UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

MAY 05 2015

OFFICE OF
WATER AND WATERSHEDS

Ms. Michelle Hale, Director
Water Division
Alaska Department of Environmental Conservation
410 Willoughby Avenue, Suite. 303
P.O. Box 111800
Juneau, Alaska 99811-1800

Re: Approval of the Cottonwood Creek Total Maximum Daily Load (TMDL) for Fecal Coliform Bacteria in Wasilla, Alaska

Dear Ms. Hale:

The Alaska Department of Environmental Conservation DEC submitted the Cottonwood Creek TMDL for fecal coliform bacteria to the U.S. Environmental Protection Agency on April 20, 2015. Following our review, the EPA is pleased to approve the fecal coliform bacteria TMDL for Cottonwood Creek (Alaska ID Number: 20505-001) in Wasilla, Alaska.

Our review indicates that the allocations have been established at a level that, when fully implemented, will lead to the attainment of the water quality criteria addressed by this TMDL. Therefore, DEC does not need to include Cottonwood Creek on the next 303(d) list of impaired waters for fecal coliform bacteria.

We greatly appreciate the opportunity to work with your staff throughout the development of this TMDL. We are impressed with Laura Eldred's cooperation, helpfulness and commitment in the development of this TMDL.

By EPA's approval, this TMDL is now incorporated into the State's Water Quality Management Plan under Section 303(e) of the Clean Water Act. We look forward to continuing to work collaboratively on water quality issues in Cottonwood Creek. If you have any questions, please feel free to call me at (206) 553-1855, or have your staff contact Jayne Carlin at (206) 553-8512, of my staff.

Sincerely,

Daniel D. Opalski, Director
Office of Water and Watersheds

cc: Ms. Laura Eldred, Non-Point Source Section, DEC
Ms. Cindy Gilder, Manager, Non-Point Source Section, DEC
Ms. Nancy Sonafrank, Manager, WQS, Assessment and Restoration Program, DEC

Alaska Department of Environmental Conservation
555 Cordova Street
Anchorage, Alaska 99501

Total Maximum Daily Load for Fecal Coliform Bacteria in the Waters of Cottonwood Creek, Wasilla, Alaska

FINAL

February 2015

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CONTENTS

TABLES

FIGURES

ACRONYMS

AAC	Alaska Administrative Code
ACWA	Alaska’s Clean Water Actions
ADEC	Alaska Department of Environmental Conservation
AFES	Agricultural and Forestry Experiment Station - University of Alaska at Fairbanks Matanuska station
APDES	Alaska Pollutant Discharge Elimination System
CFR	Code of Federal Regulations
CWA	Clean Water Act
CWP	Center for Watershed Protection
DNA	Deoxyribonucleic Acid
EPA	Environmental Protection Agency
fc/100 mL	fecal coliforms per 100 milliliters
HUC	Hydrologic Unit Code
LA	Load Allocation
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer System
MST	Microbial Source Tracking
NLCD	National Land Cover Dataset
TMDL	Total Maximum Daily Load
UAF	University of Alaska Fairbanks
USGS	United States Geological Survey
WLA	Wasteload Allocation

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Total Maximum Daily Load (TMDL) for Fecal Coliform Bacteria in Cottonwood Creek, Alaska

TMDL at a Glance:

Water Quality Limited? Yes
Alaska ID Number: 20505-001
Criteria of Concern: Fecal coliform bacteria
Designated Uses Affected: (1) water supply and (2) water recreation
Major Source(s): Urban Runoff and Unspecified Septic Sources
Loading Capacity: 1.97×10^{12} fc/year
Future Wasteload Allocation: 1.39×10^{12} fc/year (Section 6 contains seasonal and daily allocations)
Load Allocation: 3.84×10^{11} fc/year (Section 6 contains seasonal and daily allocations)
Margin of Safety: 1.97×10^{11} fc/year
Necessary Reductions: 90%

	Fecal coliform bacteria (fc/year)					Percent Reduction to Load Allocation
Waterbody	Existing Load	Loading Capacity	Future Wasteload Allocation[a]	Load Allocation	Margin of Safety[b]	
Cottonwood Creek HUC 190204010803	1.81×10^{13}	1.97×10^{12}	1.39×10^{12}	3.84×10^{11}	1.97×10^{11}	90%

[a] Note that the Future Wasteload Allocation is currently considered to be part of the Load Allocation until the expected Municipal Separate Storm Sewer System permit is in place. See Tables 6-1 and 6-2 for details.
[b] Margin of Safety was included explicitly as 10 percent of the loading capacity.

Executive Summary

Cottonwood Creek is a 39.4 square mile (mi^2) spring-fed watershed located near Wasilla in south central Alaska in the Matanuska-Susitna Borough. The Alaska Department of Environmental Conservation (ADEC) included Cottonwood Creek on its 2010 Clean Water Act (CWA) Section 303(d) list as water quality-limited due to fecal coliform (FC) bacteria, identifying urban runoff and unspecified septic sources as the expected pollutant sources (ADEC 2010a). The presence of fecal coliform bacteria indicates an increased risk of pathogen contamination in a waterbody. Consumption of or contact with pathogen contaminated waters can result in a variety of gastrointestinal, respiratory, eye, ear, nose, throat and skin diseases. A Total Maximum Daily Load (TMDL) is established in this document to meet the requirements of CWA Section 303(d)(1)(C) and the U.S. Environmental Protection Agency's implementing regulations (40 Code of Federal Regulations Part 130), which require the establishment of a TMDL for the achievement of water quality standards when a waterbody is water quality-limited.

A TMDL is composed of the sum of individual wasteload allocations for point sources of pollution and load allocations for nonpoint sources of pollution and natural background loads. In addition, the TMDL must include a margin of safety, either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. A TMDL represents the amount of a pollutant the waterbody can assimilate while maintaining compliance with applicable water quality standards.

Applicable water quality standards for fecal coliform bacteria in Cottonwood Creek establish water quality criteria for the protection of designated uses for water supply and water recreation. The TMDL is developed for the most stringent fecal coliform bacteria criteria that protect the water supply use for drinking, culinary, and food processing. These criteria state that in a 30-day period, the geometric mean may not exceed 20 FC/100 mL, and not more than 10 percent of the samples may exceed 40 FC/100 mL (18 Alaska Administrative Code 70.020(b)(2)(A)(i)).

Fecal coliform bacteria data indicate that Cottonwood Creek does not meet the applicable water quality criteria. Concentrations steadily increase during spring months, with increased surface runoff during spring thaw and breakup. The largest and most frequent exceedances of the water quality criteria occur during summer months, particularly during heavy rain storms. Because of the seasonal variation in fecal coliform bacteria levels, the Cottonwood Creek TMDL is developed on a seasonal basis to isolate times of similar weather, runoff and in-stream conditions.

Because Cottonwood Creek has limited fecal coliform bacteria data and does not have continuous flow data, the TMDL was developed using the Simple Method (Schueler, 1987). The Simple Method is a lumped parameter empirical model used to estimate stormwater pollutant loadings under conditions of limited data availability and an absence of flow data. The approach calculates pollutant loading using drainage area, pollutant concentrations, precipitation and a runoff coefficient based on impervious area in the watershed. The method was used to calculate existing fecal coliform bacteria loading based on observed fecal coliform bacteria data and the loading capacity for the stream based on in-stream concentrations representing water quality criteria.

Section 6 focuses on the TMDL analysis and loading calculations. The margin of safety was included explicitly as 10 percent of the loading capacity. Currently the entire loading capacity is assigned to nonpoint sources as the load allocation (minus the margin of safety). However, it is expected that in the next three years stormwater discharges in the Cottonwood Creek watershed will be regulated by an Alaska Pollutant Discharge Elimination System (APDES) stormwater permit for municipal separate storm sewer systems (MS4); therefore, fecal coliform bacteria loads delivered to Cottonwood Creek from the expected MS4 area will be addressed through the future wasteload allocation component of this TMDL for ease of implementation. Nonpoint source loads delivered from the area outside of the expected MS4 boundary would still be addressed through the load allocation.

Additionally, the fecal coliform bacteria allocations for Cottonwood Creek are provided as seasonal load and wasteload allocations and are equal to the loading capacity minus the margin of safety. The seasons are defined as Spring (April 1 – May 31) and Summer (June 1 – September 30). These seasons then have loads calculated as overall seasonal loads (Tables 6-1 and 6-2) and also as daily loads (Tables 6-3 and 6-4) for both current conditions and under the expected MS4 conditions. Note that there are no fecal coliform bacteria data available for the winter months (October 1 – March 31) because winter conditions do not typically allow for sampling. Therefore, analyses were not conducted for this season. During winter months, precipitation falls primarily as snow, resulting in little to no surface runoff. Snow and ice accumulated during winter melts with the increasing temperatures during spring, creating increased surface runoff and steadily increasing in-stream flows. Therefore, little fecal coliform bacteria loading to Cottonwood Creek is expected during the winter months and allocations have not been provided for the winter months.

ADEC believes that waterfowl and wildlife contribute little fecal coliform bacteria in most of the watershed, but at some locations may contribute higher amounts at certain times of the year. Both domestic and non-domestic waterfowl are present in the watershed; however, it is not possible to determine the specific contributions from either source. Therefore, natural background conditions from non-domestic waterfowl and wildlife are included in the load allocation for this TMDL, but implementation practices do not apply to these sources since the pollutant loads are not a result of human actions and are considered to pose a minimal risk of pathogen transmission.

The implementation of the Cottonwood Creek TMDL will focus on reductions from existing sources of fecal coliform bacteria. Microbial source tracking identified bacteria from human, horses, dogs, and waterfowl in Cottonwood Creek (Davis et al. 2010). The likely sources include:

- Horse pastures/stables/trails
- Nonpoint source stormwater runoff (fecal matter in pet waste, sewage (such as diapers) from trash stored near the creek, informal camps along the creek, and poorly maintained septic systems or aging leach fields)
- Waterfowl (domestic and non-domestic)

The most effective means of addressing these sources of pollution is to prevent the fecal coliform bacteria from entering Cottonwood Creek, both directly and indirectly through polluted runoff. Maintaining healthy riparian areas should be encouraged to ensure runoff is filtered prior to reaching the streams. Additional implementation of the TMDL will occur through outreach and education in the watershed (including the proper installation and ongoing maintenance of on-site septic systems), as well as through the issuance of the expected MS4 permit (see Section 7).

Addressing the potential contribution of fecal coliform bacteria from an MS4 is typically expressed in an MS4 permit as best management practices (BMPs) or other similar requirements, rather than as numeric effluent limits. ADEC recognizes the need for an iterative approach to control pollutants in stormwater discharges and anticipates that a suite of BMPs will be used in the initial permit issuance, and subsequent permit issuances may become more tailored based on BMP effectiveness and performance.

Follow-up monitoring is recommended to track the progress of TMDL implementation and subsequent water quality response, track BMP effectiveness, and track the water quality of Cottonwood Creek to evaluate future attainment of water quality standards.

1. Overview

Section 303(d)(1)(C) of the Clean Water Act (CWA) and the U.S. Environmental Protection Agency's (EPA) implementing regulations at title 40 Code of Federal Regulations (CFR) Part 130 require the establishment of a Total Maximum Daily Load (TMDL) to achieve state water quality standards when a waterbody is water quality-limited. A TMDL identifies the amount of a pollutant that a waterbody can assimilate and still maintain compliance with applicable water quality criteria. A TMDL also identifies the level of pollutant control needed to reduce pollutant inputs to a level (or "load") that fully supports the designated uses of a given waterbody and includes an appropriate margin of safety to account for uncertainty or lack of knowledge regarding the pollutant loads and the response of the receiving water. The mechanisms used to address water quality problems after the TMDL is developed can include a combination of best management practices (BMPs) for nonpoint sources and/or effluent limits and monitoring required through ADEC's Alaska Pollutant Discharge Elimination System (APDES) program responsible for issuance of permits for discharges from point sources to surface waters.

In 2010, ADEC listed seven miles of Cottonwood Creek on its CWA Section 303(d) list as water quality-limited for fecal coliform bacteria (ADEC 2010a). Table 1-1 summarizes the information for Cottonwood Creek included in Alaska's 2012 Integrated Water Quality Monitoring and Assessment Report (ADEC, 2013a). The non-attainment of the fecal coliform bacteria criteria affects the designated uses of (1) water supply and (2) water recreation. The CWA Section 303(d) impairment listing is supported by water quality monitoring conducted in 2004 through 2008 that confirmed exceedances of applicable criteria.

Table 1-1. Cottonwood Creek CWA Section 303(d) impairment listing information from Alaska's 2012 Integrated Water Quality Monitoring and Assessment Report.

<table>
<tr><th>Alaska ID Number</th><th>Waterbody</th><th>Area of Concern</th><th>Water Quality Standard</th><th>Pollutant Parameters</th><th>Pollutant Sources</th></tr>
<tr><td>20505-001</td><td>Cottonwood Creek</td><td>7 miles</td><td>Fecal Coliform Bacteria</td><td>Fecal Coliform Bacteria</td><td>Urban Runoff, Unspecified Septic Sources</td></tr>
<tr><td colspan="6">Cottonwood Creek (13 miles) was CWA Section 303(d) listed for non-attainment of the residues standard for foam and debris in 2002/2003. ADEC has received numerous complaints about foam in Cottonwood Creek and foam was observed in the creek in 1998, 2000, 2001, and 2002. Through grant funds, an intensive water quality evaluation was conducted on Cottonwood Creek beginning in September 2004 and continuing through June 2006 for a TMDL assessment. Water quality sampling conducted in 2004 and 2005 indicated that the foam present in Cottonwood Creek is most likely naturally occurring. However, hydrologic changes within the watershed may be influencing the amount and timing of the foam. Continued water quality sampling in 2006 focused on determining the extent of FC bacteria and temperature exceedances discovered during the sampling for foam, as well as further investigation of the foam. Foam and temperature were determined to be naturally occurring hence meeting water quality standards. However, FC bacteria exceeded applicable water quality criteria. DEC conducted a study in 2010 using Microbial Source Tracking to determine if detected bacteria were from humans, Fecal Coliform Bacteria Source Assessment in the waters of Cottonwood Creek, Wasilla, and Little Campbell Creek, Anchorage (November 2010). Results indicate that humans are a source of the increase FC bacteria in Cottonwood Creek. Cottonwood Creek is now in Category 2 for attainment of the residues (foam) criteria and impaired for FC bacteria.</td></tr>
</table>

Source: ADEC (2013a)

1.1. Location

Cottonwood Creek is a 39.4 square mile (mi^2) spring-fed watershed located near Wasilla in south central Alaska in the Matanuska-Susitna Borough (Figure 1-1). The headwaters of Cottonwood Creek are formed from springs located between the Little Susitna River and Wasilla Creek watersheds. The creek is composed of two first order tributaries: Cottonwood Creek, which flows into and out of Cornelius Lake to the east, and Dry Creek, which flows out of Anderson Lake to the west (Davis et al. 2010). Both streams flow into Neklason Lake (Figure 1-2). The total length of all streams in the watershed is 16.6 miles. The watershed also contains 10 lakes totaling over 1,000 acres and 22 miles of shoreline (Davis and Davis 2005). An estimated 20.69 percent of the Cottonwood Creek watershed is developed (Davis et al. 2010). Development upstream of Wasilla Lake is primarily residential. Development from Wasilla Lake to the Old Matanuska Road is mixed commercial and residential. The lower 8 miles of Cottonwood Creek, from the Old Matanuska Road to Cook Inlet, is primarily residential development. Seven miles of Cottonwood Creek below Wasilla Lake (from Parks Highway downstream to Surrey Road) were placed on Alaska's 2010 CWA Section 303(d) list for non-attainment of the fecal coliform bacteria criteria (ADEC 2010) (Figure 1-2).

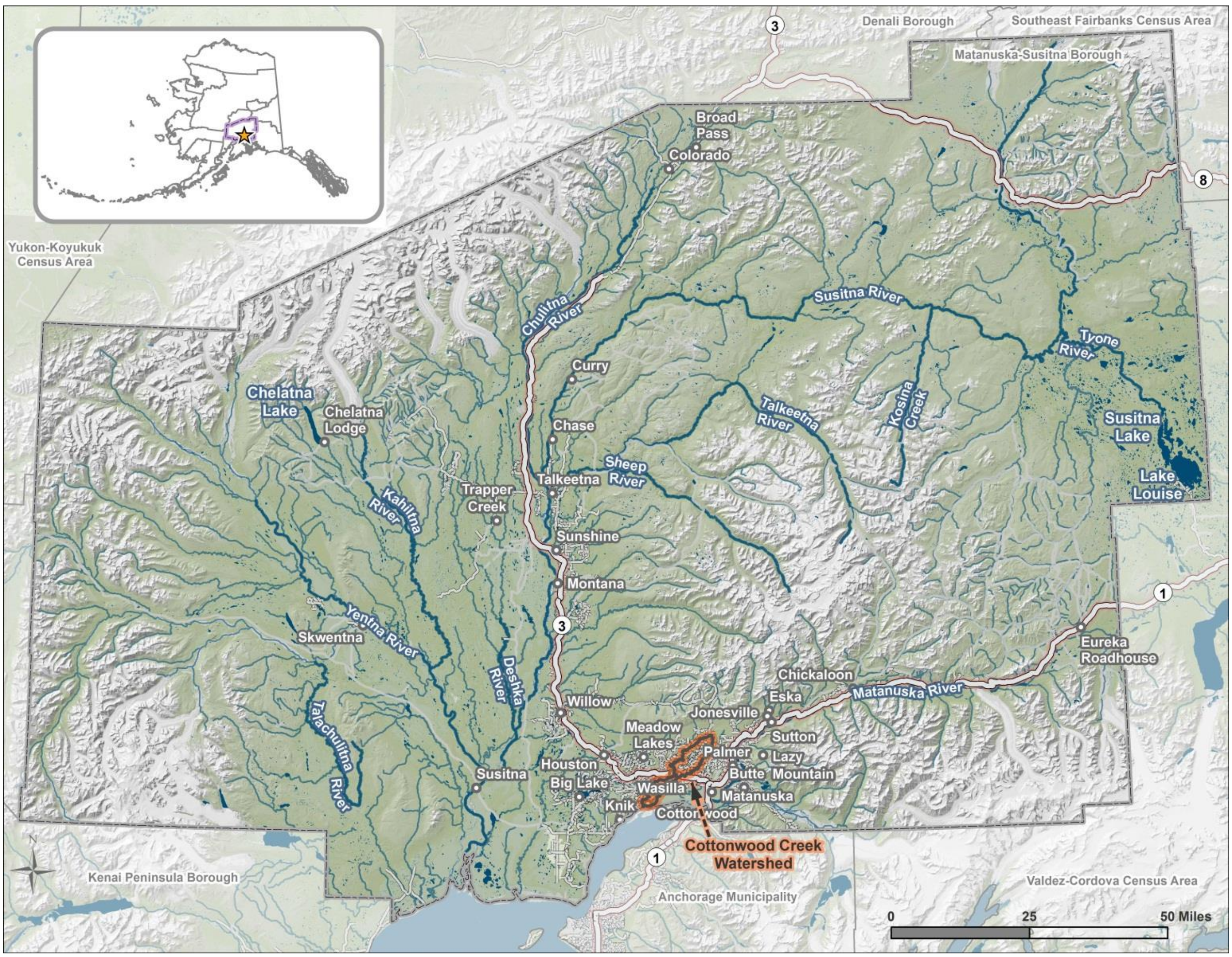

Figure 1-1. Regional location of the Cottonwood Creek study area.

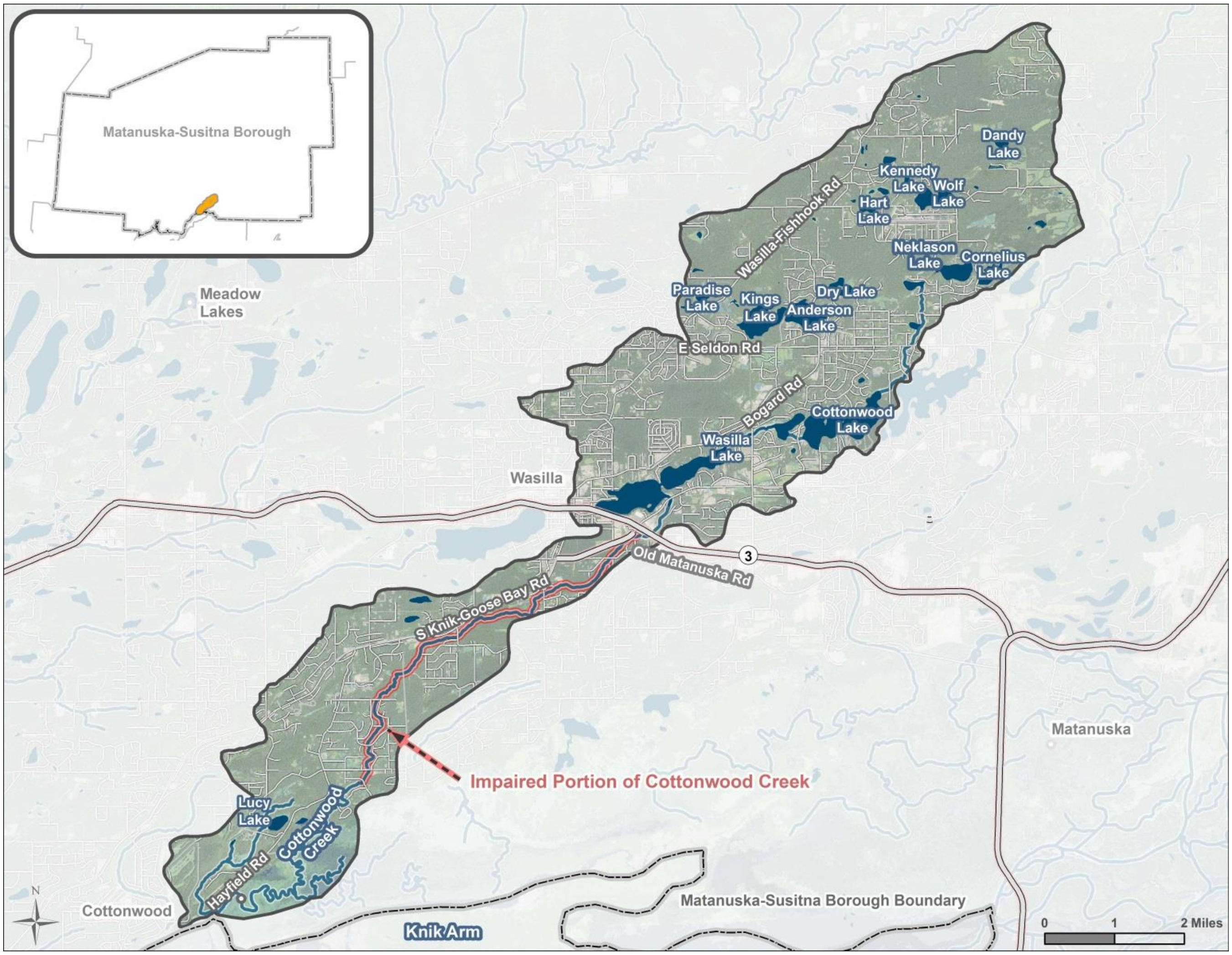

Figure 1-2. Cottonwood Creek watershed study area.

1.2. Population

Rapid rate of urban development throughout the Matanuska-Susitna Borough and the Cottonwood Creek watershed has occurred in recent years (Davis and Davis 2008). The population for the Matanuska-Susitna Borough recorded in the 2010 U.S. Census is 88,995, with more than 7,831 people in the City of Wasilla and 14,923 people in the Knik-Fairview census area, which is the area most closely correlated with the seven-mile impaired segment of Cottonwood Creek. The Knik-Fairview census area has seen a 112 percent population increase from 2000 to 2010.

1.3. Topography

The topography of the Cottonwood Creek watershed ranges from 12 to 779 feet. Elevation at the Old Matanuska Road is near 300 feet and stream slope through this reach is 0.7 percent (Davis et al. 2010).

1.4. Land Use

Land use data were obtained from the 2001 United States Geological Survey (USGS) National Land Cover Data set (NLCD). The NLCD data are based on satellite imagery from 2001. The Cottonwood Creek watershed is 65 percent forested and approximately 21 percent developed (Figure 1-3 and Table 1-2). Development upstream of

Wasilla Lake is primarily residential (Davis et al. 2010). Development is mixed commercial and residential from Wasilla Lake to the Old Matanuska Road. The lower eight miles of Cottonwood Creek, from the Old Matanuska Road to the Knik Arm of Cook Inlet, is primarily residential development. These percentages should be considered as best estimates until newer data becomes available.

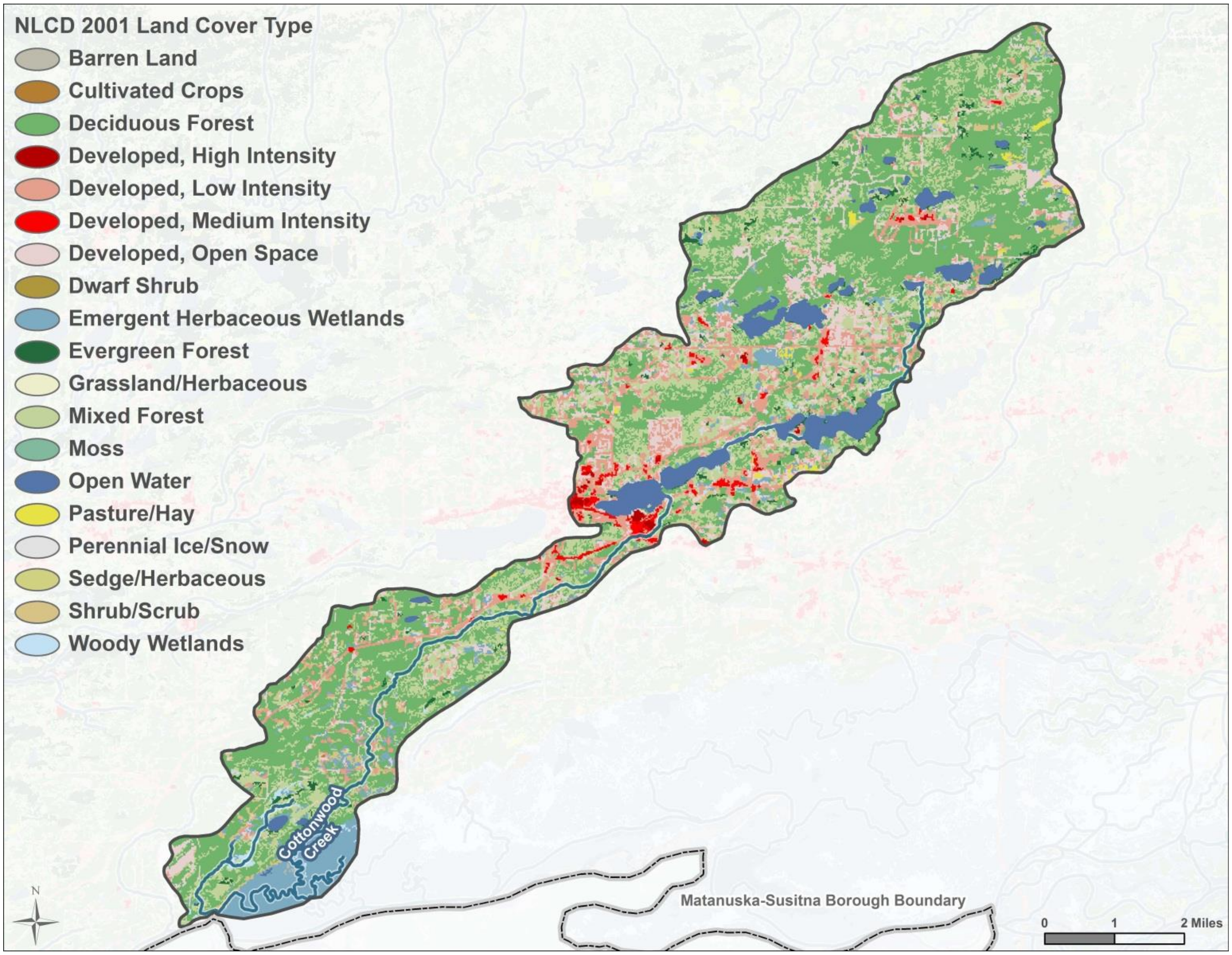

Figure 1-3. Land use in the Cottonwood Creek watershed (Source: NLCS 2001).

Table 1-2. Land use/cover distribution in the Cottonwood Creek watershed.

Land Use	Area (acres)	Percent of total area
Open Water	1,148	4.5 %
Developed	5,246	20.8 %
Barren	12	0.05 %
Forest	16,309	64.6 %
Shrub/Scrub	682	2.7 %
Pasture/Hay	115	0.5 %
Cropland	1	0.004 %
Wetlands	1,729	6.8 %
TOTAL	25,242	100 %

1.5. Climate

The Wasilla area is located in the "transition" climate zone of Alaska between the maritime and continental zones. Temperatures in the transition zone typically range between zero and the low 60s degrees Fahrenheit (°F) (Western Regional Climate Center (WWRC) accessed January 2013). Average annual precipitation was 14.42 inches for the period of record (1998-2012) at the University of Alaska at Fairbanks's (UAF) Matanuska Agricultural and Forestry Experiment Station (AFES). The average monthly precipitation for the period of record ranges from 0.33 inches in April to 2.70 inches in August. The highest temperatures occur in July on average with an annual average temperature of about 59 °F. The lowest air temperatures occur in January with minimum average temperature of about 28.1°F.

Autumn begins in early September and ends in mid-October with temperatures falling in September and snowfalls increasing in October. Winter lasts from mid-October to early April with the coldest temperatures typically occurring in January. Spring begins in late April and May with less precipitation and increasing temperatures.

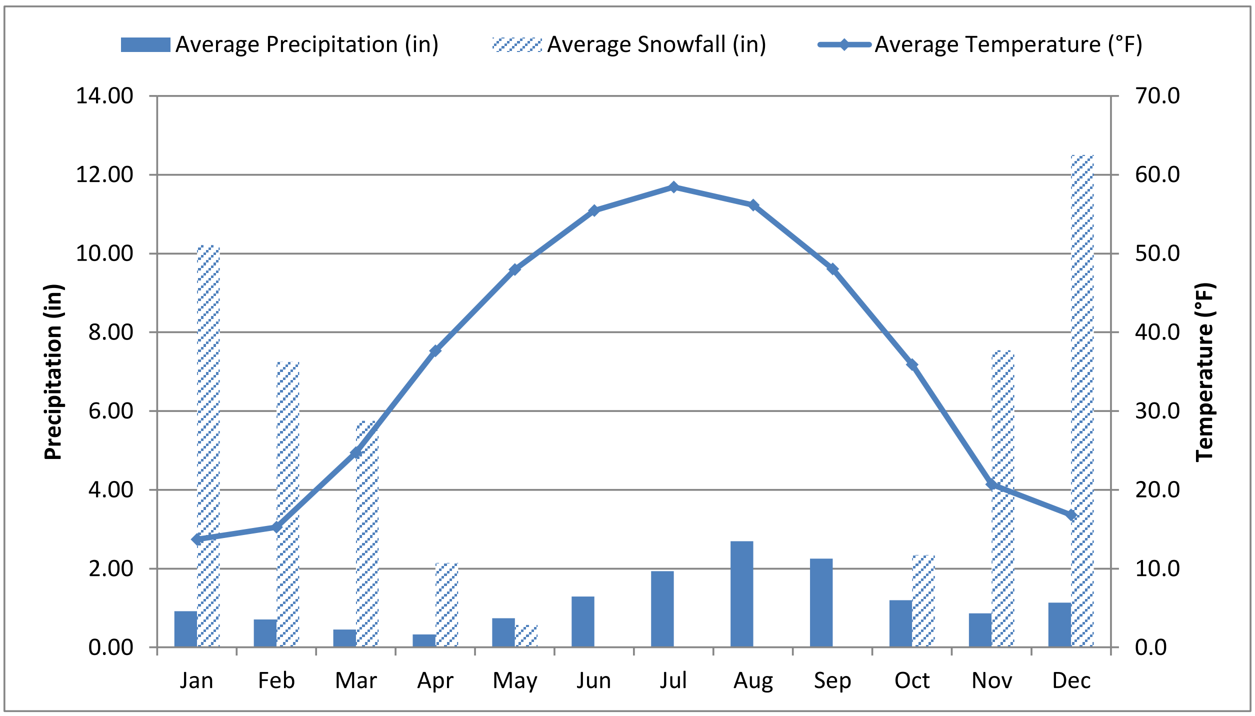

Figure 1-4. Monthly average precipitation and temperatures at UAF's Matanuska AFES from January 1998 to November 2012.

Table 1-3. Monthly average precipitation, snowfall, and temperatures at UAF's Matanuska AFES.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Precipitation (in)	0.92	0.71	0.45	0.33	0.74	1.29	1.93	2.70	2.25	1.20	0.87	1.13
Average Snowfall (in)	10.22	7.25	5.75	2.14	0.57	0.00	0.00	0.00	0.00	2.35	7.55	12.51
Average Temperature (°F)	13.7	15.3	24.7	37.6	48.0	55.5	58.5	56.2	48.1	35.9	20.68	16.80

1.6. Hydrology and Waterbody Characteristics

Cottonwood Creek drains to the Knik Arm of Cook Inlet. The creek is a groundwater fed stream with minor variations in discharge and slightly stained or brown water (Davis and Davis 2005; 2008). There are multiple different physical habitat conditions throughout the Cottonwood Creek watershed (Davis et al 2006). The upper portion of the creek, above Cornelius Lake, typically has a lower water temperature (below 50°F) and similarly, Dry Creek is cooler than most downstream sites. The creek flows over large gravel and cobble between Neklason Lake and Mud Lake. Water temperatures are higher in this portion due to warming in upstream lakes.

Macrophytes are present along the margins of the creek and in depositional areas. Stream slopes and water velocities are much lower downstream from Wasilla Lake to below Edlund Road. The substrate in this reach is dominated by fine material. In addition to the several lakes in the watershed, there are a number of areas where the stream channel is wide with slow velocities. The stream substrate in many locations is composed of fine material colonized by aquatic macrophytes, which is typical of systems that do not receive flushing flows during snowmelt or storm events (Davis and Davis 2008). Below Edlund Road the channel slope and velocities increase again (Davis et al. 2006). Channel width and the abundance of macrophytes decrease while substrate size increases. Stream water temperatures decrease as the stream flows through this reach. Large woody debris is common in this reach and forms debris dams and step pools.

2. Water Quality Standards and TMDL Target

Water quality standards designate the "uses" to be protected (e.g., water supply, recreation, growth and propagation of fish, shellfish, other aquatic life and wildlife) and the "criteria" for their protection (e.g., how much of a pollutant can be present in a waterbody without impairing its designated uses). Total Maximum Daily Loads (TMDLs) are developed to meet applicable water quality standards, which may be expressed as numeric water quality criteria or narrative criteria for the support of designated uses. The TMDL target identifies the numeric goals or endpoints for the TMDL that equate to attainment of the water quality standards. The TMDL target may be equivalent to a numeric water quality criterion where one exists, or it may represent a quantitative interpretation of a narrative criterion. This section reviews the applicable water quality standards and identifies an appropriate target for calculation of the fecal coliform bacteria TMDL for Cottonwood Creek.

2.1. Applicable Water Quality Standards

Title 18, Chapter 70 of the Alaska Administrative Code (AAC) establishes water quality standards for the waters of Alaska, including the designated uses to be protected and the water quality criteria necessary to protect the uses. State water quality criteria are defined for both marine and fresh waterbodies. The fresh water criteria are applicable to Cottonwood Creek.

Designated uses established in the Alaska Water Quality Standards (18 AAC 70) for fresh waters include (1) water supply; (2) water recreation; and (3) growth and propagation of fish, shellfish, other aquatic life, and wildlife and are applicable to all fresh waters, unless specifically exempted. Cottonwood Creek is protected for all three designated uses. Table 2-1 summarizes the water quality criteria for fecal coliform bacteria, which are used to determine the Clean Water Act (CWA) Section 303(d) listing for Cottonwood Creek.

Table 2-1. Fresh water quality criteria for fecal coliform bacteria in 18 AAC 70.020(b).

Pollutant and Water Use	Criteria
(2) Fecal coliform bacteria (FC), for fresh water uses (see note 1)	
(A) Water supply	
(i) Drinking, culinary, and food processing	In a 30-day period, the geometric mean may not exceed 20 FC/100 ml, and not more than 10% of the samples may exceed 40 FC/100 ml. For groundwater, the FC concentration must be less than 1 FC/100 ml, using the fecal coliform Membrane Filter Technique, or less than 3 FC/100 ml, using the fecal coliform most probable number (MPN) technique.
(ii) Agriculture, including irrigation and stock watering	The geometric mean of samples taken in a 30-day period may not exceed 200 FC/100 ml, and not more than 10% of the samples may exceed 400 FC/100 ml. For products not normally cooked and for dairy sanitation of unpasteurized products, the criteria for drinking water supply, (2)(A)(i), apply.
(iii) Aquaculture	For products normally cooked, the geometric mean of samples taken in a 30-day period may not exceed 200 FC/100 ml, and not more than 10% of the samples may exceed 400 FC/100 ml. For products not normally cooked, the criteria for drinking water supply, (2)(A)(i), apply.
(iv) Industrial	Where worker contact is present, the geometric mean of samples taken in a 30-day period may not exceed 200 FC/100 ml, and not more than 10% of the samples may exceed 400 FC/100 ml.

Pollutant and Water Use	Criteria
(i) Contact recreation	In a 30-day period, the geometric mean of samples may not exceed 100 FC/100 ml, and not more than one sample, or more than 10% of the samples if there are more than 10 samples, may exceed 200 FC/100 ml.
(ii) Secondary recreation	In a 30-day period, the geometric mean of samples may not exceed 200 FC/100 ml, and not more than 10% of the total samples may exceed 400 FC/100 ml.
(C) Growth and propagation of fish, shellfish, other aquatic life, and wildlife	Not applicable.

Notes:
1. Wherever criteria for fecal coliform bacteria are provided in this section, fecal coliform bacteria enumeration must be determined by the membrane filter technique or most probable number procedure according to any edition of *Standard Methods for the Examination of Water and Wastewater*, adopted by reference in (c)(1) of this section, and adopted by reference, or in accordance with other standards approved by the department and the United States Environmental Protection Agency (EPA).

2.2. Designated Use Impacts

Cottonwood Creek was placed on the 2010 CWA Section 303(d) list for non-attainment of the water quality standards for fecal coliform bacteria (ADEC 2010a). The non-attainment affects the designated uses of (1) water supply and (2) water recreation in fresh water. Cottonwood Creek does not support its designated uses of water supply and water recreation due to elevated in-stream fecal coliform bacteria levels. The presence of fecal coliform bacteria indicates an increased risk of pathogen contamination in a waterbody, which could affect human health. Consumption of or contact with pathogen-contaminated waters can result in a variety of gastrointestinal, respiratory, eye, ear, nose, throat and skin diseases.

2.3. TMDL Target

Cottonwood Creek has applicable numeric water quality criteria for fecal coliform bacteria, and the TMDL is developed to meet the most stringent of these criteria to protect the water supply use for drinking, culinary, and food processing (water supply). As documented in Section 2.1, these criteria represent the most stringent criteria protecting all designated uses. The water quality criterion of not-to-exceed 40 FC/100 mL in no more than 10 percent of the samples will be used as the basis for this TMDL. Using the 40 FC/100 mL not-to exceed criterion results in the most stringent loading capacity, and it is expected that maintenance of the not-to-exceed criterion will also result in maintaining the geometric mean criterion of 20 FC/100 mL. If water quality data become available that show the geometric mean criterion is not being met, then the TMDL can be revised.

3. Data Review

The compilation and analysis of data and information is an essential step in understanding the general water quality conditions and trends in an impaired water. This section outlines and summarizes all of the data reviewed and includes the following information:

- Data inventory—describes the available data and information used to evaluate water quality conditions.
- Data analysis—presents results of various data analyses evaluating trends and relationships in in-stream data.

3.1. Data Inventory

Fecal coliform bacteria and flow data are available for Cottonwood Creek at 11 sampling stations collected in 2004, 2005, 2007, and 2008 (ADEC 2010b). Figure 3-1 shows the locations of the sampling stations. Table A-1 in Appendix A presents all of the available data. The data were collected during baseflow, storm flow, and spring runoff conditions. A summary of the fecal coliform bacteria data at the 11 sampling stations is shown in Table 3-1 and a summary of the flow data is shown in Table 3-2. The data are presented in Tables 3-1 and 3-2 from the upper most station near the headwaters (Settlement Avenue) moving downstream to Surrey Road. Wasilla Lake is located approximately midway between Settlement Avenue and Surrey Road.

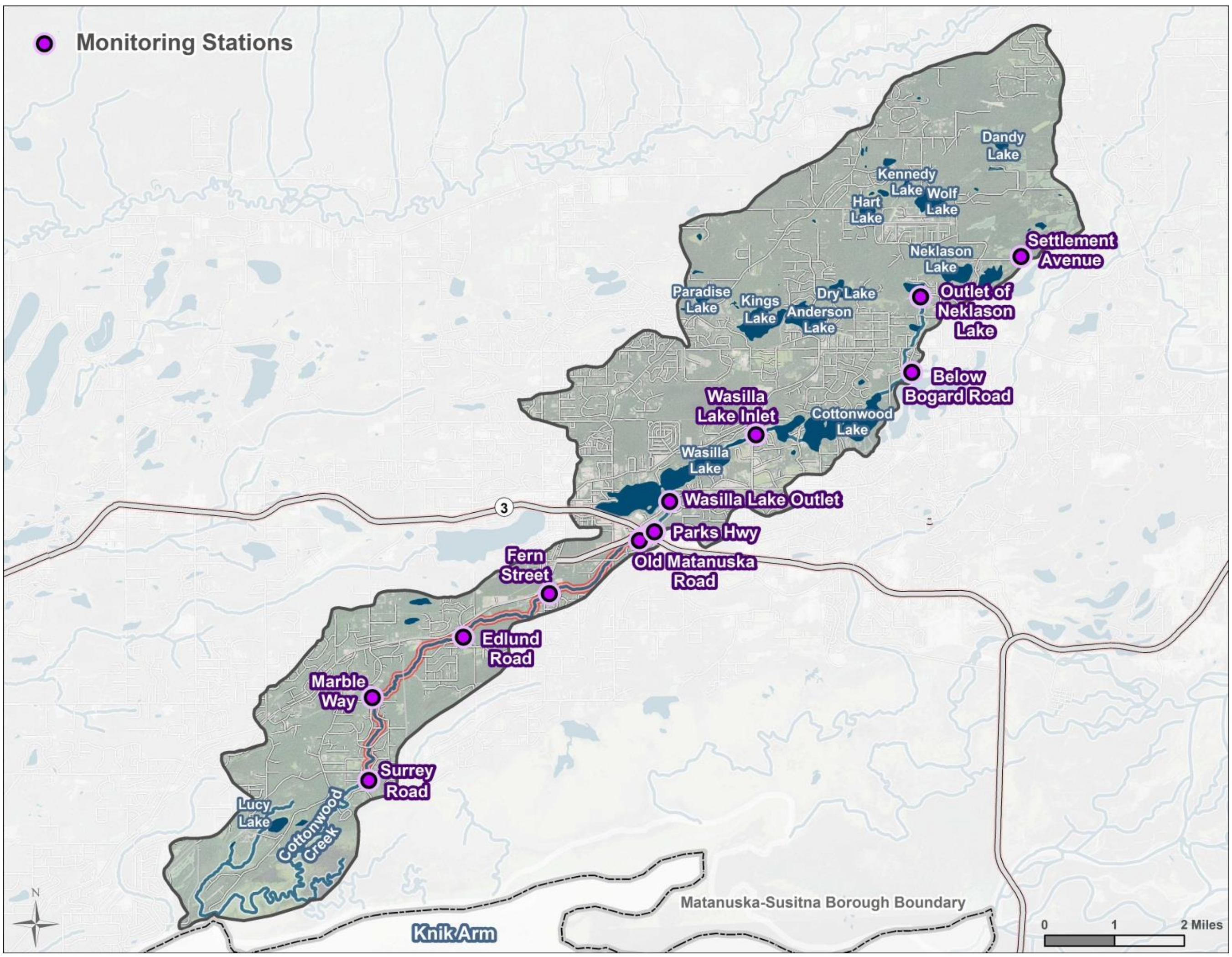

Figure 3-1. Location of water quality monitoring stations in the Cottonwood Creek watershed.

Table 3-1. Summary of available fecal coliform bacteria data for Cottonwood Creek.

Sampling site	Number of observations	Start Date	End Date	Minimum (fc[a]/100mL)	Average (fc/100mL)	Median (fc/100mL)	Maximum (fc/100mL)
Settlement Avenue	6	4/21/2004	9/14/2004	0.5	328.9	30	1600/260[b]
Neklason Outlet	6	4/21/2004	9/14/2004	0.5	12.3	6	50
Below Bogard	10	4/21/2004	8/30/2005	2.7	19.9	11	94
Wasilla Lake Inlet	8	7/30/2007	5/7/2008	0.5	9	7	30
Wasilla Lake Outlet	11	7/30/2007	5/7/2008	0.0	1.4	1	7
Parks Highway	10	7/30/2007	5/7/2008	0.5	22.5	13	116
Old Matanuska Road	21	4/21/2004	5/7/2008	0.5	56.6	50	197.5
Fern Crossing	6	4/21/2004	9/14/2004	10	85	95	130
Edlund Road	14	4/21/2004	5/7/2008	0.5	71.8	55	240
Marble Way	8	7/30/2007	5/7/2008	2	27	15	59
Surrey Road	34	4/21/2004	5/7/2008	4	168.4	93	1200

[a] fc = fecal coliform bacteria

[b] The Matanuska-Susitna Borough conducted a culvert replacement project at the Settlement Avenue sample site during the summer of 2004. The high fecal coliform bacteria results are attributed to the type of soil and fertilizer used for the bank restoration and hydroseeding work. 260 fc/100 mL is the next highest observation at this station.

Table 3-2. Summary of available flow data for Cottonwood Creek.

Sampling site	Number of observations	Start Date	End Date	Minimum (cfs[a])	Average (cfs)	Maximum (cfs)
Settlement Avenue	6	4/21/2004	9/14/2004	5.5	10.65	16.1
Neklason Outlet	6	4/21/2004	9/14/2004	5.5	10.65	16.1
Below Bogard	10	4/21/2004	8/30/2005	5.5	13.4	20
Wasilla Lake Inlet	8	7/30/2007	5/7/2008	14.4	15.7	17.3
Wasilla Lake Outlet	10	7/30/2007	5/7/2008	14.4	15.9	18.1
Parks Highway	10	7/30/2007	5/7/2008	14.4	15.9	18.1
Old Matanuska Road	20	4/21/2004	5/7/2008	5.5	14.7	20
Fern Crossing	6	4/21/2004	9/14/2004	5.5	10.65	16.1
Edlund Road	14	4/21/2004	5/7/2008	5.5	13.5	17.3
Marble Way	8	7/30/2007	5/7/2008	14.4	15.7	17.3
Surrey Road	30	4/21/2004	5/7/2008	5.5	14.1	20

[a] cfs = cubic feet per second

3.2. Data Analysis

The following sections discuss data analyses conducted to evaluate any important trends or aspects of the fecal coliform bacteria levels in Cottonwood Creek. Monitoring was conducted on Cottonwood Creek in 2004, 2005, 2007, and 2008 at 11 stations (Figure 3-1). Data at all 11 stations were reviewed to characterize the water quality of Cottonwood Creek.

3.2.1. Impairment Analysis

An impairment analysis compares available in-stream data with applicable water quality criteria to confirm the listed impairment (i.e., nonsupport of fecal coliform bacteria water quality criteria and associated uses). The analysis also evaluates the magnitude and frequency of water quality criteria exceedances. Fecal coliform bacteria data collected by ADEC in Cottonwood Creek were compared to the geometric mean and not-to-exceed criterion to evaluate impairment and water quality criteria exceedances.

Figure 3-2 shows all of the available fecal coliform bacteria data for Cottonwood Creek compared to the not-to-exceed and geometric mean water quality criterion. It is apparent that bacteria levels are highly variable and that the concentrations measured in recent years often exceed Alaska’s water quality criteria for fecal coliform bacteria.

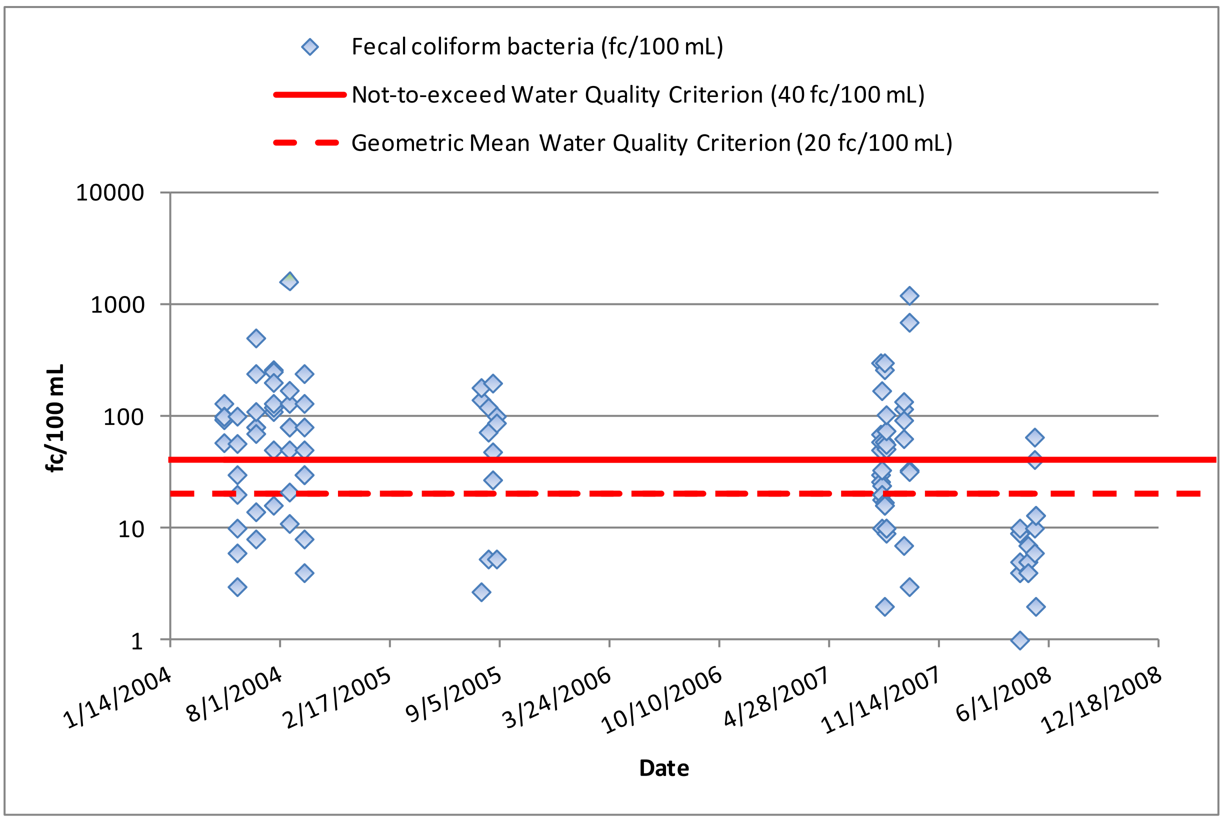

Figure 3-2. Fecal coliform bacteria data for Cottonwood Creek compared to water quality criteria.

For comparison to the geometric mean criterion at each sampling station, geometric means were calculated for every possible 30-day period included in the dataset, based on all individual observations within that 30-day period. Table 3-3 summarizes the calculated geometric means and their comparison to the geometric mean criterion of 20 fc/100 mL. Data at the Settlement Avenue, Neklason Outlet, and Fern Crossing stations were only collected once per month from April through September 2004; therefore, not enough data are available to calculate geometric means at those three stations. Comparison of the geometric means at all other stations show exceedances of the 20 fc/100 mL criterion at five of the stations (Parks Highway, Old Matanuska Road, Edlund Road, Marble Way, and Surrey Road). Table A-2 in Appendix A lists all of the calculated exceedances of the geometric mean criterion.

Table 3-3. Summary of geometric mean criterion exceedances at all stations in the Cottonwood Creek watershed.

Sampling site	Start Date	End Date	Minimum (fc[a]/100mL)	Average (fc/100mL)	Maximum (fc/100mL)	Number of calculated geometric means	Over 20 fc/100mL	
							Number	Percent
Settlement Avenue[b]	4/21/2004	9/14/2004	NA	NA	NA	NA	NA	NA
Neklason Outlet[b]	4/21/2004	9/14/2004	NA	NA	NA	NA	NA	NA
Below Bogard	4/21/2004	8/30/2005	6.7	6.7	6.7	1	0	0%
Wasilla Lake Inlet	7/30/2007	5/7/2008	1.0	7.8	14.6	2	0	0%
Wasilla Lake Outlet	7/30/2007	5/7/2008	0.5	1.93	4.6	3	0	0%
Parks Highway	7/30/2007	5/7/2008	0.8	26.4	61.9	3	1	33%
Old Matanuska Road	4/21/2004	5/7/2008	0.8	46.3	118.8	4	3	75%
Fern Crossing[b]	4/21/2004	9/14/2004	NA	NA	NA	NA	NA	NA
Edlund Road	4/21/2004	5/7/2008	3.6	27.4	51.2	2	1	50%
Marble Way	7/30/2007	5/7/2008	4.8	24.6	44.4	2	1	50%
Surrey Road	4/21/2004	5/7/2008	12.0	136.4	266.0	6	4	67%

[a] fc = fecal coliform bacteria
[b] Sampling site did not have adequate data to calculate a 30-day geometric mean.

The fecal coliform bacteria data for Cottonwood Creek were also compared to the not-to-exceed criterion (i.e., not to exceed 40 fc/100 mL in more than 10 percent of the samples in a 30-day period). Table 3-4 summarizes the minimum, average, and maximum of all instantaneous observations at each sampling station for samples within any possible 30-day period and then compared to the not-to-exceed criterion. Exceedances were observed at all of the stations except for Wasilla Lake Inlet and Wasilla Lake Outlet, with the highest percentage of exceedances at Fern Crossing and Surrey Road. Table A-2 in Appendix A lists all of the individual exceedances of the not-to-exceed criterion.

Table 3-4. Summary of exceedances of the not-to-exceed criterion in Cottonwood Creek.

Sampling site	Start Date	End Date	Minimum (fc[a]/100mL)	Average (fc/100mL)	Maximum (fc/100mL)	Number of observations	Over 40 fc/100mL[b]	
							Number	Percent
Settlement Ave.	4/21/2004	9/14/2004	0.5	328.9	1600/260[b]	6	3	50%
Neklason Outlet	4/21/2004	9/14/2004	0.5	12.3	50	6	1	17%
Below Bogard	4/21/2004	8/30/2005	2.7	19.9	94	10	1	10%
Wasilla Lake Inlet	7/30/2007	5/7/2008	0.5	9	30	8	0	0%
Wasilla Lake Outlet	7/30/2007	5/7/2008	0.0	1.4	7	11	0	0%
Parks Highway	7/30/2007	5/7/2008	0.5	22.5	116	10	1	10%
Old Matanuska Road	4/21/2004	5/7/2008	0.5	56.6	197.5	21	11	52%
Fern Crossing	4/21/2004	9/14/2004	10	85	130	6	5	83%
Edlund Road	4/21/2004	5/7/2008	0.5	71.8	240	14	8	57%
Marble Way	7/30/2007	5/7/2008	2	27	59	8	3	38%
Surrey Road	4/21/2004	5/7/2008	4	168.4	1200	34	27	79%

[a] fc = fecal coliform bacteria

[b] The "Number" is the number of observations exceeding the 40 fc/100 mL criterion in greater than 10 percent of the samples in a 30-day period. The "Percent" is the percentage of all samples exceeding the 40 fc/100 mL criterion in greater than 10 percent of the samples in a 30-day period.

3.2.2. Spatial and Temporal Variation / Flow versus Fecal Coliform Bacteria

Evaluation of the relationship between water quality and flow can indicate conditions under which loading and impairment occur and can provide insight into the types of sources contributing pollutant loads. No continuous flow data are available for Cottonwood Creek; however, flow data were simultaneously collected with most fecal coliform bacteria data collection in the creek (see Table A-1 in Appendix A). Flow and water quality measurements from matching days were used to evaluate the relationship between flow and fecal coliform bacteria (Figures 3-3 and 3-4). No strong correlation was found. The relationship between flow and fecal coliform bacteria varies by station. Fecal coliform bacteria are higher during higher flows at some stations while other stations show higher fecal coliform bacteria concentrations at lower flows. This indicates variable sources of fecal coliform bacteria in the watershed (see Section 4).

Evaluation of spatial and temporal patterns can assist in identifying potential sources in the watershed, seasonal variations, or declining/improving water quality trends. Figure 3-5 shows the average fecal coliform bacteria concentrations from the most upstream station (Settlement Avenue) to the most downstream station (Surrey Road). The fecal coliform bacteria concentrations tend to increase downstream of the Wasilla Lake outlet.

Figures 3-6 and 3-7 present a monthly distribution of average fecal coliform bacteria observations at each sampling station in Cottonwood Creek. The highest levels of fecal coliform bacteria in Cottonwood Creek were observed during the summer months (July-September) and were likely due to increased rain events and resulting stormwater runoff. No water quality data were available for the winter months (October through March) because winter conditions typically result in ice cover on the creek that does not allow for sampling. Some high averages of fecal coliform bacteria at the Below Bogard and Fern Crossing stations are likely due to runoff from spring break-up and thaw.

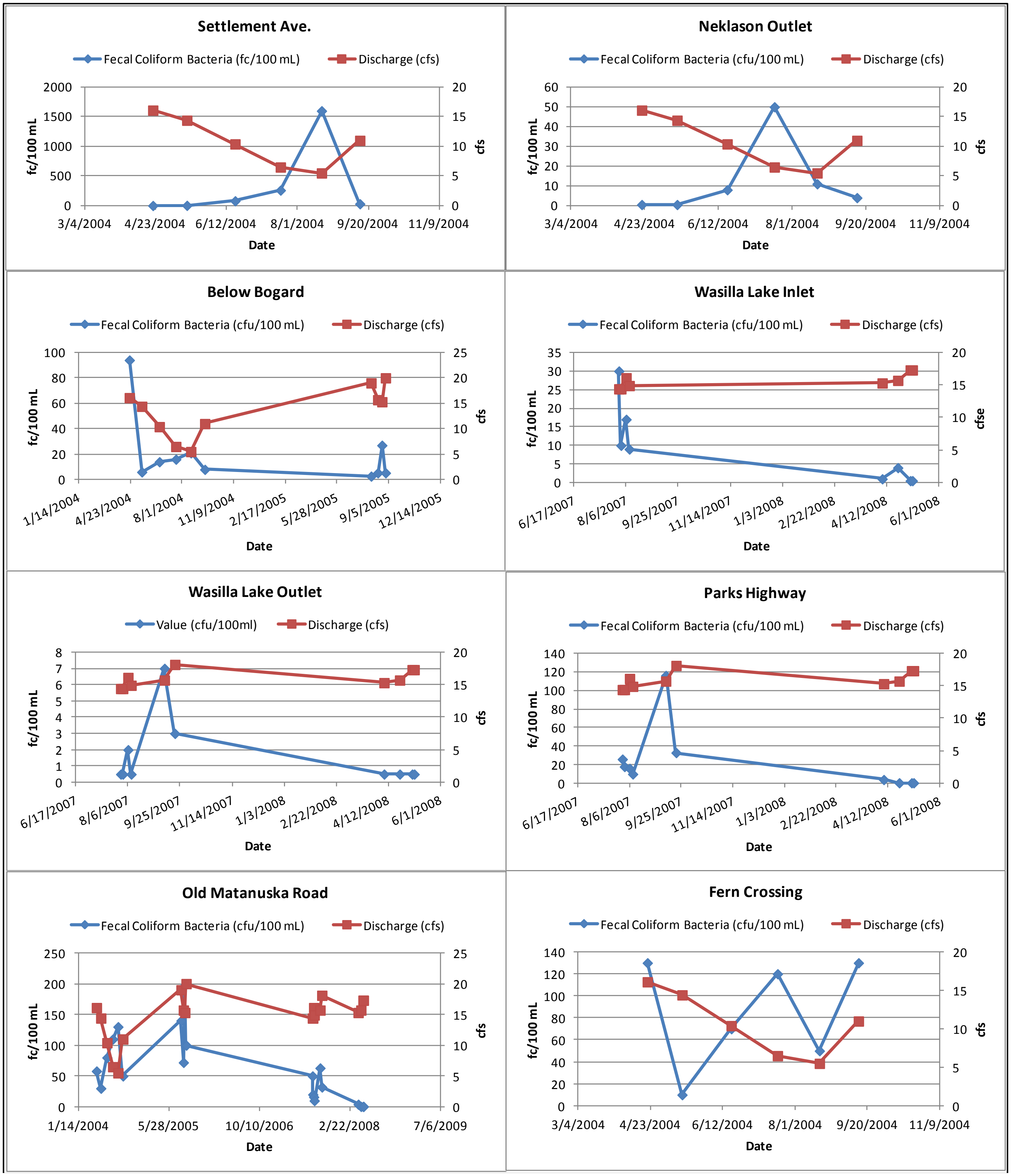

Figure 3-3. Flow versus fecal coliform bacteria observations at each sampling station in the Cottonwood Creek watershed (Settlement Avenue, Neklason Outlet, Below Bogard, Wasilla Lake Inlet, Wasilla Lake Outlet, Parks Highway, Old Matanuska Road, Fern Crossing).

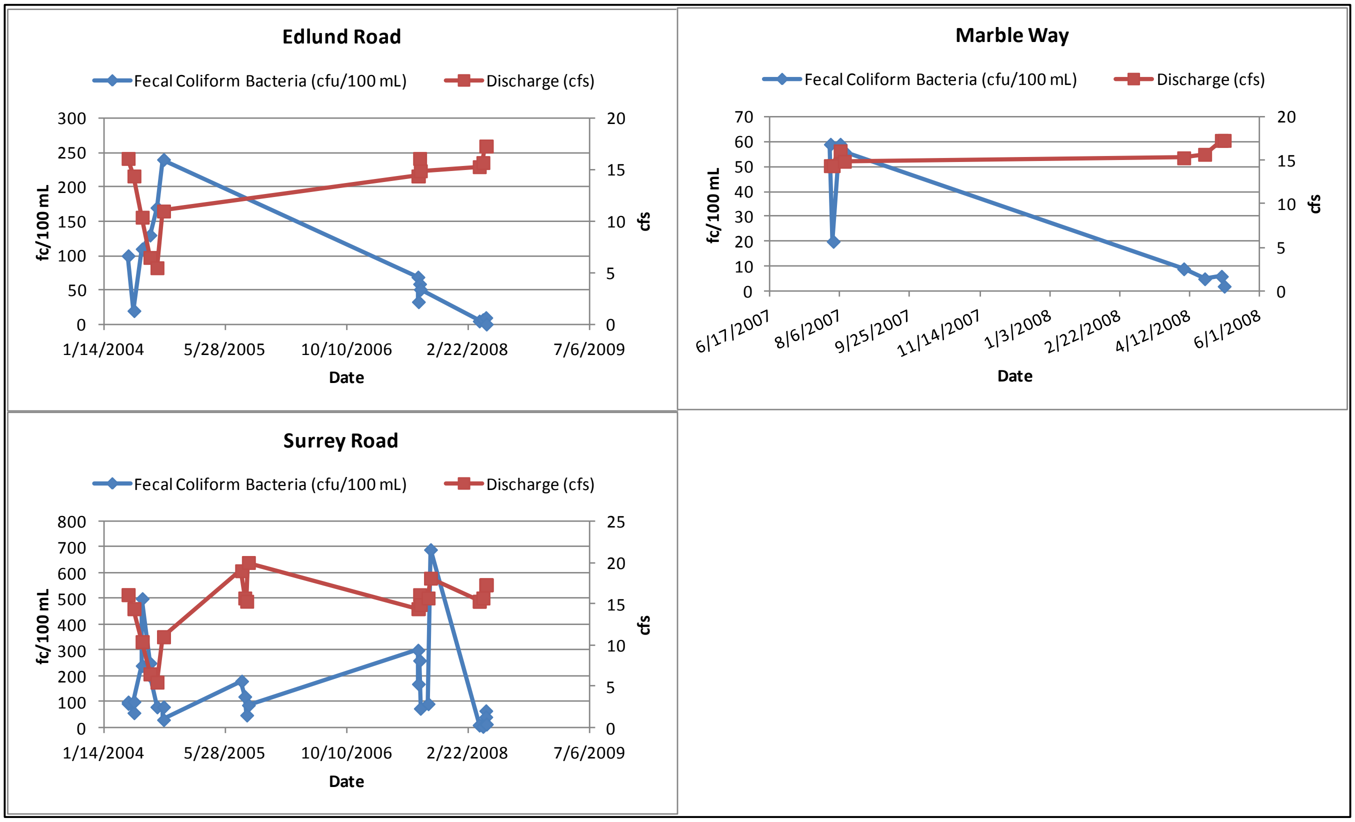

Figure 3-4. Flow versus fecal coliform bacteria observations at each sampling station in the Cottonwood Creek watershed (Edlund Road, Marble Way, and Surrey Road).

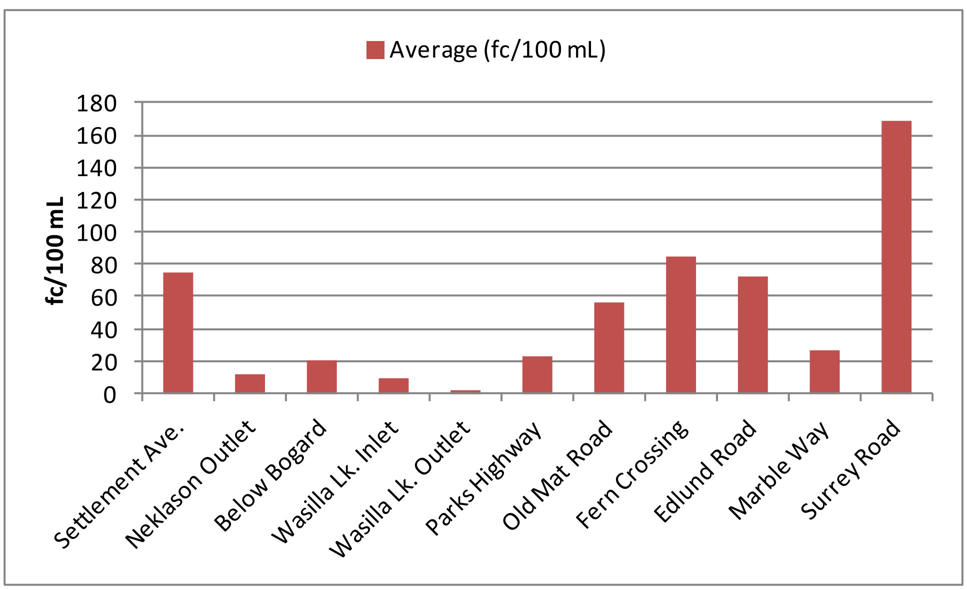

Figure 3-5. Average fecal coliform bacteria observations at the Cottonwood Creek sampling stations.

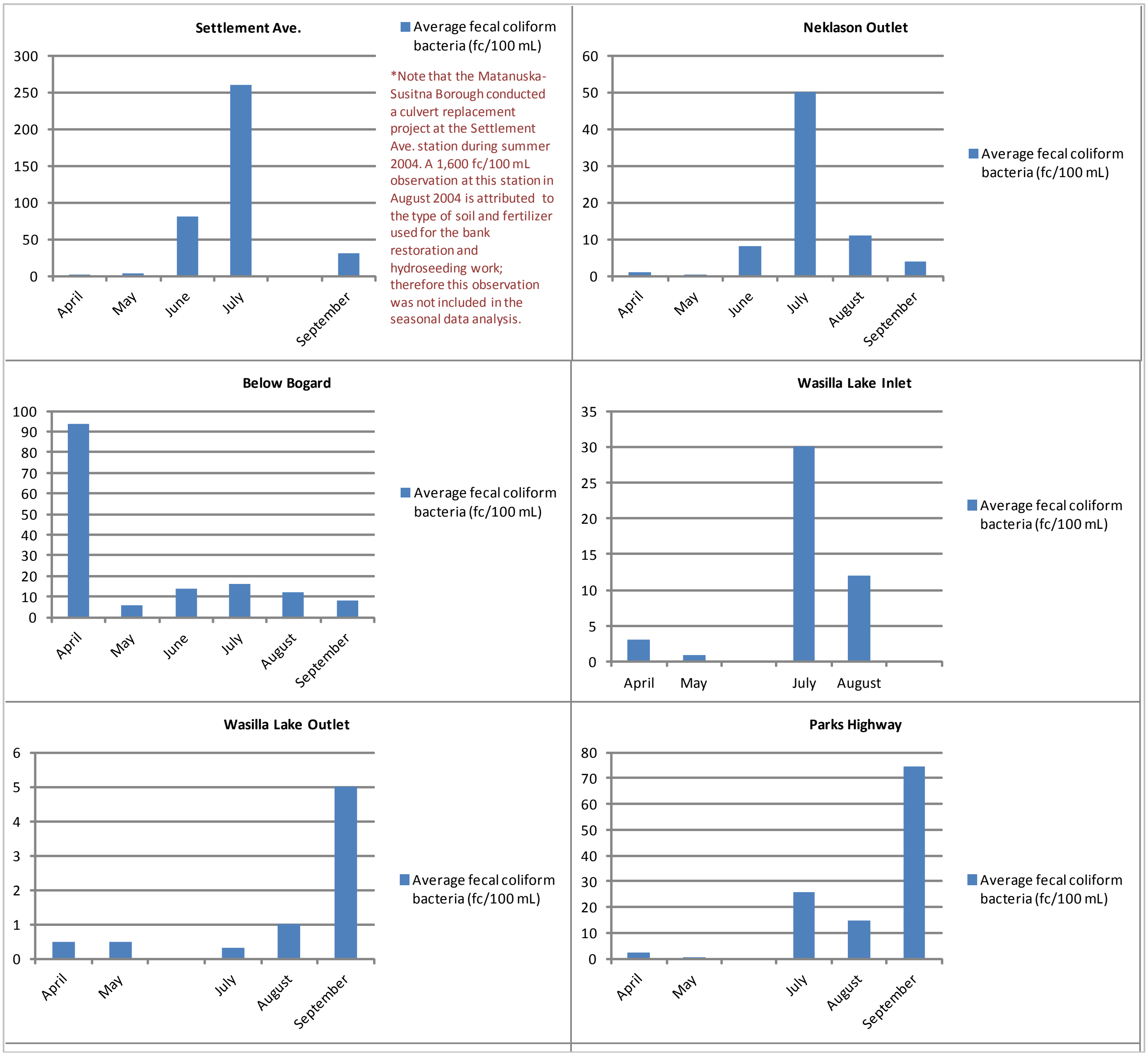

Figure 3-6. Monthly average fecal coliform bacteria observations at each station in the Cottonwood Creek watershed (Settlement Avenue, Neklason Outlet, Below Bogard, Wasilla Lake Inlet, Wasilla Lake Outlet, and Parks Highway).

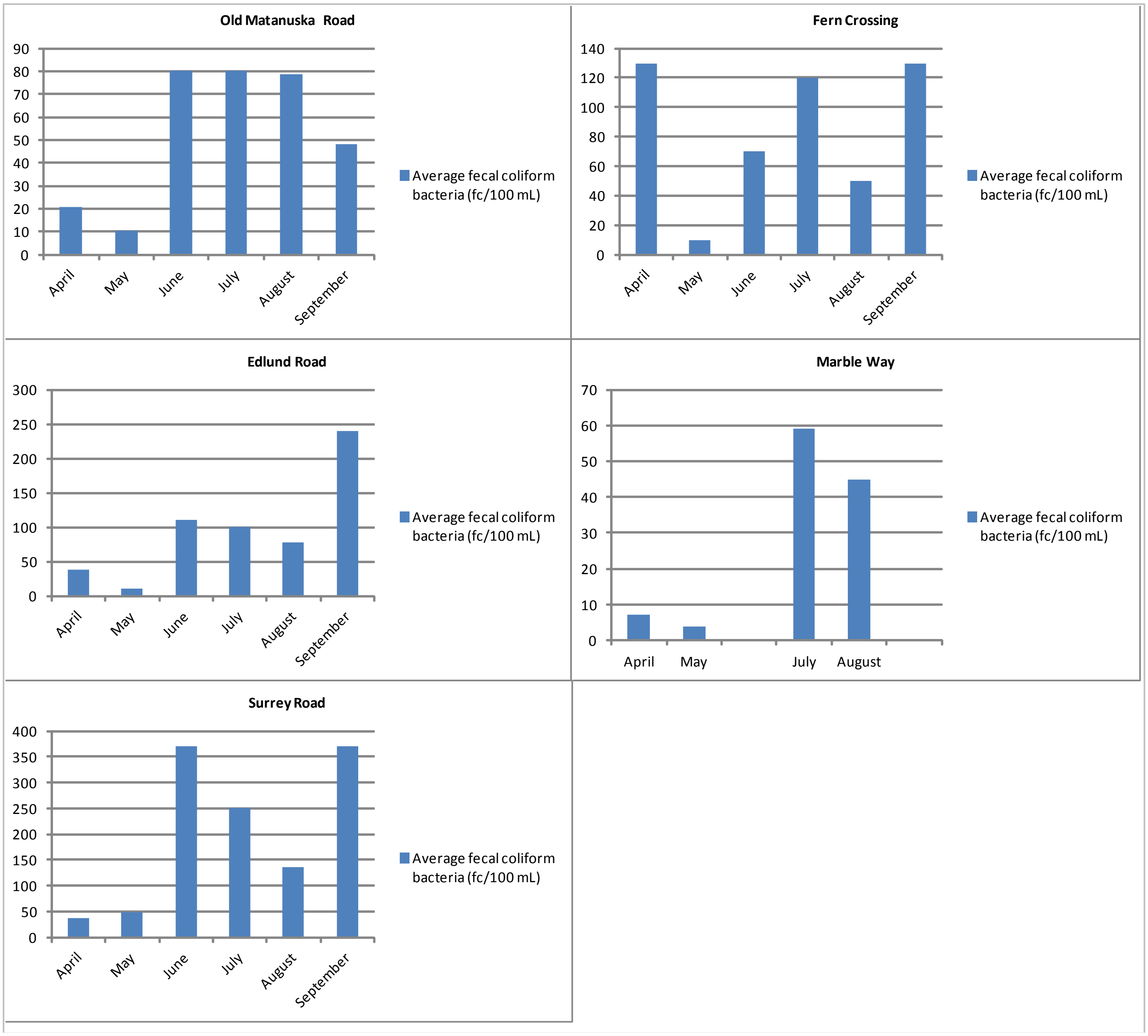

Figure 3-7. Monthly average fecal coliform bacteria observations at each station in the Cottonwood Creek watershed (Old Matanuska Road, Fern Crossing, Edlund Road, Marble Way, and Surrey Road).

4. Pollutant Sources

This section discusses the potential sources of fecal coliform bacteria to Cottonwood Creek, including point, nonpoint and natural sources. Alaska's 2010 Clean Water Act (CWA) Section 303(d) list identified urban runoff and nonspecific septic sources as the expected sources (ADEC 2012); however, additional potential sources exist as well. Two recent reports that evaluate fecal coliform bacteria in the Cottonwood Creek watershed are: *Cottonwood Creek Fecal Coliform and Temperature Evaluation* (Davis and Davis 2008) and *Fecal Coliform Bacteria Source Assessment in the Waters of Cottonwood Creek, Wasilla, and Little Campbell Creek, Anchorage – Final Report* (MST Report, Davis et al. 2010). The two reports provide much of the pollutant source information for the Cottonwood Creek watershed presented in this section.

Sources of fecal coliform bacteria in waterbodies can be determined through the differences in the populations of the bacteria residing in the digestive system of warm-blooded animals. These isolated groups of bacteria evolve genetically allowing for differentiation based upon deoxyribonucleic acid (DNA) analyses (Davis et al. 2010). A project was completed in 2010 that used microbial source tracking (MST) to determine if the fecal coliform bacteria contamination in Cottonwood Creek is due to humans or human related activities (Davis et al. 2010). Water samples were collected at three locations on Cottonwood Creek during spring runoff, summer base flow, and following storm events. The three Cottonwood Creek sampling locations were Old Matanuska Road, Marble Way, and Surrey Road (Figure 3-1). Sampling was conducted on April 12, May 3, May 17, June 22, June 24, August 11, August 30, and September 30, 2010. Water samples from each site on each sampling date were analyzed for fecal coliform bacteria and genetic markers for fecal *Bacteroides* and *Bacteroides* DNA segments specific to humans, dogs, horses, and waterfowl.

As part of the MST study, stream surveys were conducted on Cottonwood Creek to identify land use and potential sources of fecal coliform bacteria contamination. The stream surveys documented the types of development and riparian modifications along Cottonwood Creek from the outlet of Wasilla Lake to Surrey Road. The stream surveys were used to identify any potential sources of fecal coliform bacteria contamination including presence of waterfowl, horses, dog waste, and stormwater or wastewater outfalls.

The primary objective of the MST project was to determine whether fecal coliform bacteria concentrations in Cottonwood Creek were directly or indirectly caused by humans. Results support the conclusion that fecal coliform bacteria from humans are present in Cottonwood Creek following precipitation (Davis et al. 2010).

MST methods can be very useful in identifying fecal coliform bacteria sources in impaired watersheds; however, there are limitations to the use of MST. MST methods should be used only to supplement other identification tools such as traditional monitoring of fecal coliform bacteria indicators, sanitary surveys and watershed tours, and local knowledge. The results are most useful to confirm the presence or absence of a particular bacteria source or to gain a qualitative understanding of the types and relative abundance of different bacteria sources. MST methods lack the accuracy required for quantifying fecal coliform bacteria sources, and the use of MST to quantify source loading estimation or distribution of load allocation is not recommended. MST results can, however, be used to qualitatively identify sources that are likely contributing more bacteria or are more abundant in the watershed and can therefore be prioritized for management or additional characterization (Tetra Tech, Inc. and Herrera Environmental Consultants 2011).

4.1. Point Sources

Stormwater runoff to Cottonwood Creek is one of the likely sources of fecal coliform bacteria. Stormwater carries pollutants to receiving waterbodies through surface runoff, which is generated when precipitation from rain and snowmelt events flows over land or impervious surfaces (paved streets, parking lots, and building rooftops) and does not percolate into the ground. As the runoff flows over the land or impervious surfaces, it accumulates debris, chemicals, sediment or other pollutants that could adversely affect water quality if the runoff is discharged untreated. When a community or urbanized area meets the population threshold and population density to be regulated as a municipal separate storm sewer system (MS4), all stormwater carried through constructed conveyances owned or operated by a public entity become a regulated discharge. The regulated discharge is considered a point source, which requires an MS4 permit issued under the Alaska Pollutant Discharge Elimination System (APDES) program. Current population numbers and density of the urbanized area that contains the Cottonwood Creek watershed will likely meet the criteria to become a regulated MS4 in approximately three years. Unlike most constant point sources (e.g., wastewater treatment plant discharges), stormwater is precipitation-driven.

Currently, an APDES MS4 permit is not required to addresses stormwater conveying fecal coliform bacteria to Cottonwood Creek. Two stormwater outfalls were identified that discharge to Cottonwood Creek: one just upstream of the Parks Highway and one downstream of the Parks Highway. The outfalls are currently not permitted but their discharge would be assigned a waste load allocation (WLA) and included in the expected MS4 permit. The City of Wasilla, Matanuska-Susitna Borough, Department of Transportation, and the City of Palmer are anticipated to apply for an MS4 permit as co-permittees. Therefore, fecal coliform bacteria loads delivered to Cottonwood Creek from the expected MS4 area are given their own load allocation (LA) in this TMDL that will be converted to a WLA in the issued MS4 permit (see Section 6).

Industrial and construction activities can also generate contaminated stormwater. No industrial stormwater permittees discharge directly into Cottonwood Creek; therefore, a WLA for industrial stormwater is not included in this TMDL. Currently, 12 projects authorized under the construction general permit have been issued with the receiving water designated in the impaired reach of Cottonwood Creek (Table 4-1). Authorizations under the construction general permit are temporary with any potential discharges occurring only during the permitted period. Therefore, the total number of permitted construction projects in the Cottonwood Creek watershed will change over time. Any discharges from the permitted construction projects are considered to be an insignificant source of fecal coliform bacteria and establishing WLAs is not necessary.

Figure 4-1 shows the boundary of the expected MS4 area and the locations of the 12 projects authorized under the construction general permit in 2013, the two stormwater outfalls, and two highways in relation to the impaired reach of Cottonwood Creek.

Table 4-1. Construction permits in the Cottonwood Creek watershed.

Site Name	Site Owner	Date Issued	Permit ID
Valley Native Primary Care Center_4	Neeser Construction INC	11/22/11	AKR10DX24
Valley Native Primary Care Center_5	Southcentral Foundation	12/5/11	AKR10DY00
Valley Church of Christ	Byler Construction	9/19/12	AKR10EG51
2485 East Zak Circle	Tutka LLC	12/11/12	AKR10EH47
Wasilla Lithia	MCN	7/8/13	AKR10EM16
Wasilla Lithia_2	Lithia Motors	7/9/13	AKR10EM17
Knik-Goose Bay Road and Fern Street Improvements	Granite Construction Inc	7/10/13	AKR10EM24
51896 Knik-Goose Bay Road and Fern Street Improvements	Alaska DOT_PF CR	7/10/13	AKR10EM34
Eagle Eye Lot 4	Pacific North Construction Inc	8/15/13	AKR10EN75
Terrace on the Lake_3	Dennis Byler of Byler Contracting Inc.	11/13/13	AKR10EO99
Terrace on the Lake_2	Asbury Moore IV, Manager of Terrace Properties LLC	8/27/13	AKR10EN36
Gemstone Estates Subdivision	Jess Hall, President Selway Corp.	9/18/12	AKR10ED93

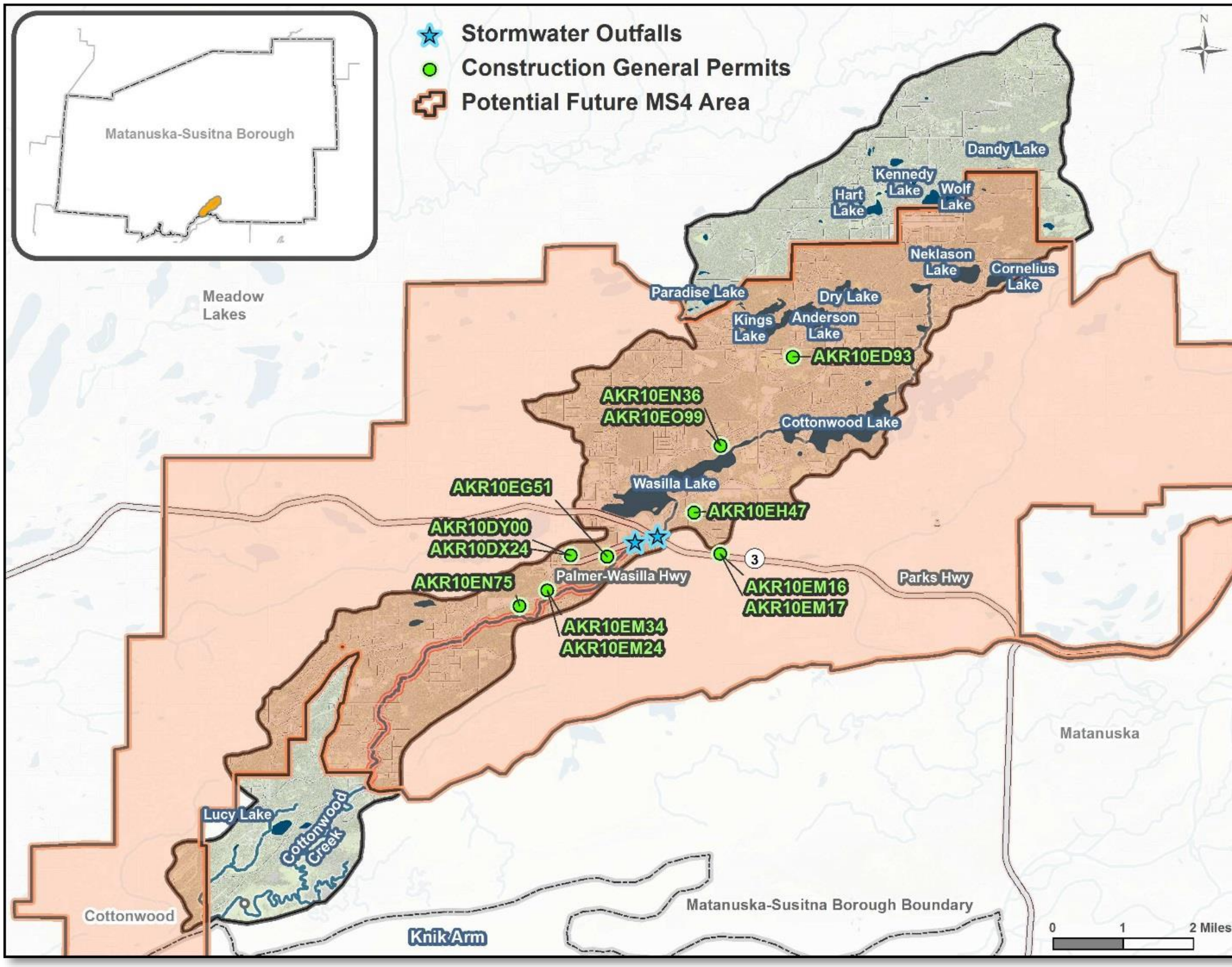

Figure 4-1. Potential point sources in the Cottonwood Creek watershed.

4.2. Nonpoint Sources

Based on the results of the data reviewed in Section 3 and the results of the MST report (Davis et al. 2010), the persistence of fecal coliform bacteria in Cottonwood Creek increases downstream from Wasilla Lake to Surrey Road. Likely sources of the fecal coliform bacteria are urban runoff and aging or improperly installed or maintained on-site septic systems. (ADEC 2010). ADEC does not believe on-site septic systems to be a major source bacteria, but during times of heavy rainfall and runoff, leach fields located near the creek may be contributing bacteria to the creek through shallow sub-surface groundwater flow.

The Old Matanuska Road sampling location evaluates potential sources including waterfowl concentrated at Wasilla Lake outlet, runoff from the Parks Highway and shopping areas, and potential discharge from wastewater pipes that cross under Cottonwood Creek. Sampling sites at Marble Way and Surrey Road bracket a section of Cottonwood Creek that has residential development, private duck ponds, and a few horse stables (Davis et al. 2010). Fecal coliform bacteria loading from failing septic systems would most likely occur between Marble Way and Surrey Road as there is a relatively high concentration of homes in this area that are not serviced by a municipal sewer system (Davis and Davis 2008). The exact number of septic systems in the Cottonwood Creek watershed is unknown. However, a map from ADEC's Cottonwood Creek Septic Smart Program (ADEC 2013b) shows parcels along Cottonwood Creek located 500-1,000 feet, 200-499 feet, and less than 200 feet from

Cottonwood Creek. The map was used to estimate the number of septic systems adjacent to Cottonwood Creek. There are 193 parcels located less than 200 feet from the creek; 163 parcels located within 200 – 499 feet from the creek; and 309 parcels located between 500 and 1,000 feet of the creek. While not all of these parcels contain septic systems, the map provides a good estimate of the potential number of septic systems along the stream corridor. The parcels in red will be targeted for participation in the ADEC's Septic Smart Program, which is a septic pumping cost-share and education program. Figure 4-2 shows the locations of the parcels within the three distances from the creek.

Land use in between Wasilla Lake and Old Matanuska Road is primarily commercial. Ducks are often present between the Palmer-Wasilla and Parks Highways, and duck feces are present on rocks and other resting areas (Davis et al. 2010). Land use is primarily residential downstream of the Old Matanuska Road to Surrey Road, with the highest development occurring below Marble Way.

4.2.1. MST Report Results

The MST report found that markers specific for humans, dogs, horses, or waterfowl were detected in 33 percent of samples with greater than 20 fc/100 mL observations and 63 percent of samples with over 100 fc/100 mL observations (Davis et al. 2010). Markers were found at all sites on August 30, 2010 following a rain event and stormwater runoff. Human-specific markers were detected at the two downstream locations (Marble Way and Surrey Road) following a rain event prior to the August 30, 2010 sampling date. Horse and dog markers were found at two locations (Old Matanuska Road and Marble Way, respectively) during base-flow conditions. *Bacteroides* markers were absent from spring samples, which may be due to their inability to survive more than 4 to 5 days in aerobic environments outside of their host species (David et al. 2010).

Old Matanuska Road
Markers for horses and waterfowl were detected at the Old Matanuska Road site. The horse marker was found during base flow conditions in June 2010. However, there was a low abundance of horse markers, which is supported by the low fecal coliform bacteria counts on this date (3 fc/100 mL). The marker for waterfowl was present on August 30, 2010, coinciding with higher flow in the creek and following a rain event.

Marble Way
Markers for dogs, humans, horses, and waterfowl were detected at the Marble Way sampling location. The marker for dogs was found in June 2010 when discharge was low. This coincided with the highest fecal coliform bacteria count for this location. Markers for humans, horses, and waterfowl were detected on August 30, 2010 following a rain event.

Surrey Road
Markers for humans and horses were detected at the Surrey Road site on August 30, 2010 following the rain event.

Overall results indicate that bacteria from humans and human activities are contributing to the exceedances of the fecal coliform bacteria water quality criteria in Cottonwood Creek (Davis et al. 2010). The presence of these markers following storm events indicates that fecal material is being transported to Cottonwood Creek in surface or shallow subsurface flows.

The surface transport of fecal coliform bacteria from humans could be coming from the residential developments adjacent to Cottonwood Creek. However, another potential source was identified through stream surveys on Cottonwood Creek. A camp set up on an island in the stream contained a "Honey Bucket" and toilet paper. Another possible source could be stored garbage containing diapers or other fecal material (Davis et al. 2010).

Species-specific markers for horses, dogs, and waterfowl were found in Cottonwood Creek; however, their presence is infrequent and cannot account for high fecal coliform bacteria counts on other sampling dates. Stables and gardens are more common in the lower section of the creek and horse fecal material transported in surface flow is reasonable (Davis et al. 2010). A potential source of fecal coliform bacteria from horses includes the use of horse manure as a fertilizer on lawns or gardens. Dogs are common throughout the residential areas. However, markers from dogs were not seen in Cottonwood Creek following rain storms.

Overall, markers were detected at all three Cottonwood Creek sites on August 30, 2010 following a rain event showing that surface and/or shallow sub-surface transportation of fecal contaminants in storm flows is occurring. Both humans and human-related activities are contributing to the fecal coliform bacteria contamination of Cottonwood Creek from Marble Way to Surrey Road due to surface or shallow sub-surface transport of contaminants following storm events. MST does not provide insight on the sources of high fecal coliform bacteria counts when markers are absent. High fecal coliform bacteria counts in the absence of markers might be due to other sources (i.e., wildlife), or it could be that species-specific markers were present but not detected.

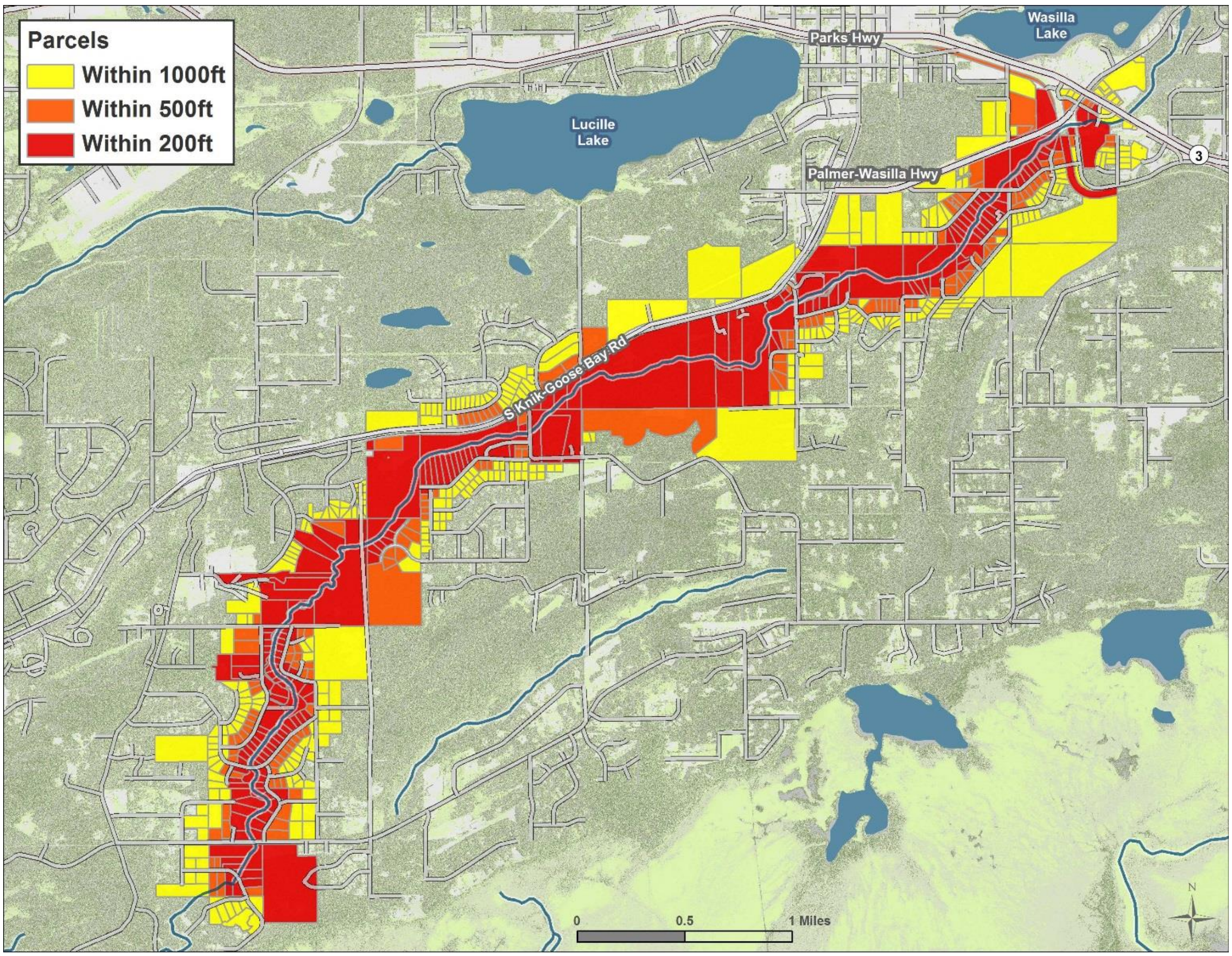

Figure 4-2.Parcels that may contain septic systems within 200, 500 and 1,000 feet of Cottonwood Creek.

4.3. Natural Sources

Fecal coliform bacteria are present in the digestive system of all warm blooded animals. Waterfowl congregations at the Wasilla Lake outlet and downstream from the Palmer Wasilla Highway road crossing may be a source of bacterial contamination. The lake outlet has open water all year (even in freezing temperatures) and attracts dozens of ducks, particularly during the winter months (Davis and Davis 2008).

Results from the Old Matanuska Road sampling location were used to evaluate waterfowl as a potential source of fecal coliform bacteria. Feces from waterfowl were observed on substrate in or adjacent to the channel on surveys along the entire length of Cottonwood Creek (Davis et al. 2010). Ducks may congregate at the outlet of Wasilla Lake or be present on private ponds adjacent to Cottonwood Creek.

Due to the data results, ADEC considers that waterfowl and wildlife overall contribute little fecal coliform bacteria through most of the watershed, but at some locations may contribute higher amounts at certain times of the year. Domestic and non-domestic waterfowl are present in the watershed; however, it is not possible to differentiate domesticated ducks from the natural waterfowl community.

Note that natural background conditions from non-domestic waterfowl and wildlife are included in the load allocation for this TMDL (see Section 6.2), but implementation practices do not apply to these natural sources since the pollutant loads are not a result of human actions.

5. Technical Approach

A Total Maximum Daily Load (TMDL) represents the total amount of a pollutant that can be assimilated by a receiving waterbody while still achieving water quality standards—also called the *loading capacity*. A TMDL is composed of individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background loads. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody.

The analytical approach used to estimate the loading capacity and allocations for Cottonwood Creek is based on the best available information to represent the impairment and expected sources.

5.1. Analysis Background

Data at all 11 stations were reviewed to characterize the water quality of Cottonwood Creek (see Section 3); however, only the data at the Surrey Road station were used to calculate the TMDL. The Surrey Road station is the most downstream station in the watershed and has the most robust dataset (34 observations).

When developing a TMDL based on in-stream observed data, existing loads can typically be estimated using corresponding observed flow and water quality data. Similarly, allowable loads can be calculated using observed flows and an appropriate TMDL target concentration. For example, a loading capacity curve can be developed by multiplying observed flow values by the water quality criteria and graphing the resulting loads. An existing load curve can be developed by multiplying the observed flow values by the observed water quality data. Existing loads that plot above the TMDL curve therefore represent deviations from the most stringent water quality criterion and those plotting below the curve represent compliance with criteria. The area beneath the TMDL curve represents the loading capacity of the stream.

To conduct a load duration curve analysis, it is necessary to have a continuous flow record or a dataset of flows covering a broad range of flow conditions during times of water quality sampling in the impaired stream. Although Cottonwood Creek has fecal coliform bacteria data from 2004-2008, it does not have continuous flow data corresponding to the time and location of the available fecal coliform bacteria data.

Cottonwood Creek had a continuous U.S. Geological Survey (USGS) flow gage (15286000 Cottonwood C Nr Wasilla AK) from 7/1/1949 – 9/30/1954 and 5/1/1998 – 9/30/2000. Additional flow data were collected by ADEC at the 11 sampling stations on Cottonwood Creek between 2004 and 2008. These are not continuous flow observations, but are considered occasional samples collected at each of the 11 stations with the number of flow observations ranging from 6 to 11 per station. Nearby Wasilla Creek (USGS 15285000 Wasilla C Nr Palmer AK) flow data were reviewed for use as a surrogate for the lack of continuous flow data at Cottonwood Creek. However, it was determined that Wasilla Creek was not an appropriate surrogate because the Wasilla Creek watershed does not contain lakes similar to those in the Cottonwood Creek watershed and differences in hydrology are expected. Therefore, the TMDL development approach was done using a simpler approach that uses an empirical equation to calculate pollutant loading in the absence of continuous flow data.

The Simple Method (Schueler 1987) was used to calculate existing fecal coliform loading based on watershed characteristics and observed fecal coliform bacteria data. The method was also used to calculate loading capacity for the stream, based on in-stream concentrations representing water quality criteria. The Simple Method was used in 2004 and 2006 to develop several fecal coliform bacteria TMDLs for the Anchorage Bowl – Campbell Creek (ADEC 2006), Ship Creek, Fish Creek, Furrow Creek, Little Campbell Creek, Little Rabbit Creek, and Little Survival Creek (ADEC 2004). The Simple Method is described in greater detail in Section 5.2.

Cottonwood Creek experiences seasonal variation in in-stream fecal coliform bacteria levels; therefore, the TMDL analysis calculates loads and reductions on a seasonal basis to isolate times of similar in-stream, weather, and flow conditions. While Alaska's water quality standards for fecal coliform bacteria apply year round, the TMDL analysis is conducted only for the spring (April 1 - May 31) and summer (June 1 - September 30) seasons in the watershed. No fecal coliform bacteria data are available for the winter months (October 1 – March 31), because winter conditions do not typically allow for sampling. Therefore, analyses were not conducted for the winter season. During winter months, precipitation falls primarily as snow, resulting in little to no surface runoff. Snow and ice accumulated during winter melts with the increasing temperatures during spring, creating increased surface runoff and steadily increasing in-stream flows. Summer experiences warmer temperatures and summer storms that produce peaks of high in-stream flows. Therefore, fecal coliform loading to the watershed during the winter months is expected to be minimal with most fecal coliform bacteria loading to Cottonwood Creek occurring in the spring and summer.

The following sections discuss the TMDL analysis in more detail, including the data inputs and results.

5.2. Existing Loads

The Simple Method (Schueler 1987) was used to calculate fecal coliform bacteria loading in Cottonwood Creek. The Simple Method is a lumped parameter empirical model to estimate stormwater pollutant loadings under conditions of limited data availability. The approach calculates pollutant loading using drainage area, pollutant concentrations, a runoff coefficient, and precipitation. In the Simple Method, the amount of rainfall runoff is assumed to be a function of the imperviousness of the contributing drainage area. More densely developed areas have more impervious surfaces, such as rooftops and pavement, causing more stormwater to runoff rather than be absorbed into the soil. The Simple Method equation is:

$$L = CF \cdot P \cdot Pj \cdot Rv \cdot C \cdot A$$

where:

L = Pollutant load (fecal coliform bacteria counts per time interval)
CF = Conversion factor (1,028,270 mL/in-acre)
P = Precipitation depth (inches) over desired time interval
Pj = Fraction of rainfall that produces runoff (assumed to be 0.9 [Schueler 1987])
Rv = Runoff coefficient, which expresses the fraction of rainfall that is converted into runoff
C = Pollutant concentration (fc/100 mL)
A = Area of the watershed (acres)

The following sections discuss the identification of the parameters for calculation of fecal coliform bacteria loading in Cottonwood Creek using the Simple Method.

5.2.1. Precipitation (P)

Seasonal precipitation totals for use in the Simple Method were determined based on historical records at the University of Fairbanks's Matanuska Agriculture and Forestry Experiment Station (AFES), which is located approximately 3 miles to the east of the Cottonwood Creek watershed (Figure 5-1). Precipitation totals measured at the AFES station represent water-equivalent totals of rain, snow, and other forms of precipitation. Precipitation falling as snow during the winter months accumulates and does not result in surface runoff as rainfall would. Therefore, if precipitation totals from winter months are used in the Simple Method, the calculations result in unrealistic surface runoff and loading to the stream. To account for this, precipitation totals were modified, as discussed in the next paragraph, to more realistically reflect runoff patterns in the area.

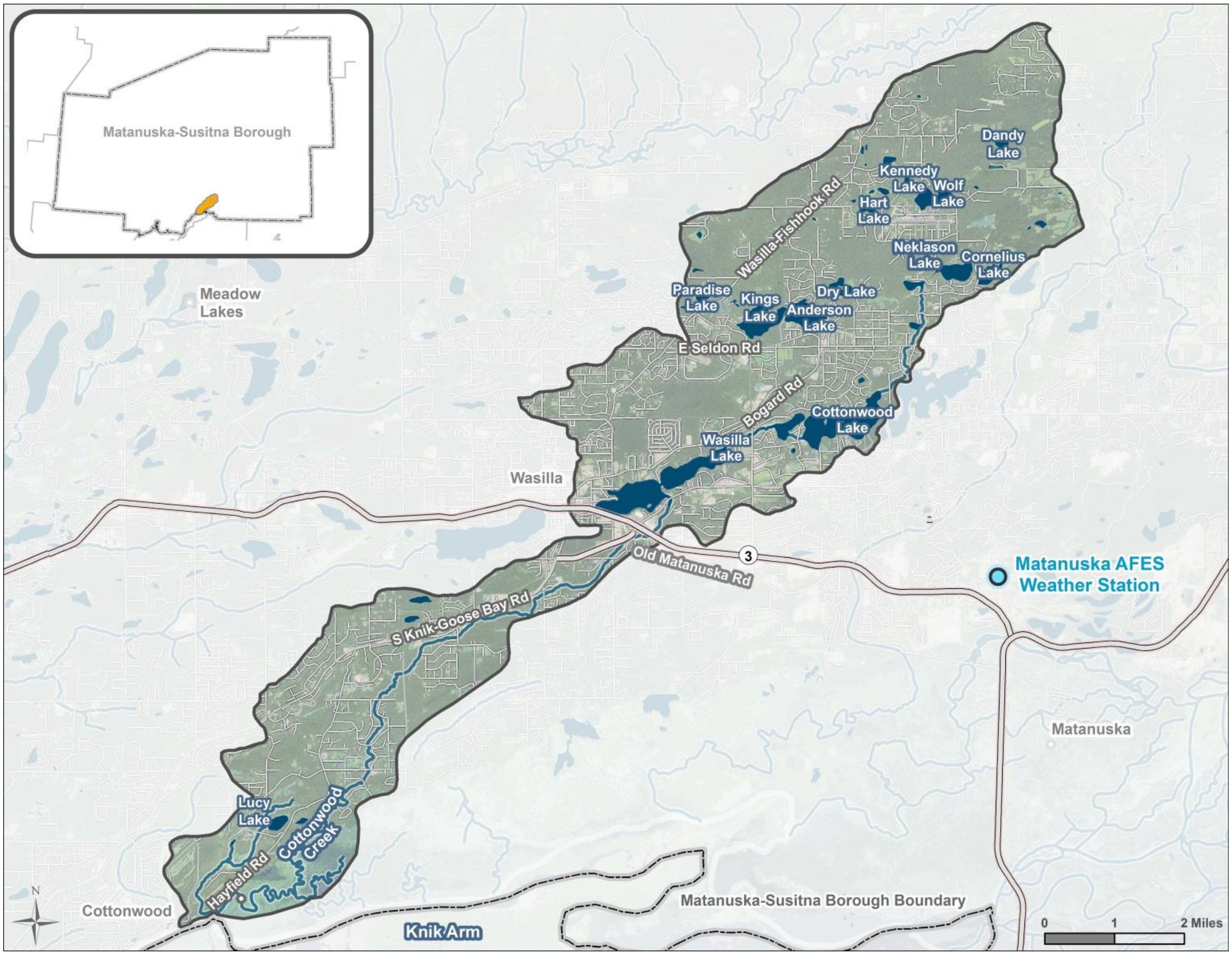

Figure 5-1. Location of Matanuska Agricultural and Forestry Experiment Station.

Precipitation during the winter months was divided into snow and rainfall to isolate the portion of measured precipitation that would result in runoff (i.e., rainfall) and that portion that would remain frozen on the watershed surface (i.e., snow). The snow portion was then added to the spring precipitation totals to reflect the time period that the accumulated snow would melt and contribute to surface runoff. To divide the precipitation into rainfall and snowfall portions, monthly snowfall totals from the AFES weather station were converted to water-equivalent precipitation and subtracted from the monthly precipitation totals at the AFES weather station.

To convert the snow to water-equivalent precipitation it was necessary to identify a conversion factor relating snow depth to water-equivalent depth. Monthly snowfall and total precipitation depths recorded at the Matanuska AFES weather station for January, February, and December of every year from 1998 through 2012 were evaluated to establish a relationship between the two measures. Note that December 2012 data were not available at the time this report was developed; therefore, 2012 data only include January and February. Monthly totals measured during months with average temperatures below 20° F were used to establish a correlation between snowfall and water-equivalent precipitation, as shown in Figure 5-2. The regression equation representing the relationship between the two parameters (Figure 5-2) was used to convert recorded winter snowfalls to water-equivalent precipitation.

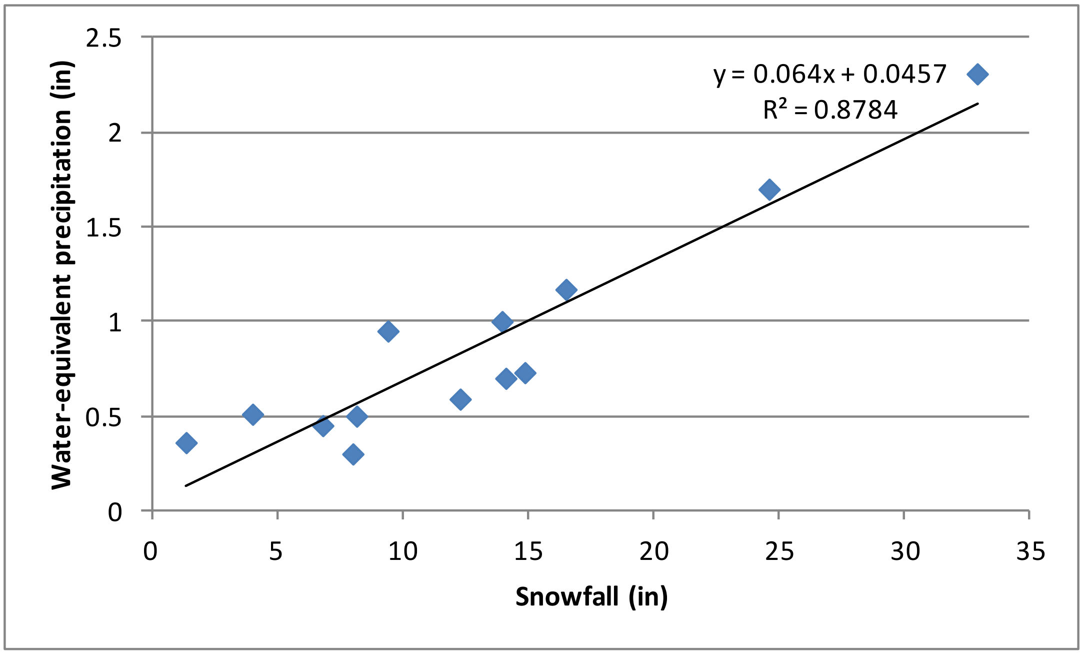

Figure 5-2. Relationship between snowfall and water-equivalent precipitation.

Monthly average snowfall and rainfall precipitation values were then calculated for the period of record used in the TMDL analysis—April 2004 through May 2008, corresponding to available fecal coliform bacteria data. The monthly averages were summed to calculate the corresponding seasonal totals. Additionally, the average monthly snowfall totals for winter were summed and added to the spring totals to account for the effect of runoff during spring melt. Table 5-1 summarizes the seasonal precipitation totals and corrections for snowfall.

Table 5-1. Seasonal precipitation totals.

Season	Total Measured Precipitation (inches)	Snowfall Correction (inches)	Corrected Precipitation (inches)
Winter (October 1 – March 31)	6.30	-2.94	3.36
Spring (April 1 – May 31)	1.09	2.94	4.03
Summer (June 1 – September 30)	9.69	0	9.69

5.2.2. Runoff Coefficient (Rv)

Because site-specific runoff coefficients were not available for the Wasilla area, a relationship between watershed imperviousness and the storm runoff coefficient (Rv) developed by Schueler (1987) was used to determine the runoff coefficient (Rv) for the Cottonwood Creek watershed. Schueler (1987) used nationwide data collected for the Nationwide Urban Runoff Program study (USEPA 1983) with additional data collected from Washington, DC area watersheds to establish the relationship, represented by the following equation:

$Rv = 0.05 + 0.9(I)$

where:

I = Impervious fraction of the drainage area

A runoff coefficient for the expected municipal separate storm sewer system (MS4) permitted area and the area outside of the MS4 permitted area in the Cottonwood Creek watershed (see Figure 4-1) were calculated based on the amount of impervious cover in each area. The impervious areas were determined using the percentage of impervious cover in the Cottonwood Creek watershed provided by The Nature Conservancy (Geist and Smith 2011). This value (I) was used with the Schueler (1987) equation to determine the runoff coefficients (Rv) for the Cottonwood Creek watershed. Table 5-2 presents the total watershed area, total impervious area, percent imperviousness, and the resulting Rv value.

Table 5-2. Runoff coefficient for the Cottonwood Creek watershed

	Area (acres)	Total impervious area (acres)	Overall percent imperviousness[a]	Runoff coefficient (Rv)
Non-MS4 area	8,836	475	5.4	0.10
Expected MS4 area	16,406	2,496	15.2	0.19

[a]Source: Geist and Smith (2011)

5.2.3. Pollutant Concentration (C)

Observed fecal coliform bacteria data collected from 2004-2008 were used to calculate the C value for use in the Simple Method. The C value represents the average pollutant concentration, preferably the event mean concentration (EMC), which is a flow-weighted average concentration. Because concentrations of pollutants can widely vary throughout a storm event and between events, a flow-weighted average can account for variability and result in a more representative "average" concentration. The available flow and fecal coliform bacteria data for Cottonwood Creek at Surrey Road are very limited (24 days of observations over 4 years), prohibiting the calculation of EMCs. To be consistent with water quality criteria used for the TMDL target, the 90th percentile of observed fecal coliform bacteria samples is used as the C value. The seasonal C values were calculated as the 90th percentile based on the available data at Surrey Road and were calculated using all observations within a season. For example, the representative 90th percentile of 98 fc/100 mL for spring was calculated using all samples collected in April and May during the period of record (i.e., April 2004 – May 2008). The resulting seasonal C values for Cottonwood Creek are included in Table 5-3.

5.2.4. Calculation of Existing Load

Table 5-3 summarizes the information used to calculate the existing seasonal fecal coliform bacteria loads from the expected MS4 area and outside of the expected MS4 area using the Simple Method and the resulting loads.

Table 5-3. Simple Method values and resulting fecal coliform bacteria loads for Cottonwood Creek.

Season	Expected MS4* Area	P** (in)	Pj^	Rv^^	C † (fc/100 mL)	A ‡ (acres)	Existing Loading (fc/season)
Spring (April 1 – May 31)	MS4 area	4.03	0.90	0.19	98.4	16,406	1.11×10^{12}
	Non-MS4 area	4.03	0.90	0.10	98.4	8,836	3.08×10^{11}
Summer (June 1 – September 30	MS4 area	9.69	0.90	0.19	480.0	16,406	1.31×10^{13}
	Non-MS4 area	9.69	0.90	0.10	480.0	8,836	3.61×10^{12}
Total (fc/yr)							1.81×10^{13}

* MS4 = municipal separate storm sewer system
** P = precipitation depth (inches) over desired time interval
^ Pj = fraction of rainfall that produces runoff
^^ Rv = runoff coefficient, which expresses the fraction of rainfall that is converted into runoff
† C = pollutant concentration measured in fecal coliform per 100 milliliters
‡ A = area of the watershed measured in acres

5.3. Loading Capacity

The loading capacity is equivalent to the TMDL and is the greatest amount of a given pollutant that a waterbody can receive without exceeding the applicable water quality standards, as represented by the TMDL water quality target.

The Simple Method was also used to calculate seasonal loading capacities for the expected MS4 area and the area outside of the expected MS4 area. The parameters representing watershed characteristics (e.g., precipitation, runoff coefficients and area) remain the same for the loading capacity calculation; however, the pollutant concentration (C) is changed to reflect TMDL conditions—conditions meeting water quality criteria. Therefore, the C value for calculation of loading capacities is equal to the not-to-exceed water quality criterion of 40 fc/100 mL. The calculated loading capacities are summarized in Table 5-4, along with the existing loadings and resulting load reductions. Note that precipitation changes seasonally, but the same values are used for both the existing and TMDL conditions.

Table 5-4. Seasonal fecal coliform loading capacities for Cottonwood Creek.

Season	Expected MS4 Area	Existing Loading (fc/season)	Loading Capacity (fc/season)	Percent Reduction
Spring (April 1 – May 31)	MS4 area	1.11×10^{12}	4.53×10^{11}	63%
	Non-MS4 area	3.08×10^{11}	1.25×10^{11}	
Summer (June 1 – September 30)	MS4 area	1.31×10^{13}	1.09×10^{12}	93%
	Non-MS4 area	3.61×10^{12}	3.01×10^{11}	
Total (fc/yr)		1.81×10^{13}	1.97×10^{12}	90%

6. TMDL

A Total Maximum Daily Load (TMDL) is composed of the sum of individual waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources and natural background loads, and a margin of safety (MOS) that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is denoted by the equation

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

Table 6-1 summarizes the overall seasonal fecal coliform bacteria TMDL for Cottonwood Creek. The fecal coliform bacteria loads for Cottonwood Creek are broken into daily loads in Table 6-2. As discussed in Section 5.1, the TMDL analysis calculates loads and reductions on a seasonal basis to isolate times of similar in-stream, weather, and flow conditions. Alaska's water quality criteria for fecal coliform bacteria apply year round; however, the TMDL was only calculated for the spring (April 1 - May 31) and summer (June 1 - September 30) seasons because there are no fecal coliform bacteria data available for the winter months (October 1 – March 31). Winter conditions do not typically allow for sampling due to ice cover. During winter months, precipitation falls primarily as snow, resulting in little to no surface runoff. Snow and ice accumulated during winter melts with the increasing temperatures during spring, creating increased surface runoff and steadily increasing in-stream flows. Summer experiences warmer temperatures and summer storms that produce peaks of high in-stream flows. Therefore, fecal coliform loading to the watershed during the winter months is expected to be minimal with most fecal coliform bacteria loading to Cottonwood Creek occurring in the spring and summer. The bacteria accumulated in the watershed during the winter months are assumed to be washed off during spring runoff.

This TMDL will be implemented using adaptive management and will be revised, as necessary, based on future information on sources and in-stream conditions. Adaptive management is an approach where monitoring and source controls are used to provide more information for future review and revision of a TMDL. This process recognizes that water quality monitoring data and knowledge of watershed dynamics may be insufficient at the time a TMDL is developed, but that the TMDL uses the best information available during its development. An adaptive management strategy seeks to collect additional monitoring data to understand better how systems react to best management practices (BMPs) and reduced pollutant loading into a system. Information from an adaptive management process can then be used to refine a future TMDL, so that the future TMDL and allocations best represent how to improve water quality in a specific watershed.

6.1. Wasteload Allocation

The WLA is the portion of the loading capacity allocated to point source discharges to the waterbody. No point sources of fecal coliform bacteria currently exist in the Cottonwood Creek watershed. However, it is expected that in the near future, stormwater discharges in the Cottonwood Creek watershed will be regulated by an Alaska Pollutant Discharge Elimination System (APDES) municipal separate storm sewer system (MS4) permit. Environmental Protection Agency (EPA) policy and regulation indicate that stormwater runoff regulated by an MS4 permit must be addressed through wasteload allocations in a TMDL (USEPA 2002). Therefore, fecal coliform bacteria loads delivered to Cottonwood Creek from the expected MS4 area are addressed through the future WLA component of this TMDL in anticipation of the issuance of an MS4 permit.

The fecal coliform bacteria WLAs for Cottonwood Creek are provided as seasonal allocations for both current conditions (no MS4 permit) (Table 6-1) and for conditions under the expected MS4 permit (Table 6-2). The loads are also calculated on a daily basis for both current conditions (Table 6-3) and under the expected MS4 (Table 6-4). The daily loads for each season were calculated by dividing the total seasonal load for each season by the number of days in each season, i.e., spring – 61 days; summer – 122 days. Additionally, if data or information from future monitoring efforts can be used to identify and quantify stormwater or natural loads that are not delivered through the stormwater conveyances, the TMDL and its allocations will be revised accordingly. The future WLA for Cottonwood Creek was calculated by applying the Simple Method (Schueler 1987) to the area of the Cottonwood Creek watershed within the expected MS4 boundary (see Figure 4-1).

6.2. Load Allocation

The LA is the portion of the loading capacity allocated to nonpoint source discharges to the waterbody. Nonpoint sources are typically represented by loads carried to receiving waters through surface runoff resulting from precipitation events. The fecal coliform bacteria load allocations for Cottonwood Creek are provided as seasonal allocations for the area of the watershed outside of the expected MS4 boundary.

As discussed in Section 4, runoff from residential areas and horse or other livestock area are the likely primary sources of fecal coliform bacteria to Cottonwood Creek. However, LAs were not allocated to specific types of nonpoint sources because while source tracking was done, there is no way to determine the amount of fecal coliform bacteria coming from each individual source.

Table 6-1 summarizes the seasonal allocations for Cottonwood Creek along with the necessary percent reductions of fecal coliform bacteria under the current conditions with no MS4 permit. Table 6-2 summarizes the seasonal allocations under the expected MS4 permit. Additionally, the daily loads for each season were calculated by dividing the total seasonal load for each season by the number of days in each season (i.e., spring – 61 days; summer – 122 days). The daily allocations are shown in Tables 6-3 and 6-4 along with the needed percent reductions of fecal coliform bacteria for both the current condition and under the expected MS4 permit.

6.3. Margin of Safety

The MOS accounts for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The MOS can be implicit (e.g., incorporated into the TMDL analysis through conservative assumptions) or explicit (e.g., expressed in the TMDL as a portion of the loading) or a combination of both. For the Cottonwood Creek TMDL, the MOS was included explicitly as 10 percent of the loading capacity.

Table 6-1. Cottonwood Creek TMDL allocation summary for fecal coliform bacteria per season under the current conditions.

Season	Existing Load (fc/season)	Loading Capacity (fc/season)	Wasteload Allocation (fc/season)	Load Allocation (fc/season)	MOS* (fc/season)	Percent Reduction (for LA and WLA)
Spring (April 1-May 31)	1.42×10^{12}	5.78×10^{11}	0	5.20×10^{11}	5.78×10^{10}	63%
Summer (June 1-Sept 30)	1.67×10^{13}	1.39×10^{12}	0	1.25×10^{12}	1.39×10^{11}	93%
Total (fc/yr)	1.81×10^{13}	1.97×10^{12}	0	1.77×10^{12}	1.97×10^{11}	90%

* MOS was included explicitly as 10% of the loading capacity.

Table 6-2. Cottonwood Creek TMDL allocation summary for fecal coliform bacteria per season under the expected MS4 permit.

Season	Existing Load (fc/season)	Loading Capacity (fc/season)	Future Wasteload Allocation (fc/season)	Future Load Allocation (fc/season)	MOS* (fc/season)	Percent Reduction (for LA and WLA)
Spring (April 1-May 31)	1.42×10^{12}	5.78×10^{11}	4.08×10^{11}	1.13×10^{11}	5.78×10^{10}	63%
Summer (June 1-Sept 30)	1.67×10^{13}	1.39×10^{12}	9.80×10^{11}	2.71×10^{11}	1.39×10^{11}	93%
Total (fc/yr)	1.81×10^{13}	1.97×10^{12}	1.39×10^{12}	3.84×10^{11}	1.97×10^{11}	90%

* MOS was included explicitly as 10% of the loading capacity.

Table 6-3. Cottonwood Creek TMDL allocation summary for fecal coliform bacteria per day under current conditions.

Season	Existing Load (fc/day)	Loading Capacity (fc/day)	Wasteload Allocation (fc/day)	Load Allocation (fc/day)	MOS* (fc/day)	Percent Reduction (for LA and WLA)
Spring (April 1-May 31)	2.33×10^{10}	9.48×10^{09}	0	8.53×10^{09}	9.48×10^{08}	63%
Summer (June 1-Sept 30)	1.37×10^{11}	1.14×10^{10}	0	1.03×10^{10}	1.14×10^{09}	93%
Total (fc/day)	1.60×10^{11}	2.09×10^{10}	0	1.88×10^{10}	2.09×10^{09}	90%

* MOS was included explicitly as 10% of the loading capacity.

Table 6-4. Cottonwood Creek TMDL allocation summary for fecal coliform bacteria per day under the expected MS4 permit.

Season	Existing Load (fc/day)	Loading Capacity (fc/day)	Future Wasteload Allocation (fc/day)	Future Load Allocation (fc/day)	MOS* (fc/day)	Percent Reduction (for LA and WLA)
Spring (April 1-May 31)	2.33×10^{10}	9.48×10^{09}	6.68×10^{09}	1.85×10^{09}	9.48×10^{08}	63%
Summer (June 1-Sept 30)	1.37×10^{11}	1.14×10^{10}	8.03×10^{09}	2.22×10^{09}	1.14×10^{09}	93%
Total (fc/day)	1.60×10^{11}	2.09×10^{10}	1.47×10^{10}	4.07×10^{09}	2.09×10^{09}	90%

* MOS was included explicitly as 10% of the loading capacity.

6.4. Seasonal Variation and Critical Conditions

Seasonal variation and critical conditions associated with pollutant loadings, waterbody response, and impairment conditions can affect the development and expression of a TMDL. Therefore, a TMDL must be developed with consideration of seasonal variation and critical conditions to ensure the waterbody will maintain water quality standards under all expected conditions.

Fecal coliform bacteria concentrations and loading in Cottonwood Creek vary seasonally, likely due to variations in weather and source activity. The time of highest loading for Cottonwood Creek is expected to be during the summer months (July, August and September) when the largest rainfalls occur. Higher amounts of rainfall result in increased runoff, which results in increased loads of fecal coliform bacteria to the creek from the surrounding area. It is important to note that applicable water quality criteria for fecal coliform bacteria apply year round in Cottonwood Creek. However, impairment has only been observed during spring and summer months. No known data are available during the fall and winter months; therefore, the extent to which impairments occur during these seasons is unknown. Precipitation falls primarily as snow during winter months, resulting in little to no surface runoff. Fecal coliform bacteria loading to the creek during the winter months is likely minimal. Snow and ice accumulated during winter melts with the increasing temperatures once spring arrives, creating increased surface runoff and steadily increasing in-stream flows. Fecal coliform bacteria accumulated in the watershed during the winter months are assumed to runoff with the spring melt. To account for seasonality, this TMDL establishes seasonal allocations. Seasonal allocations represent loads allocated to time periods of similar weather, runoff, and in-stream conditions and can help to identify times of greatest impairment and focus TMDL implementation efforts by identifying times needing greater load reductions.

Available fecal coliform bacteria data suggest that fecal coliform bacteria loading to Cottonwood Creek during the summer months reflects the critical period. However, conditions during the winter months have not been assessed, and loading reductions should be pursued year-round to address impairments. Using all available fecal coliform bacteria observations to calculate the existing load reflects the worst case scenario and using the not-to-exceed water quality criterion to determine the loading capacity ensures that loading reductions represent levels necessary to ensure that water quality standards are met during all conditions.

6.5. Reasonable Assurance

EPA requires that there is reasonable assurance that a mixed source TMDL can be implemented (USEPA 1991). A mixed source TMDL is developed for waters that are impaired by both point and nonpoint sources. The WLA in a mixed source TMDL is based on the assumption that nonpoint source load reductions will occur. Reasonable assurance is necessary to determine that the combination of a TMDL’s WLAs (assigned to point sources) and LAs (assigned to nonpoint sources) are established at levels that provide a high degree of confidence that the goals outlined in the TMDL can be achieved. This TMDL was not developed as a mixed source TMDL to include point source contributions and a WLA because an MS4 permit has not yet been issued. The allocation for the stormwater source is expressed in the TMDL as a "LA" contingent on the source remaining unpermitted; however, the portion of the "LA" covered by the expected MS4 permit will be deemed a "WLA" once the stormwater discharge from the source is required to obtain an MS4 permit coverage. In anticipation of the issuance of an MS4 permit in approximately the next three years, a description of reasonable assurance has been included.

The Simple Method (Schueler 1987) used the expected MS4 boundary and impervious cover (Geist and Smith 2011) of the Cottonwood Creek watershed to quantify the fecal coliform bacteria loads contributed to the creek by land within and outside of the expected MS4 area. This approach separately characterizes the contribution of fecal coliform bacteria from both nonpoint sources and future point sources to Cottonwood Creek. The future WLA for Cottonwood Creek was allocated for the expected MS4 permit. The determination of the WLA was determined using the same methodology as the LA (the Simple Method, Schueler 1987) but only for the area within the expected MS4 area.

Education, outreach, technical and financial assistance, permit administration, and permit enforcement will all be used to ensure that the goals of this TMDL are met. The following rationale helps provide reasonable assurance that the Cottonwood Creek TMDL goals will be met.

6.5.1. Technically Achievable Load Reductions

ADEC’s stormwater permitting regulations require municipalities to obtain permit coverage for all stormwater discharges from regulated MS4s. Due to the variability of storm events and discharges from storm sewer systems, it is difficult to establish numeric limits on stormwater discharges that accurately address projected loadings. As a result, ADEC regulations and EPA guidance recommend expressing APDES permit limitations for MS4s as BMPs and only using numeric limits in unique instances. A BMP plan should accompany monitoring plans that test the performance of BMPs and provide a basis for revised management techniques. This iterative strategy allows for an implementation plan where realistic goals can be set to improve water quality through the use of BMPs throughout the watershed. The intention is to implement BMPs with the ultimate goal of achieving the WLA (USEPA 2002). Recommended BMPs are presented in Section 7 and in the documents described below.

The Matanuska-Susitna Borough Stormwater Management Plan: *The Matanuska-Susitna Borough Stormwater Management Plan* (November 2013) was developed by the Matanuska-Susitna (Mat-Su) Borough to respond to the expected MS4 regulatory requirements (Mat-Su 2013). The plan is intended to provide guidance for managing stormwater in the Mat-Su region through voluntary efforts. The plan is intended for use by the Mat-Su Borough, as well as the region's cities, agencies, community interests, and citizens. It includes tools for working together regionally on issues such as water quality protection and flood prevention. The plan may also be used as the primary requirement for the expected MS4 permit application when required by ADEC. Additional details about the Stormwater Management Plan are presented in Section 7.

The Alaska Storm Water Guide: The diversity of Alaska's geography, geology and climate can make designing and implementing stormwater controls particularly challenging. The *Alaska Storm Water Guide* (ADEC 2011) provides detailed guidance on the implementation of stormwater BMPs to comply with water quality standards. The *Alaska Storm Water Guide* addresses some of the unique challenges posed by the diversity of Alaska's climate, soils, and terrain and recommends design and selection of stormwater BMPs in an effort to optimize their effectiveness. Chapter 2 of the *Alaska Stormwater Guide* provides stormwater considerations for the various climatic regions in Alaska. Cottonwood Creek is located in the south-central region.

6.5.2. Identified Programs to Achieve the Nonpoint Source Reductions

The load from the area outside of the expected MS4 boundary was assigned to the LA. With regard to LAs for nonpoint sources, programs including CWA Section 319 funded Alaska Clean Water Action (ACWA) grants are available to help achieve fecal coliform bacteria reductions. Section 7 provides more detail on implementation plans for the Cottonwood Creek watershed. The following activities already support this TMDL and add to the assurance that fecal coliform bacteria in the Cottonwood Creek watershed will meet load allocations and water quality criteria for fecal coliform bacteria (assuming that the activities described below are continued and maintained).

Cottonwood Creek Septic Smart: In 2013 ADEC began supporting a 2-year project called Septic Smart for Cottonwood Creek through the ACWA grant program (ACWA 2013 and ACWA 2014). This project focuses on neighborhood education and maintenance of on-site septic systems along the impaired section of Cottonwood Creek beginning July 1, 2013 through June 30, 2015. The goal of the project is to develop and implement a program that reduces the individual cost of maintaining on-site septic systems in subdivisions in the Cottonwood Creek watershed by assisting neighbors to a septic pumping cost-share cooperative. Another project goal is to have a better informed local community about on-site septic system maintenance practices for protecting water quality.

Mat-Su Borough Stormwater Management Program: The Mat-Su Borough *Stormwater Management Plan* (Mat-Su 2013) was mentioned above as a way to reach technically achievable load reductions for the future WLA, but is in place voluntarily until the MS4 permit is issued. Implementing the stormwater management plan now addresses the nonpoint sources and the TMDL's LA throughout the watershed.

National Water Quality Initiative (NWQI) Program: The U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) has a voluntary program and financial assistance available to livestock owners within the Cottonwood Creek watershed through the National Water Quality Initiative (NWQI) program. The goal of the NWQI is to implement conservation practices and improve water quality. Eligible landowners or tenants will receive financial assistance from NRCS for installing conservation practices such as nutrient management, cover crops, filter strips, and livestock waste management. The Alaska NRCS is the local lead for the nationwide NWQI program.

6.5.3. Monitoring and Tracking Approach to Evaluate Progress

The Implementation Section (Section 7) includes a description of monitoring recommendations to evaluate progress towards achieving TMDL reductions and to make adjustments, where needed.

6.5.4. Follow-Up Actions

ADEC's legal authorities allow for the possibility of requiring more stringent permit limits or more effective nonpoint controls if there is insufficient progress in the expected nonpoint source control implementation. While ADEC is authorized under Alaska Statutes Chapter 46.03 to impose strict requirements or issue enforcement actions to achieve compliance with state water quality standards, it is the goal of all participants in the Cottonwood Creek TMDL process to achieve clean water through cooperative efforts.

To provide additional assurance beyond existing programs and planned activities, the actions described in the Implementation Section (Section 7) are provided to help permittees and property owners better understand how implementing various BMPs and stormwater management techniques could help towards achieving the WLA and LA goals in the TMDL.

7. Implementation and Monitoring Recommendations

This section of the Total Maximum Daily Load (TMDL) presents recommendations for implementation and monitoring to assist in meeting the fecal coliform bacteria waste load allocation (WLA) and load allocation (LA) established for Cottonwood Creek.

7.1. Implementation

The implementation of the Cottonwood Creek TMDL should focus on increased reductions from existing sources of fecal coliform bacteria and prevention of new sources. Establishing and maintaining healthy riparian areas should be encouraged to ensure runoff is filtered prior to reaching the stream. Healthy riparian areas also discourage animals and birds from congregating along streams where they can deposit fecal wastes.

As discussed in section 4, microbial source tracking (MST) was used to determine whether the fecal coliform bacteria found in Cottonwood Creek is from human sources, naturally occurring (wildlife), or caused by human-related activities (pets and horses) (Davis et al. 2010). MST identified species-specific markers for human, horses, dogs, and waterfowl in Cottonwood Creek. Knowing the source(s) of fecal coliform bacteria can help determine which best management practices (BMPs) to use to reduce the amount of fecal coliform bacteria reaching the stream.

The MST study showed that fecal coliform bacteria in the Cottonwood Creek watershed primarily enter the creek from the following sources:

- Horse pastures/stables/trails
- Nonpoint source stormwater runoff (fecal matter in pet waste, sewage (such as diapers) from trash stored near the creek, informal camps along the creek, and poorly maintained septic systems or aging leach fields)
- Waterfowl (domestic and non-domestic)

The most effective means of addressing these sources is preventing the fecal coliform bacteria from entering Cottonwood Creek directly or indirectly through polluted runoff. The following section describes actions that can be taken to prevent fecal coliform bacteria loadings from the above sources.

7.1.1. Livestock, Horse Pastures/Stables and Dog Yards

The MST study found DNA markers for horses in Cottonwood Creek. There are a few horse stables/pastures in the Cottonwood Creek watershed, as well as other livestock and dogs. It is not known if the fecal coliform bacteria were directly deposited by these animal sources or whether the bacteria were deposited in the creek through stormwater runoff. Fecal material from livestock, horses and dogs should never be directly disposed of in the creek or in any other water sources. The use of horse manure as fertilizer on lawns and gardens is another potential source. Riparian fencing and off-stream watering should always be provided in areas with horses or other livestock. Any manure storage structures or areas should not be near surface waters and should be covered when possible. In areas without riparian vegetation, the planting of vegetated filter strips should be considered. Vegetated filter strips trap sediments, organic wastes and other pollutants in stormwater runoff. The filter strips must be regularly maintained to function effectively. Constructed wetlands in low-lying areas can also serve a similar purpose.

7.1.2. Stormwater

Existing urban land uses can contribute to nonpoint source pollutant loading from a variety of sources and activities, including increased flow and wash-off of accumulated pollutants from impervious surfaces, accelerated upland and channel erosion, pet waste, and failing septic systems. Many best management practices (BMPs) exist to reduce runoff that can transport bacteria to streams via stormwater.

BMPs for urban land uses are designed to reduce the effects of these sources on surface waters. Education focused on urban residents, businesses, and decision makers is essential to the success of BMPs. An effective strategy for public education and outreach regarding urban nonpoint source pollution could include the following:

- Community education programs and outreach events (home shows, fairs)
- School curriculum and community workshops
- Media (TV, radio, videos, and others)
- Fact sheets, guidance documents and other outreach materials
- Outreach to political and policy leaders in the watershed
- A responsible or lead coordinating agency
- Economic incentives for implementing education programs

An important source of bacteria in stormwater can be pet waste that is left on the ground. The MST study identified DNA markers from dogs in Cottonwood Creek (Davis et al. 2010). Educating residents regarding the practice of picking up and properly disposing of pet waste is an important step that can be taken to reduce bacteria in stormwater.

On-site Septic Systems

The MST study did not identify human DNA markers during base flow, which is typically when failing septic systems would be observed (Davis et al. 2010). However, due to the limitations of MST (see Section 4), on-site septic systems cannot be completely ruled out since human DNA markers were identified in the creek during higher creek flow and most of the population in the Cottonwood Creek watershed is serviced by on-site septic systems. On-site septic systems effectively remove fecal coliform bacteria when properly installed and maintained. Improperly installed or maintained septic systems can fail and lead to pollutants entering waterways. This includes the leach field. Failing on-site septic systems can result in a discharge of waste to the soil surface where it is available for wash-off into surface waters. This was not observed. Improperly treated sewage can also leach pollutants into the groundwater, which can travel to nearby streams. This could be the result of a sub-standard or aging leach field near the creek. Failing on-site septic systems can deliver high bacteria loads to surface waters, depending on the proximity of the discharge to a waterbody and the timing of rainfall events. On-site septic system failures typically occur in older systems that are not adequately maintained with periodic inspections and sewage pump-outs. To avoid failing on-site septic systems, homeowners should be educated about the proper maintenance and inspection of septic systems. Strategies for septic system management include:

- surveying and testing programs to identify failing septic systems
- educating on proper maintenance of septic systems
- encouraging to conduct maintenance or make repairs through incentives or other programs

ADEC has a current on-site septic system education and incentive project (called Septic Smart) for Cottonwood Creek funded by Alaska's Clean Water Actions (ACWA) grant program (ACWA 2013 and ACWA 2014). Septic Smart addresses septic system education and maintenance along the impaired section of Cottonwood Creek beginning July 1, 2013 through June 30, 2014 and was funded for a second year running July 1, 2014 – June 30, 2015. The goal of the project is to investigate, develop, and implement a program that reduces the individual cost of maintaining on-site septic systems in subdivisions along Cottonwood Creek from the Parks Highway downstream to Palmer Hayflats. The program provides cost-sharing for homeowners to have timely and regular septic system pumping and inspection to identify possible needed maintenance. Multiple systems can be planned to be pumped/inspected in the same area, thus reducing individual costs. The program includes educating homeowners on the relationship of water quality and properly installed and maintained septic systems.

Expected Municipal Separate Storm Sewer System (MS4) Permit

As discussed in Section 6.5, according to Environmental Protection Agency (EPA) policy on addressing regulated stormwater in TMDLs (USEPA 2002), wasteload allocations can be translated to effluent limitations in the applicable permit through the use of BMPs. Appropriate BMPs will be identified for implementation in the Cottonwood Creek watershed in the expected MS4 permit. One such BMP that should be included in the permit is ensuring that any connections to the City of Wasilla's wastewater treatment system are done properly with tight connections and regular inspection for any leaks. Information on the applicability of the BMPs for removal of fecal coliform bacteria and on the feasibility of implementation in the Cottonwood Creek watershed will be taken into account when identifying BMPs.

The following sources should be considered when evaluating BMPs for the expected MS4 permit:

- **Matanuska-Susitna Borough Stormwater Management Plan** (Mat-Su 2013) is described in section 6.5.1.
- **Alaska Storm Water Guide** (ADEC 2011) is also described in section 6.5.1.
- **International Stormwater Best Management Practices Database** (WERF 2014) (http://www.bmpdatabase.org/) provides access to BMP performance data in a standardized format for over 500 BMP studies conducted since 1996 through 2014. The database was developed by the Urban Water Resources Research Council of American Society of Civil Engineers under a cooperative agreement with the EPA. Some studies on BMP effectiveness have evaluated the ability of certain BMPs to remove fecal coliform bacteria and other bacteria.
- **Center for Watershed Protection** (CWP 1997) has compiled a stormwater treatment database containing information from studies conducted from 1990 to 2014. CWP discusses the use and effectiveness of BMPs in cold climates.
- **Comparative Pollutant Removal Capability of Urban Stormwater Treatment Practices** (Schueler 2000) provides a summary of the information in the database. The included studies do not provide sufficient fecal coliform bacteria data to statistically evaluate the effectiveness of BMPs in removing bacteria from urban runoff, but Schueler (2000) indicates that mean fecal coliform bacteria removal rates typically range from 65 to 75 percent from ponds and wetlands and 55 percent for filters. Schueler (2000) and SMRC (2000) report that water quality swales (including biofilters and wet and dry swales) consistently exported bacteria. Although it is possible that the bacteria thrive in the warm swale soils, the studies do not account for potential sources of bacteria directly to the swales, such as wildlife and domestic pets.

Table 7-1 provides examples of BMP removal efficiencies for bacteria. Because information on BMP efficiency for fecal coliform bacteria is limited, information in Table 7-1 should be applied with consideration of local knowledge of the environmental conditions and BMP performance in the Wasilla area.

Due to the characteristics such as freezing temperatures and snowmelt events, some BMPs are not appropriate or require modifications for use in cold climates. Table 7-2 provides a summary of the applicability of BMPs to colder climates.

Table 7-1. Fecal coliform bacteria removal efficiency for various BMPs.

BMP Type	Fecal Coliform Bacteria Removal (%)
Detention and Dry Extended Detention Ponds	78
Wet Ponds	70
Constructed Shallow Marsh Wetland	76
Constructed Submerged Gravel Wetland	78
Filters (excluding vertical sand filters)	37
Infiltration Basins	90
Water Quality Swales	-25
Ditches	5

Sources: Schueler (2000) and SMRC (2000)

Table 7-2. Applicability of BMPs to cold climate conditions (CWP 1997).

Type		BMP	Classification	Notes
Constructed Ponds		Wet Pond	□	Can be effective, but needs modifications to prevent freezing of outlet pipes. Limited by reduced treatment volume and biological activity in the permanent pool during ice cover.
		Wet ED Pond	●	Some modifications to conveyance structures needed. Extended detention storage provides treatment during the winter season.
		Dry ED Pond	□	Few modifications needed. Although this practice is easily adapted to cold climates, it is not highly recommended overall because of its relatively poor warm season performance.
Constructed Wetlands		Shallow Marsh	■	In climates where significant ice formation occurs, shallow marshes are not effective winter BMPs. Most of the treatment storage is taken up by ice, and the system is bypassed.
		Pond/Wetland System	□	Pond/Wetland systems can be effective, especially if some ED storage is provided. Modifications for both pond and wetland systems apply to these BMPs. This includes changes in wetland plant selection and planting.
		ED Wetland	●	See Wet ED Pond. Also needs modifications to wetland plant species.
Infiltration		Porous Pavement	■	This practice is restricted in cold climates. It cannot be used on any pavement that is sanded, because the pavement will clog.
		Infiltration Trench	□	Can be effective, but may be restricted by groundwater quality concerns related to infiltrating chlorides. Also, frozen ground conditions may inhibit the infiltration capacity of the ground.
		Infiltration Basin	□	See infiltration trench.
Filtering Systems		Surface Sand Filter	■	Frozen ground considerations, combined with frost heave concerns, make this type of system relatively ineffective during the winter season.
		Underground Sand Filter	●	When placed below the frost line, these systems can function effectively in cold climates.

Type		BMP	Classification	Notes
		Perimeter Sand Filter	■	See Surface Sand Filter.
		Bioretention	☐	Problems functioning during the winter season because of reduced infiltration. It has some value for snow storage on parking lots, however.
		Submerged Gravel Wetlands	☐	Some concerns of bypass during winter flows. Has been used in relatively cold regions with success, but not tested in a wide range of conditions.
Open Channel Systems		Grassed Channel	☐	Reduced effectiveness in the winter season because of dormant vegetation and reduced infiltration. Valuable for snow storage.
		Dry Swale	☐	Reduced effectiveness in the winter season because of dormant vegetation and reduced infiltration. Very valuable for snow storage and meltwater infiltration.
		Wet Swale	☐	Reduced effectiveness in the winter season because of dormant vegetation. Can be valuable for snow storage.
		Vegetated Filter Strip	☐	See Dry Swale.

ED: Extended Detention

● Easily applied to cold climates; can be effective during the winter season.

☐ Can be used in cold climates with significant modifications; moderately affective during the winter season

■ Very difficult to use in cold climates. Generally not recommended.

7.1.3. Waterfowl

Waterfowl can congregate along streams and deposit fecal matter directly to the water or on nearby surfaces that are washed off during storm events. Riparian vegetation should be planted and maintained along Cottonwood Creek to discourage wildlife congregation and filter polluted runoff.

According to ADEC, both wild and loose domestic ducks congregate at the outlet of Wasilla Lake in Cottonwood Creek because it remains open water year round. This is a popular spot for people to feed the ducks. Feeding ducks at this location encourages more ducks to congregate. It is recommended that feeding waterfowl be discouraged at this location through signage as well as riparian vegetation. In addition, any homeowners with duck ponds in the watershed should have the ponds designed so that they are not discharging directly to Cottonwood Creek.

7.2. Monitoring Recommendations

Follow-up monitoring for a TMDL is important in tracking the progress of TMDL implementation and subsequent water quality response, as well as in evaluating any assumptions made during TMDL development. Monitoring results can be used to support any necessary future TMDL revision or to determine whether BMPs should be added or modified.

Currently, no official future monitoring plans are in place for Cottonwood Creek; however, ADEC expects water quality to be monitored after sufficient BMPs have been implemented to determine whether improvements in water quality are observed through a reduction of fecal coliform bacteria.

In addition, ADEC has conducted fecal coliform bacteria sampling over four years at 11 sites in the Cottonwood Creek watershed (ADEC 2010b). The sampling results show increasing exceedances of fecal coliform bacteria water quality criteria downstream of Wasilla Lake. Because much of the available data are distributed over a large number of stations and there are limited data at each station, a goal for future monitoring should be to establish fewer station locations that can be sampled more often during all subsequent sampling efforts in the watershed. This will better allow for evaluation of temporal trends in watershed data. Future sampling events should focus on specific areas or sources of concern and on tracking progress of water quality improvement as BMPs are implemented. Monitoring events should occur during high and low flows.

8. Public Comments

Federal regulations require EPA to notify the public and seek comments concerning TMDLs it prepares. This TMDL was developed under a contract from EPA to TetraTech, Inc. and in cooperation with the ADEC.

ADEC posted the notice for the Total Maximum Daily Load (TMDL) public review period on December 8, 2014, and the review period closed on February 10, 2015. The notice was posted on ADEC's website and on the State of Alaska's Public Notice Web Site. A fact sheet was also available on ADEC's website. The public notice was advertised in the Frontiersman newspaper. Public presentations regarding the Cottonwood Creek fecal coliform bacteria TMDL were given at the regular meeting of the Matanuska-Susitna Borough Assembly on December 16, 2014 and at the regular meeting of the Wasilla City Council on January 12, 2015.

Comments on the TMDL were received during the public comment period from the Matanuska-Susitna Borough's Wastewater and Septage Advisory Board and from concerned citizens. Comments and additional information submitted were used to inform or revise this TMDL document as needed. Appendix B has the ADEC's response to comments.

9. References

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Appendix A

Table A-1. Fecal coliform bacteria and flow data for Cottonwood Creek.

Station Name	Date	Fecal coliform bacteria (fc/100 mL)	Discharge (cfs)
Settlement Ave.	4/21/2004	0.5	16.1
Settlement Ave.	5/15/2004	3	14.4
Settlement Ave.	6/18/2004	80	10.4
Settlement Ave.	7/20/2004	260	6.5
Settlement Ave.	8/18/2004	1600	5.5
Settlement Ave.	9/14/2004	30	11
Neklason Outlet	4/21/2004	0.5	16.1
Neklason Outlet	5/15/2004	0.5	14.4
Neklason Outlet	6/18/2004	8	10.4
Neklason Outlet	7/20/2004	50	6.5
Neklason Outlet	8/18/2004	11	5.5
Neklason Outlet	9/14/2004	4	11
Below Bogard	4/21/2004	94	16.1
Below Bogard	5/15/2004	6	14.4
Below Bogard	6/18/2004	14	10.4
Below Bogard	7/20/2004	16	6.5
Below Bogard	8/18/2004	21	5.5
Below Bogard	9/14/2004	8	11
Below Bogard	8/2/2005	2.7	19
Below Bogard	8/15/2005	5.3	15.7
Below Bogard	8/23/2005	27	15.3
Below Bogard	8/30/2005	5.3	20
Wasilla Lk. Inlet	7/30/2007	30	14.4
Wasilla Lk. Inlet	8/1/2007	10	14.4
Wasilla Lk. Inlet	8/6/2007	17	16.1
Wasilla Lk. Inlet	8/9/2007	9	14.9
Wasilla Lk. Inlet	4/8/2008	1	15.3
Wasilla Lk. Inlet	4/23/2008	4	15.7
Wasilla Lk. Inlet	5/5/2008	0.5	17.3
Wasilla Lk. Inlet	5/7/2008	0.5	17.3
Wasilla Lk. Outlet	7/30/2007	0.5	14.4
Wasilla Lk. Outlet	8/1/2007	0.5	14.4
Wasilla Lk. Outlet	8/6/2007	2	16.1
Wasilla Lk. Outlet	8/9/2007	0.5	14.9
Wasilla Lk. Outlet	9/10/2007	7	15.7
Wasilla Lk. Outlet	9/20/2007	3	18.1
Wasilla Lk. Outlet	4/8/2008	0.5	15.3
Wasilla Lk. Outlet	4/23/2008	0.5	15.7
Wasilla Lk. Outlet	5/5/2008	0.5	17.3
Wasilla Lk. Outlet	5/7/2008	0.5	17.3
Wasilla Lk. Outlet	7/30/2007	0	
Parks Highway	7/30/2007	26	14.4
Parks Highway	8/1/2007	18	14.4
Parks Highway	8/6/2007	16	16.1

Station Name	Date	Fecal coliform bacteria (fc/100 mL)	Discharge (cfs)
Parks Highway	8/9/2007	10	14.9
Parks Highway	9/10/2007	116	15.7
Parks Highway	9/20/2007	33	18.1
Parks Highway	4/8/2008	4	15.3
Parks Highway	4/23/2008	0.5	15.7
Parks Highway	5/5/2008	0.5	17.3
Parks Highway	5/7/2008	0.5	17.3
Old Mat Road	4/21/2004	58	16.1
Old Mat Road	5/15/2004	30	14.4
Old Mat Road	6/18/2004	80	10.4
Old Mat Road	7/20/2004	110	6.5
Old Mat Road	8/18/2004	130	5.5
Old Mat Road	9/14/2004	50	11
Old Mat Road	8/2/2005	140	19
Old Mat Road	8/15/2005	72	15.7
Old Mat Road	8/23/2005	197.5	15.3
Old Mat Road	8/30/2005	100	20
Old Mat Road	7/30/2007	50	14.4
Old Mat Road	8/1/2007	20	14.4
Old Mat Road	8/6/2007	16	16.1
Old Mat Road	8/9/2007	10	14.9
Old Mat Road	9/10/2007	63	15.7
Old Mat Road	9/20/2007	32	18.1
Old Mat Road	4/8/2008	4	15.3
Old Mat Road	4/23/2008	0.5	15.7
Old Mat Road	5/5/2008	0.5	17.3
Old Mat Road	5/7/2008	0.5	17.3
Old Mat Road	8/1/2007	24	
Fern Crossing	4/21/2004	130	16.1
Fern Crossing	5/15/2004	10	14.4
Fern Crossing	6/18/2004	70	10.4
Fern Crossing	7/20/2004	120	6.5
Fern Crossing	8/18/2004	50	5.5
Fern Crossing	9/14/2004	130	11
Edlund Road	4/21/2004	100	16.1
Edlund Road	5/15/2004	20	14.4
Edlund Road	6/18/2004	110	10.4
Edlund Road	7/20/2004	130	6.5
Edlund Road	8/18/2004	170	5.5
Edlund Road	9/14/2004	240	11
Edlund Road	7/30/2007	69	14.4
Edlund Road	8/1/2007	33	14.4
Edlund Road	8/6/2007	59	16.1
Edlund Road	8/9/2007	51	14.9
Edlund Road	4/8/2008	5	15.3
Edlund Road	4/23/2008	7	15.7

Station Name	Date	Fecal coliform bacteria (fc/100 mL)	Discharge (cfs)
Edlund Road	5/5/2008	10	17.3
Edlund Road	5/7/2008	0.5	17.3
Marble Way	7/30/2007	59	14.4
Marble Way	8/1/2007	20	14.4
Marble Way	8/6/2007	59	16.1
Marble Way	8/9/2007	56	14.9
Marble Way	4/8/2008	9	15.3
Marble Way	4/23/2008	5	15.7
Marble Way	5/5/2008	6	17.3
Marble Way	5/7/2008	2	17.3
Surrey Road	4/21/2004	93	16.1
Surrey Road	5/15/2004	57	14.4
Surrey Road	6/18/2004	240	10.4
Surrey Road	7/20/2004	250	6.5
Surrey Road	8/18/2004	80	5.5
Surrey Road	9/14/2004	80	11
Surrey Replicate	4/21/2004	99	16.1
Surrey Replicate	5/15/2004	100	14.4
Surrey Replicate	6/18/2004	500	10.4
Surrey Replicate	7/20/2004	200	6.5
Surrey Replicate	8/18/2004	80	5.5
Surrey Replicate	9/14/2004	30	11
Surrey Road	8/2/2005	180	19
Surrey Road	8/15/2005	120	15.7
Surrey Road	8/23/2005	48	15.3
Surrey Road	8/30/2005	87	20
Surrey Road	7/30/2007	300	14.4
Surrey Road	8/1/2007	169	14.4
Surrey Road	8/6/2007	260	16.1
Surrey Road	8/9/2007	74	14.9
Surrey Road	9/10/2007	92	15.7
Surrey Road	9/20/2007	690	18.1
Surrey Road Rep	8/6/2007	300	
Surrey Road Rep	8/9/2007	103	
Surrey Road Rep	9/10/2007	135	
Surrey Road Rep	9/20/2007	1200	
Surrey Road	4/8/2008	9	15.3
Surrey Road	4/23/2008	5	15.7
Surrey Road	5/5/2008	65	17.3
Surrey Road	5/7/2008	13	17.3
Surrey Replicate	4/8/2008	10	15.3
Surrey Replicate	4/23/2008	4	15.7
Surrey Replicate	5/5/2008	41	17.3
Surrey Replicate	5/7/2008	13	17.3

[1] The Mat-Su Borough conducted a culvert replacement project at the Settlement Ave. sample site during the summer of 2004. The high bacteria results are attributed to the type of soil and fertilizer used for the bank restoration and hydroseeding work.

Table A-2. Exceedances of not-to exceed and geometric mean criteria.

Station Name	Date	Fecal coliform bacteria (fc/100mL)	Geometric Mean (fc/100 mL)[a]
Settlement Ave.	4/21/2004	0.5	
Settlement Ave.	5/15/2004	3	
Settlement Ave.	6/18/2004	80[b]	
Settlement Ave.	7/20/2004	260	
Settlement Ave.	8/18/2004	1600	
Settlement Ave.	9/14/2004	30	
Neklason Outlet	4/21/2004	0.5	
Neklason Outlet	5/15/2004	0.5	
Neklason Outlet	6/18/2004	8	
Neklason Outlet	7/20/2004	50	
Neklason Outlet	8/18/2004	11	
Neklason Outlet	9/14/2004	4	4.1
Below Bogard	4/21/2004	94	
Below Bogard	5/15/2004	6	
Below Bogard	6/18/2004	14	
Below Bogard	7/20/2004	16	
Below Bogard	8/18/2004	21	
Below Bogard	9/14/2004	8	
Below Bogard	8/2/2005	2.7	
Below Bogard	8/15/2005	5.3	
Below Bogard	8/23/2005	27	
Below Bogard	8/30/2005	5.3	6.7
Wasilla Lk. Inlet	7/30/2007	30	
Wasilla Lk. Inlet	8/1/2007	10	
Wasilla Lk. Inlet	8/6/2007	17	
Wasilla Lk. Inlet	8/9/2007	9	14.6
Wasilla Lk. Inlet	4/8/2008	1	
Wasilla Lk. Inlet	4/23/2008	4	
Wasilla Lk. Inlet	5/5/2008	0.5	
Wasilla Lk. Inlet	5/7/2008	0.5	1.0
Wasilla Lk. Outlet	7/30/2007	0.5	
Wasilla Lk. Outlet	8/1/2007	0.5	
Wasilla Lk. Outlet	8/6/2007	2	
Wasilla Lk. Outlet	8/9/2007	0.5	0.7

Station Name	Date	Fecal coliform bacteria (fc/100mL)	Geometric Mean (fc/100 mL)[a]
Wasilla Lk. Outlet	9/10/2007	7	
Wasilla Lk. Outlet	9/20/2007	3	4.6
Wasilla Lk. Outlet	4/8/2008	0.5	
Wasilla Lk. Outlet	4/23/2008	0.5	
Wasilla Lk. Outlet	5/5/2008	0.5	
Wasilla Lk. Outlet	5/7/2008	0.5	0.5
Wasilla Lk. Outlet	7/30/2007	0	
Parks Highway	7/30/2007	26	
Parks Highway	8/1/2007	18	
Parks Highway	8/6/2007	16	
Parks Highway	8/9/2007	10	16.5
Parks Highway	9/10/2007	116	
Parks Highway	9/20/2007	33	61.9[c]
Parks Highway	4/8/2008	4	
Parks Highway	4/23/2008	0.5	
Parks Highway	5/5/2008	0.5	
Parks Highway	5/7/2008	0.5	0.8
Old Mat Road	4/21/2004	58	
Old Mat Road	5/15/2004	30	
Old Mat Road	6/18/2004	80	
Old Mat Road	7/20/2004	110	
Old Mat Road	8/18/2004	130	
Old Mat Road	9/14/2004	50	
Old Mat Road	8/2/2005	140	
Old Mat Road	8/15/2005	72	
Old Mat Road	8/23/2005	197.5	
Old Mat Road	8/30/2005	100	118.8
Old Mat Road	7/30/2007	50	
Old Mat Road	8/1/2007	20	
Old Mat Road	8/1/2007	24	
Old Mat Road	8/6/2007	16	
Old Mat Road	8/9/2007	10	20.7
Old Mat Road	9/10/2007	63	
Old Mat Road	9/20/2007	32	44.9
Old Mat Road	4/8/2008	4	
Old Mat Road	4/23/2008	0.5	
Old Mat Road	5/5/2008	0.5	

Station Name	Date	Fecal coliform bacteria (fc/100mL)	Geometric Mean (fc/100 mL)[a]
Old Mat Road	5/7/2008	0.5	0.8
Fern Crossing	4/21/2004	130	
Fern Crossing	5/15/2004	10	
Fern Crossing	6/18/2004	70	
Fern Crossing	7/20/2004	120	
Fern Crossing	8/18/2004	50	
Fern Crossing	9/14/2004	130	
Edlund Road	4/21/2004	100	
Edlund Road	5/15/2004	20	
Edlund Road	6/18/2004	110	
Edlund Road	7/20/2004	130	
Edlund Road	8/18/2004	170	
Edlund Road	9/14/2004	240	
Edlund Road	7/30/2007	69	
Edlund Road	8/1/2007	33	
Edlund Road	8/6/2007	59	
Edlund Road	8/9/2007	51	51.2
Edlund Road	4/8/2008	5	
Edlund Road	4/23/2008	7	
Edlund Road	5/5/2008	10	
Edlund Road	5/7/2008	0.5	3.6
Marble Way	7/30/2007	59	
Marble Way	8/1/2007	20	
Marble Way	8/6/2007	59	
Marble Way	8/9/2007	56	44.4
Marble Way	4/8/2008	9	
Marble Way	4/23/2008	5	
Marble Way	5/5/2008	6	
Marble Way	5/7/2008	2	4.8
Surrey Replicate	4/21/2004	99	
Surrey Replicate	5/15/2004	100	
Surrey Replicate	6/18/2004	500	
Surrey Replicate	7/20/2004	200	
Surrey Replicate	8/18/2004	80	
Surrey Replicate	9/14/2004	30	

Station Name	Date	Fecal coliform bacteria (fc/100mL)	Geometric Mean (fc/100 mL)[a]
Surrey Replicate	8/6/2007	300	
Surrey Replicate	8/9/2007	103	
Surrey Replicate	9/10/2007	135	
Surrey Replicate	9/20/2007	1200	266.0
Surrey Replicate	4/8/2008	10	
Surrey Replicate	4/23/2008	4	
Surrey Replicate	5/5/2008	41	
Surrey Replicate	5/7/2008	13	12.1
Surrey Road	4/21/2004	93	
Surrey Road	5/15/2004	57	
Surrey Road	6/18/2004	240	
Surrey Road	7/20/2004	250	
Surrey Road	8/18/2004	80	
Surrey Road	9/14/2004	80	
Surrey Road	8/2/2005	180	
Surrey Road	8/15/2005	120	
Surrey Road	8/23/2005	48	
Surrey Road	8/30/2005	87	97.5
Surrey Road	7/30/2007	300	
Surrey Road	8/1/2007	169	
Surrey Road	8/6/2007	260	
Surrey Road	8/9/2007	74	176.7
Surrey Road	9/10/2007	92	
Surrey Road	9/20/2007	690	252.0
Surrey Road	4/8/2008	9	
Surrey Road	4/23/2008	5	
Surrey Road	5/5/2008	65	
Surrey Road	5/7/2008	13	14.0

[a]Geometric means were calculated for every possible 30-day period included in the dataset, based on all individual observations within that 30-day period.
[b]Yellow highlight indicates geometric means within a 30-day period that exceed the state water quality criterion of 20 fc/100 mL [18 AAC 70.020(b)(3)(A)(i)]
[c]Blue highlight indicates sample exceeds the state water quality criterion of 40 fc/100 mL in >10% of samples [18 AAC 70.020(b)(3)(A)(i)]

APPENDIX B

Table B-1. ADEC Response to Public Comments

	Public Comment	Department Response
1	Table 6-3 was a duplicate of Table 6-4.	This clerical error has been corrected.
2	Why are older septic tanks, within 200 feet of the stream, not considered a significant contributor to the pollution?	Section 4 in the TMDL identifies several potential sources of bacteria pollution, including septic systems. Although bacteria associated with human waste was identified, the exact source of the waste (e.g., older septic systems) was not definitive. Stream surveys did note a "honey bucket" and toilet paper adjacent to the creek. Comment did not result in any changes to the TMDL document.
3	Resolution from the Matanuska-Susitna Borough Wastewater and Septage Advisory Board to the Matanuska-Susitna Assembly recommending that the Borough, City of Wasilla and ADEC investigate further the potential sources of human fecal coliform in Cottonwood Creek and address those sources cooperatively.	ADEC intends to continue working cooperatively with local government and the Natural Resource Conservation Service to address the pollution in Cottonwood Creek. Comment did not result in any changes to the TMDL document.