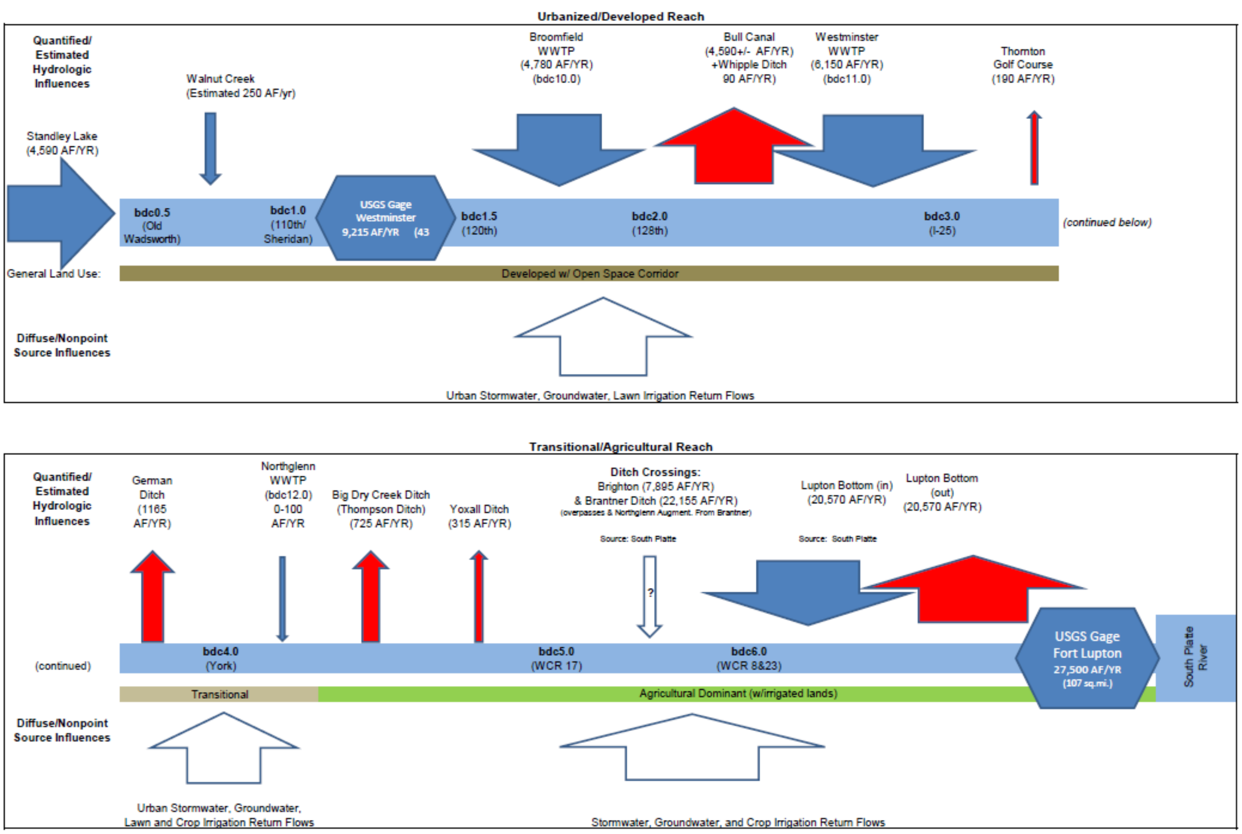

Figure 1.3-1 Hydrologic influences on Big Dry Creek flows based on average AF/yr 2005-2009 (WWE, 2015).

2.0 Water Quality Standards

Waterbodies in Colorado are divided into discrete units or "segments". The Colorado *Basic Standards and Methodologies for Surface Water*, Regulation 31(WQCC 2006b), discusses segmentation of waterbodies in terms of several broad considerations:

31.6(4)(b)…Segments may constitute a specified stretch of a river mainstem, a specific tributary, a specific lake or reservoir, or a generally defined grouping of waters within the basin (e.g., a specific mainstem segment and all tributaries flowing into that mainstem segment.

(c) Segments shall generally be delineated according to the points at which the use, physical characteristics or water quality characteristics of a watercourse are determined to change significantly enough to require a change in use classifications and/or water quality standards

2.1 Beneficial Uses

As noted in paragraph 31.6(4)(c), the use or uses of surface waters are an important consideration with respect to segmentation. In Colorado there are four categories of beneficial use which are recognized. These include Aquatic Life Use, Recreational Use, Agricultural Use and Water Supply Use. A segment may be designated for any or all of these "Use Classifications". Three of the four use classifications apply to Segment 1 of Big Dry Creek; aquatic life, recreational and agriculture. These uses are described further in Table 2.1-1, and impairment status only refers to *E. coli*.

Table 2.1-1: Designated Use Descriptions		
Designated Use Classification	**Use Description**	***E. coli* Impairment Status**
Aquatic Life; Warm 2	Class 2 – Warm Water Aquatic Life; These are waters that are not capable of sustaining a wide variety of cold or warm water biota, including sensitive species, due to physical habitat, water flows or levels, or uncorrectable water quality conditions that result in substantial impairment of the abundance and diversity of species.	Not Impaired
Recreation; P	Potential Primary Contact; waters where primary contact (activities where the ingestion of small quantities of water is likely to occur) uses will occur, where a reasonable level of inquiry has failed to identify any existing primary contact uses	**Impaired**
Water Supply	After treatment, surface waters suitable for drinking water supplies	NA
Agriculture	Water suitable for irrigation and livestock watering	Not Impaired

Each assigned use is associated with a series of pollutant specific numeric standards. These pollutants may vary and are relevant to a given classified use. Numeric pollutant criteria are identified in sections 31.11 and 31.16 of the Basic Standards and Methodologies for Surface Water (WQCC, 2015a).

2.2 Recreation Use

In 2004 the division proposed changing the classification of Big Dry Creek segment 1 from no primary contact use (recreation class N) to existing primary contact use (recreation class E). A Recreational Use Attainability Analysis completed in 2000 followed by a recreational uses survey of students conducted in 2003 were used as evidence in opposition to the class E proposal. This evidence was accepted by the commission and Segment 1 was classified as potential primary contact use (recreation class P) during the 2004 Regulation 39 Rulemaking Hearing (WQCC, 2016b).

E. coli concentrations within Big Dry Creek Segment 1 exceed "potential primary contact" standards. To understand the potential primary contact classification (recreation class P), it is helpful to first understand the existing primary contact (recreation class E) classification. Existing primary contact is defined as recreational activities where the ingestion of small quantities of water is likely to occur. Such activities include but are not limited to swimming, rafting, kayaking, tubing, windsurfing, water-skiing, and frequent water play by children (WQCC, 2015a). The potential primary contact (recreation class P) criterion of 205 cfu/100 ml is based on a policy decision to accept a slightly higher risk level (10 illnesses per 1000 swimmers for this classification, compared to 8 illnesses per 1000 swimmers for existing primary contact) based on the assumption that primary contact uses are not currently likely to be occurring for these water segments, although such uses may be a potential in the future.

2.3 *E. coli* Water Quality Standard

E.coli criteria and resulting standards for individual water segments are established as indicators of the potential presence of pathogenic organisms. The U.S. Environmental Protection Agency (EPA) published the current national water quality criteria for bacteria in surface water in 1986 (Ambient Water Quality Criteria for Bacteria, 1986 (EPA440/5-84-002)). The criteria are based upon currently accepted illness rates, which are an estimated 8 illnesses per 1,000 swimmers at fresh water beaches. That rate of illness was calculated using the fecal coliform indicator group at the maximum geometric mean of 200 cfu/100 mL of water. In the 1986 criteria document, EPA made a transition from fecal coliform to *E. coli* at the same illness rate, which was correlated to a maximum geometric mean of 126 cfu/100 mL of water.

The Colorado *E. coli* standard established by the Commission for potential primary contact recreation is contained in Colorado Regulation 31. In Section 31.16 of Regulation 31, the *E. coli* standard expressed as a two month geometric mean of 205 CFU/100 mL, applicable year-round. This enforceable *E. coli* water quality standard for Segment 1 has been adopted in Regulation 38, the South Platte Basin regulation.

2.4 Listing History

Historically Big Dry Creek was classified as not primary contact use with a corresponding standard of 630 cfu/100mL. Segment 1 was designated as a Recreation Class P use with the corresponding standard of 205 cfu/100 mL *E. coli* at the South Platte Rulemaking Hearing in 2004. The class P criterion of 205 cfu/100 mL is based on a policy decision to accept a higher risk level of 10 illnesses per 1,000 swimmers, based on the assumption that primary contact are not currently likely to be occurring. Consequently, in 2006, the segment was identified on the State's 303(d) List of Impaired Waterbodies as impaired by *E. coli*. And has remained on the subsequent 2008, 2010, 2012 and 2016 303(d) Lists.

Table 2.4-1 Water Quality Criteria for Impaired Designated Uses

WBID	Impaired Designated Use	Applicable Water Quality Criteria and Status
COSPBD01	Recreation; P	*E. coli*[1] / Not attained

1. Classifications and Numeric Standards for South Platte River Basin (Reg. 38)

3.0 Problem Identification

Substantial monitoring of *E. coli* has occurred on segment 1. Several agencies and entities have performed monitoring, including the Big Dry Creek Watershed Association (BDCWA), EPA and the division. The data used in developing the TMDL are strictly from the consistent and ongoing monitoring done by the association at 8 well established locations along Big Dry Creek.

E. coli levels in segment 1 are not spatially or temporally consistent, which makes it difficult to show a consistent pattern or location of *E. coli* loading or significant die-off. In general, *E. coli* levels in segment 1 are higher in the summer than other months.

4.0 Water Quality Goal and Target

The goal of this TMDL assessment is to protect public health through attainment of the *E. coli* water quality standard throughout segment 1. To achieve this goal, the Division is proposing a density-based allocation approach to this TMDL that will encompass nonpoint and point sources of *E. coli*. The ambient water-quality standard is reflective of the entire stream segment as a whole; therefore any point sampled on Segment 1 should meet the *E. coli* standard of 205 cfu/100 ml. Attainment of the numeric target will be determined by the calculation of an *E. coli* geometric mean for the entire segment as a whole, in addition to CDPS permitted WWTFs complying with an *E. coli* limit of 205 cfu/100 mL. The limit will not be based on acute exceedances. There are no acute *E. coli* standards, however the WWTF permits contain an acute limit. The acute limit is double the chronic standard, 410 cfu/100mL.

5.0 Instream Conditions

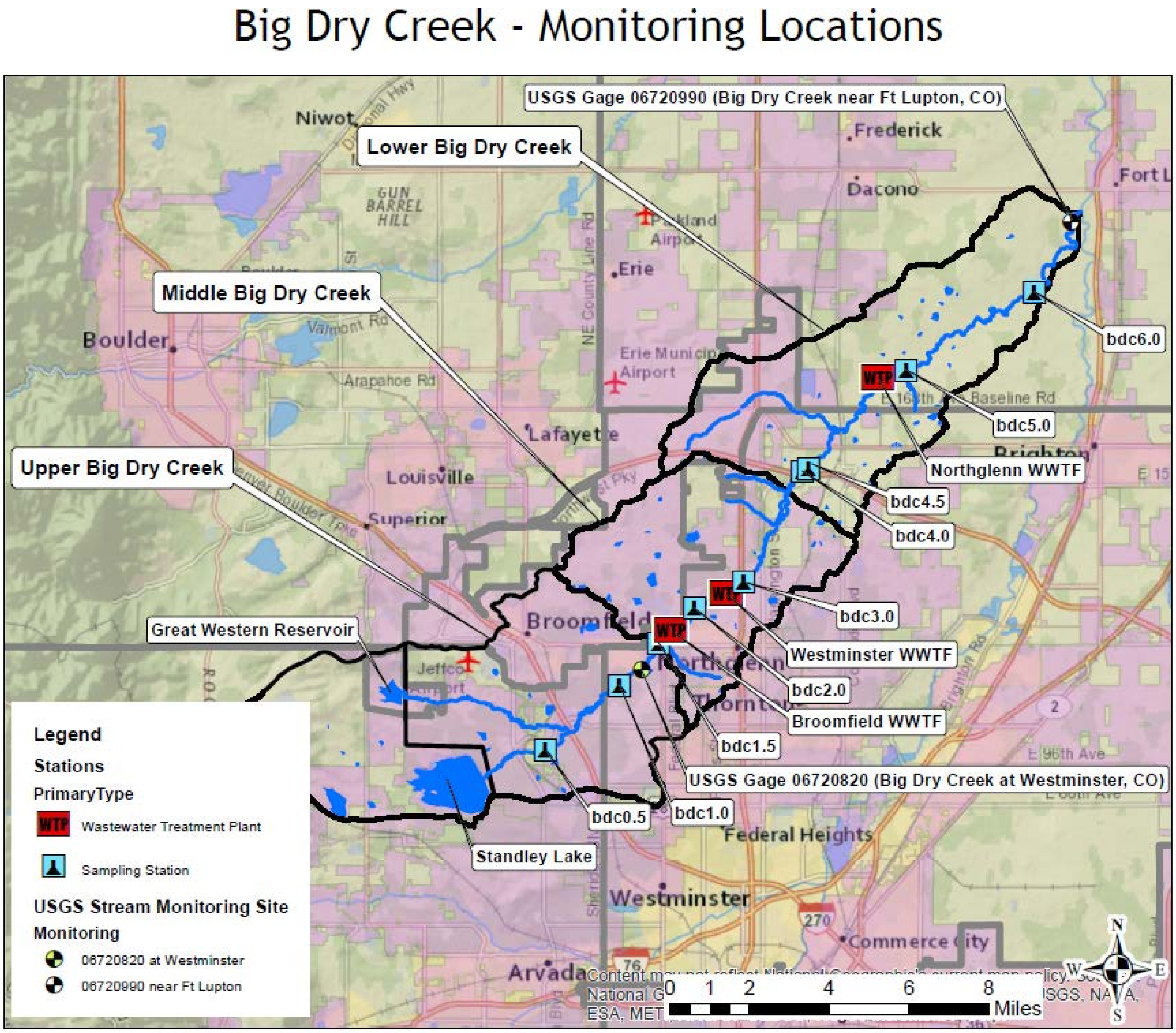

Figure 5.0-1. Location map of instream monitoring locations, flow gaging stations and WWTF discharge locations.

5.1 Hydrology and Climate

The hydrograph of Big Dry Creek, both upstream near Westminster and further downstream near the confluence with the South Platte River (near Fort Lupton), is typical of a highly managed stream, with low flows occurring in the late fall to early spring followed by a large increase in flow, which usually begins in April, due to snowmelt and spring rains that tail off through the early summer months (Figure 5.1-1). Big Dry Creek demonstrates greater influences from summer rain events and releases from Standley Lake upstream.

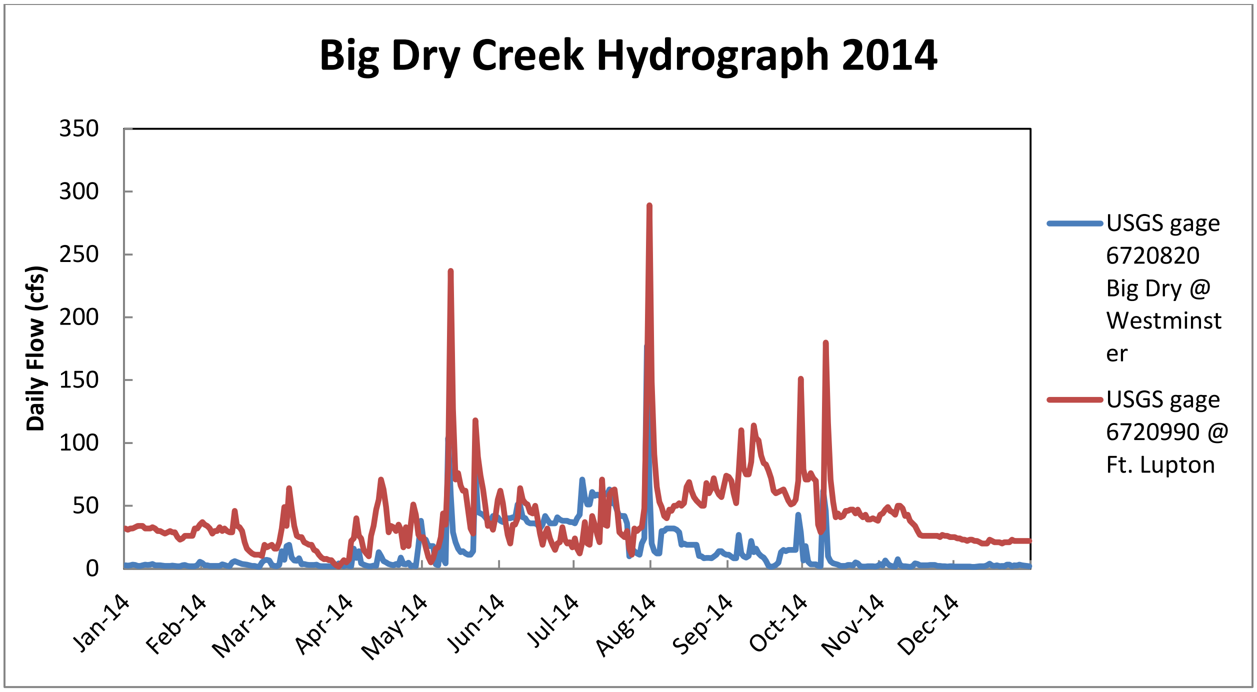

Figure 5.1-1. Hydrographs of Big Dry Creek at two USGS gage locations.

The hydrographs demonstrate the flow changes in Big Dry Creek from the upper portion, Westminster gage, to the lower portion, Ft Lupton gage near the confluence. The Westminster gage is upstream of the Broomfield and Westminster WWTFs and Bull canal. There are releases from Standley Lake which affect the flow, as well as big diversions. The greatest difference in flow at the two gages occurs in non-summer months. Flow in Big Dry Creek was modeled as part of a report (Lewis, 2007) for the permitted WWTFs, completed in preparation of their permit renewal. Flows at the Fort Lupton gage are higher than at the upstream Westminster gauge as a result of WWTF discharges, irrigation return flows, ditch conveyances of South Platte River water into Big Dry Creek, groundwater inflows, stormwater runoff and other sources.

These significant changes in hydrology affect the flow assumptions made for each reach, in particular the middle portion. The hydrologic influence on the stream (see Figure 1.3-1) made it impossible to use one stream gage as the critical condition for calculating the TMDL, and distributing appropriate WLAs and LAs. Dividing Segment 1 into three reaches helped to better isolate the distinct variation, and hydrologic influences along the segment. It is clear that the upper portion critical condition is best represented using the Westminster Gage, while the lower portion critical condition is the Ft. Lupton Gage. The problem lies in determining the middle portion critical condition, which is affected by flow contributions from two major WWTFs. Neither the Westminster Gage, nor the Ft Lupton Gage is representative of critical conditions for the middle portion. In order to estimate critical flow conditions for the middle portion, the Division used a combination of the Westminster Gage and estimated flow contributions from the two WWTFs. Further details on flow assumptions are discussed in Section 8.0.

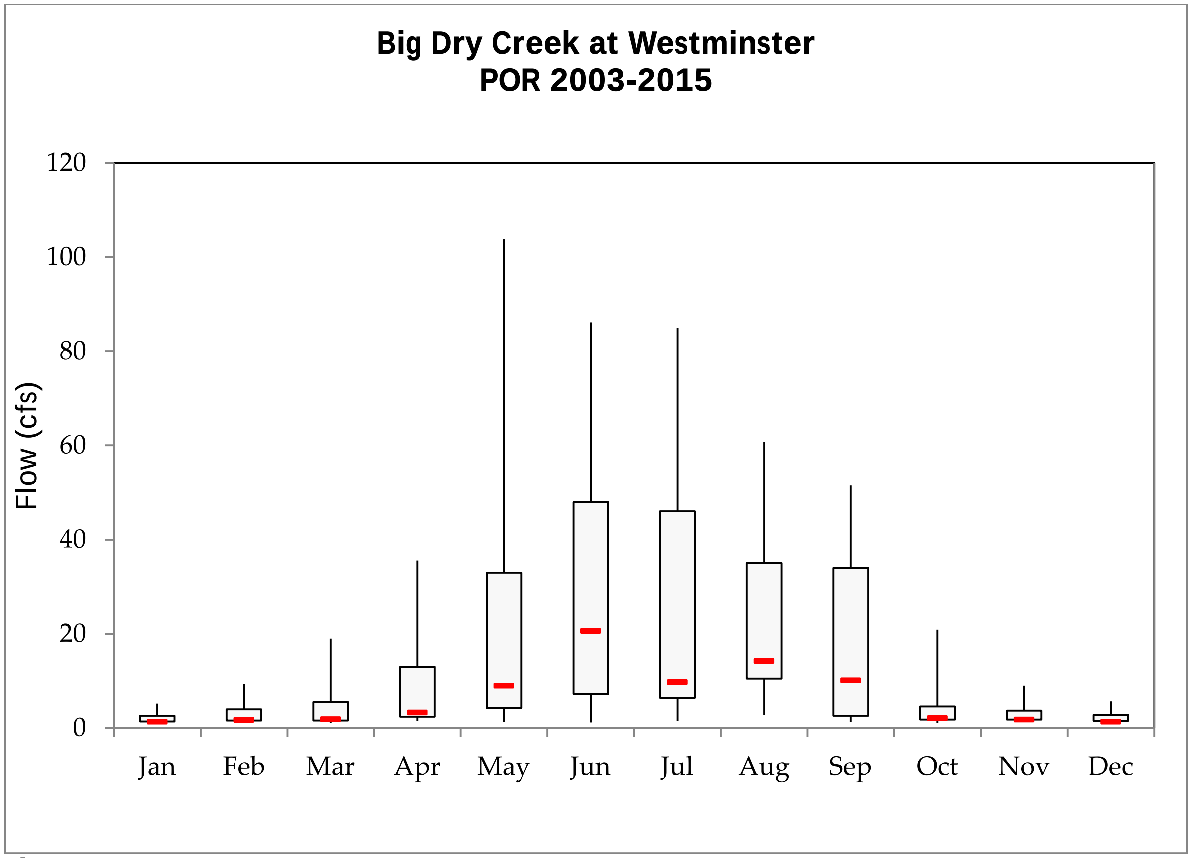

Figure 5.1-2. Monthly flow distribution of Big Dry Creek at Westminster, CO. The box-and-whisker plots delineate the 95th, 75th, 25th, and 5th percentiles of the measured flow concentrations. Taller boxes indicate more variability in flows during that month. A red line indicates the median concentration in each month. Flow is in cubic feet per second (cfs).

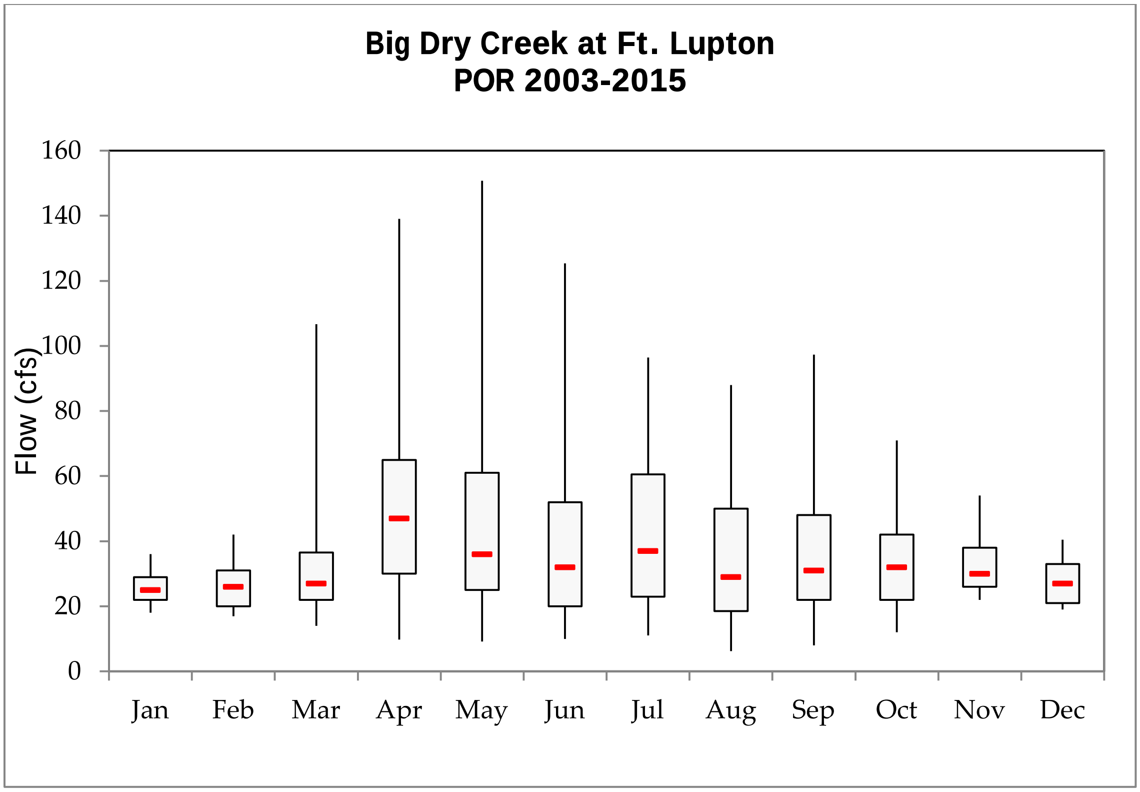

Figure 5.1.3. Monthly flow distribution of Big Dry Creek near Fort Lupton, CO. The box-and-whisker plots delineate the 95^{th}, 75^{th}, 25^{th}, and 5^{th} percentiles of the measured flow concentrations. Taller boxes indicate more variability in flows during that month. A red line indicates the median concentration in each month. Flow in cfs.

Median monthly flows were calculated from the nearest USGS gage. The variability in monthly stream flows along the mainstem of Big Dry Creek is illustrated in Figures 5.1-2 and 5.1-3. The largest range of flows occurs in the months of May-July. Flows at Big Dry Creek near the Fort Lupton gage are as much as twice that of flows recorded at the upper gage on Big Dry Creek at Westminster, CO during periods of higher flow which may correspond with irrigation season (i.e. May through September). Flows at Big Dry Creek near the Fort Lupton gage are twelve to sixteen times greater than flows recorded at the upper gage on Big Dry Creek at Westminster, CO during periods of lower flow which may correspond with non-irrigation season (i.e. October through April).

Historic gage flow data are captured in Table 5.1-1. Monthly median flows for Big Dry Creek at Westminster, USGS gage 6720820 (POR 1987-2012) and Big Dry Creek near Fort Lupton, USGS gage 6720990 (POR 1992-2012) were calculated.

Table 5.1-1. Monthly median flows for Big Dry Creek, USGS gage daily flow data.		
Month	**BDC at Westminster (cfs)**	**BDC near Fort Lupton (cfs)**
Jan	1.5	25.0
Feb	1.8	24.0
Mar	1.9	26.0
Apr	3.8	48.0
May	14.0	37.0
Jun	36.5	35.0
Jul	22.0	36.0
Aug	24.0	32.0
Sep	13.0	35.0
Oct	2.5	33.0
Nov	2.5	29.0
Dec	1.7	25.0

In the Big Dry Creek watershed, data was taken from the weather station at Northglenn, Colorado (#055984). Climate data for the Northglenn Weather Station, for the period of September 1984 through September 2012 is summarized as follows:

Average annual precipitation: 14.15 in.
Month of highest precipitation: May (2.17 in.)
Month of lowest precipitation: January (0.39 in.)
Average annual snowfall: 42.9 in.
Average annual temperature: 51.35º F
Month of highest average temperature: July (73.8º F)
Month of lowest average temperature: December (31.8º F)
(Source : http://www.wrcc.dri.edu/summary/climsmco.html)

5.2 Ambient Water Quality

E. coli data have been collected at eight routine instream monitoring sites on Big Dry Creek since 2000 (Table 5.2-1). Sites bdc4.0 and bdc4.5 are in close proximity to each other, with bdc4.5 replacing bdc4.0 in the routine sampling program in 2011 due to field staff safety issues. Table 5.2-2 illustrates *E. coli* geometric mean data collected at eight routine sampling locations by the Big Dry Creek Watershed Association from 2003 to 2014, which is the period of record considered in the TMDL. The BDCWA monitoring program represents ambient conditions on the scheduled sampling dates, inclusive of both dry and wet weather conditions.

Table 5.2-1. Sampling locations of routine monitoring sites on Big Dry Creek Segment 1	
Sampling Stations	**Sampling Location Description**
bdc 0.5	Downstream of Old Wadsworth & Church Blvd; Church Ranch Open Space
bdc 1.0	Downstream of 112th Ave. (100 yds N. of 112th & Vrain; also reported at 110th & Sheridan)
bdc 1.5	Downstream of 120th Ave.
bdc 2.0	Upstream of 128th Ave., 0.5 miles West of Huron, downstream of Broomfield WWTP discharge
bdc 3.0	I-25 & Thorn Creek Golf Course, downstream of Westminster WWTP Discharge
bdc 4.0	York Street (0.5 miles S of 160th & York)
Bdc 4.5*	Downstream of York St; replacement site for bdc 4.0 for field staff safety
bdc 5.0	Downstream of Weld County Road 4, 0.3 miles West of Road 17
bdc 6.0	Upstream from bridge on Weld County Road 8, Near Wattenberg & Weld County Rd 23

*Location of bdc 4.0 was moved in April 2011, becoming bdc 4.5. For purposes of evaluating the entire period of record bdc 4.0 and bdc 4.5 were considered the same location.

Table 5.2-2. *E. coli* geomeans for routine sampling locations on Big Dry Creek for period of record used in TMDL			
Sampling Stations	***E. coli* Geomean**	**Count**	**Years Considered in TMDL**
bdc 0.5	164	153	2003-2014
bdc 1.0	186	119	2003-2014
bdc 1.5	241	165	2003-2014
bdc 2.0	408	168	2003-2014
bdc 3.0	325	171	2003-2014
bdc 4.0	258	142	2003-2014
bdc 5.0	219	168	2003-2014
bdc 6.0	388	134	2003-2014

Geometric mean concentrations are highest at site bdc 2.0, Big Dry Creek upstream of 128th Avenue, downstream of the Broomfield WWTF, while the second highest observed concentrations are seen at site bdc 6.0, upstream from Weld County Road 8. The 12-year record of *E. coli* concentrations in Big Dry Creek does not indicate a significant trend in *E. coli* concentrations over the period of record (Figure 5.2-1). Slightly higher concentrations during 2001 and 2002 may indicate the influence of drought conditions on stream *E. coli* concentrations. However, direct comparison of concentrations among years may be misleading unless some consideration is given to flow conditions in each year.

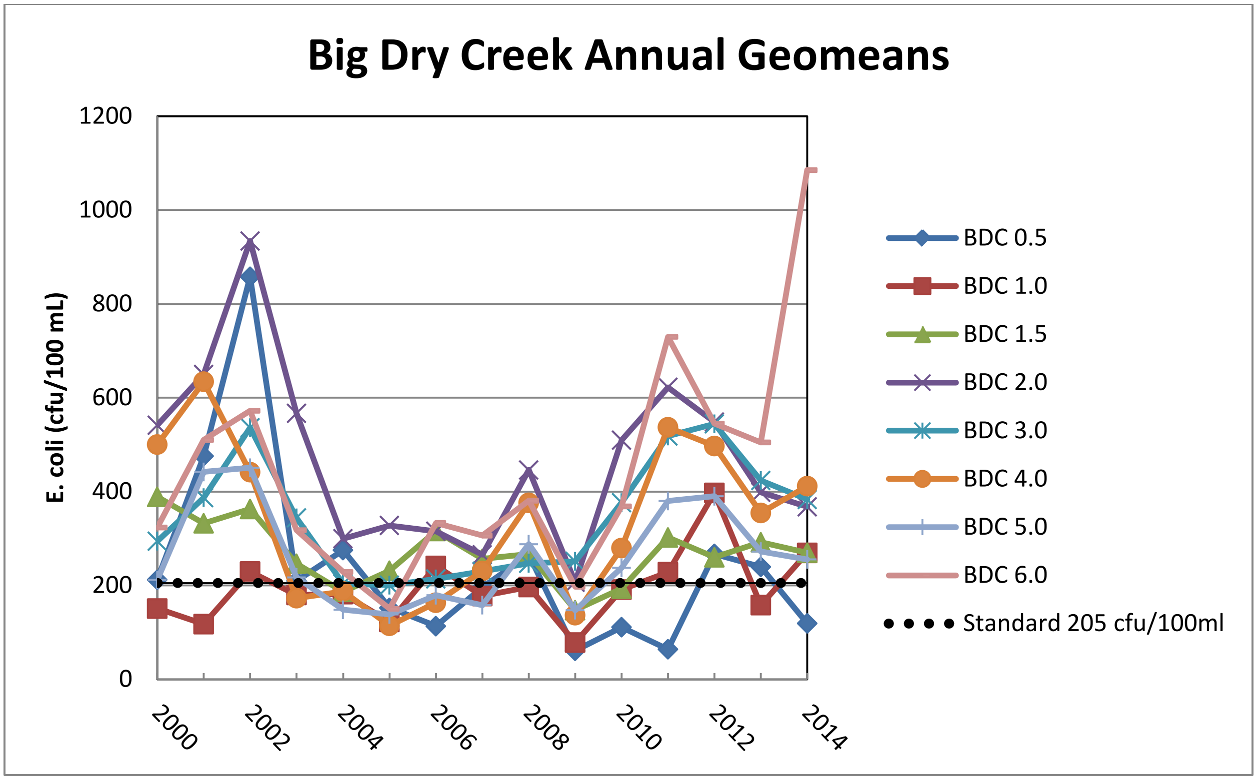

Figure 5.2-1 Annual *E. coli* geomeans at routine monitoring sites along Big Dry Creek

The variability in *E. coli* concentrations among years is displayed effectively with box-and-whisker plots showing the distribution of values observed in each year (Figure 5.2-2). The box-and-whisker plots delineate the 95th, 75th, 25th, and 5th percentiles of the measured concentrations. Taller boxes indicate more variability in *E. coli* concentrations during that year. A red line indicates the median concentration in each year. The *E. coli* values were averaged across all sites for a given day, before percentiles were calculated for the year. The yearly percentiles represent variation for the entire segment. Thus Figure 5.2-2 represents variation for the entire segment, from year to year.

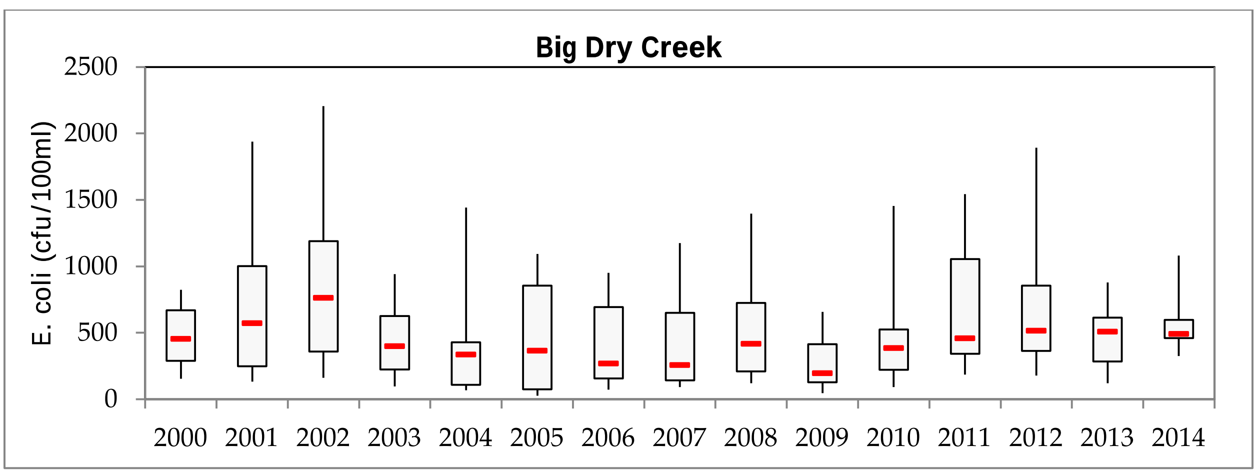

Figure 5.2-2. Annual distribution of *E. coli* concentrations in Big Dry Creek.

There are an inadequate number of samples to calculate annual geomeans (5 samples per 60 day period) per listing methodology guidance. Therefore, Table 5.2.3 shows two month geomeans along Big Dry Creek, upstream to downstream (left to right) from 2003-2014. Any exeedance of the 205 cfu/100 mL standard have been highlighted. Nearly all two-month intervals, at all sampling locations, exceed the standard in the recreation season (May-Oct). The recreation season is the time where human contact would most likely occur.

Table 5.2-3 Big Dry Creek instream sampling location, two month geomeans (cfu/100mL)

Two Month Interval	bdc 0.5	bdc 1.0	bdc 1.5	bdc 2.0	bdc 3.0	bdc 4.0	bdc 5.0	bdc 6.0
Jan/Feb	43	23	66	**337**	**213**	138	105	148
Mar/Apr	79	74	100	147	146	76	72	**263**
May/Jun	**377**	**522**	160	**556**	**414**	**462**	**483**	**816**
Jul/Aug	**350**	**656**	**838**	**809**	**558**	**493**	**470**	**733**
Sep/Oct	**262**	**291**	**486**	**622**	**640**	**504**	**430**	**628**
Nov/Dec	63	46	147	**320**	**255**	**240**	149	145

6.0 Technical Analysis

6.1 Load Duration Curve

Load duration curves (LDC) are used in this TMDL to determine the load reductions necessary to meet the target concentrations for *E. coli* of 205 cfu/100 mL. A duration curve is a cumulative frequency graph that represents the percentage of time during which the value of a given parameter is equaled or exceeded. Load duration curves are develop from flow duration curves and can illustrate existing water quality conditions, compared to desired targets, and the portion of the segment flow represented by these existing loads. The flow duration curve relates flow values to the percent of time those values have been met or exceeded. According to the EPA 841-B-07-006 document (USEPA, 2007):

"The use of "percent of time" provides a uniform scale ranging between 0 and 100. Thus, the full range of stream flows is considered. Low flows are exceeded a majority of the time, while floods are exceeded infrequently.

A basic flow duration curve runs from high to low along the x-axis. The x-axis represents the duration amount, or "percent of time" , in a cumulative frequency distribution. The y-axis represents the flow value (e.g. cubic feet per second) associated with the "percent of time" (or duration)…"

Flow duration curves represent the percent of time a flow is likely to be equaled or exceeded within the stream based on historic flow data. This allows for the grouping of flow conditions, in this case into five general indicator categories. The "high-flow" category represents flows observed during the greatest 10 percent of all flow values; 'moist conditions' represents flow values observed 30 percent of the time (they are equaled or exceeded 10-40 percent of the time); 'mid-ranges' represents 20 percent of all flows (equaled or exceeded 40-60 percent of the time); 'dry-conditions' represents 30 percent of all flows (equaled or exceeded 60 to 90 percent of the time);and ‘low-flow’ conditions exist about 10 percent of the time, with 90 to 100 percent of all flows equaling or exceeding those in the low flow category (previously mentioned in Section 5.1). Daily flow data from the two gages were used to calculate flow duration curves (Figures 6.1-1 and 6.1-2). The period of record for the gage data was 2003-2014.

Table 6.1-1 Flow duration curve values for USGS Big Dry Creek Westminster Gage			
Flow Regime	**Flow Range (cfs)**	**Median Flow (cfs)**	**% of time flows equal or greater occur**
High	44-418	58	<10%
Moist	6.6-43	16	10-40 %
Mid-Range	2.9-6.5	4	40-60 %
Dry	1.5-2.8	2	60-90%
Low	0.11-1.4	1.2	90-100%

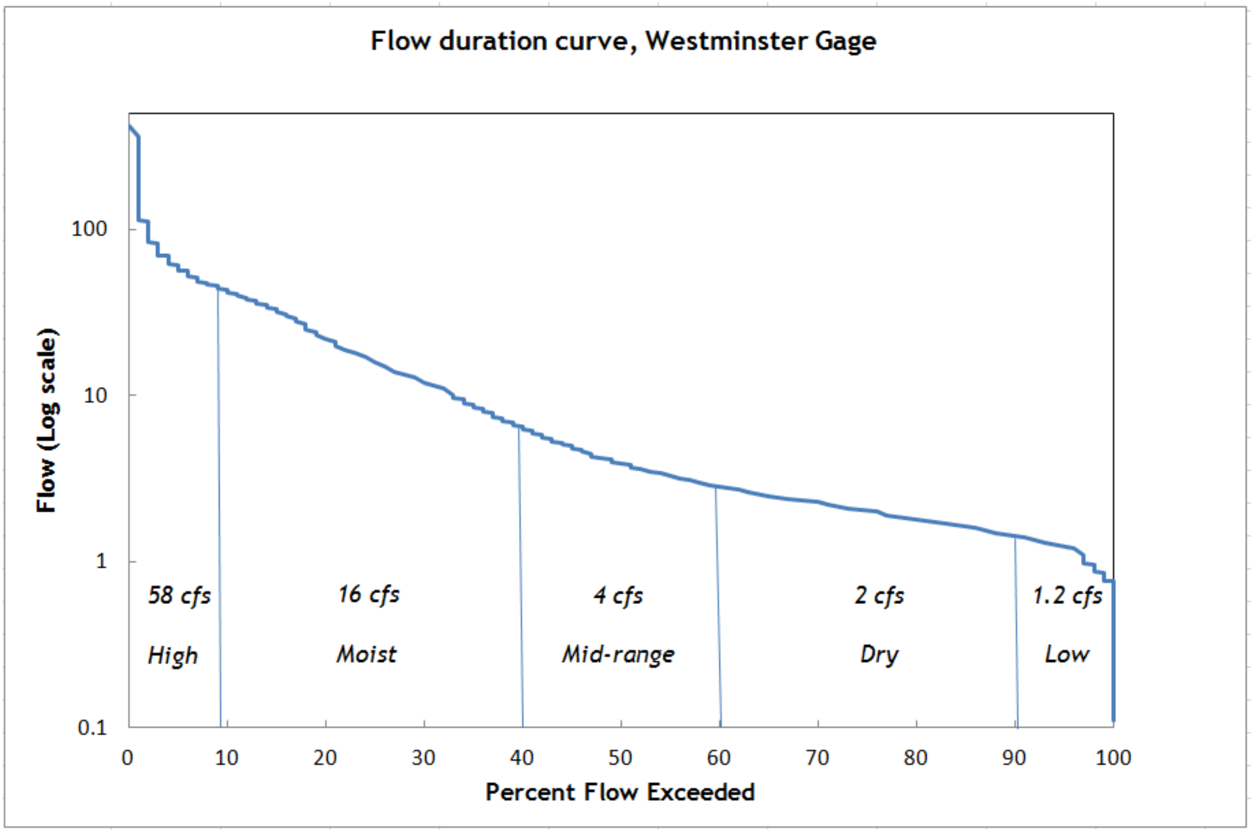

Figure 6.1-1. Flow duration curve using daily flow data from USGS gage 6720820, Big Dry Creek at Westminster, including median flow values for each flow regime.

Table 6.1-2 Flow duration curve values for USGS Big Dry Creek Ft. Lupton Gage			
Flow Regime	**Flow Range (cfs)**	**Median Flow (cfs)**	**% of time flows equal or greater occur**
High	69-736	92	<10%
Moist	35-68	45	10-40 %
Mid-Range	28-34	30	40-60 %
Dry	18-27	23	60-90%
Low	0.4-17	13	90-100%

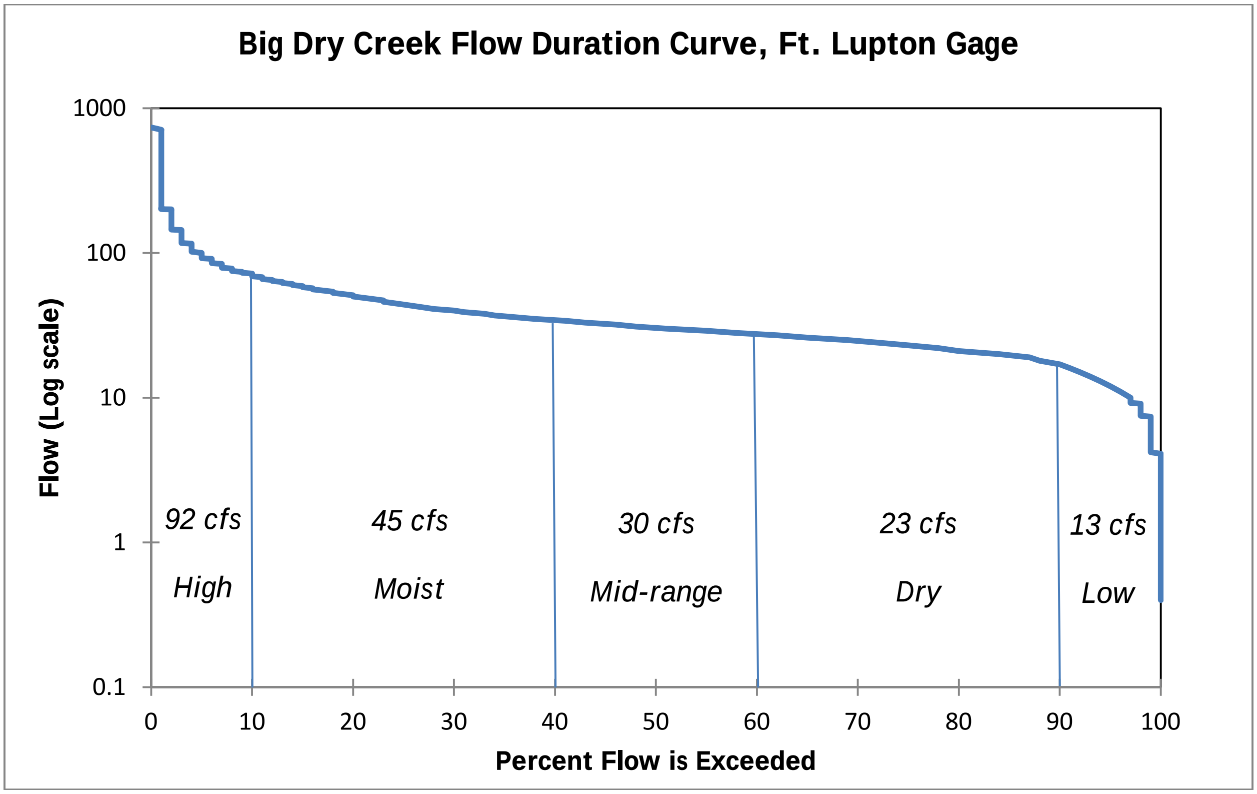

Figure 6.1-2. Flow duration curve using daily flow data from USGS gage 6720990, Big Dry Creek near Ft Lupton, including median flow values for each flow regime.

In order to analyze monitoring data collected by stakeholders within the watershed, and to determine if any sources could be identified based on flow conditions, load durations curves were evaluated at all sampling sites along Big Dry Creek, as well as the entire segment. According to the EPA guidance document (USEPA, 2007), the LDC method allows a visual display relating stream flow and loading capacity, as well as accounting for seasonal variations. The flow groupings, or regimes identified in the flow duration curve, can then be applied to the LDC. The water quality standards can then be represented on the same graph, by multiplying the instream flow values by the water quality target (205 cfu/100ml) and a conversion factor (24465888 to get to cfu/day). This trendline (blue solid line) represents the assimilative capacity (or water quality target) of the stream. The collected *E. coli* data are then plotted to illustrate exceedance/attainment of the standard, and also seasonality. In particular, he recreation season is from May thru October and poses a higher human health risk (as recreation typically occurs in the summer), therefore it is important to examine the data on a seasonal basis.

6.2 Loading Assessment

Specific *E. coli* data was plotted on load duration curves for each segment to evaluate and identify patterns (Figures 6.2-1 thru 6.2-3). Load assessments were evaluated at the sampling site within each reach with the highest overall E. coli geomeans (2003-2014). In general, exceedances that occur in the zero to ten percent area of the flow curve may be considered to represent unique high flow problems that may exceed feasible management remedies (Nevada DEP, 2003). Wet weather events can range from high flows and moist conditions due to severe thunderstorms to lower surface runoff following light rains (Cleland, 2003). For all three reaches, no distinct pattern emerged to identify potential source(s) to be addressed. For any distinct pattern related to seasonal flow influences to be observed, there are load exceedances in particular flow regimes. While the majority of *E. coli* values during the recreation season (May thru Oct) consistently exceed the standard, exceedances occur in both seasons in all flow regimes. Therefore, no distinct pattern could be identified.

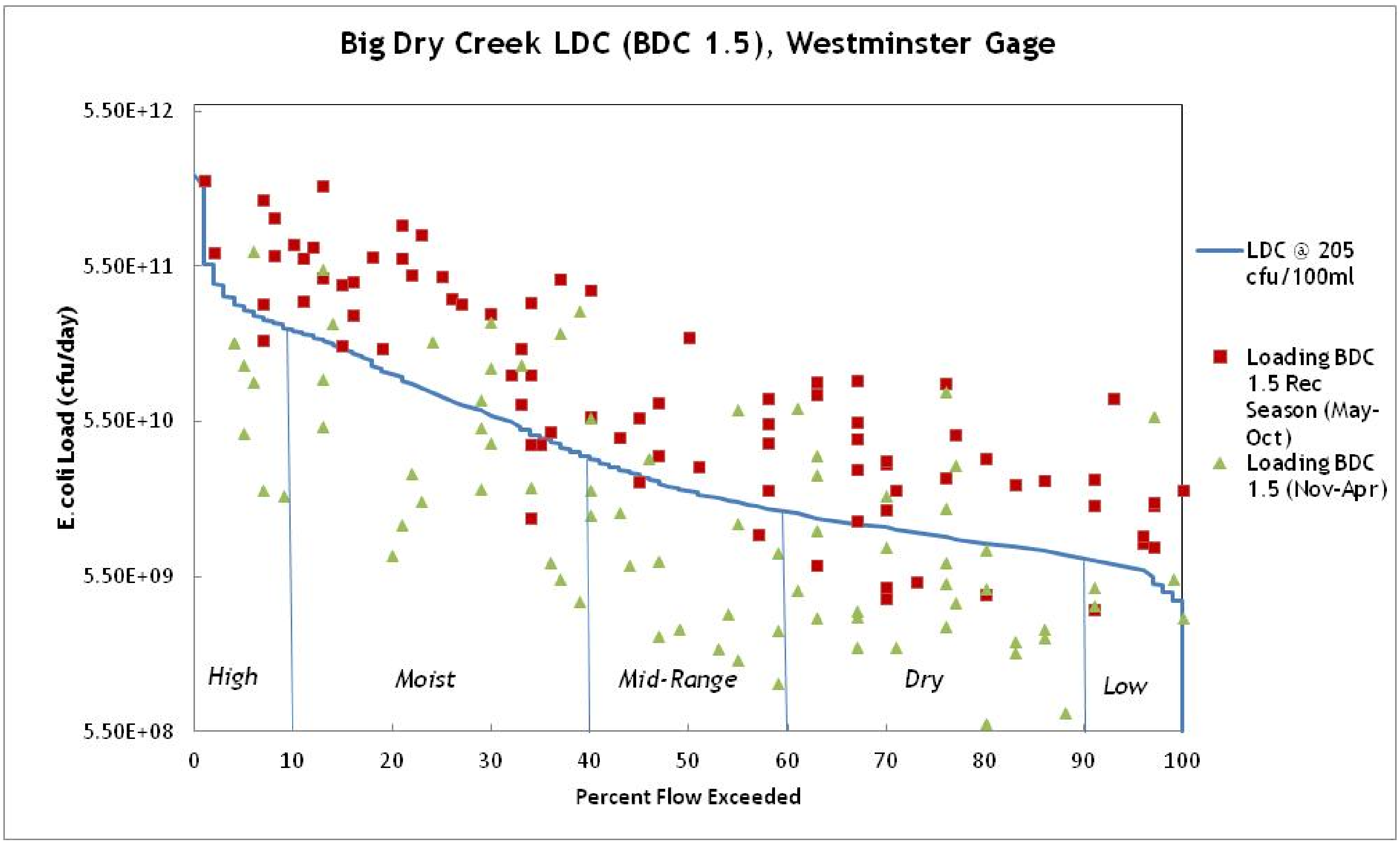

Figure 6.2-1 E. coli data (2003-2014) for bdc1.5 plotted on load duration curve based on Westminster flow gage.

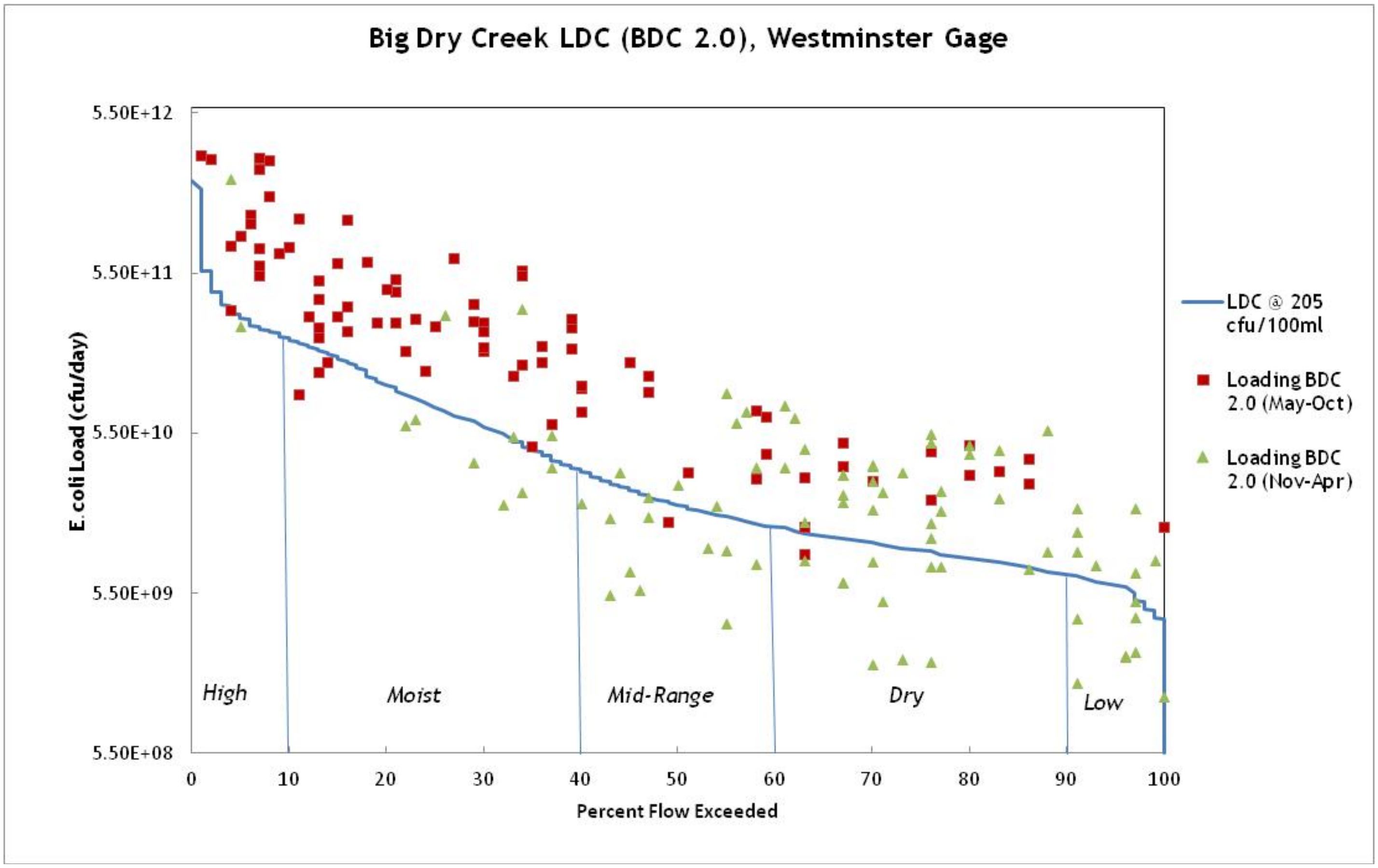

Figure 6.2-1 *E. coli* data (2003-2014) for bdc2.0 plotted on load duration curve based on Westminster flow gage.

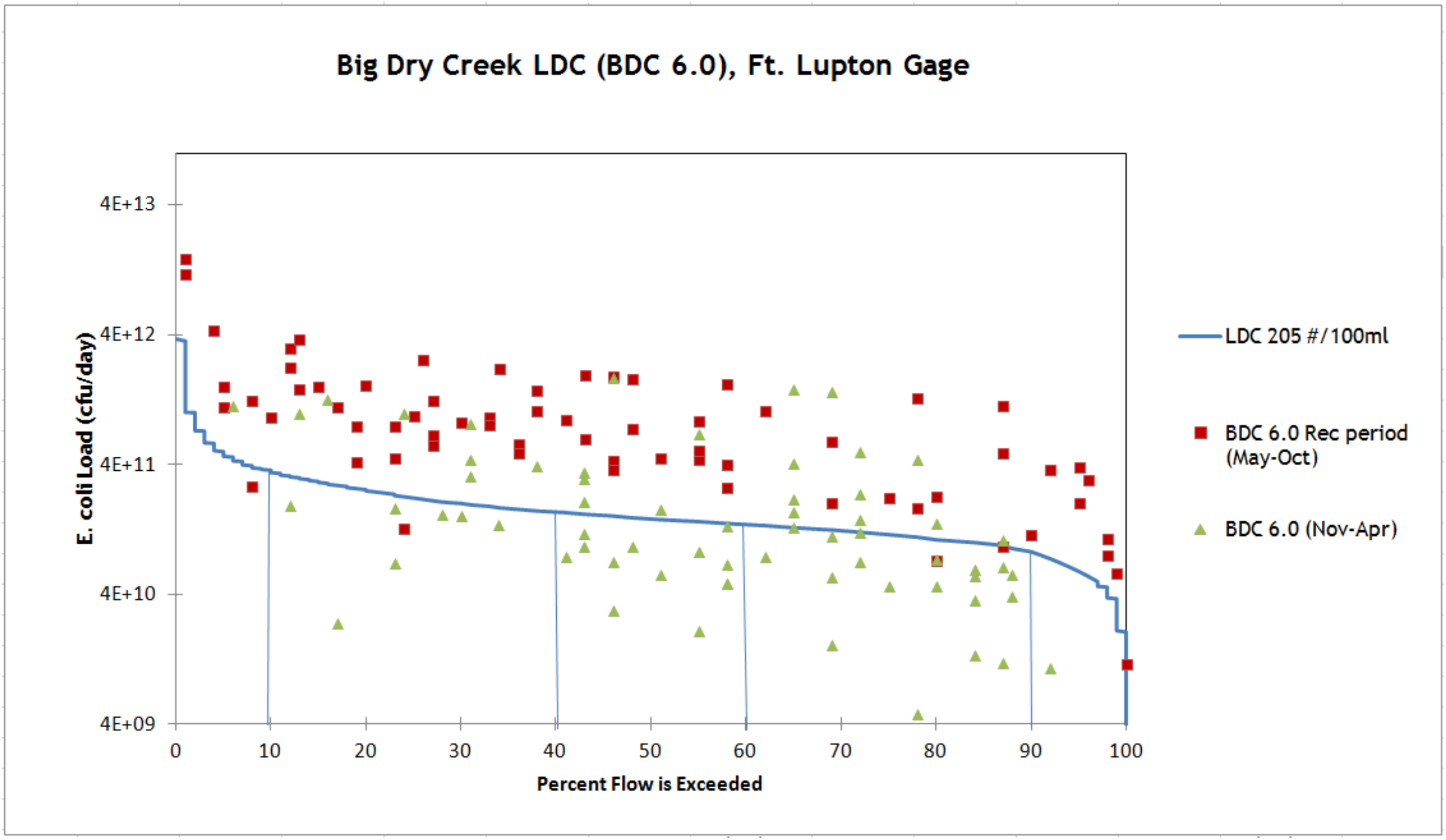

Figure 6.2-1 *E. coli* data (2003-2014) for bdc6.0 plotted on load duration curve based on Ft. Lupton flow gage.

7.0 Analysis of Pollutant Sources

7.1 Tributaries and Nonpoint *E. coli* Sources

Historic *E. coli* source identification data are lacking for tributaries to Big Dry Creek Segment 1. Nonpoint source *E. coli* is transported to segment 1 through runoff not captured by a regulated stormwater collection system; these sources may include human-made sources such agricultural return flows and failing septic systems and naturally occurring nonpoint sources such as wildlife, naturalized sources of bacteria and re-suspension of sediment in the stream. Because there is currently no information available to the Division to differentiate between sources of nonpoint *E. coli*, the Division cannot make those distinctions and therefore addresses these sources as a combined load allocation in the TMDL.

Table 7.1-1. Combined land cover areas for all three reaches (does not include area above lakes).		
NLCD Group	**Area (Acres)**	**Percent of Watershed**
Water	604.1	1%
Developed	25365.0	45%
Barren	104.4	0%
Forest	101.1	0%
Shrubland	317.0	1%
Herbaceous	4133.8	7%
Planted/Cultivated	23070.1	41%
Wetlands	2142.0	4%
Total	***55837.4***	***100%***

7.2 CDPS Process Water Permits

CDPS process water permits include construction dewatering, groundwater remediation, mining, minimal industrial discharges, water and wastewater treatment, and other permits not falling into the above categories. There are numerous CDPS process water permits that discharge directly to segment 1.

The CDPS Regulation (WQCC Regulation No. 61) requires the Division to develop permit limitations for any discharged pollutant that causes or contributes to, or that has the reasonable potential to cause or contribute to, an exceedance of water quality standards. The Division has developed a guidance (*Determination of the Requirement to Include Water Quality Standards-Based Limits in CDPS Permits Based on Reasonable Potential, Procedural Guidance, February 2003*) to determine a discharge's reasonable potential to cause or contribute to an exceedance of water quality standards.

There are several CDPS process water permits that discharge to segment 1 that have demonstrated reasonable potential to discharge *E. coli* at a level that may cause or contribute to an exceedance of the *E. coli* water quality standard, which are the City and County of Broomfield (CDPS permit CO-0026409) and the City of Westminster (CDPS permit CO-0024171). These permits were all renewed in April 2010. The design capacity of the Broomfield Wastewater Treatment Facility is currently 12.0 million gallons per day (MGD) for hydraulic flow (30-day average). The design capacity of the Westminster Wastewater Treatment Facility is currently 11.9 million gallons per day (MGD) for hydraulic flow (30-day average).

Chronic limits are reported as a 30-day average, calculated as geomean, and acute limits are reported as a maximum 7-day average. A summary of discharge data (2011-2015) shows no violations of permit effluent limits. Northglenn discharged to Big Dry Creek only in most recent years (2013-2015).

Table 7.2-1. Summary of DMR data, most recent 5 years (2011-2015).				
Facility	Reporting statistic	Max	Min	Geomean
Broomfield	Chronic	21.3	1.26	4.8
	Acute	53	1.76	10.6
Westminster	Chronic	22	3	8.8
	Acute	93	5	14.5
Northglenn	Chronic	81.6	1	7.7
	Acute	313	1	15.2

CDPS permitted discharges from WWTFs have been monitored in Big Dry Creek for *E. coli* since 2003. Prior to 2010 when CDPS permit limits for *E. coli* changed from 630 cfu/100 mL to 205/100 mL, WWTFs were permitted to discharge higher levels of *E. coli* than what are currently allowed to meet the stream standard of 205/100 mL. All of the municipal WWTFs routinely discharge *E. coli* concentrations well below the currently applicable stream standard and CDPS permit limits for WWTFs.

7.2.1 Broomfield WWTF

The Broomfield facility currently has effluent limits for both *E. coli*. The current *E. coli* permit limit is set to a 30-day average of 205 cfu./100ml and 7-day average maximum concentration of 410 cfu/100ml. The facility uses UV disinfection to treat pathogens and reports *E. coli* at levels below the permitted effluent limits.

7.2.2 Westminster WWTF

Similar to the Broomfield facility, the current *E. coli* permit limit is set to a 30-day average of 205 cfu./100ml; and a 7-day average maximum concentration of 410 cfu/100ml. In addition to changing from chlorination to UV disinfection in 2008, disinfected water which used to be stored in ponds prior to discharge, is now discharged directly to the creek (or to the reclaim plant) rather than being stored in ponds. Ducks and geese were an issue with these ponds, but as a result of the plant upgrades, these ponds are no longer in use. Elevated values in fall of 2007 were likely influenced by construction-related conditions. Currently, the facility discharges at levels below permitted effluent limits.

7.2.3 Northglenn WWTF

The current permit limits for Northglenn include the underlying *E. coli* standard of 205 cfu/100 mL as a 30-day average, and 410 cfu/100 mL as the 7-day average concentration. To date, the facility has not discharged at or above permitted effluent limits (Table 7.2-1). Northglenn has two outfalls on Big Dry Creek. Discharges from Northglenn to Big DryCreek are used for water rights augmentation purposes, and only recently (since 2013) have they consistently discharged into Segment 1.

The City of Northglenn also diverts effluent to Bull Canal for agricultural use. Additionally, Northglenn has the option to discharge treated effluent to one of two outfalls on Thompson Ditch, also for agricultural uses. Neither of those ditches feed into Big Dry Creek, and the *E. coli* limits do not apply to those outfalls.

Northglenn's WWTF was upgraded from an aerated lagoon system to a three-stage Biological Nutrient Removal system in 2007. The facility continues to undergo process upgrades.

7.3 Municipal Separate Storm Sewer System (MS4) Permits

Under Colorado's Municipal Separate Storm Sewer (MS4) program, municipalities are authorized to discharge stormwater, discharges authorized under separate CDPS process water permits, and other allowable non-stormwater discharges from their stormwater collection system. Table 7.2.4-1 provides a list of phase II, CDPS MS4 permittees within Big Dry Creek drainage, below Standley Lake and Great Western Reservoir (Figure 7.3-1). Not all permits listed have stormwater outfalls that discharge directly to Big Dry Creek. The land area boundary used for purposes of the TMDL calculations is focused on the areas below Standley Lake and Great Western Reservoir. It is possible that future development in the vicinity of Standley Lake may contribute flows to Big Dry Creek via storm sewer outfalls or ditch conveyances. In the event that these areas are determined to cause or contribute to the exceedance of the *E. coli* standard on Segment 1 of Big Dry Creek, then MS4 permit requirements for these discharges would be expected to be subject to similar requirements to MS4s currently discharging to Big Dry Creek. The WLAs for these potential discharges could be covered under a portion of the Reserve Capacity developed in this TMDL.

Table 7.3-1. MS4s within the Big Dry Creek watershed

CDPS Permit	Permit Holder
COR090051	City of Westminster
COR090054	City and County of Broomfield
COR090010	City of Northglenn
COR090024	Jefferson County
COR090034	City of Thornton
COR090041	Adams County
COR090037	Weld County
COR090038	Federal Heights
COR070049	Front Range Community College
COS000005	Colorado Department of Transportation (CDOT)

Allowable non-stormwater discharges include:

- landscape irrigation
- lawn watering
- diverted stream flows
- irrigation return flow
- rising ground waters
- uncontaminated ground water infiltration
- uncontaminated pumped ground water
- springs
- flows from riparian habitats and wetlands
- water line flushing

- discharges from potable water sources
- foundation drains
- air conditioning condensation
- water from crawl space pumps
- footing drains
- individual residential car washing
- dechlorinated swimming pool discharges
- street wash water
- discharges or flows from fire fighting activities
- dye testing in accordance with the manufacturers recommendations
- stormwater runoff with incidental pollutants
- discharges authorized by a CDPS or NPDES permit
- agricultural stormwater runoff
- discharges that are in accordance with the division's Low Risk Policy guidance documents or other Division policies and guidance documents where the Division has stated that it will not pursue permit coverage or enforcement for specified point source discharges.
- other discharges that the permittee will not consider as an illicit discharge and approved by the Division in accordance with the Phase II MS4 Permit Part 1, Section E.2.v.

Under the MS4 permit, municipalities must implement a program to detect and eliminate other non-stormwater discharges into their drainage or collection system.

The loading of *E. coli* from dry weather flows from stormwater outfalls is typically considered to be a controllable source through Best Management Practices (BMPs) that target *E. coli* sources. Municipalities and facilities with a CDPS MS4 permit are assigned a waste load allocation under this TMDL. Permits are renewed every five years, and the general permit that covers the phase II MS4s in the watershed was last renewed in April 2016.

At present, the only water quality data from stormwater outfalls along Big Dry Creek was collected by the BDCWA during 2006-2008. Municipalities in the watershed voluntarily conducted dry weather outfall screening of MS4 outfalls between 112th Avenue and I-25 to determine whether illicit connections to the MS4 were present. This area was identified as the highest priority for several reasons: elevated *E. coli* at instream sample locations BDC1.5 and BDC2.0, open space access and cooperation between Westminster and Broomfield MS4 phase II permit holders. One illicit connection was identified and removed in 2007, and the remaining outfalls in this reach did not indicate that controllable dry weather sources of *E. coli* were being discharged from the MS4s. Potential MS4 dry weather sources downstream of I-25 have not yet been evaluated. Wet weather runoff in both urban and agricultural areas is a potential source for *E. coli* to Big Dry creek, as are dry weather urban sources.

MS4 coverage areas are based on year 2000 US census urbanized areas, and city jurisdictional boundaries (Figure 7.2.4-1). The jurisdictional boundaries between municipalities and counties change periodically as annexations occur and as urban growth boundaries change. Federal heights and Boulder County do not have outfalls discharging directly to Big Dry Creek, and their permit coverage areas account for less than 1% of the watershed area. Adams County, Weld County, and Northglenn also do not have outfalls directly to segment 1, and stormwater presumably flows into another MS4 permit coverage area before reaching the creek. There are smaller non-standard MS4s not represented on this map, which include school districts. Currently, only Front Range Community College (COR070049) has reported to the division as discharging to Big Dry Creek. Due to limitations in the ability to query for non-standard permits, as well as limitations associated with how non-standards report, Table 7.3-1 may not include all non-standards that discharge directly to Big Dry Creek. As these direct dischargers become known, they will be required to meet the TMDLs. Additionally, Colorado Department of Transportation's stormwater permit includes land in the Big Dry Creek watershed.

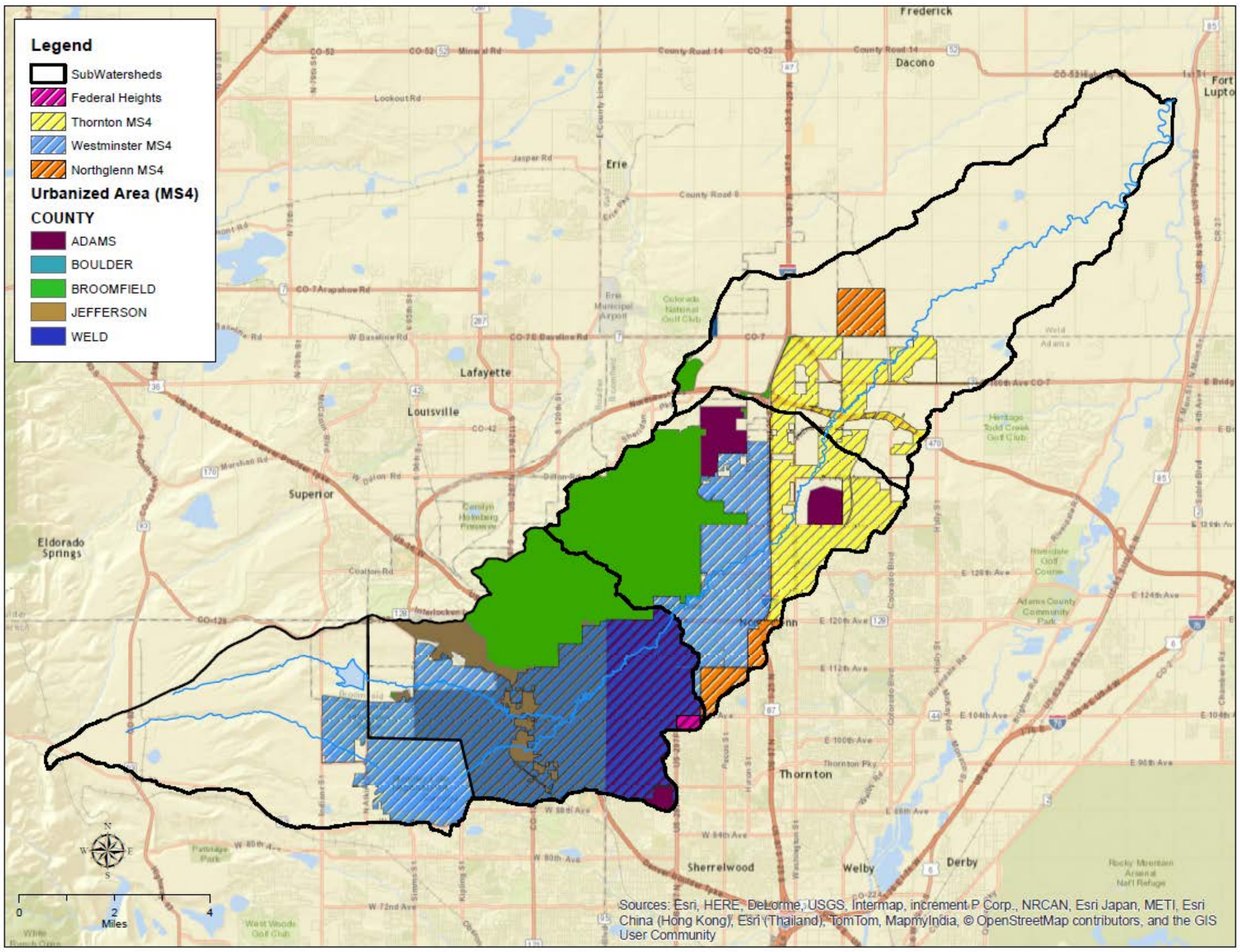

Figure 7.3-1. 2016 map of MS4s coverage within the Big Dry Creek watershed boundary, information provided by BDCWA

7.4 Other Permitted Sources

The division reviewed and considered other potential sources of *E. coli* including permitted combined animal feeding operations (CAFO) and industrial stormwater permits. In a search of the database of record, EPA's Integrated Compliance Information System (ICIS), no permitted CAFO dischargers were found in the watershed HUC12 boundaries. Additionally, the industrial stormwater permits do not contain *E. coli* as pollutant of concern. It was determined there is no reasonable potential for the industrial stormwater permits to contribute to an exceedance of the standard. If, at a later date, it is found there are additional dischargers with reasonable potential for *E.coli*, these permits will need WLA, and the reserve capacity will be utilized for this purpose.

8.0 TMDL Allocation

TMDL assessments traditionally utilize a mass per time accounting of pollutant sources. However, since *E. coli* sources are non-additive and extremely variable due to both natural and anthropogenic processes in the watershed, and flows in segment 1 fluctuate on a non-seasonal basis due to the intensive water management of the Big Dry system, traditional mass-based load allocations for segment 1 are not the best estimate of the pollutant sources for *E. coli* and their associated contribution to the *E. coli* load in Big Dry Creek. For this TMDL, the division has used density-based load allocations. The load allocations are equivalent to the number of colony forming units per day. The TMDL is divided into load and waste load allocations.

As a protective assumption to ensure beneficial uses throughout the entire segment are attained, required reductions were calculated based on data collected at the monitoring site on each reach that exhibited the highest *E. coli* concentrations relative to other monitoring locations within each reach of Big Dry Creek.

TMDLs have been developed by dividing the entire segment into three distinct reaches. The reaches were divided based on factors such as land use, key hydrologic influences (e.g., WWTF discharges) and *E. coli* results at BDCWA's long-term monitoring locations. The three reaches consist of 1) the upper reach, from the outlet of the Standley Lake to sampling point BDC 1.5; 2) middle reach, from BDC below 1.5 to 152nd Ave.; and 3) lower reach, 152nd Ave to the confluence with the South Platte River.

A conversion factor (CF) was needed to convert the *E. coli* concentration (cfu/100 mL) to a density-based load (cfu/day). Existing and allowable loads, along with percent reductions to attain standards were calculated using the following equation:

$$Load\ \left(\frac{CFU}{day}\right) = E.coli\ Concentration\ \left(\frac{CFU}{100\ mL}\right) \times Flow(cfs) \times Conversion\ Factor$$

Where,

$$Conversion\ Factor\ = \frac{1}{100} \times \frac{28317\ mL}{ft^3} \times \frac{86400\ sec}{day} = 24465888$$

Allocations for the upper, middle and lower reaches are presented in Tables 8.0-1, 8.0-2 and 8.0-3, respectively. The upper reach is primarily urban, with 77% developed land use; this reach has comparatively lower *E. coli* levels than the middle and lower reaches. The USGS gage, Big Dry Creek at Westminster, represents the flow in the upper reach and was used in determining the allowable load. The MS4s were given a WLA, with no other permitted discharges found in the reach to have *E. coli* as a pollutant of concern. A reserve capacity was also calculated to be distributed to any future MS4 or other dischargers with reasonable potential to exceed the *E. coli* standard in the upper reach of Big Dry Creek.

Table 8.0-1. Upper Reach TMDL: allocations for point and nonpoint sources					
Loading Calculations (Giga cfu/day)	High Flow	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flow
TMDL	290.90	80.25	20.06	10.03	6.02
MOS (10%)	29.09	8.02	2.01	1.00	0.60
WLA					
MS4s	201.59	55.61	13.90	6.95	4.17
Reserve Capacity	10.08	2.78	0.70	0.35	0.21
LA					
Nonpoint Source	50.14	13.83	3.46	1.73	1.04

The middle reach is also primarily urban, with 60% developed area, with some agricultural areas transitioning to urban land use. There are also two major WWTFs that discharge to this portion, which do not contribute to the impairment, but have a significant impact on the flow. As previously mentioned in the hydrology section, this is a highly managed stream, with large volumes of water being discharged to and diverted from the creek in multiple locations. Because of the complex hydrology in this reach and due to the large volumes of treated effluent discharged from the WWTFs with very low *E. coli*, mathematical adjustments to the WLA calculation procedure were required to develop WLAs for the WWTFs for purposes of representing the WLA in the TMDL. In order to estimate the flow contributions from the WWTFs, the division used facility monthly discharge data (most recent 5 years) to create flow duration curves for each facility. Median flows were calculated for each flow regime, these flows were then added to the Westminster Gage flows. The added contributions for the two facilities, for each flow regime are in Table 8.0-2.

Table 8.0-2. Middle Reach TMDL: Estimated WWTF flow contributions					
	High	Moist	Mid-Range	Dry	Low
Westminster Median Flow	11.6	10.8	10.3	6.4	3.4
Broomfield Median Flow	14.8	12.8	11.5	6.3	1.0

As with the upper reach, an MS4 WLA and a reserve capacity were also calculated for the middle reach. The reserve capacity may be used for WWTF, MS4, or other permitted discharges.

Table 8.0-3. Middle Reach TMDL: allocations for point and nonpoint sources					
Loading Calculations (Giga-cfu/day)	**High Flow**	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flow**
TMDL	423.34	198.56	129.18	73.58	27.94
MOS (10%)	42.33	19.86	12.92	7.36	2.79
WLA					
Westminster WWTF	58.24	54.32	51.49	31.97	16.99
Broomfield WWTF	74.20	64.00	57.63	31.58	4.92
MS4s	149.14	36.23	4.29	1.60	1.94
Reserve Capacity	7.46	1.81	0.21	0.08	0.10
LA					
Non-point Source	91.97	22.34	2.64	0.99	1.19

The lower reach demonstrates the most significant change in land use, being primarily agricultural, and only 12% developed. This reach has nearly as high reductions required as the middle reach, however the implementation of the TMDL to meet the standard relies mainly on nonpoint source reductions. The WLAs were distributed as follows: one WWTF that intermittently discharges to Big Dry Creek; an MS4 allocation; and a reserve capacity for any future discharges.

Table 8.0-4. Lower Reach TMDL: allocations for point and nonpoint sources					
Loading Calculations (Giga cfu/day)	**High Flow**	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flow**
TMDL	461.43	225.70	150.47	115.36	65.20
MOS (10%)	46.14	22.57	15.05	11.54	6.52
WLA					
Northglenn WWTF	50.44	50.44	50.44	50.44	50.44
MS4s	43.78	18.32	10.20	6.41	0.99
Reserve Capacity	4.38	1.83	1.02	0.64	0.10
LA					
Nonpoint Source	316.68	132.53	73.76	46.33	7.15

8.1 Waste Load Allocation

The waste load allocation contains allocation to permitted point source discharges which include NPDES permitted wastewater facilities and regulated MS4 stormwater discharges. The waste load allocation for the treatment facilities was assigned as the Recreation P *E. coli* standard of 205 cfu/100 ml. The contribution of MS4 regulated stormwater to the associated waste load allocation was calculated using the percentage of the watershed that is covered by urban areas, which varied depending on the reach. Urban areas were calculated as combined area of four categories of NLCD developed land use: open space, low intensity, medium intensity, and high intensity, as defined in Table 1.1-2.

Normally when WLAs are given to WWTFs, they are determined using the facility design capacity and the water quality standard. In this instance, the flow monitoring gages at either end of the stream do not account for the managed flow (ditches and diversions) throughout Big Dry Creek, specifically where the WWTFs discharge. Considerations had to be made in the middle portion to account for the fact that facilities discharge *E. coli* well below the standard, and provide dilution in this part of the stream. The monthly average flow discharges reported in Broomfield and Westminster discharge monitoring reports (DMRs) for the past five years were used to calculate flow duration curves for each facility (EPA, 2016). Similar to the flow duration curves for the stream gages, median flows were calculated for the five different flow regimes. And the WWTF WLAs were calculated as the facility median flows multiplied by the standard (Table 8.1-1). As Northglenn discharges to the lower portion, where flow is greater, their design capacity was used in determining their WLAs.

All of the mentioned WWTFs (Broomfield, Westminster, and Northglenn) with reasonable potential to exceed the standard have adequate treatment in place (UV disinfection) to discharge well below the standard. Therefore, there are no load reductions expected from the WWTFs, and their permit limits set at the standard end-of-pipe are adequate in meeting the TMDL

Table 8.1-1. Calculation of loading for Broomfield and Westminster WWTFs

Facility Loading Calculations	High	Moist	Mid-Range	Dry	Low
Westminster Median Flow (cfs)	11.6	10.8	10.3	6.4	3.4
Westminster Load @ standard (Giga cfu/day)	58.24	54.32	51.49	31.97	16.99
Broomfield Median Flow (cfs)	14.8	12.8	11.5	6.3	1.0
Broomfield Load @ standard (Giga cfu/day)	74.20	64.00	57.63	31.58	4.92

The percent of developed land use was calculated as a proxy for MS4 land area for each reach using GIS land use (NLCD, 2006) and watershed delineation (USGS, 2011) layers. The resulting percent developed areas for each reach were upper (77% developed), middle (60% developed) and lower (12% developed). The MS4 WLA was then calculated for each reach based on subtracting the WWTF WLA from the allowable load and multiplying that value by the percent developed area. This calculation was the best available estimate to represent stormwater discharged from MS4 outfalls that the division was able to provide at the time that this TMDL was developed.

As was the case for the WLAs for the WWTFs in the watershed, WLA calculations for the MS4s are also affected by the complex hydrology in the creek. Based on current best practice and watershed-specific information at the time this TMDL was completed, the division intends that MS4 WLAs will be implemented on a programmatic, best management practice (BMP) approach implemented to the maximum extent practicable (MEP) which is consistent with Colorado's current MS4 general permit. If in the future MS4 outfall-specific WLAs are needed to, for example, support numeric effluent limits, additional data and analyses would be necessary to refine the MS4 WLAs identified in this TMDL document in order to address the uncertainties resulting from limited MS4 outfall-specific data and the associated assumptions made and limitations of the methods available for developing the current TMDLs.

8.2 Reserve Capacity

The TMDL assumptions and calculations in this TMDL were based on best available information at the time the TMDL was developed. The TMDL provides a framework for working towards attainment of the *E. coli* standard for Big Dry Creek. As more accurate source identification data are generated over time, the TMDL may need to be revised. The Reserve Capacity established in this TMDL is intended to provide flexibility with implementation of this TMDL. It takes into account future changes which may include expansion of WWTFs, addition of WWTFs, increase in urbanized area (resulting in change in MS4 permit coverage) or projections that some other nonpoint sources will come into the watershed.

It is anticipated that there will be some growth in the watershed. Projections from the state demographers' office (CO SDO, 2016) report percent population change by county (Table 8.2-1) and show a significant projected increase in population in Weld County in 20 years. As Weld County makes up a majority of the lower portion, the population growth projections illustrate a need for a reserve capacity in each of the three reaches of Big Dry Creek.

Table 8.2-1. State demographer statistics by county

County	10 year - % population change	20 year - % population change
Weld	36.48%	78.01%
Adams	19.19%	37.35%
Broomfield	19.9%	29.88%
Jefferson	8.32%	13.33%

With urbanized growth in mind, the reserve capacity was based on a percent increase in the MS4 WLA. The upper and middle portions are already highly urbanized, and the reserve capacity accounts for a 5% increase in urbanization. The lower portion requires accounting for a higher 10% increase. Reserve capacity WLAs for each reach are shown in Tables 8.0-1, 8.0-2 and 8.0-3.

8.3 Load Allocation

The load allocations developed in this TMDL account for the natural background sources of *E. coli* in addition to the contribution from agriculture (dry land and irrigated crops and livestock) and additional nonpoint sources. To achieve the water quality goals of this TMDL, each source must meet its load or waste load allocation. Tables 8.0-1 through 8.0-3 present the *E. coli* load and waste load allocations proposed for Big Dry Creek Segment 1. After the WLAs were given to the point sources, the remaining load was determined to be the load allocation. Equation 1 then becomes:

$$LA = TMDL - MOS - WLA$$

Where, the WLA includes allocations for permitted point sources dischargers and a reserve capacity, as indicated in Tables 8.0-1, 8.0-2 and 8.0-3.

8.4 Margin of Safety

According to the Federal Clean Water Act, TMDLs require a margin of safety (MOS) component that accounts for the uncertainty about the relationship between the pollutant loads and the receiving waterbody. This MOS is included to account for the uncertainty in the analysis of the relationship between the TMDL loading allocations and the desired water quality target.

A MOS can be either implicit or explicit. Implicit MOS are incorporated into the TMDL analysis through conservative assumptions, and explicit MOS can be expressed in the TMDL as a portion of the loadings. This TMDL uses both an explicit and an implicit MOS. An implicit MOS considered appropriate because the standard was used to calculate the WLAs for the facilities, when in fact they are discharging well below the standard.

In addition to an implicit margin of safety, a ten percent (10%) explicit margin of safety was added to account for any uncertainties within the TMDL development process. While there is ample instream data throughout the impaired reach, there is only one year of dry weather outfall monitoring to determine MS4 contributions.

8.5 Examples of Load Reductions

E. coli levels instream oscillate with natural die off and diurnal fluctuations. Also, flows in segment 1 fluctuate dramatically on a non-seasonal basis due to water diversions and upstream reservoir releases. Thus it is difficult to determine a load reduction that is a fixed number. A conservative approach of showing loading reductions needed to attain the standard in each reach is used (Tables 8.3-1-8.3-3). This is an example of the reductions necessary for the entire segment. Reductions for each monitoring location can similarly be calculated. Determining reductions for each stormwater outfall, however, is more difficult. As only dry weather outfall monitoring was completed during the recreation season (Apr-Oct) in 2007, specific outfall loading and reductions cannot be determined based on this limited data set.

Reductions are calculated using the allowable and existing load. Where the observed geomean does not exceed the standard, the existing load is less than the allowable load, and no reductions are required. This can be seen in the high and mid-range flows in the upper reach (Table 8.3-1)

Table 8.5-1. Upper Reach: Allowable loading and required reductions.					
Loading Calculations	**High Flow**	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flow**
Median Flow (cfs)	58	16	4	2	1.2
WQS, TMDL Target (cfu/100mL)	205	205	205	205	205
Observed Geomean @ BDC 1.5 (cfu/100mL)	165	319	171	208	428
Allowable Load, TMDL minus MOS (Giga cfu/day)	261.81	72.22	18.06	9.03	5.42
Existing Load @ BDC 1.5 (Giga cfu/day)	234.61	124.74	16.69	10.18	12.56
Required Reduction (%)	0%	42%	0%	11%	57%

Table 8.5-2. Middle Reach: Allowable loading and required reductions.					
Loading Calculations	**High Flow**	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flow**
Median Flow (cfs)	84.4	39.6	25.8	14.7	5.6
WQS, TMDL Target (cfu/100mL)	205	205	205	205	205
Observed Geomean @ BDC 2.0 (cfu/100mL)	542	439	387	319	697
Allowable Load, TMDL minus MOS (Giga cfu/day)	381.01	178.71	116.26	66.22	25.14
Existing Load @ BDC 2.0 (Giga cfu/day)	1119.13	425.48	244.05	114.49	94.98
Required Reduction (%)	66%	58%	52%	42%	74%

Table 8.5-3. Lower Reach: Allowable loading and required reductions.					
Loading Calculations	**High Flow**	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flow**
Median Flow (cfs)	92	45	30	23	13
WQS, TMDL Target (cfu/100mL)	205	205	205	205	205
Observed Geomean @ BDC 6.0 (cfu/100mL)	747.33	562.74	349.20	239.29	442.71
Allowable Load, TMDL minus MOS (cfu/day)	415.28	203.13	135.42	103.82	58.68
Existing Load @ BDC 6.0 (cfu/day)	1682.14	619.55	256.30	134.65	140.81
Required Reduction (%)	75%	67%	47%	23%	58%

9.0 Implementation

Implementation of this TMDL will be an iterative process involving the CDPS permittees that discharge to segment 1 and other nonpoint source pollution programs. The CDPS permitted domestic wastewater treatment facilities have already been addressed with effluent limits for *E. coli* equal to the water quality standard (205 cfu/100mL). These facilities already discharge well below these limits according to submitted discharge monitoring data. Further reductions from these facilities are unnecessary at this time. While these sources have been addressed, other controls are necessary to achieve full restoration of the waterbody.

The MS4 permitted discharges in the watershed require a stormwater management program to reduce discharge of pollutants to the maximum extent practicable (MEP) to protect water quality (WQCC 2015b). There are minimum control measures already required in MS4 permits, which include: public education and outreach; public involvement/participation; illicit discharge detection and elimination; construction site stormwater runoff control; post-construction stormwater management in new development and redevelopment; and pollution prevention/good housekeeping for municipal operations. The division is authorized to include more stringent limitations based on a TMDL that determines such limitations are needed to protect water quality which is the case for Big Dry Creek, Segment 1. Therefore, additional requirements will be necessary for the MS4 permits identified in this TMDL (WQCC 2015b).

In compliance with Regulation 61, the division cannot issue a permit that allows discharges that cause or have the potential to cause an exceedance of a numeric water quality standard unless the permit contains effluent limitations and a schedule of compliance specifying treatment requirements. Currently, Regulation 61 allows the effluent limit to consist of best management practices (BMPs) to ensure protection of the water quality standard.

9.1 Recommended Actions

Implementation of the TMDL through the coordinated efforts of the Big Dry Creek Watershed Association is encouraged, given that the most effective strategies for pollutant load reductions require integration among entities with land draining to Big Dry Creek. However, each permit will have its own clear, specific and measurable requirements. Implementation actions may include, but are not limited to, the following: additional monitoring; infrastructure maintenance and upgrades; education and outreach; and stormwater BMPs.

The assumptions and calculations in this TMDL were based on best available information at the time the TMDL was developed. More accurate source identification could support revisions to loading calculations and/or TMDL allocations. Source identification investigation techniques to identify likely *E. coli* sources include a broad range of methods ranging from basic visual outfall investigation with *E. coli* sampling to use of advanced molecular methods. Better identification of sources through, for example, acquiring additional, targeted dry weather data at stormwater outfalls could support loading and/or TMDL allocation revisions, with the basis for determining the potential to contribute to an exceedance of the water quality standard being outfall data that exceeds the density-based TMDL. Source identification investigations could also support high priority implementation of this TMDL through the identification and correction of potential sanitary (human) sources of *E. coli* through illicit discharge detection and elimination investigations

9.2 Post-Implementation Monitoring

The division encourages BDCWA to continue its voluntary instream monitoring program. MS4s in the segment may be required to collect additional dry-weather based outfall-monitoring data to determine if dry weather discharges exist that could exceed the density based TMDL. The division recognizes that dry weather outfall monitoring has already been conducted in the portion of the watershed between 112th Ave and I-25. The division will work with BDCWA and other stakeholders to determine additional monitoring that may be beneficial for identifying sources of *E. coli* and evaluating instream trends over time as the TMDL is implemented.

Additional monitoring and evaluation could also be done in support of evaluating an alternative site-specific stream standard. During the 2012 Recreational Water Quality Criteria (RWQC) update, EPA explored the issue of relative risk from non-human sources of pathogens by conducting two literature reviews and sponsoring research related to Quantitative Microbial Risk Assessment (QMRA). As a result of these efforts, EPA ultimately concluded that a national-level source exclusion for wildlife was not supportable in the 2012 RWQC; however, the criteria also recognized that wildlife sources are generally expected to pose a lower human health risk. EPA's 2012 RWQC provide a new opportunity for alternative site-specific streams standards if human contamination sources are controlled and further epidemiological studies or QMRA for a waterbody shows that the human health risk in a waterbody is equal to or less than EPA's equivalent illness rate thresholds.

9.3 TMDL Endpoint

The endpoint of this TMDL will be attainment of the *E. coli* water quality standard using the commissions' approved 303(d) Listing Methodology.

10.0 Public Involvement

The Big Dry Creek watershed association formed in 1997, and has done extensive work in the watershed. The association consists of City and County of Broomfield, City of Northglenn, City of Westminster, Adams Co., and Weld Co. Over the past 20 years, BDCWA has conducted voluntary long-term water quality monthly monitoring of eight locations on Big Dry Creek, as well as produced annual water quality reports and publically available newsletters summarizing water quality conditions. BDCWA also maintains a long-term water quality database with approximately 70,000 water quality results collected and analyzed during this timeframe. Additional work has included several special studies regarding *E. coli*, long-term biannual biological monitoring, special studies of the stream hydrology and long-term financial support of the USGS Gauge in Westminster.

The division was an active member of the Water Quality Forum *E. coli* work group (2007-2010), and has initiated discussions with the group about the development of *E. coli* TMDLs, including Big Dry Creek Segment 1. Several meetings were attended by the association, the division, and EPA, to discuss TMDL development in detail. The most recent meetings occurred February and April 2016. The steps taken in the TMDL process have been outlined by the division. This TMDL was noticed for 30-day public comment on June 13, 2016.

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APPENDIX A

A.1 Routine Instream Monitoring Data

Sample Date	bdc 0.5 (cfu/100 ml)	bdc 1.0 (cfu/100 ml)	bdc 1.5 (cfu/100 ml)	bdc 2.0 (cfu/100 ml)	bdc 3.0 (cfu/100 ml)	bdc 4.0 (cfu/100 ml)	bdc 4.5 (cfu/100 ml)	bdc 5.0 (cfu/100 ml)	bdc 6.0 (cfu/100 ml)
4/13/2000	1454	76	176	106	116	172		133	413
5/11/2000	28	86	219	144	107	192		199	240
6/8/2000	114	290	517	548	240	649		119	250
8/10/2000	435	387	461	1553	613	816		272	481
9/14/2000	1046	687	1414		649	687		687	411
10/12/2000	138	276	1120	1120	308	816		326	435
11/16/2000	66	83	104	387	157	308		68	115
12/21/2000		23	345	2419	980	1298		308	488
1/18/2001		3	14	172	39	727		197	648
2/15/2001		14	82	547	326	179		308	121
3/8/2001	96	24	50	1553	249	238		64	70
4/19/2001	160	19	488	172	82	102		105	135
5/10/2001	921	687	291	411	461	580		435	866
6/14/2001	153	629	755	721	689	2419.2		2419.2	2419.2
7/12/2001	1986	2419.2	2419.2	2419.2	1733	2419		2419.2	2419.2
8/9/2001	435		579	517	980	547		345	1046
9/13/2001	921	548	579	517	435	548		435	517
10/11/2001	385	517	1120	2419.2	816	1046		517	461
11/8/2001	2419.2	866	980	2419.2	2419.2	1986		1553	649
12/13/2001		12		200	94				
1/17/2002		11	172	291	108	120		78	99
2/14/2002		12	70	326	140	199		62	517
3/14/2002	147	236	22	866	687	308		51	93
4/11/2002	579	153	248	222	119	88		980	649
5/9/2002	770	411	1300	727	122	161		411	980
6/20/2002	1553	1414	1046	1046	1203	240		488	435
7/11/2002	2419	2419.2	2419.2	2419.2	2419.2	2419.2		2419.2	2419.2
8/15/2002	488	727	2419.2	1203	649	1203		308	326
9/12/2002	1986	2419	2419.2	2419	1733	1553		1986	1300
10/10/2002	435	153	687	770	579	517		1046	435
11/14/2002	2419	52	66	2419.2	816	387		387	866
12/12/2002			91	2419.2	2419.2	2419.2		2419.2	2419.2
2/6/2003	24		17		308	162		248	
2/13/2003		70	16	1046	326	10		122	
2/20/2003	31		16	152	166			115	

Sample Date	bdc 0.5 (cfu/100 ml)	bdc 1.0 (cfu/100 ml)	bdc 1.5 (cfu/100 ml)	bdc 2.0 (cfu/100 ml)	bdc 3.0 (cfu/100 ml)	bdc 4.0 (cfu/100 ml)	bdc 4.5 (cfu/100 ml)	bdc 5.0 (cfu/100 ml)	bdc 6.0 (cfu/10 0 ml)
2/27/2003	18		57	980	292			138	
3/6/2003			105		816			276	
3/13/2003	13	13	102	548	122			15	84
3/27/2003	173	114	178	178	291			461	
4/3/2003	77		33	114	50			33	
4/9/2003						86			
4/17/2003				816	980			83	
4/24/2003	1986			1414	1300				
5/8/2003	328		99	158	126			50	
5/14/2003	659	147	99	344	91	866		260	148
5/22/2003	1413		921	1120	980			276	
5/29/2003	501		961	961	914			1011	
6/5/2003	205		517	488	517			866	
6/12/2003	185	866	1203	687	517	162		365	687
6/19/2003	184		1414	1986					
6/26/2003	102			649				345	
7/3/2003	980		687		308			52	
7/17/2003	411	980	687	980	921	579		435	816
7/24/2003	727		770	770	816			687	
7/31/2003	248		921	921	387			1733	
8/7/2003	517		727	770	199			249	
8/14/2003	365	687	461	1120	201			579	1300
8/21/2003	162		548	649	461			816	
8/28/2003	649				172			980	
9/3/2003	225		265	240	161			613	
9/11/2003	206	613	613	816	1300	291			866
9/18/2003	1300		517	461	517				
10/2/2003	548		317	980	411				330
10/9/2003	178		488	1046	866			387	
10/16/2003	206	50	308	866	613	192		291	276
10/23/2003	50		166	866				109	
10/30/2003	147		687	579	461			112	
11/6/2003	107		135	231	148			130	
11/13/2003	166	178	93	488	178	218		140	122
11/20/2003	166		140	517	166			130	
12/4/2003	76		1733	240	579			32	
12/11/2003	345	130	184	435	172	144		236	120
12/18/2003	156		65	275	214			129	
1/8/2004	1203	108	613	488	148	86		178	118
1/15/2004	45		50	770	291			76	
1/22/2004			64	126	84			111	

Sample Date	bdc 0.5 (cfu/100 ml)	bdc 1.0 (cfu/100 ml)	bdc 1.5 (cfu/100 ml)	bdc 2.0 (cfu/100 ml)	bdc 3.0 (cfu/100 ml)	bdc 4.0 (cfu/100 ml)	bdc 4.5 (cfu/100 ml)	bdc 5.0 (cfu/100 ml)	bdc 6.0 (cfu/10 0 ml)
1/28/2004	308		54	199	411			135	
2/19/2004	111	29	43	109	70			86	115
3/11/2004	104	12	110	111	32	43		58	130
4/8/2004	866	104	137	291	214	291		21	921
5/12/2004	547	240	249	178	190	156		150	980
6/10/2004	1300	2419	1986		1986	1203		1732	2419
7/8/2004	436	461	461	613	436	219		201	1046
8/12/2004	435	1046	687	816	649	461		649	980
9/9/2004	259	488	547	547	238	142		150	613
10/14/2004	1120	1986	1203	1733	770	1120		1046	1120
11/10/2004	20	60	80	120	60	200		320	100
12/9/2004	110	20	20	140	50	20		10	30
1/20/2005	25	3	14	50	170	13		6	9
2/10/2005	38	1	21	44	15	8		4	28
3/17/2005	96	8	38	41	19	7		14	30
4/21/2005	1986	1120	1120	816	687	1414		1120	
5/12/2005	1203	548	921	980	727	770		1203	
6/9/2005	157	770	517	488	240	488		326	548
7/14/2005	488	613	1553	1986	579	248		365	866
8/18/2005	365	613		1553	517	155		225	435
9/15/2005	281	365	1986	1300	727	770		1733	
10/18/2005	126	517	326	225		240		222	345
11/10/2005	79	770	326	307	222	40			276
12/8/2005	9	18	52	158	75	44		75	261
1/12/2006	2	22	105	199	81	16		32	26
2/9/2006		96	34	260	48	29		41	72
3/9/2006	1986	980	980	214	162	167		167	921
4/13/2006	31	308	276	109	162	44		75	411
5/11/2006	28	126	192	147	88	53		67	770
6/15/2006	365	866	2419	816	770	816		547	980
7/13/2006	517	1733	1733	649	517	727		727	1046
8/10/2006	206	866	1120	980	921	261		547	387
9/14/2006	225	275	325	365	345	261		261	579
10/19/2006	816	488	579	687	517	1046		727	687
11/16/2006	33	52	275	275	118	179		387	345
12/14/2006	48	54	22	153	132	261		62	63
1/10/2007	20	20		133	68	96		126	155
2/8/2007	260	60	88	178	148	184		192	126
3/15/2007	33	64	236	114	57	105		70	79
4/12/2007	27	54	56	64	43	26		11	548
5/10/2007	93	108	365	96	96	79		79	1733

Sample Date	bdc 0.5 (cfu/100 ml)	bdc 1.0 (cfu/100 ml)	bdc 1.5 (cfu/100 ml)	bdc 2.0 (cfu/100 ml)	bdc 3.0 (cfu/100 ml)	bdc 4.0 (cfu/100 ml)	bdc 4.5 (cfu/100 ml)	bdc 5.0 (cfu/100 ml)	bdc 6.0 (cfu/100 ml)
6/14/2007	435	1300	1300	1414	687	727		687	548
7/12/2007	517	1986	1986		1414	1733			
8/9/2007	1120	921	411	1203	308	387		326	488
9/13/2007	517	214	345	308	308	387		222	365
10/11/2007	866	488	276	579	1120	488		866	649
11/8/2007	126	49	84	345	365	225		155	91
12/13/2007	54		88		248	291		156	261
1/10/2008			308	517	613	326		166	185
2/21/2008	29		63	73	54	96		68	649
3/13/2008	55	24	38	75	178	81		66	206
4/17/2008	1203	167	170	205	145	78		172	649
5/8/2008	365	461	816	921	866	866		1300	1414
6/19/2008	687	816	488	980	649	2419		1986	2419
7/17/2008	687	2419	1986	2419	2419	1553		435	141
8/14/2008	866	133	308	816	687	387		461	1203
9/11/2008	980	387	517	488	579	1203		687	548
10/9/2008	517	260	579	687	921	548		225	116
11/13/2008	50	9	96	387	461	248		133	93
12/11/2008	64		150	461	261	196		236	167
1/8/2009	12		115	291	365	187		127	71
2/12/2009	18		26	71	93	52		16	124
3/12/2009	18	52	56	77	117	34		31	27
4/9/2009	23	19	36	35	86	44		35	18
5/14/2009	1120	120	411	210	115	96		67	2419
6/18/2009	488	517	649	461	365	248		435	649
7/9/2009	411	488	1046	756	1046	1046		921	387
8/13/2009	118	196	308	276	178	102		461	488
9/10/2009	119	276	178	326	548	119		727	866
10/15/2009	7	17	152	387	345	161		127	201
11/12/2009	21	4	135	155	345	194		204	162
12/10/2009			55	276	365	308		201	96
1/14/2010			32	517	345	225		147	147
2/11/2010			29	613	285	116		49	387
3/11/2010	6	29	14	248	93	31		19	39
4/8/2010	31	219	20	40	52	40		64	462
5/13/2010	687	366	580	462	308	462		548	649
6/10/2010	326	326	649	1554	518	313		548	388
7/8/2010	1120	2419	2419	2419	1987	2419		2419	2419
8/12/2010	166	345	921	436	326	489		687	518
9/9/2010	72	128	366	817	1414	326		225	548
10/14/2010	250	250	1204	1047	687	1204		1120	981

Sample Date	bdc 0.5 (cfu/100 ml)	bdc 1.0 (cfu/100 ml)	bdc 1.5 (cfu/100 ml)	bdc 2.0 (cfu/100 ml)	bdc 3.0 (cfu/100 ml)	bdc 4.0 (cfu/100 ml)	bdc 4.5 (cfu/100 ml)	bdc 5.0 (cfu/100 ml)	bdc 6.0 (cfu/100 ml)
11/4/2010	68	70	366	388	462	489		152	276
12/9/2010	30	46	76	388	366	215		192	130
1/13/2011				1120	366	436		276	123
2/10/2011				614	462	462		273	
3/10/2011	12	7	24	88	196	119		53	816
4/20/2011	1	111	152	105	81		146	161	870
5/12/2011	2420	1300	1733	1300	1120		1733	1733	2420
6/9/2011	866	2420	2420	2420	921		921	816	2420
7/14/2011	162	1046	727	1046	649		1414	1203	1553
8/4/2011	78	461	240	649	1046		411	179	365
9/8/2011	9	649	727	1203	921		2420	1986	2420
10/13/2011	179	50	214	687	770		184	291	613
11/10/2011	35	44	57	326	411		517	184	435
12/8/2011			517	921	687		770	435	167
1/12/2012			157	980	613		308	260	199
2/9/2012				1046	260		236	140	248
3/8/2012	21	29	23	91	131		99	42	210
4/12/2012	1733	1414	2419	1414	1553		921	1733	866
5/10/2012	179	1987	106	152	134		225	548	2420
6/14/2012	366	649	291	489	1047		2420	2420	2420
7/12/2012	138	580	489	345	366		436	361	981
8/9/2012	111	326	980	649	687		613	345	1120
9/13/2012	2420	2420	1987	2420	2420		2420	2420	2420
10/11/2012	981	236	269	436	867		727	308	727
11/8/2012	80	43	102	518	727		326	185	74
12/13/2012			52	614	388		411	205	91
1/10/2013				1554	921		614	262	142
2/14/2013			115	461	488		225	192	231
3/14/2013	84	40	47	130	86		74	55	461
4/11/2013	199	51	816	44	110		119	96	88
5/9/2013	548	435	387	387	196		488	1046	1986
6/13/2013	236	816	727	866	1413		1414	1300	0
7/11/2013	613	613	613	517	613		345	387	1203
8/8/2013	816	0	727	579	980		488	435	649
9/26/2013	291	548	365	326	411		687	236	1203
9/26/2013							461		
10/10/2013	179	50	214	687	770		184	291	613
11/14/2013	46	32	70	166	162		276	96	
12/12/2013			435	1046	921		613	411	147
1/8/2014			517	1203	548		435	435	0

Sample Date	bdc 0.5 (cfu/100 ml)	bdc 1.0 (cfu/100 ml)	bdc 1.5 (cfu/100 ml)	bdc 2.0 (cfu/100 ml)	bdc 3.0 (cfu/100 ml)	bdc 4.0 (cfu/100 ml)	bdc 4.5 (cfu/100 ml)	bdc 5.0 (cfu/100 ml)	bdc 6.0 (cfu/100 ml)
1/9/2014			518	1204	548		436	436	>
2/13/2014			105	249	326		411	179	981
3/13/2014	45	69	35	123	102		99	45	>
4/10/2014	42	326	64	42	104		52	72	2420
6/12/2014	152	167	276	416	366		345	308	1300
7/10/2014	99	345	548	649	345		980	365	1553
8/14/2014	135	365	387	548	727		461	308	326
9/11/2014	866	1300	1046	866	1300		1300	1553	1553
10/9/2014	365	167	980	214	687		548	411	461
11/19/2014	40		308	687	403		866	276	345
12/11/2014	99		128	173	291		613	115	

A.2 Response to Comments Received during Public Notice

Comments were received during public notice period. Collaborative comments were received from the BDCWA, which includes input from City and County of Broomfield, City of Westminster, City of Northglenn, Adams County, Weld County, and City of Thornton. Additional comments were received from the City of Northglenn, as well as a letter of support from Broomfield, endorsing the BDCWA comments. Comments were also received from the U.S. Environmental Protection Agency, Region 8.

The following are comments received from BDCWA:

Comment 1: Wasteload allocations (WLAs) for municipal separate storm sewer systems are not realistic representation of stormwater flows- additional caveats on appropriate use of the WLAs are needed (p.39)

The WLAs calculated for MS4s for high and moist conditions are approximately an order of magnitude lower than what would actually be expected for runoff from the MS4 land area. This statement is based on reasonableness checks that assumed an 80th percentile runoff producing event, consistent with Urban Drainage and Flood Control District's U*rban Storm Drainage Criteria Manual (Volume 3)* design criteria for the water quality capture volume, and an *E. coli* concentration set at the stream standard. For this reason, we believe it is important to explicitly state the intended use of the WLAs in the TMDL. We recommend adding the following text in Section 8.1, bottom of p. 39:

As was the case for the WLAs for WWTFs in the watershed, WLA calculations for the MS4s are also affected by the complex hydrology in the creek. The Division does not intend that calculations completed for MS4 WLAs would be construed to require MS4s to meet numeric limits more stringent than the stream standard or preclude discharge of stormwater runoff to the stream. Based on current best practice and watershed-specific information at the time this TMDL was completed, the Division intends that MS4 WLAs will be implemented on a programmatic, best management practice (BMP) approach implemented to the maximum extent practicable (MEP), consistent with Colorado's MS4 general permit. The Division and EPA recognize that the WLAs calculated for the MS4s are not suitable for application at individual MS4 outfalls. Instead, the sole purpose of the WLA calculations for MS4s is to fulfill requirements of TMDL development and to provide approximate proportioning of wasteloads among dischargers. If, in the future, outfall-specific wasteload allocations are needed, then more advanced modeling would be necessary to refine WLAs based on more detailed consideration of watershed hydrology.

Response1: The division agreed to continue work on TMDL implementation language with the BDCWA during the response to comment period, prior to final public notice. The agreement was to include an introductory paragraph in the implementation section of the document to clarify intent and understanding of the TMDL WLA so that it is clear for those who did not participate in stakeholder meetings how the TMDL is to be implemented. After much consideration, the division decided that the TMDL include only a general discussion about potential future permit requirements rather than any offering any specific statements in the TMDL about potential future permit requirements.

The division calculated MS4 WLAs based on best available information. Given the non-conservative nature of *E. coli* (i.e. the pollutant changes considerably after entering the receiving water), it is very hard to accurately account for MS4 WLA at individual outfalls without extensive outfall specific data and modeling. However, the division does not agree with statements that speak to whether the WLAs are suitable to be implemented as numeric limits applied at stormwater outfalls because that would imply that numeric limits would never be applied at stormwater outfalls. MS4 permits are iterative and the division cannot predict specific requirements in future permits.

Also, it is inaccurate to state stormwater permits (or any discharge permit) would never be required to meet numeric limits more stringent than the stream standard. The permit writer must consider changes in the standard or antidegradation requirements, as well as TMDL WLAs, when determining applicable permit limits.

The division has similar responses to suggested edits made in Comment #6.

Comment 2: Incomplete Representation of Dry Weather Studies Completed in the Watershed (p. 34)

BDCWA began working with Division staff (Rebecca Anthony) in the 2006-2008 timeframe to provide information to support development of the TMDL, including special dry weather studies to assess the expected contribution of dry weather loads from MS4s between 112th Ave. and I-25. This work was completed following similar protocols to those that the Division had recommended for the City and County of Denver and that had been included in the Water Quality Forum *E. coli* Work Group White Paper (Colorado Water Quality Forum and WWE 2009). The discussion of the dry weather study is only partially characterized in the TMDL. BDCWA would like the following aspects of this special study to be recognized in the TMDL:

- From 2006-2008, BDCWA conducted a dry weather study of storm sewer outfalls located between 112th Avenue and I-25, following dry weather investigation procedures recommended by the Division at that time. This study included mapping of storm sewer outfalls, identification of flowing outfalls, and several rounds of dry weather sampling for flowing outfalls, resulting in approximately 200 dry weather outfall and investigative samples. The investigation successfully identified one illicit connection, which was corrected in 2007.

- Additionally, supplemental instream sampling was conducted in targeted areas where sanitary sewer interceptors cross Big Dry Creek. This sampling did not indicate that the interceptors were contributing *E. coli* loading.

Because of this investigation, we disagree with some of the statements in p. 34. For example, there is no watershed-specific evidence to date that supports the statement that "significant and controllable dry weather sources" of bacteria from MS4 outfalls are contributing to *E. coli* loading in Segment 1. For the portions of the stream that have been studied, BDCWA actually suspects diffuse wildlife in the urban stream corridor and agriculture in the lower watershed. These hypotheses are supported by field observations, documented in photographs of multiple beaver dams, bird nests over bridges, animal tracks and scat, and aerial photo review of cattle in and along the stream in the lower watershed. Therefore, we request the following changes to the wording of these paragraphs on p. 34:

The loading of E. coli from dry weather flows from stormwater outfalls is typically considered to be ~~a significant and~~ controllable ~~source~~ through Best Management Practices (BMPs) that target ~~of~~ E. coli sources. ~~to segment 1~~. Between 112th Ave. and I-25, BDCWA conducted dry weather monitoring of outfalls during 2006-2008 that resulted in correction of one illicit sanitary connection during the summer of 2007; however, other controllable dry weather sources from outfalls were not identified in this reach. Over 200 dry weather samples were collected and analyzed for E. coli during this special investigation, which was sponsored by BDCWA in cooperation with Westminster and Broomfield, which are MS4 Phase II permit holders. Dry weather flows from outfalls in other portions of the watershed have not yet been evaluated.

Based on the findings of the 2006-2008 dry weather outfall study, BDCWA does not anticipate that readily-controllable sources of E. coli such as illicit sanitary connections are present in the portion of the watershed above I-25. Additionally, correction of the illicit connection identified in 2007 resulted in no statistically significant difference in instream E. coli concentrations below the outfall at bdc2.0. These initial findings suggest that diffuse sources and direct loading from wildlife (e.g., birds, beavers) to the stream may be present in this area.

~~*At present, the only water quality data from stormwater outfalls along Big Dry Creek was collected by the BDCWA in 2007. The data characterized dry weather conditions for a portion of segment 1, from 112th to 128th avenues. This area was identified as the highest priority for several reasons: elevated E. coli at instream sample locations BDC1.5 and BDC2.0, open space access, and cooperation with MS4 phase II permit holders Westminster and Broomfield. The results identified one illicit connection upstream of BDC1.5, which was corrected in the summer of 2007.*~~

Additional references to add regarding source investigations that were provided to the Division on March 19, 2009 to support TMDL development include:

Wright Water Engineers, 2007. Memorandum to Big Dry Creek Watershed Association Board of Directors Re: Findings of *E. coli* Sampling (Ambient Instream and Dry Weather Outfall Screening). December 27, 2007.

Wright Water Engineers, 2008. Memorandum to Big Dry Creek Watershed Association Board of Directors Re: Results for Big Dry Creek *E. coli* Dry Weather Screening and Sampling from bdc2.0 to bdc3.0. May 6, 2008 (finalized March 12, 2009).

Wright Water Engineers, 2008. Memorandum to Big Dry Creek Watershed Association Board of Directors Re: Interim Memorandum 3: Big Dry Creek *E. coli* from bdc3.0 (I-25) to bdc6.0 (Confluence). August 28, 2008 (finalized March 12, 2009)

Response 2: The division does not wish to minimize the efforts conducted by the BDCWA to advance source identification in the segment. The division included some of the suggested language in Comment #2 in combination with statements in Comment #5. The division believes that this summarization best characterizes the 2008-2009 studies for the purposes of the TMDL. As this information will also be useful for future TMDL implementation, these studies will also be evaluated upon renewal of MS4 Phase II general permit for the facilities identified in the TMDL.

Comment 3: Errors in Calculations in Loading Tables (pp. 7 & 43)
In Table 4 and Table 8.3-3, allowable loads and required reductions are calculated incorrectly. The correct entries for the rows highlighted in yellow are shown below. For the Section 8.3 tables, we also suggest changing the wording of "Allowable Load, TMDL w/MOS" to "Allowable Load (TMDL minus MOS)" for consistency with the terminology between tables.

Table 4

Loading Calculations (Giga cfu/day)	High Flow	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flow
TMDL	461.43	225.70	150.47	115.36	65.20
MOS (10%)	46.14	22.57	15.05	11.54	6.52
Allowable Load	415.28	203.13	135.42	103.82	58.68
Existing Load	1682.14	619.55	256.30	134.65	140.81
Required Reductions	75%	67%	47%	23%	58%
WLA					
Northglenn WWTF	50.44	50.44	50.44	50.44	50.44
MS4s	43.78	18.32	10.20	6.41	0.99
Reserve Capacity	4.38	1.83	1.02	0.64	0.10
LA					
Non-point Source	316.68	132.53	73.76	46.33	7.15

Table 8.3-3

Loading Calculations	High Flow	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flow
Median Flow (cfs)	92	45	30	23	13
WQS, TMDL Target (cfu/100mL)	205	205	205	205	205
Observed Geomean @ BDC 6.0 (cfu/100mL)	747.33	562.74	349.20	239.29	442.71
Allowable Load, (TMDL minus MOS) (cfu/day)	415.28	203.13	135.42	103.82	58.68
Existing Load @ BDC 6.0 (cfu/day)	1682.14	619.55	256.30	134.65	140.81
Required Reduction (%)	75%	67%	47%	23%	58%

Response 3: The division recognizes there was a miscalculation in the allowable load and required reductions. The MOS was unaccounted for, resulting in incorrect loadings. The above- referenced tables were corrected. Additionally, the table referenced as Table 8.3-3 was corrected to Table 8.5-3 in the final document.

Comment 4: Inaccurate Characterization of Recreational Uses of Big Dry Creek (pp. 8 & 16)

Several locations in the document (beginning on p. 8) imply frequent recreational use of Big Dry Creek. It is important to recognize that although the Big Dry Creek trail and open space area may be frequently used for recreation, the stream itself is not. The Division and Commission agreed with findings from a Use Attainability Analysis completed for Big Dry Creek (WWE 2000) followed by a survey of recreational uses (WWE 2003), which resulted in the Potential Primary Contact standard being adopted for the stream instead of a Primary Contact standard. Some of the factors that limit use of the creek include steep banks, shallow flows, dense vegetative cover along the banks, and the presence of drop structures and culverts which make boating unsafe. Most of the property in the lower watershed is privately-owned agricultural land, with restricted access. Specific edits that are needed include:

- p. 8. Recreational use of the open space in upper portion of Big Dry Creek occurs frequently.
- p. 16, Section 2.2, the text is somewhat difficult to follow and the following edits are suggested to improve clarity:

~~The high~~ E. coli concentrations within Big Dry Creek Segment 1 exceed "Potential Primary Contact" ~~the~~ standards. ~~to protect human health. The standards adopted on this segment protect potential primary contact use~~ (Recreation Class P). To understand the Potential Primary Contact classification, it is helpful to first understand the Existing Primary Contact (Recreation Class E) Classification. Existing Primary Contact is defined as recreational activities where the ingestion of small quantities of water is likely to occur. Such activities include but are not limited to swimming, rafting, kayaking, tubing, windsurfing, water-skiing, and frequent water play by children. (WQCC, 2015a). The Potential Primary Contact (Class P) criterion of 205 cfu/100 ml is based on a policy decision to accept a slightly higher risk level (10 illnesses per 1000 swimmers for this classification, compared to 8 illnesses per 1000 swimmers for Existing Primary Contact) based on the assumption that primary contact uses are not currently likely to be occurring for these water segments, although such uses may be a potential in the future.

Response 4: The division accepted these edits; the corrections were made to the document.

Comment 5: Assumptions and Statements Not Supported by Watershed-Specific Information (p. 5)

Monitoring results to date do not support the last full paragraph on p. 5, which is generally misleading regarding expected sources of *E. coli* in the watershed. Alternative suggested text for this paragraph includes:

The sources ~~organismal contributions~~ of E. coli in S~~s~~egment 1 are presently unconfirmed, i.e. wildlife, human, agriculture or domestic animal sources. However, CDPS permitted discharges from WWTFs have been monitored in Big Dry Creek for E. coli since 2003. ~~Significant contributions of E. coli are conveyed to segment 1 through urban stormwater collection systems during storm events and exceedances of the E. coli standard routinely occurred in wastewater treatment effluent during summer months prior to 2008.~~ Prior to

2010 when CDPS permit limits for E. coli changed from 630 cfu/100 mL to 205/100 mL, WWTFs were permitted to discharge higher levels of E. coli than what are currently allowed to meet the stream standard of 205/100 mL. All of the municipal WWTFs routinely discharge E. coli concentrations well below the currently applicable stream standard and CDPS permit limits for the WWTFs. Municipalities in the watershed voluntarily conducted dry weather outfall screening of MS4 outfalls between 112th Avenue and I-25 to determine whether illicit connections to the MS4 were present. One illicit connection was identified and removed in 2007, and the remaining outfalls in this reach did not indicate that controllable dry weather sources of E. coli were being discharged from the MS4s. Potential MS4 dry weather sources downstream of I-25 have not yet been evaluated. Wet weather runoff in both urban and agricultural areas is a potential source of E. coli to Big Dry Creek, as are agricultural return flows, direct deposition of fecal material into the stream from birds and mammals, and resuspension of sediment in the stream.

Additionally, agriculture and wildlife sources of bacteria seem to be generally under-represented in the TMDL. Cattle grazing along the creek in the lower watershed is well documented by BDCWA (WWE, 2008), and significant wildlife presence has also been documented, including geese, birds, beavers, coyotes, and raccoons, among others.

Response 5: The division agreed with the source language and the other suggested edits; however, some text was moved to more relevant sections of the document (i.e., information about potential wildlife sources in the watershed was included in the executive summary and the details about the WWTF discharges and dry weather stormwater outfall monitoring were moved to Section 7.2 and 7.3, respectively).

Comment 6: Recommended Revisions to Implementation Text in Section 9 (pp.43-45)

The implementation portion of the TMDL is important because it sets expectations and provides an initial framework for the types of requirements that local governments may expect in CDPS permits, particularly MS4 Phase II permits. BDCWA recognizes and appreciates that the Division incorporated some of the implementation text that had been suggested by BDCWA for this section. However, BDCWA has several concerns with the text as provided in the TMDL. Suggested redlines to this section are provided below.

> *9.0 Implementation (copied from draft TMDL)*
>
> *Implementation of this TMDL will be an iterative process involving the CDPS permittees that discharge to segment 1 and other nonpoint source pollution programs. The CDPS permitted domestic wastewater treatment facilities ~~that with elevated E. coli levels in their effluent discharge~~ have already been addressed~~. The~~ with effluent limits for E. coli ~~are~~ equal to the water quality standard (205 cfu/100mL). ~~, although the~~ These facilities already discharge well below these limits according to submitted discharge monitoring data. Further reductions from these facilities are unnecessary at this time and are not anticipated to be necessary in the future. While these sources have been addressed, other controls are necessary to achieve full restoration of the waterbody.*
>
> *The approach for the MS4 sources is more complex. Currently ~~all~~ the Phase II MS4 permits in the watershed ~~are phase II and~~ require a stormwater management program to reduce discharge of pollutants to the maximum extent practicable (MEP) to protect*

water quality (WQCC 2015b). There are minimum control measures already required in their permits, which include: public education and outreach; public involvement/participation; illicit discharge detection and elimination; construction site stormwater runoff control; post-construction stormwater management in new development and redevelopment; and pollution prevention/good housekeeping for municipal operations. The division is authorized to ~~may~~ include more stringent limitations based on a TMDL that determines such limitations are needed to protect water quality. Additional requirements ~~will~~ may be necessary for the MS4 permits identified in this TMDL (WQCC 2015b).

In compliance with Regulation 61, the division cannot issue a permit that allows discharges that cause or have the potential to cause an exceedance of a numeric water quality standard unless the permit contains effluent limitations and a schedule of compliance specifying treatment requirements. Regulation 61 allows the effluent limit to consist of best management practices (BMPs) to ensure protection of the water quality standard when numeric effluent limits are infeasible, or when practices are reasonably sufficient to achieve effluent limits or standards. Therefore, the Division ~~WQCD~~ must issue permits that contain effluent limits for those MS4s with illicit dry weather discharges identified as being in excess of the TMDL allocations. At this time, no existing illicit dry weather connections have been identified for MS4 outfalls in the Big Dry Creek Watershed. The Division envisions a BMP-based approach to address controllable E. coli sources at MS4 outfalls to Big Dry Creek. ~~However, Regulation 61 allows the effluent limit to consist of best management practices (BMPs) to ensure protection of the water quality standard when numeric effluent limits are infeasible, or when practices are reasonably necessary[1] to achieve effluent limits or standards.~~

1 The word "necessary" was confusing—we replaced this word with "sufficient" in the relocated sentence.

9.1 Recommended Actions

Implementation of the TMDL through the coordinated efforts of the Big Dry Creek Watershed Association is encouraged, given that the most effective strategies for pollutant load reductions require integration among entities with land draining to Big Dry Creek. However, each permit will have its own clear, specific and measurable MEP-based BMP requirements. Implementation actions may include, but are not limited to, the following: additional monitoring; infrastructure maintenance and upgrades (if determined to be a controllable source of E. coli); education and outreach; and stormwater BMPs.

The assumptions and calculations in this TMDL were based on best available information at the time the TMDL was developed. More accurate source identification could support revisions to loading calculations and/or TMDL allocations. Examples of information that could support such revisions include ~~This would include~~ additional targeted dry weather investigations at flow monitoring and water quality data from dry weather stormwater outfalls similar to those conducted during 2006-2008. The basis for determining the potential to contribute to an exceedance of the water quality standard would be dry weather outfall results for E. coli ~~data~~ that exceeds the density based TMDL, based on the geometric mean of five or more representative *samples at outfalls with dry weather flows greater than 5 gpm during the non-irrigation season.* ~~*Activities to expand source identification of nonpoint source loading may include development of GIS layers to identify directional storm drainage flow. Also, expand current illicit discharge detection and elimination monitoring programs to ensure human sources of E. coli in the system are addressed. Activities such as camera scoping and dye study to identify leaking infrastructure, and lining pipes in prioritized areas, may be necessary.*~~

Selection of BMPs to reduce E. coli loading from MS4s and nonpoint sources should be based on a reasonable understanding of likely sources. Source identification investigation techniques to identify likely E. coli sources include a broad range of methods ranging from basic visual outfall investigations with E. coli sampling to use of advanced molecular methods. Identification and correction of potential sanitary (human) sources of E. coli through illicit discharge detection and elimination investigations are foundational to implementation of this TMDL.

Each MS4 permit currently has its own education and outreach program; however, it is recommended that a collective effort is made through BDCWA to identify cross jurisdictional efforts to target specific public awareness that would help reduce the E. coli load in segment 1. Examples may include expansion of educational programs involving pet waste management or incentives to encourage proper irrigation and landscaping to reduce runoff. In addition to these nonstructural BMPs, structural BMPs may be needed to reduce the effects of urban developments on stormwater.

9.2 Post-Implementation Monitoring

The Division encourages BDCWA to continue its voluntary instream monitoring program. ~~*and will continue to work with stakeholders, such as the BDCWA, to maintain and improve the current level of sampling on the segment.*~~ *MS4s in the segment may* ~~*would*~~ *be required to collect additional dry-weather based outfall-monitoring data to determine if dry weather discharges exist that could exceed the density based TMDL. The Division recognizes that dry weather outfall monitoring has already been conducted in the portion of the watershed between 112th Ave. and I-25. The Division will work with BDCWA and other stakeholders to determine additional monitoring that may be beneficial for identifying sources of E. coli and evaluating instream trends over time as the TMDL is implemented.*

Response 6: The division would like to emphasize that there will be additional requirements in the next MS4 permit iteration to implement the TMDL. However, it is unknown exactly what those requirements will be. The division agrees with some BDCWA suggested edits to remove/reword details of potential permit requirements as reflected in changes to the document. Additionally, the division removed the paragraph on education and outreach. In consideration of other edits to this section, leaving this language seemed to over emphasize the importance of education and outreach when we should be advancing the permit to implement other, potentially more effective, control measures.

BDCWA comments 7 through 32 include technical corrections, most of which the division agreed with and made the suggested changes. Where changes were not made as specifically requested, a response rationale is provided below; otherwise, the comments are provided as documentation for the record with a summary response of "the division accepted these edits; the corrections were made to the document."

Comment 7: pp. 5, 8 & 9. Stream length is inconsistently referenced in the report: p. 5, p. 8 = 48 stream miles, p. 9 = 42 miles.

Response 7: The division corrected this inconsistency.

Comment 8: p. 5 & p. 8. Differentiation between watershed area and stream miles: In several locations, statements are made that mix stream miles and watershed area. The following edits are needed:

> p. 5. Approximately 21% of the watershed area ~~segment~~ lies in Jefferson County, 41% in Adams County, 11% in Broomfield County, and the remaining 27% in Weld County.
>
> p. 8 The values in the following sentence need to be recalculated, particularly for the City and County of Broomfield. Less than one mile of Big Dry Creek flows through Broomfield.

Approximately 10.1 stream miles of Segment 1 lies within Jefferson County, 19.8 miles in Adams County, 5.4 miles in Broomfield and approximately 12.8 stream miles lies within Weld County.

Response 8: Corrections were made to the use of the terms watershed area and stream miles. Stream miles were calculated as all stream miles (mainsteam and tributaries) within the watershed area. While less than one mile of the mainstem of Big Dry Creek flows through Broomfield County, the calculation in GIS was based on all stream miles of segment 1, which include tributary miles. This is the standard approach the division uses in determining stream miles.

Comment 9: p. 5. Flow Period of Record Used for Load Duration Curves: The period of record referenced for the flows used in the Load Duration Curves is inconsistent. It appears that the actual period of record used for purposes of the Load Duration Curves is 2003 through September 2015 for the Fort Lupton gauge and 2003 through December 2015 for the Westminster gauge. A few additional comments related to flows:

- p. 5. Summary table: …the stream flow data period of record (2000-2014)…. Note: the period of record for both gauges is much longer than this. Suggest editing to say the period of record used to calculate load duration curves was 2003-2015. Also suggest changing the phrase "several years of flow data" to "multiple years of flow data."

Response 9: The division accepted these edits; the corrections were made to the document.

Comment 10: pp. 5, 32, 40. Interchangeable use of pathogens and E. coli: In several locations in the document, the term pathogen (or pathogens) should be replaced with E. coli or fecal indicator bacteria. Pathogen monitoring has not been conducted in the watershed. Stream impairment determinations and permit limits are based on fecal indicator bacteria, not pathogens (disease-causing organisms). The following uses of pathogens are incorrect:

p. 5. Segment 1 routinely exceeds current ~~pathogen~~ *E. coli* standards.

p. 32. The Broomfield facility currently has ~~pathogen~~ effluent limits for both fecal coliform and E. coli.

p. 40. Tables 8.0-1 through 8.0-3 present the ~~pathogen~~ *E. coli* load and waste load allocations proposed for Big Dry Creek Segment 1.

Response 10: The division accepted these edits; the corrections were made to the document.

Comment 11: p. 8. Two references to Big Dry Creek being identified as "high priority due to human health risk" should be changed to "medium" priority, as listed in the 2016 303(d) List. The stream is not listed as high priority because of the "potential primary contact" use, which poses less human health risk than would be the case if a "primary contact" use was in place. Suggested rephrasing " …a medium priority due to potential human health risk."

Response 11: At the time this TMDL was initially being developed, it was designated as a high priority for TMDL development in the 2012 303(d) List. While the severity of impairment would be considered low priority due to potential human health risk (and is reflected as such in the 2016 303(d) List), other considerations are made when determining TMDL priority. Secondary considerations that made this TMDL high priority include; an active stakeholder group, division resources, and availability of adequate data. The document was edited to accurately reflect the priority status.

Comment 12: p. 10. Suggested edits to paragraph to improve clarity and accuracy related to HUC-12 vs. TMDL reaches:

The TMDL reaches are also divided into upper, middle and lower portions, with slightly different boundaries than the HUC12 breaks in the upper and middle portions (Figure 1.1-1). The portioning was decided based on ~~significant changes in flow throughout the entire segment, due to reservoir releases, diversions, and WWTF discharges.~~ factors such as land use, key hydrologic influences (e.g., WWTF discharges) and E. coli results at BDCWA's long-term monitoring locations. ~~As well as, changes in landuse. This is~~ Changes in land use are illustrated in the national land cover dataset (NLCD 2006) for the watershed (Figure 1.1-2). Three TMDL reaches were identified as follows: Upper Reach (from outlet of Standley Lake and Great Western Reservoir to sample location BDC 1.5); Middle Reach (from below BDC 1.5 to 152nd Avenue); and Lower Reach (from 152nd Avenue to the confluence with the South Platte River). For the remainder of this document, the terms Upper Reach, Middle Reach and Lower Reach refer to the TMDL reaches, as opposed to the HUC subwatersheds shown in Table 1.1-1 and Figure 1.1-1.

Response 12: The division accepted these edits; the corrections were made to the document.

Comment 13: p. 11. Rephrase "77%-66% developed" to "77% and 60% developed land use, respectively."

Response 13: The division accepted these edits; the corrections were made to the document.

Comment 14: p. 16. Edit table footnote to improve clarity and accuracy of the statement:

> **A Recreational Use Attainability Analysis was completed in 2000, followed by a recreational use survey of students in 2003. ~~*A student recreational use survey~~ ~~was~~ These were used as evidence and accepted by the WQCC to classify ~~water~~ Segment 1 as potentiall~~y~~ primary contact in the 2004 Regulation 38 Rulemaking Hearing (WQCC, 2016b).*

Response 14: The division accepted these edits; however, the sentence was moved from the footnote of Table 2.1-1, to the recreation use discussion in Section 2.2

Comment 15: p. 17, Section 2.3. We recommend recognizing EPA's 2012 Recreational Water Quality Criteria. In Section 2.3 on p. 17, the discussion only references EPA's 1986 criteria. Although Colorado's currently applicable standards are derived from the 1986 criteria, the section should be updated to also reference EPA's 2012 Recreational Water Quality Criteria. As part of these edits, we would suggest deleting the reference to fecal coliform. Additionally, we would suggest adding a statement regarding relative risk from wildlife sources and QMRA, such as:

During the 2012 Recreational Water Quality Criteria (RWQC) update, EPA explored the issue of relative risk from non-human sources of pathogens by conducting two literature reviews and sponsoring research related to Quantitative Microbial Risk Assessment (QMRA). As a result of these efforts, EPA ultimately concluded that a national-level source exclusion for wildlife was not supportable in the 2012 RWQC; however, the criteria also recognized that wildlife sources are generally expected to pose a lower human health risk. EPA's 2012 RWQC provide a new opportunity for alternative site-specific streams standards if human contamination sources are controlled and further epidemiological studies or QMRA for a waterbody shows that the human health risk in a waterbody is equal to or less than EPA's equivalent illness rate thresholds.

EPA's 2012 criteria are important because BDCWA suspects that wildlife is a key source of elevated E. coli in portions of the watershed. There are practical limits to controlling wildlife source of E. coli, which may have implications for attainability of the stream standard at some point in the future.

Response 15: The division believes including the 2012 RWQC in Section 2.3 would confuse the discussion on the criteria used for the current *E. coli* standard. Based on the information addressing attainability of the stream standard in the future, this discussion was moved to Section 9.2.

Comment 16: p. 18, Section 3 Problem Identification. The following sentences are out of place and we suggest deleting or moving to another location since evaluation of diurnal patterns has not been conducted in the watershed. (We don't disagree that this is likely true—the discussion is simply out of place.)

> *E. coli levels in segment 1 are not spatially or temporally consistent, which makes it difficult to show a consistent pattern or location of E. coli loading or significant die-off. In general, E. coli levels in segment 1 are higher in the summer than other months. ~~E. coli also typically has a diurnal pattern with E. coli levels generally highest in the early morning due to ultraviolet radiation from sunlight later in the~~*

~~*day causing genetic mutation in E. coli (Burkhardt, 2000). As a result of the mutation, individual organisms are not able to reproduce.*~~

Response 16: The division accepted these edits; the corrections were made to the document.

Comment 17: p. 18, Section 4. The following edits are suggested to clearly communicate the intent discussed in stakeholder meetings with the Division:

> *Attainment of the numeric target will be determined by the calculation of an E. coli geometric mean for the entire segment as a whole, in addition to ~~compliance with NPDES~~ CDPS permitted WWTFs ~~treatment facilities~~ complying with an E. coli limit of 205 cfu/100 mL. The limit will not be based on acute exceedances. There are no acute E. coli standards, however the WWTF permits contain an acute limit. MS4 implementation will be based on implementation of BMPs to the maximum extent practicable.*

Response 17: The division accepted the majority of these edits; however, because this section's purpose is to discuss the water quality goal and target, we moved the implementation-related discussion about MEP to the implementation section of the document.

Comment 18: p. 20. Please reword last two sentences on flow, which are not accurate as written.

~~The report explains the disparity in flow gages as typical of front range streams. And ungaged flow (seepage) would account for the accumulations of flow between upstream and downstream gages.~~

Replace with:
Flows at the Fort Lupton gauge are higher than at the upstream Westminster gauge as a result of WWTF discharges, irrigation return flows, ditch conveyances of South Platte River water into Big Dry Creek, groundwater inflows, stormwater runoff and other sources.

Response 18: The division accepted these edits; the corrections were made to the document.

Comment 19: p. 23, Section 5.2 Ambient Water Quality. Statement and table need to be corrected. There are only eight routine instream monitoring locations.

- E. coli data has have been collected at eight routine instream monitoring sites on Big Dry Creek since 2000. and two additional sites since 2003 (Table 5.2-1). Sites bdc4.0 and bdc4.5 are in close proximity to each other, with bdc4.5 replacing bdc4.0 in the routine sampling program in 2011 due to field staff safety issues. Table 5.2-2 illustrates E. coli geometric mean data collected at eight routine sampling locations by the Big Dry Creek Watershed Association from 2003 to 2014. The BDCWA monitoring program represents ambient conditions on the scheduled sampling dates, inclusive of The data is considered to be data collected during both dry and wet weather conditions periods.

- Table 5.2-1. Suggest deleting the WWTF sites bdc10.0 and bdc11.0 since DMR data are being relied on to characterize WWTF discharges.

• Table 5.2-2. Suggest editing table headers to clarify that this is the period of record used for the TMDL. The period of record in the table is somewhat confusing when compared to the next two figures and text narrative. Suggested edits include:

i. Table 5.2-2 header: Table 5.2-2. E. coli geomeans for routine sampling locations on Big Dry Creek for Period of Record Used in TMDL

ii. Last column header in Table 5.2-2, rename to Years Considered in TMDL

Response 19: The division accepted these edits; the corrections were made to the document.

Comment 20: p. 31, Section 7. Did the Division confirm that no permitted confined animal feeding operation (CAFO) permits are active in the watershed? If so,it may be beneficial to state this, given the agricultural nature of the lower watershed.

Response 20: The division did search the permitting database of record, EPAs Integrated Compliance Information System (ICIS). The search was completed by HUC and permits (CAFO) and found no permitted sources. As suggested in the comment made by BDCWA, additional text was included in Section 7.4 of the document.

Comment 21: pp. 31 & 35, Section 7. Please clarify what is intended by "human" in the context of nonpoint sources. Should human be replaced with failing septic systems, recreational trail users, RV dumping, transient encampments, etc.? Additionally, we suggest adding the words "may potentially include" along with other potential sources since formal source identification has not been conducted.

Nonpoint sources of E. coli to segment 1 may potentially include agriculture, wildlife, humans (e.g., failing septic systems), ~~and~~ domesticated animals, naturalized sources of bacteria and other sources.

Additionally, are Sections 7.1 and 7.3 substantively different? They seem to be addressing nonpoint sources. The discussion would be clearer if there were two headers: permitted point sources and non-point sources.

Response 21: The division accepted these edits; the corrections were made to the document.

Comment 22: p. 32, Section 7.2.2. Broomfield does not have a fecal coliform limit in their discharge permit.

Response 22: The division accepted these edits; the corrections were made to the document.

Comment 23: p. 32, Section 7.2.3. Description of Northglenn's WWTF is incorrect. Please replace the WWTF description with the following (or similar) text:

The current permit limits for Northglenn include the underlying E. coli standard of 205 cfu/100 mL as a 30-day average, and 410 cfu/100 mL as the 7-day average *concentration. To date, the facility has not discharged at or above permitted effluent limits (Table 7.2-1). Northglenn has two outfalls on Big Dry Creek. Discharges from Northglenn to Big Dry Creek are used for water rights augmentation purposes, and only recently (since 2013) have they consistently discharged into Segment 1.*

The City of Northglenn also diverts effluent to Bull Canal for agricultural use. Additionally, Northglenn has the option to discharge treated effluent to one of two outfalls on Thompson Ditch, also for agricultural uses. Neither of those ditches feed into Big Dry Creek, and the E. coli limits do not apply to those outfalls.

Northglenn's WWTF was upgraded from an aerated lagoon system to a three-stage Biological Nutrient Removal system in 2007. The facility continues to undergo process upgrades.

Response 23: The division accepted these edits; the corrections were made to the document.

Comment 24: p. 33-34. Allowable List of Non-stormwater Discharges. Please expand this list to be consistent with pp. 13-15 of the most current Phase II MS4 permit (https://www.colorado.gov/pacific/sites/default/files/COR090000%20Permit%20mod%201.pdf), adding the following to the existing list of allowable discharges:

• Dye testing in accordance with the manufacturers recommendations
• Stormwater runoff with incidental pollutants
• Discharges resulting from emergency fire fighting activities
• Discharges authorized by a CDPS or NPDES permit
• Agricultural stormwater runoff
• Discharges that are in accordance with the Division's Low Risk Policy guidance documents or other Division policies and guidance documents where the Division has stated that it will not pursue permit coverage or enforcement for specified point source discharges.
• Other discharges that the permittee will not consider as an illicit discharge and approved by the Division in accordance with the Phase II MS4 Permit Part 1, Section E.2.v.

Response 24: The division accepted these edits; the corrections were made to the document.

Comment 25: p. 34. Section 7.2.4. Should this section be 7.3 instead of 7.2.4? Permit-related discussion:

• last sentence of second paragraph - Permits are renewed every five years, and the general permit that covers the Phase II MS4s in the watershed…

• first sentence of last paragraph: MS4 coverage areas are based on the year 2000 US census urbanized areas, and city jurisdictional boundaries (Figure 7.2.4-1). The jurisdictional boundaries between municipalities and counties change periodically as annexations occur and as urban growth boundaries change.

• last sentence of the last paragraph - There are smaller non-standard MS4s not represented on this map, which include school districts. Additionally, Colorado Department of

Transportation's stormwater permit includes land in the Big Dry Creek watershed. ~~, and are within a phase II MS4 coverage area.~~

(Reason for second edit: Non-standards are only included in a Phase II MS4 if there is an agreement. Otherwise they have a separate permit area, which the Phase II General Permit does not cover.)

• Industrial stormwater permits are not currently listed in the TMDL and should be acknowledged in the TMDL.

Response 25: The division accepted these edits and a discussion about industrial stormwater permits is included in Section 7.4.

Comment 26: p. 34, Table 7.2.4-1. Need inclusive list of all MS4 permittees in the watershed. All MS4 permittees in the watershed should be included in this table, not just the Phase II MS4s. Examples of missing permittees include Non-standard MS4 permittees and Colorado Department of Transportation.

Additionally, although the TMDL boundary focuses on Segment 1 and the land areas below Standley Lake and Great Western Reservoirs, the TMDL should also recognize Jefferson County and Arvada as MS4 permit holders in the overall watershed. In our previous correspondence with the Division, BDCWA had suggested the following text:

> *The land area boundary used for purposes of the TMDL calculations is focused on the areas below Standley Lake and Great Western Reservoir. It is possible that future development in the vicinity of Standley Lake may contribute flows to Big Dry Creek via storm sewer outfalls or ditch conveyances. In the event that these areas are determined to cause or contribute to the exceedance of the E. coli standard on Segment 1 of Big Dry Creek, then MS4 permit requirements for these discharges would be expected to be subject to similar requirements to MS4s currently discharging to Big Dry Creek. The WLAs for these potential discharges would be covered under a portion of the Reserve Capacity developed in this TMDL.*

Comment 26: All non-standards that report to the division as discharging to Big Dry Creek were added to the document discussion, as was CDOT. Due to limitations in the ability to query for non-standard permits, as well as limitations associated with how non-standards report, Table 7.3-1 may not include all non-standards that discharge directly to Big Dry Creek. As these direct dischargers become known, they will be required to meet the TMDLs.

The division accepted the additional language edits, with one change in the last sentence. At this time, the loading from future development is unknown; therefore, it is more accurate to state that the WLAs *could* be covered under a portion of the reserve capacity.

Comment 27: p. 36. Suggested edits to improve clarity and accuracy:

> *As a conservative assumption ~~In order~~ to ensure protection of beneficial uses throughout the entire segment, required reductions were calculated based on data collected at the monitoring site on each reach that exhibited the highest E. coli concentrations relative to ~~in comparison with the~~ other monitoring locations within each reach of Big Dry Creek.*

TMDLs have been developed by~~,~~ dividing the entire segment into three distinct reaches. The reaches were divided based on factors such as land use, key hydrologic influences (e.g., WWTF discharges) and E. coli results at BDCWA's long-term monitoring locations. ~~The reaches were determined based predominantly on change in land use throughout the segment, as well as impacts to stream flow (tributaries, diversions, WWTF contributions, reservoir releases).~~ The three reaches consist of 1) the upper reach, from the outlet of the Standley Lake to sampling point BDC 1.5; 2) the middle reach, from below BDC 1.5 to 152nd Ave.; and 3) the lower reach, 152nd Ave to the confluence with the South Platte River.

Response 27: The division accepted these edits; the corrections were made to the document.

Comment 28: p. 37. Suggested edits to improve clarity and accuracy:

Allocations for the upper, middle and lower reaches are presented in Tables 8.0-1, 8.0-2 and 8.0-3, respectively. The upper reach is primarily urban, with 77% developed land use~~; and the highest levels of E. coli in the reach are~~ this reach has comparatively lower E. coli levels than ~~levels in~~ the middle and ~~upper~~ lower reaches. The USGS gage, Big Dry Creek at Westminster, represents the flow in the upper reach and was used in determining the allowable load. The MS4s were given a WLA, with no other permitted discharges found in the reach to have E. coli as a pollutant of concern. A reserve capacity was also calculated to be distributed to any future MS4 or other dischargers with reasonable potential to exceed the E. coli standard in the upper reach of Big Dry Creek.

The middle reach is also primarily urban, with 60% developed area, with some agricultural areas transitioning to urban land use. ~~showing some transition in predominant land use. This reach has the highest exceedances of the standard in the entire segment.~~ There are also two major WWTFs that discharge to this portion, which do not contribute to the impairment, but have a significant impact on the flow. As previously mentioned in the hydrology section ~~portion~~, this is a highly managed stream, with large volumes of water being discharged to and diverted from the creek in multiple locations. ~~amount of water being diverted in and out of Big Dry Creek along the entire segment. This portion being effluent dominant~~ Because of the complex hydrology in this reach and due to the large volumes of treated effluent discharged from the WWTFs with very low E. coli, mathematical adjustments to the WLA calculation procedure were required to develop WLAs ~~determine the directly impacted how WLAs were determined~~ for the WWTFs for purposes of representing the WLA in the TMDL. As with the upper reach, an MS4 WLA and a reserve capacity were ~~was also~~ calculated for the middle reach.~~, as well as MS4 WLA.~~ The reserve capacity may be used for WWTF, MS4, or other permitted discharges.

Response 28: The division accepted these edits; the corrections were made to the document.

Comment 29: p. 39. The following paragraph needs significant editing to improve accuracy. Also, it is unclear why NLCD 2006 was used instead of NLCD 2011. The last sentence in this paragraph is out of context and inaccurate, so it should be deleted, regardless of whether other edits for clarity are incorporated. Additionally, this would be a good location to explicitly state that the WLAs are not intended to be applied in MS4 permits, as discussed at the June 20, 2016 stakeholder meeting with the Division and EPA for the reasons discussed in Comment #1.

> *The percent of developed land use was calculated as a proxy for MS4 land area for each reach using GIS land use (NLCD, 2006) and watershed delineation (USGS, 2011) layers. The resulting percent developed areas for each reach were upper (77% developed), middle (60% developed) and lower (12% developed) ~~portions~~. The MS4 WLA was then calculated for each reach based on subtracting the WWTF WLA from the allowable load and multiplying that value by the percent developed area. This calculation was the best available estimate to represent stormwater discharged from MS4 outfalls that the Division was able to provide at the time that this TMDL was developed. The MS4 WLAs are not appropriate for application as a numeric load or effluent limit in the context of MS4 permit requirements. ~~For the remaining allowable load, the MS4s were allocated a percent WLA allocation equivalent to the developed urban land use in each portion of Big Dry Creek. The TMDL makes the assumption that the percent of developed land use equates to the stormwater runoff that is collected and conveyed through the MS4 and discharged to the stream via stormwater outfalls. This assumption accounts for infiltration of stormwater, and supports green infrastructure in the watershed.~~*

Response 29: The division decided that the TMDL should include only a general discussion about potential future permit requirements and that statements in the TMDL regarding specific future permit requirements would be inappropriate. Please refer to Responses #1 and #6. All other edits were accepted.

Comment 30: p. 40. Suggested edits to Load Allocation paragraph:

> *The load allocations developed in this TMDL account for the natural background sources of E. coli in addition to the contribution from agriculture (dry land and irrigated crops and livestock) and additional nonpoint sources. To achieve the water quality goals of this TMDL, each source must meet its load or waste load allocation. Tables 8.0-1 through 8.0-3 present the ~~pathogen~~ E. coli load and waste load allocations proposed for Big Dry Creek Segment 1. ~~After the WLAs were given to the point sources, the remaining load was determined to be the load allocation.~~ The load allocation for nonpoint sources is calculated as the TMDL minus the wasteload allocations for permitted point source dischargers minus the Reserve Capacity.*

Response 30: The division accepted edits where needed to clarify the load allocation; corrections were made to the document.

Comment 31: p. 41. The basis for the flows assumed for the Middle Reach in Table 8.3-2 are not clearly described. Previous Flow Duration Curves and Load Duration Curves discussed to this point in the TMDL have been based on the Westminster Gauge for both the upper and middle reaches. The basis of the flows in Table 8.3-2 should be described as the Westminster gauge instream flows plus the median Broomfield and Westminster WWTF discharges summarized in Table 8.1-1 on p. 39. Some discussion of these flow assumptions should also be introduced earlier in the document in Section 5.1.

BDCWA also believes that the method used to add the flow duration curves for the WWTFs to the instream flow duration curve may not be appropriate. For example, the lowest discharges from the Westminster WWTF are in the summer when the reuse program is being maximized; however, this timeframe would coincide with the high/moist conditions in the creek itself. Thus, adding the WWTF "low flow" conditions to the stream "low flow" conditions combines different timeframes. Both Broomfield and Westminster have implemented reclaimed water programs, which causes flow characterization at bdc2.0 to be particularly challenging for purposes of this TMDL.

In lieu of developing an alternative method for flow characterization at bdc2.0, additional caveats regarding the limitations of this approach should be provided. These limitations are an additional reason that the suggested language in Comment #1 is critically important to ensuring that the calculated WLAs are not misused in the future.

Response 31: The division added language to Section 5.1 discussing the flow assumption made in the TMDL for the middle reach. Additionally, clarification was added to Section 8.0. With respect to the specific comment about the flow duration curve method used, as discussed in the stakeholder meetings held while the TMDL was being developed, a number of different approaches were tried during TMDL development, each with limitations. The division believes the approach ultimately used, while smoothing the extremes, is protective of the resource. In addition, the division tried to be consistent with assumptions made in other EPA approved E. coli TMDLs.

Comment 32: p. 45. The following sentence currently understates the long-term work completed by BDCWA. Suggested edits include:

> ~~*Several studies have been conducted since its origination, as well as regular monitoring at several instream locations along big dry creek.*~~
>
> Replace with:
>
> <u>*Over the past 20 years, BDCWA has conducted voluntary long-term water quality monthly monitoring of eight locations on Big Dry Creek, as well as produced annual water quality reports and publically available newsletters summarizing water quality conditions. BDCWA also maintains a long-term water quality database with approximately 70,000 water quality results collected and analyzed during this timeframe. Additional work has included several special studies regarding E. coli, long-term biannual biological monitoring, special studies of the stream hydrology and long-term financial support of the USGS Gauge in Westminster.*</u>

Response 32: The division accepted these edits; the corrections were made to the document.

BDCWA comments 33 through 38 were corrections of typos, grammatical errors and editorial issues in the draft TMDL. The division incorporated those suggested changes that were consistent with AP style guidelines. The original comments are provided below as documentation for the record but because of the nature of the comments, no comment-by-comment resolution is offered.

33. Significant Figures: In many tables in the document, numeric values include multiple significant figures that imply a false level of precision. We suggest rounding to show fewer digits to the right of decimal points in most of the tables.

34. Global changes needed to address editorial issues in multiple locations:

o Big Dry Creek should be capitalized consistently throughout the document (e.g., p. 9, 35, 38, others).
o Landuse should be spelled as two words consistently throughout the document (e.g., p. 11).
o Segment 1 should be consistently capitalized.
o Division and Commission should be consistently capitalized (e.g., p. 44).
o Total Maximum Daily Load should be capitalized (p. 5).
o Use consistent style for cfu/100 mL (as opposed to "cfu. /100ml" or cfu per 100 mLs in some locations).
o Broomfield should be consistently referred to as the City and County of Broomfield. Corrections need to be made in multiple locations in the text and tables where "Broomfield County" or "City of Broomfield" are referenced. (e.g., p. 8, 13, 14, 33).
o References to Town of Arvada should be replaced with City of Arvada.
o Capitalize Federal Heights (e.g., p. 34).
o Capitalize Bull Canal (e.g., p. 20).
o Capitalize Phase II (e.g., p. 34).
o Big Dry Creek Watershed Association (as well as reference to Association) should be consistently capitalized. Also, a consistent reference should be used once BDCWA is introduced. We suggest consistently using BDCWA instead of Association.
o E. coli—the "c" should always be lower case.
o Data "are", rather than data "is".
o NPDES should be replaced with CDPS throughout the document.
o WLA vs. Waste load allocation vs. Wasteload Allocation—consistently reference preferred term throughout document.

35. Acronym Use

o p. 13 Incorrect acronym definition for CDPS, which should be: Colorado <u>Discharge Permit</u> System (pg. 13).
o Define HUC for first usage, Hydrologic Unit Code.
o Division vs. WQCD. We suggest using Division.
o Define LDC as acronym for first use of Load Duration Curve, p. 26.

36. References to figures are wrong on the following pages and/or figures are numbered incorrectly:

o p. 14. Reference to Figure one should be Figure 1.3-1.
o p. 16. Table should be 2.1-1.
o P. 18. Table 2.3-1 should be 2.4-1, is not referenced (also seems redundant to Table 2.2-1).
o p. 26. table number run-on with word (5.2-3Big…).
o pp. 29-31. three figures are named Figure 6.2.-1.
o p. 36. Table 7.2.5-1…there is no Section 7.2.5.
o Several tables/figures are included in the TMDL but not referenced in the text.

37. Spell-check is needed for both tables and text. Specific typos and grammatical issues:

• p. 6. typo "Require<u>d</u> Reduction"

• p. 7. typo “Required Re~~c~~ductions”
• p. 7. typo “Exis~~i~~ting load”
• p. 9. replace semi-colon with colon.
• p. 10. incomplete sentence: “As well as, changes in land use.” Need to connect phrase to previous sentence.
• p. 14. managed is spelled incorrectly (mana~~ga~~ged).
• p. 17. No apostrophe after Lists (last word on page).
• p. 28. Figure 6.1-2 “Cure” should be “Curve”
• p. 29. “he” should be “the”.
• p. 31. Capitalize “Gage” on graph.
• p. 33. Typo 1st paragraph, last sentence—“the” should be “they”.
• p. 38 edit semi-colon and text as follows:
o The WLAs were distributed as follows: ~~;~~ one WWTF that intermittently discharges to Big Dry Creek; an MS4 allocation; and ~~as well as~~ a reserve capacity for any future discharges.
• P. 39. “the fact that facilities discharge…”

38. Other editorial suggestions to improve clarity:
• pp. 12-13. Figures—suggest deleting the 0% entries for the figures.
• p. 14. Hydrologic Influence paragraph, suggest replacing the word “impact” with “influence” or “effect”. Change “demonstrate” to “illustrate”.
• p. 16. Third column header in table. Change “E. coli Impairment Status” to “Impairment Status”. (Column header doesn't make sense—E. coli impairment is only associated with Recreational Use.)
• p. 33. Section 7.2.4 phrase should be “provides a list of phase II.
• p. 34. Insert an “s” in the last paragraph “areas account”.
• p. 37. “with a large amount” (missing word, last paragraph).
• p. 38. Last paragraph “were calculated as the combined area of four categories of NLCD developed land use: open space, low intensity, medium intensity and high intensity, as defined in Table 1.1-2.
• p. 40. Paragraph under table “~~While t~~ The lower portion requires accounting for a higher, 10% increase. Reserve capacity WLAs for each reach are is shown in Tables 8.0-1, 8.0-2 and 8.0-3.”

The following are comments received from the City of Northglenn:

The City of Northglenn supports all comments prepared by BDCWA, in addition to stating that it should be noted that Northglenn does not directly discharge stormwater to Big Dry Creek, and request stating this in the land use or implementation section of the TMDL.

Division Response: Section 7.3 of the TMDL states Northglenn does not directly discharge stormwater to Big Dry Creek so no changes were made to the document.

Additional comments were received from Ms Evelyn Rhodes, City of Northglenn. The majority of which were addressed in BDCWA response to comments. With the exception of one comment:

Section 1.2 – This section seems to imply that all the WWTPs had to undergo upgrades because of the E. coli re-classification. Most upgrades are part of continuous planning processes for each city, and include upgrades for multiple other regulations.

Division Response: It is understood that upgrades are a part of a city's continuous planning process and the decision or ability to upgrade is based on many complex factors. However, there is a direct correlation between WWTF upgrades and the need to address more stringent stream standards. The document states this correlation and does not intend to imply other factors are ignored.

The following are comments received from the U.S. Environmental Protection Agency, Region 8:

The distinction of only including "wildlife" for non-point sources in the table on page 4 (under Source Identification) should be removed or other assumed NPS sources added, as the Division stated that this level of detail (i.e., specific sources) could not be determined in their analysis, and that several non-point sources were assumed based on land-use data (not just wildlife).

Division Response: Table 1 was corrected to included additional nonpoint sources.