FINAL DRAFT

TOTAL MAXIMUM DAILY LOADS (TMDL)

FOR THE

JEMEZ RIVER WATERSHED

MAY 11, 2021

Prepared by

New Mexico Environment Department, Surface Water Quality Bureau

Monitoring, Assessments, and Standards Section

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For Additional Information please visit:

https://www.env.nm.gov/surface-water-quality/

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Cover photo: Rio Guadalupe at Gilman Tunnels; Photo: SWQB staff, 2010

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List of Abbreviations

4Q3	4-Day, 3-year low-flow frequency
6T3	Temperature not to be exceeded for 6 or more consecutive hours on more than 3 consecutive days
AU	Assessment Unit
BMP	Best management practices
CFR	Code of Federal Regulations
cfs	Cubic feet per second
cfu	Colony forming units
CGP	Construction general storm water permit
CoolWAL	Cool Water Aquatic Life
CWA	Clean Water Act
CWAL	Cold Water Aquatic Life
^{o}C	Degrees Celsius
DMR	Discharge Monitoring Report
^{o}F	Degrees Fahrenheit
HUC	Hydrologic unit code
$j/m^2/s$	Joules per square meter per second
km^2	Square kilometers
LA	Load allocation
lbs/day	Pounds per day
mgd	Million gallons per day
mg/L	Milligrams per Liter
mi^2	Square miles
mL	Milliliters
MCWAL	Marginal Coldwater Aquatic Life
MOS	Margin of safety
MOU	Memorandum of Understanding
MS4	Municipal separate storm sewer system
MSGP	Multi-sector general storm water permit
NM	New Mexico
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint source
QAPP	Quality Assurance Project Plan
RFP	Request for proposal
SEE	Standard Error of the Estimate
SLO	State Land Office
SSTEMP	Stream Segment Temperature Model
SWPPP	Storm water pollution prevention plan
SWQB	Surface Water Quality Bureau
TMDL	Total Maximum Daily Load
UAA	Use Attainability Analysis
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
WBP	Watershed-based plan
WLA	Waste load allocation
WQCC	Water Quality Control Commission

WQS	Water quality standards (20.6.4 NMAC as amended through 2/28/18)

EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act, 33 U.S.C. § 1313(CWA), requires states to develop Total Maximum Daily Load (TMDL) management plans for water bodies determined to be water quality limited. A TMDL is defined as "*a written plan and analysis established to ensure that a water body will attain and maintain water quality standards including consideration of existing pollutant loads and reasonably foreseeable increases in pollutant loads*" (USEPA, 1999). A TMDL defines the amount of a pollutant a water body can assimilate without violating a state's water quality standards. It also allocates that load capacity to known point sources and nonpoint sources at a given flow. It further identifies potential methods, actions, or limitations that could be implemented to achieve water quality standards. TMDLs are defined in 40 Code of Federal Regulations Part 130 (40 C.F.R. § 130.2(i)) as the sum of individual Waste Load Allocations (WLAs) for point sources, and Load Allocations (LAs) for nonpoint source and background conditions, and a Margin of Safety (MOS) in acknowledgement of various sources of uncertainty in the analysis.

The New Mexico Environment Department (NMED) Surface Water Quality Bureau (SWQB) conducted a water quality survey of the Jemez basin in 2013 (some additional monitoring activities took place in 2012 and 2014). Water quality monitoring stations were located to evaluate the impact of tributary streams and ambient water quality conditions. Assessment of data generated during the 2013 survey was conducted according to the 2014-2016 SWQB Assessment Protocols (NMED/SWQB, 2015a).

Impairments addressed in this TMDL document, as well as existing approved TMDLs, are shown on **Tables ES-1 to ES-5**, below. Additional information regarding these impairments can be reviewed in the current Clean Water Act §303(d)/§305(b) Integrated Report and List (IR) (NMED/SWQB, 2018).

The next scheduled water quality monitoring date for the Jemez basin is 2021-2022. Once the survey is completed, and the data has been verified and validated, TMDL targets will be re-examined and potentially revised, as this document is an evolving management plan. If new data indicate that the targets used in this analysis are not appropriate and/or if new standards are adopted, the load capacity will be adjusted accordingly. When water quality standards have been achieved, the reaches will be moved to the appropriate category in the IR.

Table ES-1. TMDL for Clear Creek (Rio de las Vacas to San Gregorio Lake)	
New Mexico Standards Segment	20.6.4.108 NMAC
Assessment Unit Identifier	NM-2106.A_54
NPDES Permit(s)	None
Segment Length (mi)	5.14
Parameters of Concern	Temperature
Designated Uses Affected	High Quality Coldwater Aquatic Life
USGS Hydrologic Unit Code	13020202 - Jemez
Scope/size of Watershed (mi^2)	26.98
USEPA Ecoregion	21f Sedimentary Mid-Elevation Forests
Land Use/Cover	71.8% Evergreen forest; 8.7% Deciduous forest; 7.1% Mixed forest; 5.1% Wetlands; 3.6% Grassland; 3.3% Shrub/scrub
Land Management	100.0% Forest Service
Geology	68.3% Igneous; 14.6% Sedimentary; 9.6% Unconsolidated and Sedimentary; 7.5% Igneous and Metamorphic
Probable Sources	Dam or impoundment; Highway/Road/Bridge runoff; Rangeland grazing
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	Total Organic Carbon, Turbidity (2003); *E. coli*, Nutrients (2016)
WLA + LA + MOS = TMDL	
Temperature (kJ/day)	0 + (1.20×10^7) + (2.12×10^6) = (1.41×10^7)

Table ES-2. TMDL for Jemez River (Zia Pueblo bnd to Jemez Pueblo bnd)	
New Mexico Standards Segment	20.6.4.106 NMAC
Assessment Unit Identifier	NM-2105_75
NPDES Permit(s)	None
Segment Length (mi)	1.86
Parameters of Concern	Temperature
Designated Uses Affected	Marginal Warmwater Aquatic Life
USGS Hydrologic Unit Code	13020202 - Jemez
Scope/size of Watershed (mi^2)	591
USEPA Ecoregion	22m Albuquerque Basin
Land Use/Cover	54.5% Evergreen forest; 20.6% Shrub/scrub; 14.9% Grassland; 5.3% Deciduous forest; 2.1% Mixed forest; 1.6% Wetlands
Land Management	64.6% Forest Service; 23.0% National Park Service; 7.7% tribal; 4.4% private
Geology	52.1% Igneous; 26.3% Sedimentary; 8.0% Unconsolidated; 5.6% Unconsolidated and Sedimentary; 5.3% Igneous and Sedimentary; 2.7% Igneous and Metamorphic
Probable Sources	Crop production (dry land); Crop production (irrigated); Highway/Road/Bridge runoff; Low water crossing; Off-road vehicles; Other recreation (fishing); Pavement/impervious surfaces; Residential area; Water diversions; Wildlife other than waterfowl
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	Arsenic, Boron (2009); *E. coli* (2016)
WLA + LA + MOS = TMDL	
Temperature (kJ/day)	0 + (1.22×10^9) + (1.36×10^8) = (1.36×10^9)

Table ES-3. TMDL for Rio Guadalupe (Jemez River to confl with Rio Cebolla)	
New Mexico Standards Segment	20.6.4.108 NMAC
Assessment Unit Identifier	NM-2106.A_30
NPDES Permit(s)	None
Segment Length (mi)	12.6
Parameters of Concern	Specific conductance
Designated Uses Affected	High Quality Coldwater Aquatic Life
USGS Hydrologic Unit Code	13020202 - Jemez
Scope/size of Watershed (mi^2)	267
USEPA Ecoregion	21f Sedimentary Mid-Elevation Forests
Land Use/Cover	69.6% Evergreen forest; 10.8% Shrub/scrub; 9.8% Deciduous forest; 3.7% Mixed forest; 3.7% Grassland; 1.8% Wetlands
Land Management	95.0% Forest Service; 3.4% private
Geology	59.8% Igneous; 33.3% Sedimentary; 3.9% Igneous and Metamorphic; 2.9% Unconsolidated and Sedimentary;
Probable Sources	Crop production (irrigated); Forest fire runoff; Highway/Road/Bridge runoff; Impervious surface runoff; Other recreation (fishing); On-site treatment systems; Rangeland grazing; Residential area
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	Aluminum (2003); Sedimentation/siltation, Turbidity (2004); Temperature (2009); Nutrients (2016)
	WLA + LA + MOS = TMDL
Specific conductance (lb/day TDS)	0 + 6315.7 + 701.8 = 7017.5

Table ES-4. TMDL for Rito de los Indios (San Antonion Creek to headwaters)					
New Mexico Standards Segment	20.6.4.108 NMAC				
Assessment Unit Identifier	NM-2106.A_24				
NPDES Permit(s)	None				
Segment Length (mi)	4.47				
Parameters of Concern	Turbidity, Temperature				
Designated Uses Affected	High Quality Coldwater Aquatic Life Use				
USGS Hydrologic Unit Code	13020202 - Jemez				
Scope/size of Watershed (mi^2)	7.32				
USEPA Ecoregion	21f Sedimentary Mid-Elevation Forests				
Land Use/Cover	49.2% Grassland; 47.5% Evergreen forest; 1.4% Deciduous forest				
Land Management	87.3% National Park Service; 12.3% Forest Service				
Geology	45.8% Igneous; 41.2% Igneous and Sedimentary; 13.0% Unconsolidated				
Probable Sources	Forest fire; Rangeland grazing; Wildlife other than waterfowl				
IR Category	5/5A				
Priority Ranking	High				
Existing TMDLs	None				
WLA + LA + MOS = TMDL					
Temperature (kJ/day)	$0 + 1.19 \times 10^8 + 1.32 \times 10^7 = 1.32 \times 10^8$				
Turbidity (lb/day TSS)	**Duration (consecutive hrs)**	**WLA**	**MOS (15%)**	**LA**	**TMDL**
	720	0.00	12.81	72.58	85.39
	336	0.00	10.16	57.57	67.72
	168	0.00	8.67	49.13	57.80

	144	0.00	7.40	41.95	49.35
	120	0.00	6.85	38.83	45.68
	96	0.00	5.21	29.50	34.71
	72	0.00	4.45	25.20	29.65

Table ES-5. TMDL for Vallecito Ck (Jemez Pueblo bnd to Div abv Ponderosa)	
New Mexico Standards Segment	20.6.4.98 NMAC
Assessment Unit Identifier	NM-2105.5_20
NPDES Permit(s)	None
Segment Length (mi)	3.03
Parameters of Concern	Dissolved arsenic
Designated Uses Affected	Marginal Warmwater Aquatic Life (HH-OO)
USGS Hydrologic Unit Code	13020202 - Jemez
Scope/size of Watershed (mi^2)	37.73
USEPA Ecoregion	21d Foothill Shrublands
Land Use/Cover	65.3% Evergreen forest; 21.8% Shrub/Scrub; 11.5% Grassland/Herbaceous; 1.3% Deciduous forest
Land Management	95.0% Forest Service; 4.1% private
Geology	72.4% Igneous; 27.6% Sedimentary
Probable Sources	Crop production (dry land); Crop production (Irrigated); Dam or impoundment; Highway/Road/Bridge Runoff; Residential area; Water diversions
IR Category	5/5A
Priority Ranking	High
Existing TMDLs	None
WLA + LA + MOS = TMDL	
Dissolved Arsenic (lb/day)	0 + 0.0020 + 0.0003 = 0.0023

1.0 BACKGROUND

1.1 Watershed Description

This document establishes TMDLs for five Assessment Units (AUs) in the Jemez watershed, HUC 13020202 (**Figure 1.1, Table 1.1**). Impairment determinations were based on data collected during the 2013 SWQB water quality survey. Hydrologic Unit Code 13020202 is 1038.94 square miles, almost entirely within Sandoval County, New Mexico, with the northern tip of the watershed extending into Rio Arriba County. The Jemez River watershed is located in the Jemez Mountains, east of Cuba, New Mexico. The dominant geologic feature of the Jemez watershed is the Valles Caldera, the remains of a volcano which experienced two major eruptions, a little over one million years ago, ejecting huge volumes of volcanic gases, ash, pumice and rock fragments. The two massive eruptions depleted the magma chamber beneath the volcano. No longer supported from below, the volcano, ringed by fractures, collapsed, forming a vast caldera 14 miles across. The caldera is now managed as Valles Caldera National Preserve, by the National Park Service. Surface geology of HUC 13020202 is 36.0% sedimentary, 32.4% igneous, 15.7% unconsolidated and sedimentary, 10.5% unconsolidated, 3.0% igneous and sedimentary, and 2.4% igneous and metamorphic (**Figure 1.2**).

The Jemez River drainage originates with third and fourth order, high elevation streams located in the San Pedro Parks Wilderness and Valles Caldera, that drain into the Rio San Antonio, the East Fork of the Jemez River, the Rio Cebolla and the Rio de las Vacas. The East Fork of the Jemez River and the Rio San Antonio join to form the main stem of the Jemez River below La Cueva, New Mexico. At the confluence of the East Fork of the Jemez River and San Antonio Creek, the Jemez River cuts through the volcanic rock and into a series of sedimentary strata that form the valley floor (NMED/SWQB, 2015b; **Figure 1.2**). Approximately 1500 L/min (0.88 cfs) of geothermal water from the Valles Caldera system enters the Jemez River from Soda Dam and associated features in the vicinity of Jemez Springs. Hardness is approximately two times greater in the Jemez River below Soda Dam, as compared to above it. Discharge temperatures at these springs range from 30° to 75°C (Reid et al., 2003).

The confluence of the Rio Cebolla and Rio de las Vacas marks the origin of the Rio Guadalupe which joins the Jemez River main stem below the village of Jemez Springs. The Rio Guadalupe is the major tributary that flows into the Jemez River from the west, approximately 31 miles upstream of the Rio Grande. The headwaters of both streams originate in volcanic rocks, principally basalts and Bandelier tuffs, associated with the Valles Caldera. Vallecito Creek is the largest tributary to the Jemez River from the east. In recent years, flow from the Jemez River is intermittent at the confluence with the Rio Grande on Santa Ana Pueblo.

Land cover in the watershed is 50.9% Shrub/scrub, 33.3% Evergreen forest, 9.1% Grassland, 3.1% Deciduous forest, 1.4% Wetlands, and 1.2% Mixed forest (**Figure 1.3**). The primary landowners are the US Forest Service (37.6%) and the Jemez, Zia and Santa Ana Pueblo tribes (35.5%, mostly in the lower elevations). Valles Caldera National Park occupies 13.2% of the surface area, near the top of the watershed (**Figure 1.4**). Land uses in HUC 13020202 include ranching, silviculture, recreation, mining (including several closed pumice mines in various stages of reclamation, **Figure 1.5**) and some urban and residential development, including the village of Jemez Springs.

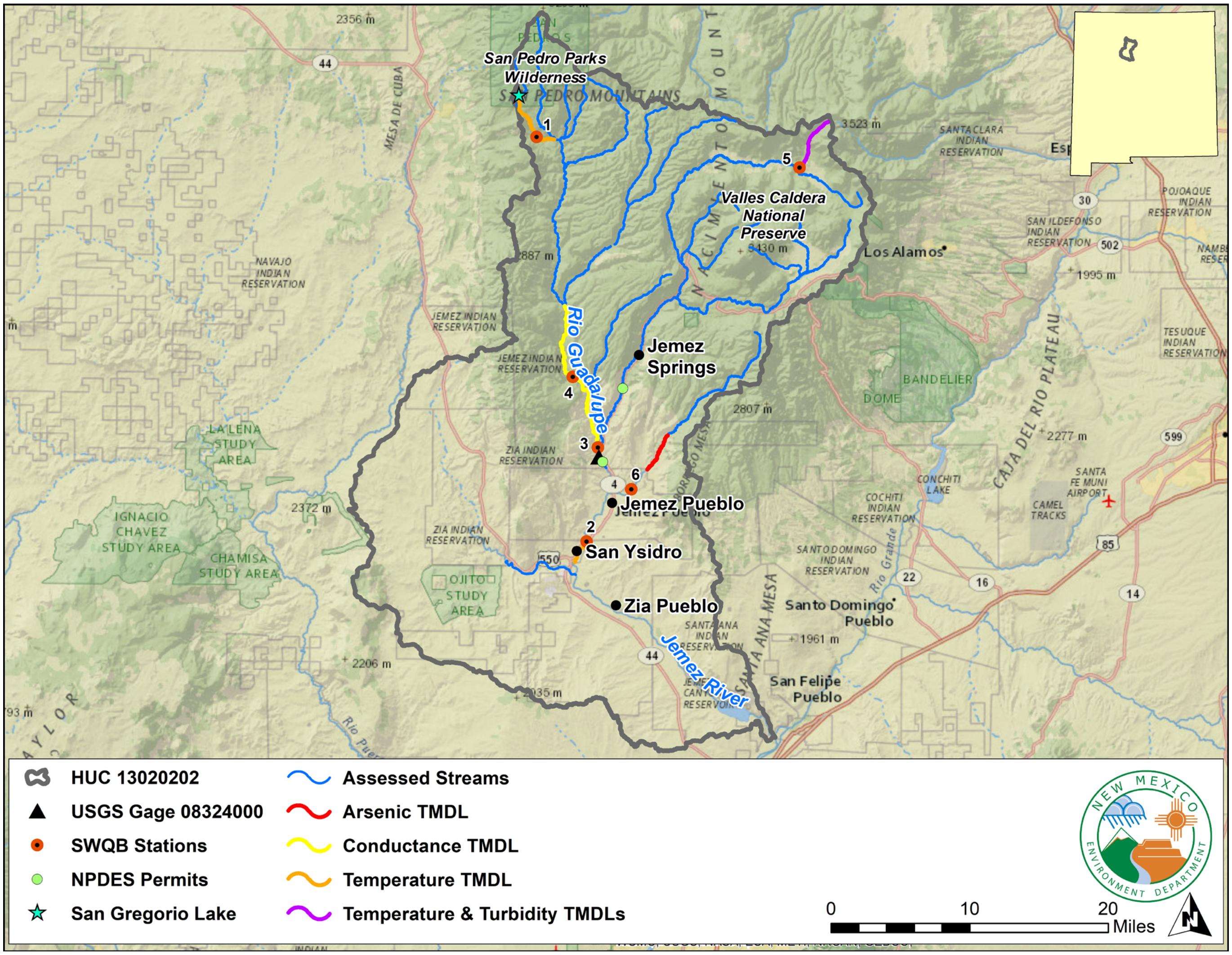


Figure 1.1. Overview of new HUC 13020202 TMDLs.

Table 1.1 Monitoring stations shown on Figure 1.1

Site #	Assessment Unit	STORET ID	Site Name
1	Clear Creek (Rio de las Vacas to San Gregorio Lake)	31ClearC002.3	Clear Creek at NM 126
2	Jemez River (Zia Pueblo bnd to Jemez Pueblo bnd)	31JemezR037.0	Jemez River above San Ysidro at NM Hwy 4
3	Rio Guadalupe (Jemez River to confl with Rio Cebolla)	31RGuada000.1	Rio Guadalupe above Jemez River
4	Rio Guadalupe (Jemez River to confl with Rio Cebolla)	31RGuada010.0	Rio Guadalupe at Deer Creek Landing
5	Rito de los Indios (San Antonion Creek to headwaters)	31RIndio000.2	Rito de los Indios above San Antonio Creek
6	Vallecito Ck (Jemez Pueblo bnd to Div abv Ponderosa)	31Vallec003.2	Vallecitos Creek below Diversion

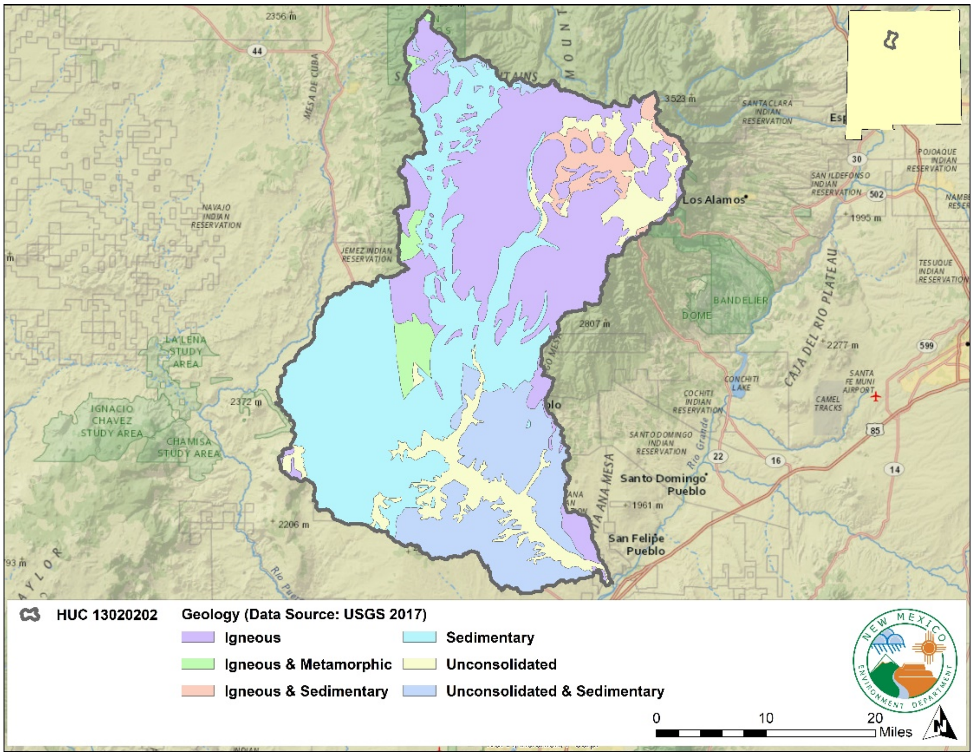


Figure 1.2 General surface geology of HUC 13020202

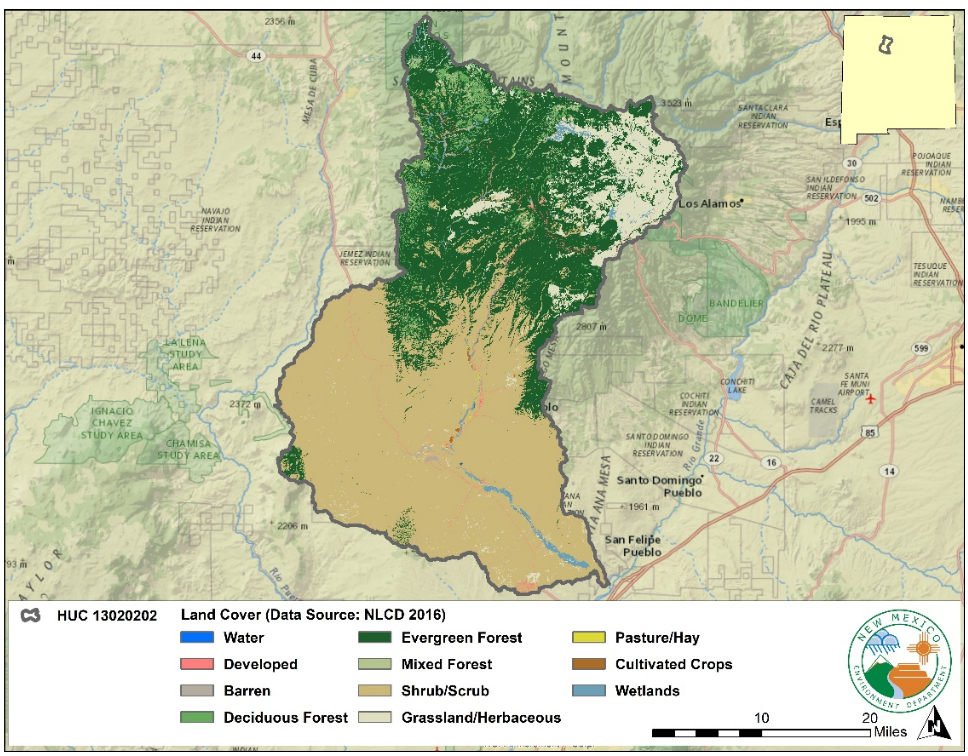


Figure 1.3 Land cover of HUC 13020202

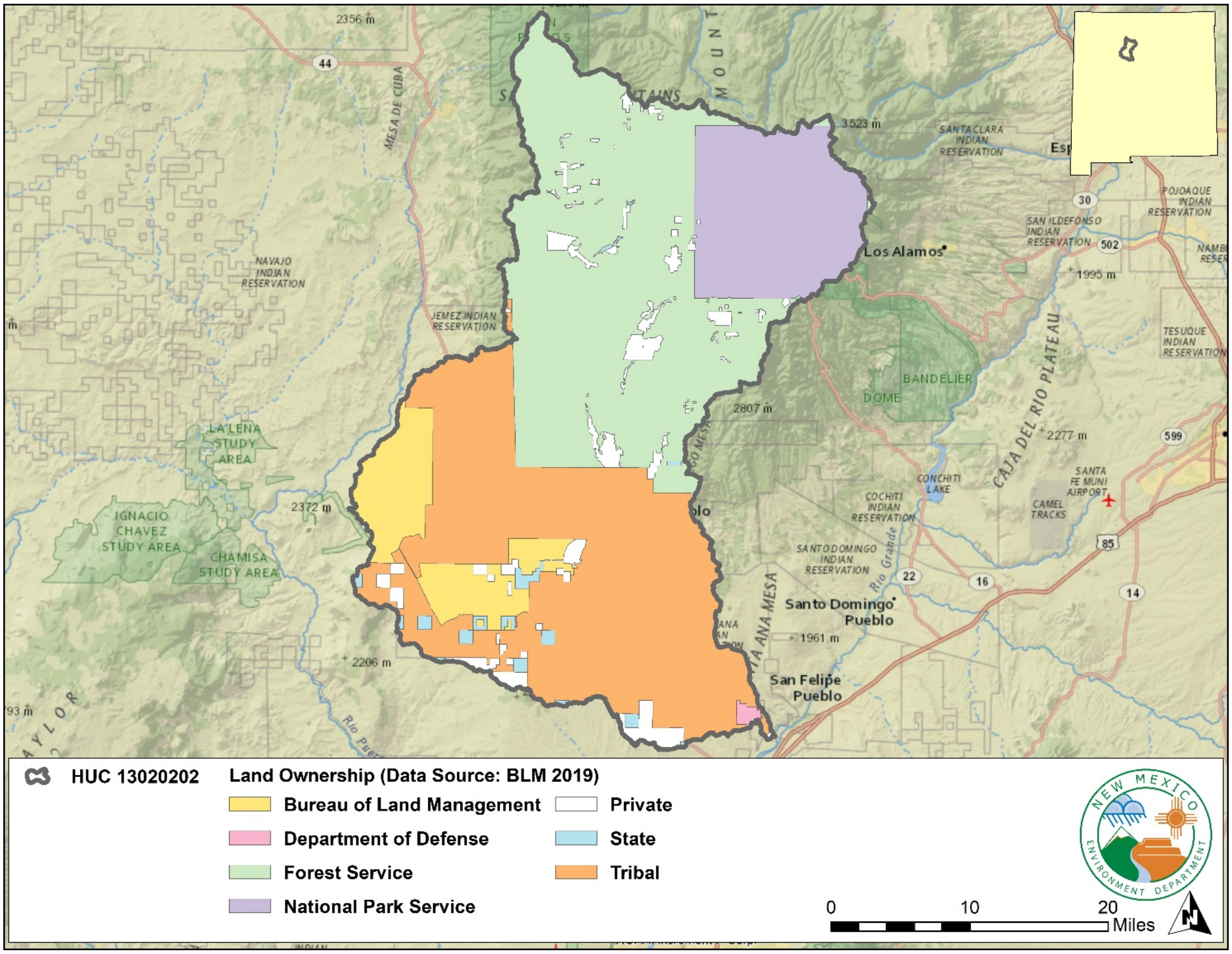


Figure 1.4 Land ownership in HUC 13020202

Species listed by the federal Fish & Wildlife Service (USFWS) and/or the New Mexico Department of Game & Fish as Threatened or Endangered, which are known to occur in the Jemez HUC-8, are shown on **Table 1.2** (Natural Heritage New Mexico Conservation Information System, https://nhnm.unm.edu/bcd/results, accessed on 10/10/19). Of those, the Rio Grande Silvery Minnow, Yellow-Billed Cuckoo, Southwestern Willow Flycatcher, Wrinkled Marshsnail, New Mexican Meadow Jumping Mouse, and Parish's Alkali Grass have primary habitat association with aquatic, riparian or wetland habitats (Biota Information System of New Mexico, https://www.bison-m.org and New Mexico Rare Plants website, http://nmrareplants.unm.edu, both accessed 11/14/19). There is USFWS designated Critical Habitat in the watershed for Jemez Mountains Salamander, Mexican Spotted Owl, and New Mexican Meadow Jumping Mouse (USFWS, Environmental Conservation Online System, https://ecos.fws.gov/ecp/, accessed on 10/10/19).

Table 1.2 Federal and state listed species known to occur in HUC 13020202.

Common Name	Scientific Name	Federal Status*	State Status**
Rio Grande Silvery Minnow	*Hybognathus amarus*	LE	E
Jemez Mountains Salamander	*Plethodon neomexicanus*	LE	E
Yellow-Billed Cuckoo	*Coccyzus americanus*	LT	--
American Peregrine Falcon	*Falco peregrinus anatum*	--	T
Mexican Spotted Owl	*Strix occidentalis lucida*	LT	--
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	LE	E
Gray Vireo	*Vireo vicinior*	--	T
Wilcox's Fishhook Cactus	*Mammillaria wrightii var. wilcoxii*	--	E
Wrinkled Marshsnail	*Stagnicola caperata*	--	E
New Mexican Meadow Jumping Mouse	*Zapus hudsonius luteus*	LE	E
Pacific Marten	*Martes caurina*	--	T
Spotted Bat	*Euderma maculatum*	--	T
Mountain Lily	*Lilium philadelphicum var. andinum*	--	E
Parish's Alkali Grass	*Puccinellia parishii*	--	E

*Federal Status: LE – listed Endangered; LT – listed Threatened. **State Status: E – Endangered; T – Threatened.

Two wildfires burned large portions of the Jemez River watershed (**Figure 1.5**), shortly before and during the water sampling events upon which these TMDLs are based. The Las Conchas fire burned from June 26 to August 3, 2011 and covered a total of 154,349 acres. The Thompson Ridge fire burned from May 31 to July 1, 2013 (during the SWQB water quality survey) and covered a total of 23,965 acres, all within the Valles Caldera. Since that time, an additional fire burned a small area of the watershed just south of the East Fork of the Jemez River. The 1412-acre Cajete fire was active from June 15 to June 24, 2017. A number of smaller fires have occurred in the watershed, both before and after the water quality survey. Potential water quality impacts of the wildfires are discussed in more detail in the pollutant TMDL chapters.

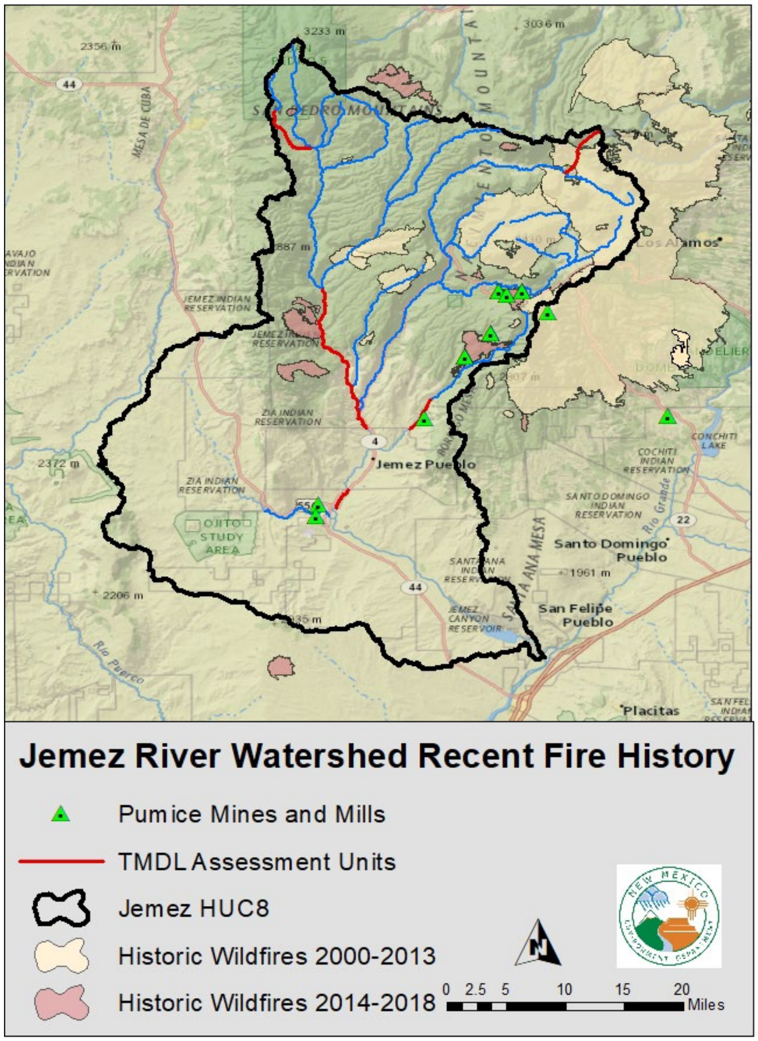


Figure 1.5 Historic fires through 2018 (the latest year available) and pumice mining in the Jemez River watershed.

1.2 Water Quality Standards

Water quality standards (WQS) for all assessment units in this document are set forth in the following sections of New Mexico Standards for Interstate and Intrastate Surface Waters (20.6.4 New Mexico Administrative Code [NMAC], 2018):

Vallecito Ck (Jemez Pueblor bnd to Div abv Ponderosa) is in water quality segment 20.6.4.98.

20.6.4.98 INTERMITTENT WATERS: All non-perennial surface waters of the state, except those ephemeral waters included under section 20.6.4.97 NMAC or classified in 20.6.4.101-899 NMAC.

A. Designated uses: livestock watering, wildlife habitat, marginal warmwater aquatic life and primary contact.

B. Criteria: the use-specific criteria in 20.6.4.900 NMAC are applicable to the designated uses, except that the following site-specific criteria apply: the monthly geometric mean of E. coli bacteria 206 cfu/100 mL or less, single sample 940 cfu/100 mL or less. [20.6.4.98 NMAC - N, 5/23/2005; A, 12/1/2010; A, 3/2/2017]

Jemez River (Zia Pueblo bnd to Jemez Pueblo bnd) is in water quality segment 20.6.4.106.

20.6.4.106 RIO GRANDE BASIN: - The main stem of the Rio Grande from Alameda bridge (Corrales bridge) upstream to the Angostura diversion works, excluding waters on Santa Ana pueblo, and intermittent water in the Jemez river below the Jemez pueblo boundary, excluding waters on Santa Ana and Zia pueblos, that enters the main stem of the Rio Grande. Portions of the Rio Grande in this segment are under the joint jurisdiction of the state and Sandia pueblo.

A. Designated uses: irrigation, marginal warmwater aquatic life, livestock watering, wildlife habitat and primary contact; and public water supply on the Rio Grande.

B. Criteria:
(1) The use-specific numeric criteria set forth in 20.6.4.900 NMAC are applicable to the designated uses.
(2) At mean monthly flows above 100 cfs, the monthly average concentration for: TDS 1,500 mg/L or less, sulfate 500 mg/L or less and chloride 250 mg/L or less. [20.6.4.106 NMAC - Rp 20 NMAC 6.1.2105.1, 10/12/2000; A, 5/23/2005; A, 12/1/2010]

20.6.4.108 RIO GRANDE BASIN: - Perennial reaches of the Jemez river and all its tributaries above Soda dam near the town of Jemez Springs, except San Gregorio lake and Sulphur creek above its confluence with Redondo creek, and perennial reaches of the Guadalupe river and all its tributaries.

A. Designated uses: domestic water supply, fish culture, high quality coldwater aquatic life, irrigation, livestock watering, wildlife habitat and primary contact.

B. Criteria: the use-specific numeric criteria set forth in 20.6.4.900 NMAC are applicable to the designated uses, except that the following segment-specific criteria apply: specific conductance 400 µS/cm or less (800 µS/cm or less on Sulphur creek); the monthly geometric mean of *E. coli* bacteria 126 cfu/100 mL or less, single sample 235 cfu/100 mL or less; and pH within the range of 2.0 to 8.8 on Sulphur creek. [20.6.4.108 NMAC - Rp 20 NMAC 6.1.2106, 10/12/2000; A, 5/23/2005; A, 12/1/2010; A, 7/10/2012] [**NOTE:** The segment covered by this section was divided effective 5/23/2005. The standards for the additional segment are under 20.6.4.124 NMAC. The standards for San Gregorio lake are in 20.6.4.134 NMAC, effective 7/10/2012]

20.6.4.900 NMAC provides criteria applicable to existing, attainable or designated uses unless otherwise specified in an AU's specific segment. 20.6.4.13 NMAC lists general criteria that apply to all surface waters of the state at all times, unless a specified standard is provided elsewhere in the NMAC.

1.3 Antidegradation and TMDLs

New Mexico's antidegradation policy, which is based on the requirements of 40 C.F.R. § 131.12, describes how waters are to be protected from degradation (20.6.4.8.A NMAC). At a minimum, the policy mandates that "the level of water quality necessary to protect the existing uses shall be maintained and protected in all surface waters of the state." Furthermore, the policy's requirements must be met whether or not a segment is impaired. TMDLs are consistent with this policy because implementation of a TMDL restores water quality so that existing uses (defined as the highest quality of water that has been attained since 1975) are protected and water quality criteria are achieved.

The Antidegradation Policy Implementation Procedure establishes the process for implementing the antidegradation policy (Appendix A of NMED/SWQB, 2020). However, certain specific requirements in the Antidegradation Policy Implementation Procedure do not apply to the Water Quality Control Commission's (WQCC) approval of TMDLs because these types of water quality-related actions already are subject to extensive requirements for review and public participation, as well as various limitations on degradation imposed by state and federal law (NMED/SWQB, 2020).

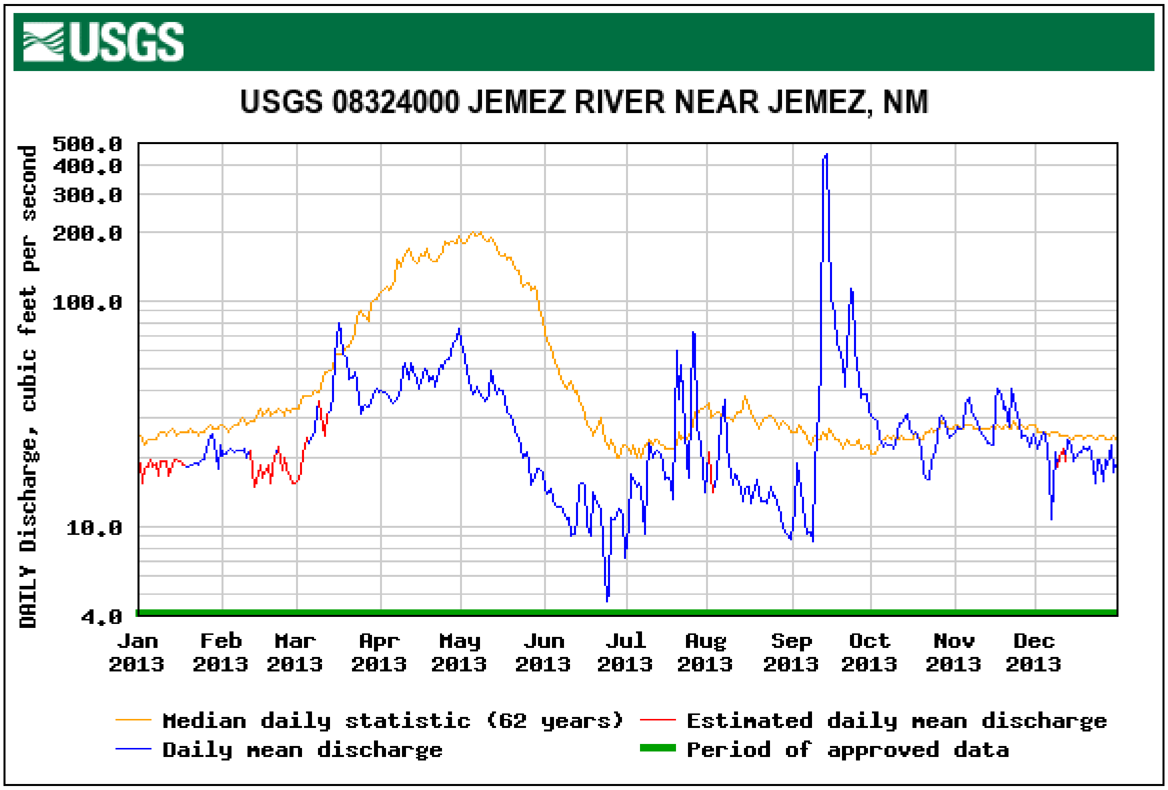
1.4 Water Quality Monitoring Survey

Monitoring of surface waters across the State has traditionally occurred using a rotational watershed approach, meaning a given waterbody is generally surveyed intensively, on average, every eight years. Monitoring occurs during the non-winter months (March through November); focuses on physical, chemical, and biological conditions in perennial waters; and includes sampling for most pollutants that have numeric and/or narrative criteria in the WQS. Each assessment unit is represented by a small number of monitoring stations (often only one). More detailed information about the 2013 survey can be seen in the survey sampling report (NMED/SWQB, 2015b).

The 2013 survey included the Jemez River and tributaries from the headwaters to the boundary of Zia Pueblo and excluding reaches within tribal boundaries. In addition, long-term data were made available to SWQB by the Santa Fe National Forest and the Valles Caldera National Preserve (VCNP). Rivers were divided into AUs based on differing geological and hydrological properties, and each AU was assessed individually using data from one or more monitoring sites located within the AU. Based on a variety of factors, selected monitoring locations were sampled for water quality constituents from 2 to 12 times in 2013, and nutrient and geomorphology data were collected at least once for each perennial AU. Supplemental data were collected in 2014 and 2015. Impaired AUs addressed in this TMDL report are shown on **Figure 1.1** and **Table 1.1**.

1.5 Hydrologic Conditions

All water chemistry and thermograph data on which these TMDLs are based, were collected in the year 2013, except for the turbidity record for Rito de los Indios, which was taken in 2014. In order to characterize streamflow conditions in which the data were collected, discharge records were obtained from USGS gage 08324000 – Jemez River near Jemez, NM (**Figure 1.6**). There are no other active USGS flow gages in the watershed. The discharge data show that flow in the Jemez River during the 2013 water quality survey was lower than the median daily statistic over the 62-year period of record, with the exception of monsoon storm flow during the last half of July, and much higher than normal flow during the month of September. Flow was also lower in 2014 than the mean daily statistic over the period of record, with the exception of storm events in mid-July, and again in late July through early August.



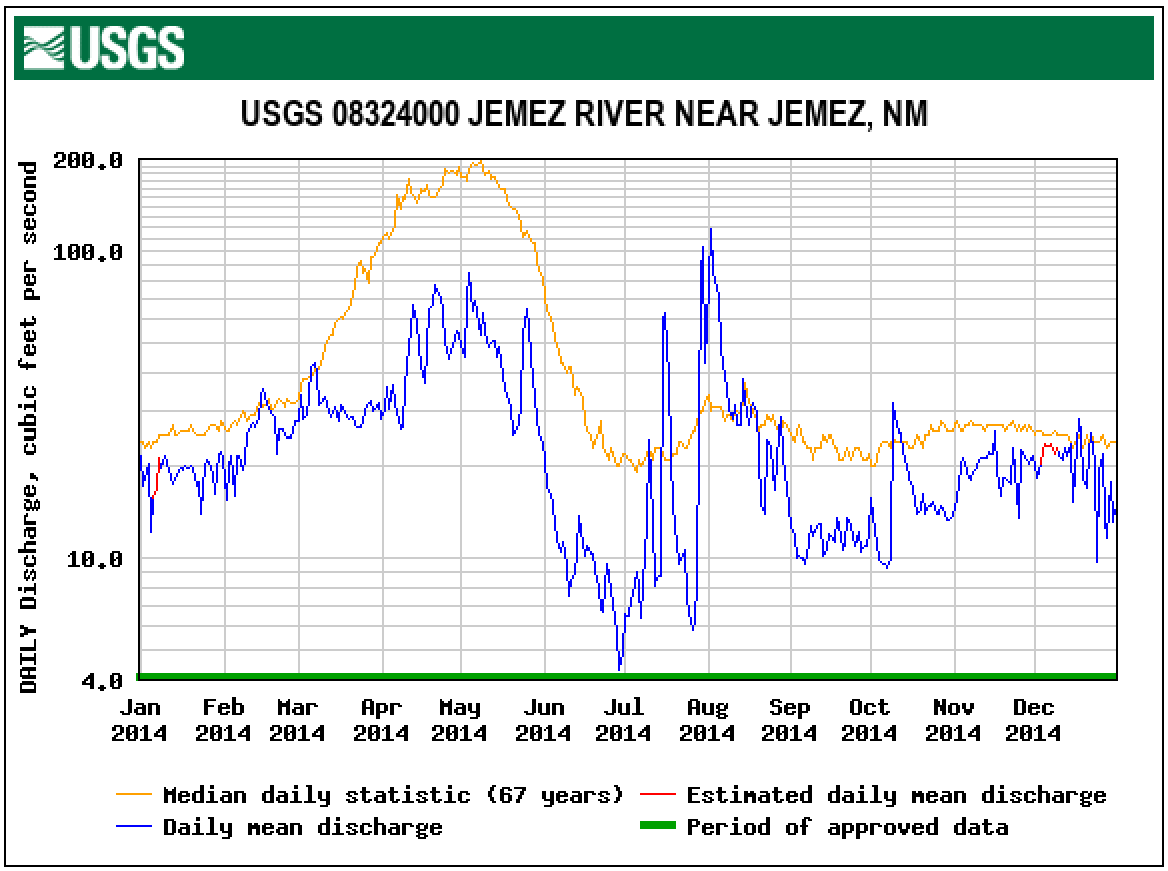


Figure 1.6 Daily discharge on the Jemez River below its confluence with the Rio Guadalupe, 2013 and 2014.

1.6 TMDL Uncertainties

Per EPA guidance (EPA, 2002), TMDLs "should contain documentation supporting the TMDL analysis, including the basis for any assumptions; a discussion of strengths and weaknesses in the analytical process; and results from any water quality modeling." Uncertainties and assumptions in the TMDL process are detailed in the individual Margin of Safety subsections for each TMDL parameter. Uncertainties and assumptions related to the size of the available datasets and/or flow are detailed in the Target Loading Capacity and Flow subsections for each TMDL parameter. When modeling is used to develop a TMDL, water quality modeling results are summarized in the individual TMDL parameter sections and detailed in an appendix to the TMDL. In general, weaknesses in the TMDL analytical process include the limited availability of water quality data during the assessment process, limited flow and habitat measurements for TMDL development, and limited flow and water quality long-term gaging sites to be used during both the assessment and TMDL processes. Strengths in the TMDL analytical process include the robust assessment processes outlined in the Comprehensive Assessment and Listing Methodology (CALM; NMED/SWQB, 2019) especially related to assessments of narrative water quality standards, such as nutrients, sedimentation, and turbidity. Additional strengths include the use of regression equations to calculate TMDLs such as turbidity and specific conductance as well as the collection and subsequent discussion of NPDES permit effluent data as part of the TMDL development process.

2.0 ARSENIC

Arsenic (As) is a metalloid element (one whose properties are intermediate between metals and nonmetals) which is widespread in the environment. Natural levels may be particularly high in soils derived from volcanic activity, and in geothermal waters (ATSDR, 2007; Dunbar et al., 2002; Sharma and Sohn, 2009). Silica rich volcanic rocks such as those in the Jemez Mountains can contain as much as several hundred parts per million (Dunbar et al., 2002). Anthropogenic sources of As release to the environment include mining, coal combustion, wood combustion, waste incineration, and agriculture. Soil on agricultural lands treated with arsenical pesticides may retain substantial amounts of arsenic. Ash from power plants is often incorporated into cement and other materials that are used for roads and construction, and As may be released from such material into the soil (ATSDR, 2007).

In aquatic systems, inorganic As occurs primarily in two oxidation states, As(V) and As(III). Both forms generally co-exist, although As(V) predominates under oxidizing conditions and As(III) predominates under reducing conditions (Kumari et al., 2016; ATSDR, 2007). Much of the As will adsorb to particulate matter and sediment. Arsenic that is adsorbed to iron and manganese oxides may be released under reducing conditions, which often occur in sediment or flooding conditions (ATSDR, 2007). Although inorganic As dominates in both marine and freshwaters, it is biotransformed to methyl and organoarsenic species by aquatic organisms. Both redox potential and pH impose important controls on As speciation in the natural environment (Kumari et al., 2016).

Terrestrial plants growing on land bordering As-contaminated waters show relatively little As content. While As bioaccumulates in animals, it does not appear to biomagnify between trophic levels; the major bioaccumulation transfer is between water and algae (ATSDR, 2007). One study observed no evidence of As uptake or accumulation from water in both rainbow and brown trout (Sharma and Sohn, 2009). Arsenic accumulation in the body of aquatic organisms primarily occurs in various organic forms, with a low percentage accumulated in the more toxic inorganic form. The high toxicity of As(III) results from its greater affinity with the sulfhydryl groups of biomolecules, whereas As(V) does not directly bind to the sulfhydryl group. Toxicity of organic forms of As is associated with the formation of reactive oxygen species (Sharma and Sohn, 2009; Kumari et al., 2016). Arsenic induces hyperglycemia, depletion of enzymatic activities, various acute and chronic toxicity, and immune system dysfunction, adversely affecting various physiological processes such as growth, reproduction, ion regulation, smoltification, gene expression, immune function, enzyme activities, and histopathology of fish (Sharma and Sohn, 2009).

Reported toxicity of As to human health includes skin lesions, cardiovascular disease, hypertension, diabetes, anemia, and cancers of the brain, liver, kidney, and stomach (Dunbar et al., 2002; Kumari et al., 2016). Low levels of As are commonly found in food; the highest levels are found in seafood, meats, and grains. Levels in freshwater fish are approximately two orders of magnitudes lower than those found in ocean fish. Arsenic exposure from drinking water may be elevated when using groundwater from areas where it occurs naturally in the soil (ATSDR, 2007).

2.1 Target Loading Capacity

Of the designated uses assigned to Vallecito Creek (Jemez Pueblo bnd to Div abv Ponderosa), the aquatic life criterion listed for As under human health-organism only (HH-OO) was exceeded. Arsenic criteria for other applicable designated uses were not exceeded. Human health-organism only criteria are intended to protect human health when aquatic organisms are consumed from waters containing pollutants. These criteria do not protect the aquatic life itself; rather, they protect the health of humans who ingest fish or other aquatic organisms. To meet aquatic life designated uses, the SWQB Assessment Protocol (NMED SWQB, 2015a) says that for any one toxic pollutant, there shall be no more than one exceedence of the HH-OO criterion. Exceedences of the WQS were identified by assessment of the data from the 2013 SWQB Jemez basin intensive water quality survey, as shown on **Table 2.1**. Consequently, the AU Vallecito Creek (Jemez Pueblo boundary to diversion above Ponderosa) was listed on the 2016-2018 Integrated CWA §303(d)/§305(b) List (NMED/SWQB, 2016) for arsenic. Results of laboratory analyses of the samples are shown in Appendix A.

Table 2.1 Exceedences of the Dissolved Arsenic Water Quality Standard (HH-OO)

Assessment Unit	WQS (µg/L)	Exceedances
Vallecito Creek (Jemez Pueblo bnd to Div abv Ponderosa)	9	4/4

2.2 Flow

40 C.F.R. § 130.7(c)(1) requires states to calculate a TMDL using critical conditions for stream flow. The TMDL is a value calculated at a defined critical flow condition as part of a planning process designed to achieve water quality standards. For this TMDL, the appropriate critical flow condition is at low flow in order to be protective when the assimilative capacity of a stream is at its lowest. The low flow, or 4Q3, is defined as the 4-day, 3-year low-flow frequency. The 4Q3 is the annual lowest four (4) consecutive day flow that occurs with a frequency of at least once every three (3) years (Waltemeyer 2002).

There is no flow gage on Vallecito Creek which could be used to generate data to calculate critical low flow. Because the diversion structure at Ponderosa diverts essentially the entire flow of the creek, regression equations are not applicable. Therefore, the lowest flow (0.05 cfs) visually estimated during water quality survey monitoring events, was used. The critical flow was converted from cfs to million gallons per day (MGD) using Equation 2.1, for a critical flow of 0.03 MGD.

Equation 2.1

$$\text{Flow (MGD)} = \text{Flow (cfs)} \times 0.646$$

2.3 TMDL Calculations

The TMDL is defined as the mass of pollutant that can be carried under critical flow conditions without violating the target concentration for that constituent. The TMDL is calculated based on simple dilution using critical flow, the numeric target, and a conversion factor to correct the units of measure.

Equation 2.2

$$\text{Critical Flow (MGD)} \times \text{WQS (mg/L)} \times 8.34 = \text{TMDL (lb/day)}$$

A TMDL is presented on **Table 2.2** for the critical low flow condition.

Table 2.2 Calculation of Target Loads for Dissolved Arsenic

Assessment Unit	Chronic criterion (mg/l)	Flow (MGD)	Conversion Factor	TMDL (lbs/day)
Vallecito Creek (Jemez Pueblo bnd to Div abv Ponderosa)	0.009	0.03	8.34	0.0023

The TMDL is a planning tool to be used to achieve water quality standards. Since flows vary throughout the year in these systems the target load will vary based on the changing flow. Management of the load to improve stream water quality and meet water quality criteria is the goal of SWQB actions.

The TMDL is further allocated to a MOS, WLA (permitted point sources), and LA (non-point sources), according to the formula: WLA + LA + MOS = TMDL.

2.4 Margin of Safety

The CWA requires that each TMDL be calculated with a MOS. This statutory requirement that TMDLs incorporate a MOS is intended to account for uncertainty in available data or in the actual effect controls will have on loading reductions and receiving water quality. A MOS may be expressed as unallocated assimilative capacity or conservative analytical assumptions used in establishing the TMDL (e.g., derivation of numeric targets, modeling assumptions or effectiveness of proposed management actions). The MOS may be implicit, utilizing conservative assumptions for calculation of the loading capacity, WLAs, and LAs. The MOS may also be explicitly stated as an added separate quantity in the TMDL calculation. For this arsenic TMDL, the MOS was developed using a combination of conservative assumptions and explicit allocations. Therefore, this MOS is the sum of the following two elements:

- *Implicit Margin of Safety*
  Treating arsenic as a conservative pollutant, meaning a pollutant that does not readily degrade in the environment, was used as a conservative assumption in developing these loading limits.

- *Explicit Margin of Safety*
  An explicit MOS of 15% was assigned to the arsenic impaired AU, to account for the inherent error in visual estimation of streamflow.

2.5 Waste Load Allocation

There are no active National Pollutant Discharge Elimination System (NPDES) permits that discharge to Vallecito Creek (Jemez Pueblo bnd to Div abv Ponderosa), therefore the WLA for this TMDL is zero.

Stormwater discharges from construction activities are transient because they occur mainly during the construction itself, and then only during storm events. Coverage under the USEPA NPDES Construction General Permit (CGP) for construction sites of one or more acres, or smaller if part of a common plan of development, 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 and/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.

Stormwater discharges from industrial activities and facilities, based on industrial classification codes, may be eligible for coverage under the current NPDES Multi-Sector General Permit (MSGP). The MSGP also requires preparation of a SWPPP. Some of the industrial facilities and activities covered under the MSGP have technology based effluent limitation and/or benchmark monitoring for pollutants. The current MSGP includes state-specific requirements that the benchmark values be protective of State of New Mexico WQS.

It is not possible to calculate individual WLAs for facilities covered by the General Permits at this time using the available tools. The discharges from these permits are typically transitory as the activities are temporary. Loads that are in compliance with the General Permits are therefore currently included as part of the Load Allocation (LA). While these sources are not given individual allocations, they are addressed through other means, including BMPs, stormwater pollution prevention conditions, and other requirements.

2.6 Load Allocation

Load Allocation (LA) is pollution from any non-point source(s) or natural background and is addressed through Best Management Practices. Since there are no WLAs for these AUs, the LA is equal to the TMDL value minus the MOS, as shown on **Table 2.3**. The MOS was developed using a combination of conservative assumptions and explicit recognition of potential errors (see Section 2.4 for details).

Table 2.3 TMDL Allocations for Dissolved Arsenic

Assessment Unit	WLA (lbs/day)	MOS (lbs/day)	LA (lbs/day)	TMDL (lbs/day)
Vallecito Ck (Jemez Pueblo bnd to Div abv Ponderosa)	0	0.0003	0.0020	0.0023

The extensive data collection and analyses necessary to determine background arsenic loads were beyond the resources available for this study. It is therefore assumed that a portion of the load allocation is made up of natural background levels. The load reduction that would be needed in order to achieve the target loading is the difference between the average measured load and the target load, divided by the measured load. Results are shown on **Table 2.4.**

Table 2.4 Load Reduction Estimate to meet WQS for Dissolved Arsenic

Assessment Unit	Target Load[a] (lbs/day)	Measured Load[b] (lbs/day)	Load Reduction[c]
Vallecito Ck (Jemez Pueblo bnd to Div abv Ponderosa)	0.0020	0.0046	43.5%

(a) *Target Load = TMDL – MOS. 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.*

(b) *The measured load is the magnitude of point and nonpoint sources. It is calculated using mean measured concentration values (Appendix A), at the critical flow for comparison with the target load.*

(c) *Load reduction is the percent by which 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.*

2.7 Identification and Description of Pollutant Sources

SWQB fieldwork includes an assessment of the probable sources of impairment in the AU drainage area (Appendix B). Probable Source Sheets are filled out by SWQB staff during watershed surveys and watershed restoration activities. The list of probable sources is not intended to single out any particular land owner or land management activity and generally includes several sources per pollutant. **Table 2.5** displays probable pollutant sources that have the potential to contribute to As impairment within the Vallecito Creek (Jemez Pueblo bnd to Div abv Ponderosa) AU, as determined by field reconnaissance and knowledge of watershed activities. The draft probable source list will be reviewed and modified as necessary, with stakeholder input during the TMDL public meeting and comment period. Probable sources of impairment will be further evaluated, refined, and changed as necessary through the Watershed-Based Plan (WBP).

Table 2.5 Probable source summary for dissolved arsenic

Assessment Unit	Probable Sources
Vallecito Creek (Jemez Pueblo bnd to Div abv Ponderosa)	Crop production (dry land); Crop production (Irrigated); Dam or impoundment; Highway/Road/Bridge runoff; Residential area; Water diversions

Surface mining operations can impact stream water arsenic loading by increasing the delivery of sediment load. The two pumice mines near the headwaters of Vallecito Creek (**Figure 1.5**) are Copar South Pit (closed, reclamation complete, as of 2021) and a US Forest Service mine (closed, reclamation unknown). The mining operation adjacent to the Vallecito Creek (Jemez Pueblo bnd to Div abv Ponderosa) AU (**Figure 1.5**) is the Shopyard Plant mill (closed, reclamation unknown).

Wildfires can affect the physical, chemical, and biological quality of streams, rivers, and lakes. After a fire, increased runoff provides the pathway for the transport of chemical-laden sediment to surface water, which may have substantial water quality impacts. Potential wildfire impacts to water quality are discussed on the SWQB website at https://www.env.nm.gov/surface-water-quality/wildfire-impacts-on-surface-water-quality/. The 2014 Pino Fire occurred in the headwaters area of Vallecito Creek (**Figure 1.5**), subsequent to the 2013 water quality survey.

Figure 2.1 Pond and diversion structure above Ponderosa on Vallecito Creek. (Photo: SWQB staff, 8/30/2019)

Several other AUs in the Jemez basin are also listed as impaired for dissolved As (NMED/SWQB, 2009a), based on a survey conducted in 2005. Arsenic occurs naturally in groundwater of the Jemez River watershed. Data from a 2005 SWQB survey confirmed that hot spring waters in the basin contain substantial concentrations of As. Each AU in the 2009 Jemez TMDL document that is impaired for As also has at least one known warm or hot spring discharging into its waters, strongly suggesting that warm/hot springs are substantial sources of As in the Jemez watershed water bodies. However, Vallecito Creek does not have any known warm or hot spring discharge to its waters and is classified as intermittent below the Ponderosa diversion. Most dissolved As probably ultimately originates from regional geology and enters the stream in the form of fine sediment via overland flow, although there may be some direct input of groundwater. Vallecito Creek above the diversion is not impaired for As. It is possible that some dissolution of As occurs in the reducing conditions of the sediment layer in the large pond above the diversion structure, and its associated wetlands.

2.8 Consideration of Seasonal Variation

Arsenic exceedances were documented in Vallecito Creek below the Ponderosa diversion during all sampling events throughout the monitoring season (May through September), with no evidence of a seasonal trend in concentrations.

2.9 Future Growth

Growth estimates by county and Water Planning Region (WPR) are available from the New Mexico Bureau of Business and Economic Research (BBER, 2008). These estimates project growth to the year 2060. Vallecito Creek falls within the Middle Rio Grande WPR, which includes the Albuquerque metropolitan area. Approximately 14% of the Middle Rio Grande WPR population lives in Sandoval County. BBER projects continuing growth for the Sandoval County portion of the Middle Rio Grande WPR, although the rate of growth will slow, as detailed on **Table 2.6**.

Table 2.6 TMDL study area Water Planning Region population projections

WPR	2020	2030	2040	2050	2060	% Increase (2020-2060)
Middle Rio Grande (Sandoval County portion)	161,078	198,168	230,993	261,951	292,367	81.5

Estimates of future growth are not anticipated to lead to a significant increase in arsenic that cannot be controlled with BMP implementation. BMPs should be utilized and improved upon while continuing to improve watershed conditions and adhering to SWPPP requirements related to construction and industrial activities covered under the general permit.

3.0 SPECIFIC CONDUCTANCE

Conductivity is measured by SWQB in microSiemens per centimeter (µS/cm). The conductivity of rivers in the United States generally ranges from 50 to 1500 µmhos/cm (an equivalent unit of measure). Studies of inland fresh waters indicate that streams supporting good mixed fisheries have a range between 150 and 500 µS/cm. Conductivity outside this range could indicate that the water is not suitable for certain species of fish or macroinvertebrates (Behar, 1997). Conductivity is influenced by water temperature, increasing as temperatures rise. Specific conductance (SC) is conductivity corrected to 25°C.

The electrical conductivity of water is directly related to the concentration of dissolved solids in the water because total dissolved solids (TDS) concentrations are equal to the sum of positively charged ions (cations) and negatively charged ions (anions) in the water. These electrically charged dissolved particles make ordinary natural water a good conductor of electricity. Conversely, pure water has a high electrical resistance, and resistance is frequently used as a measure of its purity.

TDS refers to the total amount of all inorganic and organic substances – including minerals, salts, metals, anions, and cations – that are dissolved within a volume of water. Higher concentrations of TDS may occur during and after precipitation events. In the United States, elevated TDS is often due to natural environmental features such as mineral springs, carbonate deposits, salt deposits, and silt, the decomposition of leaves and plankton, and the weathering erosion of rocks. Other sources may include stormwater and agricultural runoff, mining operations, industrial wastewater, and sewage.

3.1 Target Loading Capacity

The NM Water Quality Control Commission has adopted numeric water quality criteria for specific conductance (SC) to protect the designated use of High Quality Coldwater Aquatic Life (HQCWAL). The HQCWAL use designation requires that a stream have water quality, streambed characteristics, and other attributes of habitat sufficient to protect and maintain HQCWAL. For this TMDL document, target values for SC are based on the reduction in TDS necessary to achieve numeric SC criteria.

Table 3.1 Exceedences of the Specific Conductance Water Quality Standard

Assessment Unit	WQS (µS/cm)	Exceedances
Rio Guadalupe (Jemez River to confl with Rio Cebolla)	400	3/13

During the 2013 SWQB intensive water quality survey, three exceedences of the NM water quality criterion for SC were documented in the Rio Guadalupe (Jemez River to confl with Rio Cebolla). The segment-specific SC criterion in 20.6.4.108 NMAC for this AU is 400 µS/cm or less.

3.2 Flow

40 C.F.R. § 130.7(c)(1) requires states to calculate a TMDL using critical conditions for stream flow. The TMDL is a value calculated at a defined critical flow condition as part of a planning process designed to achieve water quality standards. For this TMDL, the appropriate critical flow condition is at low flow in order to be protective when the assimilative capacity of a stream is at its lowest. The low flow, or 4Q3, is defined as the 4-day, 3-year low-flow

frequency. The 4Q3 is the annual lowest four (4) consecutive day flow that occurs with a frequency of at least once every three (3) years (Waltemeyer 2002).

SC in a stream can vary as a function of flow. As flow decreases, TDS can increase, thereby increasing the SC. It is often necessary to estimate critical flow for a portion of a watershed where there is no active flow gage. 4Q3 derivations for ungaged streams were based on analysis methods described by Waltemeyer (2002). In this analysis, two regression equations for estimating 4Q3 were developed based on physiographic regions of NM (i.e., statewide and mountainous regions above 7500 feet in elevation). The 4Q3 was estimated using the regression equation for mountainous regions because the mean elevation for this AU is above 7500 feet in elevation (Table 4.1). The following regression equation for mountainous regions above 7500 feet in elevation is based on data from 40 gaging stations with non-zero discharge (Waltemeyer 2002):

Equation 3.1

$$4Q3 \quad = \quad 7.3287 \times 10^{-5} \ DA^{0.70} \ P_w^{\ 3.58} \ S^{1.35}$$

where,

DA = Drainage area (mi^2)
P_w = Average basin precipitation Oct-Apr (inches)
S = Average basin slope (ft/ft)

Variables for input to the Waltemeyer equation were obtained using the USGS StreamStats web tool (https://streamstats.usgs.gov/ss/). The 4Q3 value was converted from cubic feet per second (cfs) to units of million gallons per day (mgd) using the conversion factor 0.64.

Table 3.2 Calculation of 4Q3 for the Rio Guadalupe (Jemez River to confl with Rio Cebolla) AU

Average Elevation (ft.)	Drainage Area (mi^2)	Mean winter precipitation (in)	Average basin slope (ft/ft)	4Q3 (cfs)	4Q3 (mgd)
8410	267	13.6	0.23	5.75	3.71

The TMDL itself is a value calculated at a defined critical condition, 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 and achieve WQS is the goal of SWQB efforts.

3.3 TMDL Calculations

In order to calculate a load in pounds per day (lbs/day), TDS is used as a surrogate for SC. The TDS to SC ratio ranges from 0.5 to 0.9 mg/L: µS/cm (American Public Health Association, 1998). Specific correlation should be derived by site, if TDS values are available. TDS and SC data from the 2013 SWQB sampling season can be found in Appendix A. Data was collected from two stations in the AU, 31RGuada000.1 and 31RGuada010.0. All of the exceedences occurred at 31RGuada000.1, and the range of TDS:SC ratios did not overlap between the stations. Therefore only data from 31RGuada000.1 was used for calculation of the TMDL and measured load.

The TDS to SC ratio average value was 0.567. The WQS to protect the designated HQCWAL use states that SC shall not exceed 400 µmhos/cm. The TDS concentration required to achieve State WQS is defined by **Equation 3-2.**

$$TDS (mg/L) \cong SC (\mu S/cm) \times (ratio)$$

Using the site-specific ratio and an SC value of 400 µS/cm /cm, the TDS concentration required to achieve the WQS is:

$$400 \mu S/cm \times 0.567 = 226.8 mg/L TDS$$

The TMDL for TDS is calculated based on the 4Q3 flow, the applicable WQS, and a conversion factor of 8.34, that is used to convert the TMDL to pounds per day (lbs/day) units.

Equation 3.3

$$\text{Critical Flow (mgd)} \times \text{WQS (mg/L)} \times 8.34 = \text{TMDL (lb/day)}$$

Table 3.3 Calculation of TMDL for TDS (as SC surrogate) for the Rio Guadalupe (Jemez River to confl with Rio Cebolla)

4Q3 Flow (mgd)	TDS Standard (mg/L)	Conversion Factor	TMDL (lbs/day)
3.71	226.8	8.34	7017.5

The TMDL is further allocated to a MOS, WLA (permitted point sources), and LA (non-point sources), according to the formula: WLA + LA + MOS = TMDL.

3.4 Margin of Safety (MOS)

The CWA requires that each TMDL be calculated with a MOS. This statutory requirement that TMDLs incorporate a MOS is intended to account for uncertainty in available data or in the actual effect controls will have on loading reductions and receiving water quality. A MOS may be expressed as unallocated assimilative capacity or conservative analytical assumptions used in establishing the TMDL (e.g., derivation of numeric targets, modeling assumptions or effectiveness of proposed management actions). The MOS may be implicit, utilizing conservative assumptions for calculation of the loading capacity, WLAs, and LAs. The MOS may also be explicitly stated as an added separate quantity in the TMDL calculation. For this TDS (as SC surrogate) TMDL, the MOS was developed using a combination of conservative assumptions and explicit allocations. Therefore, this MOS is the sum of the following two elements:

- *Implicit Margin of Safety*
  Treating TDS as a conservative pollutant, meaning a pollutant that does not readily degrade in the environment, was used as a conservative assumption in developing these loading limits.

- *Explicit Margin of Safety*
  An explicit MOS of 10% was assigned to the SC impaired AU, to account for the inherent error in estimation of streamflow.

3.5 Waste Load Allocation

There are no active point source dischargers on this AU. Neither are there any Municipal Separate Storm Sewer System (MS4) storm water permits. Therefore, the WLA for this TMDL is zero. However, TDS may be a component of some (primarily construction) storm water discharges so these discharges should be addressed.

Stormwater discharges from construction activities are transient because they occur mainly during the construction itself, and then only during storm events. Coverage under the USEPA NPDES Construction General Permit (CGP) for construction sites of one or more acres, or smaller if part of a common plan of development, 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 and/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.

Stormwater discharges from industrial activities and facilities, based on industrial classification codes, may be eligible for coverage under the current NPDES Multi-Sector General Permit (MSGP). The MSGP also requires preparation of a SWPPP. Some of the industrial facilities and activities covered under the MSGP have technology based effluent limitation and/or benchmark monitoring for pollutants. The current MSGP includes state-specific requirements that the benchmark values be protective of State of New Mexico WQS.

It is not possible to calculate individual WLAs for facilities covered by the General Permits at this time using the available tools. The discharges from these permits are typically transitory as the activities are temporary. Loads that are in compliance with the General Permits are therefore currently included as part of the Load Allocation (LA). While these sources are not given individual allocations, they are addressed through other means, including BMPs, stormwater pollution prevention conditions, and other requirements.

3.6 Load Allocation

Load Allocation (LA) is pollution from any non-point source(s) or natural background and is addressed through Best Management Practices. Since there are no WLAs for these AUs, the LA is equal to the TMDL value minus the MOS, as shown on **Table 3.4**. The MOS was developed using a combination of conservative assumptions and explicit recognition of potential errors (see Section 3.4 for details).

Table 3.4 Load Allocation of TMDL for TDS (as SC Surrogate) for the Rio Guadalupe (Jemez River to confl with Rio Cebolla)

WLA (lbs/day)	LA (lbs/day)	MOS (lbs/day)	TMDL (lbs/day)
0	6315.7	701.8	7017.5

The extensive data collection and analyses necessary to determine natural background TDS loads were beyond the resources available for this study. It is therefore assumed that a portion of the load allocation is made up of natural background levels. The load reduction that would be needed in order to achieve the target loading is the difference between the average measured load and the target load, divided by the measured load. Results are presented in **Table 3.5**.

Table 3.5 Load Reduction Estimate to meet WQS for TDS (as SC surrogate)

Assessment Unit	Target Load [(a)] (lbs/day)	Measured Load [(b)] (lbs/day)	Load Reduction [(c)]
Rio Guadalupe (Jemez River to confl with Rio Cebolla)	6315.7	7735.4	18.4%

(a) *Target Load = TMDL – MOS. 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.*
(b) *The measured load is the magnitude of point and nonpoint sources. It is calculated using mean measured concentration values (Appendix A), at the critical flow for comparison with the target load.*
(c) *Load reduction is the percent by which 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.*

3.7 Identification and Description of Pollutant Source(s)

SWQB fieldwork includes an assessment of the probable sources of impairment in the AU drainage area (Appendix B). Probable Source Sheets are filled out by SWQB staff during watershed surveys and watershed restoration activities. The list of probable sources is not intended to single out any particular land owner or land management activity and generally includes several sources per pollutant. **Table 3.6** displays probable pollutant sources that have the potential to contribute to sedimentation impairment within each AU in the TMDL study area, as determined by field reconnaissance and knowledge of watershed 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 of impairment will be further evaluated, refined, and changed as necessary through the Watershed-Based Plan (WBP).

Table 3.6 Pollutant Source Summary

Assessment Unit	Probable Sources
Rio Guadalupe (Jemez River to confl with Rio Cebolla)	Crop production (irrigated); Forest fire; Highway/Road/Bridge runoff; Impervious surface runoff; Other recreation (fishing); On-site treatment systems; Rangeland grazing; Residential area

All of the exceedences occurred at low flows (**Figure 3.1**). As previously noted, there were no exceedances of the SC standard at the monitoring station 10 kilometers upstream. The range of ratios of SC to TDS also did not overlap between the two stations. Hence it seems likely that some intervening factor, such as a change in soil type, land use, or a contribution from Virgin Canyon, caused a change in the water chemistry. Conductivity in streams and rivers is affected primarily by the geology of the area through which the water flows. Streams that run through areas with granite bedrock tend to have lower conductivity because granite is composed of more inert materials that do not dissolve into ionic components when washed into the water. On the other hand, streams that run through areas with clay soils tend to have higher conductivity because of the presence of materials that ionize when washed into the water. Groundwater inflows can have the same effects depending on the bedrock they flow through. In addition, discharges to streams can change the conductivity depending on their make-up. For example, a failing sewage system would raise the conductivity because of the presence of chloride, phosphate, and nitrate.

Wildfires can affect the physical, chemical, and biological quality of streams, rivers, and lakes. After a fire, increased runoff provides the pathway for the transport of chemical-laden sediment to surface water, which may have substantial water quality impacts. Potential wildfire impacts to water quality are discussed on the SWQB website at https://www.env.nm.gov/surface-water-quality/wildfire-impacts-on-surface-water-quality/. There were large wildfires in the tributary headwaters of the Rio Guadalupe (Jemez River to confl with Rio Cebolla) AU in 2002, 2003 and 2010. Since the 2013 water quality survey, there have been large fires in the upland areas of this AU in 2017 and 2018 (**Figure 1.5**).

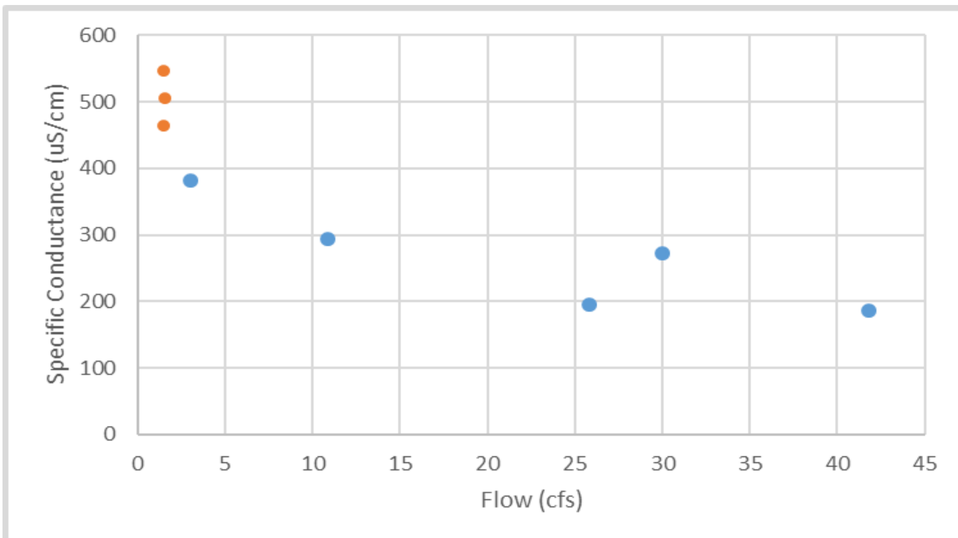


Figure 3.1 Specific Conductance at various flows at water quality station 31RGuada000.1 during the 2013 SWQB survey. Exceedences of the 400 µS/cm WQS are shown in orange.

3.8 Consideration of Seasonal Variation

Data used in the calculation of this TMDL were collected during high and low flow seasons in order to ensure coverage of any potential seasonal variation in the system. Exceedences were observed in June and July of 2013, and also probably occurred in August, based on the TDS measurement (SC was not directly measured during the August sampling event). These months coincided with the lowest observed flow values.

3.9 Future Growth

Growth estimates by county and Water Planning Region (WPR) are available from the New Mexico Bureau of Business and Economic Research (BBER, 2008). These estimates project growth to the year 2060. The Rio Guadalupe falls within the Middle Rio Grande WPR, which includes the Albuquerque metropolitan area. Approximately 14% of the Middle Rio Grande WPR population resides in Sandoval County. BBER projects continuing growth for the Sandoval County portion of the Middle Rio Grande WPR, although the rate of growth will slow, as detailed on **Table 3.7**.

Table 3.7 TMDL study area Water Planning Region population projections

WPR	2020	2030	2040	2050	2060	% Increase (2020-2060)
Middle Rio Grande (Sandoval County portion)	161,078	198,168	230,993	261,951	292,367	81.5

Estimates of future growth are not anticipated to lead to a significant increase in specific conductance that cannot be controlled with BMP implementation. BMPs should be utilized and improved upon while continuing to improve watershed conditions and adhering to SWPPP requirements related to construction and industrial activities covered under the general permit.

4.0 TEMPERATURE

Water temperature influences the metabolism, behavior, and mortality of fish and other aquatic organisms. Natural temperatures of a water body fluctuate daily and seasonally. These natural fluctuations do not eliminate indigenous populations, but may affect existing community structure and geographical distribution of species. Anthropogenic impacts such as thermal pollution, deforestation, flow modification and climate change can modify these natural temperature cycles, often leading to deleterious impacts on aquatic life communities. Such modifications may contribute to changes in geographical distribution of species and their ability to persist in the presence of additional stressors such as introduced species. One mechanism by which temperature affects fish is that warmer water has a lower capacity for dissolved oxygen. Water temperature within the stream substrate can influence the growth of aquatic insects and fish eggs. In addition to direct effects, the toxicity of many chemical contaminants increases with temperature (Caissie, 2006).

Temperature criteria for aquatic life uses in New Mexico are shown on **Table 4.1**. New Mexico's aquatic life temperature criteria are expressed as 4T3, 6T3 and T_{MAX}. T_{MAX} is the maximum recorded temperature, 4T3 means the temperature not to be exceeded for four or more consecutive hours in a 24-hour period on more than three consecutive days, and 6T3 means the temperature not to be exceeded for six or more consecutive hours in a 24-hour period on more than three consecutive days.

Table 4.1 Aquatic Life Use Water Quality Criteria for Temperature (°C), as defined at 20.4.6.900 NMAC

Criterion	*High Quality Coldwater*	*Coldwater*	*Marginal Coldwater*	*Coolwater*	*Warmwater*	*Marginal Warmwater*
4T3	20	---	---	---	---	---
6T3	---	20	25	---	---	---
T_{MAX}	23	24	29	29	32.2	32.2

Fish and other aquatic organisms have specific ranges of temperature tolerance and preference. Cold water fish such as salmonids (salmon and trout) are especially vulnerable to increased water temperature. For that reason, coldwater criteria are typically established primarily to support reproducing populations of salmonids throughout the entire year. A coolwater aquatic life use (ALU) was approved by the WQCC in October 2010, to support aquatic life whose physiologic tolerances are intermediate between those of warm and coldwater aquatic life (NMED/SWQB, 2009b). Acute temperature criteria (such as New Mexico's T_{MAX}) are intended to protect aquatic life from acute lethal exposures, whereas chronic criteria (the 4T3 or 6T3) protect from sub-lethal exposures sufficient to cause long-term detrimental effects (Todd et al., 2008). The acute and chronic criteria are established to protect the most sensitive members of fish communities, based on laboratory studies of the upper thermal limits of individual species.

4.1 Target Loading Capacity

Assessment of the Jemez watershed thermograph data determined that three of the AUs exceeded the T_{MAX} for their designated Aquatic Life Use (ALU). There was no exceedance of the 4T3 chronic temperature criterion in either Clear Creek or the Rito de los Indios. For this TMDL document, target values for temperature are based on the reduction in thermal loading necessary to achieve numeric criteria.

Table 4.2 Jemez temperature impaired AUs

AU Name	AU ID	Designated ALU	T_{MAX} Criterion (°C)	Date of Measured T_{MAX}	Measured T_{MAX} (°C)
Clear Creek (Rio de las Vacas to San Gregorio Lake)	NM-2106.A_54	High Quality Coldwater	23	8/5/13	23.16
Jemez River (Zia Pueblo bnd to Jemez Pueblo bnd)	NM-2105_75	Marginal Warmwater*	32.2	7/8/13	36.25
Rito de los Indios (San Antonio Creek to headwaters)	NM-2106.A_24	High Quality Coldwater	23	6/26/13	24.63

***** "Marginal warmwater" in reference to an aquatic life use means natural intermittent or low flow or other natural habitat conditions severely limit the ability of the surface water of the state to sustain a natural aquatic life population on a continuous annual basis; or historical data indicate that natural water temperature routinely exceeds 32.2°C (90°F) (20.4.6.7 NMAC).

4.2 Flow

40 C.F.R. § 130.7(c)(1) requires states to calculate a TMDL using critical conditions for stream flow. The TMDL is a value calculated at a defined critical flow condition as part of a planning process designed to achieve water quality standards. For this TMDL, the appropriate critical flow condition is at low flow in order to be protective when the assimilative capacity of a stream is at its lowest. The low flow, or 4Q3, is defined as the 4-day, 3-year low-flow frequency. The 4Q3 is the annual lowest four (4) consecutive day flow that occurs with a frequency of at least once every three (3) years (Waltemeyer 2002).

When available, USGS gages are used to estimate flow. Where continuous gage data is not available, the 4Q3 flows were obtained using a 4-day, 3-year low-flow frequency (4Q3) regression model developed 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 7500 ft in elevation).

Table 4.3 4Q3 flow values for Jemez temperature TMDLs

Assessment Unit	Average Elevation (ft)	Drainage Area (mi^2)	Mean Winter Precipitation (in)	Average Basin Slope (ft/ft)	4Q3 (cfs)
Jemez River (Zia Pueblo bnd to Jemez Pueblo bnd)	8160	596	11.4	0.23	5.37
Rito de los Indios (San Antonio Creek to headwaters)	9570	7.32	14.8	0.29	0.86

Waltemeyer's equation for mountainous regions above 7500 feet is:

Equation 4.1

$$4Q3 = 7.3287 \times 10^{-5} \times DA^{0.70} \times P_w^{3.58} \times S^{1.35}$$

Where:

4Q3 = Four-day, three-year low-flow frequency (cfs)

DA = Drainage area (mi^2)
Pw = Average basin precipitation Oct-Apr (inches)
S = Average basin slope (ft/ft)

Variables for input to the Waltemeyer equation were obtained using the USGS StreamStats web tool (https://streamstats.usgs.gov/ss/).

Critical flow for the Rito de los Indios estimated by the Waltemeyer regression analysis is 0.86 cfs.

To obtain critical flow for the Jemez River (Zia Pueblo bnd to Jemez Pueblo bnd), 4Q3 estimated using the Waltemeyer regression (5.37 cfs) was added to the published 0.88 cfs flow from Soda Springs and associated spring features around the village of Jemez Springs (Reid, 2003), and the permitted design flow for the two point sources discharging to the Jemez River. Those sources are Village of Jemez Springs Wastewater Treatment Plant - NM0028011 (0.12 cfs) and Jemez Valley Public Schools - NM0028479 (.016 cfs). The critical flow for this AU totals 6.53 cfs. This value is likely to be an overestimate of actual low flows, since it does not account for irrigation withdrawals from the Jemez River above the monitoring station.

Flow through the Clear Creek (Rio de las Vacas to San Gregorio Lake) AU is controlled by the dam on San Gregorio Lake, therefore use of a regression equation to estimate critical flow is not appropriate. Instead, the lowest flow value observed during the water quality survey was used. That value is 0.1 cfs, observed by visual estimation on August 21 and August 28 of 2013.

It is important to remember that the TMDL is a value calculated at a defined critical condition as part of a 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 is the goal of SWQB efforts.

4.3 TMDL Calculations

The calculation of a TMDL is governed by the basic equation,

WQS criterion x flow x conversion factor = TMDL

For temperature TMDLs, the WQS criterion is a temperature specified either by the designated ALU or site-specific criteria and can be either a maximum temperature or time-duration temperature such as the 4T3 or 6T3. The conversion factor is a variable needed to convert units used by SWQB for temperature (in Celsius) and flow (in cfs) to units needed to balance the thermal energy equation. Substituting the appropriate unit conversion factors, the equation used for temperature is the following:

Equation 4.2

$$WQS\ (^{o}C)\ x\ Flow\ (cfs)\ x\ 1.023^{7} = TMDL\ (kJ/day)$$

Details of the derivation of the TMDL equation are presented in Appendix C. **Table 4.4** shows the TMDL calculation variables for each impaired AU.

Table 4.4 Temperature TMDL calculations based on WQS T_{MAX}

Assessment Unit Name	WQS T_{MAX} (°C)	4Q3 critical flow (cfs)	Conversion factor	TMDL (kJ/day)
Clear Creek (Rio de las Vacas to San Gregorio Lake)	23	0.1	1.023×10^7	1.41×10^7
Jemez River (Zia Pueblo bnd to Jemez Pueblo bnd)	32.2	6.39	1.023×10^7	1.36×10^9
Rito de los Indios (San Antonio Creek to headwaters)	23	0.86	1.023×10^7	1.32×10^8

The TMDL is further allocated to a MOS, WLA (permitted point sources), and LA (non-point sources), according to the formula: WLA + LA + MOS = TMDL.

4.4 Margin of Safety (MOS)

The CWA requires that each TMDL be calculated with a MOS, intended to account for uncertainty in available data or in the actual effect controls will have on loading reductions and receiving water quality. A MOS may be expressed as unallocated assimilative capacity or conservative analytical assumptions used in establishing the TMDL (e.g., derivation of numeric targets, modeling assumptions or effectiveness of proposed management actions). The MOS may be implicit, utilizing conservative assumptions for calculation of the loading capacity, WLAs, and LAs. The MOS may also be explicitly stated as an added separate quantity in the TMDL calculation.

Because of the uncertainty in estimating critical low flow using the regression equation, **an explicit MOS of 10% is assigned** to this TMDL for the Jemez River and Rito de los Indios. Because of the uncertainty in estimating critical low flow using visual estimation, **a 15% MOS is assigned** to the TMDL for Clear Creek.

4.5 Waste Load Allocation

There are no National Pollutant Discharge Elimination System (NPDES) individual permits that discharge to the Clear Creek or Rito de los Indios Assessment units, therefore the WLAs for these TMDLs are zero.

The Village of Jemez Springs Wastewater Treatment Plant (NM0028011) discharges to the Jemez River (Rio Guadalupe to Soda Dam near Jemez Springs) AU and the Jemez Valley Public Schools (NM0028479) discharges to the Jemez River (Jemez Pueblo boundary to Rio Guadalupe) AU. Neither permit includes limitations or monitoring requirements for temperature. Both AUs receiving direct discharge are temperature-impaired relative to a WQS T_{MAX} of 25 °C (20.6.4.107 NMAC). Both permitted facilities discharge upstream of Jemez Pueblo. The AU Jemez River (Zia Pueblo bnd to Jemez Pueblo bnd), subject of the current temperature TMDL, is located immediately downstream of the Pueblo boundary.

Water temperature at the outfall of Permit NM0028011, as measured by SWQB during 2013, ranged from 15.01-26.4 °C (mean = 19.8°C). Water temperature at the outfall of Permit NM0028479, as measured by SWQB during 2013, ranged from 15.2-21.8 °C (mean = 18.5°C). No measurement exceeded the WQS T_{MAX} standard for Jemez River (Zia Pueblo bnd to Jemez Pueblo bnd). If both permitted facilities were operating at permitted design flow on July 8, 2013, the day the T_{MAX} was recorded in the river, their combined flow (0.131 cfs) would equal only 1.4% of the flow recorded that day at USGS gage 08324000 – Jemez River near Jemez, NM (9.27 cfs), which is located approximately ½ mile from the Permit NM0028479 outfall. The weight of evidence indicates no impact on river water temperature from the permitted facilities, therefore the WLA for this reach is zero.

Stormwater discharges from construction activities are transient because they occur mainly during the construction itself, and then only during storm events. Coverage under the USEPA NPDES Construction General Permit (CGP) for construction sites of one or more acres, or smaller if part of a common plan of development, 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 and/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.

Stormwater discharges from industrial activities and facilities, based on industrial classification codes, may be eligible for coverage under the current NPDES Multi-Sector General Permit (MSGP). The MSGP also requires preparation of a SWPPP. Some of the industrial facilities and activities covered under the MSGP have technology based effluent limitation and/or benchmark monitoring for pollutants. The current MSGP includes state-specific requirements that the benchmark values be protective of State of New Mexico WQS.

It is not possible to calculate individual WLAs for facilities covered by the General Permits at this time using the available tools. The discharges from these permits are typically transitory as the activities are temporary. Loads that are in compliance with the General Permits are therefore currently included as part of the Load Allocation (LA). While these sources are not given individual allocations, they are addressed through other means, including BMPs, stormwater pollution prevention conditions, and other requirements.

4.6 Load Allocation

Load Allocation (LA) is pollution from any non-point source(s) or natural background and is addressed through Best Management Practices. Since there are no WLAs for these AUs, the LA is equal to the TMDL value minus the MOS, as shown on **Table 4.5**. The MOS was developed using a combination of conservative assumptions and explicit recognition of potential errors (see Section 4.4 for details).

Table 4.5 Temperature TMDL allocation summary. Units are kilojoules per day.

Assessment Unit	MOS	WLA	LA	TMDL
Clear Creek (Rio de las Vacas to San Gregorio Lake)	2.12×10^6	0	1.20×10^7	1.41×10^7
Jemez River (Zia Pueblo bnd to Jemez Pueblo bnd)	1.36×10^8	0	1.22×10^9	1.36×10^9
Rito de los Indios (San Antonio Creek to headwaters)	1.32×10^7	0	1.19×10^8	1.32×10^8

Load reductions necessary to meet the target loads could not be calculated for these ungaged AUs because no flow data are not available for the date of the maximum thermograph reading. Section 7 of this document, Implementation of TMDLs, includes the results of temperature modeling which provide estimated increases in riparian shading, and/or decreases in stream channel width, which may result in achievement of the WQS criteria.

4.7 Identification and Description of Pollutant Source(s)

SWQB fieldwork includes an assessment of the probable sources of impairment in the AU drainage area (Appendix B). Probable Source Sheets are filled out by SWQB staff during watershed surveys and watershed restoration activities. The list of probable sources is not intended to single out any particular landowner or land management activity and generally includes several sources per pollutant. **Table 4.6** displays probable pollutant sources that have the potential to contribute to temperature impairment within each AU in the TMDL study area, as determined by field reconnaissance and knowledge of watershed 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 of impairment will be further evaluated, validated, refined and changed as necessary through the Watershed-Based Plan (WBP).

Table 4.6 Probable Source summary for AU temperature impairments within the Jemez watershed.

Assessment Unit	Probable Sources
Clear Creek (Rio de las Vacas to San Gregorio Lake)	Dam or impoundment; Highway/Road/Bridge runoff; Rangeland grazing
Rito de los Indios (San Antonio Creek to headwaters)	Forest fire; Rangeland grazing; Wildlife other than waterfowl
Jemez River (Zia Pueblo bnd to Jemez Pueblo bnd)	Crop production (dry land); Crop production (irrigated); Highway/Road/Bridge runoff; Low water crossing; Off-road vehicles; Other recreation (fishing); Pavement/impervious surfaces; Residential area; Water diversions; Wildlife other than waterfowl

Increases in thermal loading in a given AU can often be correlated to changes in shade and/or canopy cover. Detention of runoff in a dammed pond can also cause an increase in temperature. San Gregorio reservoir, in the San Pedro Parks Wilderness, has a headgate on one end of the dam that flows into the headwater of Nacimiento Creek (part of the Rio Puerco watershed). The dam also has a spillway that empties into Clear Creek, which is in the Jemez watershed (**Figure 1.1).**

Wildfires can affect the physical, chemical, and biological quality of streams, rivers, and lakes. After a fire, increased runoff provides the pathway for the transport of sediment to surface water, which may have substantial water quality impacts. Forest fires can result in increased water temperature due to reduced infiltration and loss of shading vegetation. Potential wildfire impacts to water quality are discussed on the SWQB website at https://www.env.nm.gov/surface-water-quality/wildfire-impacts-on-surface-water-quality/.

The Rito de los Indios was extensively and severely impacted by the 2011 Las Conchas Fire (**Figure 1.5**). In 2013, a Wild Earth Guardians project replaced some fenced-off riparian plantings along the Rito de los Indios that had been lost in the wildfire. A restoration project was conducted by Los Amigos del Valles Caldera from 2015 to 2018, which involved the placement of several gully repair structures, notably a large number of "plug-and-pond" installations, along Rito de los Indios, its tributary drainages, and nearby La Garita Creek (Vrooman, 2018). Sedimentation was expected to be reduced measurably by the capture of sediment in these wetland restoration structures. Shallow open water ponds may have some potential to temporarily cause increased surface water temperature but can also result in lower water temperature by storing water below the soil surface, and provide increased habitat diversity including the presence of temperature refugia. Site-specific effect will depend on the nature of local subsurface connectivity.

Clear Creek was not affected by any large wildfires since 2000. The Jemez River (Zia Pueblo bnd to Jemez Pueblo bnd) AU may have been indirectly affected by fires in the headwaters, but is more than 10 miles from the nearest large fire since 2000.

4.8 Consideration of Seasonal Variation

Section 303(d)(1) of the CWA requires TMDLs to be "established at a level necessary to implement the applicable WQS with seasonal variations." Both stream temperature and flow vary seasonally and from year to year. New Mexico is affected by the North American Monsoon System (NAMS; https://www.weather.gov/abq/prepawaremonsoonintro). Upper level and surface circulations associated with the NAMS transport moisture from the Pacific Ocean, the Gulf of California and the Gulf of Mexico into Mexico and the Southwest U.S. The northward progression of convective precipitation from southern Mexico in early June spreads northward into the southwest U.S. by early July. For New Mexico, the beginning of summer (before the monsoon season) is generally the hottest time of the year and coincides with the dry season, and consequently the lowest stream flows.

Water temperatures are coolest in the winter and early spring months. The warmest stream temperatures correspond to prolonged solar radiation exposure, warmer air temperature, and low flow conditions. These conditions occur during late summer and early fall and promote the warmest seasonal instream temperatures. It is assumed that if critical conditions are met, coverage of any potential seasonal variation will also be met. Temperature exceedances occurred during the 2013 SWQB Jemez survey in June, July and August.

4.9 Future Growth

Growth estimates by county and Water Planning Region (WPR) are available from the New Mexico Bureau of Business and Economic Research (BBER, 2008). These estimates project growth to the year 2060. Clear Creek, Rito de los Indios, and the Jemez River fall within the Middle Rio Grande WPR, which includes the Albuquerque metropolitan area. Approximately 14% of the Middle Rio Grande WPR population lives in Sandoval County. BBER projects continuing growth for the Sandoval County portion of the Middle Rio Grande WPR, although the rate of growth will slow, as detailed on **Table 4.7**.

Table 4.7 TMDL study area Water Planning Region population projections

WPR	2020	2030	2040	2050	2060	% Increase (2020-2060)
Middle Rio Grande (Sandoval County portion)	161,078	198,168	230,993	261,951	292,367	81.5

Estimates of future growth are not anticipated to lead to a significant increase in temperature that cannot be controlled with BMP implementation. BMPs should be utilized and improved upon while continuing to improve watershed conditions and adhering to SWPPP requirements related to construction and industrial activities covered under the general permit.

5.0 TURBIDITY

The New Mexico WQS has general criteria applicable to all waters of the state. The general narrative standard at 20.6.4.13(J) NMAC for turbidity reads:

> *"Turbidity attributable to other than natural causes shall not reduce light transmission to the point that the normal growth, function, or reproduction of aquatic life is impaired or that will cause substantial visible contrast with the natural appearance of the water…"*

Turbidity is an expression of the optical property in water that causes incident light to be scattered and absorbed rather than transmitted in straight lines. It is the condition resulting from suspended solids in the water, including silts, clays, and plankton. Such particles absorb heat in the sunlight, thus raising water temperature, which in turn lowers dissolved oxygen levels. It also prevents sunlight from reaching plants below the surface. This decreases the rate of photosynthesis, so less oxygen is produced by plants. Turbidity may harm fish and their larvae.

The impacts of suspended sediment and turbidity are well documented in the scientific literature. An EPA monitoring guidelines report states that increased sediment load is often the most important adverse effect of human activities on streams (USEPA, 1991). An increase in suspended sediment concentration will reduce the penetration of light, decrease the ability of fish or fingerlings to capture prey, and reduce primary production (USEPA, 1991). As stated by Relyea et al. (2000), "increased turbidity by sediments can reduce stream primary production by reducing photosynthesis, physically abrading algae and other plants, and preventing attachment of autotrophs to substrate surfaces."

The assessment approach used to determine turbidity impairments is described in detail in the Comprehensive Assessment and Listing Methodology (CALM; NMED/SWQB, 2019). Target values for this TMDL were based on the turbidity thresholds identified in the CALM. It relies upon the use of biotranslators to derive numeric thresholds from the narrative standard above. A biotranslator is a physical or chemical water quality parameter that has been isolated and effects an impairment of a quantifiable attribute of an indicator organism. In some cases, the quantifiable attribute may be the lethal dose or concentration of the parameter. In the case of turbidity, the attribute is typically based upon observed behavior and the Severity of Ill Effects ("SEV") index.

The Rito de los Indios turbidity-impaired AU is designated for high quality coldwater aquatic life use. The most representative fish to use in determining the appropriate turbidity thresholds for coldwater aquatic life stream segments are salmonids, as that group constitutes the majority of New Mexico's coldwater fish species, and a majority of studies on turbidity in fish have been conducted with them. The numeric thresholds in the CALM have also been supported with studies of turbidity effects on benthic macroinvertebrates.

A SEV index of 3.5 was selected to develop thresholds for turbidity impairment in New Mexico. This SEV index value corresponds to the boundary between conditions that effect changes to feeding in aquatic organisms and conditions that have been found to reduce growth rate and habitat size. The relationship between turbidity, duration, and a SEV of 3.5 is given in Equation 5.1, where x is duration in hours and y is the turbidity in Nephelometric Turbidity Units (NTUs) for durations from 7 hours to 720 hours. Shorter-term turbidity excursions are unlikely to impair the growth, function, and reproduction of aquatic life as required by New Mexico's narrative turbidity water quality standard, while thresholds for durations longer than 720 consecutive hours result in turbidity values that are lower than supported by literature available at the time of the assessment protocol development. The CALM provides a series of turbidity thresholds and durations which are listed in **Table 5.1**.

Equation 5.1

$$x = 37{,}382y^{-1.9887}$$

Where:

x = duration (hours)

y = turbidity (NTU)

Applicable for durations between 7 and 720 hours.

Table 5.1 Turbidity impairment thresholds and durations

Turbidity Threshold (NTU)	Allowable Duration (consecutive hours)	Allowable Duration (consecutive days)
23	72	3
20	96	4
18	120	5
16	144	6
15	168	7
11	336	14
7	720	30

NTU = Nephelometric Turbidity Units

5.1 Target Loading Capacity

This section describes the relationship between the numeric target and the allowable pollutant load by determining the total assimilative capacity of a waterbody, or loading capacity, for turbidity. The loading capacity, or TMDL, is the maximum amount of pollutant that a waterbody can receive, at a specific flow, while meeting its water quality objectives. Turbidity was measured using sonde multiparameter dataloggers. During the deployment in the Rito de los Indios above San Antonio Creek (**Figure 5.1**), turbidity exceeded one or more thresholds on **Table 5.1**.

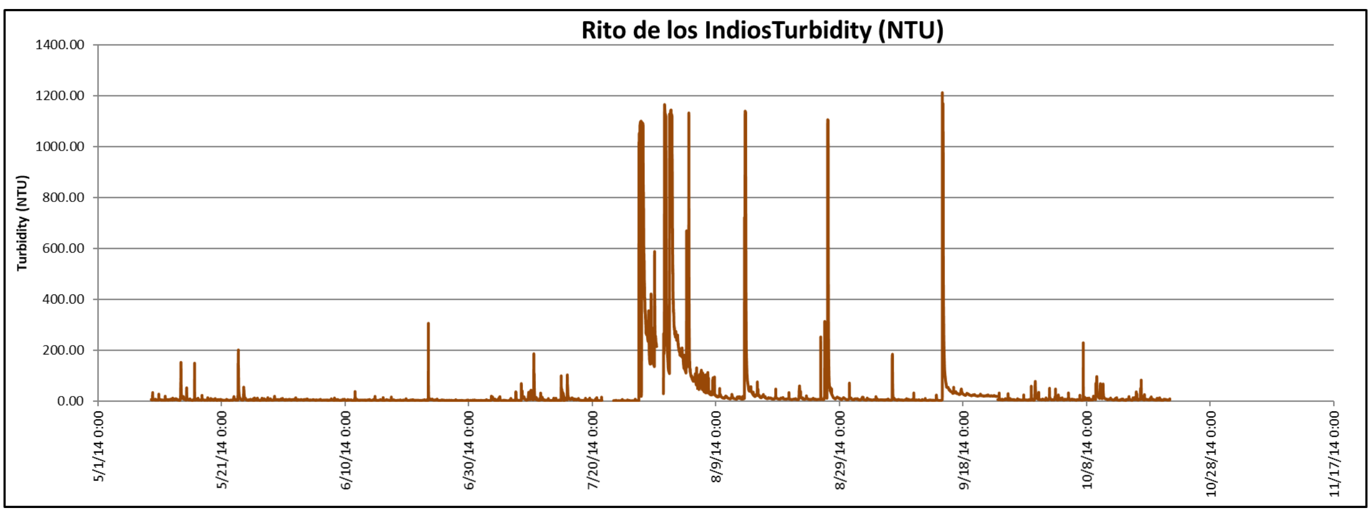


Figure 5.1 Turbidity log for the Rito de los Indios above San Antonio Creek, May 9 – Oct 21, 2014.

Because a TMDL requires a mass-based numeric loading component which cannot be directly derived from turbidity, Total Suspended Solids (TSS) is used as a turbidity surrogate. TSS is a commonly used measurement of suspended material in surface water because it is acceptable for regulatory purposes and is an inexpensive laboratory procedure. Since there are no facilities with NPDES permits discharging into or upstream of the impaired AU, it is assumed that TSS measurements in these ambient stream samples are representative of erosional activities, re-suspension of bedded sediments, or biosolids from livestock or wildlife.

A close relationship can typically be found between turbidity and TSS in a watershed or waterbody. Hence, suspended sediment levels may be inferred from turbidity studies; alternatively, turbidity levels may be inferred from studies that monitor suspended sediment concentrations. Extrapolation from these studies is possible when a site-specific relationship between concentrations of suspended sediments and turbidity is confirmed. Activities that generate varying amounts of suspended sediment will proportionally change or affect turbidity (USEPA, 1991). TSS and simultaneous turbidity results from the 2013 water quality survey are shown in Appendix A.

The R^2 (coefficient of determination) value is a measure of how well a dataset fits the applied model; R^2 values approaching one represent better fits than R^2 values closer to zero. Based on the R^2 value, equations offering the best fit for the data were selected. The equations and regression statistics for the TMDL AU are displayed in **Figure 5.2**.

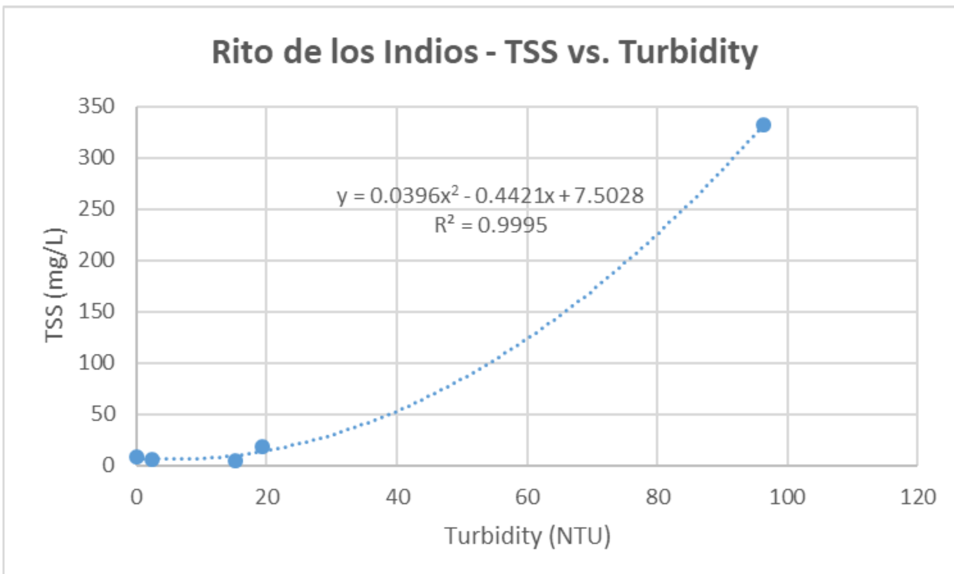


Figure 5.2 Regression relationship between turbidity and TSS in the Rito de los Indios during 2013 water quality survey.

5.2 Flow

The TMDL is a value calculated at a defined critical flow condition as part of a planning process designed to achieve water quality standards. For this turbidity TMDL, the appropriate critical flow condition is at low flow in order to be protective when the assimilative capacity of a stream is at its lowest. According to the New Mexico Water Quality Standards, the low flow critical condition for numeric criteria (excluding human health-organism only criteria) set in 20.6.4.97 through 20.6.4.900 NMAC and 20.6.4.13(F) NMAC is defined as the 4-day, 3-year low-flow frequency (4Q3, 20.6.4.11(B)(2) NMAC). The 4Q3 is the annual lowest four consecutive day flow that occurs with a frequency of at least once every three years.

The critical flow value used to calculate the turbidity TMDL was obtained using a regression model. Because the Rito de los Indios is ungaged, an analysis method developed by Waltemeyer (2002) was used to estimate the critical low flow. 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 7500 ft in elevation). The average elevation of the turbidity impaired watersheds is above 7500 ft, so the mountainous regions regression equation was used. The following mountainous regions regression equation (**Equation 5.1**) is based on data from 40 gaging stations located above 7500 ft in elevation with non-zero discharge (Waltemeyer, 2002):

Equation 5.2 $4Q3 = 7.3287 \times 10^{-5} DA^{0.70} {P_w}^{3.58} S^{1.35}$

Where:

4Q3 = Four-day, three-year low-flow frequency (cfs)
DA = Drainage area (mi^2)
P_w = Average basin precipitation Oct-Apr (inches)
S = Average basin slope (ft/ft)

The 4Q3 value calculated using Waltemeyer's method is presented in **Table 5.2**. Variables for input to the Waltemeyer equation were obtained using the USGS StreamStats web tool (https://streamstats.usgs.gov/ss/). The critical flow was converted from cfs to million gallons per day (MGD) using a conversion factor of 0.646. The TMDL itself is a value calculated at a defined critical condition as part of a 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 and achieve WQS is the goal of SWQB efforts.

Table 5.2 Calculation of 4Q3 for Turbidity TMDL

Assessment Unit	Average Elevation (ft)	Drainage Area (mi^2)	Mean Winter Precipitation (in)	Average Basin Slope (ft/ft)	4Q3 (cfs)	4Q3 (MGD)
Rito de los Indios (San Antonio Creek to headwaters)	9570	7.32	14.8	0.29	0.86	0.56

5.3 TMDL Calculations

Because impairment of a waterbody is dependent on the duration of elevated turbidity, a separate TMDL has been determined for each NTU/duration threshold identified in the turbidity assessment protocol. This TMDL was developed using the turbidity/duration thresholds identified in the SWQB turbidity assessment protocol (NMED/SWQB, 2015a), the site-specific relationship between turbidity and TSS, the 4Q3 flow condition, and a unit conversion factor to translate the target value into pounds per day (lbs/day). Using the regression equations shown on **Figure 5.2**, TSS values for each turbidity threshold were calculated (**Table 5.3**).

Table 5.3 Calculated Total Suspended Solids thresholds for the Rito de los Indios (San Antonio Creek to headwaters)

Turbidity (NTU)	TSS (mg/L)	Duration (consecutive hrs)
23	18.28	72
20	14.50	96
18	12.38	120
16	10.57	144
15	9.78	168
11	7.43	336
7	6.35	720

The 4Q3 critical low flow from Section 5.2, above, and the TSS threshold values calculated on **Table 5.3,** were substituted into Equation 5.3 to determine the TMDL at each turbidity/duration threshold (**Table 5.4**).

Equation 5.3

$$Critical\ Flow\ (MGD) \times WQS\ mg/L) \times Unit\ Conversion\ Factor\ (8.34) = Target\ Loading\ Capacity$$

Note that each TMDL is for a particular turbidity/duration pairing. It should not be extrapolated to longer or shorter durations.

Table 5.4 Turbidity-TSS/Duration TMDLs for the Rito de los Indios (San Antonio Creek to headwaters)

Turbidity (NTU)	TSS (lb/day)	Duration (consecutive hrs)
23	85.39	72
20	67.72	96
18	57.80	120
16	49.35	144
15	45.68	168
11	34.71	336
7	29.65	720

The TMDL is further allocated to a MOS, WLA (permitted point sources), and LA (non-point sources), according to the formula: WLA + LA + MOS = TMDL .

5.4 Margin of Safety

TMDLs should reflect a MOS based on the uncertainty or variability in the data, the point and nonpoint source loading estimates, and the model analysis. The MOS can be expressed implicitly, explicitly, or a combination of the two. An implicit MOS is incorporated by making conservative assumptions in the TMDL analysis, such as allocating a conservative load to background sources. An explicit MOS is applied by reserving a portion of the TMDL and not allocating it to any other sources.

For the turbidity TMDL presented in this document, there are no permitted point sources on the reach, so there will be no MOS associated with point sources. The MOS for the TMDLs was developed using a combination of conservative assumptions and allocating an explicit portion of the TMDL in recognition of potential errors. Therefore, this MOS is the sum of the following two elements:

Implicit Margin of Safety

- TSS is a conservative parameter that does not settle out of the water column.

Explicit Margin of Safety

- Uncertainty exists in the relationship between TSS and turbidity. A conservative MOS for this element is **5%**.

- There is inherent error in all flow calculations. A conservative MOS for this element for AUs which used the regression equation is therefore **10%**.

Total MOS for this TMDL is 15%.

5.5 Waste Load Allocation

There are no individually permitted point source facilities or MS4/sMS4 stormwater permits in this AU, so the WLA is zero. Sediment may be a component of some (primarily construction) stormwater discharges that contribute to suspended sediment impacts, and should be addressed.

Stormwater discharges from construction activities are transient because they occur mainly during the construction itself, and then only during storm events. Coverage under the USEPA NPDES Construction General Permit (CGP) for construction sites of one or more acres, or smaller if part of a common plan of development, 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 and/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.

Stormwater discharges from industrial activities and facilities, based on industrial classification codes, may be eligible for coverage under the current NPDES Multi-Sector General Permit (MSGP). The MSGP also requires preparation of a SWPPP. Some of the industrial facilities and activities covered under the MSGP have technology based effluent limitation and/or benchmark monitoring for pollutants. The current MSGP includes state-specific requirements that the benchmark values be protective of State of New Mexico WQS.

It is not possible to calculate individual WLAs for facilities covered by the General Permits at this time using the available tools. The discharges from these permits are typically transitory as the activities are temporary. Loads that are in compliance with the General Permits are therefore currently included as part of the Load Allocation (LA).

While these sources are not given individual allocations, they are addressed through other means, including BMPs, stormwater pollution prevention conditions, and other requirements.

5.6 Load Allocation

Load Allocation (LA) is pollution from any non-point source(s) or natural background and is addressed through Best Management Practices. Since there are no WLAs for these AUs, the LA is equal to the TMDL value minus the MOS, as shown on **Table 5.5**. The MOS was developed using a combination of conservative assumptions and explicit recognition of potential errors (see Section 5.4 for details).

Table 5.5 TMDL Allocations for Turbidity

Assessment Unit	Load Allocation				
	Duration (consecutive hrs)	**WLA (lbs/day)**	**MOS (15%) (lbs/day)**	**LA (lbs/day)**	**TMDL (lbs/day)**
Rito de los Indios (San Antonio Creek to headwaters)	720	0.00	12.81	72.58	85.39
	336	0.00	10.16	57.57	67.72
	168	0.00	8.67	49.13	57.80
	144	0.00	7.40	41.95	49.35
	120	0.00	6.85	38.83	45.68
	96	0.00	5.21	29.50	34.71
	72	0.00	4.45	25.20	29.65

5.7 Identification and Description of Pollutant Sources

SWQB fieldwork includes an assessment of the probable sources of impairment in the AU drainage area (Appendix B). Probable Source Sheets are filled out by SWQB staff during watershed surveys and watershed restoration activities. The list of probable sources is not intended to single out any particular land owner or land management activity and generally includes several sources per pollutant. **Table 5.6** displays probable pollutant sources that have the potential to contribute to turbidity impairment in the Rito de los Indios, as determined by field reconnaissance and knowledge of watershed 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 of impairment will be further evaluated, validated, refined, and changed as necessary through the Watershed-Based Plan (WBP).

Table 5.6 Probable source summary for turbidity

Assessment Unit	Probable Sources
Rito de los Indios (San Antonio Creek to headwaters)	Forest fire; Rangeland grazing; Wildlife other than waterfowl

Turbidity exceedances have historically been attributed to soil erosion, excess nutrients, various wastes and pollutants, and the re-suspension of sediments up into the water column during high flow events. As reflected in SWQB data, turbidity values along the impaired reach exceeded the applicable standard for the protection of designated uses. The components of a watershed continually change through natural ecological processes such as vegetation succession, erosion, and evolution of stream channels. Human activity often affects watershed function in ways that are inconsistent with the natural balance. These changes, often rapid and sometimes irreversible, occur when people cut forests, clear and cultivate land, remove riparian vegetation, alter the drainage of the land, channelize watercourses, withdraw water for irrigation, build towns and cities, and discharge pollutants into waterways. Disturbances may be historical or current in nature.

Wildfires can affect the physical, chemical, and biological quality of streams, rivers, and lakes. After a fire, increased runoff provides the pathway for the transport of chemical-laden sediment to surface water, which may have substantial water quality impacts. Forest fires can result in increased water temperature due to reduced infiltration and loss of shading vegetation. Potential wildfire impacts to water quality are discussed on the SWQB website at https://www.env.nm.gov/surface-water-quality/wildfire-impacts-on-surface-water-quality/.

The Rito de los Indios was extensively and severely impacted by the 2011 Las Conchas Fire (**Figure 1.5**). In 2013, a Wild Earth Guardians project replaced some fenced-off riparian plantings that had been lost in the fire. A restoration project was conducted by Los Amigos del Valles Caldera from 2015 to 2018, which involved the placement of several gully repair structures, notably a large number of "plug-and-pond" installations, along Rito de los Indios, its tributary drainages, and nearby La Garita Creek (Vrooman, 2018). Sedimentation was expected to be reduced measurably by the capture of sediment in these wetland restoration structures.

5.8 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. Sonde data used to document the turbidity exceedance in Rito de los Indios were collected during the summer of 2014. Higher turbidity values are typically associated with higher flows. However, as precipitation events are infrequent and transitory in nature, the 4Q3 is considered a more conservative estimate of the long-term stream condition. Since the critical flow condition is set to estimate low flow discharge, it is assumed that if critical conditions are met, coverage of any potential seasonal variation will also be met. **Figure 5.1** shows particularly high turbidity values in the Rito de los Indios in late July and early August of 2014.

5.9 Future Growth

Growth estimates by county and Water Planning Region (WPR) are available from the New Mexico Bureau of Business and Economic Research (BBER, 2008). These estimates project growth to the year 2060. Rito de los Indios falls within the Middle Rio Grande WPR, which includes the Albuquerque metropolitan area. Approximately 14% of the Middle Rio Grande WPR population resides in Sandoval County. BBER projects continuing growth for the Sandoval County portion of the Middle Rio Grande WPR, although the rate of growth will slow, as detailed on **Table 5.7**.

Table 5.7 TMDL study area Water Planning Region population projections

WPR	2020	2030	2040	2050	2060	% Increase (2020-2060)
Middle Rio Grande (Sandoval County portion)	161,078	198,168	230,993	261,951	292,367	81.5

Estimates of future growth are not anticipated to lead to a significant increase in turbidity that cannot be controlled with BMP implementation. BMPs should be utilized and improved upon while continuing to improve watershed conditions and adhering to SWPPP requirements related to construction and industrial activities covered under the general permit.

6.0 MONITORING PLAN

Pursuant to CWA Section 106(e)(1), 33 U.S.C. Section 1251, the SWQB has established appropriate monitoring methods, systems and procedures in order to compile and analyze data on the quality of the surface waters of New Mexico. In accordance with the New Mexico Water Quality Act, NMSA 1978, Sections 74-6-1 to -17, the SWQB has developed and implemented a comprehensive water quality monitoring strategy for the surface waters of the State.

The monitoring strategy establishes the methods of identifying and prioritizing water quality data needs, specifies procedures for acquiring and managing water quality data, and describes how these data are used to progress toward three basic monitoring objectives: to develop water quality-based controls, to evaluate the effectiveness of such controls, and to conduct water quality assessments. SWQB revised its 10-year monitoring and assessment strategy (NMED/SWQB, 2016) and submitted it to USEPA Region 6 for review in June 2016. The strategy details both the extent of monitoring that can be accomplished with existing resources plus expanded monitoring strategies that could be implemented given additional resources. The SWQB utilizes a rotating basin approach to water quality monitoring. In this approach, a select number of watersheds are intensively monitored each year with an established return frequency of approximately every eight years. The next scheduled monitoring date for the Jemez River watershed is 2021-2022.

The SWQB maintains current quality assurance and quality control plans to cover all monitoring activities. This document, called the Quality Assurance Project Plan (NMED/SWQB, 2018), is updated regularly and approved by USEPA Region 6. In addition, the SWQB identifies the data quality objectives required to provide information of sufficient quality to meet the established goals of the program. Current SWQB priorities for monitoring are driven by the CWA Section 303(d) list of streams requiring TMDLs or TMDL alternatives; water bodies identified as needing ALU verification; the need to monitor unassessed perennial waters; and water bodies receiving point source discharge(s). Short-term efforts were directed toward those waters that were on the USEPA TMDL consent decree list, however NMED/SWQB completed the final remaining TMDL on the consent decree in December 2006 and USEPA approved this TMDL in August 2007. The U.S. District Court terminated the Consent Decree on April 21, 2009.

Once assessment monitoring is completed, those reaches showing impacts and requiring a TMDL will be targeted for more intensive monitoring. The methods of data acquisition include fixed-station monitoring, intensive surveys of priority assessment units (including biological assessments), and compliance monitoring of industrial, federal, and municipal dischargers, as specified in the SWQB Standard Operating Procedures.

Long-term monitoring for assessments will be accomplished through the establishment of sampling sites that are representative of the water body and which can be revisited approximately every eight years. This information will provide time-relevant information for use in CWA Section 303(d) listing and 305(b) report assessments and to support the need for developing TMDLs. The approach provides:

- a systematic, detailed review of water quality data which allows for a more efficient use of valuable monitoring resources;
- information at a scale where implementation of corrective activities is feasible;
- an established order of rotation and predictable sampling in each basin which allows for enhanced coordinated efforts with other programs; and
- program efficiency and improvements in the basis for management decisions.

It should be noted that a watershed would not be ignored during the years in between water quality surveys. The rotating basin program will be supplemented with other data collection efforts such as on-going studies being performed by the USGS and USEPA. Data will be analyzed and field studies will be conducted to further characterize acknowledged problems, and TMDLs will be developed and implemented accordingly. Both long-term and intensive field studies can contribute to the State's Integrated §303(d)/§305(b) listing process for waters requiring TMDLs.

7.0 IMPLEMENTATION OF TMDLs

When approving TMDL documents, USEPA takes action on the TMDL, LA, WLA, and other components of the TMDL as needed (e.g., MOS and future growth). USEPA does not take action on the implementation section of the TMDL, and USEPA is not bound to implement any recommendations found in this section, in particular if they are found to be inconsistent with CWA and NPDES regulations, guidance, or policy.

7.1 Nonpoint Sources

7.1.1 Watershed Based Plan and Best Management Practice Coordination

Implementation of these TMDLs can best be achieved through the development of WBPs that incorporate information from TMDLs that have been developed in the watershed. A WBP is a written plan intended to provide a long-range vision for various activities and management of resources in a watershed. It includes opportunities for private landowners and public agencies in reducing and preventing nonpoint source impacts to water quality. The WBP is essentially the Implementation Plan, or Phase Two of the TMDL process. This long-range strategy will become instrumental in coordinating efforts to achieve water quality standards in the watershed. Public awareness and involvement will be crucial to the successful implementation of these plans and improved water quality.

The first of nine elements of a WBP required by the USEPA, is Element a: Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan. Sources that need to be controlled should be identified along with estimates of the extent to which they are present in the watershed. The draft probable source lists from the TMDL report will be further evaluated, validated, refined, and changed as necessary.

The completion of the TMDLs and WBP leads directly to the development of on-the-ground projects to address surface water impairments in the watershed. Additional information about the reduction of non-point source pollution can be found online at: https://www.epa.gov/polluted-runoff-nonpoint-source-pollution. SWQB staff will continue to provide technical assistance such as selection and application of BMPs needed to meet WBP goals. Stakeholder and public outreach and involvement in the implementation of this TMDL will be ongoing.

7.1.2 Clean Water Act Section 319(h) Funding

The Watershed Protection Section of the SWQB can potentially provide USEPA Section 319(h) funding to assist in implementation of BMPs to address water quality problems on reaches listed as category 4 or 5 waters on the Integrated 303(d)/§305(b) list. These monies are available to all private, for-profit, and nonprofit organizations that are authenticated legal entities, or governmental jurisdictions including: cities, counties, tribal entities, federal agencies, or agencies of the state. Proposals are submitted through a Request for Proposal (RFP) process. Selected projects require a non-federal match of 40% of the total project cost consisting of funds and/or in-kind services. Funding is potentially available, generally annually, for both watershed-based planning and on-the-ground projects to improve surface water quality and associated habitat. Further information on funding from the CWA Section 319(h) can be found at the SWQB website: https://www.env.nm.gov/surface-water-quality/.

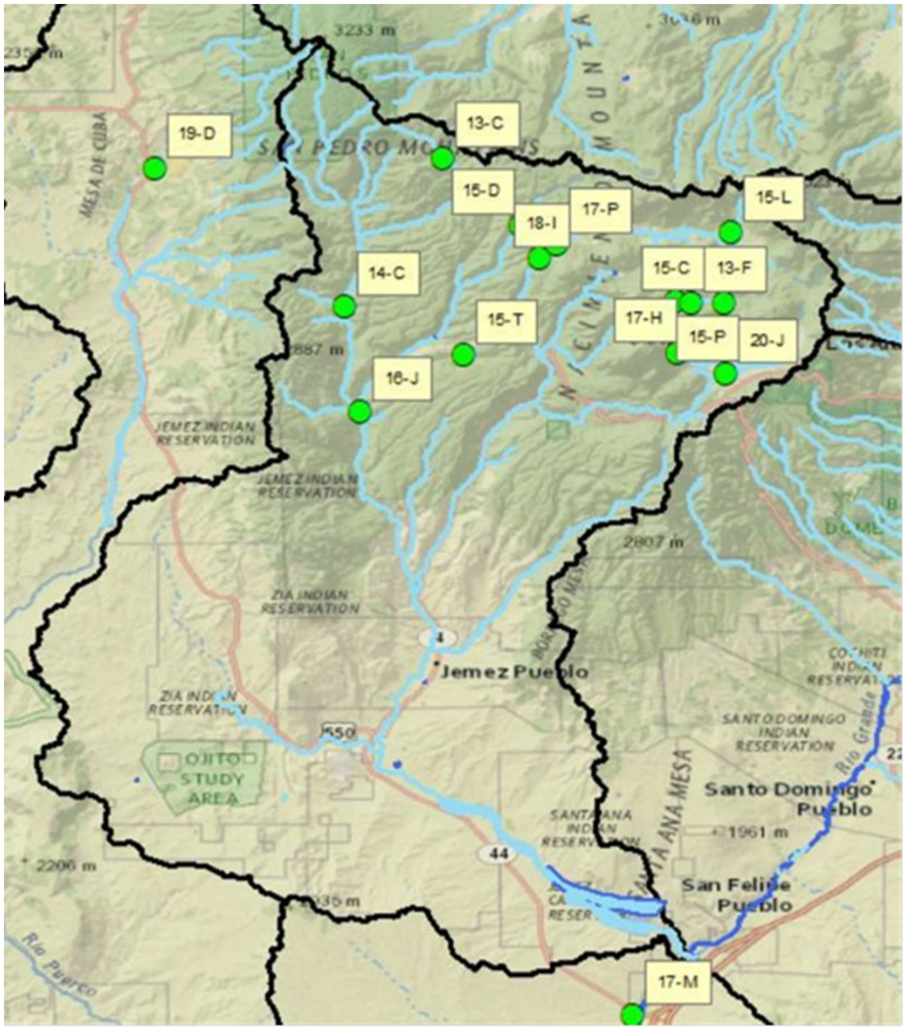


Figure 7.1 Section 319 and River Stewardship Program projects completed in and around HUC 13020202 between 2012 and 2020. Specific project information can be found at https://www.env.nm.gov/surface-water-quality/wp-content/uploads/sites/25/2020/09/NMED_319_and_RSP_Project_List.pdf by clicking on the project ID shown on the labels in the figure.

A Watershed Restoration Action Strategy (precursor to the WBP format) was completed in 2005, but there is currently no approved WBP or active watershed group working in the Jemez River watershed. SWQB staff will continue to conduct outreach related to the CWA Section 319(h) funding program which could lead to the formation of a watershed group in the area. There is a Southwest Jemez Collaborative Forest Landscape Restoration Program that also has funded some restoration projects in the Jemez.

7.1.3 Other Funding Opportunities and Restoration Efforts

Several other sources of funding exist to address impairments discussed in this TMDL document. NMED's Construction Programs Bureau assists communities in need of funding for WWTP upgrades and improvements to septic tank configurations. They can also provide matching funds for appropriate CWA Section 319(h) projects using state revolving fund monies. The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Environmental Quality Incentive Program (EQIP) program can provide assistance to private landowners in the basin. The USDA Forest Service aligns their mission to protect lands they manage with the TMDL process, and is another source of assistance. The US Bureau of Land Management (BLM) has several programs in place to provide assistance to improve unpaved roads and grazing allotments.

The SWQB annually makes available CWA Section 604(b) funds through a Request for Quotes (RFQ) process. The SWQB requests quotes from regional public comprehensive planning organizations to conduct water quality management planning as defined under CWA Sections 205(j) and 303(e). The SWQB seeks proposals to conduct water quality management planning with a focus on projects that clearly address the State's water quality goals to preserve, protect and improve the water quality in New Mexico. The SWQB encourages proposals focused on TMDLs and UAAs or other water quality management planning activities that will directly address identified water quality impairments. The 604(b) RFQ is released annually in September.

The New Mexico Legislature appropriated $1,250,000 in state funds for the River Stewardship Program during the 2020 Legislative Session. The River Stewardship Program has the overall goal of addressing the root causes of poor water quality and stream habitat. Objectives of the River Stewardship Program include: "restoring or maintaining hydrology of streams and rivers to better handle overbank flows and thus reduce flooding downstream; enhancing economic benefits of healthy river systems such as improved opportunities to hunt, fish, float or view wildlife; and providing state matching funds required for federal CWA grants." A competitive Request for Proposals will be conducted each year to select projects for funding. Responsibility for the program is assigned to NMED, and SWQB staff administer the projects. Additional funding sources for watershed protection and improvement projects are listed in Appendix C of the New Mexico Nonpoint Source Management Plan, available at https://www.env.nm.gov/surface-water-quality/nps-plan.

Information on additional watershed restoration funding resources is available on the SWQB website at- https://www.env.nm.gov/surface-water-quality/funding-sources.

7.2 Temperature modeling

Freshwater systems have interrelated biotic and abiotic parameters that drive the temperature of the waterbody. For a stream, these parameters can be generalized into simple categories that include: vegetation and land cover, channel morphology, and hydrology. Parameters such as channel width, meteorological measurements and microclimates, and solar irradiance, can exhibit considerable spatial variability. Together these parameters affect heat transfer and mass transfer processes to varying degrees. Due to the complexity of these systems, temperature modeling techniques are useful to facilitate the computation and prediction of the extent to which different parameters can affect a freshwater system. Temperature models can also identify the sensitivity of water temperature to individual parameters, to inform understanding of actions most likely to succeed in TMDL implementation. BMPs to be considered as part of on-the ground-projects to address temperature include establishment of additional woody riparian vegetation for shade and/or stream channel restoration work, particularly at road crossings.

The SSTEMP Model, Version 2.0.8, developed by the USGS Biological Resource Division (Bartholow, 2002) was used to predict stream temperatures of the impaired AUs based on watershed geometry, hydrology, and meteorology (**Figure 7.2**). The model predicts mean, minimum, and maximum daily water temperatures throughout a stream reach by estimating the heat gained or lost from a parcel of water as it passes through a stream segment (Bartholow, 2002). The model is calibrated by comparing predicted temperature values with actual thermograph readings measured in the field. SSTEMP is useful to inform TMDL implementation practices for temperature impaired AUs. The model analysis focuses mainly on changes in the riparian shade percentage and/or modification to channel dimensions. Total percent shade was chosen as a first-step analysis for TMDL implementation since it is easily translated into quantifiable management objectives.

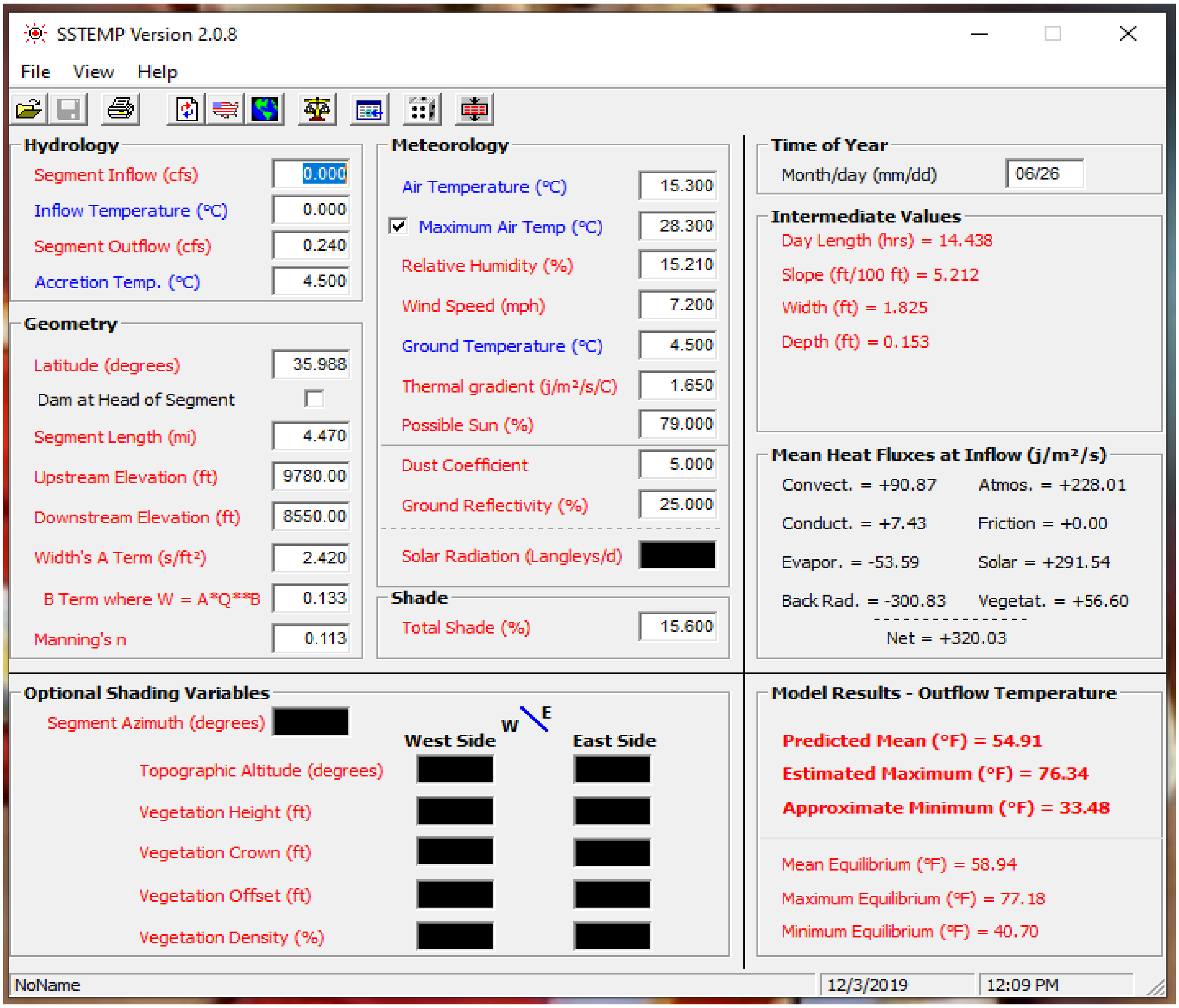


Figure 7.2 Example of SSTEMP output for Rito de los Indios (San Antonio Creek to headwaters)

A series of assumptions are associated with the SSTEMP model run conditions. Running the model outside of these assumptions may result in inaccuracies or model instability. The assumptions used in the development of SSTEMP that are most relevant to the present TMDLs are listed below. For a complete list of assumptions and model deficiencies, please see the SSTEMP user manual (Bartholow, 2002).

- Water in the system is instantaneously and thoroughly mixed at all times; there is no lateral temperature distribution across channel OR vertical gradients in pools.
- Stream geometry is characterized by mean conditions.
- Solar radiation and other meteorological and hydrological variables are 24-hour means.
- Distribution of lateral inflow is uniformly apportioned throughout the segment length
- Manning's n and travel time do not vary as functions of flow.
- Modeled/representative time periods must be long enough for water to flow the full length of the segment.

- SSTEMP is not able to model cumulative effects; for example, adding or deleting vegetation mathematically is not the same as in real life.

Water temperature can be expressed as heat energy per unit volume. SSTEMP provides an estimate of heat energy expressed in joules per square meter per second ($j/m^2/s$). The program will predict the minimum, mean, and maximum daily water temperature for the set of variables input into the model. The theoretical basis for the model is strongest for the mean daily temperature. The predicted maximum is largely an estimate and likely to vary widely with the maximum daily air temperature. The predicted minimum is computed by subtracting the difference between maximum and mean, from the mean; but the predicted minimum is always above 0 degrees Celsius (Bartholow, 2002).

SSTEMP input values are presented in Appendix D. The SSTEMP predicted maximum temperature was calibrated against thermograph data. Then the percent total shade was increased until the maximum 24-hour temperature decreased to the applicable temperature criterion. Width's A term was then decreased, at the existing percent shade, until the criterion was reached. **Table 7.1** details model outputs for the TMDL AUs. The model predicts that, since the Clear Creek AU exceeds its WQS by only a small margin, only a small increase in riparian canopy would be needed to result in support of the designated ALU. The Jemez River AU is temperature impaired by a wider margin, so a very large increase in shade would be needed to result in support of the designated ALU. Morphological changes which decrease channel width of both streams, would also be expected to result in lower water temperatures. The Rito de los Indios would need a large increase in shade.

SSTEMP may be used to compute, one at a time, the sensitivity to input values. This analysis varies most active input by 10% in both directions and displays a screen showing the resulting changes to estimated maximum temperature. The "Relative Sensitivity" schematic graph that accompanies the display gives an indication of which variables most strongly influence the results (Bartholow, 2002). Sensitivity analysis outputs are shown in **Figure 7.3**. Meteorological variables will always have the greatest impact on predicted maximum temperature. For Clear Creek, the sensitivity analysis indicates that maximum water temperature is sensitive to total shade. For the Jemez River, the model is moderately sensitive to total shade, width, streamflow and inflow temperature. The non-meteorological variables to which the model is moderately sensitive for Rito de los Indios are flow and width.

The SSTEMP model does not consider any impacts of climate change. SWQB encourages implementation practitioners to design projects to decrease water temperatures beyond simply meeting the applicable WQS, such that currently impaired AUs will be likely to meet WQS standards well into the future with some resiliency to climate change. Another example of designing for resiliency would be the creation of habitat refugia wherein water temperatures would be expected to remain cooler than the average for that water body.

Table 7.1 SSTEMP model results for Jemez River watershed temperature impaired AUs

Assessment Unit	Estimated % Shade [(a)]	WQS % Shade [(b)]	% Shade Increase [(c)]	Width's A	WQS Width's A [(d)]
Clear Creek (Rio de las Vacas to San Gregorio Lake)	37.4	39	4.3	8.66	2.7
Jemez River (Zia Pueblo bnd to Jemez Pueblo bnd)	3.3	42	1173	15.77	2.2
Rito de los Indios (San Antonio Creek to headwaters)	15.6	29	85.9	2.42	NA [(e)]

(a) *Estimates of AU vegetative canopy were generated using the attribute table of the USDA NorWest Stream Temperature Modeled Stream Temperature Scenario map for New Mexico (see Appendix D).*

(b) *% shade at which the SSTEMP predicted maximum temperature is held below the applicable WQS, all other variables being held the same.*

(c) *% by which SSTEMP predicts that shade must be increased to hold maximum water temperature below the applicable WQS, all other variables being held the same.*

(d) *Width's A term at which the SSTEMP predicted maximum temperature is held below the applicable WQS, all other variables being held the same.*

(e) *Width's A term cannot be less than 1.0. Setting Width's A at 1.0 did not bring the SSTEMP predicted maximum temperature below the applicable WQS.*

Sensitivity Analysis - SSTEMP (2.0.8)

Sensitivity for maximum temperature values (10% varaition) SSTEMP (2.0.8)
Original maximum temperature = 23.17°C

Variable	Temperature change (°C) if variable is: Decreased	Increased	Relative Sensitivity
Segment Inflow (cfs)	0.00	+0.01	
Inflow Temperature (°C)	0.00	+0.00	
Segment Outflow (cfs)	+0.01	0.00	
Accretion Temp. (°C)	+0.00	+0.00	
Width's A Term (s/ft²)	0.00	+0.00	
B Term where W = A*Q**B	+0.00	0.00	
Manning's n	+0.00	0.00	
Air Temperature (°C)	-0.44	+0.41	******************
Relative Humidity (%)	-0.44	+0.46	******************
Wind Speed (mph)	+0.36	-0.39	****************
Ground Temperature (°C)	-0.02	+0.02	*
Thermal gradient (j/m²/s/C)	+0.07	-0.07	***
Possible Sun (%)	-0.37	+0.39	****************
Dust Coefficient	+0.02	-0.02	*
Ground Reflectivity (%)	-0.02	+0.02	*
Total Shade (%)	+0.42	-0.41	*****************
Maximum Air Temp (°C)	-0.73	+0.74	******************************

A

Sensitivity Analysis - SSTEMP (2.0.8)

Sensitivity for maximum temperature values (10% varaition) SSTEMP (2.0.8)
Original maximum temperature = 36.22°C

Variable	Temperature change (°C) if variable is: Decreased	Increased	Relative Sensitivity
Segment Inflow (cfs)	+0.02	+0.16	*****
Inflow Temperature (°C)	-0.28	+0.30	**********
Segment Outflow (cfs)	+0.25	-0.08	********
Accretion Temp. (°C)	+0.00	+0.00	
Width's A Term (s/ft²)	-0.11	+0.13	****
B Term where W = A*Q**B	-0.04	+0.04	*
Manning's n	+0.08	-0.04	***
Air Temperature (°C)	-0.46	+0.43	***************
Relative Humidity (%)	-0.37	+0.38	*************
Wind Speed (mph)	+0.23	-0.24	********
Ground Temperature (°C)	-0.04	+0.04	*
Thermal gradient (j/m²/s/C)	+0.07	-0.08	**
Possible Sun (%)	-0.47	+0.50	*****************
Dust Coefficient	+0.03	-0.03	*
Ground Reflectivity (%)	-0.03	+0.03	*
Total Shade (%)	+0.03	-0.03	*
Maximum Air Temp (°C)	-0.87	+0.90	******************************

B

Sensitivity Analysis - SSTEMP (2.0.8)

Sensitivity for maximum temperature values (10% varaition) SSTEMP (2.0.8)
Original maximum temperature = 24.63°C

Variable	Temperature change (°C) if variable is: Decreased	Increased	Relative Sensitivity
Segment Inflow (cfs)	+0.00	+0.00	
Inflow Temperature (°C)	0.00	0.00	
Segment Outflow (cfs)	+0.08	-0.08	***
Accretion Temp. (°C)	-0.02	+0.02	*
Width's A Term (s/ft²)	-0.08	+0.10	****
B Term where W = A*Q**B	+0.03	-0.02	*
Manning's n	+0.06	-0.06	**
Air Temperature (°C)	-0.07	+0.06	**
Relative Humidity (%)	-0.12	+0.12	****
Wind Speed (mph)	+0.45	-0.48	*****************
Ground Temperature (°C)	-0.02	+0.02	*
Thermal gradient (j/m²/s/C)	+0.09	-0.09	***
Possible Sun (%)	-0.61	+0.65	***********************
Dust Coefficient	+0.03	-0.03	*
Ground Reflectivity (%)	-0.02	+0.02	*
Total Shade (%)	+0.19	-0.19	*******
Maximum Air Temp (°C)	-0.83	+0.85	******************************

C

Figure 7.3 SSTEMP sensitivity analyses for Clear Creek (A), Jemez River (B) and Rito de los Indios (C) Assessment Units

8.0 APPLICABLE REGULATIONS AND REASONABLE ASSURANCES

New Mexico's Water Quality Act, NMSA 1978 §§ 74-6-1 to -17 (Act), authorizes the WQCC to "promulgate and publish regulation to prevent or abate water pollution in the state" and to require permits. The Act authorizes a constituent agency to take enforcement action against any person who violates a water quality standard. Several statutory provisions on nuisance law could also be applied to NPS water pollution. The Act states in Section 74-6-12(A):

> *The Water Quality Act (this article) does not grant to the commission or to any other entity the power to take away or modify the property rights in water, nor is it the intention of the Water Quality Act to take away or modify such rights.*

In addition, the State of New Mexico Standards for Interstate and Intrastate Surface Waters (20.6.4.6(C) NMAC) state:

> *Pursuant to Subsection A of Section 74-6-12 NMSA 1978, this part does not grant to the water quality control commission or to any other entity the power to take away or modify property rights in water.*

New Mexico policies are in accordance with the federal CWA Section 101(g):

> *It is the policy of Congress that the authority of each State to allocate quantities of water within its jurisdiction shall not be superseded, abrogated or otherwise impaired by this Act. It is the further policy of Congress that nothing in this Act shall be construed to supersede or abrogate rights to quantities of water which have been established by any State. Federal agencies shall co-operate with State and local agencies to develop comprehensive solutions to prevent, reduce and eliminate pollution in concert with programs for managing water resources.*

New Mexico's CWA Section 319 Program has been developed in a coordinated manner with the State's CWA Section 303(d) process. All watersheds that are targeted in the annual §319 request for proposal process coincide with the State's biennial impaired waters list as approved by USEPA. The State has given a high priority for funding, assessment, and restoration activities to these watersheds.

As a constituent agency, NMED has the authority under NMSA 1978, Section 74-6-10 to issue a compliance order or commence civil action in district court for appropriate relief if NMED determines that actions of a "person" (as defined in the Act) have resulted in a violation of a water quality standard including a violation caused by a NPS. The NMED NPS water quality management program has historically strived for and will continue to promote voluntary compliance to NPS water pollution concerns by utilizing a voluntary, cooperative approach. The State provides technical support and grant monies for implementation of BMPs and other NPS prevention mechanisms through Section 319 of the CWA. Since portions of this TMDL will be implemented through NPS control mechanisms, the New Mexico Watershed Protection Program will target efforts to this and other watersheds with TMDLs.

In order to obtain reasonable assurances for implementation in watersheds with multiple landowners, including federal, state, and private land, NMED has established Memoranda of Understanding (MOUs) with various federal agencies, in particular the U.S. Forest Service and the BLM. MOUs have also been developed with other state agencies, such as the New Mexico Department of Transportation. These MOUs provide for coordination and consistency in dealing with NPS issues.

The time required to attain standards for all reaches is estimated to be approximately 10-20 years. This estimate is based on a five-year time frame implementing several watershed projects that may not be starting immediately or may be in response to earlier projects. Stakeholders in this process will include SWQB, and other parties identified in the WBP. The cooperation of watershed stakeholders will be pivotal in the implementation of these TMDLs as well.

9.0 PUBLIC PARTICIPATION

Public participation was solicited in development of this TMDL. The draft TMDL was first made available for a 30-day comment period February 22 and ending on March 24, 2021. The draft document notice of availability was advertised via email distribution lists and webpage postings. A public meeting will be held virtually online on March 1 from 530-7:30pm. No written comments were received by SWQB during the public comment period.

Once the TMDL is approved by the WQCC, the next step for public participation will be development of WBPs and watershed protection projects, including those that may be funded by CWA Section 319(h) grants managed by SWQB.

10.0 REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 2007. Toxicological profile for Arsenic. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. Available online at: https://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=22&tid=3

Bartholow, J.M, 2002. SSTEMP for Windows: The Stream Segment Temperature Model (Version 2.0). U.S. Geological Survey computer model and documentation. Available online at: https://www.sciencebase.gov/catalog/item/53ea4091e4b008eaa4f4c457. Revised August 2002.

Behar, Sharon. 1997. Testing the Waters: Chemical and Physical Vital Signs of a River. Montpelier, VT: River Watch Network.

Bureau of Business and Economic Research (BBER). 2008. A Report on Historical and Future Population Dynamics in New Mexico Water Planning Regions. Prepared for the New Mexico Interstate Stream Commission, August, 2008.

Caissie, Daniel. 2006. The thermal regime of rivers: a review. Freshwater Biology 51:1389-1406.

Dunbar, N.W., C.E. Chapin, L.A. Brandvold and L.G. Price. 2002. Arsenic in New Mexico's Waters. New Mexico Bureau of Geology and Mineral Resources New Mexico Earth Matters Newsletter, Vol. 2, No. 2.

Kumari, B., V. Kumar, A. Sinha, J. Ahsan, A. Ghosh, H. Wang and G. De Boeck. 2016. Toxicology of arsenic in fish and aquatic systems. Environ. Chem. Lett. Vol. 14. Available online at: https://www.researchgate.net/publication/308942768_Toxicology_of_arsenic_in_fish_and_aquatic_systems

New Mexico Administrative Code (NMAC). 2018. State of New Mexico Standards for Interstate and Intrastate Streams. 20.6.4. New Mexico Water Quality Control Commission. As amended through February 13, 2018.

New Mexico Environment Department/ Surface Water Quality Bureau (NMED/SWQB). 2020. Statewide Water Quality Management Plan and Continuing Planning Process. Available online at: https://www.env.nm.gov/surface-water-quality/wqmp-cpp/

———. 2019. Comprehensive Assessment and Listing Methodology. Available online at: https://www.env.nm.gov/surface-water-quality/protocols-and-planning/

———. 2018. Quality Assurance Project Plan for Water Quality Management Programs. Available online at: https://www.env.nm.gov/surface-water-quality/protocols-and-planning/

———. 2016. 2016-18 State of New Mexico Clean Water Act Integrated §303(d)/ §305(b) Integrated Report, Appendix A – Integrated List. Available online at: https://www.env.nm.gov/surface-water-quality/303d-305b/

———. 2015a. Procedures for Assessing Water Quality Standards Attainment for the State of New Mexico CWA §303(d)/ §305(b) Integrated Report. Available online at: https://www.env.nm.gov/surface-water-quality/calm/

———. 2015b. Sampling Summary Jemez River Watershed Water Quality Survey. Available online at: https://www.env.nm.gov/surface-water-quality/water-quality-monitoring/

———. 2009a. Total Maximum Daily Load for the Jemez River Watershed (from San Ysidro to headwaters excluding waters in the Valles Caldera National Preserve). Available online at: https://www.env.nm.gov/surface-water-quality/tmdl/

———. 2009b. Proposed Coolwater Aquatic Life Use. August 2009.

Reid, K.D., Goff, F. and Counce, D.A. 2003. Arsenic concentration and mass flow rate in natural waters of the Valles caldera and Jemez Mountains region, New Mexico. New Mexico Geology 25(3):75-82.

Relyea, C.D., C.W. Marshall, and R.J. Danehy. 2000. Stream insects as indicators of fine sediment. Stream Ecology Center, Idaho State University, Pocatello, ID. Presented at WEF 2000 Watershed Management Conference.

Sharma, V.K. and M. Sohn. 2009. Aquatic arsenic: toxicity, speciation, transformations and remediation. Environment International 35:746-759. Available online at: https://www.ncbi.nlm.nih.gov/pubmed/19232730

Todd, A.S., M.A. Coleman, A.M. Konowal, M.K. May, S. Johnson, N.K.M. Viera and J.E. Saunders. 2008. Development of New Water Temperature Criteria to Protect Colorado's Fisheries. Fisheries 33(9):433- 443.

US EPA. 2018. National Pollutant Discharge Elimination System (NPDES). NPDES Permit Basics. Available online at: https://www.epa.gov/npdes/npdes-permit-basics . Accessed July 23, 2018.

———. 2015. BASINS 4.1 (Better Assessment Science Integrating point & Non-point Sources) Modeling Framework. National Exposure Research Laboratory, RTP, North Carolina. Available online at: https://www.epa.gov/ceam/better-assessment-science-integrating-point-and-non-point-sources-basins

———. 2002. Guidelines for Reviewing TMDLs under Existing Regulations issued in 1992. Office of Water, Washington, D.C. May 2002. Available online at: https://www.epa.gov/sites/production/files/2015-10/documents/2002_06_04_tmdl_guidance_final52002.pdf

———. 1999. Draft Guidance for Water Quality-based Decisions: The TMDL Process (Second Edition). EPA 841-D-99-001. Office of Water, Washington, D.C. August 1999.

———. 1991. Technical Support Document for Water Quality-based Toxics Control; EPA-505-2-90-001. Available online at: http://static.azdeq.gov/legal/subs_techdoc_wq_toxics_control.pdf

Vrooman, S. 2018. Restoring Hydrologic Functioning to the Rito de los Indios, Valles Caldera National Preserve. Monitoring Report, June 27, 2018.

Waltemeyer, Scott D. 2002. Analysis of the Magnitude and Frequency of the 4-Day Annual Low Flow and Regression Equations for Estimating the 4-Day, 3-Year Low-Flow Frequency at Ungaged Sites on Unregulated Streams in New Mexico. USGS Water-Resources Investigations Report 01-4271. Albuquerque, NM.

APPENDIX A

WATER QUALITY DATA

Table A1: Arsenic data

Asterisk (*) indicates exceedance of the applicable criterion. Double asterisk (**) indicates that flow was visually estimated rather than measured. MDP is a missing data point.

Vallecito Ck (Jemez Pueblo bnd to Div abv Ponderosa)			
Monitoring Station	**Date**	**Dissolved arsenic results (ug/L)**	**Flow (cfs)**
31Vallec003.2	5/14/2013	17*	0.2 **
31Vallec003.2	6/18/2013	19*	MDP
31Vallec003.2	7/18/2013	22*	0.05 **
31Vallec003.2	9/18/2013	16*	0.2 **

Table A2: Turbidity and TSS data

Double asterisk (**) indicates that flow was visually estimated rather than measured. MDP is a missing data point.

Rito de los Indios (San Antonio Creek to headwaters)				
Monitoring Station	**Date**	**Turbidity (NTU)**	**TSS (mg/L)**	**Flow (cfs)**
31RIndio000.2	4/24/2013	96.3	332	1.3
31RIndio000.2	5/21/2013	0	9	1**
31RIndio000.2	7/2/2013	15.2	5	1**
31RIndio000.2	8/1/2013	19.4	18	1**
31RIndio000.2	10/10/2013	2.3	6	0.5 **

Table A3: Specific Conductance and TDS data

Asterisk (*) indicates exceedance of the applicable criterion. Double asterisk (**) indicates that flow was visually estimated rather than measured. MDP is a missing data point.

Monitoring Station	Date	SC (uS/cm)	TDS (mg/L)	TDS:SC ratio	Flow (cfs)
31RGuada000.1	3/25/13	293	164	0.560	10.87
31RGuada000.1	4/23/13	187	MDP	NA	41.83
31RGuada000.1	5/14/13	196	MDP	NA	25.82
31RGuada000.1	6/18/13	*504	292	0.579	1.6
31RGuada000.1	7/1/13	*545	MDP	NA	1.5**
31RGuada000.1	7/18/13	*464	262	0.565	1.5**
31RGuada000.1	8/29/13	MDP	284	NA	MDP
31RGuada000.1	9/4/13	381	214	0.562	3**
31RGuada000.1	9/18/13	272	MDP	NA	30**
31RGuada010.0	4/15/13	174	MDP	NA	27.19
31RGuada010.0	5/15/13	143	MDP	NA	30.08
31RGuada010.0	6/19/13	240	146	0.608	5.5**
31RGuada010.0	7/17/13	228	166	0.728	3.75**
31RGuada010.0	8/29/13	MDP	162	NA	MDP
31RGuada010.0	9/5/13	239	156	0.653	5**

Table A4: Temperature data

See Appendix (C) for thermograph and SSTEMP input data.

APPENDIX B
SOURCE DOCUMENTATION

“Sources” are defined as activities that may contribute pollutants or stressors to a water body (USEPA 1997). The list of “Probable Sources of Impairment” in the Integrated 303(d)/305(b) List, Total Maximum Daily Load documents (TMDLs), and Watershed-Based Plans (WBPs) is intended to include any and all activities that could be contributing to the identified cause of impairment. Data on Probable Sources is routinely gathered by Monitoring and Assessment Section staff and Watershed Protection Section staff during water quality surveys and watershed restoration projects and is housed in the Assessment Database (ADB version 2). ADB was developed by USEPA to help states manage information on surface water impairment and to generate §303(d)/§305(b) reports and statistics. More specific information on Probable Sources of Impairment is provided in individual watershed planning documents (e.g., TMDLs, WBPs, etc.) as they are prepared to address individual impairments by AU.

USEPA, through guidance documents, strongly encourages states to include a list of Probable Sources for each listed impairment. According to the 1998 Section 305(b) report guidance, *“…, states must always provide aggregate source category totals…”* in the biennial submittal that fulfills CWA section 305(b)(1)(C) through (E) (USEPA 1997). 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.

The approach for identifying “Probable Sources of Impairment” was recently modified by SWQB. Any new impairment listing will be assigned a Probable Source of “Source Unknown.” Probable Source Sheets will continue to be filled out during watershed surveys and watershed restoration activities by SWQB staff. Information gathered from the Probable Source Sheets will be used to generate a draft Probable Source list in consequent TMDL planning documents. These draft Probable Source lists will be finalized with watershed group/stakeholder input during the pre-survey public meeting, TMDL public meeting, WBP development, and various public comment periods. The final Probable Source list in the approved TMDL will be used to update the subsequent Integrated List.

Literature Cited:

USEPA. 1997. Guidelines for preparation of the comprehensive state water quality assessments (305(b) reports) and electronic uptakes. Washington, D.C. https://www.epa.gov/waterdata/guidelines-preparation-comprehensive-state-water-quality-assessments-305b-reports-and

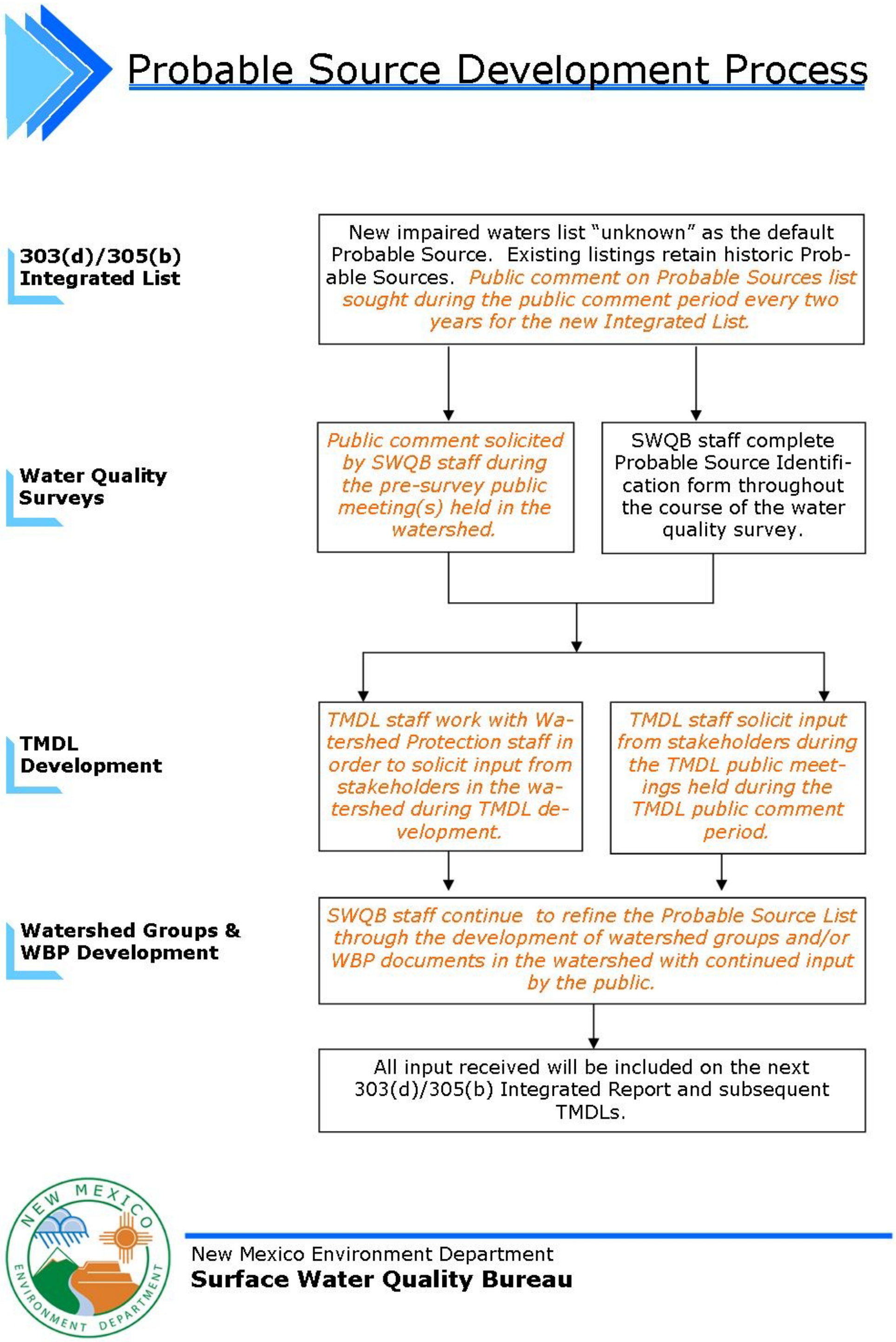


Figure B1. Probable Source Development Process and Public Participation Flowchart

Probable Source(s) & Site Condition Class Field Form

Station ID:	Station Name/Description:
AU ID:	AU Description:
Field Crew:	Comments:
Date:	Watershed protection staff reviewer: Date of WPS review:

Score the proximity, intensity and/or certainty of occurrence of the following activities in the AU upstream of the site. Consult with the appropriate staff at NMED and other agencies to score "*" cells if needed.

Activity Checklist

Hydromodifications				
Channelization	0	1	3	5
Dams/Diversions	0	1	3	5
Draining/Filling Wetlands	0	1	3	5
Dredging	0	1	3	5
Irrigation Return Drains	0	1	3	5
Riprap/Wall/Dike/Jetty Jack -- circle	0	1	3	5
Flow Alteration (from Water Diversions/Dam Ops – circle)	0	1	3	5
Highway/Road/Bridge Runoff	0	1	3	5
Other:	0	1	3	5

Habitat Modification				
Active Exotics Removal	0	1	3	5
Stream Channel Incision	0	1	3	5
Mass Wasting	0	1	3	5
Active Restoration	0	1	3	5
Other:	0	1	3	5

Industrial/ Municipal				
Storm Water Runoff due to Construction	0	1	3	5
Landfill	0	1	3	5
On-Site Treatment Systems (Septic, etc.)	0	1	3	5
Pavement/Impervious Surfaces	0	1	3	5
Inappropriate Waste Disposal	0	1	3	5
Residences/Buildings	0	1	3	5
Site Clearance (Land Development)	0	1	3	5
Urban Runoff/Storm Sewers	0	1	3	5
Power Plants	0	1	3	5
* Industrial Storm Water Discharge (permitted)	0	1	3	5
* Industrial Point Source Discharge	0	1	3	5
* Municipal Point Source Discharge	0	1	3	5
* RCRA/Superfund Site	0	1	3	5
Other:	0	1	3	5

Resource Extraction				
* Abandoned Mines (Inactive)/Tailings	0	1	3	5
* Acid Mine Drainage	0	1	3	5
* Active Mines (Placer/Potash/Other -- circle)	0	1	3	5
* Oil/Gas Activities (Permitted/Legacy – circle)	0	1	3	5
* Active Mine Reclamation	0	1	3	5
Other:	0	1	3	5

Silviculture				
* Logging Ops – Active Harvesting	0	1	3	5
* Logging Ops – Legacy	0	1	3	5
* Fire Suppression (Thinning/Chemicals)	0	1	3	5
Other:	0	1	3	5

Rangeland				
Livestock Grazing or Feeding Operation	0	1	3	5
Rangeland Grazing (dispersed)	0	1	3	5
Other:	0	1	3	5

Roads				
Bridges/Culverts/RR Crossings	0	1	3	5
Low Water Crossing	0	1	3	5
Paved Roads	0	1	3	5
Gravel or Dirt Roads	0	1	3	5

Agriculture				
Crop Production (Cropland or Dry Land)	0	1	3	5
Irrigated Crop Production (Irrigation Equip)	0	1	3	5
* Permitted CAFOs	0	1	3	5
* Permitted Aquaculture	0	1	3	5
Other:	0	1	3	5

Miscellaneous				
Angling Pressure	0	1	3	5
Dumping/Garbage/Trash/Litter	0	1	3	5
Exotic Species (describe in comments)	0	1	3	5
Hiking Trails	0	1	3	5
Campgrounds (Dispersed/Defined – circle)	0	1	3	5
Surface Films/Odors	0	1	3	5
Pesticide Application (Algaecide/Insecticide)	0	1	3	5
Waste From Pets (high concentration)	0	1	3	5
* Fish Stocking	0	1	3	5
Other:	0	1	3	5

Natural Disturbance or Occurrence				
Waterfowl	0	1	3	5
Drought-related Impacts	0	1	3	5
Watershed Runoff Following Forest Fire	0	1	3	5
Recent Bankfull or Overbank Flows	0	1	3	5
Wildlife other than Waterfowl	0	1	3	5
Other Natural Sources (describe in comments)	0	1	3	5

Legend – Proximity Score

Activity not known occur within AU upstream of station (includes unknown)	0	Activity observed or known to be present near station (1 km or less) or is known to occur in moderate frequency/intensity within the AU upstream of station	3
Activity observed or known to be present but not near the station and at low frequency/intensity within AU upstream of station	1	Activity observed or known to be present at station or known to occur in high frequency/intensity within the AU upstream of station	5

Figure B2. Probable Source & Site Condition Field Sheet for SWQB Staff

APPENDIX C
CALCULATION OF TEMPERATURE TMDL

Calculation of Temperature TMDL

Problem Statement: Convert Temperature Criteria into a Daily Load

Background

The temperature of water is essential for proper metabolic regulation in the aquatic community. Water at a given temperature has a thermal mass that can be represented in units of energy (thermal energy). There are a variety of sources of temperature loading to a waterbody, including air temperature, solar radiation and point source discharge (if present). In addition, how the temperature loading to a stream is translated to the thermal mass of the stream is dependent on its hydrologic characteristics and condition of riparian area (i.e., shading).

The calculation of a TMDL target is governed by the basic equation,

Eq1. *WQS criterion * flow * conversion factor = TMDL target capacity*

For Temperature TMDLs, the WQS criterion is a temperature specified either by the designated Aquatic Life Use (ALU) or site-specific criteria and can be either a maximum temperature or time-duration temperature such as the 4T3 or 6T3.

Flow will generally use the 4Q3 low-flow for the critical flow unless another flow statistic or multiple flow conditions are more appropriate for the situation.

The conversion factor is a variable needed to 1) convert units used by SWQB for flow (in cfs) to cubic meters (m^3) and 2) convert change in water temperature (C) to a volumetric heat capacity (kJ/(m^3*C).

Calculation of Thermal Energy

The thermal loading capacity of a volume is governed by the following equation,

Eq2. *thermal energy = specific heat capacity * mass * change in temperature*

Specific heat capacity is the amount of energy needed to raise the temperature of one kilogram of a substance by 1 degree Celsius.

Mass can be replaced by volume via density.

Accepted Scientific Units for the variables above are:

thermal energy = kilojoule (kJ) (calories are less common and considered archaic)

specific heat capacity = kJ/(kg*C)

mass = kilograms (kg)

change in temperature = Celsius (C)

The specific heat capacity of water at 25^{o}C = 4.182 kJ/(kg*C). This is the isobaric (under constant pressure) value for heat capacity at an absolute atmospheric pressure of 585 mmHg. Note: varying water temperature and absolute pressure to minimum and maximum ambient values has negligible effect on the resulting heat capacity.

Calculation of Conversion Factor

Flow (cfs) to (m^3/day)

Eq3. 1 cf/s * 86,400 s/day * 0.0283 m^3/cf = 2445.12 m^3/day

Heat Capacity to Volumetric Heat Capacity

Eq4. 4.182 kJ/(kg*C) * 1000 kg/m^3 = 4,182 kJ/(m^3*C)

Note: water density varies with temperature but only at a fraction of a percent.

Conversion Factor = 2445.12 m^3/day * 4,182 kJ/(m^3*C) = 1.023E+07 kJ/(day*C)

Form of TMDL Equation

Eq5. Δ [**^{o}C**] x [**cfs]** x 1.023E+07 = TMDL (kJ/day)

Input variables in **bold**, Δ**^{o}C** = (WQC - 0**^{o}C)** and **cfs** = critical flow

The resulting value is the increase in kJ/day above 0^o Celsius.

APPENDIX D
SSTEMP INPUT DATA

D 1.0 INTRODUCTION

This appendix provides site-specific hydrology, geometry, and meteorological data for input into the Stream Segment Temperature (SSTEMP) Model (Bartholow, 2002). Hydrology variables include segment inflow, inflow temperature, segment outflow, and accretion temperature. Geometry variables are latitude, segment length, upstream and downstream elevation, Width's A-term, Width's B-term, and Manning's n. Meteorological inputs to SSTEMP Model include maximum air temperature, air temperature, relative humidity, windspeed, ground temperature, thermal gradient, possible sun, dust coefficient, ground reflectivity, and solar radiation. In the following sections, data sources for these parameters are discussed in detail for each Assessment Unit (AU) to be modeled using SSTEMP Model. Initial input values are shown on **Table D.1**, following the discussion of data sources. Each AU was modeled on the date of the maximum recorded water temperature on the thermograph record which was used to assess impairment.

D 2.0 HYDROLOGY

D 2.1 Segment Inflow and Outflow

This parameter is the streamflow at the top and bottom of the stream segment. To be conservative, the lowest four-consecutive-day discharge that has a recurrence interval of three years, but that does not necessarily occur every three years (4Q3), was used instead of the mean daily flow. These critical low flows were used to reflect the decreased assimilative capacity of the stream to absorb and disperse solar energy.

The Clear Creek AU starts at the ungaged dam on San Gregorio Lake, so deriving flow from a watershed regression equation would not be appropriate. The lowest flow value observed (0.1 cfs, observed on August 21 and 28, 2013) at the thermograph station during the water quality survey was used for both inflow and outflow.

The 4Q3 flows were determined for the Jemez River AU inflow and outflow, by using Waltemeyer's mountainous regions regression equation (Waltemeyer, 2002; see this report Section 5.2), with input variables derived from the US Geological Survey's online tool StreamStats, Version 3.0 (https://water.usgs.gov/osw/streamstats/new_mexico.html). The regression-based 4Q3 was then added to a published flow value for Soda Springs and other geothermal input near Jemez Springs, plus the permitted design flow for the point sources at the Village of Jemez Springs WWTP and the Jemez Valley Schools.

The Rito de los Indios AU begins at a true headwaters, so a value of zero was entered for inflow, as instructed in the SSTEMP manual. The regression equation based 4Q3 value for Rito de los Indios (0.86 cfs) did not resemble the flow estimated by the WinXSPro model (0.24 cfs) at the stage at which the stream was measured. For consistency, the value estimated by WinXSPro was used as input for SSTEMP.

D 2.2 Inflow Temperature

This parameter represents the mean water temperature at the top of the segment on the modeled date. The Clear Creek AU starts at the dam on San Gregorio Lake. Water temperature was measured by SWQB in this lake on July 31, 2013, six days prior to the thermograph maximum (SSTEMP modeled date). The measured temperature at 0-1 meter depth was used for the SSTEMP model.

The Rito de los Indios AU begins at a true headwaters, so a value of zero was entered for inflow temperature, as instructed in the SSTEMP manual.

For the AU Jemez River (Zia Pueblo to Jemez Pueblo), the input value was the mean thermograph temperature on the modeled date at the nearest upstream monitoring station (31JemezR046.6). However it should be noted that this station is 9.6 kilometers distant from the modeled AU, due to the intervening section of Jemez Pueblo, where SWQB does not have jurisdiction to conduct monitoring.

D 2.3 Accretion Temperature

The temperature of the lateral inflow, barring tributaries, generally should be the same as groundwater temperature. In turn, groundwater temperature may be approximated by the mean annual air temperature. Mean annual air temperatures for 2013, obtained from the PRISM database (http://www.prism.oregonstate.edu/), were used in the absence of measured data. PRISM was queried using a 4 km grid cell covering a central portion of each AU, with the interpolation function switched on in cases where the AU spanned a number of grid cells.

D 3.0 GEOMETRY

D 3.1 Latitude

Latitude refers to the position of the stream segment on the earth's surface. Latitude was obtained from the SWQB Mapper, a GIS application, by taking the mean average between the highest and lowest values for the stream corridor for each AU.

D 3.2 Dam at Head of Segment

Clear Creek has a dam at the head of the segment. According the SSTEMP manual (Bartholow, 2002), this option is important for more accurately estimating daily maximum water temperatures. "Maximum daily water temperature is calculated by following a water parcel from solar noon to the end of the segment, allowing it to heat towards the maximum equilibrium temperature. If there is an upstream dam within a half-day's travel time from the end of the segment, a parcel of water should only be allowed to heat for this shorter time/distance. By telling SSTEMP that there is a dam at the top, it will know to heat the water only from the dam downstream."

Neither of the other AUs have a dam at the upstream end of the segment.

D 3.3 Segment Length

Segment length was obtained from the SWQB Surface Water Quality Database.

D 3.4 Upstream and Downstream Elevation

Elevations were obtained from the SWQB Mapper, a GIS application, using a USGS topographic map base layer.

D 3.5 Width's A and Width's B Term

Field measurements of particle size distribution, water surface slope, and bankfull cross-section were collected following the SWQB Standard Operating Procedure for Physical Habitat Measurements

(NMED/SWQB, 2011 and NMED/SWQB, 2013). These field data were entered into the Windows-Based Stream Channel Cross-Section Analysis (WINXSPRO 3.0) Program (USDA, 2005), to generate values for width, discharge, and Manning's n coefficient at various stages up to bankfull. Width's B Term was calculated as the slope of the regression of the natural log of width and the natural log of flow. Theoretically, the Width's A Term is the untransformed Y-intercept. However, because the width versus discharge relationship tends to break down at very low flows, Width's A Term was estimated by solving for the following equation:

$$W = A \times Q^B$$

Where,

W =Known width (feet)
A =Width's A Term (seconds per square foot)
Q =Known discharge (cfs)
B =Width's B Term (unitless)

D 3.6 Manning's n or Travel Time

Site- and stage-specific values were generated by the WINXSPRO program described above. Manning's n is a measure of channel roughness which varies with depth of flow, increasing in value at shallower stages. The Manning's n coefficient associated with the 4Q3 flow being modelled was selected.

D 4.0 METEOROLOGICAL PARAMETERS

D 4.1 Air Temperature

In the absence of measured air temperature at the thermograph stations, 24 hour mean temperature on the modelled date was obtained from the nearest available weather station posted on the New Mexico Climate Center website (https://weather.nmsu.edu/). Air temperature for the Clear Creek AUs was temperature at the Wolf Canyon weather station. Air temperature for the Jemez River AU was taken from the Jemez Dam weather station. Air temperature for the Rito de los Indios was taken from the Los Alamos 13W weather station.

D 4.2 Maximum Air Temperature

The maximum daily air temperature in SSTEMP overrides a calculated value only if the check box is checked. Since the WQS standard of concern is the T_{MAX}, which is particularly sensitive to the maximum air temperature (Bartholow, 2002), an empirical value was entered in this field. In the absence of measured air temperature at the thermograph stations, maximum temperature on the modelled date was obtained from same weather stations used for mean daily air temperature, above.

D 4.3 Relative Humidity

Mean relative humidity on the modelled date at the nearest available location was obtained from the Visual Crossing website (https://www.visualcrossing.com/). Relative humidity for the Clear Creek and Rito de los Indios AUs was from Los Alamos. Relative humidity for the Jemez River AU was from Jemez Springs.

D 4.4 Wind Speed

Wind speed is highly variable based on location, aspect and local topography. Therefor it was used as a calibration variable such that the selected value caused the SSTEMP maximum output temperature to most closely match the measured thermograph maximum on the modeled date. In all cases the selected values are intuitively plausible for the locations and dates involved.

D 4.5 Ground Temperature

Same as Accretion Temperature, above.

D 4.6 Thermal Gradient

The software default value of 1.65 was used in the absence of measured data.

D 4.7 Possible Sun

Percent possible sun was obtained from the Western Regional Climate Center (http://www.wrcc.dri.edu/htmlfiles/westcomp.sun.html#NEW_MEXICO). The nearest location with monthly possible sun data is Albuquerque.

D 4.8 Dust Coefficient

The software default value of 5 was used.

D 4.9 Ground Reflectivity

The software default value of 25% was used.

D 4.10 Solar Radiation

If you do not enter a value for solar radiation, SSTEMP will internally calculate this value. No value was entered.

D 5.0 SHADE

Estimates of vegetative canopy were generated using the attribute table of the USDA NorWest Stream Temperature Modeled Stream Temperature Scenario map for New Mexico (https://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html).

The Rito de los Indios was directly affected by the Las Conchas fire along 39% of its length. Therefore the NorWest shade value was reduced by 39%, from 25.5% shade to 15.6% shade, to better reflect conditions on the ground at the time that the temperature impairment was documented.

Table D 1 SSTEMP input data values by Assessment Unit (calibrated model)

VARIABLE	Clear Creek (Rio de las Vacas to San Gregorio Lake)	Jemez River (Zia Pueblo bnd to Jemez Pueblo bnd)	Rito de los Indios (San Antonio Creek to headwaters)
Segment Inflow (cfs)	0.1	6.53	0
Inflow Temperature (C)	18.3	24.4	0
Segment Outflow (cfs)	0.1	6.39	0.24
Accretion Temp (C)	5.5	12.4	4.5
Latitude (deg)	36.01545	35.54322	35.98778
Dam?	Yes	No	No
Segment Length (mi)	5.14	1.86	4.47
Upstream Elevation (ft)	9410	5470	9780
Downstream Elevation (ft)	8370	5450	8550
With's A Term (s/sqft)	8.66	15.77	2.42
B Term	0.2851	0.156	0.1332
Manning's n	0.371	0.015	0.113
Air Temperature (C)	16.1	26.9	15.3
Max Air Temp (C)	23.9	34.4	28.3
Relative Humidity	62.34	63.06	15.21
Wind Speed (mph)	9.6	3.1	7.2

VARIABLE	Clear Creek (Rio de las Vacas to San Gregorio Lake)	Jemez River (Zia Pueblo bnd to Jemez Pueblo bnd)	Rito de los Indios (San Antonio Creek to headwaters)
Ground Temp (C)	5.5	12.4	4.5
Thermal Gradient (j/sqm/s/C)	1.65	1.65	1.65
Possible Sun %	76	83	79
Dust Coefficient	5	5	5
Ground Reflectivity (%)	25	25	25
Total Shade (%)	37.4	3.3	25.5
Time of year	8/5/2013	7/8/2013	6/26/2013

D 6.0 REFERENCES

Bartholow, J.M. 2002. SSTEMP for Windows: The Stream Segment Temperature Model (Version 2.0). U.S. Geological Survey computer model and documentation. Available on the internet at https://www.sciencebase.gov/catalog/item/53ea4091e4b008eaa4f4c457. Revised August 2002.

New Mexico Environment Department/Surface Water Quality Bureau (NMED/SWQB). 2013. Standard Operating Procedure for Physical Habitat Measurements, Revision 2. October 1, 2013.

New Mexico Environment Department/Surface Water Quality Bureau (NMED/SWQB). 2011. Standard Operating Procedure for Physical Habitat Measurements, Revision 1. January, 2011.

U.S. Department of Agriculture (USDA). 2005. WinXSPRO 3.0. A Channel Cross Section Analyzer. WEST Consultants Inc. San Diego, CA & Utah State University.

APPENDIX E
PUBLIC COMMENTS

SWQB hosted a virtual public meeting via Webex on March 1, 2021 from 5:30 to 7:30 pm. Notes from the public meeting are available in the SWQB TMDL files in Santa Fe.

SWQB received no written public comments.

Minor changes made to the TMDL after the public comment period include:

1. References to NMAC 20.6.4.107 were removed as it does not apply to any assessment units addressed with a TMDL in the document.
2. A 2014 USGS hydrograph and accompanying text were added to Section 1.5
3. Santa Ana Pueblo was added to the list of tribes in Section 1.1
4. Updated Section 9.0
5. Minor typographic corrections throughout.

PLEASE NOTE:
When feasible, original typed letters that were not received electronically were scanned and converted to MSWord. Likewise, when feasible, letters received electronically were also converted to MSWord. All text was converted to Times New Roman 12 font with standard page margins for ease of collation. Contact information such as phone number, street addresses, and e-mail addresses from private citizens were removed for privacy reasons. All original letters of comment are on file at the SWQB office in Santa Fe, NM.