E. coli TMDL Implementation Plan
City of Boulder

GEI Consultants

Consulting Engineers and Scientists

Submitted to:

City of Boulder Public Works Department
4049 75th Street
Boulder, Colorado 80301

Submitted by:

GEI Consultants, Inc.
4601 DTC Blvd., Ste. 900
Denver, CO 80237

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Acronyms

BMP	Best Management Practice
BRC	Boulder Revised Code
BVSD	Boulder Valley School District
CAFO	Confined Animal Feeing Operation
CCR	Code of Colorado Regulations
CDPS	Colorado Discharge Permit System
cfs	cubic feet per second
CFU	Colony Forming Unit
City	City of Boulder
County	Boulder County
CU	University of Colorado, Boulder
Division	Colorado Water Quality Control Division
DCS	Design and Construction Standards
E. coli	*Escherichia coli*
ft	feet
IDDE	Illicit Discharge Detection and Elimination
LA	Load allocation
MEP	Maximum Extent Practicable
mi^2	Square miles
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer System
MST	Microbial Source Tracking
NPDES	National Pollutant Discharge Elimination System
Plan	TMDL Implementation Plan
SMP	Sewershed Management Plan
TMDL	Total Maximum Daily Load
USEPA	United States Environmental Protection Agency
WQCC	Water Quality Control Commission
WLA	Wasteload Allocation
WWTF	Wastewater Treatment Facility

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1.0 Background and Purpose

This Total Maximum Daily Load (TMDL) Implementation Plan (or Plan) update documents the activities the City of Boulder (City) will implement to reduce bacterial indicators discharged from the City's Municipal Separate Storm Sewer System (MS4) to the impaired reach of Segment 2b of Boulder Creek. This Plan provides the basis for the City's strategy to implement the *Boulder Creek, Colorado Segment 2b: From 13th Street to the Confluence with South Boulder Creek, Escherichia coli Total Maximum Daily Load (TMDL)* (Tetra Tech 2011a).and summarizes the specific steps the City will follow to not only comply with the City's wasteload allocation (WLA) applicable to the impaired reach of Segment 2b of Boulder Creek, but also meet the requirements of its MS4 Permit.

The original TMDL Implementation Plan, completed in 2011, was an initial attempt to document potential implementation actions that Segment 2b MS4 permittees would consider moving forward with their stormwater programs (Tetra Tech 2011b). **Table 1-1** summarizes the primary activities completed by the City under this original Plan. While the original Plan was helpful to initiate actions related to the mitigation of *Escherichia coli* (*E. coli*) in Boulder Creek, the City determined that that it would benefit from the development of a more mature program that incorporates state of the science recommendations and is exclusive to the City's stormwater management program. This updated Plan fulfills those objectives.

Table 1-1. Summary of City Activities to Mitigate *E. coli* in MS4

No.	Program Element	Description/Notes	Status
1	Robust Illicit Discharge Detection and Elimination (IDDE) Response Program	Currently implementing program that responds quickly to sanitary or other instances with potential to discharge *E. coli* and ensures these are cleaned up appropriately and before they enter Boulder Creek.	Ongoing
2	Continued *E. coli* Instream and Outfall Monitoring	Continued weekly and monthly monitoring to assess outfall contributions and instream water quality.	Ongoing
3	Slow the Flow Efforts	Facilitates education around reductions in dry weather* flows to the MS4. Dry weather flows* can carry bacteria from various sources in the City directly to stormwater outfalls and into Boulder Creek.	Ongoing
4	"Doo Good" Pet Waste Outreach Program	Program is implemented through the Keep It Clean Partnership. Includes collateral and educational materials to educate pet owners on appropriate pet waste management. Partners include Boulder Valley Humane Society and City Open Space and Mountain Parks.	Ongoing
5	Pet Waste Stations	Continued implementation of pet waste stations along greenways and in City open space areas.	Ongoing
6	MS4 System Cleaning	Appropriately cleaned and inspected MS4 with outfalls to the TMDL segment. Cleaning of storm sewer draining to Boulder Creek was completed in May 2016.	Major efforts 2015-2016; Ongoing
7	Stormwater Masterplan Update	Plan addresses MS4 capacity issues throughout the City, but additionally selects priority locations for water quality improvements.	2016
8	Boulder Creek Sanitary Main Investigation	TVed sanitary mains running under Boulder Creek. Discovered no apparent instances of sanitary mains contributing sewage to the creek.	2016
9	Boulder Creek Outfalls Survey	Conducted a survey at all MS4 outfalls to Boulder Creek. Visually assessed potential illicit discharges and conducted water quality sampling for *E. coli*, nutrients, and optical brighteners.	2015; 2017; Ongoing
10	Technical Memorandum: Raccoon Storm Drain Access Control - University Hill Sub-Basin Recommendations	Developed report detailing the feasibility and costs associated with installing raccoon proofing measures on storm inlets in "The Hill" area of the city.	2013
11	Marine Street Raccoon-proofing Pilot Study	Installed inlet and outfall grates on one small storm sewer line to determine the impacts on *E. coli* from raccoons in the system. Observed drastic reductions in *E. coli* concentrations.	2012

* Dry weather flows mean that no measurable rainfall has occurred in the area within the previous 72 hours

1.1 Regulatory Overview

The Water Quality Control Commission (WQCC) establishes water quality regulations for the State of Colorado. Regulation 38 establishes stream classifications and water quality standards for the South Platte River watershed including the Boulder Creek Basin.[1] Regulation 38 divides Boulder Creek into several segments. The segment of Boulder Creek that flows through the City is defined as follows: COSPBO02B Mainstem of Boulder Creek, including all tributaries and wetlands, from a point immediately below the confluence with North Boulder Creek to a point immediately above the confluence with South Boulder Creek (Segment 2b). This segment has four designated uses, defined as follows:[2]

- *Agriculture* - Surface waters suitable or intended to become suitable for irrigation of crops usually grown in Colorado and which are not hazardous as drinking water for livestock.
- *Aquatic Life Cold 1* - Waters that (1) currently are capable of sustaining a wide variety of cold water biota, including sensitive species, or (2) could sustain such biota but for correctable water quality conditions. Waters shall be considered capable of sustaining such biota where physical habitat, water flows or levels, and water quality conditions result in no substantial impairment of the abundance and diversity of species.*Recreation, Class E Primary Contact Use* - Surface waters used for primary contact recreation or have been used for such activities since November 28, 1975. Primary contact recreation means recreational activities where the ingestion of small quantities of water is likely to occur. Such activities include but are not limited to swimming, rafting, kayaking, tubing, windsurfing, water-skiing, and frequent water play by children.
- *Water Supply* - Surface waters suitable or intended to become suitable for potable water supplies. After receiving standard treatment (defined as coagulation, flocculation, sedimentation, filtration, and disinfection with chlorine or its equivalent) these waters will meet Colorado drinking water regulations and any revisions, amendments, or supplements thereto.

The Colorado Department of Public Health and Environment, Water Quality Control Division (Division) periodically assesses water quality and prepares the Colorado Section 303(d) List.[3] The Colorado 2004 303(d) List first identified Segment 2b of Boulder Creek as having an impaired recreation use due to elevated concentrations of *E. coli* bacteria. Elevated *E. coli* is an indicator for the potential presence of human pathogens and increased potential for public health risk for people engaging in water contact recreational activities. The 303(d)

[1] WQCC, Regulation No. 38 – Classifications and Numeric Standards for South Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin, 5 Code of Colorado Regulations (CCR) 1002-38
[2] WQCC, Regulation No. 31 – The Basic Standards and Methodologies for Surface Water, 5 CCR 1002-31
[3] WQCC, Regulation No. 93 – Colorado's Section 303(d) List of Impaired Waters and Monitoring and Evaluation List.

List characterized the use impairment to the specific reach of Boulder Creek Segment 2b from 13th Street to the confluence with South Boulder Creek. Per federal regulations, waterbodies designated as impaired on the 303(d) List require development of a TMDL.

1.2 Boulder Creek

1.2.1 Watershed

The Boulder Creek watershed, which encompasses approximately 450 square miles (mi^2), is located along the Front Range of the Rocky Mountains. Boulder Creek is in the South Platte River basin and is tributary to St. Vrain Creek. The confluence of Boulder and St. Vrain Creeks is located a few miles east of Longmont, Colorado. Elevation within the Boulder Creek watershed ranges from over 13,000 feet (ft) in the upper watershed to approximately 5,300 ft within the City and 5,000 ft at the confluence of Boulder Creek and St. Vrain Creek. Much of the upper watershed is undeveloped. The lower part of the watershed, including the impaired reach of Boulder Creek lies within the urbanized area of the City.

The impaired portion of Boulder Creek within Segment 2b, is approximately 4-miles in length and described as "Boulder Creek from 13th Street to the confluence with South Boulder Creek"[4] (**Figure 1-1**). The area that drains to this impaired reach covers approximately 2,303 acres (3.6 mi^2) and is made up primarily of urbanized land uses. Tetra Tech (2011a) provides a detailed breakdown of land uses in the watershed that drains to Segment 2b.

[4] Ibid

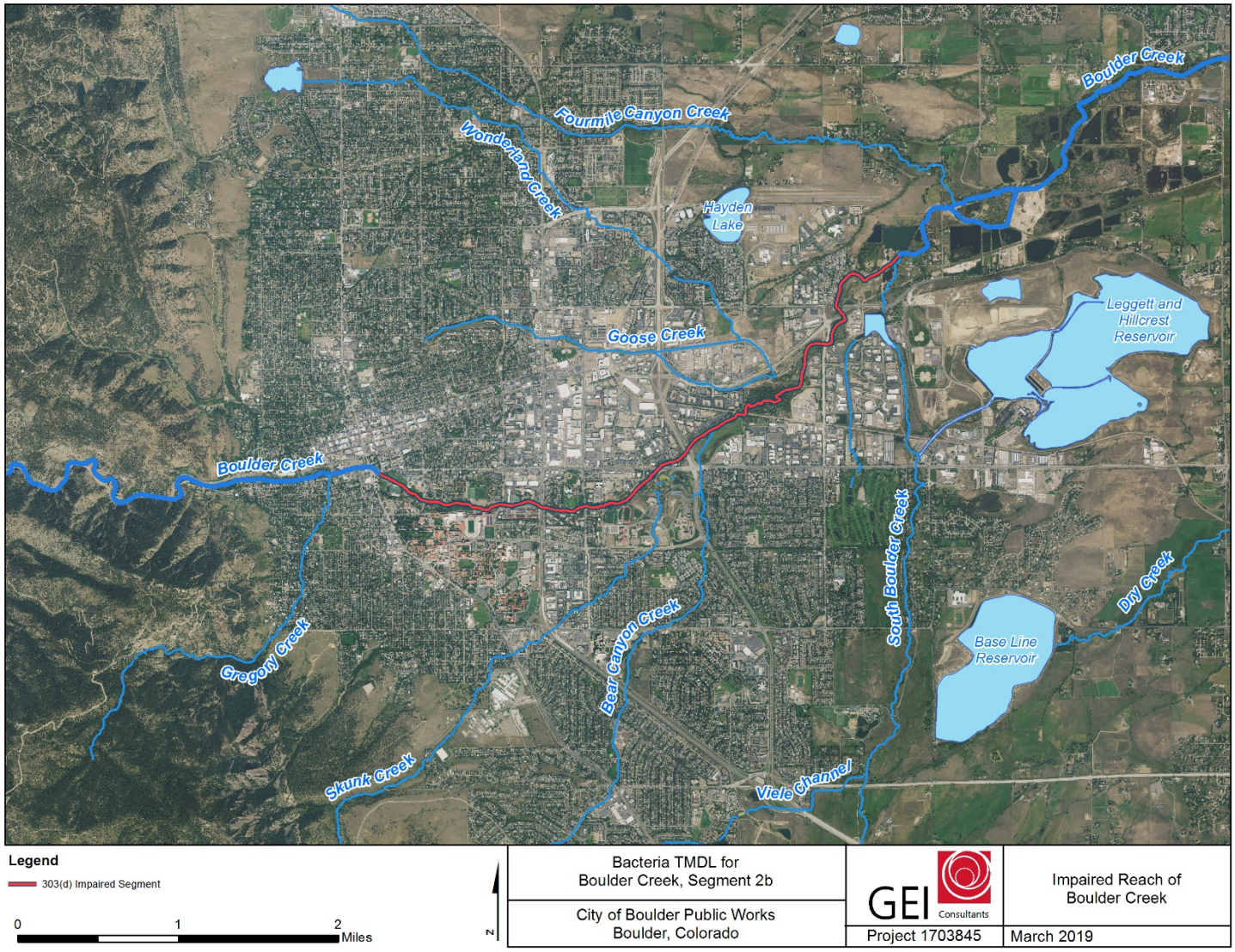

Figure 1-1. Impaired Reach of Boulder Creek Segment 2b within the City of Boulder

1.2.2 Jurisdictions

The watershed that drains to Segment 2b of Boulder Creek primarily includes areas under the jurisdiction of the City, University of Colorado (University) and Boulder County (County) (**Figure 1-2**). The relative percent area of each jurisdiction is as follows: City (1732.9 acres or approximately 75 percent of drainage), University (406 acres or approximately 18 percent) and the County (129 acres or 6 percent) (Tetra Tech 2011a). In addition, a very small portion (34.5 acres or 1.5 percent) is under the jurisdiction of the Boulder Valley School District.

1.2.3 Hydrology

The hydrology of Boulder Creek varies significantly depending on time of year, with highest flows typically occurring during the spring snowmelt runoff season between May and July. Flows typically decline during late summer months with low flows generally occurring from fall through early spring (**Figure 1-3**). Superimposed on this overall pattern are runoff events from late summer afternoon storms and changes in flow that occur as a result of water transfers in the watershed.

1.3 Total Maximum Daily Load

The TMDL establishes the maximum amount of *E. coli* Segment 2b of Boulder Creek can receive and still attain water quality standards. The City worked collaboratively with the Division and the US Environmental Protection Agency (USEPA) to develop the TMDL (Tetra Tech 2011a). Submitted by the Division to the USEPA on September 8, 2011, the USEPA approved the TMDL on September 27, 2011.

To develop the TMDL, Tetra Tech (2011a) used load duration curves to evaluate Boulder Creek Segment 2b's assimilative capacity during varying flow conditions. This analysis established a variable TMDL to reflect the range of flow conditions observed on Boulder Creek and to identify a target period or critical period (May to October) during which significant *E. coli* load reductions are necessary to meet water quality standards (**Table 1-2**) (Tetra Tech 2011a). The TMDL anticipates that meeting the required *E. coli* reductions during the critical period will result in the protection of the recreation use at all times.

The TMDL takes into account annual variations in flow by categorizing in-stream flow under five categories: (a) high flows; (b) moist conditions; (c) mid-range flows; (d) dry conditions; and (e) low flows. **Figure 1-4** illustrates the results of a flow duration analysis for the impaired reach of Boulder Creek. For example, high flow conditions, as defined by flows greater than 123 cubic feet/second (cfs) occur less than 10 percent of the time. Similarly, flows during "moist conditions," defined as a range of 23 to 123 cfs, occur between 10 and 40 percent of the time. Table 1-2 also summarizes the relationship between flow condition characteristics, including the percent of time that the flow condition is expected to occur based on historical data, and *E. coli* characteristics.

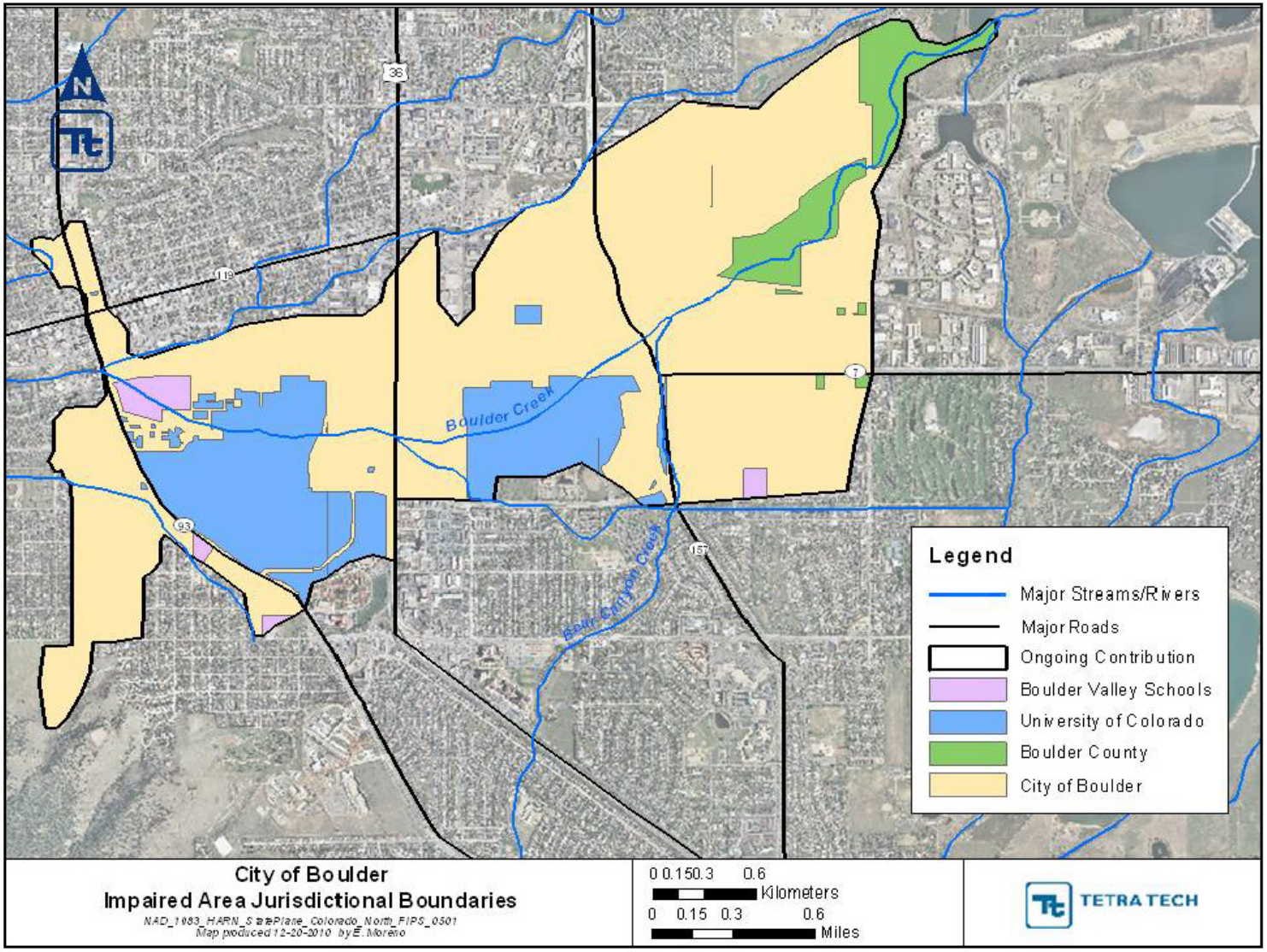

Figure 1-2. Jurisdictional Map of Segment 2b (from Tetra Tech 2011a)

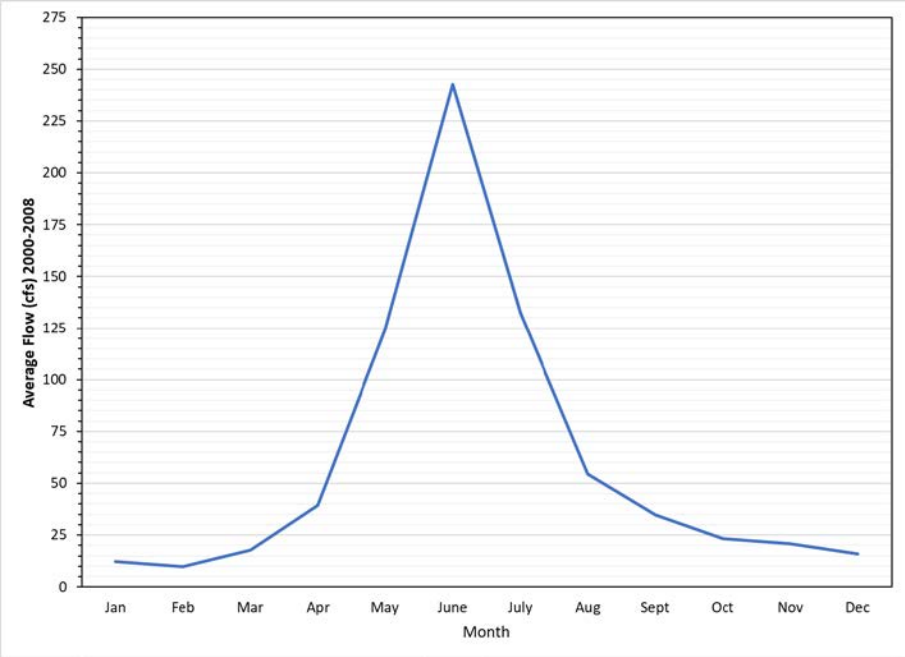

Figure 1-3. Typical Monthly Flow Pattern in Boulder Creek Based on Average Monthly Flow Data at Orodell Gage (~3 miles upstream of Segment 2b), 2000-2008.

Table 1-2. Flow and Water Quality-related Characteristics Associated with Flow Conditions in Segment 2b of Boulder Creek (adapted from Tetra Tech 2011a)

Loading Calculations	Flow Condition				
	High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flow
Flow Characteristics					
Flow Range (cfs)	> 123	23-123	11-23	2-11	< 2
Median Flow (cfs)	188.7	46.7	16.0	6.6	1.0
Percent of Time Flow Range Occurs	< 10	10 - 40	40 - 60	60 - 90	90 – 100
***E. coli* Concentrations/Loads**					
E. coli Water Quality Standards (Colony Forming Units [CFU]/100 milliliter [mL])	126	126	126	126	126
Observed *E. coli* Geometric Mean (Geomean) (CFU/100 mL)	88.9	209.3	486.8	546.1	NS[1]
TMDL (CFU/Day)[2]	5.80E+11	1.44E+11	4.92E+10	2.05E+10	3.08E+09
Existing Instream *E. coli* Load at BC-30 (CFU/Day)[3]	4.09E+11	2.39E+11	1.90E+11	8.87E+10	NS[1]
Required *E. coli* Reduction (%)	0.0	39.7	74.1	76.9	NS[1]

[1] NS = Not Sampled
[2] TMDL Based on meeting 126 CFU/100 mL water quality standard
[3] Existing loads based on observed geomean at BC-30 during flow condition

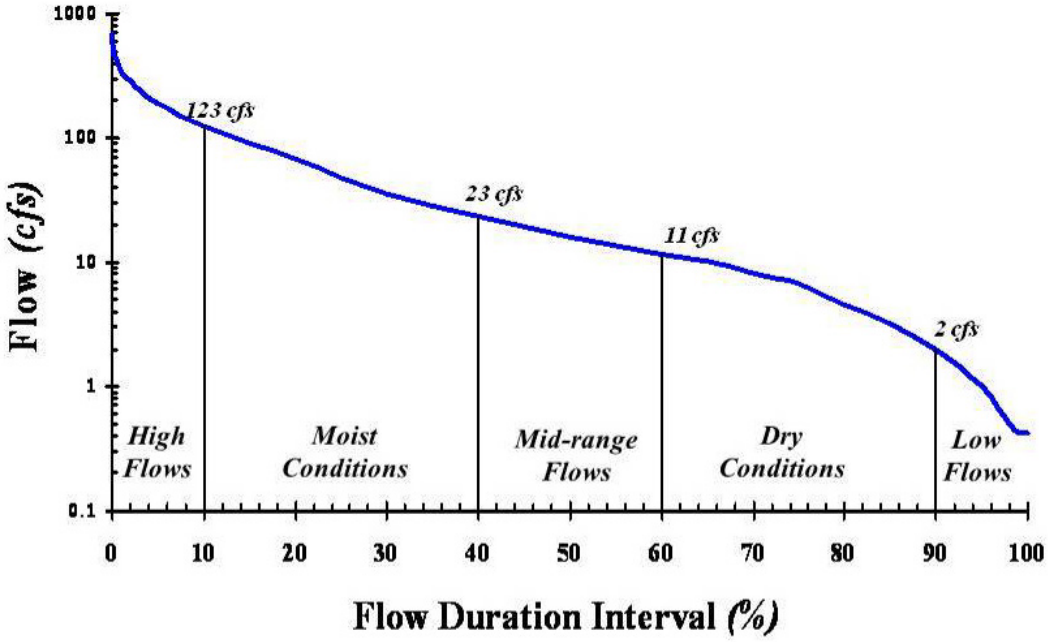

Figure 1-4. Flow Duration Analysis of Extrapolated Flow within the Impaired Reach of Boulder Creek (1980-2010) (from Figure 6-2, Tetra Tech 2011a)

Table 1-3 summarizes general information about the TMDL, including the methodology used to establish the WLAs for point sources and load allocations (LA) for nonpoint sources. Point and nonpoint sources incorporated into the TMDL are summarized in **Table 1-4**. The City's MS4, as a point source, has an assigned WLA. Tetra Tech (2011a) provides additional information regarding the development of the TMDL.

Table 1-5 summarizes the WLA/LA allocations applicable to point and nonpoint sources including the City's MS4. The method for determining the WLA applicable to MS4s, in general, and the City, specifically, is summarized in Table 1-3, based on the jurisdictional areas provided in **Table 1-6**. This Plan only addresses compliance with the WLA applicable to the City's MS4.

1.4 City of Boulder MS4 System

City stormwater runoff is collected and conveyed through a series of pipes (and ditches) to outfalls that discharge to Boulder Creek and other local tributaries. The City maintains a database of its MS4 system including the location of outfalls to Boulder Creek, inlets to the MS4 system, access points to the MS4 (including manholes and open channels) and connectivity of the system. The City regularly updates system records as required by its MS4 Permit.

Table 1-3. TMDL Summary for Segment 2b of Boulder Creek (adapted from Tetra Tech 2011a)

TMDL Element	Description
Methodology	Developed using the load duration curve methodology to ensure TMDL targets comply with the *E. coli* water quality standard (126 CFU/100 mL) during different flow conditions.
Critical Period	Water quality data (2004 to 2010) represents range of hydrologic and meteorological conditions. Critical period was identified by the large majority of exceedances during summer months. To ensure proper protection of beneficial uses, the critical period is the recreational months of May through October.
Seasonal Considerations	Thirty-year period (1980-2010) of hydrologic conditions used for load duration curve analysis. Record includes all seasons and a full range of flow and meteorological conditions. Load duration calculations based on various flow conditions to ensure the TMDL target aligns with the assimilative capacity of the stream in varying seasonal and flow conditions.
Wasteload Allocations (WLA)	WLAs adopted for the following dischargers: • Wastewater: San Lazaro Wastewater Treatment Facility (WWTF) • Stormwater (MS4): City of Boulder, University of Colorado, Boulder County, Boulder Valley School District
Load Allocations (LA)	Assigned to (1) the reach upstream of the impaired reach ("upstream loading"); and (2) open lands (non-MS4) in the impaired drainage area. The upstream LA generally includes loading from septic systems, wildlife and, recreational (or bodily) contact in the stream.
Margin of Safety (MOS)	• MOS (-5% of TMDL) - Based on incorporation of the following conservative assumptions: – Interpreted bacterial results with geomean which decreases the variability seen in single sample grabs. – Treated *E. coli* as a conservative pollutant (one that does not degrade or die-off). This likely overestimates the impact of bacteria discharged from storm drains on the stream. – Use of load duration curves to ensure that TMDL targets are based off current flow conditions, which makes sure *E. coli* standards align with the assimilative capacity of varying flow conditions and changing seasons. – Relied on the use of low flow measurements to develop flow duration curves. This ensures low flows are most accurately represented.
Calculation of WLA applicable to City's MS4	• Load applicable to all MS4s was determined by subtracting the MOS, the WLA allocated to the San Lazaro WWTF and the upstream nonpoint source LA from the TMDL. • Load allocated to the City's MS4 was based on the area (percent) of land under the City's jurisdiction within the watershed to Segment 2b (see Table 1-6).
LA Methodology	Load was calculated based on instream monitoring at site BC-Eben located at Eben G. Fine Park (upstream of Segment 2b) (see Tetra Tech 2011a).

Table 1-4. Point and Nonpoint Sources of *E. coli* Included in the TMDL

Load Type	Source Type	Facility or Jurisdiction
Point Sources (WLA)	Wastewater Treatment Facility (WWTF)	San Lazaro
	Municipal Separate Storm Sewer System (MS4)	City of Boulder
		University of Colorado
		Boulder Valley School District
		Boulder County
Nonpoint Sources (LA)	Upstream	Background load to impaired reach
	Jurisdictional Land (by area)	City of Boulder
		University of Colorado
		Boulder Valley School District
		Boulder County

Table 1-5. TMDL *E. coli* WLA and LA (CFU/Day) by Flow Condition and Jurisdiction (Shaded row is the WLA applicable to the City's MS4)

TMDL Components		High Flows	Moist Conditions	Mid-Range flows	Dry Conditions	Low Flow
TMDL	TMDL	5.80E+11	1.44E+11	4.92E+10	2.05E+10	3.08E+09
	Margin of Safety (-5%)	2.90E+10	7.19E+09	2.46E+09	1.02E+09	1.54E+08
	MS4 Allocatable Load	4.10E+11	7.92E+10	2.59E+10	7.67E+09	2.40E+09
Wasteload Allocations	San Lazaro WWTF	5.25E+08	5.25E+08	5.25E+08	5.25E+08	5.25E+08
	City of Boulder	2.66E+11	5.14E+10	1.68E+10	4.97E+09	1.56E+09
	University of Colorado	6.85E+10	1.33E+10	4.34E+09	1.28E+09	4.02E+08
	Boulder Valley School District	5.53E+09	1.07E+09	3.50E+08	1.03E+08	3.24E+07
	Boulder County	7.19E+09	1.39E+09	4.56E+08	1.35E+08	4.22E+07
Load Allocations	Upstream Load Allocation	1.41E+11	5.69E+10	2.02E+10	1.12E+10	0.00E+00
	City of Boulder	4.26E+10	8.23E+09	2.70E+09	7.97E+08	2.40E+08
	University of Colorado	3.78E+09	7.31E+08	2.39E+08	7.08E+07	2.22E+07
	Boulder Valley School District	6.07E+08	1.17E+08	3.85E+07	1.14E+07	3.56E+06
	Boulder County	1.57E+10	3.04E+09	9.96E+08	2.94E+08	9.23E+07

Table 1-6. WLA and LA Percentage by Jurisdictional Area

MS4 Jurisdiction	Percent of Total WLA and LA by Jurisdiction		
	WLA	LA	Percent Total
City of Boulder	64.86	10.39	75.26
University of Colorado	16.73	0.92	17.65
Boulder Valley School District	1.76	3.84	5.59
Boulder County	1.35	0.15	1.50
Totals	**84.70**	**15.30**	**100**

Along the impaired reach of Boulder Creek, the TMDL documented the presence of 36 storm drain outfalls. While each of those outfalls has the potential to discharge urban runoff to Boulder Creek (especially during precipitation events), the TMDL identified nine outfalls that consistently had flow under dry weather conditions and were identified as a water quality concern based on bacteria monitoring data and complaints regarding odor or visual concerns (Tetra Tech 2011a). As stated above, this updated Implementation Plan applies only to the City and thus focuses solely on the City's discharges to Boulder Creek from the MS4. **Table 1-7** and **Figure 1-5** document the characteristics and locations of these nine outfalls, including the percent *E. coli* reductions needed per the estimates in the TMDL and the jurisdictions associated with the sewersheds to each of these outfalls (Tetra Tech 2011a).

Table 1-7. Estimated Reductions Required at Outfalls Evaluated for TMDL (Adapted from Table 8-1, Tetra Tech 2011a)

TMDL Outfall	Ownership	Average Flow (cfs)	E. coli Geomean (CFU/100 mL)	Allowable Load (CFU/Day)	Existing Load (CFU/Day)	Estimated Reduction to Meet Allowable Load (%)
Outfall 1	City	0.01	31	3.08E+07	7.59E+06	0
Outfall 2	City	0.012	2498.5	3.70E+07	7.34E+08	95
Outfall 3	City/CU	0.156	85.5	4.81E+08	3.26E+08	0
Outfall 4	CU	0.038	183.8	1.17E+08	1.71E+08	31.4
Outfall 5	CU	0.013	95.5	4.01E+07	3.04E+07	0
Outfall 6	City/CU	0.11	1029.7	3.39E+08	+2.77E+09	87.8
Outfall 7	City/CU	1.64	714.7	5.06E+09	2.87E+10	82.4
Outfall 8	City	0.011	435	3.39E+07	1.17E+08	71.0
Outfall 9	City/CU	0.0086	835.2	2.65E+07	1.76E+08	84.9

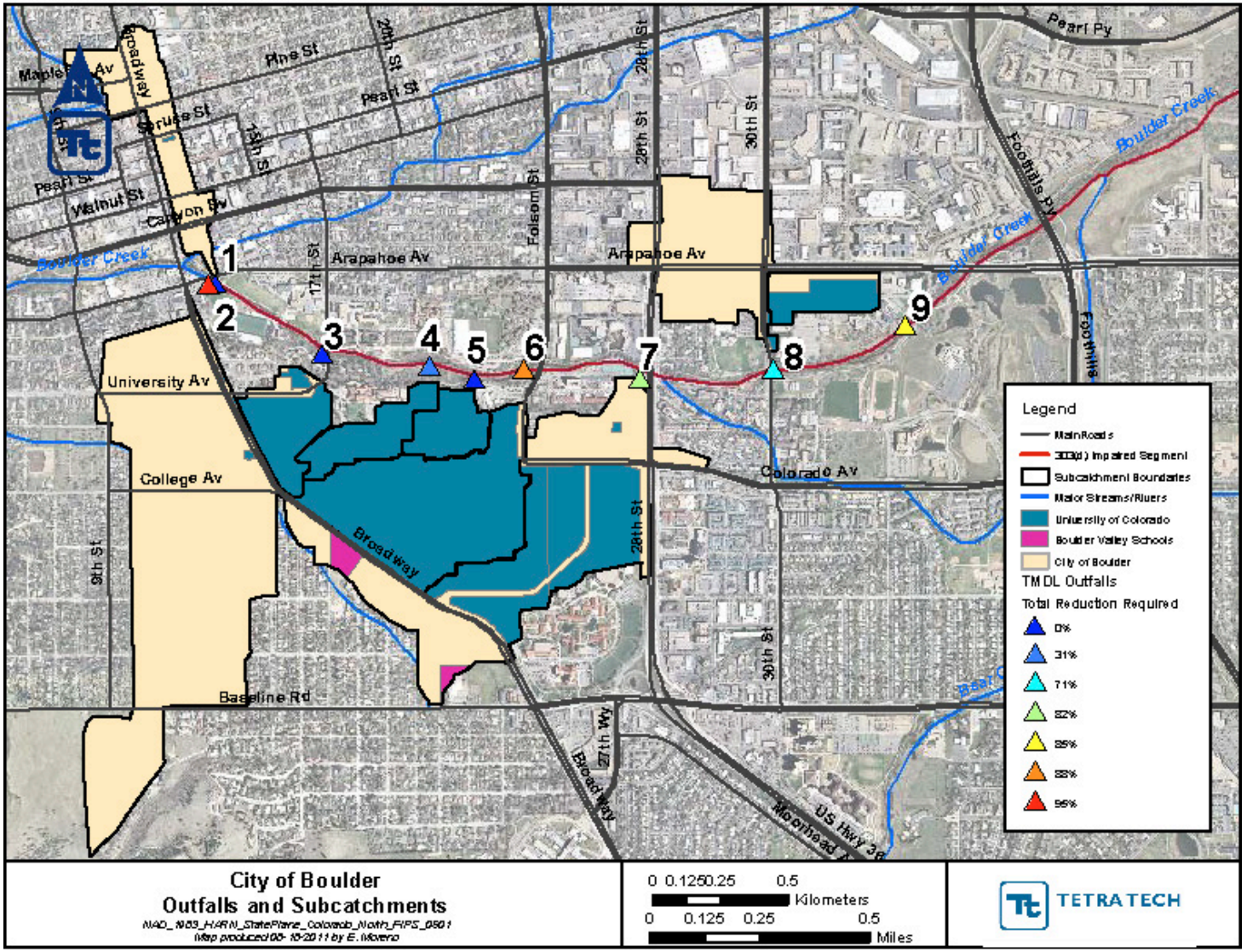

Figure 1-5. Location and Jurisdictions Associated with the Nine MS4 Outfalls Evaluated in the 2011 TMDL with Estimated Required Load Reductions (also see Table 1-7) (Tetra Tech 2011a)

2.0 City Stormwater Management Program

The City is authorized to discharge stormwater from its MS4 under Colorado Discharge Permit System (CDPS) No. COR090000. The effective date of the current MS4 Permit is July 1, 2016 and it expires June 30, 2021. The MS4 Permit, which applies to all lands within the City limits of Boulder, establishes a standard MS4 program that relies on the implementation of a range of control measures to reduce pollutants in MS4 discharges. The MS4 Permit also establishes Boulder Creek TMDL-specific monitoring and reporting requirements. The Permit requires the City to submit its application for permit renewal no later than 180 days before the expiration date, or December 31, 2020. The following sections summarize requirements for the management of stormwater based on existing City regulations, standards and policies and the requirements of the CDPS MS4 Permit.

2.1 City Codes, Standards and Policies

The City has established codes, standards and policies that provide the foundation for the implementation of stormwater management activities that support implementation of the MS4 Permit. This section provides only a brief summary of key codes, standards and policies that support MS4 Permit implementation and compliance. The referenced documents should be consulted for more information. The City periodically reviews these authorities and makes modifications as necessary to facilitate MS4 Permit implementation.

2.1.1 Boulder Revised Code

Stormwater management in the City is facilitated by the following key parts of the Boulder Revised Code (BRC), as summarized:[5, 6]

Title 11 - Utilities and Airport, Chapter 5 – Storm Water Management and Flood Management Utility (*Note: This document section will be updated following completion of the current process to update this section of the BRC*)

Key sections within this portion of the BRC that are relevant to the management of stormwater include:

- Section 11-5-1, *Legislative Intent*, establishes that the purpose for stormwater management is to protect the public health, safety and welfare. Subsections further define the City's intent when managing stormwater, including both stormwater quality and flood management.

[5] BRC code is available at: https://library.municode.com/co/boulder/codes/municipal_code?nodeId=18020
[6] This section is not intended to be an exhaustive list of BRC sections that may be applicable to stormwater management in the City.

- Section 11-5-2, *Definitions*, provides key definitions relevant to management of the MS4 system, including: facilities, pollutant, and stormwater quality best management practices (BMPs).

- Section 11-5-5(a), *Discharges to the Storm Water Utility System*, defines prohibited dischargers: No user or other person shall discharge any sewage, other polluted waters, or other deleterious substance from any premises within the city into or upon any public highway, street, sidewalk, alley, land, public place, stream, ditch, or other watercourse or into any cesspool, storm or private sewer, or natural water outlet, except where suitable treatment has been provided in accordance with provisions of applicable federal, state, and local laws.

- Section 11-5-5(d), *Discharges to the Storm Water Utility System*, exempts the following discharges from the discharge permit requirements: Landscape irrigation and lawn watering associated with single-family detached or duplex development, uncontaminated groundwater from an individual single-family residential detached or duplex foundation drainage system, individual residential car washing or car washing of less than two consecutive days in duration for charity or nonprofit fundraising, dechlorinated swimming pool discharges, water line and fire hydrant flushing, firefighting activities or street cleaning operations conducted by the city.

- Section 11-5-6, *Master Drainage Plan, Land Development and Discharges into the Storm Water System*, provides requirements associated with construction and maintenance of stormwater BMPs.

- Section 11-5-9, *Storm Water and Flood Management Utility*, authorizes the City to collect stormwater and flood management fees from the owners of developed or partially developed parcels of land and collect a stormwater and flood management investment fee from persons planning to develop property in the city or annex developed property into the City.

Title 6 – Health, Safety, and Sanitation; Chapter 1 – Animals

Management of pet waste is an important element of any stormwater management program. BRC Section 6-1-18, *Removal of Animal Excrement Required*, establishes regulations regarding the clean-up of animal excrement on property other than the property of the animal owner.

Title 9 – Land Use Code; Chapter 9 – Development Standards

City development standards particularly relevant to the management of stormwater and reducing urban runoff during dry weather conditions include:

- Section 9-9-12, *Landscape and Screening Standards*, addresses land use regulations, including City development standards and standards and criteria for water conservation and irrigation. These regulations promote development of sustainable landscapes and

improvement of the quality of the environment by, among other things, reducing the amount and rate of stormwater runoff, improving stormwater runoff quality, and increasing the capacity for groundwater recharge.

- Section 9-9-13, *Streetscape Design Standards*, establishes requirements for streetscape designs including planting requirements and compliance with water conservation and irrigation standards established in BRC Section 9-9-12.

2.1.2 Design and Construction Standards

Chapter 1, Section 1.01(A), *General Requirements, Intent*, of the City's Design and Construction Standards (DCS)[7] states that the DCS are intended to protect the public health, safety and welfare in the provision and maintenance of public improvements within the City. The DCS applies to the comprehensive design and construction of adequate and functional public improvements associated with developing, redeveloping and subdividing lands and providing necessary right-of-way, transportation, and utility services.

DCS Chapter 7, *Stormwater Design*, establishes requirements for design of MS4-related facilities. Section 7.01(A), *Intent*, provides the underlying intent of the Storm Water Design Standards. Specifically, these standards are "intended to provide for a comprehensive and integrated stormwater utility system to convey and manage storm waters in order to mitigate safety hazards and minimize property losses and disruption due to heavy storm runoff and flooding, maintain travel on public streets during storm events, enhance water quality of storm runoff by mitigating erosion, sediment and pollutant transport, control and manage increased runoff due to local development, establish effective long-term management of natural drainageways, and provide for ongoing and emergency maintenance of public storm water systems.".

DCS Chapter 7 also recognizes that stormwater systems may have multiple functions or benefits. Chapter 7, Section 7.01(I), *Multiple Functions of Major Drainageways*, recognizes the potential for stormwater utility systems to have multiple functions: "Boulder Creek's numerous tributaries are part of a comprehensive natural open drainageway system. These drainageways provide open corridors and serve multiple functions, including without limitation, storm water drainage and flood conveyance, wetlands and water quality enhancement, environmental protection and preservation, open space and wildlife areas, and recreational activities and trail corridors. Storm water improvements impacting these drainageways shall be designed and constructed to respect, restore and enhance these functions in order to maintain the creek corridor ecology, environment and aesthetic value of such drainageways."

[7] https://bouldercolorado.gov/plan-develop/design-construction-standards

2.1.3 City Homelessness Strategy

Homeless encampments can be a source of pollutants to receiving waters. BRC Section 5-6-10, *Camping or Lodging on Property Without Consent*, prohibits people from camping within parks, parkways, recreation areas, open space or other city property. The City Council approved a Homelessness Strategy for the City on June 20, 2017 (City of Boulder 2017a). The purpose of the strategy is to (https://bouldercolorado.gov/homelessness/homelessness-strategy):

- Clarify city goals in addressing homelessness;
- Maximize efficiency and effectiveness of city resources in reducing homelessness;
- Engage community and regional partners broadly in solutions; and
- Provide a strategic road map for city action on homelessness.

2.2 MS4 Permit Requirements

As stated above, the City is authorized to discharge through an MS4 Permit issued by the Division according to Colorado Regulation 61.[8] The City's MS4 is regulated under the Division's General Permit applicable to communities subject to Phase II MS4 Permit requirements. In accordance with this Permit, MS4 operators must, "develop, implement, and enforce a stormwater management program designed to reduce the discharge of pollutants from MS4 to the Maximum Extent Practicable (MEP), to protect water quality, and satisfy the appropriate water quality requirements of the Colorado Water Quality Control Act (61.8(11)(a)(i))."

The Phase II MS4 program relies on the implementation of control measures to reduce pollutants in stormwater. "Control measures" means "any best management practice or other method used to prevent or reduce the discharge of pollutants to waters of the state. Control measures include, but are not limited, to best management practices."[9] The sections below summarize the key control measures required by the City's MS4 Permit.

2.2.1 Existing Control Measures

Section E of the City's MS4 Permit establishes "Pollutant Restrictions, Prohibitions and Reduction Requirements and Recordkeeping" requirements. These Permit elements establish the minimum programmatic requirements to comply with the MS4 Permit. These requirements may be supplemented where needed to comply with other water quality requirements, e.g., as imposed by a TMDL. Following is a brief description of the existing

[8] WQCC, Regulation No. 61 – Colorado Discharge Permit System, 5CCR 1002-61
[9] Part I.B, CDPS MS4 General Permit COR090000

MS4 control measures as required by the Permit and ongoing activities to implement them to support compliance with the TMDL.[10] Their potential use as well as other potential control measures to support implementation of this plan are further discussed as needed below.

2.2.1.1 Public Education and Outreach

The MS4 Permit requires implementation of a public education and outreach program to promote changes in public behavior to reduce pollutants in discharges from the MS4. This program focuses on the following:

- *Illicit discharges* – The City is to provide information to businesses and the general public regarding prohibitions and impacts of illicit discharges on water quality. Per the Permit, the City is required to identify targeted businesses likely to cause an illicit discharge or improperly dispose of waste and develop and implement at least one education and outreach activity to those businesses identified. In addition, up to four education and outreach activities of various types are to be implemented each year.
- *Nutrients* – The Permit requires that the City provide education on reducing water quality impacts associated with nitrogen and phosphorus in discharges from the MS4. This requirement may be implemented by the City individually or collaboratively with other MS4 permittees. Program elements include identification of targeted nutrient sources (e.g., residential, industrial, agricultural, or commercial) that are contributing to, or have the potential to contribute, nutrients to surface waters. The City must prioritize which targeted sources are likely to obtain a reduction in nutrient discharges through education and distribute educational materials or conduct outreach to the prioritized targeted sources.

2.2.1.2 Illicit Discharge Detection and Elimination

The City is required to implement an IDDE program to effectively prohibit illicit non stormwater discharges. This program includes the following key elements:

- *Storm Sewer System Map* – Regular maintenance and update of a map of the location of all MS4 outfalls within the permit area, and the names and location of all waters that receive discharges from the City's MS4 outfalls.
- *Regulatory Mechanism* – The City is to ensure it has the appropriate regulatory mechanisms in place to (a) prohibit illicit discharges to the MS4; (b) have the ability to request access to a property to implement IDDE procedures; (c) have the legal ability to ensure that identified illicit discharges are ceased and/or removed; and (d) enforce the IDDE program, including imposing penalties.

[10] These are brief summaries of permit requirements and not intended to be exhaustive. The MS4 permit should be reviewed to identify the specific compliance requirements.

- *Illicit Discharge Response* – The City must have procedures to (a) trace the source of an illicit discharge; (b) remove the illicit discharge, including procedures for the cleanup of materials associated with an illicit discharge; and (c) enforce the elimination and/or removal of an illicit discharge.
- *Priority Areas* - The City is required to locate priority areas with a higher likelihood of having illicit discharges, including areas with higher likelihood of illicit connections.
- *Staff Training and Recordkeeping* – City staff is to receive appropriate training to implement the requirements of this program and keep appropriate records of implementation activities.

2.2.1.3 Construction Sites

The permittee must implement a program to reduce or prevent the discharge of pollutants to the MS4 from applicable construction activities as defined by the Permit. The program requires (a) development of site plans, that when implemented, minimize the discharge of pollutants; (b) various types of inspection procedures; (c) enforcement procedures; and (d) staff training and recordkeeping requirements.

2.2.1.4 Post-Construction Stormwater Management in New Development and Redevelopment

The MS4 Permit requires the City to implement a program to reduce the discharge of pollutants to the MS4 from site post-development. Where applicable to a development site, the Permit establishes minimum requirements that must be implemented to address the selection, installation, implementation, and maintenance of control measures. Control measures must meet a "base design standard" which is the minimum designed standard for new development and redevelopment. These base design standards vary depending on the nature of the development. The Permit also establishes (a) inspection and maintenance requirements to ensure the control measures are installed and implemented as designed; (b) enforcement procedures; (c) tracking procedures to track location of control measures; and (d) staff training and recordkeeping requirements.

2.2.1.5 Pollution Prevention/Good Housekeeping

The City is required to implement a program for Pollution Prevention/Good Housekeeping for municipal facilities and operations that they own, operate, or perform within the permit area. The program must prevent or reduce water quality impacts from pollutants being discharged to the MS4 from municipal facilities and operations that are not otherwise authorized by a separate discharge permit. The program must include (a) design, implementation and maintenance of control measures; (b) municipal facility runoff control measures; (c) municipal operations/maintenance procedures; (d) nutrient source reduction procedures; (e) secondary containment or equivalent protection procedures to prevent spills to surface waters; and (f) staff training and recordkeeping requirements.

2.2.2 Monitoring Program

Part I.F.7 of the Permit establishes general monitoring and sampling requirements and water quality analyses conducted under the Permit. Part III establishes monitoring requirements specific to the TMDL. These requirements are described below.

2.2.3 TMDL Implementation

Part III of the Permit establishes TMDL-specific monitoring and reporting requirements specific to the City and Boulder County (**Table 2-1**). Consistent with these requirements, the City conducts *E. coli* weekly/monthly monitoring at both MS4 outfall and receiving water sites in the urban areas of the Boulder Creek watershed. The City also implements special studies as needed to support TMDL implementation. For example, the City completed an outfall survey in 2015 and 2017 to assess outfall locations following the 2013 flood, identify any illicit discharges, and assess water quality (City of Boulder 2017b, 2018). In 2017, the City implemented a special study at selected outfall locations to identify potential human sources of bacteria to Boulder Creek (City of Boulder 2018).

Table 2-1. City MS4 Permit Requirements Specific to TMDL Implementation (adapted from Part III of the MS4 Permit)

Element	MS4 Permit Requirements
Monitoring	The permittee is to conduct monitoring as necessary to identify progress towards meeting the WLA in the Bacteria TMDL.
Reporting	• Description of all control measures implemented by the permittee to reduce the discharge of *E. coli* to COSPBO02b from 13th Street to South Boulder Creek. • Identification of all illicit discharges identified or suspected by the permittee to contribute to discharges from the MS4 in exceedance of the *E. coli* water quality standard. • Indication that identified illicit discharges have been eliminated. If the discharge has not been eliminated, a description of any planned control measure that the permittee intends to take to address the discharge must be included. • Description of monitoring activities conducted, or planned, to meet the monitoring requirement.

2.2.4 MS4 Reporting Requirements

The City submits an Annual Report to document the stormwater management activities conducted annually to fulfill the requirements of its MS4 Permit. The Permit includes specific TMDL reporting requirements (**Table 2-2**). Table 1-1 above summarizes the types of activities that the City has been implementing to reduce or eliminate *E. coli* in its MS4. This information is updated as part of the Annual Report submittal.

Table 2-2. MS4 Permit Annual Reporting Requirements Specific to TMDL Implementation (adapted from Part III of the MS4 Permit)

Element	MS4 Permit Requirements
First Annual Report (March 2017)	• Information on *E. coli* control measures implemented prior to the effective date of the Permit. • Information on illicit discharges identified prior to the effective date of the Permit. • Description of all control measures planned by the City to reduce the discharge of *E. coli* to Boulder Creek Segment 2b, including specific target dates for implementation. • Information on monitoring prior to the effective date of the Permit conducted to identify progress towards meeting the TMDL's WLA.
Annual Reports (2018 and following)	• Description of all control measures implemented by the permittee to reduce the discharge of *E. coli* to Segment COSPBO02b from 13th Street to South Boulder Creek. • Identification of all illicit discharges identified or suspected by the permittee to contribute to discharges from the MS4 in exceedance of *E. coli* water quality standard. • Indication that identified illicit discharges have been eliminated. If the discharge has not been eliminated, a description of any planned control measure that the permittee intends to take to address the discharge must be included. • Description of monitoring activities conducted, or planned, to meet the monitoring requirement.

3.0 TMDL Implementation Plan

This Section describes the Implementation Plan that the City will implement to facilitate compliance with the TMDL's WLAs applicable to the City's MS4. The following sections are included:

- *Section 3.1: Compliance Principles* – Summarizes the key principles that guide the City's activities to comply with the WLAs established by the TMDL.
- *Section 3.2: TMDL Implementation Activities* – Describes the stepwise approach the City is implementing to comply with the WLAs.
- *Section 3.3: Sequence of Implementation Activities* – Describes how the TMDL Implementation Plan tasks align over the long-term.

3.1 Compliance Principles

The 2011 TMDL established WLAs applicable to selected City MS4 outfalls for different flow conditions (Tetra Tech 2011a). The TMDL did not specify important considerations, such as the identification of compliance assessment locations, how to measure progress towards achieving compliance with the WLAs, or how the WLAs relate to the MEP principle applicable to discharges from an MS4 system. The TMDL also does not define any priorities, especially with regards to protecting the recreation beneficial use during the critical period. Given these uncertainties, the City developed the following key principles to guide its efforts to implement the TMDL so that resources directed towards reducing bacterial indicators in the MS4 target the highest priorities.

Principle 1 - System-wide Compliance Strategy

The TMDL includes specific WLAs for nine MS4 outfalls within the impaired reach of Boulder Creek, but states that with more data "required reductions and allocations may be revisited" (Tetra Tech 2011a). Given the likely significant variability in flows and *E. coli* concentrations in a given outfall under dry weather conditions and the uncertainty stated in the TMDL, these outfall-specific WLAs may only be considered estimates. As will be discussed below, the City's implementation approach relies on a prioritized outfall approach to focus resource allocation. Accordingly, while the City may evaluate the efficacy of reducing bacterial indicator loads from implementation of specific BMPs activities within an MS4 outfall sewershed, the City will rely on a system-wide approach for measuring compliance with the TMDL (see Principle 2).

Principle 2 - Measures of Compliance

The WLA applicable to the City's MS4 under dry weather conditions is 4.97E+09 CFU/Day (see Table 1-5 above, Tetra Tech 2011a). As noted in Table 1-3, the City's MS4 WLA was

determined by first subtracting the MOS, the WLA allocated to the San Lazaro WWTF and the upstream nonpoint source LA from the TMDL for Segment 2b. This calculation resulted in a WLA applicable to all MS4 permittees included in the TMDL. To determine the City's specific MS4 WLA, the total MS4 WLA was subdivided based on jurisdictional area of land under each MS4 jurisdiction within the watershed. The resulting WLA assumes:

- All point and nonpoint sources of bacterial indicators to the impaired reach have been correctly identified;
- The bacterial indicator load applicable to the City's MS4 is correctly estimated; and
- All *E. coli* represented by the City's WLA is controllable (also see Principle 5 below).

The TMDL assumes that if all WLAs and LAs are met then Segment 2b will attain its *E. coli* water quality standard and the recreation use will be attained. Given these assumptions, their inherent uncertainties and the recognition that bacteria reduction activities carried out by other entities responsible for TMDL implementation are necessary to achieve the TMDL, it is understood that even after the City mitigates its controllable sources of bacteria, Segment 2b of Boulder Creek may still not attain its *E. coli* water quality standard. This possible outcome is due, in part, to the potential for the presence of other unaccounted for sources of bacterial indicators and the fact that other entities are responsible for controlling their WLAs assigned by the TMDL. Because there may not be a direct relationship between City compliance and attainment of the *E. coli* water quality standard in Boulder Creek, the City will use alternative measures to evaluate the progress it makes through implementation of this Plan, e.g.:

- Re-evaluations of the mass balance of *E. coli* in Boulder Creek and the portion attributable to the City's MS4 (using the same calculation methods established in the TMDL). A decrease in the portion attributable to the MS4 would demonstrate progress.
- Evaluations of bacteria load reductions from specific outfalls that discharge to Boulder Creek during dry weather conditions.[11] The purpose of these evaluations is not to evaluate compliance with WLAs assigned by the TMDL to specific outfalls (see Table 1-7 above). Instead, the City will use these evaluations to measure the effectiveness of specific activities implemented to mitigate controllable bacteria sources in the sewershed (drainage area) that drains to the outfall.
- Documentation of a reduction or elimination of flow from MS4 outfalls under dry weather conditions because the sources of flow to the MS4 have been mitigated.
- Documentation of the implementation of targeted BMPs designed to mitigate a source of controllable bacteria (see Principle 5).

[11] Dry weather conditions mean that no measurable rainfall has occurred in the area within the previous 72 hours

Principle 3 - Demonstration of TMDL Compliance Through MS4 Permit

The USEPA recommends implementation of a BMP-based approach as the means to comply with WLAs assigned to urban runoff permitted through an MS4 Permit, as long as the defined approach includes clear, specific, and measurable elements that include milestones or other mechanisms to track progress (USEPA 2014). The stepwise approach described below results in establishment of a Sewershed Management Plan (SMP) to mitigate controllable sources of bacteria from a prioritized outfall. This plan would include milestones or other mechanisms that the City will use to track progress towards compliance with the TMDL. For the purpose of this Plan a sewershed is defined as the drainage area that contributes stormwater to a defined outfall(s).

Principle 4 - Critical Condition

This Plan targets the critical condition, i.e., the period in time defined in the TMDL when the most significant load reductions are needed to ensure attainment of water quality standards and protection of the recreational beneficial use. It is generally assumed that attainment of water quality standards under the critical condition will ensure attainment during all other conditions. The TMDL defines the critical period as May through October, the period during which recreation most frequently occurs.

Principle 5 - Mitigation of Controllable Sources of Bacteria

Sources of *E. coli* bacteria in the environment are numerous and consist of both anthropogenic and non-anthropogenic sources (**Table 3-1**). Strict compliance with WLAs for all bacteria sources in an MS4 is not only challenging, but may not be possible, given the potential uncontrollable nature of some sources (UDFCD and CCD 2016). The controllability of bacteria was recently dealt with regulatorily in the Santa Ana Region of California, which adopted regulations that distinguish between controllable and uncontrollable sources of bacteria – essentially providing definition to what is MEP in the context of an MS4 (Santa Ana Water Board[12] 2012a, 2012b, 2016). These regulations, which have been approved by the USEPA (2015a, 2015b) define what is controllable and uncontrollable and summarize what is required when implementing the regulation in an MS4 Permit (**Figure 3-1**).

Under this Plan the City focuses on mitigating controllable sources of bacteria, in particular anthropogenic sources of bacteria, with emphasis on eliminating all bacteria sources attributable to human sources, i.e., bacteria resulting from the presence of human waste and sewage. This approach addresses the greatest human health risk of exposure to *E. coli* and allocates resources to what can most reasonably be controlled in an urban environment. This

[12] The Santa Ana Water Board is the designated regulatory agency for implementation of Clean Water Act requirements within the Santa Ana River Region in southern California.

approach is consistent with the intent of implementing BMPs to reduce pollutants in the MS4 to MEP.

Table 3-1. Potential Sources of Fecal Indicator Bacteria in Urbanized Areas and Adjoining Watersheds (UDFCD & CCD 2016, originally adapted from Armand Ruby Consulting 2011)

General Category	Bacteria Source/Activity
Municipal Sanitary Infrastructure (piped)	• Sanitary sewer overflows • Leaky sewer pipes (Exfiltration) (see Sercu et al. 2011) • Illicit Sanitary Connections to MS4 • WWTFs (if inadequate treatment or upsets)
Other Human Sanitary Sources (some also attract urban wildlife)	• Homeless encampments • Porta-Potties • Dumpsters (e.g., diapers, pet waste, urban wildlife) • Swimmers/bathers, boaters, trail users (e.g., hikers, runners) • RVs (mobile) • Trash cans • Garbage Trucks
Domestic Pets	• Dogs, cats, etc.
Urban Wildlife (naturally-occurring and human attracted)	• Rodents/vectors (rats, raccoons, squirrels, opossums) • Birds (gulls, geese, ducks, pigeons, swallows, etc.) • Open space (coyotes, foxes, beavers, feral cats, etc.)
Other Urban Sources (including areas that attract vectors)	• Landfills • Food processing facilities • Outdoor dining • Restaurant grease bins • Bars/stairwells (washdown areas) • Green waste, compost/mulch • Animal-related facilities (e.g., pet boarding, zoos, off-leash parks)
Urban Non-stormwater Discharges (Potentially mobilizing surface-deposited bacteria)	• Power washing • Excessive irrigation/overspray • Car washing • Pools/hot tubs • Reclaimed water/graywater (if not properly managed)
MS4 Infrastructure	• Illegal dumping • Illicit sanitary connections to MS4 (also listed above) • Leaky sewer pipes (exfiltration) (also listed above) • Biofilms/regrowth • Decaying plant matter, litter and sediment in the storm drain system
Agricultural Sources (potentially including ranchettes within MS4 boundaries or areas in urban growth boundaries)	• Livestock, manure storage • Livestock, pasture • Livestock, corrals • Livestock, confined animal feeding operations (CAFO) (National Pollutant Discharge Elimination System [NPDES]-regulated) • Manure spreading, pastures/crops • Municipal biosolids re-use • Reclaimed water (if not properly managed) • Irrigation tailwater • Slaughterhouses (NPDES-regulated)

Table 3-1. Potential Sources of Fecal Indicator Bacteria in Urbanized Areas and Adjoining Watersheds (UDFCD & CCD 2016, originally adapted from Armand Ruby Consulting 2011)

General Category	Bacteria Source/Activity
Natural Open Space/Forested Areas	• Wildlife populations • Grazing • Natural area parks, off-leash areas
Other Naturalized Sources	• Decaying plants/algae, sand, soil (naturalized fecal indicator bacteria)

Figure 3-1. Definition of Controllable/Uncontrollable Sources of Bacteria (Santa Ana Water Board 2012a, 2016)

Whether or not sources are "controllable" affects the ability of the Regional Board and dischargers to assure that waste discharges are regulated and controlled so as to assure the reasonable protection of beneficial uses.

Uncontrollable bacteria sources refer to contributions of bacteria within the watershed from nonpoint sources that are not readily managed through technological or natural mechanisms or through source control and that may result in exceedances of water quality objectives for indicator bacteria. Specific uncontrollable indicator bacteria sources within the Santa Ana Region may include:

- Wildlife activity and waste
- Bacterial regrowth within sediment or biofilm
- Resuspension from disturbed sediment
- Marine vegetation (wrack) along high tide line
- Concentrations (flocks) of semi-wild waterfowl
- Shedding during swimming

Controllable bacteria sources refer to any bacteria indicator source that can be controlled by treatment or management methods. Requirements for the application of Best Available Treatment technology (BAT) and Best Conventional Treatment technology (BCT) apply to some of these sources (e.g., POTWs); in other cases, such as discharges regulated under the area-wide municipal separate storm system permits ("MS4" permits), reasonable actions to reduce or eliminate the contribution of these sources to the maximum extent practicable are required. These include the implementation of best management practices or other mechanisms. Controllable sources are predominantly anthropogenic in nature and can be reduced in varying degrees. Specific anthropogenic controllable indicator bacteria sources within the Santa Ana Region may include:

- Improper use of fertilizers on residential and commercial properties and agricultural lands
- Improper handling of pet waste
- Cross-connections between the sanitary and storm sewer systems
- Leaky sanitary sewer conveyances
- Discharges from POTWs
- Improper handling and disposal of food waste
- Improper management of CAFO waste and washwater
- Runoff from yards containing fertilizers, pet waste, and lawn trimmings
- Homeless encampments

Certain techniques are available to identify human sources; when practical, those techniques should be used in areas where persistent exceedances of bacteria objectives occur. These source definitions and categories may be further refined as more science becomes available.

Principle 6 - Jurisdictional Issues/Responsibilities

An important element of this Plan is to identify where urban runoff from different jurisdictions is commingled. Where this occurs, the City will work collaboratively with the other jurisdictions to reduce bacteria under dry weather flow conditions. However, the City is not responsible for complying with WLAs applicable to other jurisdictions.

3.2 TMDL Implementation Activities

Part III of the City's MS4 Permit establishes TMDL-specific requirements. Some of the City's existing MS4 program elements will facilitate compliance with the TMDL, e.g., IDDE program. However, it is expected that the City may need to implement additional activities to make progress towards compliance with the WLA.

Figure 3-2 illustrates the basic framework that will guide City efforts to make progress towards meeting the MS4 WLA. **Figure 3-3** expands on this framework to illustrate how various Plan elements are interconnected. Key elements of the framework include:

- *Water Quality Assessment Activities* – Monitoring to gather water quality data to identify priorities and support evaluations of progress towards compliance with the City's MS4 WLA.
- *Tier 1 Prioritization* – Prioritization of MS4 outfalls that contribute *E. coli* bacteria to the impaired reach.
- *Tier 2 Investigation* – Identify suite of *E. coli* bacteria mitigation activities that may be implemented within a sewershed that drains to a Tier 1 prioritized outfall.
- *Reporting and Adaptive Management* – Periodic reporting to (a) demonstrate compliance with this Plan and MS4 Permit requirements; and (b) document progress towards compliance with the WLA. As part of this effort, this Plan may be periodically updated to adapt to changing understanding regarding bacteria sources.

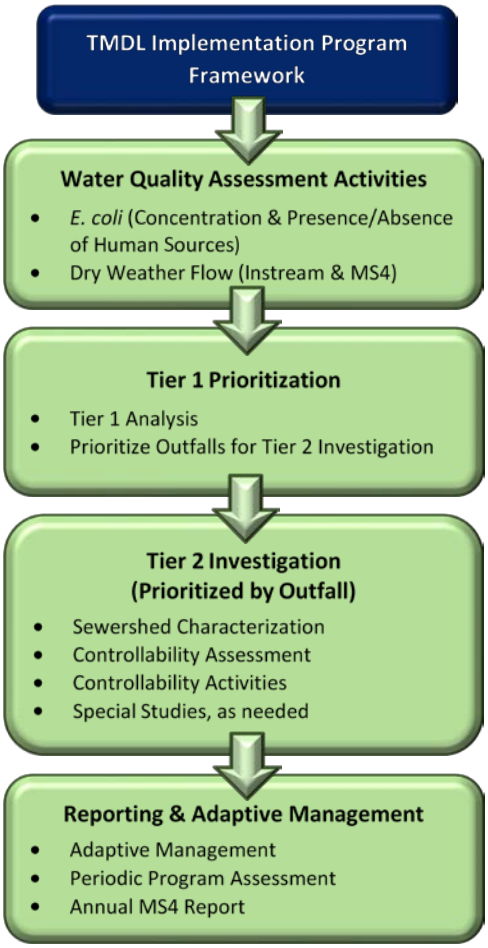

Figure 3-2. TMDL Implementation Plan Framework

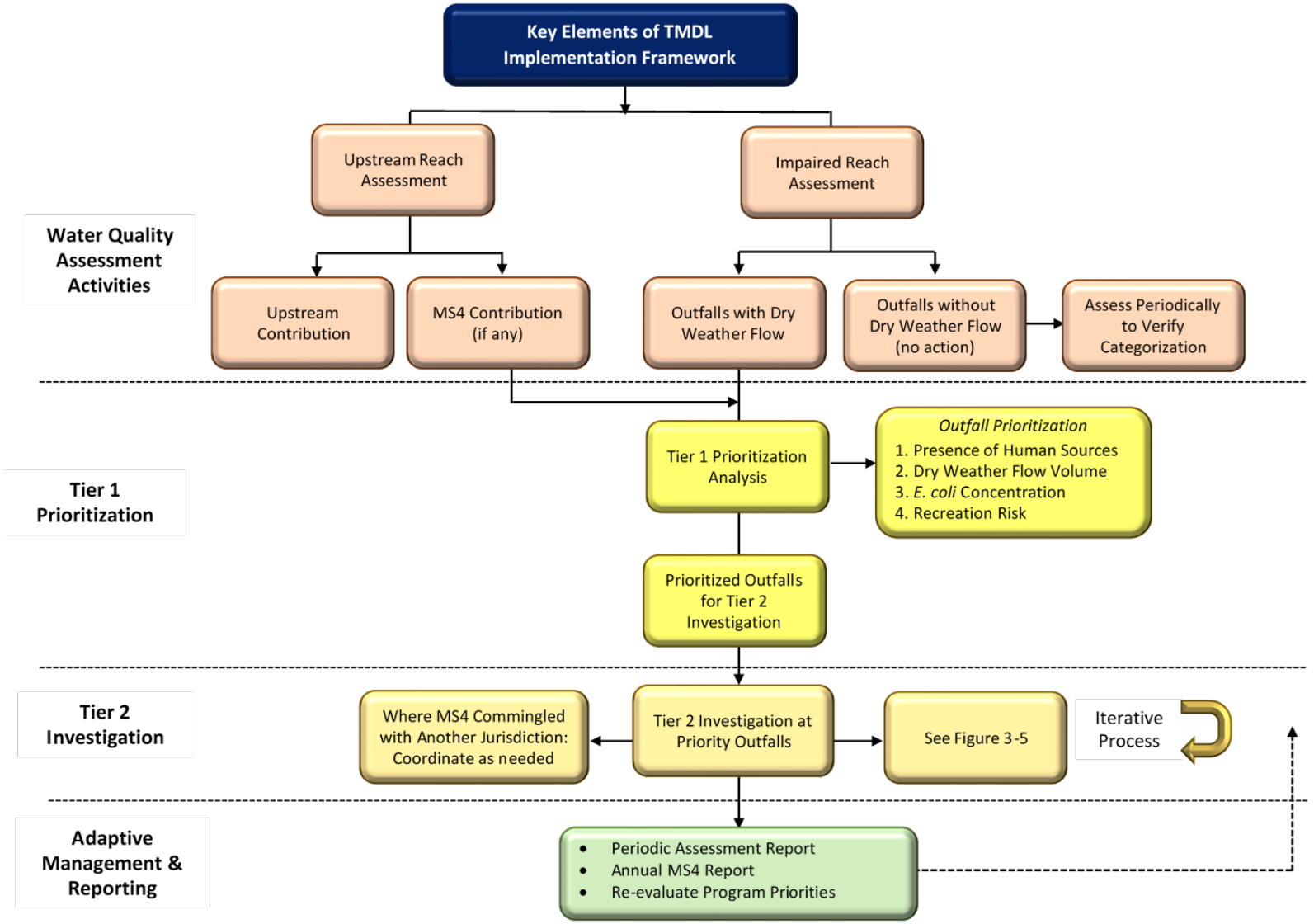

Figure 3-3. Interconnected Elements of TMDL Implementation Plan Framework (See Text)

3.2.1 Water Quality Assessment

The TMDL implementation framework relies on the establishment of priorities based on the findings from a periodic assessment of existing conditions in Boulder Creek. This assessment, which will occur during the critical period at multi-year intervals, will include the following analyses:

- *E. coli* loading from Boulder Creek upstream of the impaired reach
- *E. coli* loading from MS4 outfalls in the impaired reach[13]
- *E. coli* mass balance in the impaired reach

Specific data collection and assessment activities that the City will implement during the assessment period are described in the sections below.

3.2.1.1 Upstream Reach

The City will periodically assess flow levels and bacteria concentrations in waters entering the impaired reach from upstream. The assessment location will be at the Boulder Creek at Boulder, Colorado gage located near the Broadway Street bridge over Boulder Creek.[14] In addition, the City will evaluate, on an as needed basis, flow and bacteria concentrations under dry weather conditions in MS4 outfalls that drain to Boulder Creek upstream of the impaired reach. The findings from these data collection activities support the following:

- *Upstream Bacteria Load* – The TMDL established a LA applicable to upstream flows entering the impaired reach (see Table 1-5). Per the TMDL, "...upstream load allocation generally includes loading from septic systems, wildlife and, recreational (or bodily) contact to the stream" (Tetra Tech 2011a). New assessment data will be collected to evaluate whether this upstream load has changed.
- *MS4 Bacteria Contribution* – The TMDL does not identify bacteria loads contributed by MS4 outfalls that discharge to Boulder Creek upstream of the impaired reach. If the MS4 is contributing bacteria to this upper reach, these loads are incorporated in the upstream LA established in the TMDL. **Figure 3-4** notes the locations of MS4 outfalls upstream of the impaired reach. These MS4 outfalls have the potential to discharge flow during dry weather conditions to the upstream reach, although previous assessments have shown their contributions to be minimal. These upstream outfalls will be periodically assessed to verify that bacteria loads entering the impaired reach from these outfalls remain low. If any outfalls are found to be contributing significant bacteria loads, then these outfalls will be (a) assessed to determine their contribution to the *E. coli* load in the upstream reach; and (b) included in the Tier 1 prioritization of outfalls (see below).

[13] The City will rely on instantaneous flow measurement techniques

[14] https://www.dwr.state.co.us/SurfaceWater/data/stationdescription.aspx?ID=BOCOBOCO&MTYPE=DISCHRG

Figure 3-4. MS4 Outfalls Located Upstream of the Impaired Reach

3.2.1.2 Impaired Reach

The City will collect data from the impaired reach, as needed, to evaluate the following:

- *MS4 Outfalls* – During the critical period, the City will periodically assess the flows occurring under dry weather conditions and bacteria concentrations associated with each of the nine MS4 outfalls included in the TMDL (see Figure 1-5 and Table 1-7). These nine outfalls will be sampled for flow and *E. coli* concentrations at appropriate intervals during the critical period to verify consistency in observations. Monitoring frequencies may be tailored to individual outfalls based on data needs. For example, if the City is actively implementing bacteria mitigation activities in the sewershed draining to an outfall, an increased monitoring frequency may be warranted at that location. In addition to these nine outfalls, the City will visit, as needed, other MS4 outfalls that discharge to the impaired reach to determine if there have been any notable changes in flow characteristics during dry weather conditions (currently these other outfalls contribute minimal or no flow to the impaired reach). If a significant change in flow is observed at any outfall, the City may collect *E. coli* data from outfall.

- *In-Stream Bacteria Concentrations* – The TMDL established an existing bacteria load at Boulder Creek & 30th Street (sample site BC-30) - see Table 1-2 above or Table 7-5 in the TMDL (Tetra Tech 2011a). As part of the water quality assessment that occurs at multi-year intervals, flow and *E. coli* data will be collected from this location to assess any changes or trends in the *E. coli* concentration and load. The City may also collect Boulder Creek samples at 55th St. to evaluate changes or trends in *E. coli* concentration and load at the downstream end of the impaired reach. The only purpose for data collection from these locations is to assess changes or trends in water quality in Segment 2b; it is not to assess compliance with the TMDL as a whole, given that the City is only responsible for compliance with the WLA applicable to its MS4.

3.2.1.3 Water Quality Assessment Outcome

- *Receiving Water Ambient Conditions and Trends Assessment* - The MS4 Permit requires the City and Boulder County to monitor *E. coli* as necessary to identify progress towards meeting the WLA. Data generated from this activity can be used to document ambient *E. coli* conditions and trends in the impaired reach.

- *Source Contribution Analysis* - The TMDL source assessment chapter (Chapter 5) summarizes flow and *E. coli* concentrations contributed by point and nonpoint sources, as known at the time of TMDL development (Tetra Tech 2011a). Analyses from water quality assessment data will include the following:

  - *MS4 Outfalls* – Bacteria loads from MS4 outfalls will be evaluated, especially where mitigation activities are active within an outfall's sewershed. The results of these analyses provide a basis for evaluating progress towards reducing controllable sources of bacteria in the MS4.

- *Mass Balance Analysis* – The TMDL not only assumes that all sources of bacteria have been adequately characterized but uses that information to back-calculate a load applicable to the MS4. Periodically data collected from the MS4 (flow and bacteria) will be analyzed along with upstream publicly owned treatment works (POTW) and instream data to assess whether all nonpoint sources of bacteria have been adequately characterized. If the analysis shows that the blend of MS4 and POTW loads coupled with expected nonpoint source loads (as predicted by the TMDL) cannot explain instream *E. coli* concentrations, that finding would indicate there are "unaccounted for" sources of *E. coli* in the impaired segment. Examples of common sources that may be unaccounted for include unidentified illegal and illicit discharges, wildlife, homeless encampments, *in situ* growth, resuspension from sediments or biofilms, or even air deposition (see Table 3-1 of potential bacteria sources).

  The level of detail/data collection required to complete a mass balance analysis can vary significantly. For the purposes of this Plan, the City will develop its estimation using a similar approach as was used in the original TMDL relying on the following minimum data sources (flow and bacteria): (a) POTW effluent; (b) MS4 outfalls; and (c) instream data that best represents flow and *E. coli* concentrations immediately above and within Segment 2b. While the mass balance analysis could be conducted at any site within the impaired reach, this analysis will focus primarily on the Boulder Creek at 30th St location (sample site BC-30th), which was identified in the TMDL, "as the location with the greatest degree of impairment" (Section 6.3 in Tetra Tech 2011a). The mass balance at other sites may also be evaluated as needed to better understand bacteria concentration changes in the impaired reach.

- *Data for Tier 1 Prioritization* – Water quality assessment data will be used to establish a priority for investigation and mitigation of controllable *E. coli* sources in MS4 outfalls. Mitigating controllable *E. coli* sources in an MS4 can be challenging. Therefore, a prioritized approach is warranted because it not only targets implementation activities, but it also allows the City to allocate resources to the highest water quality priorities first. Section 3.2.2 below provides the initial Tier 1 prioritization for the impaired reach; this prioritization will be re-evaluated as needed using data from water quality assessment activities.

3.2.2 Tier 1 Prioritization

The purpose of the Tier 1 Prioritization process is to identify the priority for implementing Tier 2 investigation activities within the City's MS4. These activities will typically occur in only one sewershed at a time to focus the City's resources on the most significant water quality concerns within the MS4 discharging to the impaired reach. The sections below describe the process for completing a Tier 1 prioritization and provides the results of the initial prioritization. The City will review its Tier 1 priorities after completing a water quality assessment as described above.

3.2.2.1 Prioritization Process

Based on the findings from water quality assessment activities (see above), the City prioritizes its MS4 outfalls based on the following criteria:

1. *Risk of Exposure to Human Source Bacteria* – The greatest health risk to recreators is exposure to *E. coli* bacteria from human sources. Accordingly, sewersheds with outfalls where human source bacteria have been observed (qualitatively or quantitatively through the use of accepted Microbial Source Tracking [MST] methods) will have a higher priority for mitigation than a site where human source bacteria have not been observed.
2. *Mean Dry Weather Flow* – Outfalls with higher mean dry weather flows during the critical period are more likely to contribute a higher load of *E. coli* to Boulder Creek than outfalls with lower mean dry weather flows. Higher flows may not only transport increased bacteria loads, they may also mobilize bacteria in biofilms or sediments in the MS4. In addition, if dry weather flows are highly variable it would be important to understand the cause of such variability as this finding may be an indicator of an intermittent source of dry weather flow that may be controllable. Sewersheds with outfalls that have higher mean dry weather flows are a higher priority for implementation of bacteria indicator mitigation activities.
3. *E. coli Geomean* - Outfalls with the highest geomean *E. coli* concentrations during the critical period are more likely to be causing or contributing to an exceedance of *E. coli* in Boulder Creek. These outfalls are a higher priority for implementation of mitigation activities.
4. *Risk to Recreation Activity* – While the entire impaired reach of Boulder Creek is protected for recreation, a higher priority could be assigned to outfalls that drain at or near locations where recreational activities are most likely to occur. If these locations are near MS4 outfalls that are ranked high based on other factors such as the presence of human source bacteria, or higher *E. coli* loads, then these locations will be ranked higher. Accordingly, each outfall is weighted based on risk of exposure during recreation. The weighting is based solely on anecdotal information or direct observations of recreators. This factor is considered optional given that most recreation in Boulder Creek occurs above the impaired reach; however, if observations made during regular field activities finds that recreational activity is higher around any of the MS4 outfalls, then this factor may be used to adjust priorities.

The Tier 1 prioritization process establishes a means for the City to prioritize MS4 outfalls for subsequent work to identify and mitigate controllable sources of *E. coli*. The criteria categories consider both a scoring and weighting process as follows: (a) a higher weight is applied to sites where collection to date indicates the potential presence of human sources of bacteria and the scoring factor range is applied based on concentration levels measured (higher score for higher concentration, etc.) ; (b) lower but equal weights are applied to the dry weather flow and *E. coli* concentration factors and the scoring factor range can address

high or low flow and *E. coli* concentrations (higher score for higher flow and higher concentration, etc.); (c) a lower weight is applied to recreational activities and the scoring factor can address whether recreation occurs or not (higher score for known recreations areas, etc.). The Tier 1 prioritization score is the sum of each weighted category score. **Table 3-2** summarizes the criteria described above, the sources of data for the initial Tier 1 prioritization, the basis for scoring outfalls and any weighting factors applied to a scoring factor.

As noted above the City will focus its TMDL implementation activities on only one sewershed at a time. Where the prioritization process identifies outfalls with similar or equal prioritization scores the City will use other information to select the highest priority for implementation of mitigation activities. For example, the City will consider other activities ongoing in the City that may influence water quality at a high ranked outfall or factors such as the degree to which the City has jurisdictional control over urban runoff to the outfall.

Table 3-2. Factors for Scoring Outfalls for Tier 1 Prioritization

Factor	Data Source	Basis for Scoring	Weighting Factor
Risk of Exposure to Human Bacteria	2017 MST survey (City of Boulder 2018)[1]	High = 5; Moderate = 3; Low/Non-Detect = 1	Weight by a factor of 5, most significant human health concern
Mean Dry Weather Flow	TMDL dry weather flow data in Table 7-4 (Tetra Tech 2011a)	Outfalls ranked by quartile based on the range of observed dry weather flow in all outfalls (1 = lowest quartile; 4 = highest quartile)	Weight by a factor of 3
E. coli Geomean	Geomean of City data (2015-2017), except Outfall 8 which relied on TMDL data in Tetra Tech (2011a)	Outfalls ranked by quartile based on the range of observed dry weather flow in all outfalls (1 = lowest quartile; 4 = highest quartile)	Weight by a factor of 3
Risk to Recreation Activity	City staff observations of relative comparison of use	High = 3; Moderate = 2; Low = 1	Weight by a factor of 1

[1] The 2017 MST survey provided preliminary MST data for consideration in the initial Tier 1 prioritization. The City plans to further evaluate the presence of human sources and the potential for interference in sample results from other sources, e.g., canines or raccoons.

3.2.2.2 Initial Tier 1 Prioritization

Table 3-3 provides the initial prioritization of outfalls which will direct the City's efforts for the first few years of this Plan. This first Tier 1 prioritization relies on the best data available at this time and focuses only on the nine MS4 outfalls included in the 2011 TMDL (Tetra Tech 2011a). In the future, the Tier 1 prioritization will be revised, as needed, using

information/data collected during future water quality assessment activities from the same nine outfalls and other outfalls, where appropriate.

Table 3-3. Tier 1 Prioritization for the Nine TMDL MS4 Outfalls (See Table 3-2 for Basis)

Outfall No.	Outfall Name	Human Source Score[1] (1)	Weight (2)	Mean Dry Weather Flow Score (3)	Weight (4)	*E. coli* Geomean Score (5)	Weight (6)	Recreational Activity Score (7)	Weight (8)	Total Score[2]
1	Arap-N	1	5	1	3	1	3	3	1	13
2	Arap-S	5	5	2	3	4	3	3	1	45
3	17th W	1	5	4	3	1	3	1	1	24
4	CU-SKI	3	5	3	3	2	3	1	1	28
5	CU-POM	1	5	2	3	1	3	1	1	18
6	CU-FOLSOM	5	5	3	3	4	3	1	1	44
7	28th St.	1	5	4	3	3	3	1	1	27
8	30th St.	1	5	1	3	2	3	1	1	15
9	Marine-N91	1	5	1	3	3	3	1	1	12

[1] The City is relying on the best data it has at this time which indicates a possible presence of human sources at some locations. These data are not considered definitive; additional evaluation will occur as part of the Tier 2 investigation process or as part of a special study.

[2] Total Score = [(1) * (2)] + [(3) * (4)] + [(5) * (6)] + [(7) * (8)] (numbers refer to column numbers)

The highest identified priorities are Outfall 2 (Arap-S) and Outfall 6 (CU-Folsom). The primary factors causing these scores are high *E.coli* geomean scores and preliminary data, although not definitive, that suggest the potential presence of human source bacteria. Additional study will be conducted in the future to verify these results as part of a special study or additional water quality assessment activities. For now, these sites will remain designated as the highest priorities for Tier 2 investigation.

Initially, the City will implement a Tier 2 investigation in only one of the top two ranking sewersheds. This allows for adequate resource allocation and potential refinement of the Tier 2 investigation process prior to moving to the next highest ranked sewershed; thus, it is necessary to select one of the two identified high priorities as the first priority for implementation. Since Outfall 2 has the highest overall score and is fully under City jurisdiction, it will be the first priority outfall. The city will then plan to move to Outfall 6 where jurisdiction is shared with CU. This will additionally allow time for the city to coordinate and work through jurisdiction with CU associated with Outfall 6.

3.2.3 Tier 2 Investigation

Tier 2 investigations occur at each outfall in the order of priority established from the Tier 1 Prioritization. The goal of a Tier 2 investigation is to identify sources of *E. coli* and flow under dry weather conditions within the sewershed tributary to the outfall and mitigate identified sources where controllable. **Figure 3-5** illustrates the key steps and types of activities associated with a Tier 2 investigation. Given the high number of potential activities that could be completed as part of an investigation, implementation of each Tier 2 investigation can be resource intensive, especially in complex MS4 sewersheds. Therefore, it is anticipated that the work required to complete a Tier 2 investigation will occur over a several year period. The following subsections describe the key activities associated with the three steps that comprise a Tier 2 investigation at a priority outfall. These same steps will be implemented iteratively in each priority sewershed.

3.2.3.1 Step 1: Sewershed Characterization

This step focuses on mapping the MS4 system that drains to the priority outfall and data collection to support a Tier 2 investigation. Three activities are included as described in the following sections.

MS4 System Verification

The City maintains a georeferenced database of its MS4 system; early in the Tier 2 investigation, the database will be verified and/or updated as needed prior to initiating the controllability assessment.

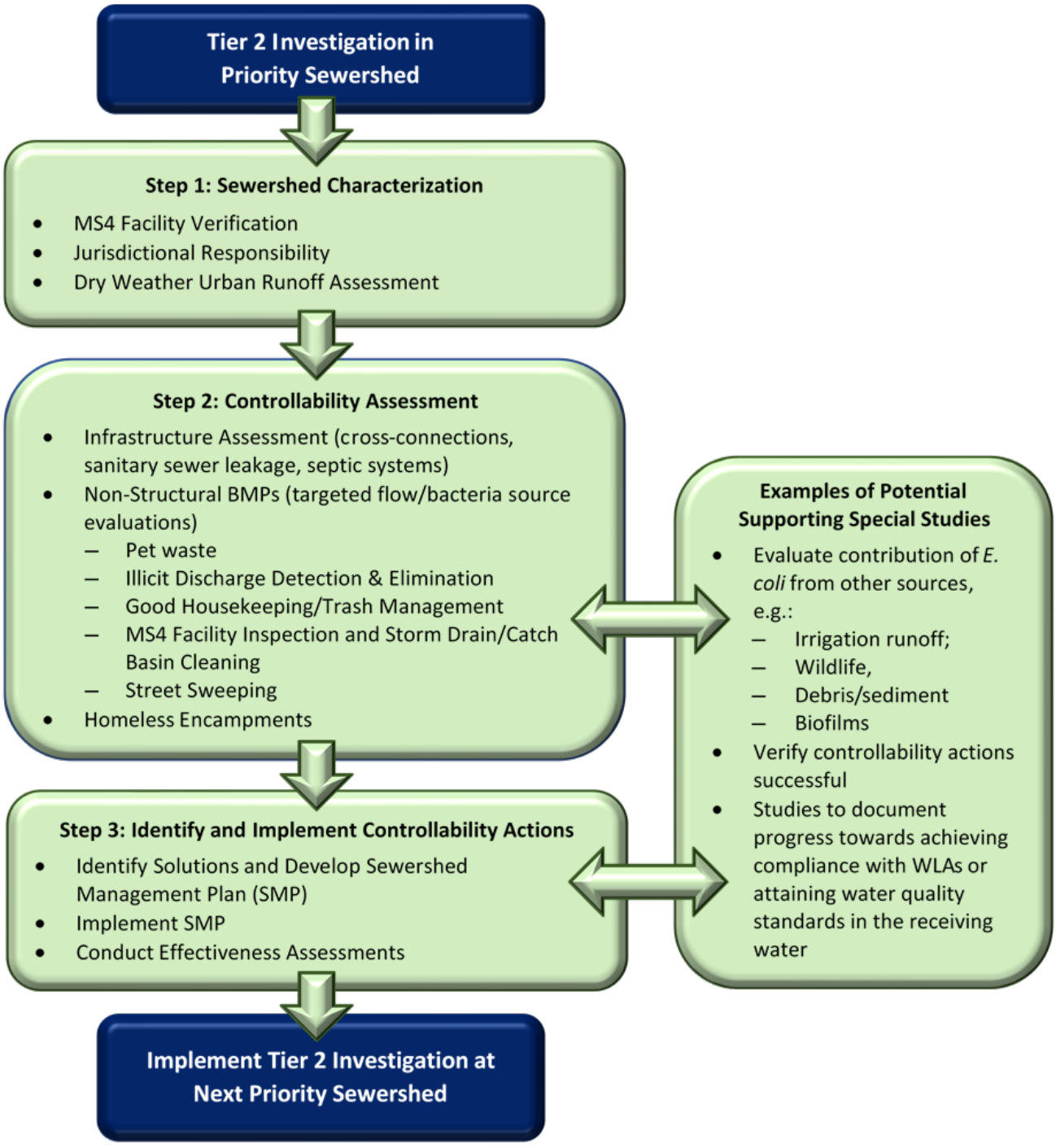

Figure 3-5. Flow Chart of Tier 2 Investigation Activities in a Priority Sewershed

Jurisdictional Responsibility

The City will verify the responsibility for dry weather flows in the storm drain system, including identifying (a) inlets within the City that receive urban runoff from Boulder Valley School District (BVSD) and University of Colorado, Boulder (CU); and (b) locations where the City's MS4 system interconnects with MS4 system owned by one of these jurisdictions. If the priority sewershed has commingled flow from BVSD or CU, the City will coordinate with them on the Tier 2 investigation.

Dry Weather Urban Runoff Assessment

During dry weather conditions, an important factor to mitigate controllable sources of bacteria is to eliminate sources of flow to storm drains. Sources of flow vary with irrigation runoff (runoff from overwatering of lawns or landscaped areas) often a primary contributor. Other flow sources specific to residential and commercial areas include valve leaks, runoff from wash-down activities, and dumpster/grease trap leaks. The potential for irrigation return flows (e.g., tailwater, tile drainage, or surfaced groundwater flow from irrigated land) to impact the MS4 will be assessed. Special studies may be warranted to evaluate the potential contribution of any of these sources to dry weather flows in the MS4.

While "drive-by" or "windshield" type observational approaches may be useful to develop a general understanding of sources of flow in the sewershed, the City will also implement a coordinated, methodical evaluation of sources of flow to the MS4 system. To facilitate this effort, the City may divide the priority sewershed into key subareas. **Figure 3-6** illustrates a hypothetical MS4 sewershed with five potential subareas. As needed, flow and/or bacteria data will be collected from each of the subareas and at key points in the primary storm sewer in the sewershed to determine if there are any subareas within the sewershed that should be higher priorities for subsequent investigation. If no clear priorities are identified, then the entire sewershed will be investigated collectively at the same time. A monitoring plan will be developed for each storm sewershed prior to monitoring.

Step 1 Outcomes

- Updated MS4 system geodatabase/MS4 system map (including co-located sanitary sewer information, if needed)
- Identification of any portions of the MS4 system in the sewershed that are the responsibility of another jurisdiction and initiation of discussions to work collaboratively to mitigate controllable sources of *E. coli*.
- Targeted dry weather flow and bacteria source evaluations to identify priority subareas, if any.

3.2.3.2 Step 2: Controllability Assessment

The Tier 2 investigation focuses on identifying controllable sources of *E. coli* within the sewershed and developing solutions to reduce or eliminate the *E. coli* to the MEP. Below is a

brief discussion of key activities that may be included in a controllability assessment within any priority sewershed:

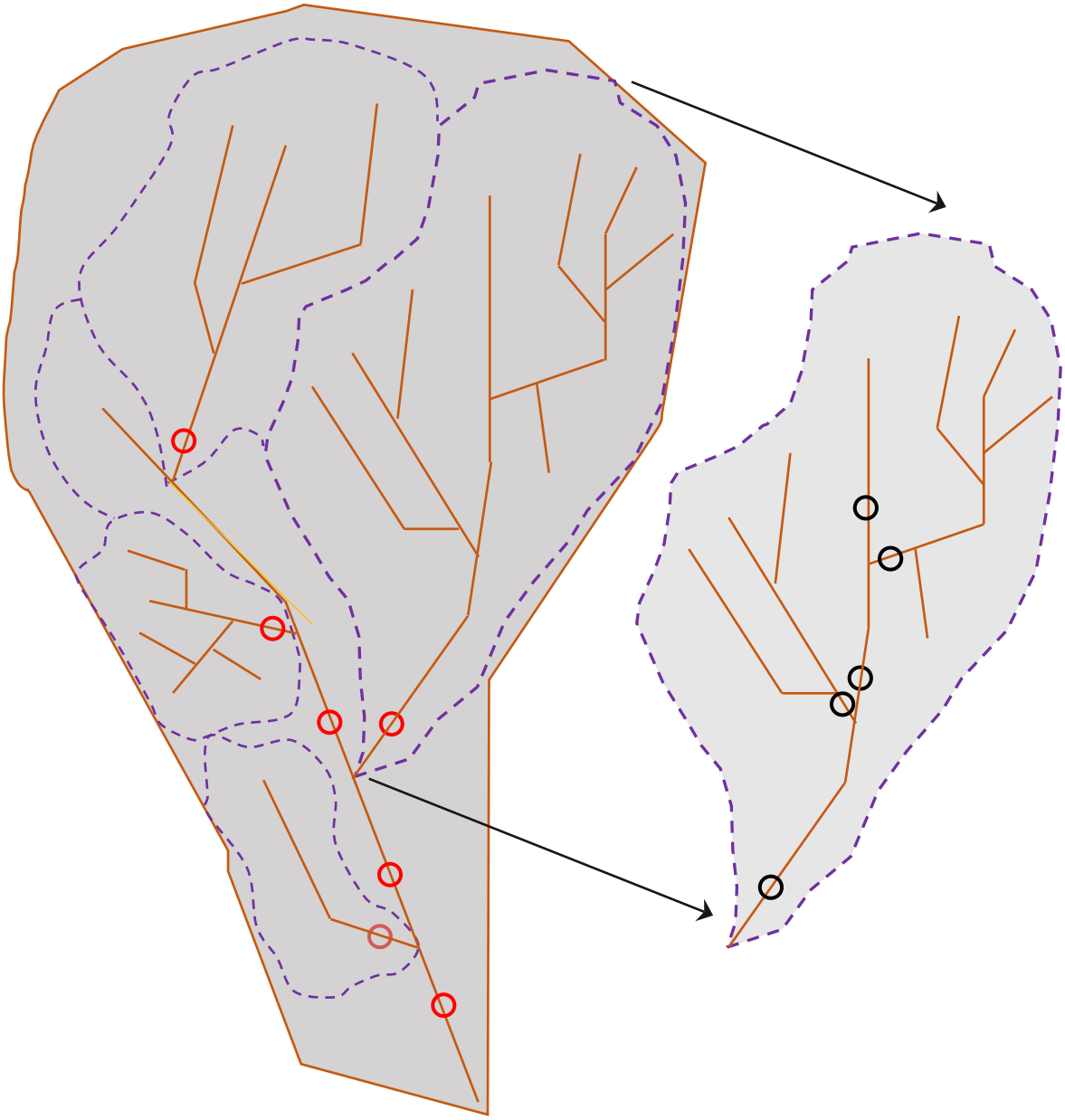

Figure 3-6 – **Example Sewershed Characterization to Determine Priorities within a Sewershed.** ○ indicates where to conduct initial Tier 2 sampling to determine if sewershed can be divided into prioritized subareas. If Subarea 1 (excerpted area) is found to contribute the highest load to the MS4 outfall and is prioritized for follow-up work, ○ indicates where to conduct initial sampling within this Subarea.

- Infrastructure Assessments
- Non-Structural BMP Assessments
- Assessment of Water Quality Impacts from Homelessness

Not all activities may be necessary in a given sewershed, i.e., the controllability assessment will be tailored to the specific sewershed. To support the assessment, the City may also implement special studies to support efforts to identify solutions to reduce or eliminate *E. coli* in the MS4.

Infrastructure Assessments

Infrastructure assessments, e.g., inspection of the system via visual observation and/or use of Closed-Circuit Television, may be necessary where such inspections may not have occurred. The City completed an inspection of the MS4 system in 2016 and no cross-connections were found. In addition, the City inspected the sanitary mains running under Boulder Creek in 2016 with no leaks detected and has lined the sanitary system in Downtown and over half of the system in the University Hill area.

The need for any of the following types of additional assessments will be determined during initiation of the Tier 2 investigation:

- Conduct more detailed re-inspection of MS4 System for sources of bacteria; and
- Additional and more detailed inspection of Sanitary Sewer Conveyances for Leakage and Exfiltration to MS4

Non-Structural BMP Assessment

The controllability assessment includes activities to evaluate ways to minimize sources of dry weather flow and *E. coli* bacteria. Both are evaluated because it may be more efficient to eliminate dry weather flow, which can mobilize and transport bacteria, than to mitigate or eliminate sources of *E. coli*. Following are potential sources for *E. coli* and/or dry weather flow that may be targeted for mitigation during a Tier 2 investigation. Some sources may be fully controllable, e.g., eliminating an illicit discharge; others may be only partially controllable, e.g., pet waste.

<u>Pet Waste</u>

The City has implemented a comprehensive pet waste management program as part of its MS4 program. This effort focuses on the use of public outreach tools and ordinances to require dog owners to pick up their pet's waste on public property and encourage residents to police their own private property. Pet waste on private property can build-up and become mobilized during wet weather or contribute bacteria in dry weather flows if the property is over-irrigated and water runs off to the street. Pet waste management is an example of a program that can only be implemented to the MEP, i.e., it is not possible to eliminate all pet waste from the urban environment. For the sewershed under investigation, the City will

determine if (a) the existing program is being fully implemented; and (b) the existing program can be modified or tailored to be more effective locally. This activity may include targeted outreach to residents and specific commercial businesses that serve pets.

Illicit Discharge Detection & Elimination (IDDE)

As required by its MS4 Permit, the City has an active program to eliminate prohibited discharges. As part of a Tier 2 investigation dry weather flows to the MS4 will be evaluated to determine the source of flow. If the source is a prohibited discharge, then the discharge will be addressed as required by IDDE program implemented through the MS4 Permit. If the source of flow is a non-prohibited discharge (e.g., landscape irrigation, lawn watering, irrigation return flow, or residential car washing), the City will evaluate whether the flow is a potentially source of bacteria to the MS4. If so, the City will determine how to best mitigate or eliminate the source under Step 3 below.

Good Housekeeping/Trash Management

Bacteria can be associated with any land use, but commercial properties which include food-related facilities (restaurants, food outlets and food distributors) have the potential to be important sources of bacteria in the urban environment (Weston 2009a). Bacteria can build up around these properties/facilities because of leaking dumpsters, poor trash management, improper oil and grease disposal, residue from the cleaning of floor mats, mops, filters, and garbage containers, disposal of wash wastewater, etc. Bacteria may also build up around trash facilities on any commercial property. Bacteria may be mobilized if wash water runs off during dry weather cleaning activities. The City is currently working with the County program Partners for a Clean Environment (PACE) to implement outreach and inspections in key areas that drain to Boulder Creek. This work will continue and may be enhanced where needed as part of the controllability assessment in a sewershed.

MS4 System Inspection and Storm Drain/Catch Basin Cleaning

Debris, e.g., sediment, organic matter, animal waste, that builds up in the MS4 system has the potential to become a reservoir for bacteria. For example, studies conducted in sediment basins have found that concentrations of bacteria in the sediments may be up to an order of magnitude higher than concentrations observed in the flow in the inlet or outlet of the same basin (EWRI and ASCE 2014, Riverside County Flood Control & Water Conservation District 2016). These bacteria may become mobilized in dry weather flows, especially if the sediment or biofilms are disturbed. The potential benefits from cleaning drains and basins can vary. For example, catch basin studies done in the San Diego area found mixed results with cleaning of basins in commercial areas likely to be more beneficial (Weston 2009b, Weston 2010). Still, the City will evaluate the build-up of debris, sediment and trash in storm drains and catch basins as potential bacteria sources.

Street Sweeping

Debris build-up on streets and parking lot surfaces can increase the presence of bacteria in the urban environment. When wetted, these bacteria are mobilized and may be discharged through the MS4, e.g., studies show that dry weather flows in the urban environment have the capacity to mobilize significant numbers of bacteria in debris along street curbing. (CDM Smith 2015, Skinner et al. 2010, Ferguson 2006). Periodic cleaning of these surfaces/ gutters has the potential to reduce urban debris as a source of bacteria in dry and wet weather flows. The City has a comprehensive street sweeping program that is being adaptively managed to provide water quality benefits. As part of the Tier 2 investigation, the City will evaluate existing street sweeping activities in the sewershed to determine if any modifications to the program could provide additional water quality benefits.

Assessment of Potential Water Quality Impacts from Homelessness

The activities of homeless people adjacent to or near a receiving water can impact water quality, including being a source of bacteria. Inputs of fecal matter may occur directly to a receiving water, especially where homeless activity occurs along a waterbody, or indirectly, e.g., from dry or wet weather runoff from a homeless impacted area into a storm drain. Where the MS4 staff identifies potential impacts to water quality from homelessness, staff will work with the City programs tasked with the implementation of the City's Homelessness Strategy (See Section 2.1.3).

Step 2 Outcome

The outcome of the Step 2 investigation activities will be an understanding of the relative importance of sources of bacteria and flows to and in the MS4 during dry weather conditions. The City will use this information to develop a Sewershed Management Plan (SMP) under Step 3 of the Tier 2 Investigation process.

3.2.3.3 Step 3: Identify and Implement Controllability Actions

The purpose of Step 3 is to use the data and information developed during Steps 1 and 2 activities to prepare an SMP for the priority sewershed that establishes an approach to reduce or eliminate sources of flow and bacteria under dry weather conditions. The SMP will identify and prioritize specific actions to implement to reduce or eliminate sources of *E. coli* (including dry weather flow) to the MEP. The SMP will also include measures to evaluate progress and provide a schedule with milestones.

SMP implementation actions may include infrastructure improvements, as determined necessary during the infrastructure assessment or continued or enhanced implementation of non-structural BMPs. The SMP may also include special studies, where needed, to further understand sources of bacteria and options available to mitigate sources where controllable.

The range of non-structural BMP activities, described above under Step 2, will be the primary focus of the City's efforts to reduce or eliminate controllable sources of bacteria in each sewershed. While enhancements of programs such as education and outreach can be beneficial, actions that are directed toward reducing sources of flow during dry weather

conditions and mitigating opportunities for bacteria growth (e.g., removal of debris/sediment in catch basins) are expected to provide the greatest water quality benefits.

Structural BMPs, e.g., as described in UDFCD & CCD (2016) and EWRI & ASCE et al. (2014), may be considered for implementation under limited circumstances, but generally only where the constructed facility can provide multiple benefits to the City. For example, structural BMPs can be designed to provide benefits beyond the capture of urban runoff, including creating more green space to support recreation and habitat, support flood management and reduce the effects of hydromodification, i.e., where the streams natural hydrology has been altered due to urbanization affecting the physical and biological integrity of the waterbody.

Each SMP will include measures of success to evaluate progress being made towards compliance with the City's WLA. Measures of success, which will be tailored to the specific SMP, vary widely. Examples include: documented elimination of human sources, volume of dry weather flow eliminated, pounds of debris removed from catch basins, number of infrastructure fixes completed, or demonstrated reductions in *E. coli* loads from the targeted outfall.

The SMP serves as a workplan to guide City efforts to implement the TMDL. The length of the SMP schedule will depend on the nature of the actions identified. If the schedule includes a long-term solution such as a structural BMP, the schedule will include implementation steps for a typical capital improvement project, e.g., project identification, funding approval, design and permitting and construction.

3.2.4 Adaptive Management and Reporting

The City will periodically evaluate this Plan and associated TMDL implementation activities through an adaptive management process. The status of implementation efforts and any modifications to the Plan will be documented through the reporting activities described below.

3.2.4.1 Adaptive Management

The City will periodically re-evaluate its findings from all implementation activities to determine whether this Plan should be updated. The need to periodically reevaluate implementation activities is consistent with the findings of UDFCD and CCD (2016), which states the following with regard to achieving expected bacteria load reductions as part of MS4 Permit compliance:

> When developing a control strategy that is enforceable under CDPS permits, it is important to include provisions for adaptive management and adjustment of practices implemented, due to the practical uncertainties currently surrounding *E. coli* load reductions.

The adaptive management evaluation will be done as part of the periodic assessment that will occur at multi-year intervals.

3.2.4.2 Reporting

The City will periodically report on the outcome of its TMDL implementation activities completed under this Plan. Two types of reporting activities are anticipated.

Annual Reports

The MS4 Permit requires submittal of an Annual Report. Table 2-1 above summarizes MS4 Permit reporting requirements relevant to TMDL implementation. Information for this report will be compiled from the results of ongoing assessment and prioritization activities, Tier 2 investigations, SMP implementation, and special studies conducted during the reporting period. Any changes to this Plan will be included in the Annual Report submittal.

TMDL Assessment Report

As described in Section 3.2.1, the City will conduct an assessment of flow and bacteria water quality in the impaired reach of Boulder Creek and MS4 outfalls discharging dry weather flow at multi-year intervals. The findings from this assessment will be summarized in a report that includes the following evaluations:

- *Progress Towards Achieving Compliance with Applicable WLAs* – This evaluation documents reductions in bacteria loads from outfalls (including where dry weather flows have been reduced or eliminated), elimination of human sources, and progress on activities designed to reduce or eliminate controllable sources of bacteria to the MEP.
- *Status of Attainment of Bacteria Water Quality Standards in Boulder Creek* - This assessment element focuses on the evaluation of receiving water data at specific locations in the impaired reach, e.g., BC-30. The findings are provided as information only and not an indication of the effectiveness of this Plan. This distinction is important because the City's mitigation efforts only address controllable sources of *E. coli* in the MS4. Non-MS4 sources of bacteria in the watershed are not addressed by this Plan.
- *Overall Effectiveness of the City's TMDL Implementation Plan* – The purpose of this assessment is to periodically re-evaluate the mass balance of bacteria. The outcome of this analysis will be an updated estimate of the relative role of MS4 sources in the impaired reach of Boulder Creek.
- *TMDL Implementation Plan Priorities* – Findings from water quality and dry weather flow assessments will be used to re-evaluate the current Tier 1 prioritization. This evaluation provides the opportunity to shift priorities if significant changes in bacteria loads have occurred, regardless of the reason for those changes.

The findings from the above evaluations will be used to support the adaptive management process to determine if any changes to the Plan are necessary. These changes will be documented as part of an Annual Report submittal.

3.2.5 Special Studies

Occasionally, the City may implement special studies to evaluate bacteria sources that may be common to all outfalls, gather MS4 outfall-specific data, or evaluate the effectiveness of a particular MS4 control measure. These studies may be implemented at any time and may be included as a SMP action item. Findings from studies will be considered where appropriate in the implementation process. Examples of studies that might aid the City in evaluating the potential need to mitigate a controllable source include, but may not be limited to:

- Non-human bacteria source analyses to determine if other sources of *E. coli* are commonly present in outfall discharges or within prioritized subareas of a sewershed. Potential source analyses could include canine and wildlife (e.g., raccoon or birds, where specific markers are available). Studies may also evaluate the potential for interference between markers, e.g., canine versus human markers.
- Source analyses to identify where potential reservoirs of bacteria may exist within the sewershed, e.g., evaluations of sediment, biofilms, and debris, wherever these potential bacteria reservoirs are a concern.
- Specific dry weather flow source analyses, e.g., irrigation return flows or irrigation runoff. The extent to which these flow sources vary (frequency, duration and magnitude) could influence bacteria loads in the MS4 where these flows enter the system.

In addition to conducting studies to evaluate potential bacteria sources, studies may also be necessary to verify that a controllability action within a sewershed was successful. For example, if a cross-connection or a leaking septic system was repaired, then follow-up sampling could be conducted to verify reductions in bacteria have occurred and human sources of bacteria have been eliminated.

3.3 Sequence of Implementation Plan Activities

Figure 3-7 illustrates the general sequencing of activities that will occur under this Plan. Key elements include:

- Water quality assessments will be completed at multi-year intervals.
- The Tier 1 prioritization will be re-evaluated as an outcome of each water quality assessment.
- Once a Tier 2 investigation is complete and the SMP is developed, the City will focus on implementation of the SMP. It is expected that a SMP will be implemented over a two to

three-year period; the length may be shorter or longer based on the schedule and milestones incorporated into the SMP.

- Figure 3-7 suggests that the assessment, prioritization and investigation processes will occur in a linear process with minimal overlap. However, Plan activities may be overlapped, where appropriate and as resources allow.
- Special studies will be implemented on an as needed basis.
- The MS4 Permit requires submittal of an Annual Report each year by March 10.
- Periodic assessments provide the City with an opportunity to evaluate the overall effectiveness of the Plan and progress being made towards achieving compliance with WLAs. These assessments will occur at multi-year intervals with the timing most likely associated with completion of activities of an SMP for a priority sewershed.

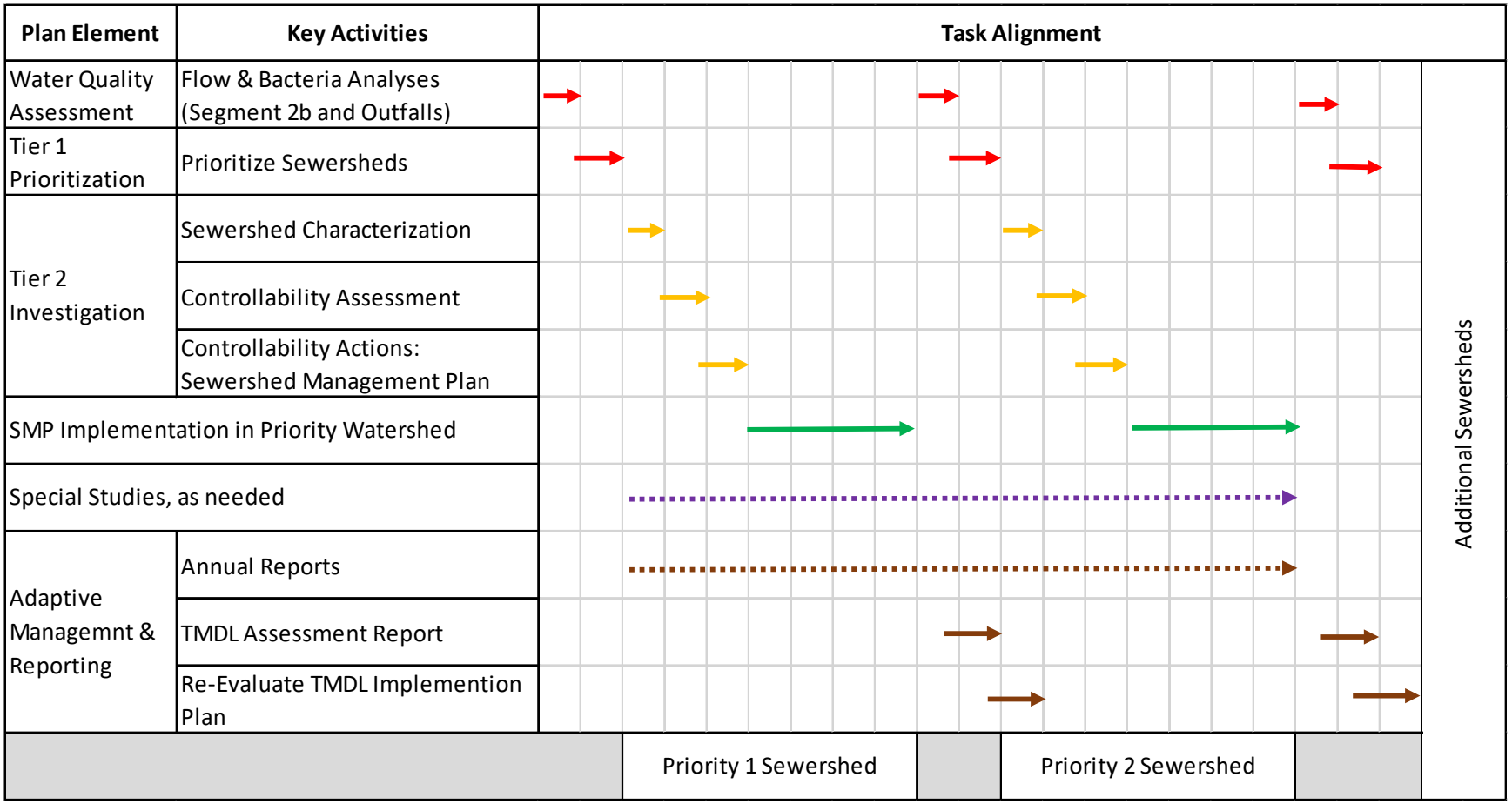

Figure 3-7. Sequence of TMDL Implementation Activities

4.0 References

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