COLORADO
Department of Public Health & Environment

TOTAL MAXIMUM DAILY LOAD (TMDL)ASSESSMENT
Upper South Platte Segment 15
COSPUS15
Adams County and Weld County, Colorado

December 2015

TMDL Summary	
Waterbody **Description/WBID**	Upper South Platte Segment 15, COSPUS15
Pollutant Addressed	*E. coli*
Relevant Portion of Segment	All
Use Classifications	Aquatic Life Warm 2, Recreation E, Water Supply, Agriculture
Water Quality Target	*E. coli* – 126 colony forming units per 100 milliliters
TMDL Goal	Attainment of recreation use

Upper South Platte River, Colorado
Segment 15 – COSPUS15

Total Maximum Daily Load
Escherichia coli

Prepared by:

South Platte Coalition for Urban River Evaluation

Prepared for:

Colorado Department of Public Health and Environment
Water Quality Control Division

September 1, 2015

Table of Contents

List of Tables

List of Figures

List of Abbreviations

CFS	cubic feet per second
CFU	colony forming units
CDPHE	Colorado Department of Public Health and Environment
CDPS	Colorado Discharge Permit System
CF	conversion factor
Commission	Water Quality Control Commission
CWA	Clean Water Act
Division	Colorado Water Quality Control Division
DWR	Division of Water Resources
E. coli	*Escherichia coli*
EPA	U.S. Environmental Protection Agency
GIGA-CFU/DAY	1 billion CFU/day
LAs	load allocations
LDC	load duration curve
MGD	million gallons per day
mL	milliliters
MOS	margin of safety
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
RWHTF	Metro Wastewater Reclamation District Robert W. Hite Treatment Facility
SACWSD	South Adams County Water and Sanitation District
TVS	table value standards
TMDL	total maximum daily load
WLAs	wasteload allocations
WWTF	wastewater treatment facility

EXECUTIVE SUMMARY

The Water Quality Control Commission has segmented all of Colorado's water bodies for the purpose of establishing appropriate water quality standards to protect classified uses. As set forth in Regulation No. 38 (5 CCR 1002-38), *Classifications and Numeric Standards, South Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin*, Segment 15 of the South Platte River is described as the "Mainstem of the South Platte River from the Burlington Ditch diversion in Denver, Colorado, to a point immediately below the confluence with Big Dry Creek."

Segment 15 has the following classified uses: Aquatic Life Warm 2, Recreation E, Water Supply, and Agriculture. With respect to antidegradation, Segment 15 is designated as Use Protected, as it meets the definition of an "effluent dominated stream" in Regulation No. 31 (5 CCR 1002-31), i.e., greater than 50 percent of the flow consists of treated wastewater for at least 183 days annually, for eight out of the last ten years.

Flow in this 26-mile stretch of the mainstem South Platte River is heavily influenced by water releases from upstream reservoirs and numerous diversions that withdraw water to meet municipal and agricultural demands. The primary diversion influencing flows in Segment 15 is the Burlington Ditch diversion, which has a total annual water decree of 4,230 cubic feet per second (cfs). Diversions from the segment often results in median flows of less than 20 cfs, with extreme flow conditions of as little as 4 cfs in the upper reach of the segment.

There are also discharges from regulated point sources. For example, approximately two miles downstream of the Burlington Ditch diversion, the Metro Wastewater Reclamation District's Robert W. Hite Treatment Facility (RWHTF), the state's largest capacity municipal point source, discharges an annual average monthly flow of 129 million gallons per day of highly treated effluent to the River. Other permitted municipal and industrial dischargers also are located along the segment. Regulated stormwater sources generally are confined to areas upstream of Segment 15 (e.g., Upper South Platte Segment 14) or have outfalls located on tributaries to Segment 15 rather than on the mainstem.

Segment 15 was placed on the State's 303(d) list of water-quality impaired water bodies for non-attainment of the *Escherichia coli* (*E. coli*) water quality standard in 2002. This impairment affects the beneficial use of existing recreation (Recreation E) and is therefore a priority for the completion of a total maximum daily load (TMDL) due to non-attainment of a human health-based standard. Table ES-1 summarizes information regarding this impairment.

In accordance with the federal Clean Water Act, a TMDL must be developed to determine the maximum amount of a pollutant (in this case, *E. coli*) a water body can assimilate and still attain water quality standards. The methodology used to determine the Segment 15 *E. coli* TMDL is summarized in Table ES-2 and is based on a load duration curve approach.

Due to a variety of non-point sources of *E. coli*, locations of permitted point sources, influences on river flow from tributaries and diversions, and land use characteristics, Segment 15 was divided into three reaches for TMDL evaluation purposes: *Reach 1* (from the Burlington Ditch diversion to 64th Avenue); *Reach 2* (from 64th Avenue to 124th Avenue); and *Reach 3* (from 124th Avenue to the confluence with Big Dry Creek). Allowable *E. coli* loads and wasteloads at varying flow conditions were developed at a representative assessment location in each of the three reaches. This information is presented in Tables ES-3 to ES-5.

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. Therefore, the Water Quality Control Division (Division) has adopted a density-based approach for this TMDL assessment, which allocates pollutant loads to sources based on the *E. coli* water quality standard of 126 CFU/100 mL.

TMDL Impairment Information	Description
State	Colorado
Watershed	South Platte
Counties	Adams and Weld
Waterbody ID	COSPUS15
Constituent of Concern	*Escherichia coli* (*E. coli*)
Segment Description	Mainstem of the South Platte River from the Burlington Ditch diversion in Denver, Colorado, to a point immediately below the confluence with Big Dry Creek.
Affected Portion of Segment	All
Description of Segment 15 Reaches	*Reach 1*: Burlington Ditch diversion to 64th Avenue *Reach 2*: 64th Avenue to 124th Avenue *Reach 3*: 124th Avenue to confluence with Big Dry Creek
Assessment Locations	*Reach 1*: at 64th Avenue *Reach 2*: at 124th Avenue *Reach 3*: at Weld County Road 8
Designated Uses and Impairment Status	Aquatic Life Warm 2: Not impaired **Recreation E: Impaired** Water Supply: Not impaired Agriculture: Not impaired
State Priority Ranking	High
National Hydrography Dataset Identification	10190003
Size of Watershed	4,900 square miles
Land use/cover	Various, including urban, semi-urban, and agricultural
Water Quality Goal	Protection of recreational classified use
Water Quality Target	Attainment of two month geometric mean *E. coli* water quality standard of 126 colony forming units of bacteria per 100 milliliters of water.

Table ES-1. Summary of TMDL Information for *E. coli* in Upper South Platte Segment 15

TMDL Methodology	Description
TMDL Scope	Segment 15 was first identified on the 2002 303(d) List as impaired due to *E. coli*. This TMDL has been developed for the entire segment. However, due to differences in flow conditions and sources of *E. coli* along Segment 15, the TMDL analysis was conducted using three reaches with associated representative assessment locations: Reach 1 (from Burlington Ditch diversion to 64th Avenue); Reach 2 (from 64th Avenue to 124th Avenue); and Reach 3 (from 124th Avenue to the confluence with Big Dry Creek). *Reach 1* assessment location: 64th Avenue *Reach 2* assessment location: 124th Avenue *Reach 3* assessment location: Weld County Road 8
Analysis / Methodology	The TMDL was developed using the Load Duration Curve methodology to ensure TMDL targets comply with the *E. coli* 126 CFU per 100 mL standard during fluctuating flow conditions.
Load Duration Curve Method	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.*
Critical Conditions	The streamflow data period of record extends over a period of twelve years (2000 - 2011). These data represent a range of recorded flow conditions for flow duration curve analysis and were used to assess compliance with the water quality standards over a range of hydrologic and meteorological conditions. The water quality data period of record extends over a period of six years (2006-2011). The critical period was identified by the large majority of exceedances during moist and high flow conditions.
Seasonal Variation	The 12-year period (2000-2011) used for hydrologic conditions and 6-years period (2006-2011) water quality analysis included all seasons and a full range of flow and meteorological conditions. Load duration calculations are based on such flow conditions to ensure the TMDL target aligns with the assimilative capacity of the stream in varying seasonal and flow conditions.
Margin of Safety	This TMDL includes a 10% explicit margin of safety. There are also a number of implicit conservative assumptions such as assuming all regulated point sources discharge *E. coli* concentrations of 126 CFU/100 mL (all point sources in this segment discharge below the 126 CFU/100 mL standard).

Table ES-2. Summary of TMDL Methodology for *E. coli* in Segment 15

***Reach 1* Assessment**	**High Flows**	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flow**
Current Daily Load at SP-64 Assessment Location (Giga-CFU/day)	6440	1520	281	41.5	28.6
Allowable Total Maximum Daily Load (Giga-CFU/day)	1840	475	92.5	30.2	17.9
Percent Reduction Needed	71%	69%	67%	27%	37%
Margin of Safety (10%)	184	47.5	9.25	3.02	1.79
Wasteload Allocations					
Xcel Energy Cherokee Facility (Giga-CFU/day)	4.8	4.8	4.8	4.8	4.8
City of Denver MS4 (Giga-CFU/day)	22.08	5.7	1.11	0.36	0.21
Reserve Capacity (5%)	92	23.75	4.63	1.51	0.90
Load Allocations					
Non-Point Sources: Background (Upstream Load from Segment 14), Humble Creek, Wildlife, Other* (Giga-CFU/day)	1537.1	393.2	72.7	20.5	10.2

*Including seasonal *E. coli* regrowth; illegal dumping; failing septic systems; pet waste; diffuse runoff associated with storm events; and background loading from unidentified pipes and culverts.

Table ES-3. TMDL *E. coli* wasteload and load allocations (Giga-CFU/day) by flow condition for Segment 15, *Reach 1*

***Reach 2* Assessment**	**High Flows**	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flow**
Current Daily Load at SP-124 Assessment Location (Giga-CFU/day)	9070	2010	955	458	264
Allowable Total Maximum Daily Load (Giga-CFU/day)	4040	1410	916	675	502
Percent Reduction Needed	55%	30%	4%	0%	0%
Margin of Safety (10%)	404	141	91.6	67.5	50.2
Wasteload Allocations					
Robert W. Hite Treatment Facility (Giga-CFU/day)	624	540	491	450	183
South Adams County Water and Sanitation District (Williams Monaco) (Giga-CFU/day)	38.2	38.2	38.2	38.2	38.2
Reserve Capacity (5%)	202	70.5	45.8	33.75	25.1
Load Allocations					
Non-Point Sources: Sand Creek, Clear Creek, Niver Creek, Bull Seep, Wildlife, Other* (Giga-CFU/day)	2771.8	620.3	249.4	85.55	205.5

*Including seasonal *E. coli* regrowth; illegal dumping; failing septic systems; pet waste; diffuse runoff associated with storm events; agricultural operations; and background loading from unidentified pipes and culverts.

Table ES-4. TMDL *E. coli* wasteload and load allocations (Giga-CFU/day) by flow condition for Segment 15, *Reach 2*

Reach 3 Assessment	**High Flows**	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flow**
Current Daily Load at RD-8 Assessment Location (Giga-CFU/day)	6990	1470	591	203	141
Allowable Total Maximum Daily Load (Giga-CFU/day)	4120	1400	936	692	488
Percent Reduction Needed	41%	5%	0%	0%	0%
Margin of Safety (10%)	412	140	93.6	69.2	48.8
Wasteload Allocations					
Brighton Wastewater Treatment Facility (Giga-CFU/day)	14.3	14.3	14.3	14.3	14.3
Northern Treatment Plant (Giga-CFU/day)	139	139	139	139	139
Reserve Capacity (5%)	206	70	46.8	34.6	24.4
Load Allocations					
Non-Point Sources: , Wildlife, Other* (Giga-CFU/day)	3349	1037	642	435	262

*Including seasonal *E. coli* regrowth; illegal dumping; failing septic systems; pet waste; diffuse runoff associated with storm events; agricultural operations; and background loading from unidentified pipes and culverts.

Table ES-5. TMDL *E. coli* wasteload and load allocations (Giga-CFU/day) by flow condition for Segment 15, *Reach 3*

Wasteloads for all regulated point sources located within Segment 15 were determined on the basis of the stream standard (126 colony forming units of bacteria per 100 milliliters of water). All applicable municipal wastewater treatment facilities currently have *E. coli* effluent limitations based upon this same standard. The Xcel Energy Cherokee facility discharge permit currently does not have an *E. coli* effluent limit, but instead has “Report” only requirements. However, based on 2009 through 2010 Cherokee Discharge Monitoring Report data evaluated for this TMDL, *E. coli* effluent concentrations from the facility were well below the stream standard.

Attainment of the *E. coli* standard in Segment 15 will depend on successful implementation of the upstream Segment 14 *E. coli* TMDL as well as efforts to control sources in tributaries flowing into the segment. Recommended management practices in Segment 15 will differ for each reach; however, because water quality generally improves downstream from urbanized land uses (e.g., moving from *Reach 1* to *Reach 3*), attainment is likely over time.

1. Introduction

Section 303(d) of the federal Clean Water Act (CWA) requires states to periodically submit a list of water bodies that are impaired, i.e., segments where one or more assigned use classifications or standards is not being achieved, to the U.S. Environmental Protection Agency (EPA). This list of water bodies is referred to as the 303(d) List. In Colorado, the Water Quality Control Division (Division) is the agency responsible for developing the 303(d) List. The 303(d) List is adopted by the Water Quality Control Commission (Commission) as Regulation No. 93, *Colorado Section 303(d) List of Impaired Waters and Monitoring and Evaluation List* (5 CCR 1002-93). The Commission adopted the most recent 303(d) List in February of 2012.

The Division is required to produce a Total Maximum Daily Load (TMDL) assessment for each water body included on the 303(d) List. A TMDL quantifies the amount of a pollutant that an impaired water body can assimilate without violating applicable water quality standards. In addition, the TMDL apportions the allowable quantity of pollutant loading among the known significant pollutant sources, both point and non-point.

A TMDL is comprised of: the Load Allocation (LA), which is the portion of the pollutant load attributed to natural background or non-point sources; the Waste Load Allocation (WLA), which is the portion of the pollutant load associated with point source discharges; and a Margin of Safety (MOS), which accounts for uncertainty in the pollutant load calculations and an allocation to accommodate future pollutant sources. The WLA in this TMDL includes a reserve capacity for the wasteload component for potential expansion of existing and/or future facilties.

The TMDL is the sum of the Waste Load Allocation, Load Allocation, and the Margin of Safety:

$$TMDL=WLA+LA+MOS$$

Alternatively, a water body may be removed from the 303(d) List if the applicable water quality standard is attained, if implementation of clean-up activities via an alternate means (e.g., a Category 4b Plan) will result in attainment of standards, or if a refined site-specific standard has been adopted by the Commission (e.g., through a Use Attainability Analysis or other method).

A TMDL is needed to address the *E. coli* 303(d) listing of Upper South Platte Segment 15. The purpose of this TMDL evaluation is to support the development of applicable *E. coli* loads and wasteloads for the segment.

2. Description of the Watershed

2.1 South Platte River Watershed Characteristics

Water quality in the Colorado portion of the South Platte River Basin is influenced by a variety of factors, including its unique geographical location beginning at the Continental Divide and ending at the Nebraska state line, varied land uses, highly populated urban centers, and water management activities.

The South Platte River Basin begins at the Continental Divide at an elevation of approximately 14,000 feet above sea level. At the confluence with the North Platte River in Nebraska, elevation drops to about 2,700 feet. According to the U.S. Geological Survey National Water

Quality Assessment Program (2013), the Basin is subject to a wide range of temperatures and seasonal precipitation is irregular. For example, mountainous areas of the basin receive an average of 30 inches of precipitation while the eastern plains are much drier, averaging approximately 7 to 15 inches annually.

Much of Colorado's population is located in Front Range communities within the basin. In this area, manufacturing, service industries, and government services are predominant. Farther downstream in the Basin, agricultural and livestock production activities are more common. In the overall Basin, 41 percent is rangeland, 37 percent is agricultural land, 16 percent is forested, 3 percent is urbanized, and 3 percent is "other lands," e.g., mining, gravel pits, etc.

2.2 Segment 15 of the Upper South Platte River

Segment 15 of the Upper South Platte River is located in the Middle South Platte – Cherry Creek Watershed, U.S. Geological Survey cataloging unit (National Hydrography Dataset Identification) number 10190003. The segment is identified by multiple reachcodes and therefore more easily identified by the CDPHE code below. The watershed location is shown in Figure 2-1 below.

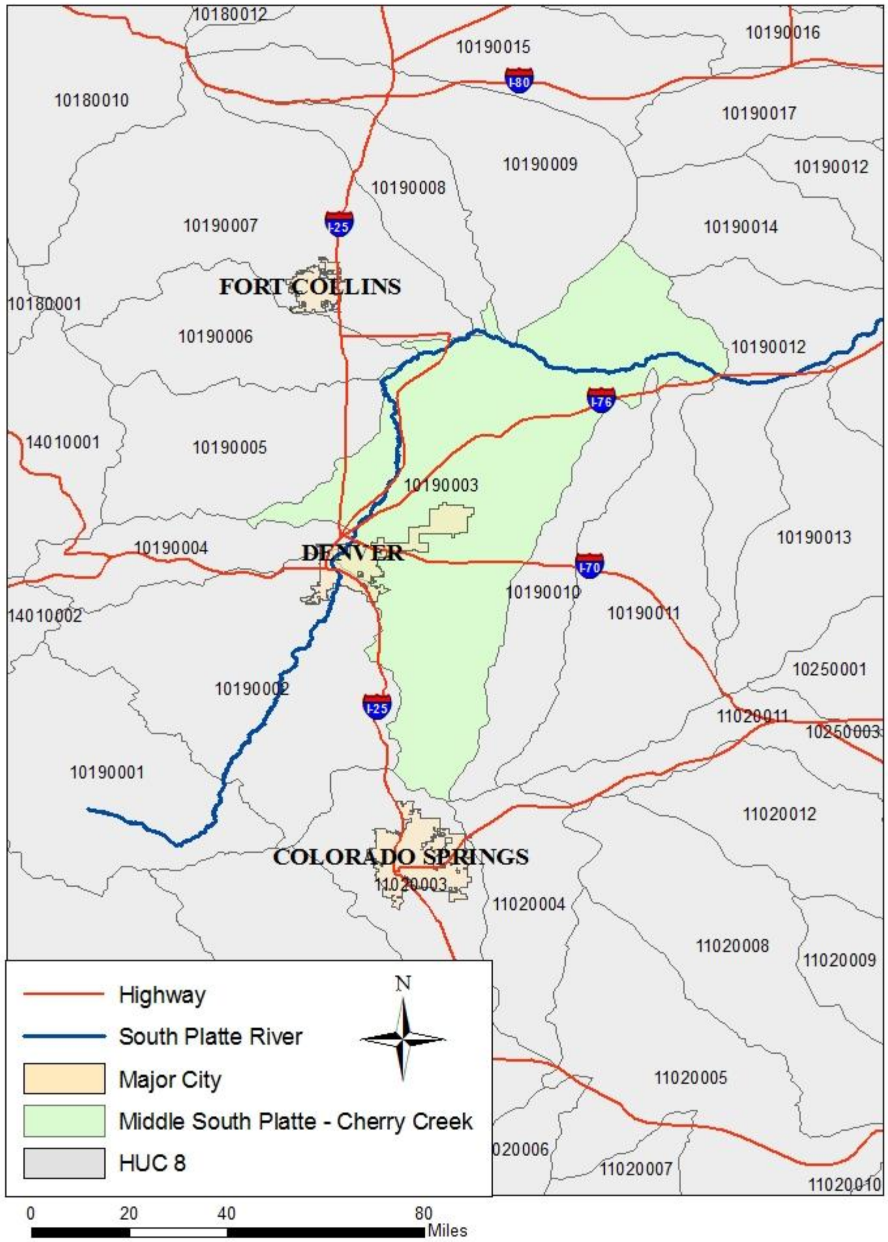

Figure 2-1. Location of Middle South Platte – Cherry Creek Watershed No. 10190003

Segment 15 is described in Regulation No. 38, *Classifications and Numeric Standards, South Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin* (5 CCR 1002-38) as: Mainstem of the South Platte River from the Burlington Ditch diversion in Denver, Colorado, to a point immediately below the confluence with Big Dry Creek. The location of Segment 15 is shown in Figure 2-2 below. The segment is identified by the code COSPUS15.

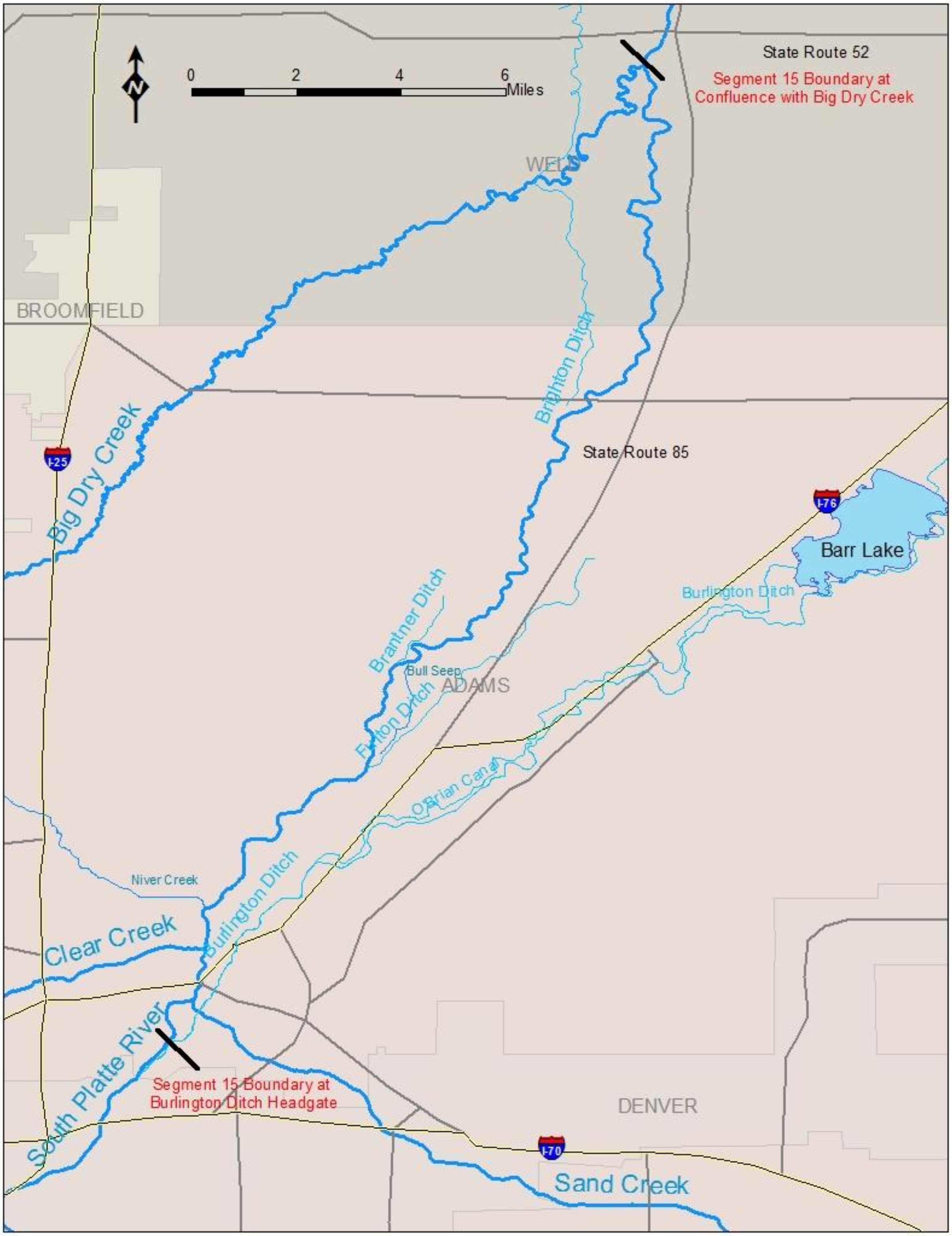

Figure 2-2. Location of Upper South Platte Segment 15

2.3 Segment 15 Land Uses

Segment 15 is approximately twenty-six miles in length, originating in the urbanized Denver metropolitan area, transitioning through areas with mixed land uses, and ending at the confluence with Big Dry Creek, a more rural area.

As discussed in more detail in following sections, for this TMDL Segment 15 was divided into three distinct reaches:

(1) *Reach 1*, from the Burlington Ditch headgate to 64th Avenue;

(2) *Reach 2*, from 64th Avenue to 124th Avenue; and

(3) *Reach 3*, from 124th Avenue to the end of the segment.

The segment was divided in this manner due to unique flow conditions and land uses. The photographs shown below are representative of the land uses applicable to each Reach. Figure 2-3 shows the Burlington Ditch headgate (at the upper end of Segment 15 – *Reach 1*). Figure 2-4 is a photograph taken near the mid-point of Segment 15 (near 124th Avenue – *Reach 2*). Figure 2-5 show an example of livestock in the mainstem of the South Platte River near Weld County Road 8 Figure 2-6 is a photograph taken near the confluence with Big Dry Creek (lower end of Segment 15 – *Reach 3*). Figure 2-7 is a typical example of the agricultural and pasture land uses that characterizes Reach 3 near the end of Segment 15.

Figure 2-3. Upper portion of Segment 15, near the Burlington Ditch headgate, *Reach 1*

Figure 2-4. Middle portion of Segment 15, near 124th Avenue, *Reach 2*

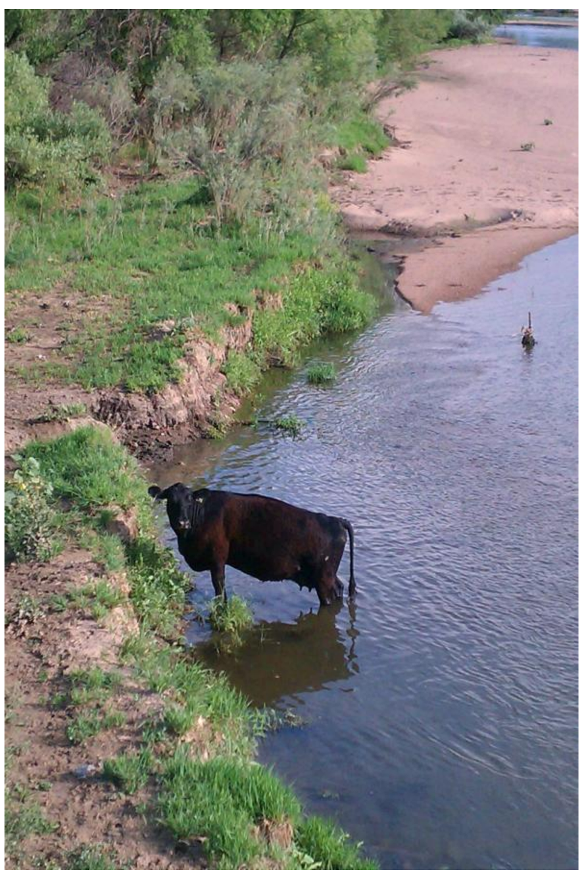

Figure 2-5. Livestock in Segment 15, *Reach 3*

Figure 2-6. Lower portion of Segment 15, near the end of *Reach 3*

Figure 2-7. Livestock adjacent to Big Dry Creek

Because land uses can affect overall water quality, it is necessary to document land use types for purposes of TMDL evaluation. Figures 2-8 through 2-10 illustrate the different land uses found throughout Segment 15.

Figure 2-8 illustrates the predominance of low, medium, and high intensity development (shades of red and pink) that surround the South Platte in *Reach 1*. The watershed around *Reach 2* (shown in Figure 2-9) has substantial development, but the River itself is buffered by water storage reservoirs until it flows into natural lands (shrub/scrub shown in brown) and agriculture (pasture/hay in yellow). *Reach 3* (shown in Figure 2-10) is surrounded primarily by natural lands and agriculture with the only exception being the City of Brighton on the east side of the South Platte River.

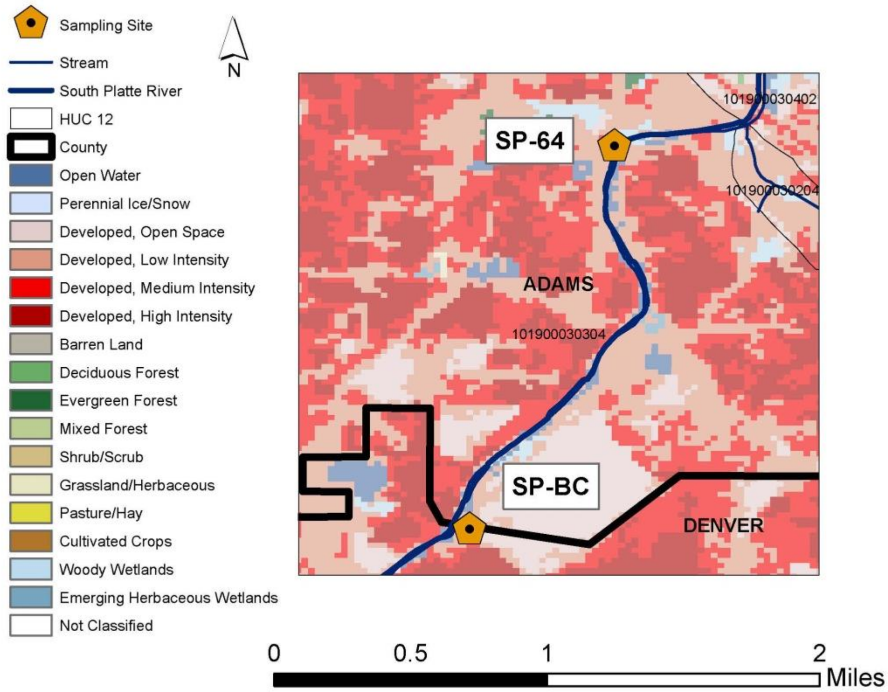

Figure 2-8. Land uses in *Reach 1*, from Burlington Ditch headgate to 64th Avenue

Data for Figures 2-8 through 2-10 are from: Fry, J., Xian, G., Jin, S., Dewitz, J., Homer, C., Yang, L., Barnes, C., Herold, N., and Wickham, J., 2011. Completion of the 2006 National Land Cover Database for the Conterminous United States, *PE&RS*, Vol. 77(9):858-864.

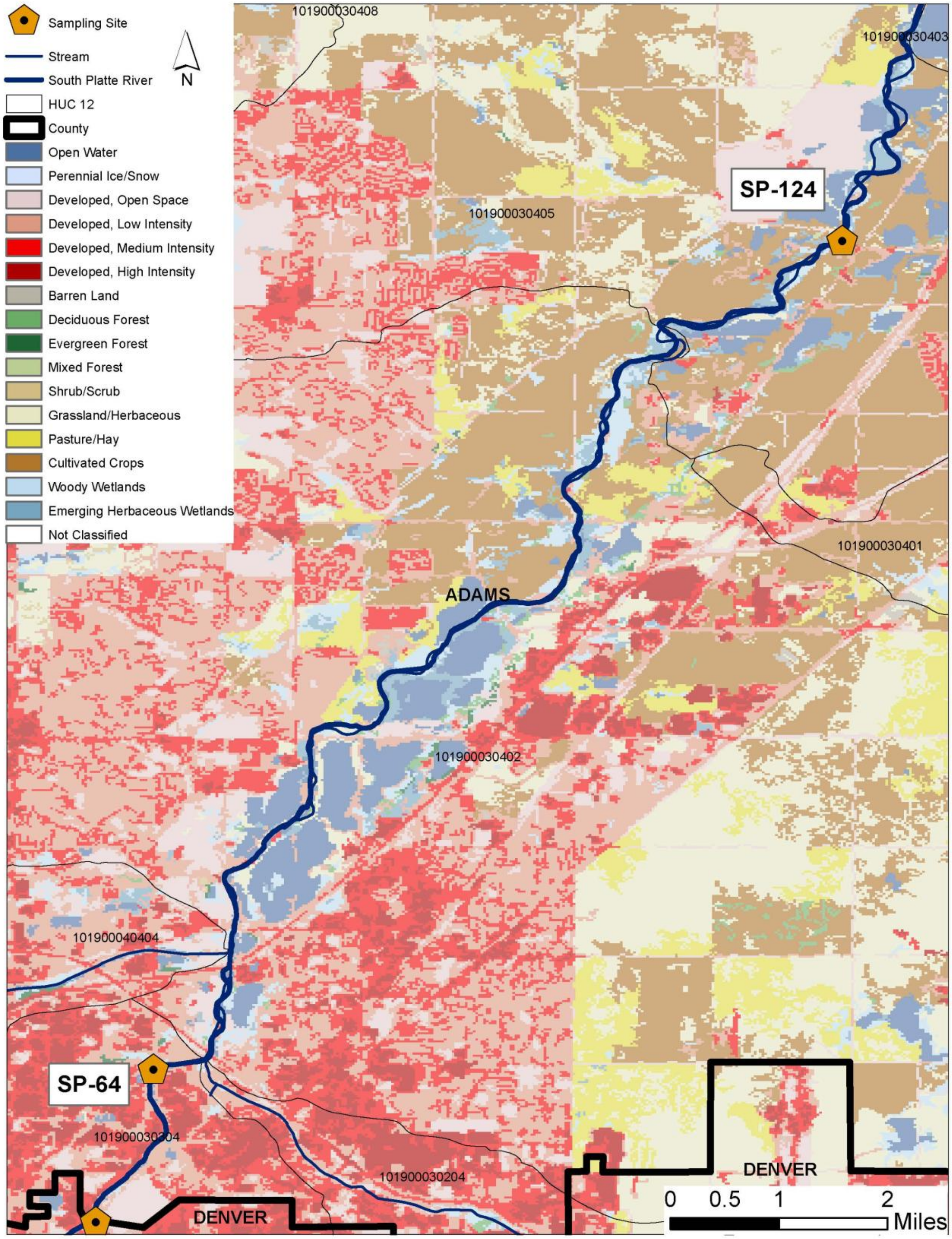

Figure 2-9. Land uses in *Reach 2*, from 64th Avenue to 124th Avenue

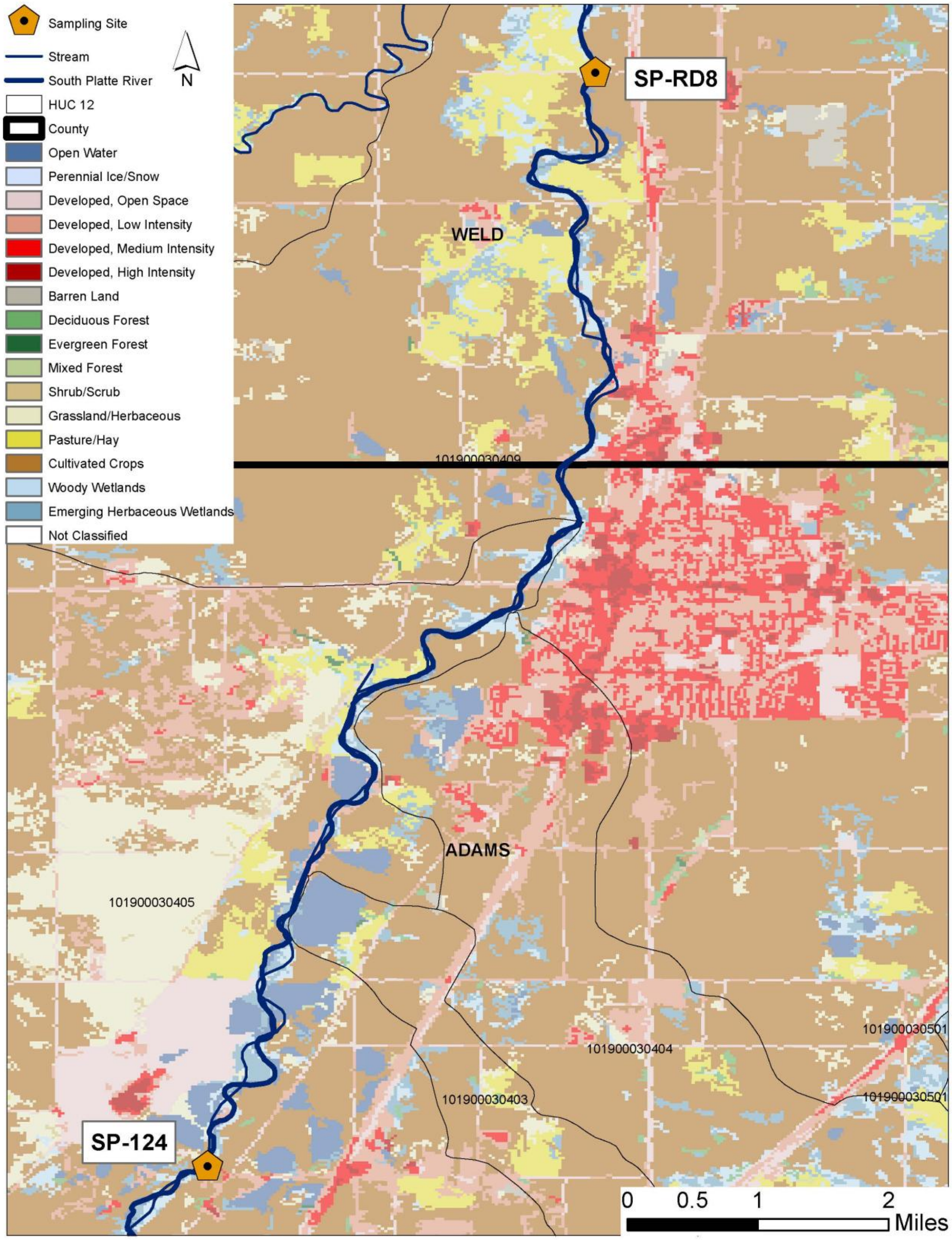

Figure 2-10. Land uses in *Reach 3*, from 124th Avenue to near the end of Segment 15

2.4 Locations of Segment 15 Water Diversions and Tributaries

Flow in this 26-mile segment of the mainstem South Platte River, which ends near Fort Lupton, Colorado, is heavily influenced by water releases from upstream reservoirs and numerous diversions that withdraw water to meet agricultural and municipal demands in the South Platte River valley. In addition, there are several tributaries entering the segment. The locations of water diversions and tributaries are shown in Figure 2-11.

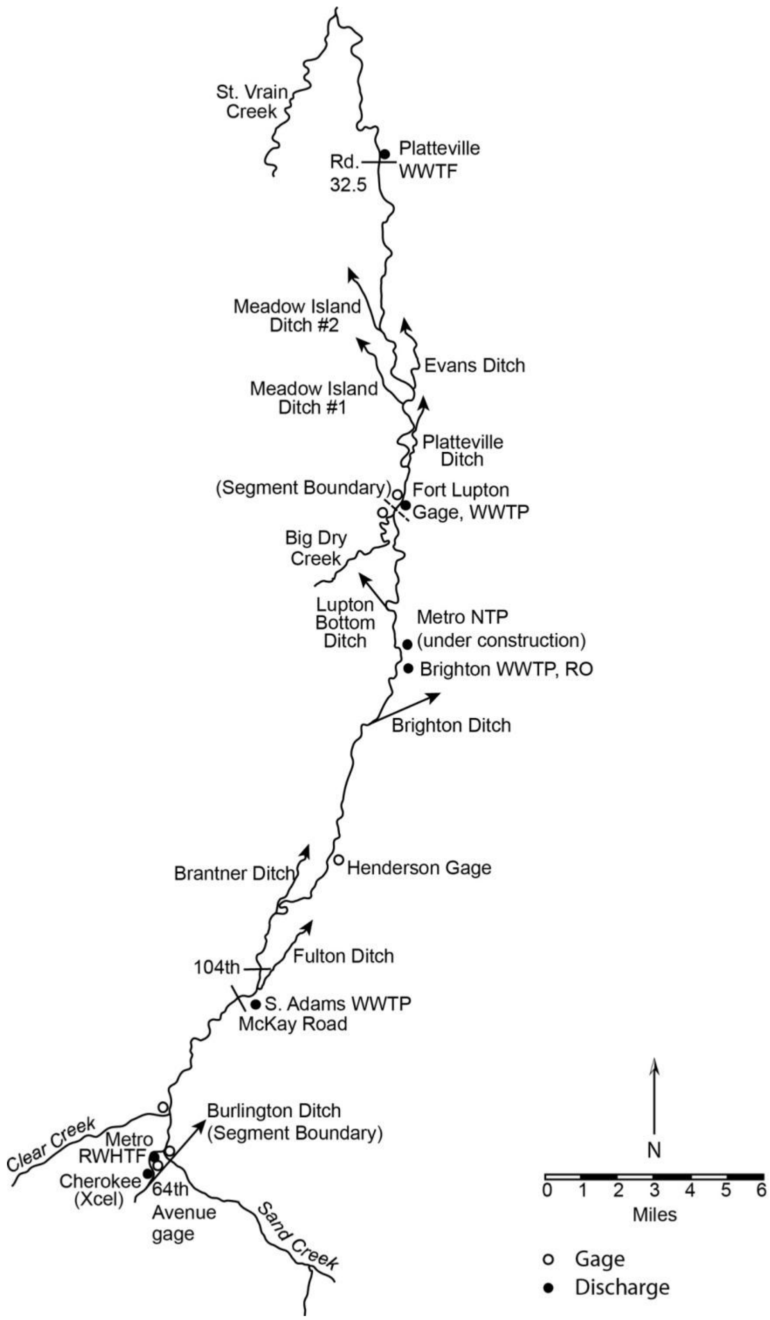

Figure 2-11. Locations of Segment 15 diversions and tributaries

2.5 Locations of Segment 15 Identified and Unidentified Discharges

There are numerous identified point source discharges (those verified as owned and/or operated by a known entity) and unidentified point source discharges (those that could not be associated with a known owner and/or operator) located throughout Segment 15. The unidentified point sources were surveyed using the "Outfall Reconnaissance Inventory/Sample Collection Field Sheet" as part of the EPA's "Illicit Discharge Detection and Elimination: Guidance Manual for Program Development and Technical Assessments" document (Brown et al., 2004). This survey identified all pipes or drains that drain directly to the mainstem of the South Platte River. While many of these sources did not have any flow during the survey, they were cataloged if, given the best professional judgment of the collectors, there was evidence of recent flow or if the potential for future flow existedInformation regarding known sources of *E. coli* is addressed in Section 6. Figures 2-12 through 2-15 below show the locations of discharges for each of the three *E. coli* evaluation reaches of Segment 15.

Permitted point sources within each reach are discussed in Section 6.

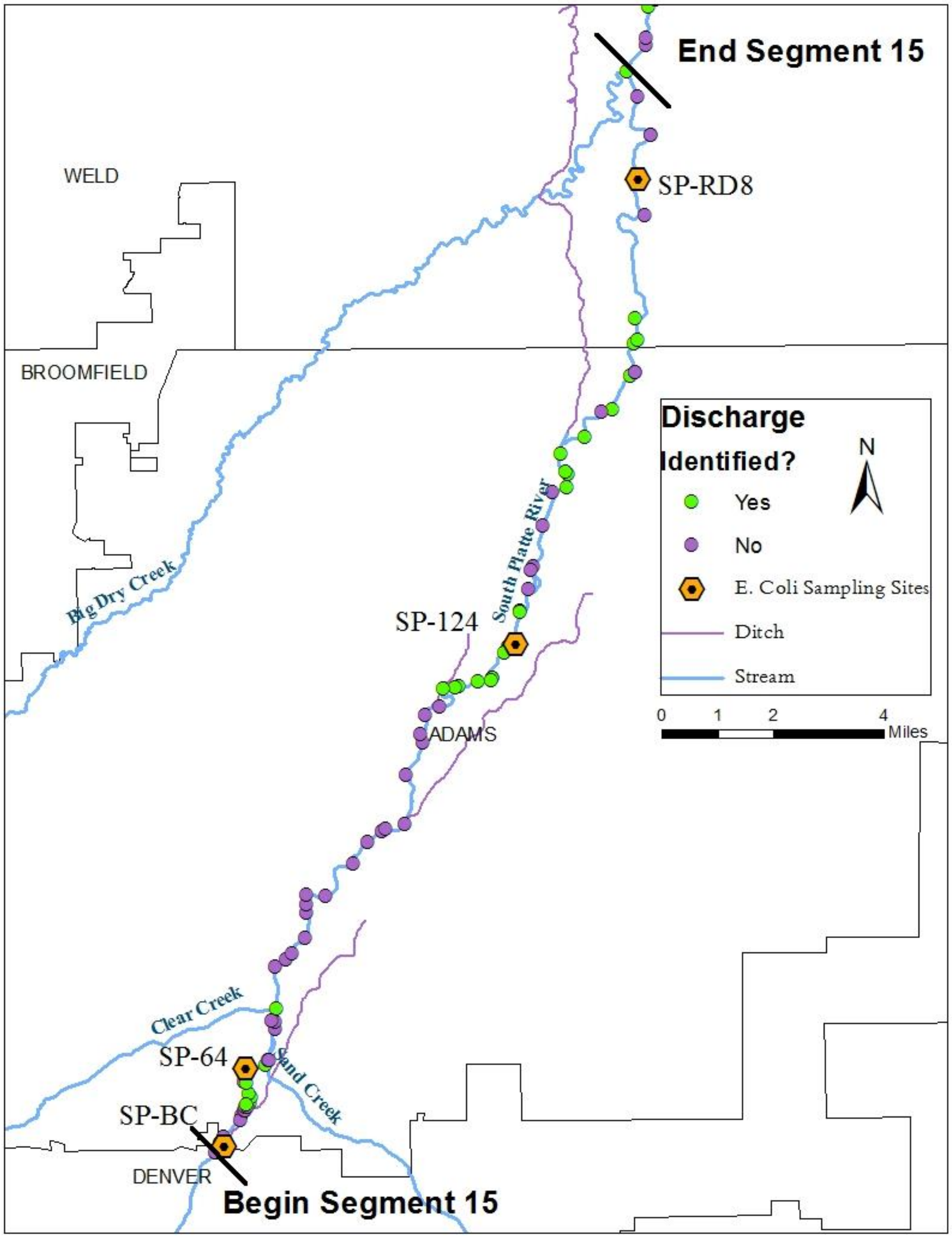

Figure 2-12. Locations of discharges within Segment 15

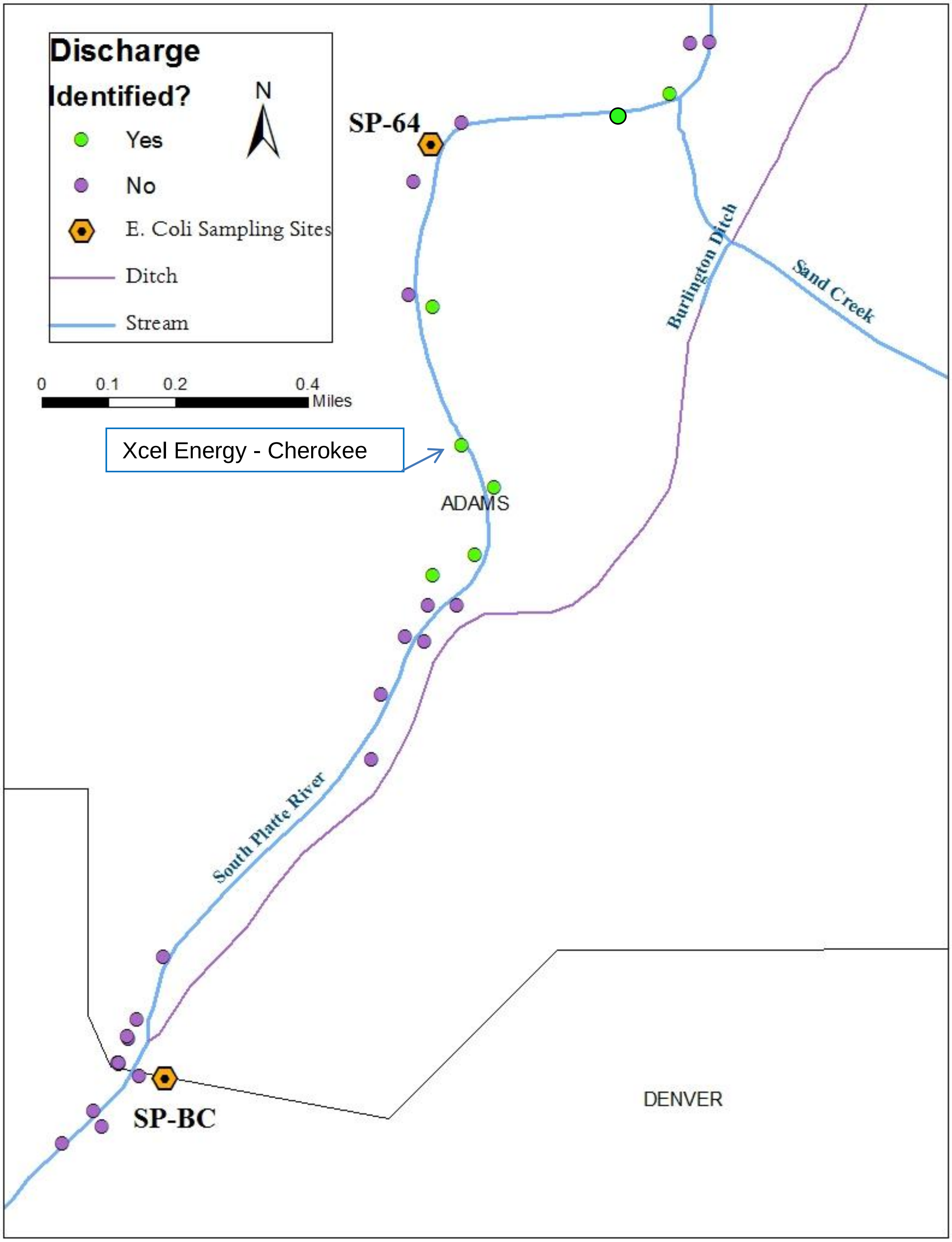

Figure 2-13. Locations of identified and unidentified discharges in *Reach 1*, from Burlington Ditch headgate to 64th Avenue

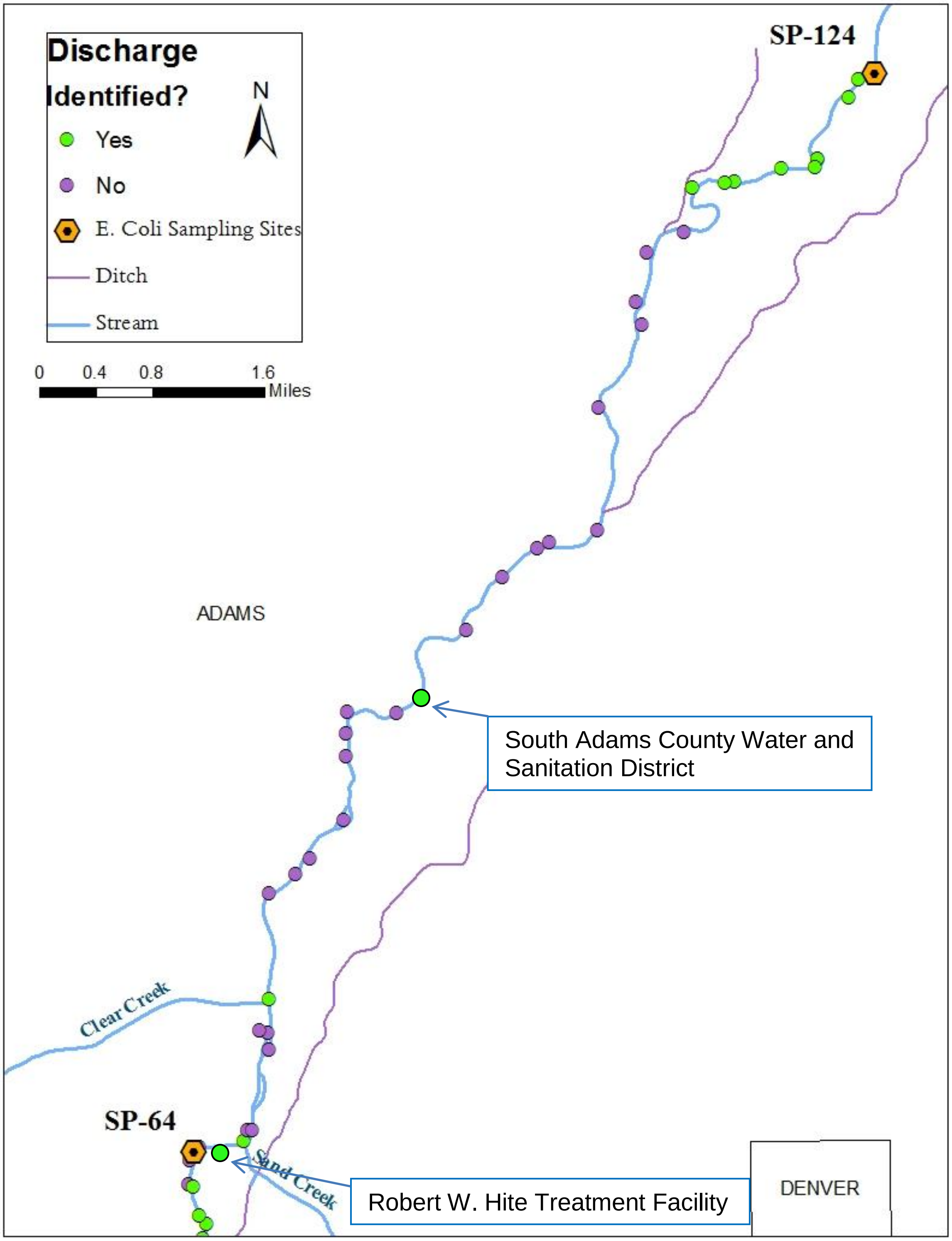

Figure 2-14. Locations of point source discharges in *Reach 2*, from 64th Avenue to 124th Avenue

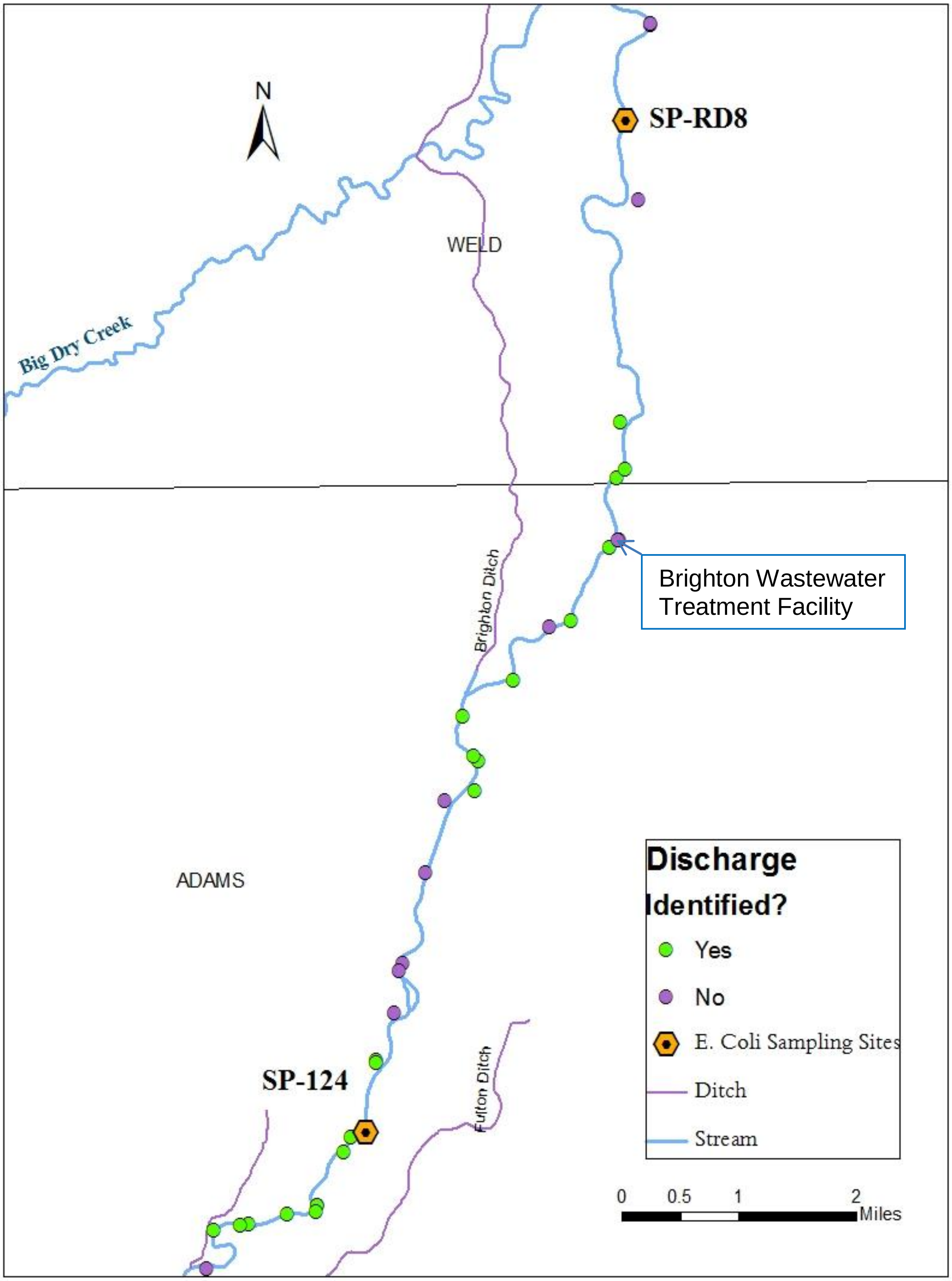

Figure 2-15. Locations of point source discharges in *Reach 3*, from 124th Avenue to near the end of Segment 15

3. Impairment Overview

Section 303(d) of the federal Clean Water Act requires Colorado to identify bodies of water that fail to meet water quality standards and classified uses. The entire length of Segment 15 was added to the 303(d) List in 2002 as impaired by *E. coli*, with a "High" priority.

E. coli is a Gram-negative, rod-shaped bacterium that belongs to a group of bacteria known as fecal coliform. It is commonly found in the lower intestine of warm-blooded organisms. Most *E. coli* strains are not harmful to humans, but some can cause serious illness. Common *E. coli* sources are humans, wildlife, birds, livestock (especially high density farms), and household pets. *E. coli* is considered an indicator for the possible presence of other harmful pathogens such as Salmonella and Giardia. *E. coli* concentrations are typically not correlated with urbanization and can be ubiquitous in the natural environment (Sprague, Zuelig, & Dupree, 2006; Russell, 2012).

Two-month E. coli geometric means were calculated to evaluate spatial and temporal trends along Segment 15 in accordance with the E. coli water quality standard. During the period of data evaluation (2006-2011), exceedances of the 126 CFU/100 mL standard were found at all monitoring locations throughout the year. In the uppermost reach of the Segment (Reach 1), the mean and median *E. coli* concentrations are relatively high. In Reach 2, concentrations generally reflect urban-related impacts as well as dilution associated with treated effluent from municipal wastewater treatment facilities. In the lowermost portion of Segment 15 (Reach 3), concentrations improve and the median concentrations are often below the standard. Generally, *E. coli* concentrations were lower in the spring (March and April), which is assumed to be explained by the dilution effects of snowmelt. The summer months (July and August) show the highest *E. coli* concentrations, possibly reflecting flow conditions associated with summertime thunderstorms and resulting diffuse runoff into the segment.

3.1 Segment 15 Classified Uses

Segment 15 has the following classified uses: Aquatic Life Warm 2, Recreation E, Water Supply, and Agriculture. With respect to antidegradation, Segment 15 is Use Protected, as it meets the definition of an "effluent dominated stream" in Regulation No. 31 (5 CCR 1002-31), i.e., greater than 50 percent of the flow in the segment consists of treated wastewater for at least 183 days annually, for eight out of the last ten years. The effluent dominated condition is attributed to significant diversion of flow at the Burlington Ditch headgate at the upper segment boundary and the proximate downstream location of the Robert W. Hite Treatment Facility (RWHTF). Table 3-1 lists all four classified uses applicable to Segment 15.

The primary concern associated with *E. coli* is ingestion through direct contact with water in Segment 15. A paved trail follows the majority of Segment 15 that is used for biking and walking activities, as well as providing access to the River. Water contact through swimming, kayaking, or tubing is rare within Segment 15, in contrast to water-based recreation that occurs upstream in Segment 14 through the heart of the metropolitan Denver area.

Beneficial Use	Designation	Description	Status
Recreation	E	Existing primary contact; waters suitable for recreational activities where ingestion is likely. Recreational activities include: swimming, kayaking, and tubing.	**Impaired for *E. coli***
Aquatic Life	Warm 2	Warm waters capable of sustaining a variety of aquatic life, including sensitive species.	Not Impaired
Water Supply		After treatment, surface waters, suitable for drinking water supplies.	Not Impaired
Agriculture		Waters suitable for crop irrigation and livestock drinking water.	Not Impaired

Table 3-1. Classified uses within Segment 15 of the Upper South Platte River applicable to *E. coli*

3.2 *E. coli* Water Quality Standard

The pollutant of concern within Segment 15 of South Platte River specific to this TMDL is *E. coli*. In 1986, the EPA published the Ambient Water Quality Criteria for Bacteria (EPA 440/5-84-002), which established national water quality criteria for bacteria in surface waters. The criteria recommended a geometric mean value of 126 colony forming units (CFU) per 100 mL as the primary contact criterion based on a risk factor of acute gastrointestinal illness corresponding to eight illnesses per 1,000 swimmers.

The Colorado *E. coli* table value standard (TVS) established by the Commission for existing primary contact recreation is contained in Colorado Regulation No. 31. In Section 31.16 of Regulation No. 31, the *E. coli* TVS is interpreted as a two month geometric mean of 126 CFU per 100 mL, applicable year-round. This enforceable *E. coli* water quality standard for Segment 15 has been adopted in Regulation No. 38, the South Platte Basin regulation.

3.3 *E. coli* Water Quality TMDL Target

When calculating a TMDL, a numeric target is selected to ensure the applicable water quality standard will be met. For this TMDL, the target value for *E. coli* is based on the existing water quality standard established under Colorado Regulation 38 to protect primary contact recreation in Segment 15. The standard is applicable year-round and is expressed as a two-month geometric mean of 126 CFU per 100 mL.

4. *E. coli* Data and Analyses

This section provides an inventory of data and a summary of data analyses to evaluate the *E. coli* impairment and support TMDL development. Both bacterial count data and daily average flow data are necessary to develop load duration curves.

4.1 *E. coli* Monitoring Locations

Biweekly *E. coli* monitoring of Segment 15 has occurred in partnership with the South Platte Coalition for Urban River Evaluation (SP CURE) since 1998 at approximately fourteen sites along the South Platte. For this TMDL, biweekly data from 2006 through 2011 were used. In addition, weekly sampling was performed at thirteen sites (both on the South Platte and in tributaries) in 2010 and 2011. Table 4-1 lists Segment 15 *E. coli* monitoring sites. Figure 4-1 shows the location of the *E. coli* monitoring sites along Segment 15.

The sampling sites located along the South Platte River were chosen for ease of access and to supply data that can accurately provide longitudinal data to show changes in the presence of *E. coli* throughout the segment.

Monitoring Site	Description	Latitude	Longitude
SP-BC	South Platte River above Burlington Headgate	39.79186	-104.96667
SP-64	South Platte River at 64th Ave.	39.81219	-104.95900
SC	Sand Creek on Burlington Ditch Flume (above FRICO Siphon)	39.81006	-104.95100
BD-64	Burlington Ditch at 64th Ave.	39.80542	-104.95200
CC	Clear Creek at York St.	39.82789	-104.95900
SP-CC	South Platte River ~100 yards upstream of confluence with Clear Creek	39.82700	-104.94900
SP-88	South Platte River at 88th Ave.	39.85607	-104.93800
SP-104	South Platte River at 104th Ave.	39.88531	-104.90200
SP-124	South Platte River at 124th Ave.	39.92278	-104.86700
SP-160	South Platte River at 160th Ave.	39.98696	-104.83200
SP-RD8	South Platte River at Adams Co. Rd. 8	40.04385	-104.82400
BDC	Big Dry Creek 50 yards Upstream of USGS Gage Station 067720990	40.06933	-104.83300
HUMBLE	Humble Creek above the confluence with the South Platte	39.8031	-104.9571
NIVER	Niver Creek above the confluence with the South Platte	39.8391	-104.9488
BULL SEEP	Bull Seep above the confluence with the South Platte	39.9056	-104.8929

Note: Sites highlighted in blue represent E. coli assessment locations, described in Section 5.

Table 4-1. Description of Segment 15 *E. coli* monitoring locations

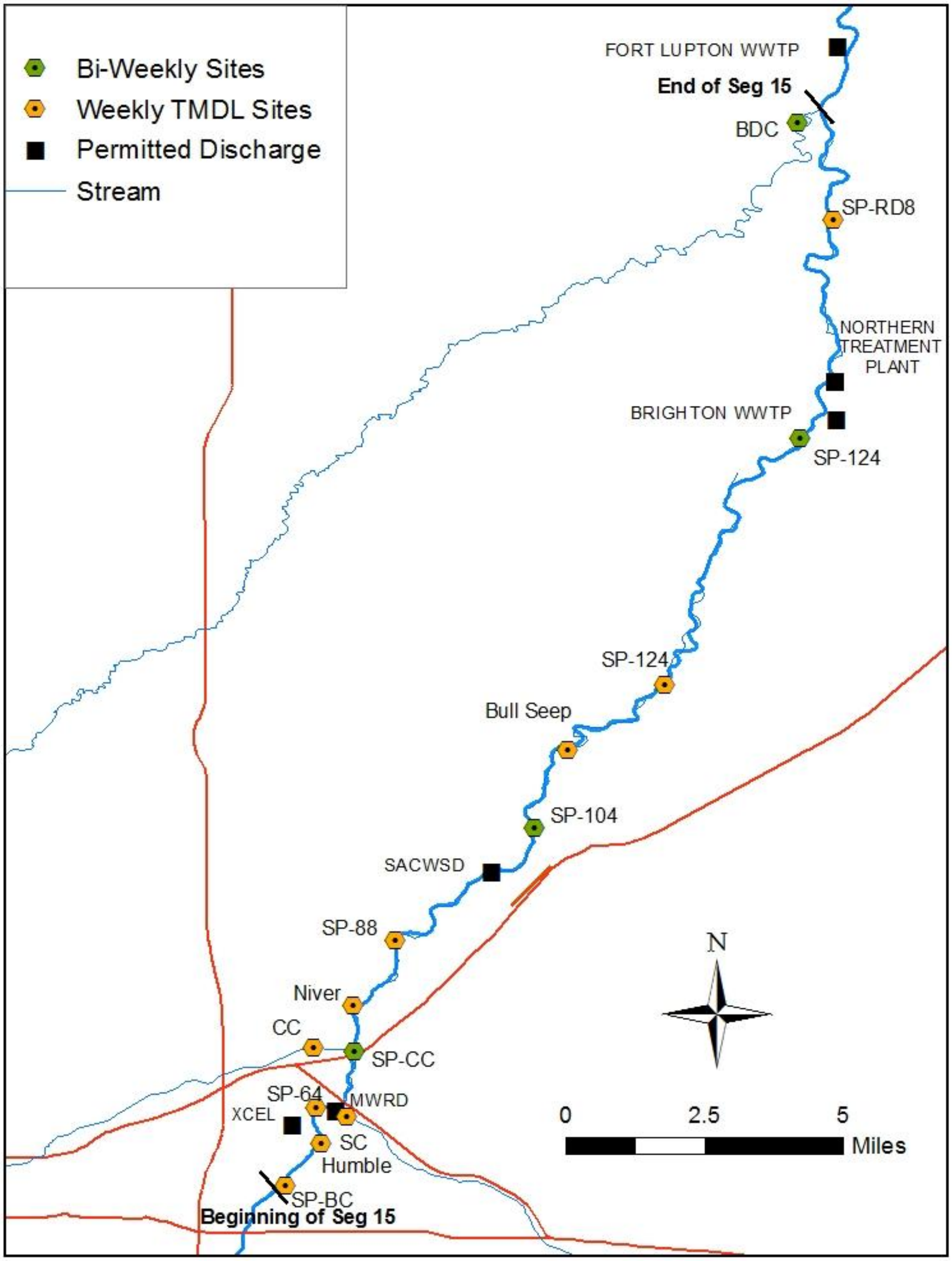

Figure 4-1. Map of Segment 15 monitoring locations

4.2 Segment 15 Stream Gage Locations

Stream gages are common on the South Platte and available for the major tributaries flowing into Segment 15 and major ditch diversions away from the River. Segment 15 stream gages and their locations are shown in Table 4-2 and in Figure 4-2.

Stream Gage	Location	Description	Available Data Range	Downloaded Data	Drainage Area (mi^2)
USGS 06710247	Lat: 39º37'57" Long: 105º00'52"	South Platte River Below Union Avenue at Englewood	2/1/1996 to Present	1/1/2000 to Present	3043
USGS 06714215	Lat: 39º48'44" Long: 104º57'28"	South Platte River at 64th Avenue, Commerce City	1/1/1982 to Present	1/1/2000 to Present	3884
DWR PLAHENCO	Lat: 39°55'20" Long: 104°52'7"	South Platte River at Henderson	1933 to 2010	1/1/2000 to 9/30/10	4768
USGS 06721000	Lat: 40º06'58" Long: 104º49'05"	South Platte River at Fort Lupton	Seasonally 2003 to 2005, 1/1/2006 to Present	4/29/03 to Present (all available data)	5007
DWR 809	Lat: 39º54'24" Long: 104º53'44"	Brantner Ditch from the South Platte River	1950 to 2010	1/1/2000 to 10/31/10	N/A
DWR 810	Lat: 39º58'27" Long: 104º51'04"	Brighton Ditch from the South Platte River	1950 to 2010	1/1/2000 to 10/31/10	N/A
DWR 802	Lat: 39º47'30" Long: 104º58'02"	Burlington Ditch River Headgate from the South Platte River	1950 to 2010	1/1/2000 to 10/31/10	N/A
DWR 808	Lat: 39º52'39" Long: 104º54'13"	Fulton Ditch from the South Platte River	1950 to 2010	1/1/2000 to 10/31/10	N/A
USGS 394839104570300	Lat: 39º48'36" Long: 104º57'00"	Sand Creek at mouth near Commerce City	1/1/1992 to Present	1/1/2000 to Present	184
DWR CLEDERCO	Lat: 39º49'42" Long: 104º57'30"	Clear Creek at Derby	1927 to Present	1/1/2000 to 9/30/10	575

Table 4-2. Segment 15 stream gage location information

Figure 4-2. Locations of stream gages along Segment 15

4.3 Impacts on Segment 15 from Diversions, Tributaries, and Discharge from the Robert W. Hite Treatment Facility

Diversions: Section 2.4 lists the various water management diversion structures throughout Segment 15. The primary diversion influencing flows in Segment 15 is the Burlington Ditch diversion, which has a total annual water decree of 4,230 cubic feet per second (cfs). Diversions from the segment often results in median flows of less than 20 cfs upstream of the Rober W. Hite Treatment Facility, with extreme low flow conditions of as little as 4 cfs. Figures 4-3 through 4-6 illustrate the condition of Segment 15 during low flow periods.

Figure 4-3. Segment 15 downstream of Burlington Ditch diversion, at 58th Avenue (*Reach 1*)

Figure 4-4. Segment 15 downstream of Burlington Ditch diversion, near 64th Avenue (*Reach 1*)

Figure 4-5. Segment 15 near District habitat improvement projects (*Reach 2*)

Farther downstream, approximately 704 cfs can be diverted annually at the Fulton Ditch near 104th Avenue in Adams County. Subsequently, diversions from the Brantner Ditch (annual decree of approximately 111 cfs), the Brighton Ditch (annual decree of approximately 47 cfs), and the Lupton Bottoms Ditch (an annual decree of approximately 190 cfs), can result in periodic low flows during the summer months in Segment 15 near the city of Fort Lupton.

Figure 4-6. Segment 15 low flow conditions near Fort Lupton (*Reach 3*)

For the Brantner and Brighton diversions, the impact of flow management is less pronounced during the months of November through February and is most significant in September and October. Figure 4-7 summarizes effects of water management at the Fulton, Brantner, and Brighton diversions on flow in Segment 15. The flow data (2000-2011) were obtained from the U.S. Geological Survey and Colorado Division of Water Resources.

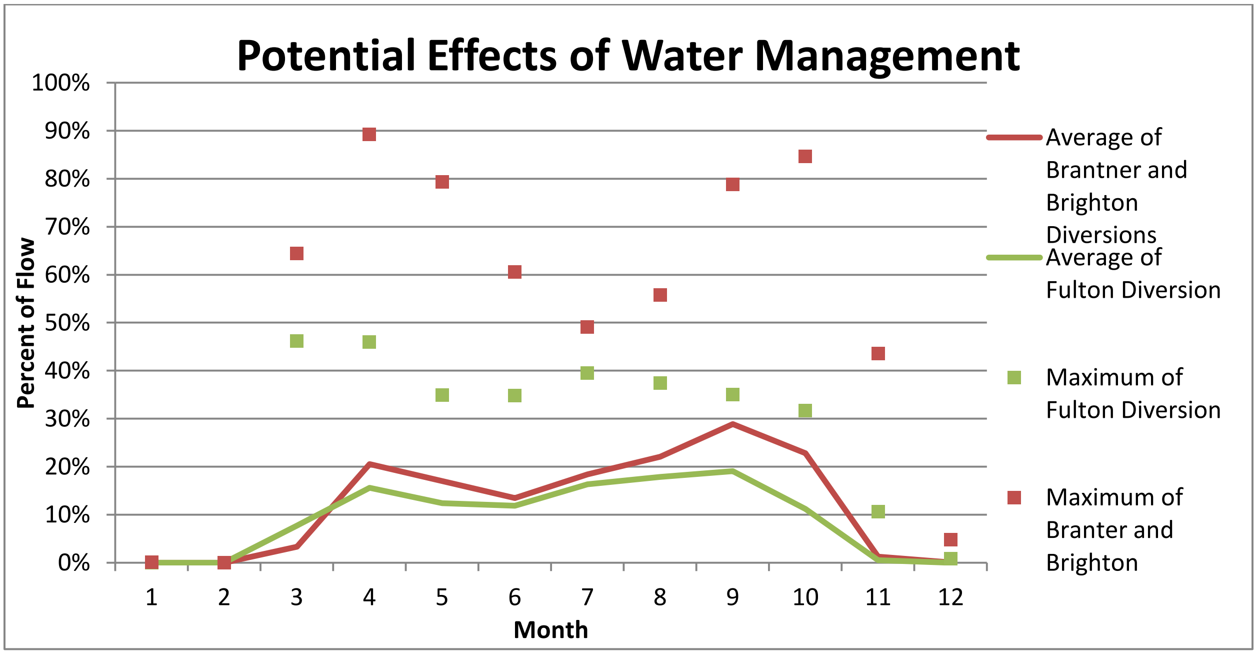

Figure 4-7. Percentage of flow removed by the Fulton, Brighton, and Brantner (combined) diversions. The data are summarized from publicly available flow records from 2000-2011.

<u>Tributaries</u>: While diversions can lower *E. coli* loads by removing water from Segment 15, *E. coli* can enter through tributaries. Table 4-3 below summarizes *E. coli* contributions from tributaries to Segment 15. Note that in addition, there is a significant background *E. coli* load entering Segment 15 from Segment 14, immediately upstream (WQCD, 2007).

Year	Assessment Period	Tributaries to Segment 15					
		Humble Creek Reach 1	**Sand Creek** Reach 2	**Clear Creek** Reach 2	**Niver Creek** Reach 2	**Bull Seep** Reach 2	**Big Dry Creek** Reach 3
		(CFU/100 mL)					
2006	Jan/Feb		75(4)	82(4)			40(4)
2006	Mar/Apr		43(4)	51(4)			51(4)
2006	May/Jun		189(4)	114(4)			246(4)
2006	Jul/Aug		349(4)	179(4)			297(4)
2006	Sep/Oct		439(4)	55(4)			485(4)
2006	Nov/Dec		67(4)	2400(4)			82(4)
2007	Jan/Feb		112(4)	115(4)			55(4)
2007	Mar/Apr		146(4)	48(4)			65(4)
2007	May/Jun		460(4)	153(4)			325(4)
2007	Jul/Aug		658(4)	163(4)			327(4)
2007	Sep/Oct		466(4)	196(4)			226(4)
2007	Nov/Dec		163(4)	68(4)			110(4)
2008	Jan/Feb		179(4)	80(4)			31(4)
2008	Mar/Apr		46(4)	60(4)			48(4)
2008	May/Jun		384(4)	761(4)			553(4)
2008	Jul/Aug		614(4)	103(4)			400(4)
2008	Sep/Oct		235(4)	96(4)			250(4)
2008	Nov/Dec		200(4)	236(4)			86(4)
2009	Jan/Feb		82(4)	22(4)			20(4)
2009	Mar/Apr		91(4)	64(4)			51(4)
2009	May/Jun		378(4)	169(4)			538(4)
2009	Jul/Aug		598(4)	275(4)			254(4)
2009	Sep/Oct		773(4)	316(4)			148(4)
2009	Nov/Dec		76(4)	426(4)			61(4)
2010	Jan/Feb		143(4)	38(4)			26(4)
2010	Mar/Apr		141(4)	35(4)			61(4)
2010	May/Jun	980(3)	645(4)	148(4)	313(3)		292(4)
2010	Jul/Aug	284(4)	796(4)	579(4)	1042(4)		373(4)
2010	Sep/Oct	81(4)	563(4)	89(4)	276(4)		137(4)
2010	Nov/Dec	10(4)	406(4)	175(4)	309(4)		90(4)
2011	Jan/Feb	18(4)	164(4)	77(4)	97(4)	36(3)	66(4)
2011	Mar/Apr	56(4)	79(4)	19(4)	34(4)	28(4)	139(4)
2011	May/Jun	307(4)	542(4)	303(4)	323(4)	109(4)	328(4)
2011	Jul/Aug	711(4)	297(4)	246(4)	702(4)	145(4)	512(4)
2011	Sep/Oct	254(4)	409(4)	313(4)	353(4)	234(4)	329(4)
2011	Nov/Dec	18(4)	132(4)	71(4)	45(4)	26(4)	125(4)

Table 4-3. Two month geometric mean assessment of available tributary weekly (2010-2011) and bi-weekly (2006-2009) *E. Coli* data. Blank values indicate that no data was available. Red text indicates values above the standard, red highlighting indicates values that are more than 2 times the standard. The number of samples (n) used to calculate the geometric means is shown in parentheses to the right of the geometric mean value.

<u>Discharge from the Robert W. Hite Treatment Facility</u>: The RWHTF is the largest discharger in the state of Colorado, providing advanced wastewater treatment for much of the urban Denver metropolitan area. Due to its location downstream of the Burlington Ditch diversion, effluent discharged from the RWHTF comprises much of the water in the segment. In fact, Segment 15 is considered to be "effluent dominated" as described in Regulation No. 31:

> "EFFLUENT-DOMINATED STREAM" means a stream that would be intermittent or perennial without the presence of wastewater effluent whose flow for the majority of the time is primarily attributable to the discharge of treated water (i.e., greater than 50 percent of the flow consists of treated wastewater for at least 183 days annually, for eight out of the last ten years).

Figures 4-8 and 4-9 below demonstrates this condition for Segment 15 in the vicinity of the RWHTF.

Figure 4-8. Segment 15 upstream of the RWHTF (*Reach 1*)

Figure 4-9. Segment 15 downstream of the RWHTF (*Reach 2*)

4.4 *E. coli* 2-month Geometric Mean Data Analysis – Entirety of Segment 15

Two-month *E. coli* geometric means were calculated to evaluate spatial and temporal trends along Segment 15 in accordance with the *E. coli* water quality standard. Exceedances of the 126 CFU/100 mL standard were found at all monitoring locations throughout the year. These data are shown in Table 4-4.

Year	Assessment Period	Monitoring Sites								
		SP-BC *Reach 1*	**SP-64** *Reach 1*	**SP-CC** *Reach 2*	**SP-78** *Reach 2*	**SP-88** *Reach 2*	**SP-104** *Reach 2*	**SP-124** *Reach 2*	**SP-160** *Reach 3*	**SP-RD8** *Reach 3*
		(CFU/100 mL)								
2006	Jan/Feb	194	388(4)	144(4)	97(4)	58(4)	54(4)	136(4)	25(4)	26(4)
	Mar/Apr	217	408(4)	54(4)	33(4)	42(4)	61(4)	102(4)	61(4)	45(4)
	May/Jun	169	214(4)	138(4)	213(4)	136(4)	128(4)	76(4)	78(4)	91(4)
	Jul/Aug	670	659(4)	394(4)	436(4)	367(4)	392(4)	296(4)	298(4)	273(4)
	Sep/Oct	565	288(4)	250(4)	281(4)	172(4)	204(4)	277(4)	174(4)	221(4)
	Nov/Dec	229	186(4)	109(4)	1173(4)	624(4)	301(4)	344(4)	144(4)	90(4)
2007	Jan/Feb	245	453(4)	228(4)	210(4)	151(4)	137(4)	186(4)	145(4)	91(4)
	Mar/Apr	265	101(4)	67(4)	62(4)	52(4)	40(4)	72(4)	39(4)	31(4)
	May/Jun	366	217(4)	152(4)	173(4)	176(4)	116(4)	128(4)	118(4)	100(4)
	Jul/Aug	474	439(4)	439(4)	646(4)	575(4)	545(4)	455(4)	414(4)	402(4)
	Sep/Oct	575	119(4)	226(4)	228(4)	182(4)	187(4)	114(4)	190(4)	172(4)
	Nov/Dec	158	252(4)	354(4)	223(4)	217(4)	109(4)	76(4)	60(4)	41(4)
2008	Jan/Feb	205	468(4)	930(4)	698(4)	341(4)	153(4)	111(4)	82(4)	67(4)
	Mar/Apr	99	49(4)	263(4)	107(4)	59(4)	31(4)	25(4)	28(4)	20(4)
	May/Jun	398	782(4)	667(4)	968(4)	804(4)	538(4)	263(4)	236(4)	223(4)
	Jul/Aug	579	410(4)	498(4)	495(4)	420(4)	330(4)	428(4)	390(4)	394(4)
	Sep/Oct	436	99(4)	161(4)	363(4)	215(4)	139(4)	111(4)	113(4)	78(4)
	Nov/Dec	412	370(4)	437(4)	370(4)	412(4)	264(4)	120(4)	55(4)	62(4)
2009	Jan/Feb	215	132(4)	125(4)	304(4)	155(4)	101(4)	39(4)	29(4)	27(4)
	Mar/Apr	81	64(4)	28(4)	51(4)	39(4)	39(4)	30(4)	26(4)	18(4)
	May/Jun	270	342(4)	466(4)	526(4)	554(4)	303(4)	191(4)	137(4)	146(4)
	Jul/Aug	1038	713(4)	489(4)	392(4)	326(4)	256(4)	243(4)	236(4)	155(4)
	Sep/Oct	313	539(4)	443(4)	300(4)	298(4)	150(4)	152(4)	77(4)	106(4)
	Nov/Dec	125	360(4)	107(4)	197(4)	100(4)	125(4)	92(4)		50(4)
2010	Jan/Feb	223	451(4)	260(4)	231(4)	199(4)	54(4)	35(4)		18(4)
	Mar/Apr	100	111(4)	84(4)	67(4)	54(4)	46(4)	16(4)	5(4)	13(4)
	May/Jun	240	163(4)	297(4)	198(4)	131(4)	124(4)	130(4)	72(4)	87(4)
	Jul/Aug	427	1041(4)	830(4)	889(4)	943(4)	916(4)	760(4)	782(4)	510(4)
	Sep/Oct	686	211(4)	98(4)	124(4)	124(4)	103(4)	140(4)	100(4)	62(4)
	Nov/Dec	361	963(4)	216(4)	230(4)	217(4)	150(4)	205(4)	106(4)	97(4)
2011	Jan/Feb	317	691(4)	404(4)	491(4)	153(4)	142(4)	65(4)	50(4)	24(4)
	Mar/Apr	167	89(4)	40(4)	26(4)	37(4)	25(4)	33(4)	15(4)	29(4)
	May/Jun	235	328(4)	68(4)	62(4)	191(4)	63(4)	193(4)	53(4)	140(4)
	Jul/Aug		693(4)	370(4)	491(4)	412(4)	259(4)	189(4)	244(4)	251(4)
	Sep/Oct		253(4)	765(4)	547(4)	445(4)	166(4)	206(4)	113(4)	132(4)
	Nov/Dec		428(4)	544(4)	395(4)	164(4)	258(4)	141(4)	76(4)	43(4)

Table 4-4. Two month geometric mean assessment of available Segment 15 weekly (2010-2011) and bi-weekly (2006-2009) *E. Coli* data. Blank values indicate that no data were available. Red text indicates values above the standard, red highlighting indicates values that are more than 2 times the standard.

The data presented in Table 4-4 are extensive and complex to evaluate, e.g., deciphering patterns throughout the entire segment is difficult. For example, values that exceed the *E. coli* standard are more common at the beginning of the segment, but occur less frequently farther downstream. However, if values are high at the beginning of the segment during summer months, all reaches may show impairment. So, there is a seasonal component that must be examined. According to research conducted at the University of Colorado at Boulder, *E. coli* concentrations vary along the segment, but there is no evidence that *E. coli* either die off or reproduce significantly in the aquatic environment; unexpectedly high values are probably caused by local conditions such as waterfowl (Appendix B. Lewis and McCutchan, 2011).

One way to look at the *E. coli* data is to examine concentrations using a longitudinal perspective along the segment. The box plot shown in Figure 4-10 below illustrates the mean (dotted line in each box), median (solid line), 25th and 75th percentiles (box edges), and outliers of the geometric means of *E. coli* concentrations at each Segment 15 monitoring site.

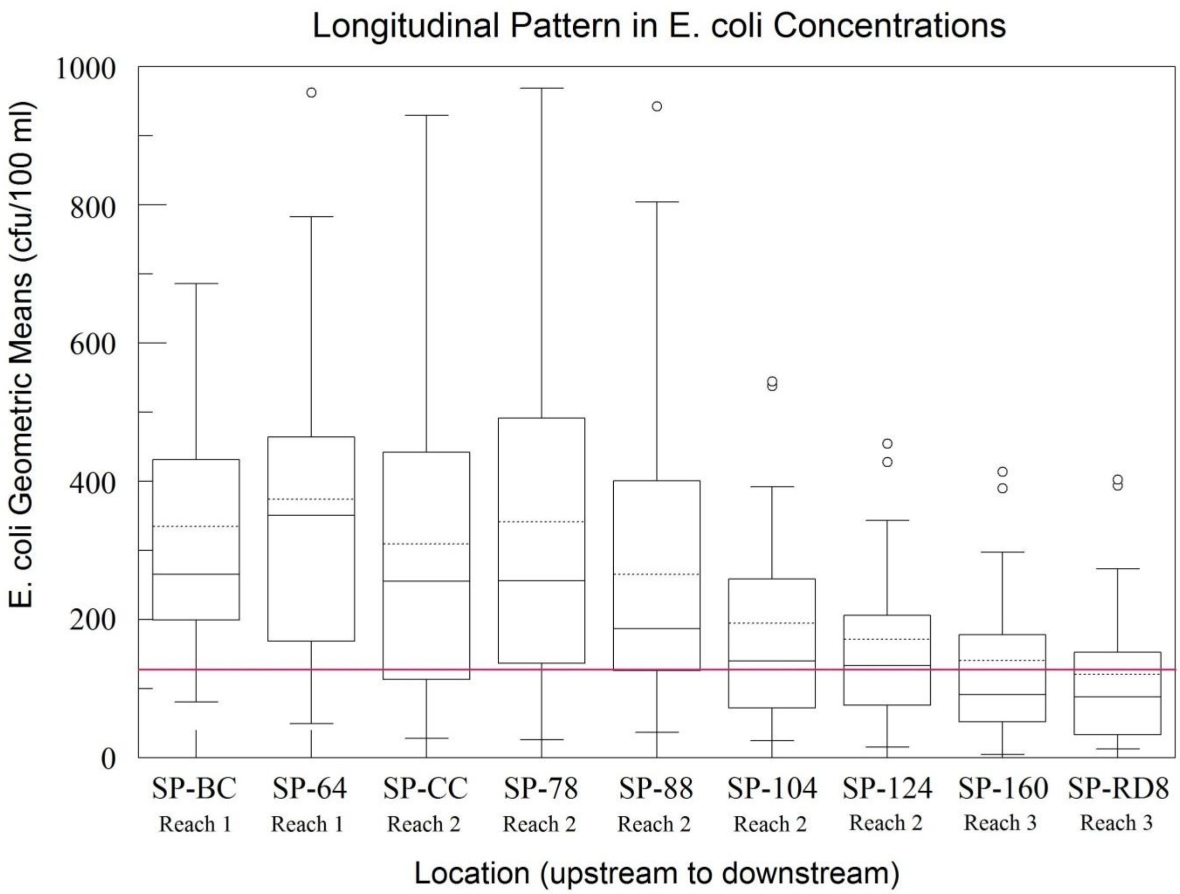

Figure 4-10. Box plot of Segment 15 longitudinal patterns using geometric means of *E. coli* concentrations. The *E. coli* standard is shown as a horizontal red line at 126 cfu/100 mL.

Although statistically relevant differences cannot be derived from these data, the graphic is helpful in that it shows the trends in *E. coli* concentrations from the beginning to the end of the segment. In the uppermost reach of the segment (*Reach 1*, represented by monitoring site SP-

64), the mean and median *E. coli* concentrations are relatively high. From SP-64 to SP-124 (*Reach 2*, represented by monitoring site SP-124), concentrations generally reflect urban-related impacts as well as dilution associated with treated effluent from municipal wastewater treatment facilities. Below SP-124 (*Reach 3*, represented by monitoring site SP-RD8), *E. coli* concentrations improve and the median concentrations are often below the standard.

E. coli seasonal patterns also can be seen throughout Segment 15, as shown in Figure 4-11 below.

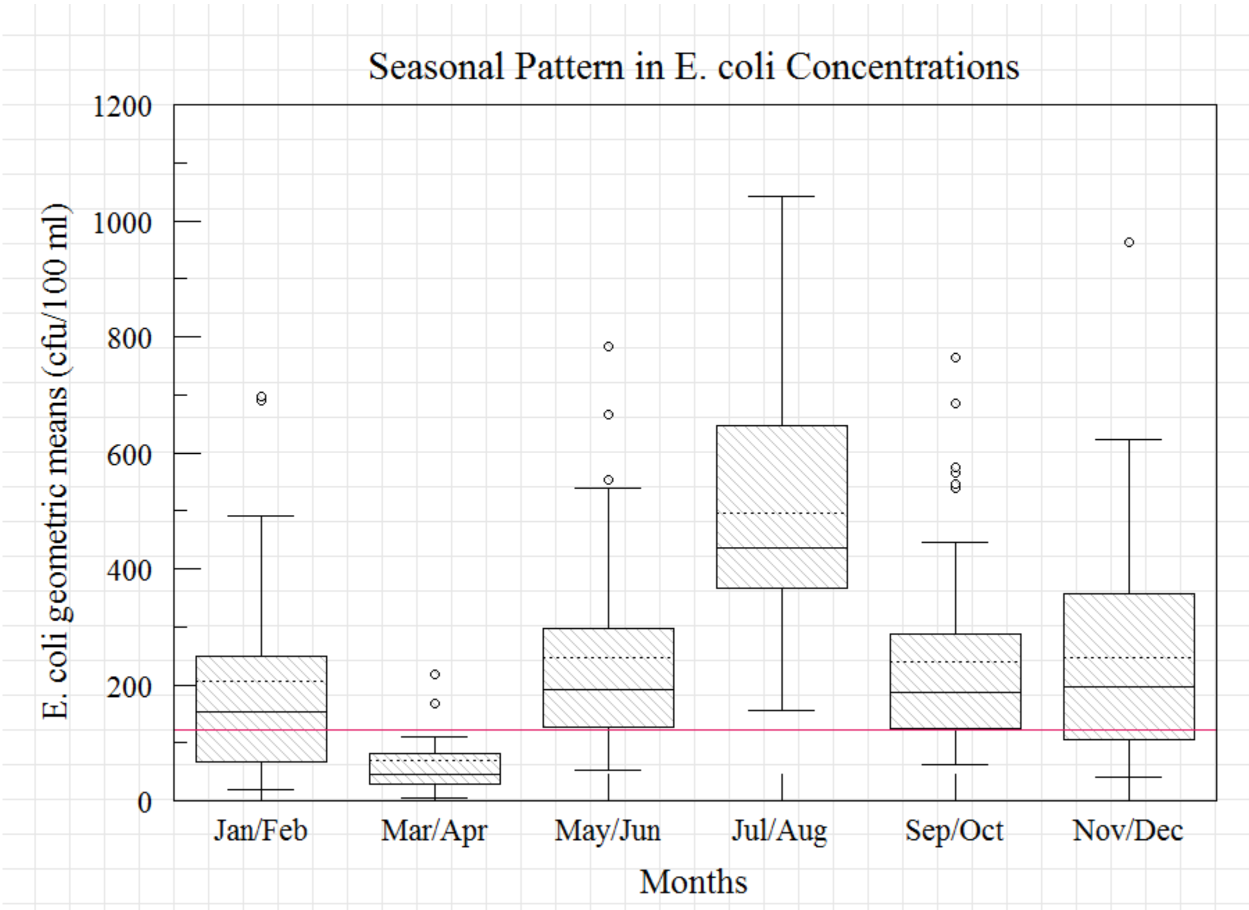

Figure 4-11. Box plot of the seasonal pattern in geometric means of *E. coli* concentrations throughout Segment 15. The standard is shown as a horizontal red line at 126 CFU/100 mL.

In this graph, geometric means from all sites are combined; and although the pattern is not statistically significant, it does show overall seasonal trends of *E. coli* concentrations throughout Segment 15. Generally, the time of year when *E. coli* concentrations are lowest is spring (March and April), which is assumed to be explained by the dilution effects of snowmelt from the mountains.

The summer months of July and August show the highest *E. coli* concentrations, possibly reflecting flow conditions associated with summertime thunderstorms and resulting diffuse runoff into the segment.

As shown in Table 4-5 below, the months of July and August have the highest average maximum precipitation. This is not surprising in that thunderstorms, which are a major source of extreme precipitation events, tend to occur in these summer months.

Month	Average Maximum Precipitation (tenths of a mm)	Average Days of Rain
January	63.9	3.5
February	72.0	4.9
March	164.1	5.7
April	256.0	10.0
May	225.7	9.5
June	180.4	7.6
July	265.7	8.8
August	300.3	8.0
September	109.0	6.1
October	158.7	7.2
November	93.4	5.4
December	130.3	5.6

Source: National Oceanic and Atmospheric Administration data (2003-2012), Denver, Colorado precipitation station (Lat: 39.7401, Long: -104.9874)

Table 4-5. Summary of Denver annual precipitation

5. Segment 15 *E. coli* Reaches and Assessment Locations

Due to the unique watershed characteristics associated with Segment 15 as they relate to the sources and effects on in-stream concentrations of *E. coli* discussed in section 4.4 above, for purposes of this TMDL the segment has been divided into three reaches for data evaluation and load/wasteload allocation development. These three reaches capture the varying sources of *E. coli* seen longitudinally along the segment as well as the influences of varying land uses, water management activities, tributary impacts, and point and non-point source loadings to the South Platte mainstem.

In addition, with respect to ultimate source control strategies, this approach allows better identification of possible reach-specific management options so that the *E. coli* standard eventually can be attained.

The assessment location concept has been utilized by the Water Quality Control Division when changes in water quality can be identified clearly but actual re-segmentation is not appropriate, typically because of spatial and temporal variability. Table 5-1 summarizes the Segment 15 *E. coli* reaches and assessment locations for the TMDL.

Reach Number	Reach Description	Reach Assessment Location	Reach Length (river miles)
1	From the Burlington Ditch diversion to 64th Avenue	At 64th Avenue (SP-64)	1.7
2	From 64th Avenue to 124th Avenue	At 124th Avenue (SP-124)	11.31
3	From 124th Avenue to confluence with Big Dry Creek	At Weld County Road 8 (SP-RD8)	13.15

Table 5-1. Segment 15 *E. coli* reaches and assessment locations

5.1 *Reach 1* TMDL Assessment Location – 64th Avenue

This is the uppermost section of Segment 15 and is characterized by dewatering of the River due to the Burlington Ditch diversion. The reach is short in length, approximately 1.7 miles. The river is channelized in this reach and the 100-year flood is largely confined to the channel. A variety of infrastructure features are present, including Metro District interceptors, and several grade control structures that cross the river channel.

Due to the channel morphology in this reach, scour potential is high. There is moderate terrestrial vegetation cover, but little or no aquatic vegetation. Substrate material consists of primarily sands, gravels, and cobbles. Channel banks are largely stabilized with vegetated riprap and rubble.

The identified assessment location for *Reach 1* is the 64th Avenue sampling site, which is upstream of the RWHTF. Based on this location and the predominant influence of upstream water quality (background conditions) with respect to *E. coli*, this site is a practical selection to represent this reach.

5.2 *Reach 2* TMDL Assessment Location – 124th Avenue

This middle section of Segment 15 is influenced by the discharge from the RWHTF and South Adams County Water and Sanitation District's Williams-Monaco Wastewater Treatment Plant, resulting in an effluent-dominated condition with respect to flow. Figure 5-1 is an aerial view of the RWHTF discharge location.

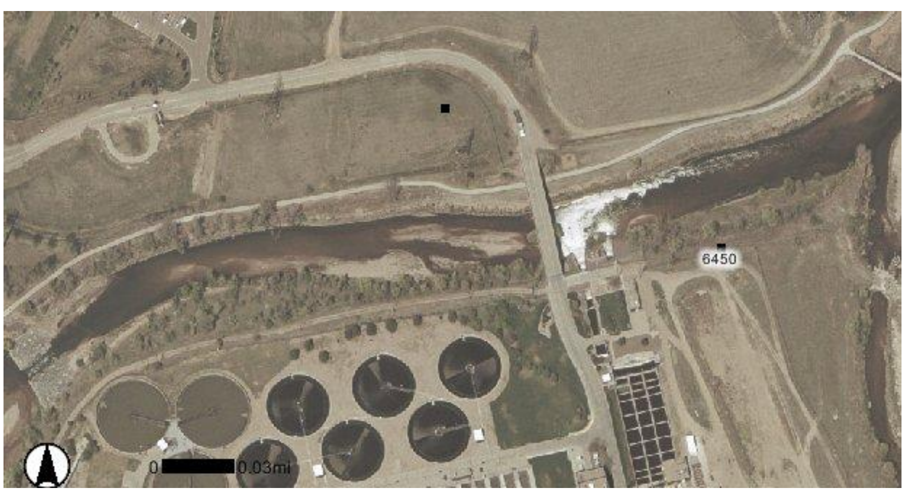

Figure 5-1. Discharge from the RWHTF in Reach 2

However, there are a number of tributaries located within the reach, including Sand Creek, Clear Creek, Niver Creek, and Bull Seep. Extensive sand and gravel mining activities have occurred in some downstream areas of the reach.

The river becomes less channelized through this reach but includes grade control structures and crossings from major highways. In recent years, efforts have been undertaken to re-vegetate channel banks in portions of the reach. However, a tamarisk/salt cedar infestation has been identified. Substrate is primarily sand and gravel. The identified assessment location for *Reach 2* is the 124th Avenue sampling site, which is representative of the impacts seen throughout this portion of Segment 15.

5.3 *Reach 3* TMDL Assessment Location – Road 8

This lowermost portion of Segment 15 is bounded by more open space land uses, including the Adams County Regional Park and the Riverdale Dunes Golf Course. Agricultural uses also become more predominant. Substrate is composed mainly of sand with small amounts of gravel.

The discharge from the Brighton Wastewater Treatment Facility is the located in *Reach 3*. Diversions from the Brighton Ditch and Lupton Bottoms Ditch can influence flow in the segment, e.g., during drought, the reach can experience periodic low flows. In addition, the Northern Treatment Plant, located immediately downstream of 168th Avenue is expected to be operational in 2016, with a design capacity of 28.8 MGD. The identified assessment location for *Reach 3* is the Weld County Road 8 sampling site.

5.4 Streamflow Characteristics of Segment 15 Reaches

Each of the three assessment locations are co-located with existing stream flow gages. These stations have been continuously operating since before the commencement of biweekly *E. coli* monitoring. They provide additional benefit as an assessment location, as *E. coli* loads are easily and accurately calculated with actual stream flow data, rather than estimated or calculated flows. Figure 5.2 displays the seasonal hydrograph at each assessment location. The effects of the dewatering of the River due to the Burlington Ditch diversion, as well as the effects of additions from facilities and tributaries can clearly be seen in the difference between the flows at SP-64 and SP-124.

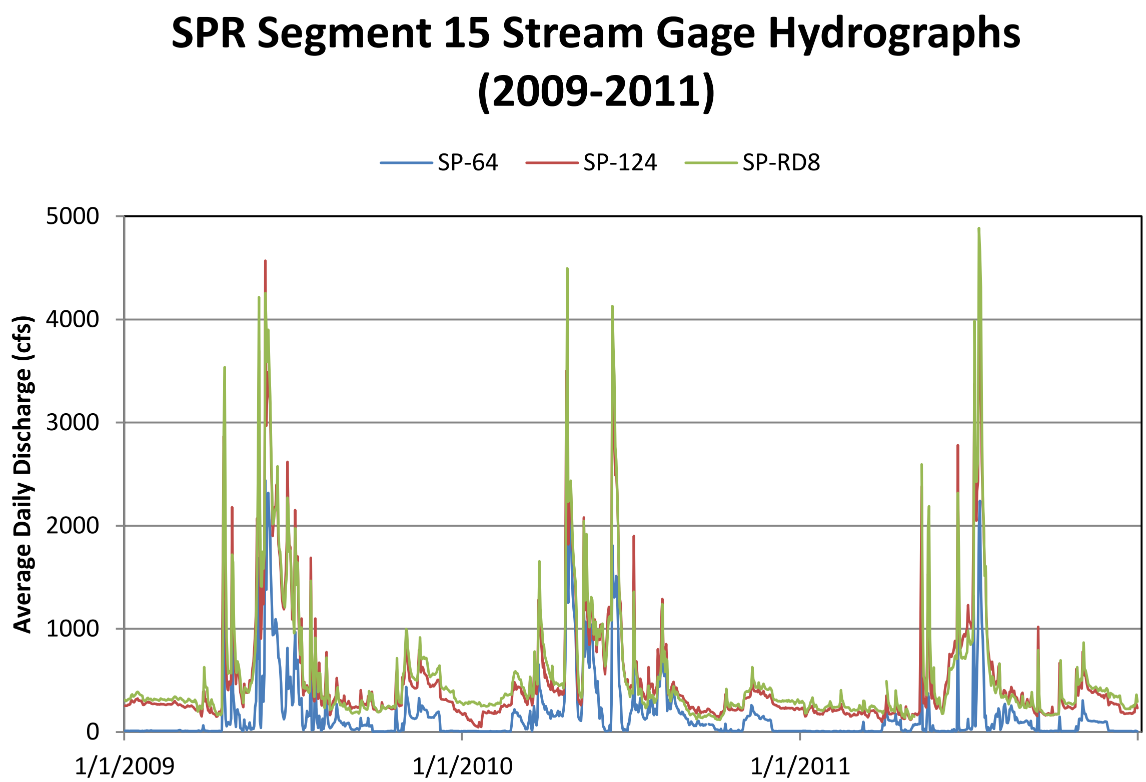

Figure 5-2. Seasonal hydrographs at three assessment locations (2009-2011)

6. Segment 15 *E. coli* Source Assessment and Evaluation

The purpose of the source assessment is to identify and quantify sources of *E. coli* within each reach of Segment 15. Bacteria such as *E. coli* can enter surface waters from both point and non-point sources. Point sources include permitted pipes, outfalls, and conveyance channels such as municipal wastewater treatment facilities, industrial facilities, and municipal separate storm sewer systems (MS4s). Not all point sources are permitted. In fact, a number of unpermitted point sources have been identified throughout Segment 15, discussed below.

In terms of TMDL development, regulated point sources, specifically domestic wastewater treatment facilities and one industrial facility (Xcel's Cherokee facility), receive wasteload allocations to achieve the underlying *E. coli* water quality standard. From a permit implementation standpoint, those wasteload allocations are based on the existing *E. coli* standard of 126 CFU per 100 mL.

Several MS4s are located within the study area, e.g., Denver, Brighton, Commerce City, and Adams County. However, because their permitted discharge points are almost exclusively to tributaries and not to the South Platte mainstem, most MS4 stormwater contributions to the mainstem are implicitly included in load allocations rather than given specific MS4 wasteload allocations for the purposes of this TMDL. The only stormwater outfalls that are assigned a wasteload allocation are the five permitted City of Denver outfalls located in the upstream portion of Reach 1. This is discussed in more detail in sections 6.1, 6.2 and 6.3.

Non-point sources are diffuse sources that have multiple routes of entry into surface waters. Such sources, including diffuse storm event runoff, agricultural inputs, wildlife, and background loads from tributaries and upstream segments receive load allocations in the TMDL. Potentially uncharacterized point sources are included in this category.

Identified point sources and non-point sources of *E. coli* for each of the three identified Segment 15 reaches are summarized in the following sections.

6.1 *Reach 1* Source Assessment

Permitted Point Sources:

While the majority of the City of Denver MS4 outfalls discharge to Segment 14, there are five individual outfalls located in the uppermost portion of Segment 15 (Figure 6-1). The Segment 14 *E. coli* TMDL accounts for all the Denver MS4 outfalls above Segment 15, but the five outfalls are treated as a permitted source and given a wasteload allocation in this TMDL. While there is a lack of actual data concerning flow and *E. coli* concentrations from these outfalls, their percent contribution is allocated based on load estimates adopted in the Barr Milton pH TMDL. Based on their modelling efforts, it is estimated that these outfalls contribute 1.2% of the load coming from Reach 1. The remainder of the E. coli loading to Reach 1 from the Denver MS4 system is considered part of the upstream background load, discussed below.

Figure 6-1. Locations of Denver MS4 outfalls in *Reach 1*

The Xcel Energy Cherokee electric generating facility (Colorado Discharge Permit System (CDPS) permit number CO-0001104) is the sole regulated point source discharger within *Reach 1*. This facility currently has a "Report Only" requirement in its discharge permit for *E. coli*. Monitoring data from this facility, shown in Table 6-1, indicate that concentrations of *E. coli* are well below the stream standard.

Date	*E.coli* (CFU/100 mL)
07/08/09	12
07/08/09	7.2
11/04/09	4.1
01/06/10	1
04/01/10	16
07/07/10	10
10/01/10	1.0

Table 6-1. *E.coli* monitoring data from the Xcel Energy Cherokee Facility

Upstream Background Load: Upstream of Segment 15, the South Platte River watershed consists of a large urban corridor through the Denver metropolitan area. Segment 14 is the segment immediately upstream of *Reach 1* and has an approved *E. coli* TMDL. Once that TMDL is fully implemented, upstream background *E. coli* standards should be met at the beginning of *Reach 1*. Loads are assigned to all sources. Although reductions aren't always necessary for all loads, because implementation of the Segment 15 TMDL has not yet been completed, a reduction is necessary to meet the load allocation from this upstream source.

Unidentified Point Sources:

There are numerous culverts and pipes located within Reach 1, associated with bridges, roadways, and other structures commonly found in heavily urbanized areas. Figure 6-2 shows an example of culverts seen along Reach 1.

Figure 6-2. Culvert located on east bank of *Reach 1* showing dry weather flow

Tributary: As shown previously in Table 4-3, Humble Creek can contribute *E. coli* loads to *Reach 1* as it enters Segment 15. Efforts to identify the source(s) of flow in Humble Creek have been unsuccessful.

6.2 Reach 2 Source Assessment

Permitted Point Sources: There are two publicly owned treatment works located in *Reach 2*: the RWHTF (CDPS permit number CO-0026638) and South Adams County Water and Sanitation District (CDPS permit number CO-0026662). *E. coli* effluent limitations for the RWHTF are shown in Table 6-2.

Effluent Parameter	Effluent Limitation Maximum Concentration	
	30-Day Average	7-Day Average
E. coli (#/100 mL)	126	252

Table 6-2. RWHTF *E. coli* effluent limitations

E. coli effluent limitations for South Adams County Water and Sanitation District are shown in Table 6-3.

Effluent Parameter	Effluent Limitation Maximum Concentration	
	30-Day Average	7-Day Average
E. coli (#/100 mL)	126	252

Table 6-3. South Adams County Water and Sanitation District *E. coli* effluent limitations

One industrial facility, Speer Mining Resource, Asphalt Specialties, does not have an *E. coli* effluent limitation in its discharge permit, indicating there is no reasonable potential for this facility to contribute to *E. coli* loading within this reach.

MS4s: According to the Water Quality Control Division's general MS4 permit number COR090000, the City of Brighton, Adams County, and Commerce City have certifications. However, the designated receiving waters are not the South Platte mainstem, but are tributaries, as shown in Table 6-4. Accordingly, these MS4s do not receive a specific wasteload allocation for purposes of this TMDL.

Entity	Permit #	ECHO Database Receiving Water / Segment	CDPS Database Immediate Waters	CDPS Database Receiving Waters
City of Brighton	COR090089	Third Creek to South Platte River	Third Creek	COSPUS16e[1]
Commerce City	COR090032	Sand Creek to South Platte River	Sand Creek	COSPUS16a[2]
Adams County	COR090041	Unnamed Tributary to Big Dry Creek	Unnamed Tributary	Big Dry Creek COSPBD01[3]

		COSPBD01		

[1] COSPUS16e is "Third Creek from the source to the O'Brien Canal" in Regulation No. 38 (5 CCR 1002-18)
[2] COSPUS16a is "Mainstem of Sand Creek from the confluence of Murphy and Coal Creek in Arapahoe County to the confluence with the South Platte River" in Regulation No. 38 (5 CCR 1002-18)
[3] COSPBD01 is "Mainstem of Big Dry Creek, including all tributaries and wetlands, from the source to the confluence with the South Platte River, except for specific listing in Segments 4a, 4b, 5 and 6" in Regulation No. 38 (5 CCR 1002-18)

Table 6-4. MS4s located within *Reach 2* area

Tributaries: A number of tributaries are located in *Reach 2*, including Sand Creek, Clear Creek, Niver Creek, and Bull Seep. *E. coli* contribution data were shown in Table 4-3 above.

Agricultural Operations: A number of agricultural facilities are located within *Reach 2* of Segment 15 that may be contributing to *E. coli* in the South Platte. For example, at least one dairy farm is operating adjacent to the river and cows are commonly seen along the banks of the South Platte. These facilities are not permitted point sources and therefore are included as part the load allocation.

6.3 *Reach 3* Source Assessment

Permitted Point Source: *E. coli* effluent limitations for the Brighton Wastewater Treatment Facility, CDPS permit number CO-0021547, are shown in Table 6-5.

Effluent Parameter	Effluent Limitation Maximum Concentration	
	30-Day Average	7-Day Average
E. coli (#/100 mL)	126	252

Table 6-5. City of Brighton *E. coli* effluent limitations

Starting in 2016, the Northern Treatment Plant, located immediately downstream of 168th Avenue will also discharge treated wastewater into Reach 3. As part of the permit, the Northern Treatment Plant will be required to meet the following concentration-based *E. coli* effluent limits:

Effluent Parameter	Effluent Limitation Maximum Concentration	
	30-Day Average	7-Day Average
E. coli (#/100 mL)	126	252

Table 6-6. Anticipated Northern Treatment Plant *E. coli* effluent limitations

For the purposes of this TMDL, the Northern Treatment Plant wasteload allocation is set based on design capacity (28.8 MGD). The flows at the RWHTF are correspondingly reduced by 28.8 MGD in this TMDL, as the Northern Treatment Plant will receive influent that would otherwise go to the RWHTF.

MS4s: According to the Water Quality Control Division's general MS4 permit number COR090000, Adams County and Brighton have certifications. However, the designated receiving waters are not the South Platte, as shown in Table 6-6. Accordingly, these MS4s do not receive specific wasteload allocations for purposes of this TMDL. For example, only several outfalls (Brighton's North Outfall at Denver Street alignment, South Outfall at Southern Street, and North Augmentation Outfall at Baseline Road) in Brighton have discharge points located near the South Platte mainstem.

Entity	Permit #	ECHO Database Receiving water/Segment	CDPS Database Immediate Waters	CDPS Database Receiving Waters
Adams County	COR090041	Unnamed Tributary to Big Dry Creek COSPBD01	Unnamed Tributary	Big Dry Creek COSPBD01[1]
City of Brighton	COR090089	Third Creek to South Platte River	Third Creek	COSPUS16e[2]

[1] COSPBD01 is "Mainstem of Big Dry Creek, including all tributaries and wetlands, from the source to the confluence with the South Platte River, except for specific listing in Segments 4a, 4b, 5 and 6" in Regulation No. 38 (5 CCR 1002-18)
[2] COSPUS16e is "Third Creek from the source to the O'Brien Canal" in Regulation No. 38 (5 CCR 1002-18)

Table 6-7. MS4s located within *Reach 3* area

Tributary: Segment 15 is defined in *Regulation 38, Classification and Numeric Standards, South Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin* (5 CCR 1002-38) as the mainstem of the South Platte River from the Burlington Ditch diversion in Denver, Colorado, to a point immediately below the confluence with Big Dry Creek. Big Dry Creek only impacts a small point of Segment 15 immediately at the confluence, but since the boundary is just below the confluence, it is still considered contributor to Segment 15 of the South Platte River. However, Bog Dry Creek is downstream of the Road 8 assessment point for Reach 3. Therefore it is not part of the load measured at Road 8. Big Dry Creek is more of a contributor to the segment downstream (COSPMS01) and will be considered in a TMDL for that segment. .

Agricultural Operations. There are numerous agricultural operations along *Reach 3*. These can include livestock and animal feeding operations as well as the use of manure as fertilizer. Such nonpoint sources can affect *E. coli* concentrations within *Reach 3*.

6.4. Other Potential Sources of *E. coli* in all Reaches

Within Segment 15, additional sources of bacteria can include failing septic systems, illegal dumping, unpermitted discharges from pipes, and/or the persistence and re-growth of *E. coli*. Because it is impracticable to quantify these individual sources, for this TMDL a combined load allocation is estimated for each of the three Segment 15 reaches.

The persistence and potential re-growth of *E. coli* may occur in natural environments (Ishii *et al*., 2005; Monroe, 2009; Garzio-Hadzick, 2010). Warmer temperatures and low flow conditions may exacerbate persistence of *E. coli*, which may be a significant source within the streambed during summer months. Thus, this can contribute to elevated *E. coli* concentrations on a seasonal basis.

Wildlife, particularly waterfowl, is prevalent throughout Segment 15. According to a 1993 survey of wintering waterfowl, an average of 7,040 birds were found on Segment 15 on any given day (Johnson, *et al*., 1993). During the survey nineteen species were observed including common and rare species. This high diversity of waterfowl is a desired component of the ecosystem of Segment 15. The dominant species included mallards, northern pintails, gadwalls, and northern shovelers. The authors noted that the species present depend on the channel morphology of Segment 15.

7. Linkage Analysis and Flow Duration Curve Methodology

The analysis of the relationship between *E. coli* loading from the identified point and non-point sources and the response of Segment 15 to this loading is referred to as the linkage analysis. The purpose of the linkage analysis is to quantify the maximum allowable *E. coli* loading that can be received by the segment and attain the *E. coli* water quality standard. This numeric value determines the TMDL. After the TMDL is calculated, it is allocated to point and non-point sources. For this *E. coli* TMDL, a linkage analysis has been performed and load and wasteload allocations have been determined for each of the three Segment 15 reaches.

Flow is an important technical component of the assimilative capacity for *E. coli* and, in systems that experience extreme seasonal fluctuations, it is important that the chosen analytical tool considers changing flow conditions. For this reason, the flow variable load capacities for the South Platte River were calculated with the development of load duration curves. Load duration curves are developed from flow duration curves and can illustrate existing water quality conditions (as represented by loads calculated from observed flow conditions and monitoring data), how these conditions compare to numeric targets, and the flow regime associated with existing loads. The methodology used to develop both flow and load duration curves is discussed below.

7.1 Flow Duration Curves

Flow duration curves are an important analytical tool used to evaluate historical flow conditions. According to EPA's *An Approach for Using Load Duration Curves in the Development of TMDLs* (EPA 841-B-07-006, August 2007):

> Flow duration curve analysis looks at the cumulative frequency of historic flow data over a specified period. A flow duration curve relates flow values to the percent of time those values have been met or exceeded. The use of "percent of time exceeded" 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 interval, or "percent of time exceeded", as in a cumulative frequency distribution. The y-axis represents the flow value (e.g. cubic feet per second) associated with that "percent of time exceeded" (or duration) . . .

Flow duration curves define intervals or groupings of flow conditions into a general indicator group. For example, the highest flow interval from 0-10% represents "high-flow" conditions, while the interval from 10-40 percent represents “moist conditions”, the interval from 40-60% represents “mid-ranges” , the interval from 60-90 percent represents “dry conditions” and the interval from 90-100 percent represents “low flow” conditions.

To develop flow duration curves, data were downloaded from both state and national long-term datasets. Two historical data sets are available within Segment 15: (1) a U.S. Geological Survey Gage (06714215) located at 64th Avenue in Commerce City, and (2) a Division of Water Resources Gage (PLAHENCO), located at 124th Avenue in Henderson. The availability of data at these locations supports the identification of SP-64 and SP-124 as appropriate assessment locations for this *E. coli* TMDL.

Daily average flow data was downloaded from these two sites (SP-64 and SP-124) from 2000-2010 to produce flow duration curves. These curves are presented in Figures 7-1 and 7-3 below. The flow duration curve graphs various flow conditions after ranking them according to size. Higher flows are grouped together under the high flow and moist condition categories and low flow conditions are grouped in the low flow and dry condition category. This allows for assessment of water quality to occur differently during different flow conditions. This is appropriate for *E. coli* because the concentrations of *E. coli* present in the River change dramatically under different flow conditions. Although daily average flows are used to produce the graph, median flow values are derived in each category and used for the remainder of the load duration curve analysis.

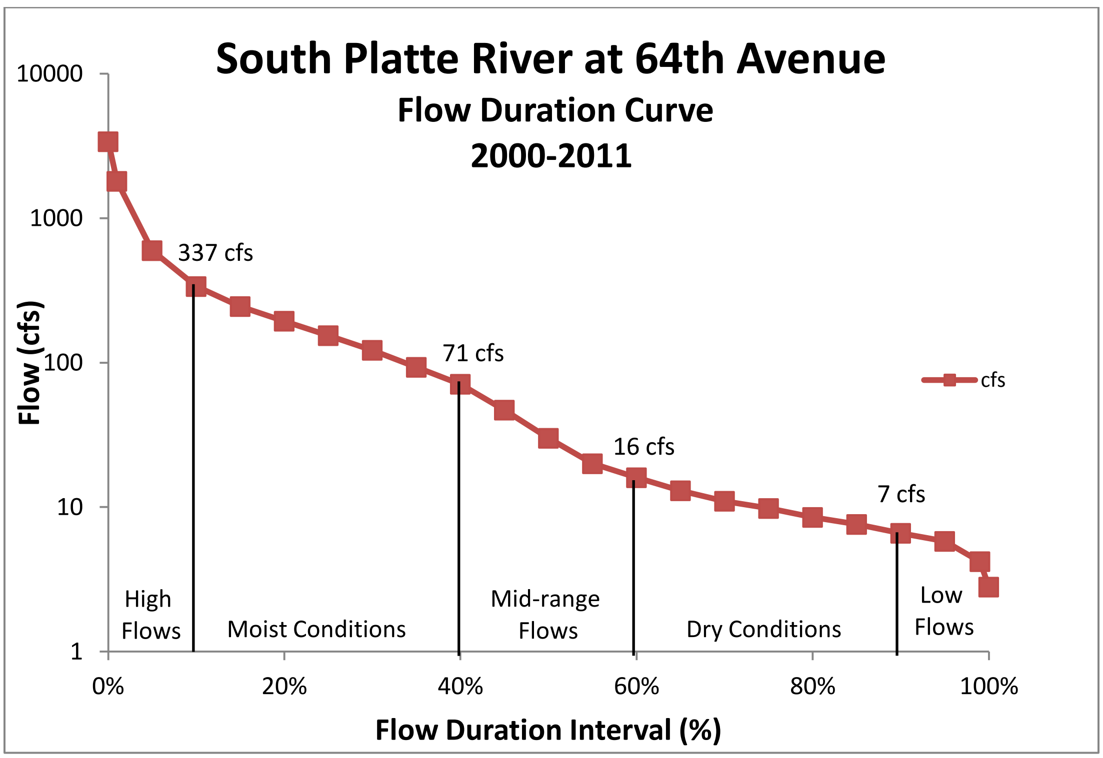

Figure 7-1. Flow duration curve for assessment location SP-64 (*Reach 1*)

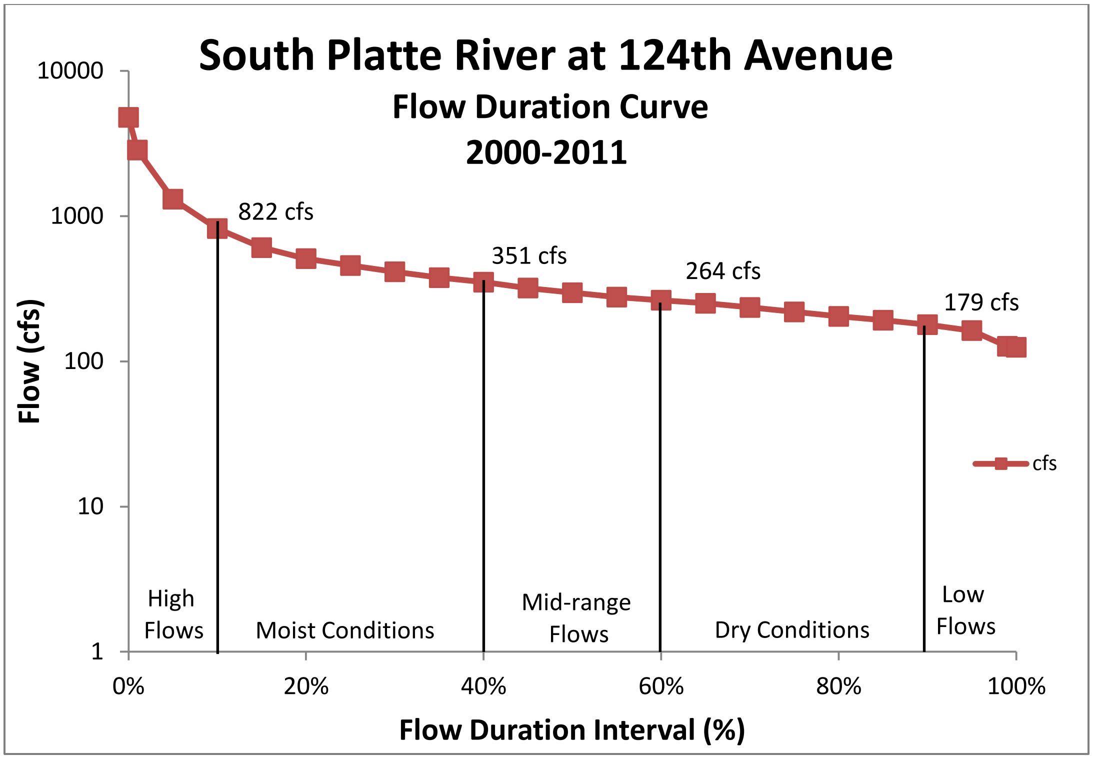

Figure 7-2. Flow duration curve for assessment location SP-124 (*Reach 2*)

Daily average flow values for the Road 8 site (RD8) were calculated using the following equation:

RD8 = PLAHENCO – DWR 810 + Brighton WWTP Flow + Ungaged Flow

The Brighton Ditch (DWR 810) removes water at approximately 160th Avenue. The Brighton Wastewater Treatment Plant contributes to the South Platte just below 160th Avenue. The ungaged flow term is derived from the South Platte Water Quality Model, which is used to develop municipal wastewater treatment discharge permit effluent limitations for facilities discharging to Segment 15. The calculated flow values, using this information, approximate conditions at Road 8.

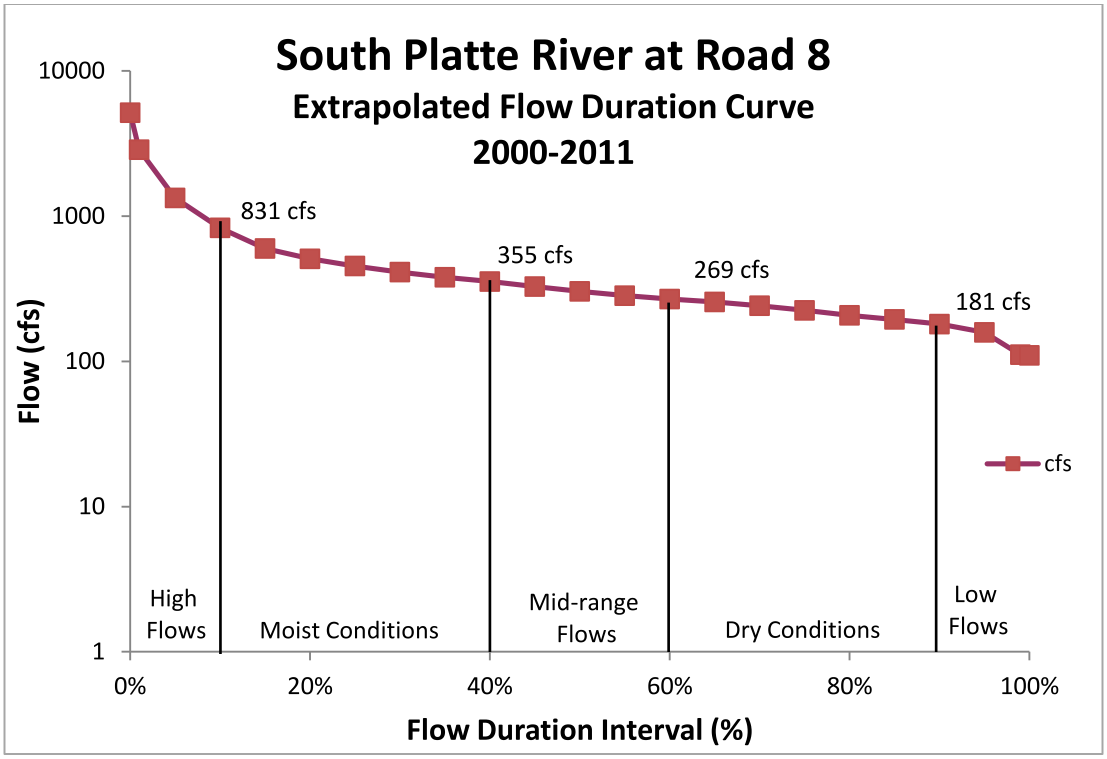

Figure 7-3. Extrapolated flow duration curve for the Segment 15 at Road 8 (*Reach 3*)

Significant variability exists among flow conditions and sites, with SP-64 having substantially lower flows than either SP-124 or SP-RD8. Flow range condition information for each assessment location is summarized in Table 7-1.

64th Avenue (*Reach 1*)

Flow Category	Flow range (cfs)	Median flow per category (cfs)	Percent of time flows equal or greater occur
High Flows	Greater than 337 cfs	597	Less than 10 percent
Moist Conditions	71 to 337 cfs	154	10 to 40 percent
Mid-Range Flows	16 to 71 cfs	30	40 to 60 percent
Dry Conditions	7 to 16 cfs	10	60 to 90 percent
Low Flows	Less than 7 cfs	6	90 to 100 percent

124th Avenue (*Reach 2*)

Flow Category	Flow range (cfs)	Median flow per category (cfs)	Percent of time flows equal or greater occur
High Flows	Greater than 822 cfs	1309	Less than 10 percent
Moist Conditions	351 to 822 cfs	457	10 to 40 percent
Mid-Range Flows	264 to 351 cfs	297	40 to 60 percent
Dry Conditions	179 to 264 cfs	219	60 to 90 percent
Low Flows	Less than 179 cfs	163	90 to 100 percent

Road 8 (*Reach 3*)

Flow Category	Flow range (cfs)	Median flow per category (cfs)	Percent of time flows equal or greater occur
High Flows	Greater than 831 cfs	1336	Less than 10 percent
Moist Conditions	355 to 831 cfs	454	10 to 40 percent

Mid-Range Flows	269 to 355 cfs	304	40 to 60 percent
Dry Conditions	181 to 269 cfs	225	60 to 90 percent
Low Flows	Less than 181 cfs	159	90 to 100 percent

Table 7-1. Range of flow conditions within each flow category at each assessment location

7.2 Load Duration Curve Methodology

Loading capacity is the maximum amount of pollutant loading that a water body can receive without violating water quality standards. Establishing the relationship between in-stream water quality and source loading is an important component of TMDL development, as it allows the determination of the relative contribution of sources (e.g., all applicable point and non-point sources) to total pollutant loading.

This relationship can be developed using a variety of techniques ranging from qualitative assumptions based on scientific principles to numerical computer modeling. This *E. coli* TMDL employed the load duration curve methodology to develop a future compliance strategy with the *E. coli* stream standard of 126 CFU/100 mL (e.g., through load and wasteload reductions) at varying flow conditions at the three *E. coli* assessment locations. This methodology is well-suited for determining loading capacity in light of the extreme flow variations within Segment 15.

According to the EPA technical support document EPA 841-B-07-006:

> The duration curve approach allows for characterizing water quality concentrations (or water quality data) at different flow regimes. The method provides a visual display of the relationship between stream flow and loading capacity. Using the duration curve framework, the frequency and magnitude of water quality standard exceedances, allowable loadings, and size of load reductions are easily presented and can be better understood.
>
> The duration curve approach is particularly applicable because stream flow is an important factor in determination of loading capacities. This method accounts for how stream flow patterns affect changes in water quality over the course of a year (i.e., seasonal variation that must be considered in TMDL development). Duration curves also provide a means to link water quality concerns with key watershed processes that may be important considerations in TMDL development.

The load duration analysis utilizes flow duration intervals to identify flow regimes. Water quality standards can be presented by multiplying in-stream flow values by the numeric concentration (for *E. coli* this equals 126 CFU/100 mL) and a conversion factor. This step forms a trendline based on flow conditions that represents the assimilative capacity of the stream at varying flow conditions. Observed data that are plotted above this line represent exceedances of the standard. Load duration curves are then used to determine load reductions required to meet the target maximum concentration for *E. coli*.

The load duration curves presented in Figures 7-4, 7-5, and 7-6 were used to assess the monthly geometric mean impairments at the SP-64, SP-124, and SP-RD8 assessment locations between 2006 and 2011. Five categories of in-stream flow conditions (e.g., high flows, moist conditions, and so forth) are associated with relative loading capacities.

The loading capacity is represented in each Figure by the trendline (labeled Standard), which represents the flow multiplied by the numeric target and a conversion factor. These lines are in fact the TMDL, which reflects varying loading capacity based on flow conditions. The observed data is divided into two seasons to better represent the seasonal influences of storm runoff. The July-October season generally includes summertime storm events that produce greater amounts of precipitation and resulting diffuse runoff compared to the November-June season. The higher likelihood of large rainstorm events in the July-October season often corresponds with higher *E. coli* loading during these months.

<u>*Reach 1* – Assessment Location SP-64</u>:

Figure 7-4 shows the loading capacity of *Reach 1*, as represented by the SP-64 assessment location. Although the data is typically analyzed as geometric means, all data in Figure 7-4 are paired E. coli concentrations and daily flow values. The analysis identified Segment 15 at 64th Avenue (SP-64) as the location with the greatest degree of *E. coli* impairment, i.e., it shows more exceedances at all flow conditions. Table 7-2 lists wasteload and load sources of *E. coli* in *Reach 1*.

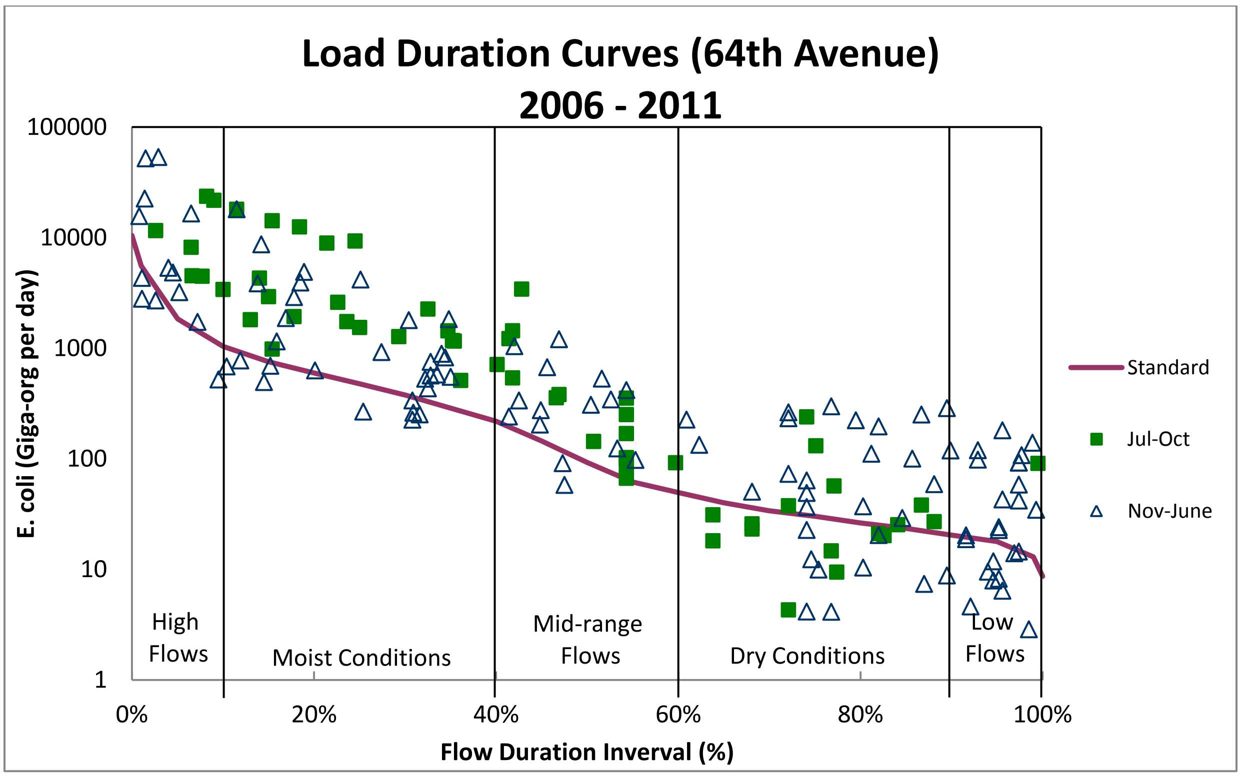

Figure 7-4. Load duration curve representing loading capacity at the SP-64 assessment location

***Reach 1* Wasteload Source**	
Permitted Industrial Facility:	Xcel Cherokee Generating Facility
Permitted MS4 Outfalls:	City of Denver MS4 outfalls (3)
***Reach 1* Load Sources**	
Background:	Upstream load from Segment 14; includes 5 Denver MS4 outfalls located within Reach 1
Tributary:	Humble Creek

Nonpoint Sources:	Wildlife (including waterfowl); seasonal *E. coli* regrowth; possible illegal dumping; failing septic systems; pet waste; diffuse runoff associated with storm events; background loading from unidentified pipes and culverts

Table 7-2. Wasteload and load sources subject to allocations within *Reach 1*

<u>*Reach 2* – Assessment Location SP-124</u>:

Figure 7-5 shows the loading capacity of *Reach 2*, as represented by the SP-124 assessment location. Although the data is typically analyzed as geometric means, all data in Figure 7-5 are paired *E. coli* concentrations and daily flow values. The exceedances at SP-124 occur more frequently during the summer months of July to October. Although exceedances can be seen at all flow levels, more exceedances are shown during High Flows and Moist conditions which may be related to the flashy summer storms that bring E. coli in from the surrounding watershed. Table 7-3 lists wasteload and load sources of *E. coli* in *Reach 2*.

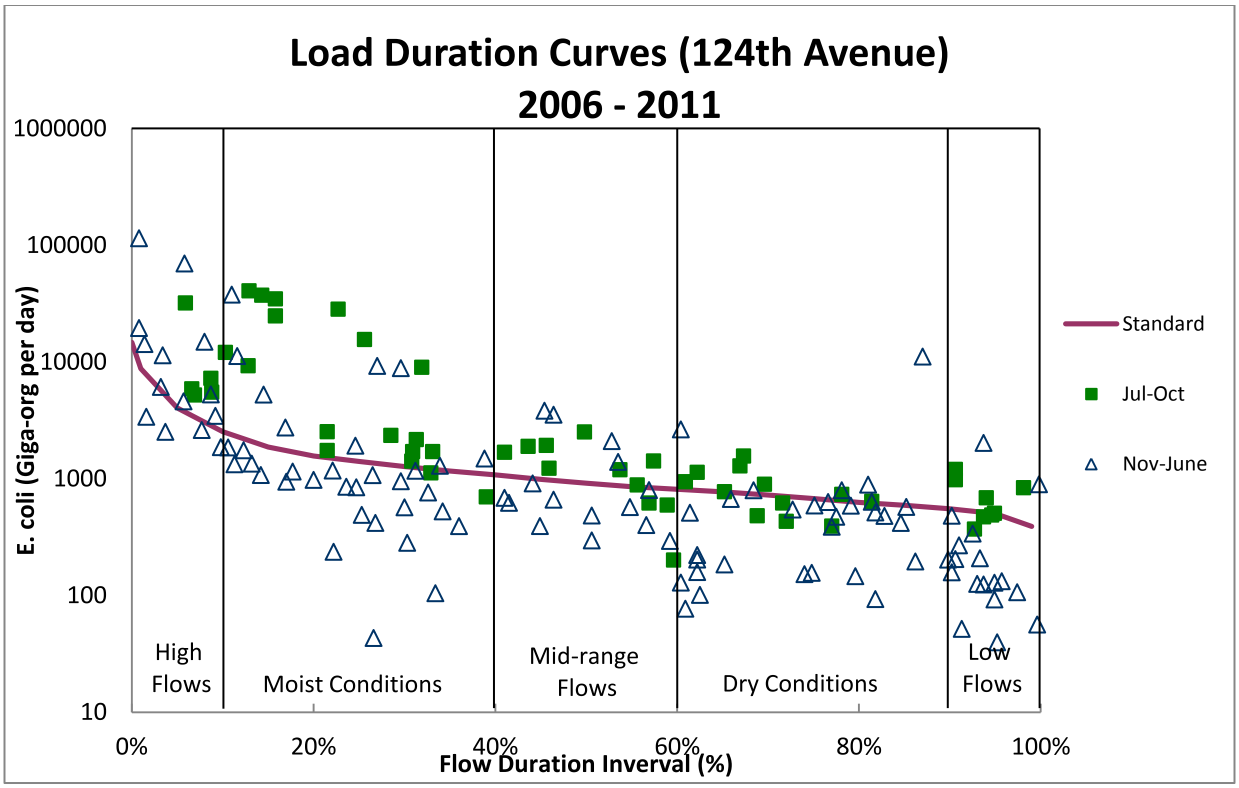

Figure 7-5. Load duration curve representing loading capacity at the SP-124 assessment location

***Reach 2* Wasteload Sources**	
Permitted Municipal Facilities:	Robert W. Hite Treatment Facility; South Adams County Water and Sanitation District
***Reach 2* Load Sources**	
Tributaries:	Sand Creek, Clear Creek, Niver Creek, and Bull Seep
Nonpoint Sources:	Wildlife (including waterfowl); seasonal *E. coli* regrowth; possible illegal

	dumping; failing septic systems; pet waste; diffuse runoff associated with storm events; agricultural operations; background loading from unidentified pipes and culverts

Table 7-3. Wasteload and load sources subject to allocations within *Reach 2*

<u>*Reach 3* – Assessment Location SP-RD8</u>:

Figure 7-6 shows the loading capacity of *Reach 3*, as represented by the SP-RD8 assessment location. Although the data is typically analyzed as geometric means, all data in Figure 7-6 are paired *E. coli* concentrations and daily flow values. The graph clearly indicates that the majority of exceedances occur during High Flows and Moist Conditions. The concentrations between July and October are typically higher than those during other months, possibly indicating that summer storm events are contributing *E. coli* to Segment 15 through diffuse runoff. Table 7-4 lists wasteload and load sources of *E. coli* in *Reach 3*.

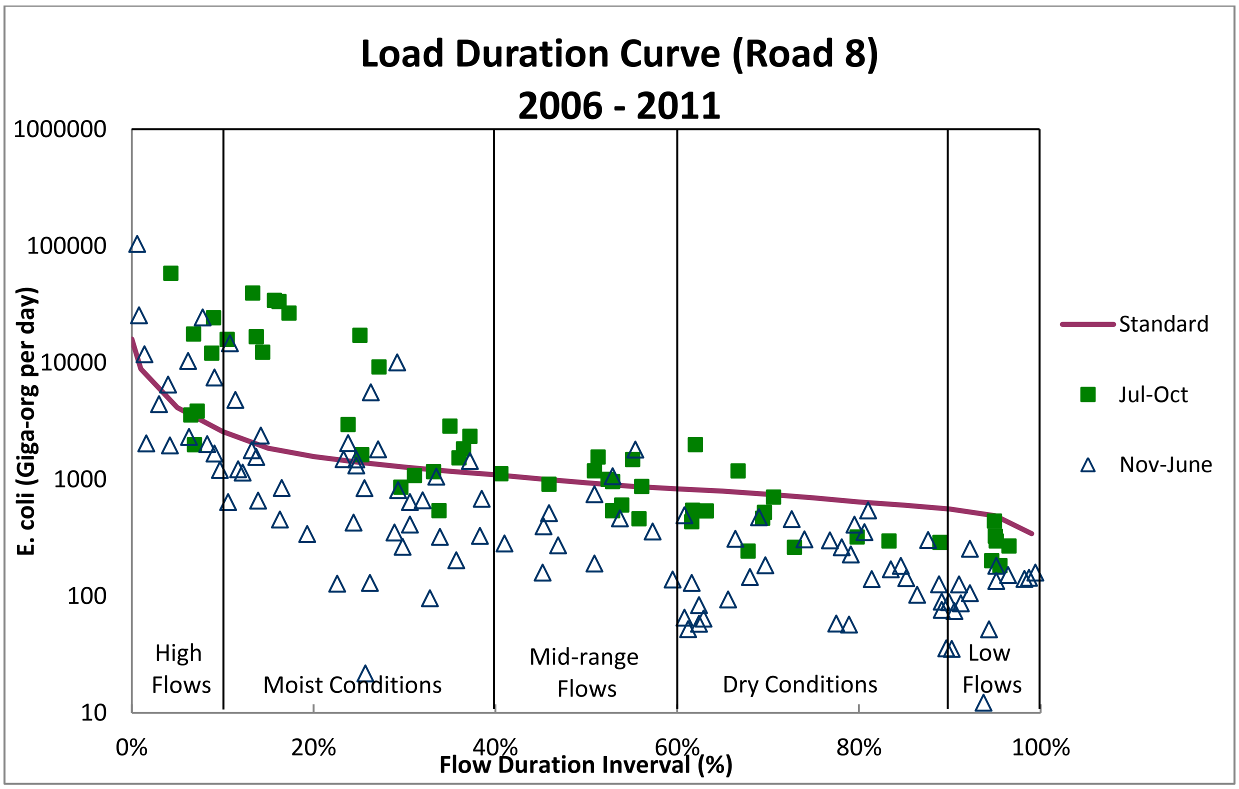

Figure 7-6. Load duration curve representing loading capacity at the SP-RD8 assessment location

***Reach 3* Wasteload Sources**	
Permitted Municipal Facility:	Brighton Wastewater Treatment Facility
	Northern Treatment Plant (anticipated 2016)
***Reach 3* Load Sources**	
Nonpoint Sources:	Wildlife (including waterfowl); seasonal *E. coli* regrowth; illegal dumping; failing septic systems; pet waste; diffuse runoff associated

	with storm events; agricultural operations; background loading from unidentified pipes and culverts

Table 7-4. Wasteload and load sources subject to allocations within *Reach 3*

8. TMDL Calculations and Setting of Allocations

The TMDL process identified the sources of the pollutant of concern, here *E. coli*, and quantified the amount that can be assimilated to attain the applicable water quality standard. The linkage analysis calculated the loading capacity based on flow conditions. After the TMDL is calculated, it must be allocated to point sources (as wasteload allocations) and non-point sources (as load allocations). A TMDL also must contain a Margin of Safety.

Conceptually, the definition of a TMDL is represented by the following equation:

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS$$

If the existing pollutant loading from point and non-point sources exceeds allocations, reductions are calculated to meet the TMDL, and thus the applicable water quality standard. This section describes the process used to determine the loading capacity, as well as resulting WLAs and LAs for the identified sources in each reach.

8.1 Establishment of the TMDL

Median flows from each flow category, and the geometric mean of E. coli in each flow interval were used to establish a TMDL target and to account for seasonal and fluctuating flow conditions in each reach (Tables 8-1, 8-2 and 8-3). Identification of critical conditions was used to identify needed reductions to ensure protection of beneficial uses year round. Critical conditions identify the period in time in which the most significant load reductions are needed.

To ensure protection of beneficial uses throughout each reach, required reductions were calculated based on data collected at the representative sample locations. Existing and allowable (TMDL) loadings were calculated with Equation 1. From the difference between the allowable and existing loads, the percent reductions were calculated.

Equation 1:

*Bacteria Concentration * Flow (cfs)* Conversion factor (CF) = Load (CFU) per day*

*Units: (CFU/100 mL) * (1 ft3/sec) *(conversion) = Load*

Where bacterial concentration equals:
For existing loads = Observed geometric means
For allowable loads = Numeric target (126 CFU/100 mL)

Conversion factor (CF):
1 ft3=28,317 mL so that CFU/100 mL to CFU/day:

*((28317 mL/100 mL) * (60 sec/min) * (60 min/hour) * (24 hour/day)) = CF*

Load Calculations	High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flow
Median Flow (cfs)	597	154	30	10	6
TMDL (Giga-CFU/day)	1840	475	92.5	30.2	17.9
Existing Load at SP-64 (Giga-CFU/day)	6440	1520	281	41.5	28.6
Required Reduction (%)	71%	69%	67%	27%	37%

Table 8-1. *Reach 1* TMDL based on flow conditions

Load Calculations	High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flow
Median Flow (cfs)	1309	457	297	219	163
TMDL (Giga-CFU/day)	4040	1410	916	675	502
Existing Load at SP-124 (Giga-CFU/day)	9070	2010	955	458	264
Required Reduction (%)	55%	30%	4%	0%	0%

Table 8-2. *Reach 2* TMDL based on flow conditions

Load Calculations	High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flow
Median Flow (cfs)	1336	454	304	225	158
TMDL (Giga-CFU/day)	4120	1400	936	692	488
Existing Load at Rd 8 (Giga-CFU/day)	6990	1470	591	203	141
Required Reduction (%)	41%	5%	0%	0%	0%

Table 8-3. *Reach 3* TMDL based on flow conditions

In all three reaches, the most severe reductions must occur during higher flows (High Flow and Moist Condition categories). In *Reach 1*, reductions are required during all flow conditions.

Once the TMDL is calculated and the margin of safety (10%) and reserve capacity (5%) is subtracted, the resulting loads are distributed as load allocations and wasteload allocations among the nonpoint and point sources in the watershed, respectively (Tables 8-6, 8-7, and 8-8). Combined load allocations are assigned to both the upstream load and background load (all non-point sources). Point sources identified include all permitted facilities.

8.2 Wasteload Allocations

Federal regulations at 40 CFR 130.7 require TMDLs to include a WLA for each regulated point source. Municipal facilities and Xcel Energy's Cherokee facility were assigned appropriate wasteload allocations. In addition, this TMDL includes a reserve capacity for the wasteload component for potential expansion of existing and/or future facilties.

Wasteload allocations for permitted facilities were calculated based on their design capacity and the in-stream standard (126 CFU/100 mL), with the exception of the RWHTF and Xcel Energy's Cherokee facility. Due to the effluent dominated condition of Segment 15, using the design capacity and the stream standard to calculate the WLA for these two facilities resulted in negative allocation values. These negative values did not result from high *E. coli* values, but from a flow value that was higher than the flow in the river at the given point of discharge.

The discharge from the RWHTF is typically a substantial percentage of the downstream flow in the segment, but it would be impossible for the amount of effluent being discharged by the facility to exceed the flow in the river downstream of the discharge at any given moment. As noted above, *E. coli* concentrations are typically lower downstream of the RWHTF discharge than above it. In order to ensure that the wasteload allocation was positive, it was determined that the wasteload allocation for the RWHTF should be based on a load duration curve of the District's discharge. This method is representative of existing conditions (i.e., effluent dominance) that are not anticipated to change over time. Use of the load duration curve provided a wasteload for each flow condition and these are presented in Table 8-4.

Load Calculations	High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flow
Median Flow (cfs)	247	220	204	190	104
Standard (CFU/100 mL)	126	126	126	126	126
Load (Giga CFU/day)	763	678	629	588	321

Table 8-4. Median flow values for RWHTF Treatment Facility under varying conditions

The flow from Xcel Energy's Cherokee Facility enters at a point in the River that is extremely low because of upstream diversions. The Cherokee facility was given a wasteload based on its annual average discharge flow as submitted on 2010 to 2011 DMRs because there was insufficient data to derive a flow duration curve.

8.3 Load Allocations

According to federal regulations at 40 CFR 130.2(g), load allocations are best estimates of the non-point source or background pollutant loading. Due to indiscrete origins, non-point source pollution can be difficult to quantify. For this TMDL, combined load allocations were developed for each reach of Segment 15 and include loading from tributaries, background sources, agricultural operations, unpermitted point sources, and wildlife.

8.4 Allocation Tables

Table 8-6 through Table 8-8 show the wasteload and load allocations for each reach of Segment 15 in Giga CFU per day.

Reach 1 **Assessment**	High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flow
Current Daily Load at SP-64 Assessment Location (Giga-CFU/day)	6440	1520	281	41.5	28.6
Allowable Total Maximum Daily Load (Giga-CFU/day)	1840	475	92.5	30.2	17.9
Percent Reduction	71%	69%	67%	27%	37%

Needed					
Margin of Safety (10%)	184	47.5	9.25	3.02	1.79
Wasteload Allocations					
Xcel Energy Cherokee Facility (Giga-CFU/day)	4.8	4.8	4.8	4.8	4.8
City of Denver MS4 (Giga-CFU/day)	22.08	5.7	1.11	0.36	0.21
Reserve Capacity (5%)	92	23.75	4.63	1.51	0.90
Load Allocations					
Non-Point Sources: Background (Upstream Load from Segment 14), Humble Creek, Wildlife, Other* (Giga-CFU/day)	1537.1	393.2	72.7	20.5	10.2

*Including seasonal *E. coli* regrowth; illegal dumping; failing septic systems; pet waste; diffuse runoff associated with storm events; and background loading from unidentified pipes and culverts.

Table 8-5. TMDL *E. coli* wasteload and load allocations (CFU/day) by flow condition for *Reach 1*

***Reach 2* Assessment**	**High Flows**	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flow**
Current Daily Load at SP-124 Assessment Location (Giga-CFU/day)	9070	2010	955	458	264
Allowable Total Maximum Daily Load (Giga-CFU/day)	4040	1410	916	675	502
Percent Reduction Needed	55%	30%	4%	0%	0%
Margin of Safety (10%)	404	141	91.6	67.5	50.2
Wasteload Allocations					
Robert W. Hite Treatment Facility (Giga-CFU/day)	624	540	491	450	183
South Adams County Water and Sanitation District (Williams Monaco) (Giga-CFU/day)	38.2	38.2	38.2	38.2	38.2
Reserve Capacity (5%)	202	70.5	45.8	33.75	25.1
Load Allocations					
Non-Point Sources: Sand Creek, Clear Creek, Niver Creek, Bull Seep, Wildlife, Other* (Giga-CFU/day)	2771.8	620.3	249.4	85.55	205.5

*Including seasonal *E. coli* regrowth; illegal dumping; failing septic systems; pet waste; diffuse runoff associated with storm events; agricultural operations; and background loading from unidentified pipes and culverts.

Table 8-6. TMDL *E. coli* wasteload and load allocations (CFU/day) by flow condition for *Reach 2*

Reach 3 Assessment	**High Flows**	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flow**
Current Daily Load at RD-8 Assessment Location (Giga-CFU/day)	6990	1470	591	203	141
Allowable Total Maximum Daily Load (Giga-CFU/day)	4120	1400	936	692	488
Percent Reduction Needed	41%	5%	0%	0%	0%
Margin of Safety (10%)	412	140	93.6	69.2	48.8
Wasteload Allocations					
Brighton Wastewater Treatment Facility (Giga-CFU/day)	14.3	14.3	14.3	14.3	14.3
Northern Treatment Plant (Giga-CFU/day)	139	139	139	139	139
Reserve Capacity (5%)	206	70	46.8	34.6	24.4
Load Allocations					
Non-Point Sources:, Wildlife, Other* (Giga-CFU/day)	3349	1037	642	435	262

*Including seasonal *E. coli* regrowth; illegal dumping; failing septic systems; pet waste; diffuse runoff associated with storm events; agricultural operations; and background loading from unidentified pipes and culverts.

Table 8-7. TMDL *E. coli* wasteload and load allocations (CFU/day) by flow condition for *Reach 3*

8.5 Margin of Safety

TMDLs must include a margin of safety (MOS) to account for the uncertainty in the analysis. There are two ways to incorporate the MOS: (1) implicitly incorporate the MOS using conservative model assumptions to develop allocations and (2) explicitly specify a portion of the total TMDL as the MOS and use the remainder for allocations (USEPA, 1991). In either case, the purpose of the MOS is to ensure that the currently impaired beneficial uses will be restored, given the uncertainties in the TMDL analysis.

For this TMDL, a 10% explicit MOS was included due to the lack of data pertaining to non-point source contributions. In addition to this 10% explicit MOS, there are a number of conservative loading estimates implicit throughout the TMDL development. The following describes key conservative considerations:

- Load duration curves ensure that numeric targets are based on current flow conditions. This ensures that standards align with the assimilative capacity of varying flow conditions and changing seasons.

- In addition, much of the segment is heavily influenced by the discharge from the RWHTF, which is consistently below the *E. coli* standard, as shown in Table 8-9 below (2009-2011). As such, this discharge is a source of dilution for upstream *E. coli* concentrations. This adds to the implicit margin of safety, since the RWHTF wasteload allocation is based on an assumption that the effluent concentration is the same as the stream standard of 126 CFU per 100 mL, i.e., actual *E coli* loads from the facility are less than predicted.

2009		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flow (MGD)*	Limit: 220	130	127	126	143	146	158	148	140	134	138	143	118
*E. coli***	Limit: 126	15.1	18.8	18.8	24.1	29.9	21.0	19.6	17.8	29.2	35.6	23.3	34.7
2010		**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow (MGD)*	Limit: 220	78	114	143	152	157	152	145	138	130	132	132	126
*E. coli***	Limit: 126	25.3	17.0	14.3	19.1	30.2	21.7	35.8	46.9	49.5	27.3	27.7	24.6
2011		**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow (MGD)*	Limit: 220	98	76	106	123	143	142	149	133	129	130	131	96
*E. coli***	Limit: 126	22.9	17.8	7.6	6.0	9.2	16.8	35.0	41.3	30.5	38.4	27.2	36.3

* Monthly average flow values in millions of gallons per day
** Monthly average values of *E.coli* per 100 mL

Table 8-8. RWHTF Discharge Monitoring Report Flow and *E. coli* data, 2009-2011

8.6 Seasonal Variations and Critical Conditions

TMDLs are required to consider critical conditions and seasonal variation for stream flow, loading, and water quality parameters. The critical condition is the set of environmental conditions for which controls designed to protect water quality will ensure attainment of water quality standards for all other conditions. The intent of this requirement is to ensure protection of water quality in water bodies during all periods.

As discussed above, this TMDL utilizes the load duration curve methodology to evaluate the assimilative capacity and numeric targets during fluctuating flow conditions. This methodology provides an excellent way to graphically present the instantaneous load and evaluate seasonal flow variations.

Utilizing the load duration method ensures seasonal variability is taken into consideration in the calculation of numeric targets. In Segment 15, the critical conditions for *E. coli* were identified as those coinciding with moist and high flow conditions in all three reaches.

However, persistent *E. coli* exceedances are only occurring in *Reach 1*, which is strongly influenced by upstream *E. coli* concentrations.

9. Implementation of the TMDL

Although not a required component of TMDLs, this section summarizes potential implementation actions and activities. The implementation of this TMDL is unique in that: (1) water quality standards attainment is heavily dependent on *E. coli* reduction strategies being implemented upstream (to address background loads); and (2) there are E. coli impairments in tributaries to Segment 15 (e.g., Clear Creek and Sand Creek) for which TMDLs will be developed and load reductions implemented.

Accordingly, improvements toward achieving the underlying *E. coli* water quality target will be an iterative process, similar to a staged implementation approach. For example, for permitting purposes regulated point sources located in Segment 15 would have effluent limits set at the *E. coli* standard so long as there is reasonable potential (as is the case for the municipal wastewater treatment facilities located within Segment 15). This alone will not be enough to achieve attainment with the standard unless upstream background and tributary sources are reduced as well.

9.1 Recommendations for Regulated Point Sources

Wasteloads for all regulated point sources located within Segment 15 were determined on the basis of the stream standard (126 colony forming units of bacteria per 100 milliliters of water). All applicable municipal wastewater treatment facilities currently have *E. coli* effluent limitations based upon this same standard. The Xcel Energy Cherokee facility discharge permit currently does not have an *E. coli* effluent limit, but instead has "Report" only requirements. However, based on 2009 through 2011 Cherokee Discharge Monitoring Report data evaluated for this TMDL, *E. coli* effluent concentrations from the facility were well below the stream standard.

9.2 Other Recommended Actions and Activities

After TMDL approval, it is recommended that interested stakeholders develop a coordinated implementation plan that could include a variety of management opportunities. Categories of implementation actions include: (1) education and outreach; (2) coordination with other watershed groups and entities in the urban South Platte Basin; (3) additional monitoring; (4) possible future microbial source tracking for source identification, and (5) possible future revision of the TMDL. Each of these is briefly summarized below.

1) <u>Education and Outreach</u>: As a source control technique, education and outreach can function as pollution prevention to reduce or eliminate the amount of bacteria washed from impervious surfaces. As one example, a pet waste clean-up education program could help reduce *E. coli* loading throughout Segment 15. Promotion of the best management practice of keeping livestock out of the River could also improve overall water quality in *Reach 2* and *Reach 3*.

2) <u>Coordination with Other Watershed Groups</u>**:** It is expected that water quality will improve over time as the Segment 14 E. coli TMDL is fully implemented and when other TMDLs on impaired tributaries to Segment 15 are developed and implemented. Keeping lines of communication open and sharing data and information on implementation activities is also an important factor to ensure water quality improvement over time.

3) <u>Monitoring</u>: Monitoring will continue as part of the SP CURE monitoring efforts on a bimonthly basis. The three new tributaries added (Humble Creek, Bull Seep, and Niver Creek) will continue to be monitored as well. Additional *E. coli* monitoring is recommended to more accurately characterize non-point source loads into all reaches of Segment 15 since the majority of the *E. coli* loading is associated with non-point sources, e.g., background.

4) Possible Future Source Tracking: Because the contributions from wildlife, especially waterfowl, could be better quantified, source tracking and species identification information could prove useful to better understand these non-point source loads.

5) Possible Future Revision of the TMDL: As more accurate non-point source data are generated over time, the TMDL may need to be revised. In addition, future upgrades at municipal wastewater treatment facilities may result in less *E. coli* loading to the segment. This information potentially could be incorporated into a revised TMDL in the future.

10. Public Participation

Final TMDL, (December 2015)

This segment (COSPUS15) was included on Colorado's 303(d) list of impaired segments in 2002. The development of the 303(d) list is a public process involving solicitation from the public of candidate waterbodies, formation of a technical review committee comprised of representatives of both the public and private sector, and a public hearing before the Colorado Water Quality Control Commission. Public notice is provided concerning both the solicitation of impaired waterbodies and the public hearing.

The TMDL itself is the subject of an independent public process. This TMDL report was made available for public review and comment during a 30 day public notice period in (November, 2015). No comments were received during the public notice.

The final TMDL report was available for public review during a 30-day public notice period in December 2015, as required by Regulation 21 (WQCC, 2015). Following this public notice period, the report was submitted to EPA.

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