4.0 BACTERIA

Assessment of the data from the 2006 SWQB water quality survey in the Cimarron River watershed identified exceedences of the New Mexico water quality standards for *E. coli* bacteria in:

- Cieneguilla Creek (Eagle Nest Lake to headwaters)
- North Ponil Creek (South Ponil Creek to Seally Canyon)
- Ponil Creek (US 64 to confluence of North and South Ponil)
- Ponil Creek (Cimarron River to US 64)
- Rayado Creek (Miami Lake diversion to headwaters)
- Sixmile Creek (Eagle Nest Lake to headwaters)
- Ute Creek (Cimarron River to headwaters)

As a result, these assessment units were listed on the Integrated CWA §303(d)/§305(b) List with *E. coli* as a pollutant of concern (NMED/SWQB 2010a). When water quality standards have been achieved, the reach will be moved to the appropriate category on the Clean Water Act Integrated §303(d)/§305(b) List of assessed waters.

4.1 Target Loading Capacity

For this TMDL document, target values for bacteria are based on the reduction in bacteria necessary to achieve numeric criteria:

> *20.6.4.306 NMAC: The monthly geometric mean of E. coli bacteria 126 cfu/100 mL or less; single sample 410 cfu/100 mL or less.*

> *20.6.4.309 NMAC: The monthly geometric mean of E. coli bacteria 126 cfu/100 mL or less; single sample 235 cfu/100 mL or less.*

The presence of *E. coli* bacteria is an indicator of the possible presence of other pathogens that may limit beneficial uses and present human health concerns. Exceedences for each assessment unit are presented in Table 4.1.

Table 4.1 *E. coli* exceedences

Assessment Unit	Designated Use Affected	Associated Criterion* (cfu/100mL)	Exceedence Ratio (# exceedences / total # samples)
Cieneguilla Creek (Eagle Nest Lake to headwaters)	SC	235	4/6
North Ponil Creek (South Ponil Creek to Seally Canyon)	SC	235	2/6
Ponil Creek (US 64 to confl of North and South Ponil)	SC	235	3/6
Ponil Creek (Cimarron River to US 64)	SC	410	2/6

Assessment Unit	Designated Use Affected	Associated Criterion* (cfu/100mL)	Exceedence Ratio (# exceedences / total # samples)
Rayado Creek (Miami Lake Diversion to headwaters)	SC	235	2/7
Sixmile Creek (Eagle Nest Lake to headwaters)	SC	235	2/6
Ute Creek (Cimarron River to headwaters)	SC	235	2/6

Notes: * = single sample criterion
SC = Secondary Contact
cfu = colony forming units
mL = milliliters

4.2 Flow

TMDLs are calculated at a specific flow and bacteria concentrations can vary as a function of flow. SWQB determined streamflow during the 2006 sampling season either by using the active USGS gage network or by taking direct in-stream flow measurements utilizing standard procedures. Water quality standard exceedences for all impaired reaches except Ute Creek occurred *only* during lower flows. Therefore, for these reaches, the critical flow value used to calculate the TMDLs was obtained using a 4-day, 3-year low-flow frequency (4Q3) regression model. The 4Q3 is the annual lowest 4 consecutive day flow that occurs with a frequency of at least once every 3 years.

When available, USGS gages are used to estimate the critical flow. There are nine gages that were active in the Cimarron Watershed around the time of the water quality survey and data collection efforts (Table 4.2). The 4Q3 flows for Cieneguilla Creek, upper Ponil Creek, Rayado Creek, and Sixmile Creek were estimated using the appropriate gage data and DFLOW software, Version 3.1b (USEPA 2006). DFLOW 3.1b is a Windows-based tool developed to estimate user selected design stream flows for low flow analysis by utilizing algorithms based on Log Pearson Type III distribution.

A climatic year starting April 1 of the prior year and ending March 31 is often used when examining critical low flow conditions in the United States. This choice reduces the likelihood of splitting low flow periods - typically found in the summer or fall - across different years and thereby affecting the results of Log Pearson Type III analysis of series of annual low flows. A different climatic year or shorter season may be used if low flow periods occur at other times of the year or overlap the boundaries of the climatic year.

DFLOW 3.1 allows the user to specify a season that lasts less than a year by indicating the start date and end date of the season. A seasonal component was added to the higher elevation reaches (e.g. Cieneguilla Creek and Sixmile Creek) because cold temperatures and freezing conditions combine to create zero dischage during the winter months. The 4Q3 flows for Cieneguilla Creek and Sixmile Creek were calculated using gage data from the typical growing season for the ecoregion and elevation (July 1 – September 30). The growing seasons were established for three general regions by using the median annual dates of the last and first frost

from the National Weather Service (Table 4.3). If a full year's worth of data were included in the critical flow calculations for these high elevation streams then the 4Q3 values would be zero.

Table 4.2 USGS gages in the Cimarron Watershed (HUC 11080002)

Agency	Site Number	Site Name	Period of Record
USGS	7204000	Moreno Creek at Eagle Nest, NM	1928 - 2008
USGS	7204500	Cieneguilla Creek near eagle Nest. NM	1928 - 2008
USGS	7205000	Sixmile Creek near Eagle Nest, NM	1958 - 2008
USGS	7205500	Eagle Nest Lake near Eagle Nest, NM	1987 - present
USGS	7206000	Cimarron River below Eagle Nest Dam, NM	1950 - present
USGS	7207000	Cimarron River near Cimarron, NM	1950 - present
USGS	7207500	Ponil Creek near Cimarron, NM	1916 - present
USGS	7208500	Rayado Creek near Cimarron, NM	1911 - present
USGS	7211000	Cimarron River at Springer, NM	1907 - 2004

Table 4.3 Growing season definitions for ecoregion and elevation classes

Regions	Ecoregion Names	Ecoregion	Begin	End	Length
Mountain >7500 ft	S. Rockies & AZ/NM Mountains	22 & 23	1-July	1-Oct	3 months
Mountains <7500 ft & Plateau	S. Rockies, AZ/NM Mountains & AZ/NM Plateau	20, 21, 22 & 23	15-Jun	1-Nov	4 ½ months
S. Deserts and Plains	SW Tablelands & Chihuahuan Desert	24, 25, 26, & 79	15-May	15-Nov	6 months

In addition, more than 80 percent of the water used in Colfax County goes into agricultural activities and surface water is the primary source of water for irrigated agriculture in the county (DBS&A 2003). Water is diverted from Ponil Creek to Chase Ranch Ditch near Cimarron, NM. Assuming a 1.5 acre-foot/acre allotment, the estimated maximum amount of water diverted from Ponil Creek could be 462 acre-feet (ac-ft) per year, or roughly 1.28 cfs during the growing season; however the ranch has never received its full 1.5 ac-ft allotment. The most it has ever received is 9.5 inches per acre, and in a typical year they receive about 4 inches per acre (DBS&A 2003) translating to approximately 0.67 cfs (highest diversion) and 0.28 cfs (average diversion) during the growing season. The 4Q3 flow for this portion of Ponil Creek was calculated using gage data from the typical growing season for the ecoregion and elevation (May 15 – November 15). The typical amount of water diverted from Ponil Creek during the growing season (0.28 cfs) was added to the calculated 4Q3 value (0.04 cfs) to obtain an estimate of the actual critical flow.

The calculated 4Q3s using DFLOW software and assumptions noted above are:

- Cieneguilla Creek (Eagle Nest Lake to headwaters) = 0.31 cfs
- Ponil Creek (US 64 to confl of North & South Ponil) = 0.32 cfs
- Rayado Creek (Miami Lake diversion to headwaters) = 1.88 cfs
- Sixmile Creek (Eagle Nest Lake to headwaters) = 0.17 cfs

It is often necessary to estimate a critical flow for a portion of a watershed where there is no active USGS flow gage. 4Q3 derivations for ungaged streams in the Cimmaron Watershed were based on analysis methods described by Waltemeyer (2002). In Waltemeyer's analysis, two regression equations for estimating 4Q3 were developed based on physiographic regions of NM (i.e., statewide and mountainous regions above 7,500 feet in elevation). The following regression equation for mountainous regions above 7,500 feet in elevation is based on data from 40 gaging stations with non-zero discharge (Waltemeyer 2002):

$$4Q3 = 7.3287 \times 10^{-5}\ DA^{0.70}\ P_w^{\ 3.58}\ S^{1.35} \qquad \text{(Eq. 4-1)}$$

where,

4Q3 = Four-day, three-year low-flow frequency (cfs)
DA = Drainage area (mi^2)
P_w = Average basin mean winter precipitation (inches)
S = Average basin slope (percent).

The average standard error of the estimate (SEE) and coefficient of determination are 94 and 66 percent, respectively, for this regression equation (Waltemeyer 2002). The 4Q3s for the North Ponil Creek and lower Ponil Creek were estimated using the regression equation for mountainous regions (Eq. 4-1) because the mean elevations for these assessment units were above 7,500 feet in elevation (Table 4.4).

Table 4.4 Calculation of 4Q3 Low-Flow Frequencies

Assessment Unit	Average Elevation (ft.)	Drainage Area (mi^2)	Mean Winter Precipitation (in.)	Average Basin Slope (percent)	4Q3 (cfs)
North Ponil Creek (South Ponil Creek to Seally Canyon)	8127	85.4	7.34	0.199	0.234
Ponil Creek (Cimarron River to US 64)	7995	325	6.78	0.277	0.702

For Ute Creek (Cimarron River to headwaters), water quality standard exceedences <u>*only*</u> occurred during higher flows. Therefore, the critical streamflow value for Ute Creek is the lowest streamflow at which the *E. coli* standard is exceeded, or the expected flow at which *E.*

coli is equal to 235 cfu/100 mL. Figure 4.1 depicts the relationship between *E. coli* and streamflow for Ute Creek ($R^2 = 0.66$).

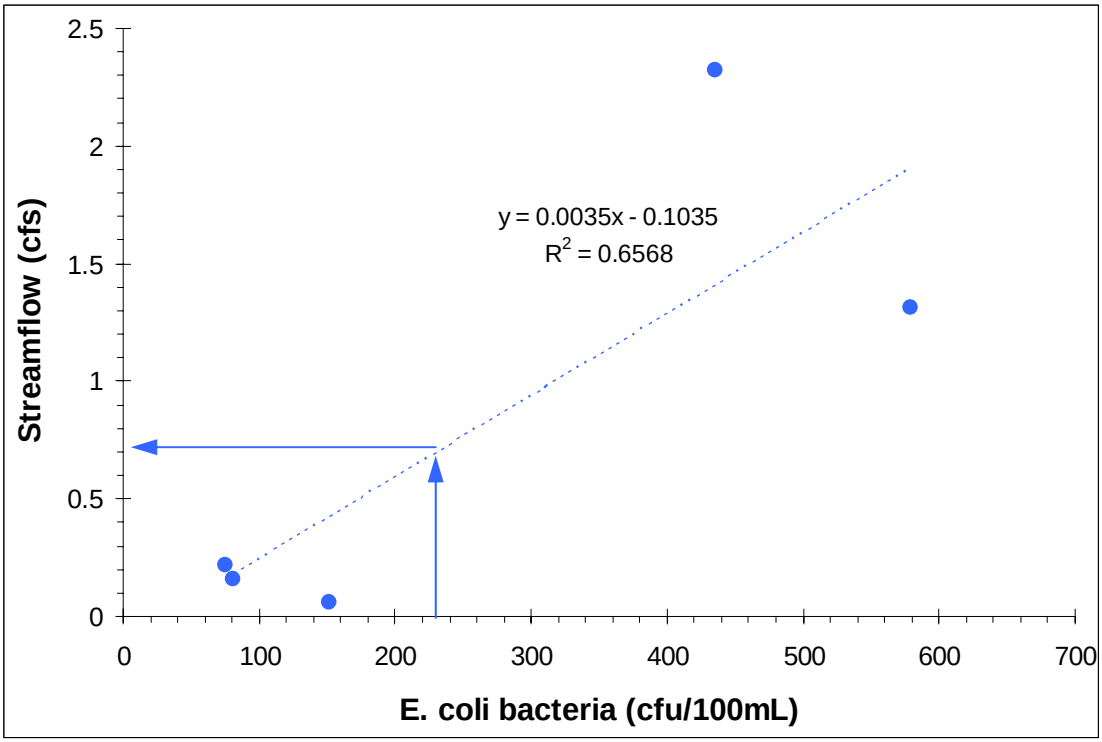

Figure 4.1 Ute Creek above US 64: *E. coli* vs. Streamflow Relationship

The critical flow for Ute Creek is based on SWQB data and was calculated using the relationship between bacteria and streamflow presented in Figure 4.1. Using the bacteria – flow relationship and a standard of 235 cfu/100mL for the x-variable, the estimated critical flow is:

- Ute Creek (Cimarron River to headwaters) =
  (0.0035 x 235 cfu/100mL) – 0.1035 ≅ 0.72 cfs

The critical streamflow value for Ute Creek was converted from cubic feet per second (cfs) to units of million gallons per day (mgd) as follows:

$$0.72\,\frac{ft^3}{\sec} \times 1{,}728\,\frac{in^3}{ft^3} \times 0.004329\,\frac{gal}{in^3} \times 86{,}400\,\frac{\sec}{day} \times 10^{-6} = 0.47\,mgd$$

Critical flows for the other reaches were converted to million gallons per day using the same formula.

It is important to remember that the TMDL itself is a value calculated at a defined critical condition, and is calculated as part of planning process designed to achieve water quality

standards. Since flows vary throughout the year in these systems, the actual load at any given time will vary based on the changing flow. Management of the load to improve stream water quality should be a goal to be attained. Meeting the calculated TMDL may be a difficult objective.

4.3 Calculations

Bacteria standards are expressed as colony forming units (cfu) per unit volume. The *E. coli* criteria used to calculate the allowable stream loads for the impaired assessment units are listed in Table 4.5. Target loads for bacteria are calculated based on flow values, water quality standards, and a conversion factor (Equation 4-2). The more conservative monthly geometric mean criteria are utilized in TMDL calculations to provide an implicit MOS. Furthermore, if the single sample criteria were used as targets, the geometric mean criteria may not be achieved.

*C as cfu/100 mL * 1,000 mL/1 L * 1 L/ 0.264 gallons * Q in 1,000,000 gallons/day = cfu/day* (Eq. 4-2)

Where C = the water quality criterion for bacteria,
Q = the critical stream flow in million gallons per day (mgd)

Table 4.5 Calculation of target loads for *E.coli*

Assessment Unit	Critical Flow (mgd)	*E.coli* geometric mean criteria (cfu/100mL)	Conversion Factor[(a)]	Target Load Capacity (cfu/day)
Cieneguilla Creek (Eagle Nest Lake to headwaters)	0.70[+]	126	3.79×10^7	3.34×10^9
North Ponil Creek (South Ponil Creek to Seally Canyon)	0.15	126	3.79×10^7	7.16×10^8
Ponil Creek (US 64 to confl of North and South Ponil)	0.21	126	3.79×10^7	1.00×10^9
Ponil Creek (Cimarron River to US 64)	0.4583[^]	126	3.79×10^7	2.19×10^9
Rayado Creek (Miami Lake Diversion to headwaters)	1.22	126	3.79×10^7	5.83×10^9
Sixmile Creek (Eagle Nest Lake to headwaters)	0.11	126	3.79×10^7	5.25×10^8
Ute Creek (Cimarron River to headwaters)	0.47	126	3.79×10^7	2.24×10^9

Notes: + Combined flow based on design capacity of Angel Fire WWTP (0.50 mgd) and 4Q3 of stream (0.20 mgd)
^ Combined flow based on maximum discharge from Cimarron WWTP (0.0083 mgd) and 4Q3 of stream (0.45 mgd)
(a) Based on equation 2.

The measured loads for *E.coli* were similarly calculated. The arithmetic mean of the data used to determine the impairment was substituted for the criterion in Equation 4-2. The same conversion factor was used. Results are presented in Table 4.6.

Table 4.6 Calculation of measured loads for *E.coli*

Assessment Unit	Critical Flow (mgd)	*E.coli* Arithmetic Mean[(a)] (cfu/100mL)	Conversion Factor[(b)]	Measured Load (cfu/day)
Cieneguilla Creek (Eagle Nest Lake to headwaters)	0.70[+]	912	3.79×10^{7}	2.42×10^{10}
North Ponil Creek (South Ponil Creek to Seally Canyon)	0.15	212	3.79×10^{7}	1.21×10^{9}
Ponil Creek (US 64 to confl of North and South Ponil)	0.21	240	3.79×10^{7}	1.91×10^{9}
Ponil Creek (Cimarron River to US 64)	0.4583[^]	446	3.79×10^{7}	7.75×10^{9}
Rayado Creek (Miami Lake Diversion to headwaters)	1.22	178	3.79×10^{7}	8.23×10^{9}
Sixmile Creek (Eagle Nest Lake to headwaters)	0.11	277	3.79×10^{7}	1.15×10^{9}
Ute Creek (Cimarron River to headwaters)	0.47	221	3.79×10^{7}	3.94×10^{9}

Notes: + Combined flow based on design capacity of Angel Fire WWTP (0.50 mgd) and 4Q3 of stream (0.20 mgd)
^ Combined flow based on maximum discharge from Cimarron WWTP (0.0083 mgd) and 4Q3 of stream (0.45 mgd)
(a) Arithmetic mean of the measured values used to make the impairment determination.
(b) Based on equation 2.

4.4 Waste Load Allocations and Load Allocations

4.4.1 Waste Load Allocation

There are no active point source dischargers on North Ponil Creek, upper Ponil Creek, Rayado Creek, Sixmile Creek, or Ute Creek AUs. However, there are existing point sources with individual NPDES permits in the Cieneguilla Creek and lower Ponil Creek assessment units. The Village of Angel Fire wastewater treatment plant (WWTP) (NM0030503) discharges directly into Cieneguilla Creek, whereas the Village of Cimarron WWTP (NM0031038) discharges to French Lake which is hydrologically linked to Ponil Creek. Each NPDES-permitted facility that discharges into an impaired reach has a wasteload allocation (WLA) included in this TMDL (Table 4.7).

There are no Municipal Separate Storm Sewer System (MS4) storm water permits in these AUs. However, excess bacteria concentrations may be a component of some storm water discharges covered under general NPDES permits, so the load for these dischargers should addressed.

Storm water discharges from construction activities are transient because they occur mainly during the construction itself, and then only during storm events. Coverage under the National Pollutant Discharge Elimination System (NPDES) Construction General Permit (CGP) for construction sites greater than one acre requires preparation of a Storm Water Pollution Prevention Plan (SWPPP) that includes identification and control of all pollutants associated with the construction activities to minimize impacts to water quality. The current CGP also includes state-specific requirements to implement site-specific interim and permanent stabilization, managerial, and structural solids, erosion, and sediment control Best Management Practices (BMPs) and/or other controls. BMPs are designed to prevent to the maximum extent practicable an increase in sediment load to the water body or an increase in a sediment-related parameter, such as total suspended solids, turbidity, siltation, stream bottom deposits, etc. BMPs also include measures to reduce flow velocity during and after construction compared to pre-construction conditions to assure that waste load allocations (WLAs) or applicable water quality standards, including the antidegradation policy, are met. Compliance with a SWPPP that meets the requirements of the CGP is generally assumed to be consistent with this TMDL.

Storm water discharges from active industrial facilities are generally covered under the current NPDES Multi-Sector General Permit (MSGP). This permit also requires preparation of an SWPPP, which includes specific requirements to limit (or eliminate) pollutant loading associated with the industrial activities in order to minimize impacts to water quality. Compliance with a SWPPP that meets the requirements of the MSGP is generally assumed to be consistent with this TMDL.

It is not possible to calculate individual WLAs for facilities covered by these General Permits at this time using available tools. Loads that are in compliance with the General Permits are therefore currently included as part of the load allocation (LA).

Table 4.7 Waste Load Allocations for *E. coli*

Assessment Unit	Facility	Design Capacity Flow (mgd)	*E. coli* Effluent Limit[(a)] (cfu/100mL)	Conversion Factor[(b)]	Waste Load Allocation (cfu/day)
Cieneguilla Creek (Eagle Nest Lake to headwaters)	**NM0030503** Village of Angel Fire WWTP (October 31, 2012 expiration)	0.50	126	3.79×10^7	2.39×10^9
Ponil Creek (Cimarron River to US 64)	**NM0031038** Village of Cimarron WWTP (September 30, 2014 expiration)	0.0083	126	3.79×10^7	3.96×10^7

Notes: *(a)* Based on current in-stream New Mexico WQS for segments 20.6.4.306 and 20.6.4.309 NMAC.
(b) Based on equation 2.

4.4.2 Load Allocation

In order to calculate the LA, the WLA and margin of safety (MOS) were subtracted from the target capacity TMDL following Equation 4-3:

$$WLA + LA + MOS = TMDL \qquad \text{(Eq. 4-3)}$$

The MOS is estimated to be 10 percent of the target load calculated in Table 4.5. Results are presented in Table 4.8. Additional details on the MOS chosen are presented in Section 4.7.

The extensive data collection and analyses necessary to determine background *E.coli* loads for the Cimarron River Watershed were beyond the resources available for this study. It is therefore assumed that a portion of the LA is made up of natural background loads.

The load reductions necessary to meet the target loads were calculated to be the difference between the calculated target loads (Table 4.5) and the measured loads (Table 4.6), and are shown in Table 4.9. These load reduction tables are presented for informational purposes only. It is important to note that WLAs and LAs are estimates based on a specific flow condition. Under differing hydrologic conditions, the loads will change. For this reason the load allocations given here are less meaningful than are the relative percent reductions. Successful implementation of this TMDL will be determined based on achieving the *E. coli* standards.

Table 4.8 TMDL for *E.coli*

Assessment Unit	WLA (cfu/day)	LA (cfu/day)	MOS (10%) (cfu/day)	TMDL (cfu/day)
Cieneguilla Creek (Eagle Nest Lake to headwaters)	2.39×10^9	6.21×10^8	3.34×10^8	3.34×10^9
North Ponil Creek (South Ponil Creek to Seally Canyon)	0	6.45×10^8	7.16×10^7	7.16×10^8
Ponil Creek (US 64 to confl of North and South Ponil)	0	9.03×10^8	1.00×10^8	1.00×10^9
Ponil Creek (Cimarron River to US 64)	3.96×10^7	1.93×10^9	2.19×10^8	2.19×10^9
Rayado Creek (Miami Lake Diversion to headwaters)	0	5.24×10^9	5.83×10^8	5.83×10^9
Sixmile Creek (Eagle Nest Lake to headwaters)	0	4.73×10^8	5.25×10^7	5.25×10^8
Ute Creek (Cimarron River to headwaters)	0	2.02×10^9	2.24×10^8	2.24×10^9

Table 4.9 Calculation of load reduction for *E.coli*

Assessment Unit	Target Load[(a)] (cfu/day)	Measured Load (cfu/day)	Load Reduction (cfu/day)	Percent Reduction[(b)]
Cieneguilla Creek (Eagle Nest Lake to headwaters)	3.01×10^{9}	2.42×10^{10}	2.12×10^{10}	88%
North Ponil Creek (South Ponil Creek to Seally Canyon)	6.45×10^{8}	1.21×10^{9}	5.61×10^{8}	47%
Ponil Creek (US 64 to confl of North and South Ponil)	9.03×10^{8}	1.91×10^{9}	1.01×10^{9}	53%
Ponil Creek (Cimarron River to US 64)	1.97×10^{9}	7.75×10^{9}	5.78×10^{9}	75%
Rayado Creek (Miami Lake Diversion to headwaters)	5.24×10^{9}	8.23×10^{9}	2.99×10^{9}	36%
Sixmile Creek (Eagle Nest Lake to headwaters)	4.73×10^{8}	1.15×10^{9}	6.82×10^{8}	59%
Ute Creek (Cimarron River to headwaters)	2.02×10^{9}	3.94×10^{9}	1.92×10^{9}	49%

Note: The MOS is not included in the load reduction calculations because it is a set aside value which accounts for any uncertainty or variability in TMDL calculations and therefore should not be subtracted from the measured load.
(a) Target Load = TMDL - MOS
(b) Percent reduction is the percent the existing measured load must be reduced to achieve the Target Load and is calculated as follows: (Measured Load – Target Load) / Measured Load x 100

4.5 Identification and Description of Pollutant Source(s)

SWQB fieldwork includes an assessment of the probable sources of impairment (Appendix B). The approach for identifying "Probable Sources of Impairment" was recently modified by SWQB to include additional input from a variety of stakeholders including landowners, watershed groups, and local, state, tribal and federal agencies. Probable Source Sheets are filled out by SWQB staff during watershed surveys and watershed restoration activities. The draft probable source list will be reviewed and modified, as necessary, with watershed group/ stakeholder input during the TMDL public meeting and comment period.

Probable sources that may be contributing to the observed load are displayed in Table 4.10:

Table 4.10 Pollutant source summary for *E.coli*

Assessment Unit	Pollutant Sources	Magnitude[(a)] (lbs/day)	Probable Sources[(b)] (% from each)
Cieneguilla Creek (Eagle Nest Lake to hw)	Point: NM0028011	2.39×10^{9}	11% Municipal point source discharge
	Nonpoint:	2.18×10^{10}	89% Rangeland grazing, other recreational pollution sources
North Ponil Creek (S Ponil Crk to Seally Cyn)	Point:	n/a	0%
	Nonpoint:	1.21×10^{9}	100% Low water crossing, rangeland grazing, forest roads (road construction and use)
Ponil Creek (US 64 to confl of N & S Ponil)	Point:	n/a	0%
	Nonpoint:	1.91×10^{9}	100% Livestock (grazing or feeding operations), rangeland grazing, wastes from pets
Ponil Creek (Cimarron River to US 64)	Point: NM0031038	3.96×10^{7}	1% Municipal point source discharge
	Nonpoint:	7.71×10^{9}	99% Avian sources (waterfowl and/or other), source unknown, wastes from pets
Rayado Creek (Miami Lake div to hw)	Point:	n/a	0%
	Nonpoint:	8.23×10^{9}	100% rangeland grazing, wildlife other than waterfowl
Sixmile Creek (Eagle Nest Lake to hw)	Point:	n/a	0%
	Nonpoint:	1.15×10^{9}	100% Animal feeding operations (NPS), livestock (grazing or feeding operations), natural sources, rangeland grazing, wildlife other than waterfowl
Ute Creek (Cimarron River to hw)	Point:	n/a	0%
	Nonpoint:	3.94×10^{9}	100% rangeland grazing, source unknown

Notes:
(a) Measured Load (Table 4.6). *Point source* magnitude is based on the WLA calculation from NPDES permit (Table 4.7).
(b) From the Integrated CWA 303(d)/305(b) List (NMED/SWQB 2010a). This list of probable sources is based on staff observation and known land use activities in the watershed. These sources are not confirmed nor quantified at this time.

The Probable Source Identification Sheets in Appendix B provide an approach for a visual analysis of a pollutant source along an impaired reach. Although this procedure is subjective, SWQB feels that it provides the best available information for the identification of probable sources of impairment in a watershed. The list of "Probable Sources" is not intended to single out any particular land owner or single land management activity and has therefore been labeled "Probable" and generally includes several sources for each known impairment. Table 4.10 displays probable sources of impairment along the reach as determined by field reconnaissance and assessment. Probable sources of *E.coli* will be evaluated, refined, and changed as necessary through the Watershed-Based Plan (WBP).

4.6 Linkage of Water Quality and Pollutant Sources

Among the probable sources of bacteria are municipal point source discharges such as wastewater treatment facilities, poorly maintained or improperly installed (or missing) septic tanks, livestock grazing of valley pastures and riparian areas, upland livestock grazing, in addition to wastes from pets, waterfowl, and other wildlife. Howell et. al. (1996) found that bacteria concentrations in underlying sediment increase when cattle (*Bos taurus*) have direct access to streams, such as the waters in the Cimarron River Watershed. Natural sources of bacteria are also present in the form of other wildlife such as elk, deer, and any other warm-blooded mammals. In addition to direct input from grazing operations and wildlife, *E. coli* concentrations may be subject to elevated levels as a result of resuspension of bacteria laden sediment during storm events. Temperature can also play a role in bacteria concentrations. Howell et. al. (1996) observed that bacteria growth increases as water temperature increases, which has the potential to occur in this watershed as well.

The bacteria loading in the Cimarron River Watershed probably originates from a combination of drought-related impacts, municipal point source discharges, and livestock and wildlife wastes. Habitat modifications such as loss of riparian habitat, road maintenance and runoff, and land development or redevelopment as well as other recreational pollution sources may also be important contributors of bacteria.

In order to determine exact sources and relative contributions, further study is needed. One method of characterizing sources of bacteria is a Bacterial, or Microbial, Source Tracking (BST) study. The extensive data collection and analyses necessary to determine bacterial sources were beyond the resources available for this study. However, sufficient data exist to support development of *E.coli* TMDLs to address the stream standards violations.

4.7 Margin of Safety

TMDLs should reflect a MOS based on the uncertainty or variability in the data, the point and nonpoint source load estimates, and the modeling analysis. For these bacteria TMDLs, the MOS was developed using a combination of conservative assumptions and explicit recognition of potential errors in flow calculations. Therefore, this MOS is the sum of the following assumptions:

- *Conservative Assumptions*
  E.coli bacteria does not readily degrade in the environment.

  Using the monthly geometric mean criterion rather than the single sample criterion, which allows for higher concentrations in individual grab samples, to calculate target loading values.

- *Explicit recognition of potential errors*
  There is inherent error in all flow measurements. A conservative MOS for this element is **10 percent**.

4.8 Consideration of Seasonal Variation

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs take into consideration seasonal variation in watershed conditions and pollutant loading. Data used in the calculation of these TMDLs were collected during the spring, summer, and fall of 2006 in order to ensure coverage of any potential seasonal variation in the system. Bacteria exceedences occurred during both high and low flow events. Higher flows may flush more nonpoint source runoff containing bacteria. It is possible the criterion may be exceeded under a low flow condition when there is insufficient dilution. Evaluation of seasonal variability for potential nonpoint sources is difficult due to limited available data.

4.9 Future Growth

Growth estimates by county are available from the New Mexico Bureau of Business and Economic Research. These estimates project growth to the year 2035. Growth estimates for Colfax County project a 14% growth rate through 2035. However, as of 2008, the largest incorporated town in the county, Raton, had an estimated population of 6,465 people. This showed a decrease of 11.22 percent from the 2000 census population and Raton's population is not expected to have much growth in the future.

According to the data, bacteria loading is primarily due to diffuse nonpoint sources. Estimates of future growth are not anticipated to lead to a significant increase in bacteria concentrations that cannot be controlled with best management practices (BMPs) in this watershed. However, it is imperative that BMPs continue to be utilized in this watershed to improve road conditions and grazing allotments and adhere to SWPPP requirements related to construction and industrial activities covered under the general permit.