*REVIEW DRAFT*

# TOTAL MAXIMUM DAILY LOADS

## FOR THE

# JEMEZ RIVER WATERSHED

**XX 2026**

*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/**
***~or~***

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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 |
| $^{o}$C | Degrees Celsius |
| DMR | Discharge Monitoring Report |
| HQCWAL | High Quality Coldwater Aquatic Life |
| $^{o}$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 |
| 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 |
| 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 3/25/2026) |

# EXECUTIVE SUMMARY

Section 303(d), or 33 U.S.C. § 1313(d), of the Federal Water Pollution Control Act, also known as the Clean Water Act (CWA), 33 U.S.C. § 1251 *et seq*., 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 (WQS). 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 the Code of Federal Regulations at Title 40, 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 natural background conditions. TMDLS are developed with a Margin of Safety (MOS) in acknowledgement of various sources of uncertainty in the analysis. 40 C.F.R. § 130.7(c).

The New Mexico Environment Department (NMED) Surface Water Quality Bureau (SWQB) conducted a water quality survey of the Jemez River Watershed in 2021-2022 (with additional monitoring activities taking place in 2023 and 2025). Water quality monitoring stations were located to evaluate the impact of tributary streams and ambient water quality conditions. Impairments addressed in this TMDL document, as well as existing approved TMDLs, are shown on Tables ES-1 to ES-25, below. Additional information regarding these impairments is available in the 2026-2028 Clean Water Act §303(d)/§305(b) Integrated Report and List (IR) (NMED/SWQB, 2026). This TMDL does not address all water quality impairments in the project area, only new listings based on 2021-2022 data, plus one older impairment (first listed in 2016 Integrated List) for the assessment unit Clear Creek (San Gregorio Lake to headwaters) which did not yet have a TMDL using data collected in 2013. Previous TMDLs were developed for other impairments in these watersheds; those TMDLs are available online at: https://www.env.nm.gov/surface-water-quality/tmdl/. Information regarding all impairments is available in the 2026-2028 Clean Water Act §303(d)/§305(b) Integrated Report and List (IR) (NMED/SWQB, 2026). The SWQB interactive Mapper (https://gis.web.env.nm.gov/oem/?map=swqb) provides a convenient interface to see where impairments exist, and to search for information about waterbodies of interest using the Identify Features tool.

The next water quality monitoring survey of the Jemez River Watershed is scheduled for 2031-2032, at which time TMDL targets will be re-examined and potentially revised, as this document is considered to be an evolving management plan. In the event that new data indicates that the targets used in this analysis are not appropriate and/or if new standards are adopted, the TMDL 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. American Creek (Rio de las Palomas to headwaters) | |
|---|---|
| New Mexico Standard's Segment | 20.6.4.108 NMAC |
| Assessment Unit Identifier | NM-2106.A_44 |
| NPDES Permit(s) | None |
| Segment Length (miles) | 4.99 |
| Parameters of Concern | *E. coli*, Temperature |
| Designated Uses Affected | PC, HQCWAL |
| USGS Hydrologic Unit Code | 13020202 - Jemez |
| Scope/Size of Watershed ($mi^2$) | 7.50 |
| Land Type | Ecoregion 21e: Sedimentary Subalpine Forests (28.4%)<br>Ecoregion 21f: Sedimentary Mid-Elevation Forests (71.6%) |
| Land Use/Cover | 96.5% forest, 1.9% shrubland, 1% wetlands, 0.5% herbaceous, 0.1% developed |
| Land Ownership/Management | 98.9% Forest Service, 1.1% Private |
| Geology | 87.5% purely sedimentary, 6.9% purely unconsolidated, 5.6% purely igneous |
| Probable Sources* | Grazing in riparian zone; Rangeland grazing; Wildlife other than waterfowl |
| IR Category | 5/5A |
| Priority Ranking | High |
| Existing TMDLs | None |
| | **WLA + LA + MOS = TMDL** |
| Temperature (kJ/day)<br><br>*E. Coli* (cfu/day) | $0.0 + 1.53 \times 10^7 + 3.82 \times 10^6 = 1.91 \times 10^7$<br><br>$0.0 + 3.49 \times 10^8 + 3.88 \times 10^8 = 8.26 \times 10^8$ |

**Probable Sources are a qualitative, alphabetical list. See section 3.4 & 6.4 for details.*

| Table ES-2. Calaveras Creek (Rio Cebolla to headwaters) | |
|---|---|
| New Mexico Standard's Segment | 20.6.4.108 NMAC |
| Assessment Unit Identifier | NM-2106.A_53 |
| NPDES Permit(s) | None |
| Segment Length (miles) | 9.51 |
| Parameters of Concern | Total Recoverable Aluminum |
| Designated Uses Affected | HQCWAL |
| USGS Hydrologic Unit Code | 13020202 - Jemez |
| Scope/Size of Watershed ($mi^2$) | 16.50 |
| Land Type | Ecoregion 21f: Sedimentary Mid-Elevation Forests (2.7%)<br>Ecoregion 21g: Volcanic Subalpine Forests (3.1%)<br>Ecoregion 21h: Volcanic Mid-Elevation Forests (94.2%) |
| Land Use/Cover | 93.4% forest, 4.2% herbaceous, 0.9% shrubland, 0.9% wetlands, 0.6% developed |
| Land Ownership/Management | 96.5% Forest Service, 3.3% Private, 0.2% State |
| Geology | 89.4% purely igneous, 8.2% sedimentary and unconsolidated, 2.4% purely sedimentary |
| Probable Sources* | Grazing in riparian zone; Other recreational pollution sources; Roads/bridges |
| IR Category | 5/5B |
| Priority Ranking | High |
| Existing TMDLs | None |
| | **WLA + LA + MOS = TMDL** |
| Total Recoverable Aluminum (lbs/day) | 0.0 + 0.315 + 0.056 = 0.37 |

**Probable Sources are a qualitative, alphabetical list. See section 2.4 for details.*

| Table ES-3. Clear Creek (Rio de las Vacas to San Gregorio Lake) | |
|---|---|
| New Mexico Standard's Segment | 20.6.4.108 NMAC |
| Assessment Unit Identifier | NM-2106.A_54 |
| NPDES Permit(s) | None |
| Segment Length (miles) | 5.37 |
| Parameters of Concern | Total Recoverable Aluminum |
| Designated Uses Affected | HQCWAL |
| USGS Hydrologic Unit Code | 13020202 - Jemez |
| Scope/Size of Watershed ($mi^2$) | 10.48 |
| Land Type | Ecoregion 21b: Crystalline Subalpine Forests (53.4%)<br>Ecoregion 21c: Crystalline Mid-Elevation Forests (15.8%)<br>Ecoregion 21f: Sedimentary Mid-Elevation Forests (30.8%) |
| Land Use/Cover | 92.5% forest, 3.6% wetlands, 1.8% shrubland, 1.1% developed, 0.7% herbaceous, 0.3% water |
| Land Ownership/Management | 100% Forest Service |
| Geology | 49.7% purely igneous, 34.6% purely sedimentary, 11.6% igneous and metamorphic, 4.1% purely unconsolidated |
| Probable Sources* | Dams/diversion; Flow alteration; Other recreational pollution sources; Rangeland grazing |
| IR Category | 5/5A |
| Priority Ranking | High |
| Existing TMDLs | Total Organic Carbon TMDL (2003), Turbidity TMDL (2003), *E. Coli* TMDL (2016), Nutrients TMDL (2016), Temperature TMDL (2021) |
| | **WLA + LA + MOS = TMDL** |
| Total Recoverable Aluminum (lbs/day) | 0.00 + 0.35 + 0.06 = 0.41 |

**Probable Sources are a qualitative, alphabetical list. See section 2.4 for details.*

| Table ES-4. Clear Creek (San Gregorio Lake to headwaters) | |
|---|---|
| New Mexico Standard's Segment | 20.6.4.108 NMAC |
| Assessment Unit Identifier | NM-2106.A_55 |
| NPDES Permit(s) | None |
| Segment Length (miles) | 3.75 |
| Parameters of Concern | Total Recoverable Aluminum |
| Designated Uses Affected | HQCWAL |
| USGS Hydrologic Unit Code | 13020202 - Jemez |
| Scope/Size of Watershed ($mi^2$) | 2.75 |
| Land Type | Ecoregion 21b: Crystalline Subalpine Forests (100%) |
| Land Use/Cover | 94.4% forest, 3.7% wetlands, 1.9% herbaceous |
| Land Ownership/Management | 100% Forest Service |
| Geology | 51.1% purely igneous, 33.3% igneous and metamorphic, 15.6% sedimentary and unconsolidated |
| Probable Sources* | Other recreational pollution sources; Rangeland grazing; Roads/bridges |
| IR Category | 5/5B |
| Priority Ranking | High |
| Existing TMDLs | Nutrients TMDL (2016) |
| | **WLA + LA + MOS = TMDL** |
| Total Recoverable Aluminum (lbs/day) | 0.00 + 0.13 + 0.02 = 0.16 |

**Probable Sources are a qualitative, alphabetical list. See section 2.4 for details.*

| Table ES-5. East Fork Jemez (San Antonio Creek to VCNP bnd) | |
|---|---|
| New Mexico Standard's Segment | 20.6.4.108 NMAC |
| Assessment Unit Identifier | NM-2106.A_13 |
| NPDES Permit(s) | None |
| Segment Length (miles) | 11.76 |
| Parameters of Concern | Total Recoverable Aluminum |
| Designated Uses Affected | HQCWAL |
| USGS Hydrologic Unit Code | 13020202 - Jemez |
| Scope/Size of Watershed ($mi^2$) | 67.72 |
| Land Type | Ecoregion 21g: Volcanic Subalpine Forests (15.2%)<br>Ecoregion 21h: Volcanic Mid-Elevation Forests (56.0%)<br>Ecoregion 21j: Grassland Parks (28.8%) |
| Land Use/Cover | 40.4% forest, 29.3% shrubland, 24.4% herbaceous, 4.1% wetlands, 1.8% developed, less than 0.1% each – barren, planted/cultivated, water |
| Land Ownership/Management | 74.5% National Park Service, 21.8% Forest Service, 3.7% Private |
| Geology | 61.6% purely igneous, 28.3% purely unconsolidated, 8.3% igneous and sedimentary, 1.8% sedimentary |
| Probable Sources* | Other recreational pollution sources; Rangeland grazing; Roads/bridges |
| IR Category | 5/5B |
| Priority Ranking | High |
| Existing TMDLs | Temperature TMDL (2008) |
| | **WLA + LA + MOS = TMDL** |
| Total Recoverable Aluminum (lbs/day) | 0.00 + 1.165 + 0.205 = 1.37 |

**Probable Sources are a qualitative, alphabetical list. See section 2.4 for details.*

| Table ES-6.  East Fork Jemez (VCNP to headwaters) | |
|---|---|
| New Mexico Standard's Segment | 20.6.4.108 NMAC |
| Assessment Unit Identifier | NM-2106.A_10 |
| NPDES Permit(s) | None |
| Segment Length (miles) | 10.44 |
| Parameters of Concern | Total Recoverable Aluminum |
| Designated Uses Affected | HQCWAL |
| USGS Hydrologic Unit Code | 13020202 - Jemez |
| Scope/Size of Watershed (mi$^2$) | 44.10 |
| Land Type | Ecoregion 21g: Volcanic Subalpine Forests (17.0%)<br>Ecoregion 21h: Volcanic Mid-Elevation Forests (39.2%)<br>Ecoregion 21j: Grassland Parks (43.8%) |
| Land Use/Cover | 34.7% shrubland, 33.5% herbaceous, 25.4% forest, 5.9% wetlands, less than 0.1% water |
| Land Ownership/Management | 98.6% National Park Service, 1.4% Forest Service, less than 0.1% Private |
| Geology | 44.8% purely igneous, 42.5% purely unconsolidated, 12.7% igneous and sedimentary |
| Probable Sources* | Grazing in riparian zone; Rangeland grazing; Wildlife other than waterfowl |
| IR Category | 5/5B |
| Priority Ranking | High |
| Existing TMDLs | Temperature TMDL (2006), Nutrients TMDL (2016) |
| | **WLA + LA + MOS = TMDL** |
| Total Recoverable Aluminum (lbs/day) | 0.00 + 0.69 + 0.12 = 0.82 |

**Probable Sources are a qualitative, alphabetical list.  See section 2.4 for details.*

| Table ES-7. Fenton Lake | |
|---|---|
| New Mexico Standard's Segment | 20.6.4.108 NMAC |
| Assessment Unit Identifier | NM-2106.B_00 |
| NPDES Permit(s) | None |
| Segment Size (acres) | 27.95 |
| Parameters of Concern | Plant Nutrients |
| Designated Uses Affected | HQCWAL |
| USGS Hydrologic Unit Code | 13020202 - Jemez |
| Scope/Size of Watershed ($mi^2$) | 47.30 |
| Land Type | Ecoregion 21f: Sedimentary Mid-Elevation Forests (0.9%)<br>Ecoregion 21g: Volcanic Subalpine Forests (13.8%)<br>Ecoregion 21h: Volcanic Mid-Elevation Forests (85.3%) |
| Land Use/Cover | 87.8% forest, 5.6% shrubland, 4.3% herbaceous, 1.1% wetlands, 0.9% developed, 0.2% water, 0.1% planted/cultivated |
| Land Ownership/Management | 91.7% Forest Service, 5% National Park Service, 2.7% Private, 0.6% State |
| Geology | 95.3% purely igneous, 3.8% sedimentary and unconsolidated, 0.9% purely sedimentary |
| Probable Sources* | Other recreational pollution sources; Rangeland grazing; Roads/bridges |
| IR Category | 5/5A |
| Priority Ranking | High |
| Existing TMDLs | None |
| | **WLA + LA + MOS = TMDL** |
| Total nitrogen (lbs/day)<br><br>Total phosphorus (lbs/day) | 0 + 403.0 + 44.8 = 447.8<br><br>0 + 13.4 + 1.5 = 14.9 |

**Probable Sources are a qualitative, alphabetical list. See section 4.4 for details.*

| **Table ES-8. Jaramillo Creek (East Fork Jemez to headwaters)** | |
|---|---|
| New Mexico Standard's Segment | 20.6.4.108 NMAC |
| Assessment Unit Identifier | NM-2106.A_12 |
| NPDES Permit(s) | None |
| Segment Length (miles) | 12.16 |
| Parameters of Concern | Total Recoverable Aluminum, *E. coli*, Sedimentation |
| Designated Uses Affected | PC, HQCWAL |
| USGS Hydrologic Unit Code | 13020202 - Jemez |
| Scope/Size of Watershed ($mi^2$) | 15.95 |
| Land Type | Ecoregion 21g: Volcanic Subalpine Forests (23.6%)<br>Ecoregion 21h: Volcanic Mid-Elevation Forests (40.1%)<br>Ecoregion 21j: Grassland Parks (36.3%) |
| Land Use/Cover | 34.9% shrubland, 30.2% forest, 29.7% herbaceous, 5.2% wetlands, less than 0.1% developed |
| Land Ownership/Management | 100% National Park Service |
| Geology | 42.1% purely igneous, 29.9% purely unconsolidated, 28% igneous and sedimentary |
| Probable Sources* | Grazing in riparian zone; Other recreational pollution sources; Rangeland grazing; Wildlife other than waterfowl |
| IR Category | 5/5A/5B |
| Priority Ranking | High |
| Existing TMDLs | Turbidity TMDL (2006), Temperature TMDL (2006), Nutrients TMDL (2016) |
| | **WLA + LA + MOS = TMDL** |
| Total Recoverable Aluminum (lbs/day) | 0.00 + 0.35 + 0.06 = 0.41 |
| *E. Coli* (cfu/day) | $0.00 + 8.26 \times 10^8 + 9.18 \times 10^7 = 9.18 \times 10^8$ |
| Sedimentation (lb TSS/day) | 0 + 11.22 + 2.80 = 14.02 |

**Probable Sources are a qualitative, alphabetical list. See section 2.4, 3.4 & 5.4 for details.*

| Table ES-9.  Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | |
|---|---|
| New Mexico Standard's Segment | 20.6.4.107 NMAC |
| Assessment Unit Identifier | NM-2105_71 |
| NPDES Permit(s) | Jemez Valley Public Schools - NM0028479 |
| Segment Length (miles) | 1.98 |
| Parameters of Concern | Nutrients, Temperature, Turbidity |
| Designated Uses Affected | CWAL |
| USGS Hydrologic Unit Code | 13020202 - Jemez |
| Scope/Size of Watershed ($mi^2$) | 472.63 |
| Land Type | Ecoregion 21b: Crystalline Subalpine Forests (4.0%)<br>Ecoregion 21c: Crystalline Mid-Elevation Forests (7.6%)<br>Ecoregion 21d: Foothill Shrublands (8.9%)<br>Ecoregion 21e: Sedimentary Subalpine Forests (1.9%)<br>Ecoregion 21f: Sedimentary Mid-Elevation Forests (16.4%)<br>Ecoregion 21g: Volcanic Subalpine Forests (9.7%)<br>Ecoregion 21h: Volcanic Mid-Elevation Forests (43.2%)<br>Ecoregion 21j: Grassland Parks (8.1%)<br>Ecoregion 22m: Albuquerque Basin (0.2%) |
| Land Use/Cover | 68.2% forest, 19.4% shrubland, 8.8% herbaceous, 2.5% wetlands, 1% developed, 0.1% planted/cultivated, less than 0.1% - barren and water |
| Land Ownership/Management | 66% Forest Service, 29% National Park Service, 4.6% Private, 0.3% Tribal, 0.1% State |
| Geology | 56.5% purely igneous, 24.2% purely sedimentary, 8.8% purely unconsolidated, 6.6% igneous and sedimentary, 2.2% igneous and metamorphic, 1.7% sedimentary and unconsolidated |
| Probable Sources | Crop production; Dams/diversion; Irrigated crop production; Onsite treatment systems; Roads/bridges; Wildlife other than waterfowl |
| IR Category[+] | 4A/5A |
| Priority Ranking | High |
| Existing TMDLs | Arsenic TMDL (2009), Boron TMDL (2009), *E. coli* TMDL (2016) |
| | **WLA + LA + MOS = TMDL** |
| Temperature (kJ/day) | $0 + 9.71 \times 10^8 + 2.43 \times 10^8 = 1.21 \times 10^9$ |
| Total Nitrogen (lbs/day)<br><br>Total Phosphorus (lbs/day) | 0.035 + 14.94 + 1.66 = 16.64<br><br>0.009 + 3.73 + 0.42 = 4.16 |

| Turbidity (lbs TSS/day) | **Duration (consecutive days)** | **WLA** | **MOS (X%)** | **LA** | **TMDL** |
|---|---|---|---|---|---|
| | 3 | 2.22 | 157.97 | 892.95 | 1053.14 |
| | 4 | 2.01 | 143.37 | 810.43 | 955.81 |
| | 5 | 1.88 | 133.64 | 755.42 | 890.93 |
| | 6 | 1.74 | 123.91 | 700.41 | 826.05 |
| | 7 | 1.67 | 119.04 | 672.90 | 793.61 |
| | 14 | 1.40 | 99.58 | 562.87 | 663.85 |
| | 30 | 1.12 | 80.11 | 452.85 | 534.09 |

**Probable Sources are a qualitative, alphabetical list. See sections 4.4, 6.4 & 7.4 for details.*

*+Nutrients: Category 4A; Temperature & Turbidity: Category 5A*

| Table ES-10. Jemez River (Rio Guadalupe to Soda Dam nr Jemez Springs) | |
|---|---|
| New Mexico Standard's Segment | 20.6.4.107 NMAC |
| Assessment Unit Identifier | NM-2105.5_10 |
| NPDES Permit(s) | Jemez Springs, Village of/WWTP – NM0028011 |
| Segment Length (miles) | 10.48 |
| Parameters of Concern | Nutrients |
| Designated Uses Affected | HQCWAL |
| USGS Hydrologic Unit Code | 13020202 - Jemez |
| Scope/Size of Watershed ($mi^2$) | 200.97 |
| Land Type | Ecoregion 21d: Foothill Shrublands (10.8%)<br>Ecoregion 21g: Volcanic Subalpine Forests (19.5%)<br>Ecoregion 21h: Volcanic Mid-Elevation Forests (50.7%)<br>Ecoregion 21j: Grassland Parks (19.0%) |
| Land Use/Cover | 51.1% forest, 15.5% shrubland, 30.5% herbaceous, 1.2% wetlands, 1.6% developed, less than 0.1% - barren, hay/pasture, and water |
| Land Ownership/Management | 67.1% National Park Service, 27.4% Forest Service, 5.4% Private, 0.1% Tribal |
| Geology | 53.3% purely igneous, 20.5% purely unconsolidated, 15.6% igneous and sedimentary, 10.5% purely sedimentary |
| Probable Sources | Dams/diversion; Onsite treatment systems; Roads/bridges; Wildlife other than waterfowl |
| IR Category | 4A |
| Priority Ranking | High |
| Existing TMDLs | Sediment (2004), Turbidity TMDL (2004), Nutrients TMDL (2009), Arsenic TMDL (2009), Boron TMDL (2009), Temperature TMDL (2009), *E. Coli* TMDL (2016), Aluminum TMDL (2018) |
| | **WLA + LA + MOS = TMDL** |
| Total Nitrogen (lbs/day)<br><br>Total Phosphorus (lbs/day) | 0.035 + 14.94 + 1.66 = 16.64<br><br>0.009 + 3.73 + 0.42 = 4.15 |

**Probable Sources are a qualitative, alphabetical list. See section 4.4 for details.*

| **Table ES-11. La Jara Creek (East Fork Jemez to headwaters)** | |
|---|---|
| New Mexico Standard's Segment | 20.6.4.108 NMAC |
| Assessment Unit Identifier | NM-2106.A_11 |
| NPDES Permit(s) | None |
| Segment Length (miles) | 5.40 |
| Parameters of Concern | Total Recoverable Aluminum, Temperature |
| Designated Uses Affected | HQCWAL |
| USGS Hydrologic Unit Code | 13020202 - Jemez |
| Scope/Size of Watershed ($mi^2$) | 5.90 |
| Land Type | Ecoregion 21g: Volcanic Subalpine Forests (34.6%)<br>Ecoregion 21h: Volcanic Mid-Elevation Forests (32.0%)<br>Ecoregion 21j: Grassland Parks (33.4%) |
| Land Use/Cover | 37.5% shrubland, 34.6% herbaceous, 18.4% forest, 9.4% wetlands, less than 0.1% - developed and water |
| Land Ownership/Management | 100% National Park Service |
| Geology | 56.5% purely igneous, 39% purely unconsolidated, 4.5% igneous and sedimentary |
| Probable Sources | Other recreational pollution; Rangeland grazing; Wildlife other than waterfowl |
| IR Category | 5/5A/5B |
| Priority Ranking | High |
| Existing TMDLs | None |
| | **WLA + LA + MOS = TMDL** |
| Total Recoverable Aluminum (lbs/day)<br><br>Temperature (kJ/day) | 0.00 + 0.07 + 0.01 = 0.08<br><br>$0 + 1.64 \times 10^7 + 4.09 \times 10^6 = 2.05 \times 10^7$ |

**Probable Sources are a qualitative, alphabetical list. See section 2.4 & 6.4 for details.*

| **Table ES-12. Redondo Creek (Sulphur Creek to headwaters)** | |
|---|---|
| New Mexico Standard's Segment | 20.6.4.108 NMAC |
| Assessment Unit Identifier | NM-2106.A_21 |
| NPDES Permit(s) | None |
| Segment Length (miles) | 6.34 |
| Parameters of Concern | Dissolved Aluminum |
| Designated Uses Affected | HQCWAL |
| USGS Hydrologic Unit Code | 13020202 - Jemez |
| Scope/Size of Watershed ($mi^2$) | 11.48 |
| Land Type | Ecoregion 21g: Volcanic Subalpine Forests (29.6%)<br>Ecoregion 21h: Volcanic Mid-Elevation Forests (70.4%) |
| Land Use/Cover | 67.8% forest, 22.5% shrubland, 6.6% herbaceous, 1.6% wetlands, 1.1% developed, 0.4% planted/cultivated, less than 0.1% - barren |
| Land Ownership/Management | 93.3% National Park Service, 6.7% Forest Service, less than 0.1% - Private |
| Geology | 64.9% purely igneous, 24.4% igneous and sedimentary, 10.7% purely unconsolidated |
| Probable Sources | Other recreational pollution; Rangeland grazing; Wildlife other than waterfowl |
| IR Category | 5/5A/5B |
| Priority Ranking | High |
| Existing TMDLs | Total Phosphorus TMDL (1999), Turbidity TMDL (2003), Temperature TMDL (2003) |
| | **WLA + LA + MOS = TMDL** |
| Dissolved Aluminum (lbs/day) | 0 + 0.08 + 0.01 = 0.09 |

**Probable Sources are a qualitative, alphabetical list. See section 2.4 for details.*

<table>
<tr><th colspan="6">Table ES-13. Rio Cebolla (Fenton Lake to headwaters)</th></tr>
<tr><td>New Mexico Standard's Segment</td><td colspan="5">20.6.4.108 NMAC</td></tr>
<tr><td>Assessment Unit Identifier</td><td colspan="5">NM-2106.A_52</td></tr>
<tr><td>NPDES Permit(s)</td><td colspan="5">NMDGF/Seven Springs Fish Hatchery - NM0030112 (2 outfalls)</td></tr>
<tr><td>Segment Length (miles)</td><td colspan="5">15.68</td></tr>
<tr><td>Parameters of Concern</td><td colspan="5">Total Recoverable Aluminum, Nutrients, Turbidity</td></tr>
<tr><td>Designated Uses Affected</td><td colspan="5">HQCWAL</td></tr>
<tr><td>USGS Hydrologic Unit Code</td><td colspan="5">13020202 - Jemez</td></tr>
<tr><td>Scope/Size of Watershed ($mi^2$)</td><td colspan="5">43.70</td></tr>
<tr><td>Land Type</td><td colspan="5">Ecoregion 21f: Sedimentary Mid-Elevation Forests (1.0%)<br>Ecoregion 21g: Volcanic Subalpine Forests (14.9%)<br>Ecoregion 21h: Volcanic Mid-Elevation Forests (84.1%)</td></tr>
<tr><td>Land Use/Cover</td><td colspan="5">91.6% forest, 4.2% herbaceous, 2.3% shrubland, 1.1% wetlands, 0.6% developed, 0.1% planted/cultivated, 0.1% water</td></tr>
<tr><td>Land Ownership/Management</td><td colspan="5">91.6% Forest Service, 5.5% National Park Service, 2.4% Private, 0.5% State</td></tr>
<tr><td>Geology</td><td colspan="5">94.9% purely igneous, 4.2% sedimentary and unconsolidated, 0.9% purely sedimentary</td></tr>
<tr><td>Probable Sources</td><td colspan="5">Deer; Illegal dumps or other inappropriate waste disposal; Grazing in riparian zone; Other recreational pollution sources; Onsite fishery; Roads/bridges; Waterfowl</td></tr>
<tr><td>IR Category</td><td colspan="5">5/5B/5C</td></tr>
<tr><td>Priority Ranking</td><td colspan="5">High</td></tr>
<tr><td>Existing TMDLs</td><td colspan="5">Sedimentation TMDL (2003), Temperature TMDL (2003)</td></tr>
<tr><th></th><th colspan="5">WLA + LA + MOS = TMDL</th></tr>
<tr><td>Total Recoverable Aluminum (lbs/day)<br><br>Total nitrogen (lbs/day)<br><br>Total phosphorus (lbs/day)</td><td colspan="5">1.52 + 0.47 + 0.35 = 2.34<br><br>5.32 + 1.37 + 0.74 = 7.44<br><br>1.33 + 0.34 + 0.19 = 1.86</td></tr>
<tr><td rowspan="6">Turbidity (lbs TSS/day)</td><th>Duration (consecutive days)</th><th>WLA</th><th>MOS (X%)</th><th>LA</th><th>TMDL</th></tr>
<tr><td>3</td><td>235.38</td><td>97.21</td><td>315.47</td><td>648.06</td></tr>
<tr><td>4</td><td>207.93</td><td>85.87</td><td>278.68</td><td>572.48</td></tr>
<tr><td>5</td><td>189.63</td><td>78.31</td><td>254.15</td><td>522.09</td></tr>
<tr><td>6</td><td>171.33</td><td>70.76</td><td>229.62</td><td>471.70</td></tr>
<tr><td>7</td><td>162.18</td><td>66.98</td><td>217.36</td><td>446.51</td></tr>
</table>

| | | | | | |
|---|---|---|---|---|---|
| | 14 | 125.57 | 51.86 | 168.30 | 345.74 |
| | 30 | 88.97 | 36.74 | 119.25 | 244.96 |

**Probable Sources are a qualitative, alphabetical list. See section 2.4, 4.4 & 7.4 for details.*

| Table ES-14. Rio Cebolla (Rio de las Vacas to Fenton Lake) | |
|---|---|
| New Mexico Standard's Segment | 20.6.4.108 NMAC |
| Assessment Unit Identifier | NM-2106.A_50 |
| NPDES Permit(s) | None |
| Segment Length (miles) | 7.25 |
| Parameters of Concern | *E. coli,* Temperature |
| Designated Uses Affected | HQCWAL, PC |
| USGS Hydrologic Unit Code | 13020202 - Jemez |
| Scope/Size of Watershed ($mi^2$) | 66.14 |
| Land Type | Ecoregion 21f: Sedimentary Mid-Elevation Forests (5.0%)<br>Ecoregion 21g: Volcanic Subalpine Forests (9.9%)<br>Ecoregion 21h: Volcanic Mid-Elevation Forests (85.1%) |
| Land Use/Cover | 84.3% forest, 9% shrubland, 4.2% herbaceous, 1.4% wetlands, 0.8% developed, 0.2% planted/cultivated 0.1% water, less than 0.1% - barren |
| Land Ownership/Management | 91.8% Forest Service, 3.9% Private, 3.6% National Park Service, 0.7% State |
| Geology | 92.7% purely igneous, 4.6% purely sedimentary, 2.7% sedimentary and unconsolidated |
| Probable Sources | Other recreational pollution sources; Rangeland grazing; Roads/bridges; Wildlife other than waterfowl |
| IR Category | 5/5A |
| Priority Ranking | High |
| Existing TMDLs | Sedimentation/Siltation TMDL (2003) |
| | **WLA + LA + MOS = TMDL** |
| Temperature (kJ/day)<br><br>*E. Coli* (cfu/day) | $0 + 8.46 \times 10^7 + 2.12 \times 10^7 = 1.06 \times 10^8$<br><br>$0.00 + 1.93 \times 10^9 + 2.15 \times 10^8 = 2.15 \times 10^9$ |

**Probable Sources are a qualitative, alphabetical list. See section 3.4 & 6.4 for details.*

| Table ES-15. Rio de las Vacas (Clear Creek to headwaters) | |
|---|---|
| New Mexico Standard's Segment | 20.6.4.108 NMAC |
| Assessment Unit Identifier | NM-2106.A_46 |
| NPDES Permit(s) | None |
| Segment Length (miles) | 10.66 |
| Parameters of Concern | Total Recoverable Aluminum |
| Designated Uses Affected | HQCWAL |
| USGS Hydrologic Unit Code | 13020202 - Jemez |
| Scope/Size of Watershed ($mi^2$) | 16.45 |
| Land Type | Ecoregion 21b: Crystalline Subalpine Forests (78.3%)<br>Ecoregion 21c: Crystalline Mid-Elevation Forests (9.7%)<br>Ecoregion 21e: Sedimentary Subalpine Forests (9.2%)<br>Ecoregion 21f: Sedimentary Mid-Elevation Forests (2.8%) |
| Land Use/Cover | 87.5% forest, 6.9% wetlands, 4.4% herbaceous, 1.1% shrubland, less than 0.1% - developed and water |
| Land Ownership/Management | 100% Forest Service |
| Geology | 80.1% purely igneous, 13.1% sedimentary and unconsolidated, 4.9% igneous and metamorphic, 1.9% purely sedimentary |
| Probable Sources | Other recreational pollution sources; Rangeland grazing; Roads/bridges |
| IR Category | 5/5B/5C |
| Priority Ranking | High |
| Existing TMDLs | None |
| | **WLA + LA + MOS = TMDL** |
| Total Recoverable Aluminum (lbs/day) | 0.00 + 0.65 + 0.11 = 0.76 |

**Probable Sources are a qualitative, alphabetical list. See section 2.4 for details.*

| Table ES-16. Rito Penas Negras (Rio de las Vacas to headwaters) | |
|---|---|
| New Mexico Standard's Segment | 20.6.4.108 NMAC |
| Assessment Unit Identifier | NM-2106.A_42 |
| NPDES Permit(s) | None |
| Segment Length (miles) | 10.10 |
| Parameters of Concern | *E. coli* |
| Designated Uses Affected | PC |
| USGS Hydrologic Unit Code | 13020202 - Jemez |
| Scope/Size of Watershed ($mi^2$) | 17.01 |
| Land Type | Ecoregion 21e: Sedimentary Subalpine Forests (20.6%)<br>Ecoregion 21f: Sedimentary Mid-Elevation Forests (62.3%)<br>Ecoregion 21h: Volcanic Mid-Elevation Forests (17.1%) |
| Land Use/Cover | 87% forest, 5.7% herbaceous, 3.8% wetlands, 3% shrubland, 0.4% developed, less than 0.1% - planted/cultivated and water |
| Land Ownership/Management | 94.3% Forest Service, 5.7% Private |
| Geology | 67.9% purely sedimentary, 18.5% purely igneous, 13.6% sedimentary and unconsolidated |
| Probable Sources | Other recreational pollution sources; Rangeland grazing; Roads/bridges |
| IR Category | 5/5A |
| Priority Ranking | High |
| Existing TMDLs | Sedimentation TMDL (2003), Temperature TMDL (2003), Total Organic Carbon TMDL (2003), Nutrients TMDL (2009) |
| | **WLA + LA + MOS = TMDL** |
| *E. Coli* (cfu/day) | $0.00 + 7.43 \times 10^8 + 8.26 \times 10^7 = 8.26 \times 10^8$ |

**Probable Sources are a qualitative, alphabetical list. See section 3.4 for details.*

| Table ES-17. Rito de los Indios (San Antonio Creek to headwaters) | |
|---|---|
| New Mexico Standard's Segment | 20.6.4.108 NMAC |
| Assessment Unit Identifier | NM-2106.A_24 |
| NPDES Permit(s) | None |
| Segment Length (miles) | 4.57 |
| Parameters of Concern | Total Recoverable Aluminum, Nutrients |
| Designated Uses Affected | HQCWAL |
| USGS Hydrologic Unit Code | 13020202 - Jemez |
| Scope/Size of Watershed ($mi^2$) | 7.30 |
| Land Type | Ecoregion 21g: Volcanic Subalpine Forests (64.2%)<br>Ecoregion 21h: Volcanic Mid-Elevation Forests (30.9%)<br>Ecoregion 21j: Grassland Parks (4.9%) |
| Land Use/Cover | 49.7% forest, 32.7 shrubland, 17.1% herbaceous, 0.5% wetlands, less than 0.1% - barren and developed |
| Land Ownership/Management | 87.3% National Park Service, 12.3% Forest Service, 0.4% Tribal |
| Geology | 45.8% purely igneous, 41.2% igneous and sedimentary, 13% purely unconsolidated |
| Probable Sources | Other recreational pollution sources; Rangeland grazing |
| IR Category | 5/5A/5B |
| Priority Ranking | High |
| Existing TMDLs | Temperature TMDL (2021), Turbidity TMDL (2021) |
| | **WLA + LA + MOS = TMDL** |
| Total Recoverable Aluminum (lbs/day)<br><br>Total nitrogen (lbs/day)<br><br>Total phosphorus (lbs/day) | 0.00 + 0.19 + 0.03 = 0.22<br><br>0 + 0.50 + 0.06 = 0.56<br><br>0 + 0.13 + 0.01 = 0.14 |

**Probable Sources are a qualitative, alphabetical list. See section 2.4 & 4.4 for details.*

| Table ES-18. San Antonio Creek (East Fork Jemez to VCNP bnd) | |
|---|---|
| New Mexico Standard's Segment | 20.6.4.108 NMAC |
| Assessment Unit Identifier | NM-2106.A_20 |
| NPDES Permit(s) | None |
| Segment Length (miles) | 12.62 |
| Parameters of Concern | Total Recoverable Aluminum |
| Designated Uses Affected | HQCWAL |
| USGS Hydrologic Unit Code | 13020202 - Jemez |
| Scope/Size of Watershed ($mi^2$) | 104.94 |
| Land Type | Ecoregion 21g: Volcanic Subalpine Forests (27.6%)<br>Ecoregion 21h: Volcanic Mid-Elevation Forests (54.6%)<br>Ecoregion 21j: Grassland Parks (17.8%) |
| Land Use/Cover | 58.7% forest, 21.3% shrubland, 15.7% herbaceous, 3.1% wetlands, 1% developed, less than 0.1% - barren, planted/cultivated, and water |
| Land Ownership/Management | 80.4% National Park Service, 17.3% Forest Service, 2.2% Private, 0.1% Tribal, less than 0.1% - barren, planted/cultivated, and water |
| Geology | 52.5% purely igneous, 24.6% igneous and sedimentary, 20.9% purely unconsolidated, 2% purely sedimentary |
| Probable Sources | Other recreational pollution sources; Rangeland grazing; Roads/bridges |
| IR Category | 5/5B |
| Priority Ranking | High |
| Existing TMDLs | Temperature TMDL (2003), Turbidity TMDL (2003), Arsenic TMDL (2009) |
| | **WLA + LA + MOS = TMDL** |
| Total Recoverable Aluminum (lbs/day) | 0.00 + 4.91 + 0.87 = 5.78 |

**Probable Sources are a qualitative, alphabetical list. See section 2.4 for details.*

| Table ES-19. San Antonio Creek (VCNP bnd to headwaters) | |
|---|---|
| New Mexico Standard's Segment | 20.6.4.108 NMAC |
| Assessment Unit Identifier | NM-2106.A_26 |
| NPDES Permit(s) | None |
| Segment Length | 19.5 |
| Parameters of Concern | Nutrients, Total Recoverable Aluminum |
| Designated Uses Affected | HQCWAL |
| USGS Hydrologic Unit Code | 13020202 - Jemez |
| Scope/Size of Watershed ($mi^2$) | 61.98 |
| Land Type | Ecoregion 21g: Volcanic Subalpine Forests (34.6%)<br>Ecoregion 21h: Volcanic Mid-Elevation Forests (36.3%)<br>Ecoregion 21j: Grassland Parks (29.1%) |
| Land Use/Cover | 44.2% forest, 27.9% shrubland, 23.4% herbaceous, 4.5% wetlands, less than 0.1% - barren, developed, and water |
| Land Ownership/Management | 86.9% National Park Service, 9.9% Forest Service, 3.2% Private |
| Geology | 44.4% purely igneous, 28.3% purely unconsolidated, 27.3% igneous and sedimentary |
| Probable Sources | Other recreational pollution; Rangeland grazing; Wildlife other than waterfowl |
| IR Category | 5/5B |
| Priority Ranking | High |
| Existing TMDLs | Temperature TMDL (2003) |
| | **WLA + LA + MOS = TMDL** |
| Total nitrogen (lbs/day) | 0 + 2.77 + 0.31 = 3.08 |
| Total phosphorus (lbs/day) | 0 + 0.69 + 0.08 = 0.77 |
| Total Recoverable Aluminum (lbs/day) | 0.00 + 1.83 + 0.32 = 2.15 |

**Probable Sources are a qualitative, alphabetical list. See section 2.4 & 4.4 for details.*

| Table ES-20. San Gregorio Lake | |
|---|---|
| New Mexico Standard's Segment | 20.6.4.134 NMAC |
| Assessment Unit Identifier | NM-2106.B_10 |
| NPDES Permit(s) | None |
| Segment Size (acres) | 35.93 |
| Parameters of Concern | Nutrients |
| Designated Uses Affected | HQCWAL |
| USGS Hydrologic Unit Code | 13020202 - Jemez |
| Scope/Size of Watershed ($mi^2$) | 3.36 |
| Land Type | Ecoregion 21b: Crystalline Subalpine Forests (100%) |
| Land Use/Cover | 93.2% forest, 4.2% wetlands, 1.7% herbaceous, 0.9% water, less than 0.1% shrubland |
| Land Ownership/Management | 100% Forest Service |
| Geology | 50.2% purely igneous, 35.6% igneous and metamorphic, 12.8% sedimentary and unconsolidated, 1.4% purely sedimentary |
| Probable Sources | Grazing in riparian zone; Other recreational pollution; Rangeland grazing |
| IR Category | 5/5A |
| Priority Ranking | High |
| Existing TMDLs | None |
| | **WLA + LA + MOS = TMDL** |
| Total nitrogen (lbs/day)<br><br>Total phosphorus (lbs/day) | 0 + 249.1 + 27.7 = 276.8<br><br>0 + 8.3 + 0.9 = 9.2 |

**Probable Sources are a qualitative, alphabetical list. See section 4.4 for details.*

| Table ES-21. Sulphur Creek (Redondo Creek to headwaters) | |
|---|---|
| New Mexico Standard's Segment | 20.6.4.124 NMAC |
| Assessment Unit Identifier | NM-2106.A_22 |
| NPDES Permit(s) | None |
| Segment Length (miles) | 8.02 |
| Parameters of Concern | Dissolved Aluminum |
| Designated Uses Affected | LAL |
| USGS Hydrologic Unit Code | 13020202 - Jemez |
| Scope/Size of Watershed ($mi^2$) | 13.41 |
| Land Type | Ecoregion 21g: Volcanic Subalpine Forests (20.3%)<br>Ecoregion 21h: Volcanic Mid-Elevation Forests (74.9%)<br>Ecoregion 21j: Grassland Parks (4.8%) |
| Land Use/Cover | 76.3% forest, 13.6% shrubland, 8.1% herbaceous, 1% developed, 1% wetlands, less than 0.1% - barren and water |
| Land Ownership/Management | 86.9% National Park Service, 9.9% Forest Service, 3.2% Private |
| Geology | 54.7% purely igneous, 43% igneous and sedimentary, 2.3% purely unconsolidated |
| Probable Sources | Other recreational pollution sources; Rangeland grazing |
| IR Category | 5/5B |
| Priority Ranking | High |
| Existing TMDLs | None |
| | **WLA + LA + MOS = TMDL** |
| Dissolved Aluminum (lbs/day) | 0 + 0.08 + 0.01 = 0.09 |

**Probable Sources are a qualitative, alphabetical list. See section 2.4 for details.*

| **Table ES-22. Sulphur Creek (San Antonio Creek to Redondo Creek)** | |
|---|---|
| New Mexico Standard's Segment | 20.6.4.108 NMAC |
| Assessment Unit Identifier | NM-2106.A_27 |
| NPDES Permit(s) | None |
| Segment Length (miles) | 1.01 |
| Parameters of Concern | Dissolved Aluminum |
| Designated Uses Affected | HQCWAL |
| USGS Hydrologic Unit Code | 13020202 - Jemez |
| Scope/Size of Watershed ($mi^2$) | 25.19 |
| Land Type | Ecoregion 21g: Volcanic Subalpine Forests (24.3%)<br>Ecoregion 21h: Volcanic Mid-Elevation Forests (73.2%)<br>Ecoregion 21j: Grassland Parks (2.5%) |
| Land Use/Cover | 72.5% forest, 17.5% shrubland, 7.3% herbaceous, 1.3% wetlands, 1.2% developed, 0.2% planted/cultivated, less than 0.1% - barren and water |
| Land Ownership/Management | 88.8% National Park Service, 9.4% Forest Service, 1.8% Private |
| Geology | 59% purely igneous, 34% igneous and sedimentary, 6.9% purely unconsolidated, 0.1% purely sedimentary |
| Probable Sources | Other recreational pollution sources; Rangeland grazing |
| IR Category | 5/5B |
| Priority Ranking | High |
| Existing TMDLs | None |
| | **WLA + LA + MOS = TMDL** |
| Dissolved Aluminum (lbs/day) | 0 + 0.16 + 0.03 = 0.19 |

**Probable Sources are a qualitative, alphabetical list. See section 2.4 for details*

| Table ES-23. Vallecito Ck (Perennial Prt Div abv Ponderosa to headwaters) | | | | | |
|---|---|---|---|---|---|
| New Mexico Standard's Segment | 20.6.4.107 NMAC | | | | |
| Assessment Unit Identifier | NM-2105.5_21 | | | | |
| NPDES Permit(s) | None | | | | |
| Segment Length (miles) | 13.14 | | | | |
| Parameters of Concern | Sedimentation/Siltation, Turbidity | | | | |
| Designated Uses Affected | ColdWAL | | | | |
| USGS Hydrologic Unit Code | 13020202 – Jemez | | | | |
| Scope/Size of Watershed (mi$^2$) | 16.3 | | | | |
| Land Type | Ecoregion 21d: Foothill Shrublands (17.4%)<br>Ecoregion 21g: Volcanic Subalpine Forests (1.5%)<br>Ecoregion 21h: Volcanic Mid-Elevation Forests (73.2%) | | | | |
| Land Use/Cover | 81.5% forest, 11.6% shrubland, 6.6% herbaceous, less than 0.1% - developed, wetlands, water | | | | |
| Land Ownership/Management | 98.4% Forrest Service, 1.1% Private, 0.3% Tribal | | | | |
| Geology | 85.1% igneous, 14.8% sedimentary | | | | |
| Probable Sources | Other recreational pollution sources; Rangeland grazing; Roads/bridges; Wildlife other than waterfowl | | | | |
| IR Category | 5/5A | | | | |
| Priority Ranking | High | | | | |
| Existing TMDLs | None | | | | |
| | **WLA + LA + MOS = TMDL** | | | | |
| Sedimentation/Siltation (lb TSS/day) | 0 + 5.14 + 1.28 = 6.42 | | | | |
| Turbidity (lb TSS/day) | **Duration (consecutive days)** | **WLA** | **MOS (X%)** | **LA** | **TMDL** |
| | 3 | 0 | 2.05 | 11.61 | 13.66 |
| | 4 | 0 | 1.85 | 10.49 | 12.34 |
| | 5 | 0 | 1.72 | 9.74 | 11.46 |
| | 6 | 0 | 1.59 | 9.00 | 10.59 |
| | 7 | 0 | 1.52 | 8.63 | 10.15 |
| | 14 | 0 | 1.26 | 7.13 | 8.39 |
| | 30 | 0 | 1.00 | 5.64 | 6.64 |

**Probable Sources are a qualitative, alphabetical list. See section 5.4 & 7.4 for details.*

# 1.0 BACKGROUND

This document establishes TMDLs for 23 Assessment Units (AUs) in the Jemez basin (**Figures 1.1** - **1.4**). Assessments of impairment were based on data collected during the 2021-2022 SWQB water quality survey.

## 1.1 Watershed Description

This document establishes TMDLs for 23 Assessment Units (AUs) in the Jemez watershed, HUC 13020202 (**Figure 1.1, Table 1.1**). Impairment determinations were based on data collected during the 2021-2022 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 U.S. 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**).

**Table 1.1 Assessment units and monitoring stations discussed in this TMDL**

| Map Point | Assessment Unit | Station Name | Station ID |
|---|---|---|---|
| 1 | American Creek (Rio de las Palomas to headwaters) | American Creek at FR 69 abv American Park | 31Americ006.4 |
| 2 | American Creek (Rio de las Palomas to headwaters) | American Creek at FR 69C | 31Americ001.5 |
| 3 | American Creek (Rio de las Palomas to headwaters) | American Creek at southern end of American Park | 31Americ003.4 |
| 4 | Calaveras Creek (Rio Cebolla to headwaters) | CALAVERAS CREEK ABOVE RIO CEBOLLA ON NM 126 | 31Calave001.1 |
| 5 | Clear Creek (Rio de las Vacas to San Gregorio Lake) | Clear Creek at NM 126 | 31ClearC002.3 |
| 6 | Clear Creek (Rio de las Vacas to San Gregorio Lake) | Clear Creek below San Gregorio Lake | 31ClearC008.1 |
| 7 | Clear Creek (San Gregorio Lake to headwaters) | Clear Creek abv San Gregorio Lake | 31ClearC009.2 |
| 8 | East Fork Jemez (San Antonio Creek to VCNP bnd) | East Fork Jemez above confluence with San Antonio Creek | 31EFkJem000.1 |
| 9 | East Fork Jemez (VCNP to headwaters) | East Fork Jemez below La Jara Creek | 31EFkJem020.7 |
| 10 | Fenton Lake | Fenton Lake at dam | 31FentonLkDam |

| | | | |
|---|---|---|---|
| 11 | Jaramillo Creek (East Fork Jemez to headwaters) | Jaramillo Creek abv road VC 02 | 31Jarami006.0 |
| 12 | Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | Jemez River below Rio Guadalupe | 31JemezR048.7 |
| 13 | Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | JEMEZ RIVER NEAR CANON, BELOW MUNICIPAL SCHOOL | 31JemezR046.6 |
| 14 | Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | Jemez Valley Public Schools WWTP Outfall | NM0028479 |
| 15 | Jemez River (Soda Dam nr Jemez Springs to East Fork) | Jemez River above Soda Dam - 31JemezR064.9 | 31JemezR064.9 |
| 16 | Jemez River (Soda Dam nr Jemez Springs to East Fork) | Jemez River at Entrada Road - 31JemezR066.4 | 31JemezR066.4 |
| 17 | Jemez River (Soda Dam nr Jemez Springs to East Fork) | Jemez River at Battleship Rock Picnic Area - 31JemezR071.0 | 31JemezR071.0 |
| 18 | La Jara Creek (East Fork Jemez to headwaters) | La Jara above headquarters (VCNP 15) | 31LaJara005.0 |
| 19 | Redondo Creek (Sulphur Creek to headwaters) | Redondo Creek Above Sulphur Creek | 31Redond000.1 |
| 20 | Redondo Creek (Sulphur Creek to headwaters) | Redondo Creek above VCNP boundary | 31Redond001.2 |
| 21 | Rio Cebolla (Fenton Lake to headwaters) | Rio Cebolla ~0.5 mile above Fenton Lake | 31RCebol011.4 |
| 22 | Rio Cebolla (Fenton Lake to headwaters) | Rio Cebolla at campground abv Seven Springs hatchery | 31RCebol017.9 |
| 23 | Rio Cebolla (Rio de las Vacas to Fenton Lake) | Rio Cebolla above the Rio de las Vacas | 31RCebol000.1 |
| 24 | Rio Cebolla (Rio de las Vacas to Fenton Lake) | Rio Cebolla at Hal Baxter Trail | 31RCebol009.6 |
| 25 | Rio Cebolla (Rio de las Vacas to Fenton Lake) | Rio Cebolla at Lake Fork Canyon | 31RCebol007.0 |
| 26 | Rio de las Vacas (Clear Creek to headwaters) | Rio de Las Vacas at SR 126 | 31RVacas023.7 |
| 27 | Rito de las Palomas (Rio de las Vacas to headwaters) | Rito de las Palomas 1.6km abv Rio de las Vacas | 31RPalom001.6 |
| 28 | Rito de las Palomas (Rio de las Vacas to headwaters) | Rito de las Palomas at NM Hwy 126 | 31RPalom000.1 |
| 29 | Rito de los Indios (San Antonio Creek to headwaters) | Rito de los Indios above San Antonio Creek | 31RIndio000.2 |
| 30 | Rito Penas Negras (Rio de las Vacas to headwaters) | Rito Penas Negras 3.2km above Rio de las Vacas | 31RPNegr003.2 |
| 31 | Rito Penas Negras (Rio de las Vacas to headwaters) | Rito Penas Negras at NM Hwy 126 | 31RPNegr000.1 |
| 32 | San Antonio Creek (East Fork Jemez to VCNP bnd) | San Antonio Creek @ La Cueva | 31SanAnt005.3 |
| 33 | San Antonio Creek (East Fork Jemez to VCNP bnd) | San Antonio Creek abv confl w East Fork Jemez River | 31SanAnt000.1 |

| | | | |
|---|---|---|---|
| 34 | San Antonio Creek (VCNP bnd to headwaters) | San Antonio Creek abv VCNP boundary | 31SanAnt017.7 |
| 35 | San Gregorio Lake | San Gregorio Deep | 33SanGregorLk |
| 36 | Sulphur Creek (Redondo Creek to headwaters) | Sulphur Creek Above Redondo Creek | 31Sulphu001.3 |
| 37 | Sulphur Creek (San Antonio Creek to Redondo Creek) | Sulphur Creek above San Antonio Creek | 31Sulphu000.1 |
| 38 | Sulphur Creek (San Antonio Creek to Redondo Creek) | Sulphur Creek at Hwy 4 | 31Sulphu000.9 |
| 39 | Sulphur Creek (San Antonio Creek to Redondo Creek) | Sulphur Creek blw Redondo Creek | 31Sulphu001.2 |
| 40 | Vallecito Ck (Perennial Prt Div abv Ponderosa to headwaters) | Vallecito Ck abv Ponderosa diversion | 31RValle012.2 |
| 41 | San Gregorio Lake | San Gregorio outlet @ Nacimiento Creek | 33SanGregorLk |

**Table 1.2 Permitted facilities discussed in this TMDL**

| Map Point | Assessment Unit | Facility Name |
|---|---|---|
| A | Rio Cebolla (Rio de las Vacas to Fenton Lake) | Seven Springs Fish Hatchery |
| B | Jemez River (Rio Guadalupe to Soda Dam nr Jemez Springs) | Village of Jemez Springs WWTP |
| C | Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | Jemez Valley Public Schools |

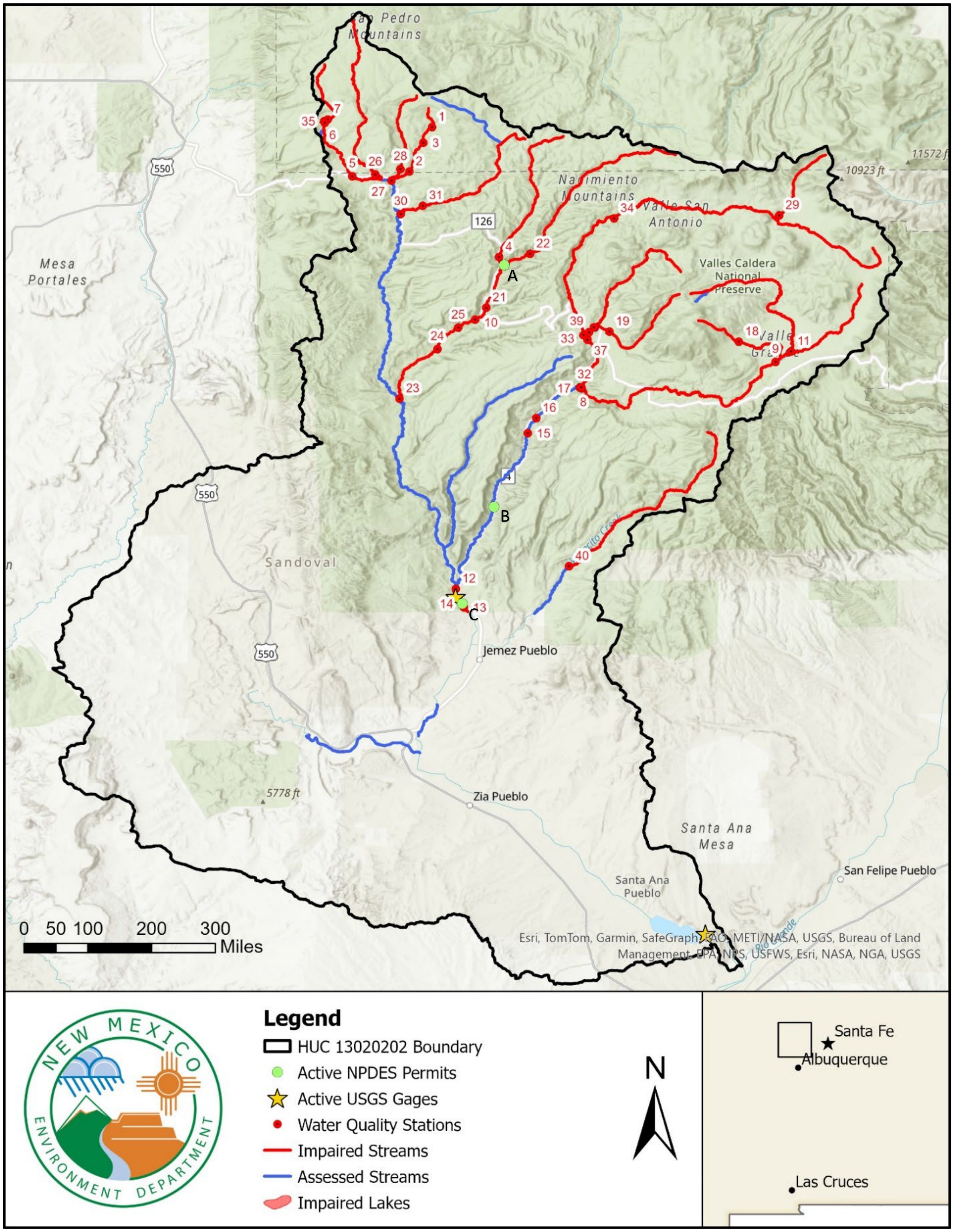


**Figure 1.1 Overview of the new TMDLs for the Jemez Watershed, HUC 13020202**

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, 2021; **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 Pueblo of Jemez, Zia Pueblo, and Santa Ana Pueblo (together, 35.5%, mostly in the lower elevations). Valles Caldera National Preserve 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 and some urban and residential development, including the Village of Jemez Springs.

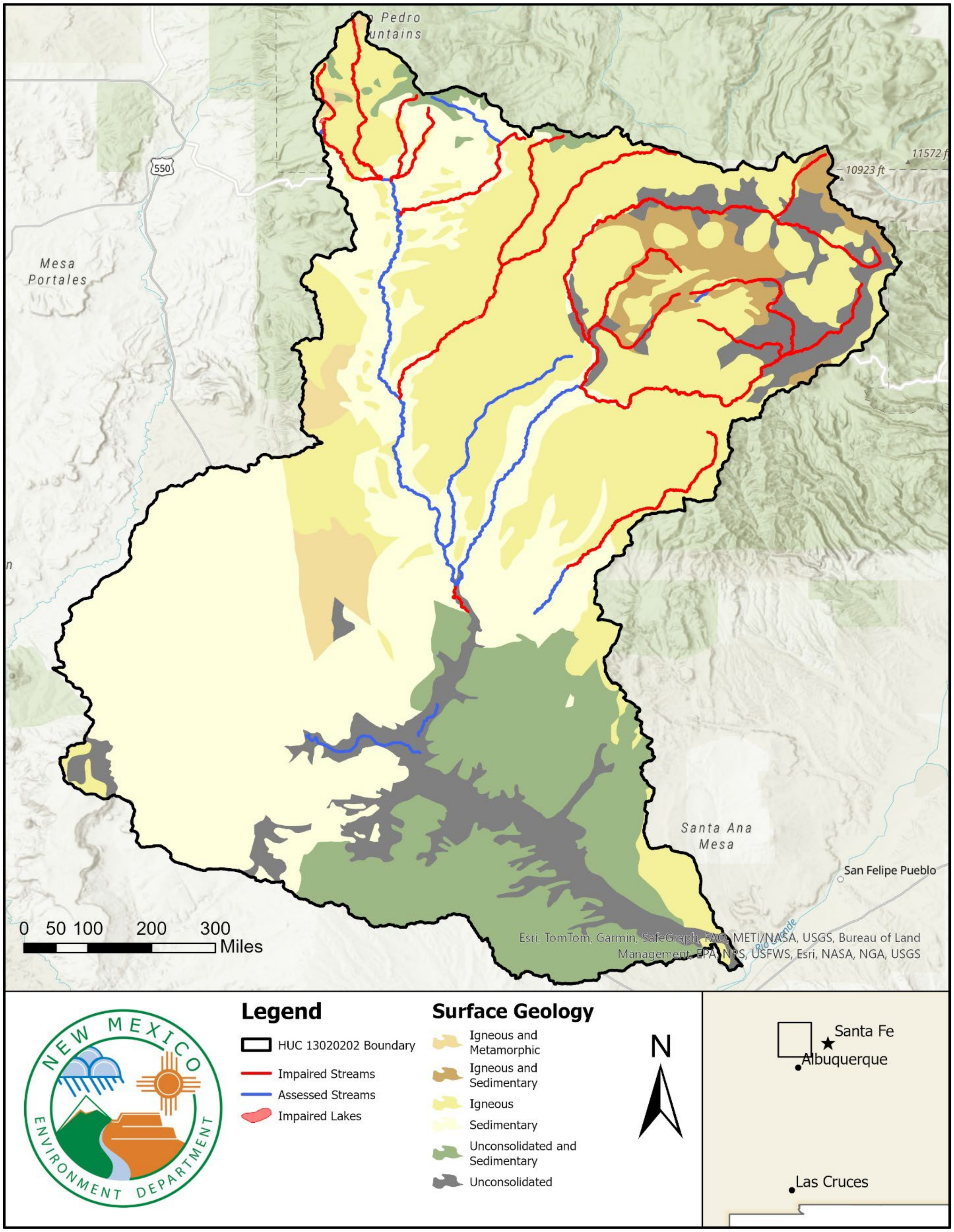


**Figure 1.2 Surface geology of the Jemez Watershed**

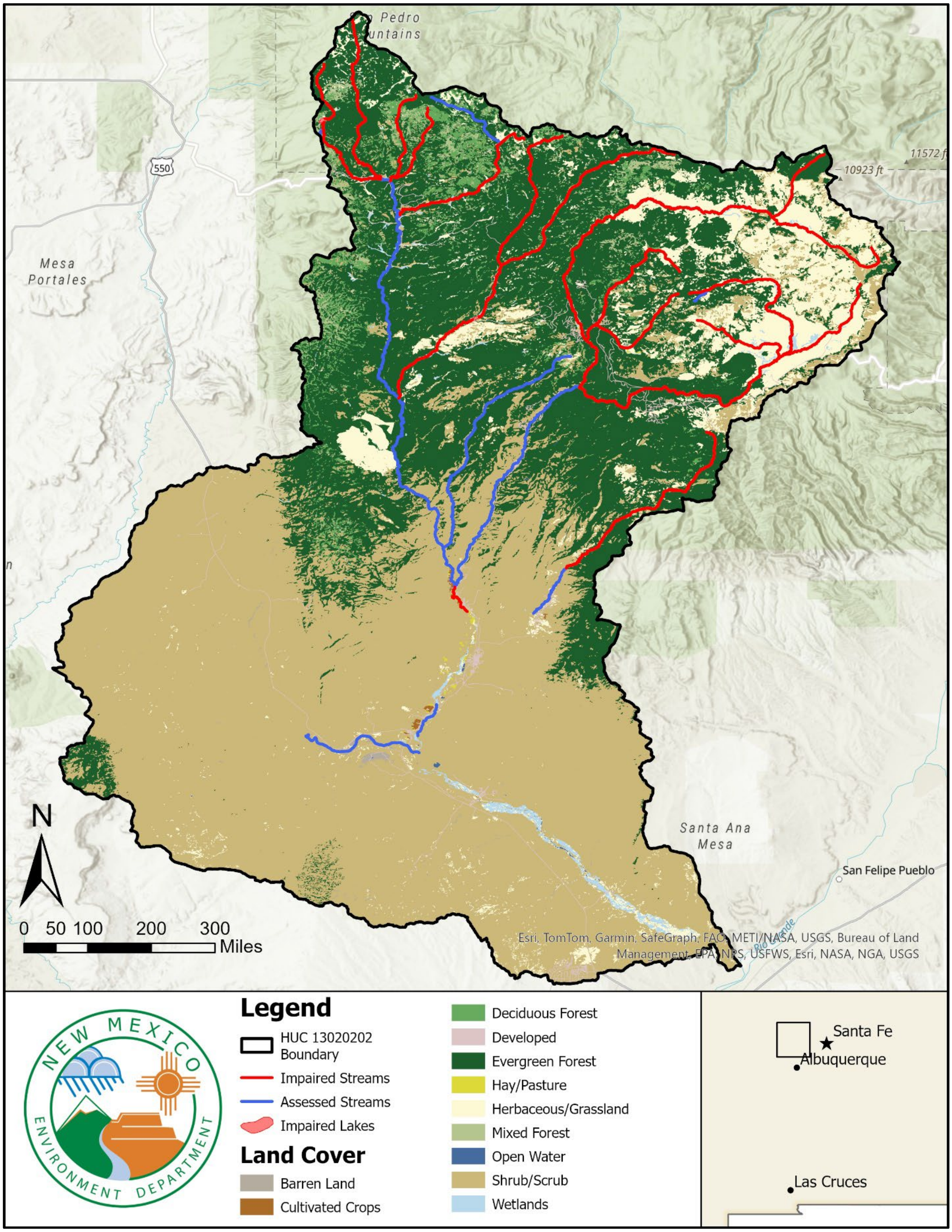


**Figure 1.3 Land cover of the Jemez Watershed**

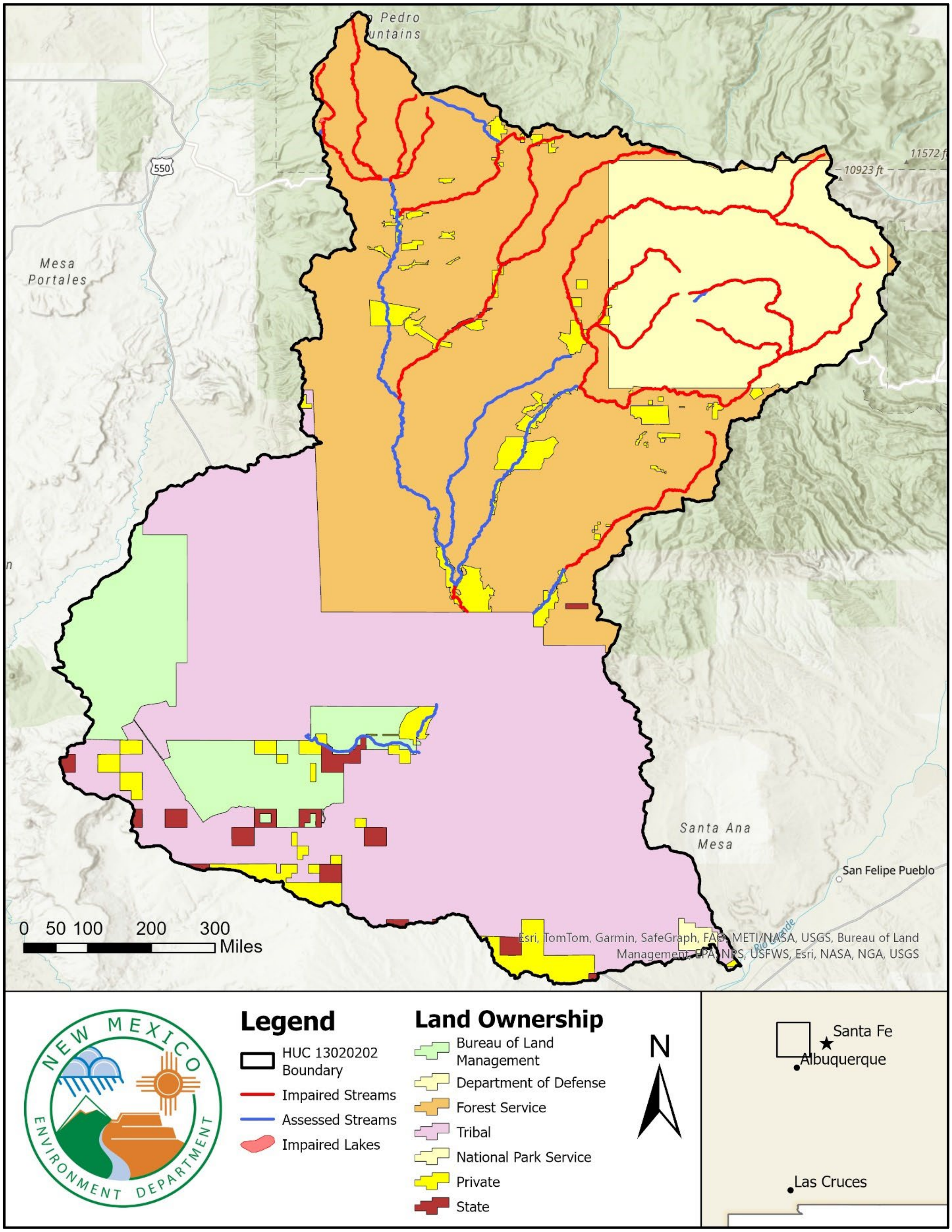


**Figure 1.3 Land ownership of the Jemez Watershed**

## 1.2 Water Quality Standards

Water quality standards (WQS) for the assessment units **Jemez River (Jemez Pueblo bnd to Rio Guadalupe)** and **Vallecito Ck (Perennial Prt Div abv Ponderosa to headwaters)** are set forth in 20.6.4.107 of New Mexico Standards for Interstate and Intrastate Surface Waters (20.6.4 New Mexico Administrative Code [NMAC], 2025, https://www.env.nm.gov/surface-water-quality/wqs/):

**20.6.4.107 RIO GRANDE BASIN: The Jemez river from the Jemez pueblo boundary upstream to Soda dam near the town of Jemez Springs and perennial reaches of Vallecito creek.**

**A. Designated uses:** coldwater aquatic life, primary contact, irrigation, livestock watering and wildlife habitat; and public water supply on Vallecito creek.

**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 criterion applies: temperature 25°C (77°F).

[20.6.4.107 NMAC - Rp 20 NMAC 6.1.2105.5, 10/12/2000; A, 5/23/2005; A, 12/1/2010]

Water quality standards (WQS) for the following assessment units are set forth in 20.6.4.108 of New Mexico Standards for Interstate and Intrastate Surface Waters (20.6.4 New Mexico Administrative Code [NMAC], 2025, https://www.env.nm.gov/surface-water-quality/wqs/):

**American Creek (Rio de las Palomas to headwaters)**

**Calaveras Creek (Rio Cebolla to headwaters)**

**Clear Creek (Rio de las Vacas to San Gregorio Lake)**

**Clear Creek (San Gregorio Lake to headwaters)**

**East Fork Jemez (San Antonio Creek to VCNP bnd)**

**East Fork Jemez (VCNP to headwaters)**

**Fenton Lake**

**Jaramillo Creek (East Fork Jemez to headwaters)**

**La Jara Creek (East Fork Jemez to headwaters)**

**Redondo Creek (Sulphur Creek to headwaters)**

**Rio de las Vacas (Clear Creek to headwaters)**

**Rito Penas Negras (Rio de las Vacas to headwaters)**

**Rito de los Indios (San Antonio Creek to headwaters)**

**San Antonio Creek (East Fork Jemez to VCNP bnd)**

**San Antonio Creek (VCNP bnd to headwaters)**

**Sulphur Creek (San Antonio Creek to Redondo Creek)**

**20.6.4.108 RIO GRANDE BASIN: Perennial reaches of the Jemez River upstream of Soda dam near the town of Jemez Springs and perennial reaches of tributaries to the Jemez River except those not specifically identified under other sections of 20.6.4 NMAC, and perennial reaches of the Guadalupe River and perennial reaches of tributaries to the Guadalupe River, and Calaveras canyon.**

**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; A, 4/23/2022]

[**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.]

Water quality standards (WQS) for the assessment unit **Sulphur Creek (Redondo Creek to headwaters)** are set forth in 20.6.4.124 of New Mexico Standards for Interstate and Intrastate Surface Waters (20.6.4 New Mexico Administrative Code [NMAC], 2025, https://www.env.nm.gov/surface-water-quality/wqs/):

**20.6.4.124 RIO GRANDE BASIN: Perennial reaches of Sulphur creek from its confluence with Redondo creek upstream to its headwaters.**

**A. Designated uses:** limited aquatic life, wildlife habitat, livestock watering and secondary contact.

**B. Criteria:** the use-specific criteria set forth in 20.6.4.900 NMAC are applicable to the designated uses, except that the following segment-specific criteria apply: pH within the range of 2.0 to 9.0, maximum temperature 30°C (86°F), and the chronic aquatic life criteria of Subsections I and J of 20.6.4.900 NMAC.

[20.6.4.124 NMAC - N, 5/23/2005; A, 12/1/2010; A, 3/2/2017]

Water quality standards (WQS) for the assessment unit **San Gregorio Lake** are set forth in 20.6.4.134 of New Mexico Standards for Interstate and Intrastate Surface Waters (20.6.4 New Mexico Administrative Code [NMAC], 2025, https://www.env.nm.gov/surface-water-quality/wqs/):

**20.6.4.134 RIO GRANDE BASIN: Cabresto lake, Canjilon lakes a, c, e and f, Fawn lakes (east and west), Hopewell Lake and San Gregorio Lake.**

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

**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 300 µS/cm or less; the monthly geometric mean of *E. coli* bacteria 126 cfu/100 mL or less, single sample 235 cfu/100 mL or less.

[20.6.4.134 NMAC - N, 7/10/2012]

## 1.3 Antidegradation and TMDLs

New Mexico's antidegradation policy, found at 20.6.4.8(A) NMAC and required under 40 C.F.R. § 131.12, describes how waters are to be protected from degradation. 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 Statewide WQMP/CPP NMED/SWQB, 2020, https://www.env.nm.gov/surface-water-quality/wqmp-cpp/). However, certain specific requirements in the Antidegradation Policy Implementation Procedure do not apply to the Water Quality Control Commission's (WQCC) establishment 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

In 2021-22 SWQB surveyed the Jemez River, Rio Puerco, San Jose, Lower Colorado, and Lower Pecos basins (NMED/SWQB, 2021). This document will only be discussing the survey of the Jemez River Watershed with the 8-digit HUC 13020202 (**Figures 1.1-1.4**).

The SWQB divides rivers and streams 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 several times over the two years. Reductions and alterations of monitoring sites in the implementation of the 2021-2022 Jemez River Watershed Field Sampling Plan were necessary due to access issues, dry conditions, closures due to fires, resource limitations, and COVID-19 restrictions.

Geomorphology and continuously logged data were collected at least once for as many as possible of the perennial AUs. Geomorphology parameters were measured following the then-current revision of the SWQB Standard Operating Procedure 5.0, Physical Habitat Measurements (https://www.env.nm.gov/surface-water-quality/sop/). Data-logged parameters may include temperature, turbidity, dissolved oxygen, pH, and/or conductivity, and were measured following the then-current revision of the SWQB Standard Operating Procedures 6.1-6.4, Sondes and Thermographs (https://www.env.nm.gov/surface-water-quality/sop/). Impaired AUs addressed in this TMDL report, and the associated monitoring stations, are shown on **Figure 1.1**.

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. More detail about the 2021-2022 water quality survey can be found in the survey summary reports (NMED/SWQB, 2021, https://www.env.nm.gov/surface-water-quality/water-quality-monitoring/).

## 1.5 Hydrologic Conditions

Water chemistry and thermograph data on which these TMDLs are based were collected in the years 2021, 2022, and 2023. In order to characterize streamflow conditions in which the data were collected, discharge records were obtained from USGS gage 08328950 – Jemez River Outlet below Jemez Canyon Dam, and USGS gage 08324000 – Jemez River near Jemez, NM (**Figures 1.5 & 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 2021-2022 water quality survey was lower than the median daily statistic over the 67-year period of record, with the exception of monsoon storm flow during the last half of July. In 2023, this trend is reversed with flow being higher than the 67-year record until the monsoon season where flow was lower than average at Jemez River near Jemez NM stream gage.

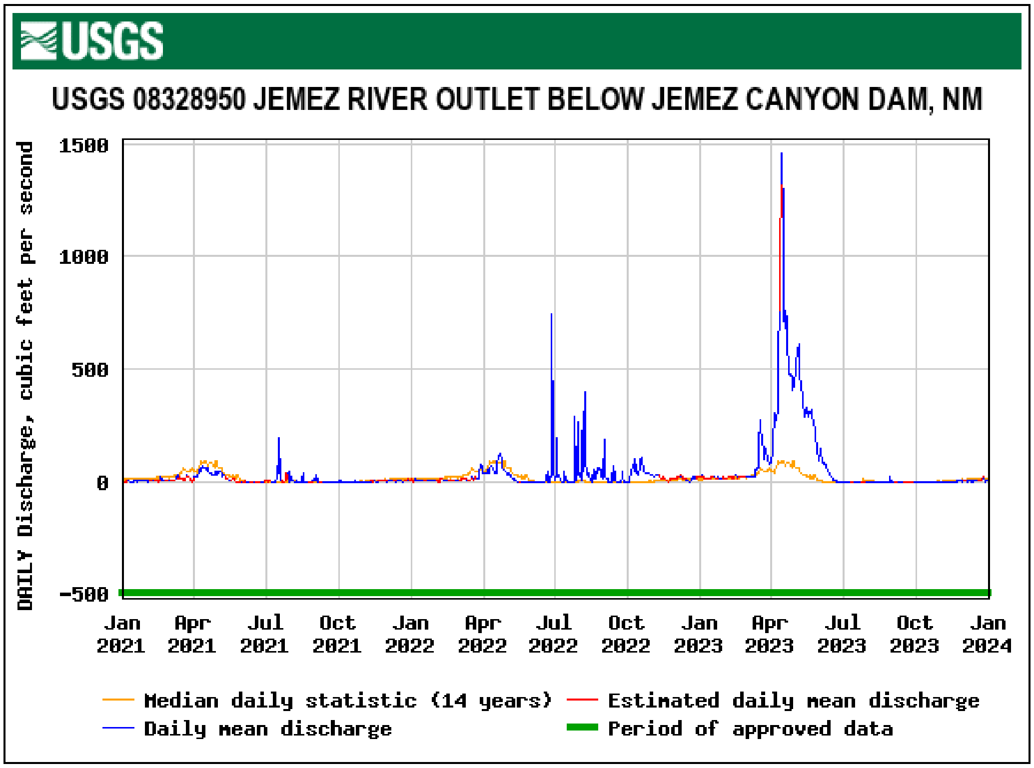


**Figure 1.5** Daily discharge of the Jemez River below Jemez Canyon Dam for the years 2021-2023

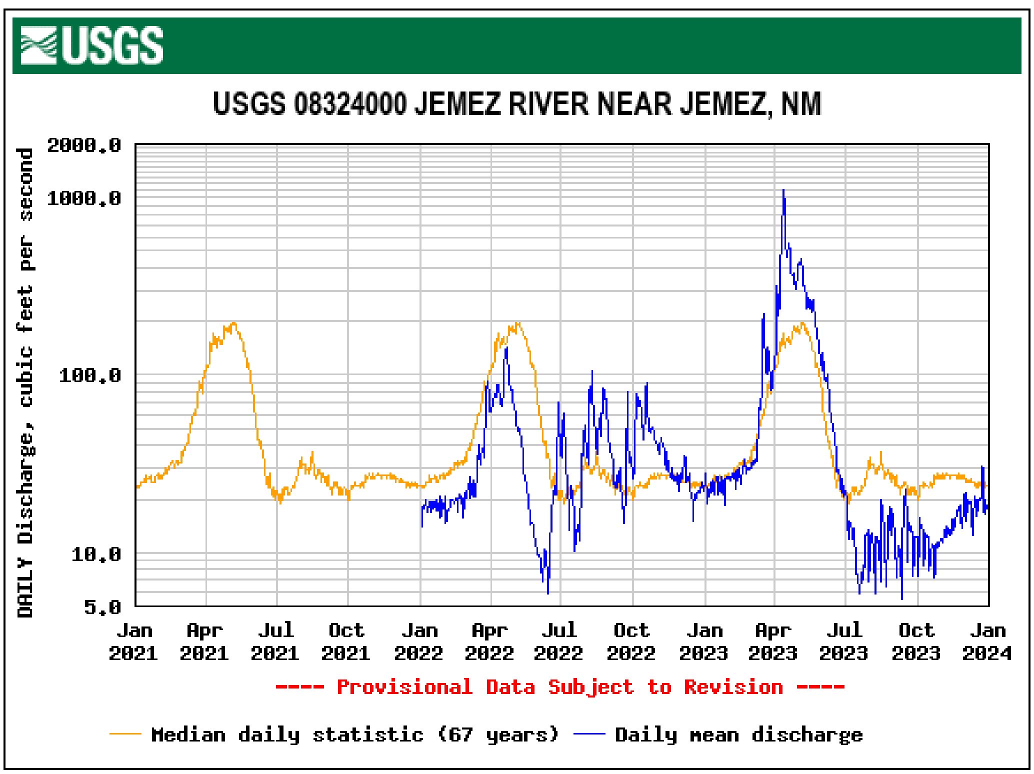


**Figure 1.6** Daily discharge of the Jemez River near Jemez NM for the years 2021-2023

## 1.6 TMDL Uncertainties

Pursuant to 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 (MOS) 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, 2025) 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 ALUMINUM

Chronic high levels of aluminum (Al) can be toxic to fish, benthic invertebrates, and some single-celled plants. Aluminum concentrations from 0.1 to 0.3 mg/L (100 to 300 ug/L) increase mortality and retard growth, gonadal development, and egg production of fish. Information on the toxic forms of aluminum in natural waters suggests that soluble trivalent aluminum (Al3+) exerts a toxic effect on fish by binding to the negative charge of gill tissues, thereby disrupting ionoregulatory and respiratory balance (Exley et al.., 1991; Gensemer and Playle, 1999). This charge interaction is complicated by subsequent polymerization of insoluble, positive-charged Al oxyhydroxides to fish gill tissues and thus both soluble and insoluble forms are implicated in the toxic response of fish to Al (Gensemer and Playle, 1999).

In 2010, the WQCC updated the aquatic life use (ALU) criteria for aluminum from dissolved aluminum to hardness-dependent total recoverable aluminum (TR Al). In 2012, USEPA approved the change for use in waters where the pH is above 6.5. Aluminum-impaired waters of the Jemez Watershed were within the applicable pH range for all but three AUs during the 2021-2022 sampling events. Those waters within the applicable pH range are listed in **Table 2.1** for total recoverable aluminum impairments. The term "total recoverable" refers to the analytical method used in laboratory analysis and is essentially interchangeable with the term "total". "Total recoverable" is used here to reflect the language in 20.6.4.900(I) NMAC. Specifically, "For aluminum, the criteria are based on analysis of total recoverable aluminum in a sample that is filtered to minimize the mineral phase as specified by the department." Based on recommendations from an aluminum filtration study conducted by SWQB staff (NMED/SWQB, 2012), if the turbidity exceeds 30 NTU, samples that will be analyzed for TR Al are filtered using a filter of 10 µm pore size that minimizes mineral-phase aluminum without restricting amorphous or colloidal phases. To be conservative, the TR Al TMDLs are calculated to protect against exceedance of the chronic criterion, which is more stringent than the acute criterion.

For waters whose pH is below 6.5, listed in **Table 2.2**, the criterion for dissolved aluminum applies. Criteria for dissolved aluminum is not hardness-dependent and is outlined in the SWQB CALM (NMED/SWQB, 2025) section 3.1.2.1, and 20.6.4.900.J(1) NMAC.

## 2.1 Target Loading Capacity

To meet aquatic life designated uses, the SWQB Comprehensive Assessment and Listing Methodology (NMED SWQB, 2021a) says that for any one chemical/physical pollutant, there shall be no more than one exceedance of the acute criterion, and no more than one exceedance of the chronic criterion in three years. Exceedances of the WQS were identified by assessment of the data from the 2021-2022 Jemez intensive water quality survey, as shown on **Table 2.1 – 2.2**. Consequently, these AUs were listed on the 2026-2028 Integrated CWA § 303(d)/§ 305(b) List (NMED/SWQB, 2026) for aluminum. Results of laboratory analyses of the samples are shown in **Appendix B**.

**Table 2.1 Total recoverable aluminum exceedances**

| Assessment Unit | Exceedances (Acute) | Exceedances (Chronic) |
|---|---|---|
| Calaveras Creek (Rio Cebolla to headwaters) | 3/4 | 4/4 |
| Clear Creek (Rio de las Vacas to San Gregorio Lake) | 1/5 | 3/5 |
| Clear Creek (San Gregorio Lake to headwaters) | 1/4 | 4/4 |

| | | |
|---|---|---|
| East Fork Jemez (San Antonio Creek to VCNP bnd) | 2/5 | 2/5 |
| East Fork Jemez (VCNP to headwaters) | 3/6 | 4/6 |
| Jaramillo Creek (East Fork Jemez to headwaters) | 3/6 | 6/6 |
| La Jara Creek (East Fork Jemez to headwaters) | 4/6 | 6/6 |
| Rio Cebolla (Fenton Lake to headwaters) | 1/9 | 5/9 |
| Rio de las Vacas (Clear Creek to headwaters) | 3/4 | 3/4 |
| Rito de los Indios (San Antonio Creek to headwaters) | 3/6 | 5/6 |
| San Antonio Creek (East Fork Jemez to VCNP bnd) | 0/4 | 3/4 |
| San Antonio Creek (VCNP bnd to headwaters) | 0/5 | 2/5 |

**Table 2.2 Dissolved aluminum exceedances**

| Assessment Unit | Exceedances (Chronic) |
|---|---|
| Redondo Creek (Sulphur Creek to headwaters) | 2/5 |
| Sulphur Creek (Redondo Creek to headwaters) | 3/4 |
| Sulphur Creek (San Antonio Creek to Redondo Creek) | 6/6 |

## 2.2 Flow

According to the New Mexico Water Quality Standards, the low flow critical condition for numeric criteria set in NMAC 20.6.4.97 through 20.6.4.900 and NMAC 20.6.4.13(F) is defined as the 4-day, 3-year low-flow frequency (4Q3, NMAC 20.6.4.11(B)(2)). The 4Q3 is the annual lowest four (4) consecutive day flow that occurs with a frequency of at least once every three (3) years.

Because all AUs discussed in this section are ungaged, an analysis method developed by USGS in partnership with NMED, authored by Bell and Tillery (Bell, 2023) was used to estimate the critical low flow. In the USGS analysis, six regression equations for estimating 4Q3 were developed based on physiographic regions of New Mexico and stream basin characteristics (i.e., statewide and mountainous regions above 8,000 ft in elevation, or basins with less than 75 square mile drainage areas). The average elevation of all impaired AUs in the Jemez watershed are above 8,000 ft and are not the San Juan River nor tributaries to the San Juan, so the 4Q3-1a statewide regression equation was used. The following regression equation is based on data from 44 gaging stations with non-zero discharge (Bell, 2023):

**Equation 2.1:** $4Q3 = DA^{1.08} \times E^{12.20} \times e^{-115.37}$

Where:

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

$DA$ = drainage area ($mi^2$)

$E$ = mean basin elevation (ft)

$e$ = mathematical constant, Euler's number

The 4Q3 values calculated using the USGS method are presented in **Tables 2.3 – 2.4** Parameters used in the calculation were obtained using the StreamStats online GIS application developed by the USGS (https://streamstats.usgs.gov/ss/). The 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 instream water quality is the goal of SWQB efforts.

**Table 2.3 Critical flow for total recoverable aluminum impaired AUs**

| Assessment Unit | Critical Flow (cfs) | Critical Flow (mgd) |
|---|---|---|
| Calaveras Creek (Rio Cebolla to headwaters) | 0.22 | 0.14 |
| Clear Creek (Rio de las Vacas to San Gregorio Lake) | 0.24 | 0.16 |
| Clear Creek (San Gregorio Lake to headwaters) | 0.15 | 0.10 |
| East Fork Jemez (San Antonio Creek to VCNP bnd) | 1.12 | 0.72 |
| East Fork Jemez (VCNP to headwaters) | 0.87 | 0.56 |
| Jaramillo Creek (East Fork Jemez to headwaters) | 0.30 | 0.19 |
| La Jara Creek (East Fork Jemez to headwaters) | 0.13 | 0.09 |
| Rio Cebolla (Fenton Lake to headwaters)+ | 1.78 | 1.15 |
| Rio de las Vacas (Clear Creek to headwaters) | 0.91 | 0.59 |
| Rito de los Indios (San Antonio Creek to headwaters) | 0.25 | 0.16 |
| San Antonio Creek (East Fork Jemez to VCNP bnd) | 1.92 | 1.24 |
| San Antonio Creek (VCNP bnd to headwaters) | 1.36 | 0.88 |

*+ Combined flow of permitted facility design capacity flow and 4Q3 (0.075mgd design flow)*

**Table 2.4 Critical flow for dissolved aluminum impaired AUs**

| Assessment Unit | Critical Flow (cfs) | Critical Flow (mgd) |
|---|---|---|
| Redondo Creek (Sulphur Creek to headwaters) | 0.20 | 0.13 |
| Sulphur Creek (Redondo Creek to headwaters) | 0.19 | 0.12 |
| Sulphur Creek (San Antonio Creek to Redondo Creek) | 0.41 | 0.27 |

## 2.3 TMDL Calculation

The TMDL is defined as the mass of pollutants that can be carried under critical flow conditions without violating the target concentration for that constituent. A conversion factor is used to correct the TMDL units to lbs/day. The TMDL is calculated based on simple dilution using **Equation 2.2**:

**Equation 2.2:** *WQS (mg/L) x Critical flow (mgd) x Conversion Factor (8.34) = TMDL (lbs/day)*

TMDLs are presented on **Tables 2.5 – 2.6** for the critical flow condition. Chronic total recoverable aluminum criteria were calculated at the average hardness value that was measured during the survey sampling events that resulted in exceedances of the WQS (data shown in **Appendix B**), while chronic dissolved aluminum criteria are 0.087 mg/L when concurrent pH is less than 6.5.

**Table 2.5 Total recoverable aluminum TMDL calculations**

| Assessment Unit | Chronic criterion (mg/l) | Critical Flow (mgd) | Conversion Factor | TMDL (lbs/day) |
|---|---|---|---|---|
| Calaveras Creek (Rio Cebolla to headwaters) | 0.32 | 0.14 | 8.34 | 0.37 |
| Clear Creek (Rio de las Vacas to San Gregorio Lake) | 0.32 | 0.16 | 8.34 | 0.41 |
| Clear Creek (San Gregorio Lake to headwaters) | 0.19 | 0.10 | 8.34 | 0.16 |
| East Fork Jemez (San Antonio Creek to VCNP bnd) | 0.23 | 0.72 | 8.34 | 1.37 |
| East Fork Jemez (VCNP to headwaters) | 0.17 | 0.56 | 8.34 | 0.82 |
| Jaramillo Creek (East Fork Jemez to headwaters) | 0.26 | 0.19 | 8.34 | 0.41 |
| La Jara Creek (East Fork Jemez to headwaters) | 0.11 | 0.09 | 8.34 | 0.08 |
| Rio Cebolla (Fenton Lake to headwaters) | 0.24 | 1.15 | 8.34 | 2.34 |
| Rio de las Vacas (Clear Creek to headwaters) | 0.15 | 0.59 | 8.34 | 0.76 |
| Rito de los Indios (San Antonio Creek to headwaters) | 0.17 | 0.16 | 8.34 | 0.22 |
| San Antonio Creek (East Fork Jemez to VCNP bnd) | 0.56 | 1.24 | 8.34 | 5.78 |
| San Antonio Creek (VCNP bnd to headwaters) | 0.29 | 0.88 | 8.34 | 2.16 |

**Table 2.6 Dissolved aluminum TMDL calculations**

| Assessment Unit | Chronic criterion (mg/l) | Critical Flow (mgd) | Conversion Factor | TMDL (lbs/day) |
|---|---|---|---|---|
| Redondo Creek (Sulphur Creek to headwaters) | 0.087 | 0.13 | 8.34 | 0.09 |
| Sulphur Creek (Redondo Creek to headwaters) | 0.087 | 0.12 | 8.34 | 0.09 |
| Sulphur Creek (San Antonio Creek to Redondo Creek) | 0.087 | 0.27 | 8.34 | 0.19 |

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

**Equation 2.3:** $WLA + LA + MOS = TMDL$

### 2.3.1 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 aluminum TMDL, the MOS was developed using a combination of conservative assumptions and explicit allocations. Therefore, this MOS is the sum of the following elements:

- *Conservative assumptions:*
    - Treating aluminum 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.
    - Calculating the TMDL based on chronic rather than acute WQS.
    - Using the average hardness value during exceedance events, rather than the average hardness of all samples. Hardness is often, though not always, lower at high flows, leading to a lower calculated chronic TR Al standard and smaller TMDL.
- *Explicit recognition of potential error:*
    - An explicit MOS of **15%** was assigned to the aluminum impaired AUs, to account for the low number of sampling events, and the inherent error in flow estimates, and the naturally high aluminum in the Jemez watershed.

The total MOS for each assessment unit in this TMDL is **15%**.

### 2.3.2 Waste Load Allocation

There is one National Pollutant Discharge Elimination System (NPDES) permitted facility on the AU Rio Cebolla (Fenton Lake to headwaters), permit number NM0030112. The facility is the Seven Springs Fish Hatchery, which is managed by the New Mexico Department of Game & Fish and has two outfalls. Outfall 001 is a kid's fishing pond, which overflows into a wetland, and then into the Rio Cebolla. Outfall 002 is a settling pond which overflows into a wetland and then into the Rio Cebolla. The mean flow (0.76mgd) of these two outfalls was used to calculate the WLA for the facility. The WLAs are presented in **Table 2.7** below.

The source water for the hatchery consists of the artesian springs, which would flow into the Rio Cebolla in the absence of the hatchery. There are monitoring requirements for total aluminum, but no numeric effluent limits. Hatchery staff collect water samples from the source of the springs, as well as the effluent from the hatchery. The source water consistently has higher concentrations than the effluent from the facility.

There are no active NPDES permits discharging to any other aluminum impaired AUs, therefore the WLA for those TMDLs is zero.

**Table 2.7 Rio Cebolla (Fenton Lake to headwaters) total aluminum waste load allocation**

| Chronic criterion (mg/l) | Flow (mgd) | Conversion Factor | WLA (lbs/day) |
|---|---|---|---|
| 0.24 | 0.76 | 8.34 | 1.52 |

Sediment and associated contaminants are considered components of industrial storm water discharges covered under NPDES General Permits. Stormwater discharges from construction activities are transient, occurring mainly during the construction itself, and then only during storm events. Coverage under the NPDES Construction General Permit (CGP) for construction sites greater than one acre, or less than one acre if they are 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 2022 CGP also includes state-specific requirements to implement site-specific interim and permanent stabilization, and managerial and structural solids, erosion, and sediment control Best Management Practices (BMPs), and/or other controls. The SWPPP must include site-specific interim and permanent stabilization, managerial, and structural solids, erosion and sediment control BMPs and/or other controls that are designed to prevent to the maximum extent practicable an increase in the sediment yield and flow velocity from pre-construction, pre-development conditions to assure that applicable standards in 20.6.4 NMAC, including the antidegradation policy, and TMDL WLAs are met. This requirement applies to discharges both during construction and after construction operations have been completed. Currently in the 2022 CGP, EPA defines "sediment-related parameter" as a pollutant parameter that is closely related to sediment such as turbidity, total suspended solids (TSS), total suspended sediment, transparency, sedimentation, and siltation. For discharge covered under the CGP to a water that is impaired for a parameter other than a sediment-related parameter or nutrients, EPA will inform the operator if any additional controls are necessary to meet water quality standards.

Stormwater discharges from industrial activities and facilities, based on industrial classification codes, may be eligible for coverage under the 2021 NPDES Multi-Sector General Permit (MSGP). The MSGP also requires preparation of a SWPPP. Based on the industrial sector, some of the industrial facilities and activities covered under the MSGP have technology based effluent limitations and/or benchmark monitoring for pollutants. The current MSGP includes state-specific requirements that the benchmark values reflect 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. While these sources are not given individual allocations, they are addressed through other means, including BMPs, and other stormwater pollution prevention conditions. Implementation of a SWPPP that meets the requirements of a General Permit is generally assumed to be consistent with this TMDL. Loads that are in compliance with the General Permits are therefore currently included as part of the LA.

### 2.3.3 Load Allocation

Load Allocation is pollution from any nonpoint source(s) or natural background and is addressed through Best Management Practices (BMPs). To calculate the LA, the WLA and the MOS were subtracted from the TMDL using **Equation 2.3**, as shown on **Tables 2.7 – 2.8**. The MOS was developed using a combination of conservative assumptions and explicit recognition of potential errors (see Section 2.3.1 for details).

**Table 2.7 TMDL allocations for total recoverable aluminum (units in lbs/day)**

| Assessment Unit | WLA | LA | 15% MOS | TMDL |
|---|---|---|---|---|
| Calaveras Creek (Rio Cebolla to headwaters) | 0.00 | 0.32 | 0.06 | 0.37 |
| Clear Creek (Rio de las Vacas to San Gregorio Lake) | 0.00 | 0.35 | 0.06 | 0.41 |
| Clear Creek (San Gregorio Lake to headwaters) | 0.00 | 0.13 | 0.02 | 0.16 |

| | | | | |
|---|---|---|---|---|
| East Fork Jemez (San Antonio Creek to VCNP bnd) | 0.00 | 1.16 | 0.21 | 1.37 |
| East Fork Jemez (VCNP to headwaters) | 0.00 | 0.69 | 0.12 | 0.82 |
| Jaramillo Creek (East Fork Jemez to headwaters) | 0.00 | 0.35 | 0.06 | 0.41 |
| La Jara Creek (East Fork Jemez to headwaters) | 0.00 | 0.07 | 0.01 | 0.08 |
| Rio Cebolla (Fenton Lake to headwaters) | 1.52 | 0.47 | 0.35 | 2.34 |
| Rio de las Vacas (Clear Creek to headwaters) | 0.00 | 0.65 | 0.11 | 0.76 |
| Rito de los Indios (San Antonio Creek to headwaters) | 0.00 | 0.19 | 0.03 | 0.22 |
| San Antonio Creek (East Fork Jemez to VCNP bnd) | 0.00 | 4.91 | 0.87 | 5.78 |
| San Antonio Creek (VCNP bnd to headwaters) | 0.00 | 1.83 | 0.32 | 2.16 |

**Table 2.8 TMDL allocations for dissolved aluminum (units in lbs/day)**

| Assessment Unit | WLA | LA | 15% MOS | TMDL |
|---|---|---|---|---|
| Redondo Creek (Sulphur Creek to headwaters) | 0 | 0.08 | 0.01 | 0.09 |
| Sulphur Creek (Redondo Creek to headwaters) | 0 | 0.08 | 0.01 | 0.09 |
| Sulphur Creek (San Antonio Creek to Redondo Creek) | 0 | 0.16 | 0.03 | 0.19 |

### 2.3.4 Load Reduction

The extensive data collection and analysis necessary to determine background aluminum 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 loads.

The measured load for aluminum was calculated using concentrations found during exceedance events. In order to achieve comparability between the target and measured loads, the same flow value was used for both calculations, although the average measured flow was typically higher than the calculated 4Q3. The arithmetic mean of the collected data was substituted for the WQS in Equation 2.1. The same unit conversion factor was utilized. The calculated measured load is shown in **Tables 2.9 – 2.10**.

**Table 2.9 Load reduction estimated to meet WQS for total recoverable aluminum**

| Assessment Unit | Target Load (lbs/day)[a] | Measured Load (lbs/day)[b] | Load Reduction (%)[c] |
|---|---|---|---|
| Calaveras Creek (Rio Cebolla to headwaters) | 0.32 | 1.23 | 74.43 |
| Clear Creek (Rio de las Vacas to San Gregorio Lake) | 0.35 | 1.55 | 77.30 |
| Clear Creek (San Gregorio Lake to headwaters)* | 0.13 | 0.38 | 65.08 |
| East Fork Jemez (San Antonio Creek to VCNP bnd) | 1.16 | 12.62 | 90.77 |
| East Fork Jemez (VCNP to headwaters) | 0.69 | 4.62 | 84.98 |
| Jaramillo Creek (East Fork Jemez to headwaters) | 0.35 | 1.39 | 74.94 |
| La Jara Creek (East Fork Jemez to headwaters) | 0.07 | 0.23 | 68.75 |
| Rio Cebolla (Fenton Lake to headwaters) | 0.47 | 3.74 | 87.40 |
| Rio de las Vacas (Clear Creek to headwaters) | 0.65 | 4.20 | 84.59 |
| Rito de los Indios (San Antonio Creek to headwaters) | 0.19 | 0.65 | 71.10 |

| | | | |
|---|---|---|---|
| San Antonio Creek (East Fork Jemez to VCNP bnd) | 4.91 | 12.38 | 60.36 |
| San Antonio Creek (VCNP bnd to headwaters) | 1.83 | 4.44 | 58.69 |

**no data available for 21-22 survey, most recent data 2013*

**Table 2.10 Load reduction estimated to meet WQS for dissolved aluminum**

| Assessment Unit | Target Load (lbs/day)[a] | Measured Load (lbs/day)[b] | Load Reduction (%)[c] |
|---|---|---|---|
| Redondo Creek (Sulphur Creek to headwaters) | 0.08 | 2.70 | 97.02 |
| Sulphur Creek (Redondo Creek to headwaters) | 0.08 | 19.10 | 99.60 |
| Sulphur Creek (San Antonio Creek to Redondo Creek) | 0.16 | 16.45 | 99.00 |

*(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 at the TMDL critical flow using the mean measured Al concentration from sampling events that resulted in exceedances of WQS criteria (**Appendix A**).*

*(c) Percent reduction is the percent the existing measured load must be reduced to achieve the target load and is calculated as follows: ((Measured Load – Target Load) / Measured Load) x 100.*

## 2.4 Identification and Description of Pollutant Sources

SWQB conducted an assessment of the probable sources of impairment in the AU drainage area, according to Standard Operating Procedure 4.1, Revision 2, Probable Source(s) Determination (https://www.env.nm.gov/surface-water-quality/sop/; see also **Appendix C**). Probable Source Sheets are filled out by SWQB monitoring staff during watershed surveys. The sheets are then reviewed by watershed protection staff familiar with the location, and the TMDL writer conducts a search of aerial imagery, GIS files, and other available resources. 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 2.11** displays probable pollutant sources that have the potential to contribute to aluminum impairment within each AU in the TMDL study areas, 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 2.11 Probable sources of excessive aluminum for aluminum impaired AUs**

| Assessment Unit | Probable Source(s) |
|---|---|
| Calaveras Creek (Rio Cebolla to headwaters) | Grazing in riparian zone; Other recreational pollution sources; Roads/bridges |
| Clear Creek (Rio de las Vacas to San Gregorio Lake) | Dams/diversion; Flow alteration; Other recreational pollution sources; Rangeland grazing |
| Clear Creek (San Gregorio Lake to headwaters) | Other recreational pollution sources; Rangeland grazing; Roads/bridges |

| | |
|---|---|
| East Fork Jemez (San Antonio Creek to VCNP bnd) | Other recreational pollution sources; Rangeland grazing; Roads/bridges |
| East Fork Jemez (VCNP to headwaters) | Grazing in riparian zone; Rangeland grazing; Wildlife other than waterfowl |
| Jaramillo Creek (East Fork Jemez to headwaters) | Grazing in riparian zone; Other recreational pollution sources; Rangeland grazing; Wildlife other than waterfowl |
| La Jara Creek (East Fork Jemez to headwaters) | Other recreational pollution; Rangeland grazing; Wildlife other than waterfowl |
| Rio Cebolla (Fenton Lake to headwaters) | Deer; Illegal dumps or other inappropriate waste disposal; Grazing in riparian zone; Other recreational pollution sources; Onsite fishery; Roads/bridges; Waterfowl |
| Rio de las Vacas (Clear Creek to headwaters) | Other recreational pollution sources; Rangeland grazing; Roads/bridges |
| Rito de los Indios (San Antonio Creek to headwaters) | Other recreational pollution sources; Rangeland grazing |
| San Antonio Creek (East Fork Jemez to VCNP bnd) | Other recreational pollution sources; Rangeland grazing; Roads/bridges |
| San Antonio Creek (VCNP bnd to headwaters) | Other recreational pollution; Rangeland grazing; Wildlife other than waterfowl |
| Redondo Creek (Sulphur Creek to headwaters) | Other recreational pollution; Rangeland grazing; Wildlife other than waterfowl |
| Sulphur Creek (Redondo Creek to headwaters) | Other recreational pollution sources; Rangeland grazing |
| Sulphur Creek (San Antonio Creek to Redondo Creek) | Other recreational pollution sources; Rangeland grazing |

## 2.5 Consideration of Seasonal Variation

Normal aqueous chemical processes, enhanced by the slight natural acidity of snow and rain, are capable of rendering some of the abundant naturally occurring aluminum available to a river system, and, as a result of snowmelt, one might expect to see higher aluminum concentrations during spring sampling events in mountainous AUs. However, there was no apparent seasonal pattern to the exceedances documented in 2021-2022.

## 2.5 Future Growth

Growth estimates by county are available from the University of New Mexico Geospatial and Population Studies (GPS) (https://gps.unm.edu/pop/population-projections.html, accessed 1/27/2025). The estimates project growth to the year 2050. Almost the entirety of the Jemez Watershed is within the boundary of Sandoval County, and the small section of HUC 13020202 that extends into Rio Arriba County is largely unpopulated. GPS projects Sandoval County population to grow until the year 2040, and then begin declining, as detailed in **Table 2.11**. These projections account for the 2020 census results, also accessed through GPS (https://gps.unm.edu/pop/population-estimates.html, accessed 1/27/2025).

TMDL implementation planners should seek out the most current projections, if the information is relevant to their project.

**Table 2.11 Sandoval County population estimates**

| 2020 (Census)[B] | 2025 | 2030 | 2035 | 2040 | 2045 | 2050[A] | % Increase[a] |
|---|---|---|---|---|---|---|---|
| 148,834 | 157,468 | 164,648 | 169,117 | 170,460 | 169,575 | 166,753 | 12.04 |

*(a) % Increase: [(A – B) / B] × 100*

Estimates of future growth are not anticipated to lead to a significant increase in aluminum 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 *E. COLI*

*Escherichia coli (E. coli)* is a species of coliform bacteria that is present in the intestinal tracts and feces of warm-blooded animals. Most *E. Coli* is harmless and is an important part of a healthy human intestinal tract. However, some strains of *E. Coli* are pathogenic, meaning they can cause illness, either diarrhea or illness outside of the intestinal tract. It is also used as an indicator of the potential presence of other pathogens that may present human health concerns.

Bacterial data collected from the impaired AUs during the 2021-2022 SWQB water quality survey is shown in **Appendix B** and summarized on **Table 3.1**, below. Samples were assessed by comparing the *E. coli* results to the applicable single sample criterion. Assessment of the data identified exceedances of the New Mexico water quality standards for *E. coli* bacteria. As a result, these AUs are listed on the Integrated CWA § 303(d)/ § 305(b) List with *E. coli* as an impairment of the primary contact designated use (NMED/SWQB, 2026).

**Table 3.1 *E. Coli* exceedances**

| Assessment Unit | Water Quality Criterion (single sample, cfu/100mL) | Number of Exceedances |
|---|---|---|
| American Creek (Rio de las Palomas to headwaters) | 235 | 2/4 |
| Jaramillo Creek (East Fork Jemez to headwaters) | 235 | 2/8 |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) | 235 | 3/10 |
| Rito Penas Negras (Rio de las Vacas to headwaters) | 235 | 2/7 |

## 3.1 Target Loading Capacity

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 these *E. coli* TMDLs, the appropriate critical flow condition is at low flow, to be protective when the assimilative capacity of a stream is at its lowest. For this TMDL document, target values for *E. coli* bacteria are based on achievement of the monthly geometric mean numeric criterion of 126 cfu/100 mL as value not to be exceeded rather than a single sample maximum of 235 cfu/100 mL, to provide a conservative protective value. If the single sample criterion was used and achieved as a target, the geometric mean criterion may still not be achieved.

## 3.2 Flow

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 (4) consecutive day flow that occurs with a frequency of at least once every three (3) years.

Because all AUs discussed in this section are ungaged, an analysis method developed by USGS in partnership with NMED, authored by Bell and Tillery (Bell, 2023) was used to estimate the critical low flow. In the Bell & Tillery analysis, six regression equations for estimating 4Q3 were developed based on physiographic regions of New Mexico and stream basin characteristics (i.e., statewide and mountainous regions above 8,000 ft in elevation, or basins with less than 75 square mile drainage areas). The average elevation of all impaired AUs in the Jemez watershed are above 8,000 ft and are not the San Juan River nor tributaries to the San Juan, so the 4Q3-1a statewide regression equation was used. The following regression equation is based on data from 44 gaging stations with non-zero discharge (Bell, 2023):

**Equation 3.1:** $4Q3 = DA^{1.08} \times E^{12.20} \times e^{-115.37}$

Where:

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

$DA$ = drainage area ($mi^2$)

$E$ = mean basin elevation (ft)

$e$ = mathematical constant, Euler's number

The 4Q3 values calculated using Bell & Tillery's method are presented in **Table 3.2**. Parameters used in the calculation were obtained using the StreamStats online GIS application developed by the USGS (https://streamstats.usgs.gov/ss/). The 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 instream water quality is the goal of SWQB efforts.

**Table 3.2 Critical flow for *E. Coli* impaired AUs**

| Assessment Unit | Drainage Area ($mi^2$) | Average Elevation (ft) | 4Q3 (cfs) | 4Q3 (mgd) |
|---|---|---|---|---|
| American Creek (Rio de las Palomas to headwaters) | 7.50 | 9029 | 0.13 | 0.08 |
| Jaramillo Creek (East Fork Jemez to headwaters) | 15.90 | 9066 | 0.30 | 0.19 |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) | 66.20 | 8567 | 0.70 | 0.45 |
| Rito Penas Negras (Rio de las Vacas to headwaters) | 17.00 | 8935 | 0.27 | 0.17 |

## 3.3 TMDL Calculations

The WQS for bacteria are expressed as colony forming units (cfu) per unit volume. TMDLs for bacteria (**Table 3.3**) were calculated based on critical flow values (**Table 3.2**), water quality standards, and a conversion factor, using **Equation 3.2**.

$$\textbf{Equation 3.2} \quad C\ as\ \frac{cfu}{100mL} * 1000\frac{mL}{L} * \frac{L}{0.264\ gallons} * Q\ in\ 1{,}000{,}000\frac{gallons}{day} = cfu/day$$

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

**Table 3.3 *E. Coli* TMDL calculations**

| Assessment Unit | Geometric Mean *E. coli* criterion (cfu/100 mL) | Critical Flow (mgd) | Conversion Factor | TMDL (cfu/day) |
|---|---|---|---|---|
| American Creek (Rio de las Palomas to headwaters) | 126 | 0.08 | $3.79 \times 10^7$ | $3.88 \times 10^8$ |
| Jaramillo Creek (East Fork Jemez to headwaters) | 126 | 0.19 | $3.79 \times 10^7$ | $9.18 \times 10^8$ |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) | 126 | 0.45 | $3.79 \times 10^7$ | $2.15 \times 10^9$ |
| Rito Penas Negras (Rio de las Vacas to headwaters) | 126 | 0.17 | $3.79 \times 10^7$ | $8.26 \times 10^8$ |

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

**Equation 3.3:** *WLA + LA + MOS = TMDL*

### 3.3.1 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 bacteria TMDL, the MOS was developed using a combination of conservative assumptions and explicit allocations. Therefore, this MOS is the sum of the following elements:

- *Conservative assumptions:*
  - *E. coli* bacteria do not readily degrade in the environment; and,
  - Basing the target load capacity on the geometric mean criterion rather than the higher-concentration single sample criterion.
- *Explicit recognition of potential errors:*

- There is inherent error in flow estimation, a conservative MOS for this element in ungaged streams is **10 %**.

The total MOS for this TMDL is **10%**.

### 3.3.2 Waste Load Allocation

There are no National Pollutant Discharge Elimination System (NPDES) individual permits that discharge to the *E. Coli* impaired TMDL drainages. Therefore, no WLA is assigned for this TMDL.

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 ensure 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.

### 3.3.3 Load Allocation

Load Allocation is pollution from any nonpoint source(s) or natural background and is addressed through Best Management Practices (BMPs). To calculate the LA, the WLA and MOS are subtracted from the TMDL using **Equation 3.3**. Since there is no WLA, the LA is equal to the TMDL minus the MOS. Results of the load calculations are presented in **Table 3.4**. The extensive data collection and analyses necessary to determine background *E. coli* loads are beyond the resources available for this study. It is assumed that a portion of the LA is made up of natural background loads. It is important to note that WLAs and LAs are estimates based on a specific flow condition. Under differing hydrologic conditions, the loads will change. Successful implementation of this TMDL will be determined based on achievement of the *E. coli* standards under all flow conditions.

**Table 3.4 TMDL allocations for *E. Coli* (units in cfu/day)**

| Assessment Unit | WLA | LA | MOS (10%) | TMDL |
|---|---|---|---|---|
| American Creek (Rio de las Palomas to headwaters) | 0 | $3.49 \times 10^8$ | $3.88 \times 10^7$ | $3.88 \times 10^8$ |
| Jaramillo Creek (East Fork Jemez to headwaters) | 0 | $8.26 \times 10^8$ | $9.18 \times 10^7$ | $9.18 \times 10^8$ |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) | 0 | $1.93 \times 10^9$ | $2.15 \times 10^8$ | $2.15 \times 10^9$ |
| Rito Penas Negras (Rio de las Vacas to headwaters) | 0 | $7.43 \times 10^8$ | $8.26 \times 10^7$ | $8.26 \times 10^8$ |

### 3.3.4 Load Reduction

*E. Coli* impairment determinations were based on exceedances of the State’s single sample criteria and the TMDL is written to address the monthly geometric mean standard. As such, a simple comparison of the numbers would not necessarily represent an amount of contaminant reduction that would result in removing the impairment and would instead result in an overestimation of the actual reduction necessary. Neither Section 303 of the Clean Water Act nor 40 C.F.R. Part 130.7 requires states to include discussions of percent reductions in TMDL documents. Although NMED believes that it is often useful to discuss the magnitude of water quality exceedances in the TMDL report, the “percent reduction” value can be calculated in multiple ways and as a result is often misinterpreted. Therefore, a percent reduction value is not provided for *E. Coli* TMDLs.

## 3.4 Identification and Description of Pollutant Sources

SWQB fieldwork includes an assessment of the probable sources of impairment in the AU drainage area, according to Standard Operating Procedure 4.1, Probable Source(s) Determination (https://www.env.nm.gov/surface-water-quality/sop/; **Appendix C**). Probable Source Sheets are filled out by SWQB monitoring staff during watershed surveys. The sheets are then reviewed by watershed protection staff familiar with the location, and the TMDL writer conducts a search of aerial imagery, GIS files, and other available resources. 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. Pollutant sources that may contribute to each impairment were determined by field reconnaissance and evaluation (**Table 3.5**). Probable sources of bacteria impairments will be evaluated, refined, and changed as necessary through the Watershed Based Plans.

**Table 3.5 Probable sources of excessive coliform for E. Coli impaired AUs**

| Assessment Unit | Probable Source(s) |
|---|---|

| | |
|---|---|
| American Creek (Rio de las Palomas to headwaters) | Grazing in riparian zone; Rangeland grazing; Wildlife other than waterfowl |
| Jaramillo Creek (East Fork Jemez to headwaters) | Grazing in riparian zone; Other recreational pollution sources; Rangeland grazing; Wildlife other than waterfowl |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) | Other recreational pollution sources; Rangeland grazing; Roads/bridges; Wildlife other than waterfowl |
| Rito Penas Negras (Rio de las Vacas to headwaters) | Other recreational pollution sources; Rangeland grazing; Roads/bridges |

## 3.5 Consideration of Seasonal Variation

Federal regulations (40 C.F.R. § 130.7(c)(1)) require that TMDLs take into consideration seasonal variation in watershed conditions and pollutant loading. Data used in the calculation of these TMDLs were collected during the spring, summer, and fall of 2021-2022 with some data gaps collected in 2023 to ensure coverage of potential seasonal variation in the system. In all AUs discussed in this TMDL, exceedances were recorded in summer through early fall. This pattern is consistent with the findings of Hulvey et al. (2021) that *E. coli* peaked in midsummer in Utah streams running through grazed or ungrazed grasslands, with higher peaks in the grazed meadows.

## 3.6 Future Growth

Growth estimates by county are available from the University of New Mexico Geospatial and Population Studies (GPS) (https://gps.unm.edu/pop/population-projections.html, accessed 1/27/2025). The estimates project growth to the year 2050. Almost the entirety of the Jemez Watershed is within the boundary of Sandoval County, and the small section of HUC 13020202 that extends into Rio Arriba County is largely unpopulated. GPS projects Sandoval County population to grow until the year 2040, and then begin declining, as detailed in **Table 3.5**. These projections account for the 2020 census results, also accessed through GPS (https://gps.unm.edu/pop/population-estimates.html, accessed 1/27/2025). TMDL implementation planners should seek out the most current projections, if the information is relevant to their project.

**Table 3.5 Sandoval County population estimates**

| 2020 (Census)[B] | 2025 | 2030 | 2035 | 2040 | 2045 | 2050[A] | % Increase |
|---|---|---|---|---|---|---|---|
| 148,834 | 157,468 | 164,648 | 169,117 | 170,460 | 169,575 | 166,753 | 12.04 |

*% Increase: [ (A – B) / B ] × 100*

Estimates of future growth are not anticipated to lead to a significant increase in *E. coli* 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 PLANT NUTRIENTS

Phosphorus and nitrogen are essential for proper functioning of ecosystems. However, excess nutrients cause conditions unfavorable for the proper functioning of aquatic ecosystems. Nuisance levels of algae and other aquatic vegetation (macrophytes) can develop rapidly in response to nutrient enrichment when other factors (e.g., light, temperature, substrate) are not limiting (**Figure 4.1**). However, the magnitude of nutrient concentration that constitutes an "excess" is difficult to determine and varies by ecoregion.

Phosphorus and nitrogen generally drive the productivity of algae and macrophytes in aquatic ecosystems, therefore they are regarded as the primary limiting nutrients in freshwater. The main reservoirs of natural phosphorus are rocks and natural phosphate deposits. Weathering, leaching, and erosion are all processes that break down rock and mineral deposits allowing phosphorus to be transported to aquatic systems via water or wind. The breakdown of mineral phosphorus produces inorganic phosphate ions ($H_2PO_4^-$, $HPO_4^{2-}$, and $PO_4^{3-}$) that can be absorbed by plants from soil or water (USEPA, 1999). Phosphorus primarily moves through the food web as organic phosphorus (after it has been incorporated into plant or algal tissue) where it may be released as phosphate in urine or other waste by heterotrophic consumers and reabsorbed by plants or algae to start another cycle (Nebel and Wright, 2000).

The largest global reservoir of nitrogen is the atmosphere. About 80% of the atmosphere by volume consists of nitrogen gas ($N_2$). Although nitrogen is plentiful in the environment, it is not readily available for biological uptake. Nitrogen gas must be converted to other forms, such as ammonia ($NH_3$ and $NH_4^+$), nitrate ($NO_3^-$), or nitrite ($NO_2^-$) before plants and animals can use it. Conversion of gaseous nitrogen into usable mineral forms occurs through three biologically mediated processes of the nitrogen cycle: nitrogen fixation, nitrification, and ammonification (USEPA, 1999). Mineral forms of nitrogen can be taken up by plants and algae and incorporated into their tissue. Nitrogen follows the same pattern of food web incorporation as phosphorus and is released in waste primarily as ammonium compounds. The ammonium compounds are usually converted to nitrates by nitrifying bacteria, making it available again for uptake, starting the cycle anew (Nebel and Wright, 2000).

Rain, overland runoff, groundwater, drainage networks, and industrial and residential waste effluents transport nutrients to receiving waterbodies. Once nutrients have been transported into a waterbody they can be taken up by algae, macrophytes, and microorganisms either in the water column or in the benthos; they can sorb to organic or inorganic particles in the water column and/or sediment; they can accumulate or be recycled in the sediment; or they can be transformed and released as a gas from the waterbody (**Figure 4.1**).

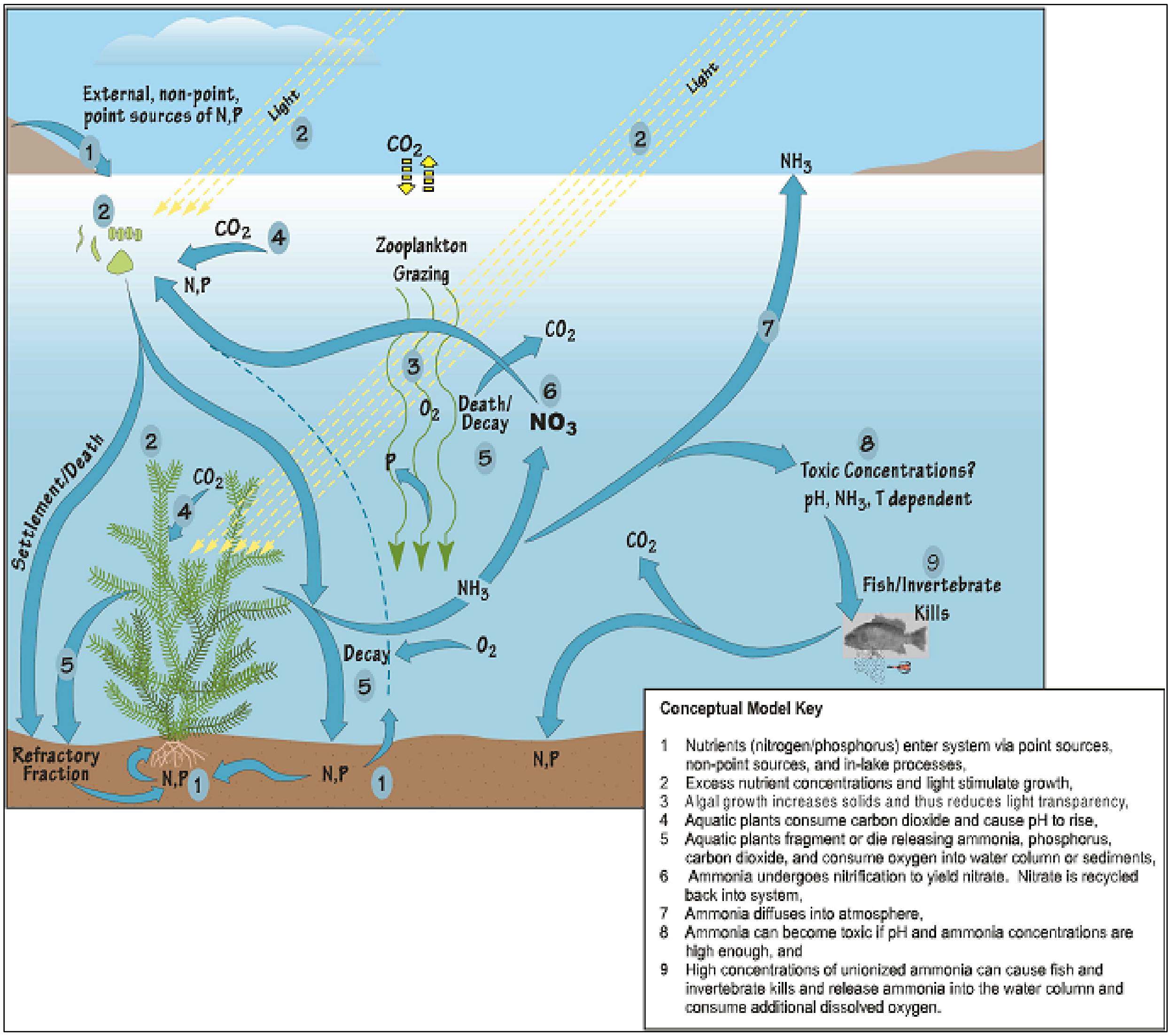


**Figure 4.1 Nutrient conceptual model (USEPA 1999)**

## 4.1 Target Loading Capacity

The intent of nutrient criteria, whether numeric or narrative, is to limit nutrient inputs to control the excessive growth of attached algae and higher aquatic plants. Controlling algae and plant growth preserves aesthetic and ecologic characteristics along the waterway. While conceptually there may be several possible combinations of total nitrogen (TN) and total phosphorus (TP) concentrations that are protective of water quality, the application of simple chemical limitation concepts to a complex biologic system to determine these combinations is challenging. One of the primary reasons for this is that different species of algae and higher aquatic plants will have different nutritional needs. Some species will thrive in nitrogen limited environments while others will thrive in phosphorous limited environments. Because of the diversity of nutritional needs amongst organisms, numeric thresholds for both TN and TP are required to preserve the aesthetic and ecologic characteristics along a waterway. Focusing on one nutrient or trading a decrease in one for an increase in the other may simply favor a particular species without achieving water quality standards.

New Mexico has a narrative criterion for plant nutrients set forth in 20.6.4.13(E) NMAC:

> ***Plant Nutrients:*** *Plant nutrients from other than natural causes shall not be present in concentrations which will produce undesirable aquatic life or result in the dominance of nuisance species in surface waters of the state.*

This narrative criterion can be challenging to assess because the relationships between nutrient levels and impairment of designated uses are not defined, and distinguishing nutrients from "other than natural causes" is difficult. Numeric thresholds are necessary to establish targets for TMDLs, to develop water quality-based permit limits and source control plans, and to support designated uses within the watershed.

In 2015 and 2016, SWQB collaborated with Tetra Tech, Inc., the EPA Region 6, and EPA's National Nutrient Criteria Program Nutrient Scientific Technical Exchange Partnership and Support (N-STEPS) program on a project to revise nutrient impairment thresholds for streams and rivers in New Mexico. This project follows EPA's nutrient criteria guidance (EPA, 2010) and Empirical Approaches for Nutrient Criteria Derivation (EPA, 2009). Statistical analyses of available state and regional data were conducted to refine nutrient thresholds using defined reference conditions, relationships between cause and response variables and a verified classification system. TN and TP candidate thresholds were derived for each site class using frequency distributions of nutrient conditions, defined as the median site value (Jessup et al. 2015), in least disturbed sites. Comparing site medians rather than individual sampling events to numeric thresholds is better aligned with the intention of identifying chronic excessive nutrients conditions. The resultant candidate thresholds were evaluated by SWQB staff, and the selected thresholds were used to revise this nutrient listing methodology. The 100+ page report (Jessup et al., 2015) detailing the N-STEPS effort is available at https://www.env.nm.gov/surface-water-quality/nutrients/. SWQB also generated and posted a shorter document which summarizes the steps taken to determine the candidate thresholds, and SWQB's logic regarding final threshold selection (NMED/SWQB, 2016).

Nutrient impairment in New Mexico's lakes and reservoirs occurs when excessive nitrogen (TN) and phosphorus (TP) disrupt designated uses such as recreation, water supply, and aquatic life by promoting harmful algal blooms, nuisance species, and oxygen-depleting plant growth. While some waters have segment-specific TP criteria, most rely on the narrative standard in 20.6.4.13 NMAC, which prohibits nutrient concentrations from non-natural sources that produce undesirable aquatic life or favor nuisance species. To translate this narrative into measurable endpoints, the Surface Water Quality Bureau, in collaboration with EPA's Nutrient Scientific Technical Exchange Partnership and Support (NSTEPS) program and Tetra Tech, conducted a comprehensive nutrient threshold refinement study in 2025. Using decades of state and national monitoring data, including the National Lakes Assessment, the Tetra Tech 2025 analysis applied ecoregion-specific stressor-response models to identify concentrations that avoid trophic decoupling and harmful algal blooms. This process produced a chlorophyll-*a* target of 10µg/L or less, which served as the basis for deriving ecoregion-specific TN and TP thresholds. These numeric criteria, used alongside dissolved oxygen and pH data, form the updated methodology for assessing nutrient impairment.

Phosphorous is found in water primarily as orthophosphate. In contrast nitrogen may be found as several dissolved species, all of which must be considered in nutrient loading. Total nitrogen is defined by SWQB as the sum of nitrate + nitrite (N+N), and Total Kjeldahl Nitrogen (TKN) (NMED/SWQB, 2017). At the present time, there is no USEPA-approved method to test for total nitrogen, however adding the results of USEPA methods 351.2 (TKN) and 353.2 (N+N) is appropriate for estimating total nitrogen. While not an EPA-approved method, Method SM4500-N for Total Nitrogen using a persulfate digest, is an approved method in the SWQB QAPP (NMED/SWQB, 2024) and is used in cases where a lower detection limit is needed. Daily delta DO, a response variable, is defined as the difference between the maximum and minimum DO concentration within a 24-hour period. The applicable threshold values for this TMDL are shown on **Table 4.1**. These threshold values were used for water quality assessments and TMDL development.

Nutrient assessments were conducted on data collected during the 2021-2022 water quality survey. Detailed assessment of water quality parameters indicated plant nutrient impairments in the AUs listed in **Tables 4.2 and 4.3**. Data contributing to the impairment determination are shown in **Appendix B**. There are two AUs (outlined in **Table 4.1**) included in this section that are not currently listed as impaired for excess plant nutrients but are receiving protective TMDLs due to having NPDES permitted facilities with potential to discharge high amounts of nutrients.

**Table 4.1 Causal and response variable thresholds for stream and river plant nutrients TMDL. Units are in mg/L.**

| Assessment Unit | Site Class | TN | TP | Delta DO | Protective TMDL?* |
|---|---|---|---|---|---|
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | TN: Moderate<br>TP: High-Volcanic | 0.42 | 0.105 | 5.02 | Yes |
| Jemez River (Rio Guadalupe to Soda Dam nr Jemez Springs) | TN: Moderate<br>TP: High-Volcanic | 0.42 | 0.105 | 5.02 | Yes |
| Rio Cebolla (Fenton Lake to headwaters) | TN: Moderate<br>TP: High-Volcanic | 0.42 | 0.105 | 5.02 | No |
| Rito de los Indios (San Antonio Creek to headwaters) | TN: Moderate<br>TP: High-Volcanic | 0.42 | 0.105 | 5.02 | No |
| San Antonio Creek (VCNP bnd to headwaters) | TN: Moderate<br>TP: High-Volcanic | 0.42 | 0.105 | 5.02 | No |

**Protective TMDL means it is currently not in category 5A, but a TMDL is being written due to wastewater treatment plants or other permitted facilities that have potential to discharge pollutants.*

**Table 4.2 Causal and response variable thresholds for lake nutrients TMDL**

| Assessment Unit | Level III Ecoregion | TN (mg/L) | TP (mg/L) | Chl. – *a* (µg/L) | Delta DO (mg/L) | Protective TMDL? |
|---|---|---|---|---|---|---|
| Fenton Lake | 21 Southern Rockies | 0.387 | 0.025 | 10 | 6.0 | No |

| | | | | | | |
|---|---|---|---|---|---|---|
| San Gregorio Lake | 21 Southern Rockies | 0.387 | 0.025 | 10 | 6.0 | No |

## 4.2 Flow

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 (4) consecutive day flow that occurs with a frequency of at least once every three (3) years.

Critical flow for the Jemez River (Jemez Pueblo bnd to Rio Guadalupe) was determined from daily discharge data, capturing at least 20 years of flow data, from 2003 through 2024 at the gage USGS 08324000 Jemez River Near Jemez, NM. USGS Hydrologic Toolbox was the software used to calculate 4Q3. The calculated 4Q3 is 7.33 cfs.

Because all other AUs discussed in this section are ungaged, an analysis method developed by USGS in partnership with NMED, authored by Bell and Tillery (Bell, 2023) was used to estimate the critical low flow. In the Bell & Tillery analysis, six regression equations for estimating 4Q3 were developed based on physiographic regions of New Mexico and stream basin characteristics (i.e., statewide and mountainous regions above 8,000 ft in elevation, or basins with less than 75 square mile drainage areas). The average elevation of all impaired AUs in the Jemez watershed are above 8,000 ft and are not the San Juan River nor tributaries to the San Juan, so the 4Q3-1a statewide regression equation was used. The following regression equation is based on data from 44 gaging stations with non-zero discharge (Bell, 2002):

**Equation 4.1:** $4Q3 = DA^{1.08} \times E^{12.20} \times e^{-115.37}$

Where:

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

$DA$ = drainage area ($mi^2$)

$E$ = mean basin elevation (ft)

$e$ = mathematical constant, Euler's number

The 4Q3 values calculated using Bell & Tillery's method are presented in **Table 4.3.** Parameters used in the calculation were obtained using the StreamStats online GIS application developed by the USGS (https://streamstats.usgs.gov/ss/). The 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 instream water quality is the goal of SWQB efforts.

Determining the critical flow condition for a lake is more complex than simply considering low-flow conditions of a stream, and subsequently TMDLs for Fenton and San Gregorio Lakes are described in concentrations per volume. Both Fenton and San Gregorio Lakes are small lakes with no historic storage level record, nor records of mean depth. Mean depth was estimated by taking 70% of the maximum recorded depth from SWQB monitoring events. Storage levels were estimated using this mean depth and using ArcGIS to determine the surface area of the lakes. Depth and storage levels are presented in **Table 4.4.**

**Table 4.3 Critical flow for nutrient impaired AUs**

| Assessment Unit | Drainage Area ($mi^2$) | Average Elevation (ft) | 4Q3 (cfs) | 4Q3 (mgd) |
|---|---|---|---|---|
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe)[ab] | -- | -- | 7.35 | 4.75 |
| Jemez River (Rio Guadalupe to Soda Dam nr Jemez Springs)[b] | 201 | 8641 | 2.68 | 1.73 |
| Rio Cebolla (Fenton Lake to headwaters)[b] | 43.7 | 8783 | 3.28 | 2.12 |
| Rito de los Indios (San Antonio Creek to headwaters) | 7.32 | 9568 | 0.25 | 0.16 |
| San Antonio Creek (VCNP bnd to headwaters) | 62 | 9104 | 1.36 | 0.88 |

*a) Calculated using USGS gage data and USGS Hydrologic Toolbox*

*b) Combined flow of permitted facility design capacity flow and 4Q3*

**Table 4.4 Estimated storage levels for Fenton & San Gregorio Lakes**

| Assessment Unit | Max Depth (ft) | Mean Depth (ft)[a] | Surface Area (acres) | Storage Area (acre-ft)[b] |
|---|---|---|---|---|
| Fenton Lake | 3.9 | 2.73 | 67.05 | 183.04 |
| San Gregorio Lake | 4.5 | 3.15 | 35.91 | 113.12 |

*a) Estimated as 70% of maximum depth.*

*b) [mean depth] × [surface area] = [storage area]*

## 4.3 TMDL Calculations

As a river flows downstream it has a specific loading capacity for nutrients. This loading capacity, or TMDL, is defined as the mass of pollutant that can be carried under critical flow conditions without violating the target concentration for that constituent. These TMDLs were developed based on simple dilution calculations using critical flows, the numeric target, and a conversion factor used to convert the resulting TMDL to lbs/day units. The specific loading capacity of a receiving water for a given pollutant was estimated using **Equation 4.2**. The calculated daily loading capacities (i.e., TMDLs) for TP and TN are summarized in **Table 4.5**.

Every lake has a specific carrying capacity for nutrients based on applicable WQS. This carrying capacity, or TMDL, is defined as the concentration of pollutant that can be carried without violating the target concentration for that constituent. These TMDLs were developed based on observed concentrations using lake storage and the numeric targets. The specific carrying capacity of a receiving water for a given pollutant was estimated using **Equation 4.3**. The calculated carrying concentrations (i.e., TMDLs) for TN and TP for the estimated storage volume are summarized in **Tables 4.6**, calculated by converting the concentration TMDL from mg/L to lbs/acre-ft using a conversion factor of 2.72, shown in **Equation 4.2**. The same calculated carrying concentrations, expressed as masses for the estimated storage volume, are summarized in **Table 4.7**. The load reductions presented in **Tables 4.14 and 4.15** are merely an absolute reduction from the measured load to the target load. This does not take into account the complex nature of nutrient loading into lakes and reservoirs. Extensive modeling was done to explore loading scenarios using the QWET model for QGIS, discussed in **Section 9.4** and in **Appendix F**.

**Equation 4.2:** *[Concentration TMDL (mg/L)] x [Conversion Factor (2.72)] x [Storage (acre-ft)]*

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

**Equation 4.3:** *Critical flow (4Q3) x WQS (mg/L) x Conversion Factor = TMDL (lbs/day)*

**Equation 4.4:** *WLA + LA + MOS = TMDL*

**Table 4.5 Stream & River TMDL calculations for TN/TP**

| Assessment Unit | Parameter | Critical Flow (mgd) | In-Stream Target (mg/L) | Conversion Factor | TMDL (lbs/day) |
|---|---|---|---|---|---|
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | Total Nitrogen | 4.75 | 0.42 | 8.34 | 16.64 |
| | Total Phosphorus | | 0.105 | | 4.16 |
| Jemez River (Rio Guadalupe to Soda Dam nr Jemez Springs) | Total Nitrogen | 1.73 | 0.42 | 8.34 | 6.06 |
| | Total Phosphorus | | 0.105 | | 1.51 |
| Rio Cebolla (Fenton Lake to headwaters) | Total Nitrogen | 2.12 | 0.42 | 8.34 | 7.44 |
| | Total Phosphorus | | 0.105 | | 1.86 |
| Rito de los Indios (San Antonio Creek to headwaters) | Total Nitrogen | 0.16 | 0.42 | 8.34 | 0.56 |
| | Total Phosphorus | | 0.105 | | 0.14 |
| San Antonio Creek (VCNP bnd to headwaters) | Total Nitrogen | 0.88 | 0.42 | 8.34 | 3.08 |
| | Total Phosphorus | | 0.105 | | 0.77 |

**Table 4.6** **Fenton & San Gregorio Lake target concentrations for TN & TP (Level III Ecoregion: 21; Southern Rockies)**

| Assessment Unit | Parameter | Target Concentration (mg/L) | Measured Arithmetic Mean Concentration (mg/L) |
|---|---|---|---|
| Fenton Lake | Total Nitrogen | 0.387 | 0.56 |
| | Total Phosphorus | 0.025 | 0.046 |
| San Gregorio Lake | Total Nitrogen | 0.387 | 0.55 |
| | Total Phosphorus | 0.025 | 0.036 |

**Table 4.7** **Fenton (183 acre-ft) & San Gregorio (113 acre-ft) Lake target concentrations for TN & TP, expressed in mass**

| Assessment Unit | Parameter | Target Concentration (lbs) | Measured Arithmetic Mean Concentration (lbs) |
|---|---|---|---|
| Fenton Lake | Total Nitrogen | 192.6 | 278.6 |
| | Total Phosphorus | 12.44 | 23.4 |
| San Gregorio Lake | Total Nitrogen | 118.9 | 169.1 |
| | Total Phosphorus | 7.7 | 11.1 |

*[Target conc. (lbs)] = [target conc. (mg/L]) x [conversion factor (2.72)] x [lake storage (acre-ft)]*

### 4.3.1 Margin of Safety

TMDLs should reflect a MOS based on the uncertainty or variability in the data, the point and nonpoint source load estimates, and the modeling analysis. The MOS can be expressed either implicitly or explicitly. 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 this nutrient TMDL, the margin of safety was developed using a combination of conservative assumptions and explicit recognition of potential errors. Therefore, this margin of safety is the sum of the following elements:

- *Conservative assumptions*
    - Treating phosphorus and nitrogen as pollutants that do not readily degrade in the environment.
    - An implicit margin of safety is added by setting a TMDL that, if achieved, would not exceed the threshold at any time, whereas the WQS thresholds are based on the median measured concentration.
- *Explicit recognition of potential errors*
    - There is inherent error in flow estimation, a conservative MOS for this element in ungaged streams is **10%**.

- There is inherent variability in lake volumes, both measured and estimated. A conservative MOS for this element in lakes is **10%.**
- There is inherent error in the lake modeling process. A conservative MOS for this element in lakes is **5%**

The total MOS for stream TMDLs is **10%**; the total MOS for lake TMDLS is **15%**.

### 4.3.2 Waste Load Allocation

There are National Pollution Discharge Elimination System (NPDES) permits for a wastewater treatment plant (WWTP) on the Jemez River (Jemez Pueblo bnd to Rio Guadalupe), a WWTP on the Jemez River (Rio Guadalupe to Soda Dam nr Jemez Springs), and a discharge permit for a fish hatchery on the Rio Cebolla (Fenton Lake to headwaters). The Jemez Valley Public Schools hold a permit (NM0028479), for a small WWTP with one outfall that is authorized to discharge to the Jemez River. The Village of Jemez Springs holds a permit (NM0028011), for a WWTP with one outfall that is authorized to discharge into the Jemez River. The New Mexico Department of Game & Fish (NMDGF) Seven Springs State Fish Hatchery holds a permit (NM0030112), with two outfalls that authorizes the discharge of wastewater into the Rio Cebolla above Fenton Lake. The table below outlines the permitted facilities, design capacity flow, and effluent limits.

**Jemez Valley Public Schools** (NM0028479, expires Oct. 31, 2029) is not currently required to report TN and TP in their discharge monitoring reports (DMR). The permitted design capacity flow is 0.01mgd. SWQB collected two samples from the effluent during the water quality survey in June 2021, and March 2022. Due to the low number of effluent samples collected during the 2019 survey, data from the previous survey, 2013, is included in this discussion. The average TN concentration from SWQB samples is 87.04 mg/L, and the average TP concentration from SWQB samples is 5.58 mg/L. TN & TP values from effluent from the Jemez Valley Public Schools WWTP are presented in **Appendix B**. The Phase 1 WLA was determined using the $85^{th}$ percentile of effluent data collected by SWQB (**Appendix B**).

**Jemez Springs WWTP** (NM0028011, this permit is currently administratively continued; may be reissued 2026) permit includes limits for total nitrogen at 4.75mg/L daily max, and total phosphorus at 1.0mg/L daily max or 2.97 lbs/day and 0.626 lbs/day, respectively. These limits were established in the 2009 TMDL. SWQB has typically provided a phased approach to WLAs for WWTPs using the $85^{th}$ percentile of data reported by the permitted facility to determine the first phase, where an eventual $n^{th}$ phase achieves WQS. SWQB collected effluent samples in 2022 in the months of February, March, August and October, presented in **Appendix B**. The average TN concentration from SWQB samples is 3.32 mg/L, and the average TP concentration from SWQB samples was 0.29 mg/L.

**Seven Springs Fish Hatchery** (NM0030112, expires Nov. 30, 2029) is not currently required to report TN and TP in their DMRs. SWQB also could not collect effluent data. An $85^{th}$ percentile cannot be directly calculated with the lack of available data, therefore the phase one allocation will be 72% of the TMDL, representing the ratio of the monthly average flow from the hatchery to the total 4Q3 of the receiving stream referenced in **Table 4.3** (the contributing flow from the hatchery is 1.52 mgd, the total 4Q3 for Rio Cebolla is 2.12 mgd; $(1.52 \div 2.12) \times 100\% = 72\%$) where an eventual $n^{th}$ phase achieves WQS.

WLAs for Jemez Valley Public Schools, Jemez Springs, and the Seven Springs Fish Hatchery are presented in **Tables 4.8 – 4.10.**

**Table 4.8 Plant nutrient waste load allocation for Jemez Valley Public Schools wastewater treatment plant, (NM0028479, expires Oct. 31, 2029)**

| Phase | Parameter | Water Quality Target (mg/L) | WLA (lbs/day) |
|---|---|---|---|
| 1st (currently achieved) | Total Nitrogen | 111.56 | 9.30 |
| | Total Phosphorus | 7.14 | 0.60 |
| 2nd (interim limit) | Total Nitrogen | TBD | TBD |
| | Total Phosphorus | TBD | TBD |
| nth (water quality based) | Total Nitrogen | 0.42 | 0.035 |
| | Total Phosphorus | 0.105 | 0.009 |

*WLA = [design capacity flow(0.01 mgd)] × [water quality target] × [conversion factor (8.34)]*

*Phased approach: Phase 1 determined using 85th percentile of DMR data, phase n achieves WQS of receiving waters*

**Table 4.9 Plant nutrient waste load allocation for Jemez Springs wastewater treatment plant (NM0028011, [date])**

| Phase | Parameter | Water Quality Target (mg/L) | WLA (lbs/day) |
|---|---|---|---|
| 1st (current permitted limits) | Total Nitrogen | 4.75 | 2.97 |
| | Total Phosphorus | 1.0 | 0.626 |
| 2nd (proposed limits) | Total Nitrogen | 4.04 | 2.53 |
| | Total Phosphorus | 0.8 | 0.50 |
| 3rd (interim limit) | Total Nitrogen | TBD | TBD |
| | Total Phosphorus | TBD | TBD |
| nth (water quality based) | Total Nitrogen | 0.42 | 0.26 |
| | Total Phosphorus | 0.105 | 0.07 |

*WLA = [design capacity flow (0.075 mgd)] × [water quality target] × [conversion factor (8.34)]*

*Phased approach: Phase 1 determined using 85th percentile of DMR data, phase n achieves WQS of receiving waters*

**Table 4.10 Plant nutrient waste load allocation for Seven Springs Fish Hatchery (NM0030112, expires Nov. 30, 2029)**

| Phase | Parameter | Water Quality Target (mg/L) | WLA (lbs/day) |
|---|---|---|---|
| 1st (current permitted limits) | Total Nitrogen | 0.45 | 5.36 |
| | Total Phosphorus | 0.11 | 1.34 |
| 2nd (interim limit) | Total Nitrogen | TBD | TBD |
| | Total Phosphorus | TBD | TBD |
| nth (water quality based) | Total Nitrogen | 0.42 | 5.33 |
| | Total Phosphorus | 0.105 | 1.33 |

*WLA = [design capacity flow] × [water quality target] × [conversion factor (8.34)]*

*Phased approach: Phase 1 determined using 85% of TMDL (TN = 7.44, TP = 1.86; **Table 4.5**) (no DMR/effluent data for this facility), phase n achieves WQS of receiving waters*

### 4.3.3 Load Allocation

Load Allocation is pollution from any nonpoint source(s) or natural background and is addressed through Best Management Practices (BMPs). To calculate the LA, the WLA and the MOS were subtracted from the TMDL using **Equation 4.4**, as shown on **Table 4.11 – 4.13**. The MOS was developed using a combination of conservative assumptions and explicit recognition of potential errors (see **Section 4.3.1** for details).

**Table 4.11 Stream & River TMDL allocations for TP & TN (units in lbs/day)**

| Assessment Unit | Parameter | WLA | LA | MOS | TMDL |
|---|---|---|---|---|---|
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | Total Nitrogen | 0.035 | 14.94 | 1.66 | 16.64 |
| | Total Phosphorus | 0.009 | 3.73 | 0.42 | 4.16 |
| Jemez River (Rio Guadalupe to Soda Dam nr Jemez Springs) | Total Nitrogen | 0.26 | 5.19 | 0.61 | 6.06 |
| | Total Phosphorus | 0.066 | 1.30 | 0.15 | 1.51 |
| Rio Cebolla (Fenton Lake to headwaters) | Total Nitrogen | 5.33 | 1.37 | 0.74 | 7.44 |
| | Total Phosphorus | 1.33 | 0.34 | 0.19 | 1.86 |
| Rito de los Indios (San Antonio Creek to headwaters) | Total Nitrogen | 0 | 0.50 | 0.06 | 0.56 |
| | Total Phosphorus | 0 | 0.13 | 0.01 | 0.14 |
| San Antonio Creek (VCNP bnd to headwaters) | Total Nitrogen | 0 | 2.77 | 0.31 | 3.08 |
| | Total Phosphorus | 0 | 0.69 | 0.08 | 0.77 |

*[TMDL] - [MOS] - [WLA] = [LA]*

**Table 4.12 Lake concentration-based TMDL allocations for TP & TN (units in mg/L)**

| Assessment Unit | Parameter | WLA | LA | MOS | TMDL |
|---|---|---|---|---|---|
| Fenton Lake | Total Nitrogen | 0 | 0.33 | 0.058 | 0.387 |
| | Total Phosphorus | 0 | 0.021 | 0.0038 | 0.025 |
| San Gregorio Lake | Total Nitrogen | 0 | 0.33 | 0.058 | 0.387 |
| | Total Phosphorus | 0 | 0.021 | 0.0058 | 0.025 |

**Table 4.13 Lake mass-based TMDL allocations for TP & TN (units in lbs)**

| Assessment Unit | Parameter | WLA | LA | MOS | TMDL |
|---|---|---|---|---|---|
| Fenton Lake | Total Nitrogen | 0 | 163.7 | 28.9 | 192.6 |
| | Total Phosphorus | 0 | 10.5 | 1.9 | 12.4 |
| San Gregorio Lake | Total Nitrogen | 0 | 101.1 | 17.8 | 118.9 |
| | Total Phosphorus | 0 | 6.5 | 1.2 | 7.7 |

### 4.3.4 Load Reduction

The extensive data collection and analysis necessary to determine background nutrient 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 loads.

Lake load reductions necessary to meet the target loads were calculated as the difference between the daily target load and the measured load. Load reductions necessary for lakes are given as both concentrations (**Table 4.14**) and masses (**Table 4.15**). All streams and rivers discussed in this section have been listed as impaired based on response variables (DO), rather than total nitrogen or phosphorus, so no load reductions are provided for TN/TP for streams and rivers.

**Table 4.14 Load reductions for lakes for total nitrogen and total phosphorus expressed as concentrations (mg/L)**

| Assessment Unit | Parameter | Target Concentraion | Mean Measured Concentration | Concentration Reduction | Percent Reduction |
|---|---|---|---|---|---|
| Fenton Lake | Total Nitrogen | 0.33 | 0.56 | 0.23 | 41% |
| | Total Phosphorus | 0.021 | 0.046 | 0.025 | 54% |
| San Gregorio Lake | Total Nitrogen | 0.33 | 0.55 | 0.22 | 40% |
| | Total Phosphorus | 0.021 | 0.036 | 0.015 | 42% |

**Table 4.15 Load reductions for lakes for total nitrogen and total phosphorus expressed as mass (lbs)**

| Assessment Unit | Parameter | Target Load | Mean Measured Load | Load Reduction | Percent Reduction |
|---|---|---|---|---|---|
| Fenton Lake | Total Nitrogen | 163.7 | 278.6 | 114.9 | 41% |
| | Total Phosphorus | 10.5 | 22.9 | 12.4 | 54% |
| San Gregorio Lake | Total Nitrogen | 101.1 | 169.1 | 68.0 | 40% |

| | | | | | |
|---|---|---|---|---|---|
| | Total Phosphorus | 6.5 | 11.1 | 4.6 | 42% |

*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.*

*Percent reduction is the percent the existing measured load must be reduced to achieve the target load and is calculated as follows: ((Measured Load – Target Load) / Measured Load) x 100.*

## 4.4 Identification and Description of Pollutant Sources

SWQB fieldwork includes an assessment of the probable sources of impairment in the AU drainage area, according to Standard Operating Procedure 4.1, Probable Source(s) Determination (https://www.env.nm.gov/surface-water-quality/sop/; **Appendix C**). Probable Source Sheets are filled out by SWQB monitoring staff during watershed surveys. The sheets are then reviewed by watershed protection staff familiar with the location, and the TMDL writer conducts a search of aerial imagery, GIS files, and other available resources. 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. Pollutant sources that may contribute to each impairment were determined by field reconnaissance and evaluation (**Table 4.16**). Probable sources of nutrient impairments will be evaluated, refined, and changed as necessary through the Watershed Based Plans.

**Table 4.16 Probable sources of excessive plant nutrients for nutrient impaired AUs**

| Assessment Unit | Probable Source(s) |
|---|---|
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | Crop production; Dams/diversion; Irrigated crop production; Onsite treatment systems; Roads/bridges; Wildlife other than waterfowl |
| Jemez River (Rio Guadalupe to Soda Dam nr Jemez Springs) | Dams/diversion; Onsite treatment systems; Roads/bridges; Wildlife other than waterfowl |
| Rio Cebolla (Fenton Lake to headwaters) | Deer; Illegal dumps or other inappropriate waste disposal; Grazing in riparian zone; Other recreational pollution sources; Onsite fishery; Roads/bridges; Waterfowl |
| Rito de los Indios (San Antonio Creek to headwaters) | Other recreational pollution sources; Rangeland grazing |
| San Antonio Creek (VCNP bnd to headwaters) | Other recreational pollution; Rangeland grazing; Wildlife other than waterfowl |
| Fenton Lake | Rangeland grazing, Other recreational pollution sources; Roads/bridges |
| San Gregorio Lake | Grazing in riparian zone; Other recreational pollution; Rangeland grazing |

## 4.5 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 variation." The AUs in the Jemez River are receiving protective/updated

TMDLs, and do not have any exceedances of the WQS during the 2021-2022 monitoring survey, and the remaining AUs do not appear to have any seasonal trends in the data.

The critical condition used for calculating the TMDL is considered conservative and protective of the water quality standard under all flow conditions. Calculations made at the critical flow, in addition to using other conservative assumptions as described in the previous section on MOS, should be protective of the water quality standards designed to preserve aquatic life in the stream. It was assumed that if critical conditions were met during this time, coverage of any potential seasonal variation would also be met.

## 4.6 Future Growth

Growth estimates by county are available from the University of New Mexico Geospatial and Population Studies (GPS) (https://gps.unm.edu/pop/population-projections.html, accessed 1/27/2025). The estimates project growth to the year 2050. Almost the entirety of the Jemez Watershed is within the boundary of Sandoval County, and the small section of HUC 13020202 that extends into Rio Arriba County is largely unpopulated. GPS projects Sandoval County population to grow until the year 2040, and then begin declining, as detailed in **Table 4.17**. These projections account for the 2020 census results, also accessed through GPS (https://gps.unm.edu/pop/population-estimates.html, accessed 1/27/2025). TMDL implementation planners should seek out the most current projections, if the information is relevant to their project.

**Table 4.17 Sandoval County population estimates**

| 2020 (Census)[B] | 2025 | 2030 | 2035 | 2040 | 2045 | 2050[A] | % Increase |
|---|---|---|---|---|---|---|---|
| 148,834 | 157,468 | 164,648 | 169,117 | 170,460 | 169,575 | 166,753 | 12.04 |

*% Increase: [ (A – B) / B ] × 100*

# 5.0 SEDIMENTATION

Stream bottom substrate provides optimum habitat for many fish and aquatic insect communities when it does not include excessive fine sediment filling the interstitial spaces. Excessive fine sediment occurs when biologically important habitat components such as spawning gravels and cobble surfaces are physically covered by fines (Chapman and McLeod, 1987). Substrate fining decreases intergravel oxygen and results in reduced or eliminated quality and quantity of habitat for fish, macroinvertebrates, and algae (Lisle, 1989; Waters, 1995). Chapman and Mcleod (1987) found that bed material size is related to habitat suitability for fish and macroinvertebrates and that excess fine sediment decreased both density and diversity of aquatic insects.

Sediment loads that exceed a stream's sediment transport capacity often trigger changes in stream morphology (Leopold et al., 1964). Streams that become overwhelmed with sediment often go through a period of accelerated channel widening and streambank erosion before returning to a stable form (Rosgen, 1996). These morphological changes can accelerate erosion, reduce habitat diversity (pools, riffles, etc.) and place additional stress on the designated aquatic life use.

## 5.1 Target Loading Capacity

The New Mexico WQS include a general narrative standard at 20.6.4.13(A)(1) NMAC for "bottom deposits and suspended or settleable solids", which reads:

> *"Surface waters of the state shall be free of water contaminants including fine sediment particles (less than two millimeters in diameter), precipitates or organic or inorganic solids from other than natural causes that have settled to form layers on or fill the interstices of the natural or dominant substrate in quantities that damage or impair the normal growth, function or reproduction of aquatic life or significantly alter the physical or chemical properties of the bottom."*

The assessment approach used to determine these sedimentation impairments is described in detail in Appendix G of the SWQB Comprehensive Assessment and Listing Methodology (CALM; NMED/SWQB, 2025). Target values for this TMDL were based on the numeric thresholds identified in the CALM. The CALM establishes a procedure for determining impairment due to excessive sedimentation/siltation in perennial, wadeable streams. Bedded sediments cannot be treated as introduced pollutants such as pesticides because they are not uniquely generated through human input or disturbance. Rather, bedded sediments are components of natural systems that are present even in pristine settings and to which stream organisms have evolved and adapted. Therefore, the detection of a sediment imbalance is more complicated than detecting an absolute concentration or percentage that represents a clear biological impact.

The SWQB and USEPA Region 6 contracted with Tetra Tech, Inc., to develop sediment translators or thresholds. The contractor generally followed the steps provided in USEPA's Framework for developing suspended and bedded sediment water quality criteria (USEPA, 2006). This effort included the identification of sediment characteristics that are expected under the range of environmental settings in New Mexico, especially in undisturbed or best available reference streams. Examining the relationships between biological measures and sediment indicators helped to identify where disturbance had caused sediment imbalance and biologically relevant habitat degradation. The analysis resulted in threshold recommendations for two bedded sediment indicators for New Mexico perennial streams (**Table 5.1**) – percent Sand & Fines (%SaFN) and log Relative Bed Stability calculated without bedrock (LRBS_NOR) -- for three different site classes, Mountains, Foothills, and Xeric. The site classes are defined by Level 3 and 4 ecoregions (Griffith et al., 2006) and distinguish sediment expectations across New Mexico. The report detailing this effort (Jessup et al., 2010) is available at https://www.env.nm.gov/surface-water-quality/sedimentation/.

**Table 5.1 Bedded sediment indicators (from Jessup et al., 2010)**

| Sediment Indicator | Description |
|---|---|
| Percent Sand & Fines (%SaFN) | **The percentage of systematically selected streambed substrate particles that are ≤2.0 mm in diameter from reach-wide pebble count.** |
| Log Relative Bed Stability (LRBS) | **A measure of the relationship of the median particle size in a stream reach compared to the critical particle size calculated to be mobilized by standardized fluvial stresses in the reach.** Median particle size is determined using a reach-wide pebble count (Peck et al. 2006). Critical particle size is calculated from channel dimensions, flow characteristics, and channel roughness factors (Kaufmann et al. 2008). The measure is expressed as a logarithm of the ratio of geometric mean to critical particle size. |
| LRBS_NOR | **RBS without bedrock or hardpan (log10).** This measure regards only the potentially mobile streambed particles in determining the geometric mean particle size, and improved associations between the bedded sediment measure and biological responses in the TetraTech analyses (Jessup et al. 2010) |

To determine if there is excessive sedimentation/siltation in the study stream reach, two levels of assessment are performed in sequential order. The first level considers the simpler indicator of biological impairment and then refines the assessment with the second indicator of geomorphic impairment as needed when the first level threshold is exceeded. The % SaFN sediment indicator is used in the Level One assessment because it is easily measured and related strongly with biological metrics. If the %SaFN indicates excessive fine sediment in the stream bed, a Level Two survey is performed to collect data used to calculate the LRBS_NOR value.

In minimally disturbed streams, the measured geometric mean particle size should trend towards the expected particle size (i.e., the size the stream is capable of moving as bedload at bankfull flow). The LRBS_NOR indicator considers site-specific hydraulic potential for moving bed sediments, so that the observed amount of fine sediments is considered impaired only when the streambed is more easily mobilized and transported than expected. It incorporates stream channel, shape, slope, flow, and sediment supply. The LRBS_NOR measure is appropriate as a second-tier indicator because it is scaled to hydro-geomorphic factors of the individual sites, as well as to the broader site classes, thus allowing evaluation of the potential of the specific site in terms of retaining or flushing fine sediments.

**Table 5.2** **Sedimentation indicator thresholds based on biological responses and reference distributions (Jessup et al., 2010)**

| Site Class | % Sand and Fines | LRBS_NOR Units |
|---|---|---|
| Mountain | < 20 | > -1.1 |
| Foothill | < 37 | > -1.3 |
| Xeric | < 74 | > -2.5 |

If the calculated LRBS_NOR is greater than the applicable site class threshold in **Table 5.2**, the AU is regarded as **Full Support** with respect to New Mexico's narrative sedimentation/siltation standard found at 20.6.4.13 NMAC. If the calculated LRBS_NOR is less than or equal to the applicable site class threshold, the AU is considered **Non-Support.** The LRBS_NOR thresholds for the Jaramillo Creek (East Fork Jemez to headwaters) and Vallecito Ck (Perennial Prt Div abv Ponderosa to headwaters) AUs are -1.1 and -1.3 respectively, and the calculated LRBS_NOR are -1.26 and -1.49 respectively, thus indicating that the streams are impaired.

**Table 5.3** **Numeric thresholds applied to sediment impaired AUs**

| Assessment Unit | Ecoregion/Site Class | % Sand and Fines Threshold | % Sand and Fines Observed | LRBS_NOR Threshold | Calculated LRBS_NOR |
|---|---|---|---|---|---|
| Jaramillo Creek (East Fork Jemez to headwaters) | 21 Mountains | 20 | 55.2 | -1.1 | -1.26 |
| Vallecito Ck (Perennial Prt Div abv Ponderosa to headwaters) | 21d Foothills | 37 | 53.3 | -1.3 | -1.49 |

A load-based indicator is needed to generate a TMDL based on mass balance. Turbidity is correlated with TSS for a given water body. Jessup et al. (2010) suggests an interpretation of the indicator value distributions for sites which fully support their designated uses, using the 90$^{th}$ percentile value for Mountain and Foothills sites and the 75$^{th}$ percentile value for Xeric sites (**Table 5.4**). Therefore, the target Total Suspended Solids (TSS) value for the sedimentation TMDL for Jaramillo Creek (East Fork Jemez to headwaters) will be 8.75 mg/L, and for Vallecito Ck (Perennial Prt Div abv Ponderosa to headwaters), the TSS value for the sedimentation TMDL will be 16.12 mg/L. Monitoring data for flow, TSS and turbidity are presented in **Appendix B**.

**Table 5.4** **Suspended sediment indicator percentiles for fully supporting sites and all sites in three site classes**

| | | Fully Supporting Sites | | | All Sites | | |
|---|---|---|---|---|---|---|---|
| | | Valid N | 75$^{th}$ | 90$^{th}$ | Valid N | 25$^{th}$ | Median |
| Mountains | Turbidity (ntu) | 68 | 4.88 | 9.50 | 217 | 1.25 | 3.10 |
| | TSS (mg/L) | 70 | 5.05 | 8.75 | 221 | 3.00 | 3.89 |
| Foothills | Turbidity (ntu) | 24 | 12.18 | 19.30 | 136 | 2.33 | 5.99 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | TSS (mg/L) | 24 | 9.88 | 16.12 | 138 | 3.71 | 6.71 |
| Xeric | Turbidity (ntu) | 83 | 68.50 | 191.76 | 289 | 5.60 | 16.00 |
| | TSS (mg/L) | 85 | 60.23 | 262.80 | 295 | 7.00 | 17.00 |

## 5.2 Flow

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 (4) consecutive day flow that occurs with a frequency of at least once every three (3) years.

Because all AUs discussed in this section are ungaged, an analysis method developed by USGS in partnership with NMED, authored by Bell and Tillery (Bell, 2023) was used to estimate the critical low flow. In the Bell & Tillery analysis, six regression equations for estimating 4Q3 were developed based on physiographic regions of New Mexico and stream basin characteristics (i.e., statewide and mountainous regions above 8,000 ft in elevation, or basins with less than 75 square mile drainage areas). The average elevation of all impaired AUs in the Jemez watershed are above 8,000 ft and are not the San Juan River nor tributaries to the San Juan, so the 4Q3-1a statewide regression equation was used. The following regression equation is based on data from 44 gaging stations with non-zero discharge (Bell, 2002):

**Equation 5.1:** $4Q3 = DA^{1.08} \times E^{12.20} \times e^{-115.37}$

Where:

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

$DA$ = drainage area ($mi^2$)

$E$ = mean basin elevation (ft)

$e$ = mathematical constant, Euler's number

The 4Q3 values calculated using Bell & Tillery's method are presented in **Table 5.5**. Parameters used in the calculation were obtained using the StreamStats online GIS application developed by the USGS (https://streamstats.usgs.gov/ss/). The 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 instream water quality is the goal of SWQB efforts.

**Table 5.5 Critical flow for sedimentation impaired AUs**

| Assessment Unit | Drainage Area ($mi^2$) | Average Elevation (ft) | 4Q3 (cfs) | 4Q3 (mgd) |
|---|---|---|---|---|
| Jaramillo Creek (East Fork Jemez to headwaters) | 15.9 | 9066 | 0.30 | 0.19 |

| | | | | |
|---|---|---|---|---|
| Vallecito Ck (Perennial Prt Div abv Ponderosa to headwaters) | 16.4 | 8066 | 0.07 | 0.05 |

## 5.3 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, according to the formula:

**Equation 5.2** *WQS (mg/L) x Critical flow (4Q3) x Conversion Factor (8.34) = TMDL (lbs/day)*

The TSS TMDL concentration is presented on **Table 5.6** for the critical low flow condition.

**Table 5.6 Sedimentation TMDL calculations**

| Assessment Unit | TSS Indicator Value (mg/L) | Critical Flow (mgd) | Conversion Factor | TMDL (lbs/day) |
|---|---|---|---|---|
| Jaramillo Creek (East Fork Jemez to headwaters) | 8.75* | 0.19 | 8.34 | 14.02 |
| Vallecito Ck (Perennial Prt Div abv Ponderosa to headwaters) | 16.12* | 0.05 | 8.34 | 6.42 |

**See Table 5.4*

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

**Equation 5.3:** *WLA + LA + MOS = TMDL*

### 5.3.1 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 sediment TMDL, the MOS was developed using explicit allocations. Therefore, this MOS is the sum of the following elements:

- *Explicit recognition of potential errors:*

- Uncertainty exists in the relationship between TSS and deposition of excess sediment. A conservative MOS for this element is **10%**.
- There is inherent error in flow estimation, a conservative MOS for this element in ungaged streams is **10 %**.

Total MOS for this TMDL is **20%**.

### 5.3.2 Waste Load Allocation

There are no active individual National Pollutant Discharge Elimination System (NPDES) permits that discharge to the sedimentation impaired AUs, therefore the WLA for these TMDLs are 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.

### 5.3.3 Load Allocation

Load Allocation is pollution from any nonpoint source(s) or natural background and is addressed through Best Management Practices (BMPs). To calculate the LA, the WLA and the MOS were subtracted from the

TMDL using **Equation 4.3**, as shown on **Table 5.7**. The MOS was developed using a combination of conservative assumptions and explicit recognition of potential errors (see **Section 5.3.1** for details).

**Table 5.7 TMDL allocations for Total Suspended Solids as an indicator for sedimentation/siltation**

| Assessment Unit | WLA (lbs/day) | LA (lbs/day) | 20% MOS | TMDL (lbs/day) |
|---|---|---|---|---|
| Jaramillo Creek (East Fork Jemez to headwaters) | 0 | 11.22 | 2.80 | 14.02 |
| Vallecito Ck (Perennial Prt Div abv Ponderosa to headwaters) | 0 | 5.14 | 1.28 | 6.42 |

### 5.3.4 Load Reduction

The extensive data collection and analyses necessary to determine background sediment 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 loads. The target load for TSS is the TMDL minus the MOS, in this case equal to the LA. Because the relationship of stream bottom sediment to instantaneous TSS loads is complex and includes a temporal element, a measured load cannot be calculated from available data, so TSS load reduction estimates are not presented for sedimentation/siltation impairments. One indicator of implementation progress could be achievement of the % SaFN threshold indicator (**Table 5.8**).

**Table 5.8 Reduction of % Sand and Fines needed to fall below the % Sand and Fines threshold indicator value for sedimentation/siltation**

| Assessment Unit | Ecoregion/Site Class | % Sand and Fines Threshold | % Sand and Fines Observed | Percent Reduction |
|---|---|---|---|---|
| Jaramillo Creek (East Fork Jemez to headwaters) | 21 Mountains | 20 | 55.2 | 63.77 |
| Vallecito Ck (Perennial Prt Div abv Ponderosa to headwaters) | 21d Foothills | 37 | 53.3 | 30.58 |

*Percent reduction is the percent the existing measured load must be reduced to achieve the target load and is calculated as follows: ((Measured Load – Target Load) / Measured Load) x 100*

## 5.4 Identification and Description of Pollutant Sources

SWQB fieldwork includes an assessment of the probable sources of impairment in the AU drainage area, according to Standard Operating Procedure 4.1, Probable Source(s) Determination (https://www.env.nm.gov/surface-water-quality/sop/; **Appendix C**). Probable Source Sheets are filled out by SWQB monitoring staff during watershed surveys. The sheets are then reviewed by watershed protection staff familiar with the location, and the TMDL writer conducts a search of aerial imagery, GIS files, and other available resources. 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. Pollutant sources that may contribute to each impairment were determined by field reconnaissance and evaluation (**Table 5.9**). Probable sources of sediment impairments will be evaluated, refined, and changed as necessary through the Watershed Based Plans.

**Table 5.9 Probable sources of excessive sedimentation**

| Assessment Unit | Probable Source(s) |
|---|---|
| Jaramillo Creek (East Fork Jemez to headwaters) | Grazing in riparian zone; Other recreational pollution sources; Rangeland grazing; Wildlife other than waterfowl |
| Vallecito Ck (Perennial Prt Div abv Ponderosa to headwaters) | Other recreational pollution sources; Rangeland grazing; Roads/bridges; Wildlife other than waterfowl |

## 5.5 Consideration of Seasonal Variation

The sediment moving capacity of a stream is exponentially related to flow velocity and discharge. Therefore, most of the work of streams is accomplished during floods, when stream velocity and discharge (and therefore capacity) are many times their level during low flow conditions. This work is in the form of bed scouring (erosion), sediment transport (bed and suspended loads), and sediment deposition. It is likely that the excess fine sediment loading and deposition occur during periods of higher flow, which in New Mexico are most likely to occur during spring snowmelt and summer monsoon storms. TSS samples were collected from June to September of 2019, and in September and October of 2020, capturing the summer and fall seasons. There was no evident seasonal pattern to turbidity and TSS results for the Vallecito Ck (Perennial Prt Div abv Ponderosa to headwaters) AU. The Jaramillo Creek (East Fork Jemez to headwaters) AU appeared to have high TSS during low flow events in June of 2021 and 2022 with both events resulting in measured TSS above the sedimentation indicator value. In the Vallecito Ck (Perennial Prt Div abv Ponderosa to headwaters) AU, every TSS measurement in both 2021 and 2022 was above the sedimentation indicator value.

## 5.6 Future Growth

Growth estimates by county are available from the University of New Mexico Geospatial and Population Studies (GPS) (https://gps.unm.edu/pop/population-projections.html, accessed 1/27/2025). The estimates project growth to the year 2050. Almost the entirety of the Jemez Watershed is within the boundary of Sandoval County, and the small section of HUC 13020202 that extends into Rio Arriba County is largely unpopulated. GPS projects Sandoval County population to grow until the year 2040, and then begin declining, as detailed in **Table 5.9**. These projections account for the 2020 census results, also accessed through GPS (https://gps.unm.edu/pop/population-estimates.html, accessed 1/27/2025). TMDL implementation planners should seek out the most current projections, if the information is relevant to their project.

**Table 5.10 Sandoval County population estimates**

| 2020 (Census)[B] | 2025 | 2030 | 2035 | 2040 | 2045 | 2050[A] | % Increase |
|---|---|---|---|---|---|---|---|
| 148,834 | 157,468 | 164,648 | 169,117 | 170,460 | 169,575 | 166,753 | 12.04 |

*% Increase: [ (A – B) / B ] × 100*

Estimates of future growth are not anticipated to lead to a significant increase in sedimentation 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 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 insects and salmon eggs. In addition to direct effects, the toxicity of many chemical contaminants increases with temperature (Caissie, 2006).

## 6.1 Target Loading Capacity

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 designed primarily to support reproducing populations of salmonids. 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 warmwater and coldwater aquatic life (NMED/SWQB, 2009). Acute temperature criteria (such as New Mexico's $T_{MAX}$) are intended to protect aquatic life from 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.

For this TMDL document, target values for temperature are based on the reduction in thermal loading necessary to achieve numeric criteria. Temperature criteria for ALUs in New Mexico are shown on **Table 6.1**. New Mexico's aquatic life temperature criteria are expressed as $T_{MAX,}$ 4T3 and 6T3. $T_{MAX}$ 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. To be conservative, in the event the chronic criterion (4T3 or 6T3 or segment specific) is exceeded, that value is selected as the target temperature for the TMDL. Target temperatures and measured exceedances are outlined in **Table 6.2**.

**Table 6.1 Aquatic Life Use Temperature (°C) Water Quality Criteria**

| 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 |
|---|---|---|---|---|---|---|

TMDLs were calculated for four Jemez watershed AUs that exceeded the $T_{MAX}$ for their designated ALU. All of those which have chronic standards also exceeded the applicable chronic standard. Thermograph data are presented in **Appendix B**.

**Table 6.2 Aquatic Life Use designations of the temperature TMDL AU**

| Assessment Unit | Designated ALU | Target Temperature | Measured Chronic |
|---|---|---|---|
| American Creek (Rio de las Palomas to headwaters) | High Quality Coldwater | 20°C (4T3) | 21.15°C |
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | Coldwater | 25°C* | 30.02°C |
| La Jara Creek (East Fork Jemez to headwaters) | High Quality Coldwater | 20°C (4T3) | 21.29°C |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) | High Quality Coldwater | 20°C (4T3) | 22.15°C |

**NMAC 20.6.4.107 segment specific criteria*

## 6.2 Flow

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 (4) consecutive day flow that occurs with a frequency of at least once every three (3) years.

Critical flow for the Jemez River (Jemez Pueblo bnd to Rio Guadalupe) was determined from daily discharge data, capturing at least 20 years of flow data, from 2003 through 2024 at the gage USGS 08324000 Jemez River Near Jemez, NM. USGS Hydrologic Toolbox was the software used to calculate 4Q3. The calculated 4Q3 is 7.33 cfs.

Because the remaining AUs discussed in this section are ungaged, an analysis method developed by USGS in partnership with NMED, authored by Bell and Tillery (Bell, 2023) was used to estimate the critical low flow. In the Bell & Tillery analysis, six regression equations for estimating 4Q3 were developed based on physiographic regions of New Mexico and stream basin characteristics (i.e., statewide and mountainous regions above 8,000 ft in elevation, or basins with less than 75 square mile drainage areas). The average elevation of all impaired AUs in the Jemez watershed are above 8,000 ft and are not the San Juan River nor tributaries to the San Juan, so the 4Q3-1a statewide regression equation was used. The following regression equation is based on data from 44 gaging stations with non-zero discharge (Bell, 2023):

**Equation 6.1:** $4Q3 = DA^{1.08} \times E^{12.20} \times e^{-115.37}$

Where:

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

$DA$ = drainage area (mi$^2$)

$E$ = mean basin elevation (ft)

$e$ = mathematical constant, Euler's number

The 4Q3 values calculated using Bell & Tillery's method are presented in **Table 6.3**. Parameters used in the calculation were obtained using the StreamStats online GIS application developed by the USGS (https://streamstats.usgs.gov/ss/). The 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 instream water quality is the goal of SWQB efforts.

**Table 6.3 Critical flow for temperature impaired AUs**

| Assessment Unit | Drainage Area (mi$^2$) | Average Elevation (ft) | 4Q3 (cfs) | 4Q3 (mgd) |
|---|---|---|---|---|
| American Creek (Rio de las Palomas to headwaters) | 7.5 | 9029 | 0.13 | 0.08 |
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe)* | -- | -- | 7.35 | 4.75 |
| La Jara Creek (East Fork Jemez to headwaters) | 5.9 | 9275 | 0.13 | 0.09 |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) | 66.2 | 8567 | 0.70 | 0.45 |

**Calculated using USGS gage data.*

## 6.3 TMDL Calculations

For temperature TMDLs, the WQS criterion is a temperature specified either by the designated ALU or segment-specific criteria, and it can be either a maximum temperature or time-duration temperature such as the 4T3 or 6T3. An AU is designated as not-supporting if maximum daily temperature measurements exceed the Aquatic Life Use maximum temperature (See **Tables 6.1 & 6.2**) on more than one day during the calendar year and are not confirmed outliers. The 4Q3 low-flow is generally used 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 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 6.1** *WQS (°C ) x Critical Flow (cfs) x Conversion Factor (1.023 x $10^7$) = TMDL (kJ/day)*

Details of the derivation of the temperature TMDL equation are presented in **Appendix D**. **Table 6.4** shows the TMDL calculation values for each TMDL AU.

**Table 6.4 Temperature TMDL calculations**

| Assessment Unit Name | Target temperature (°C) | 4Q3 critical flow (mgd) | Conversion factor | TMDL (kJ/day) |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| American Creek (Rio de las Palomas to headwaters) | 20 | 0.08 | $1.023 \times 10^{7}$ | $1.66 \times 10^{7}$ |
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | 25* | 4.75 | $1.023 \times 10^{7}$ | $1.21 \times 10^{9}$ |
| La Jara Creek (East Fork Jemez to headwaters) | 20 | 0.09 | $1.023 \times 10^{7}$ | $1.78 \times 10^{7}$ |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) | 20 | 0.45 | $1.023 \times 10^{7}$ | $9.20 \times 10^{7}$ |

**NMAC 20.6.4.107 segment specific criteria*

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

**Equation 6.3:** *WLA + LA + MOS = TMDL*

### 6.3.1 Margin of Safety

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.

- *Explicit Recognition of Potential Errors:*
    - There is inherent error in flow estimation, a conservative MOS for this element in ungaged streams is **10 %**.
    - In recognition of the likelihood of future increases in air temperature and evaporative demand, an additional explicit **10%** MOS is added to each AU for climate change.

Total MOS for this TMDL is **20%**.

### 6.3.2 Waste Load Allocation

There is a National Pollutant Discharge Elimination System (NPDES) permit on the Jemez River (Jemez Pueblo bnd to Rio Guadalupe) AU. The Jemez Valley Public Schools hold a permit (NM0028479), for a small wastewater treatment plant (WWTP) with one outfall that is authorized to discharge to the Jemez River. The permit does not include limitations or monitoring requirements for temperature. A WLA is presented in **Table 6.5**. There are no active NPDES permits discharging to any other temperature impaired AUs, therefore the WLA for all other TMDLs is zero.

There may be storm water discharges from industrial, including construction, activities covered under the National Pollutant Discharge Elimination System (NPDES) Construction General Permit (CGP) or Multi-Sector General Permit (MSGP). Excess temperature loading may be a component of some storm water discharges covered under general NPDES permits. Stormwater discharges from industrial, including construction, activities are generally considered transient because they occur mainly during the construction itself and/or only during storm events.

Coverage under the USEPA NPDES CGP for construction sites one acre or greater or smaller if part of a common plan of development require preparation of a Storm Water Pollution Prevention Plan (SWPPP) that includes identification and control of 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. Stormwater discharges from industrial activities and facilities, based on industrial classification codes, may be eligible for coverage under the current NPDES 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 reflect 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. 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. State certification of federal permits ensures that applicable water quality standards, including the antidegradation policy, are met. Compliance with a CGP or MSGP SWPPP that meets the requirements of the general permits is generally assumed to be consistent with this TMDL.

**Table 6.5 Temperature waste load allocations**

| Assessment Unit Name | Target temperature (°C) | Design Capacity Flow (mgd) | Conversion factor | WLA (kJ/day) |
|---|---|---|---|---|
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | 25 | 0.01 | $1.02 \times 10^7$ | $2.56 \times 10^7$ |

### 6.3.3 Load Allocation

Load Allocation is pollution from any nonpoint source(s) or natural background and is addressed through Best Management Practices (BMPs). To calculate the LA, the WLA and the MOS were subtracted from the TMDL using **Equation 6.3**, as shown on **Table 6.5**. The MOS was developed using a combination of conservative assumptions and explicit recognition of potential errors (see **Section 6.3.1** for details).

Table 6.5 Temperature TMDL load allocations (units are kJ/day)

| Assessment Unit | WLA | LA | 20% MOS | TMDL |
|---|---|---|---|---|
| American Creek (Rio de las Palomas to headwaters) | 0 | $1.33 \times 10^7$ | $3.32 \times 10^6$ | $1.66 \times 10^7$ |
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | $2.56 \times 10^7$ | $9.69 \times 10^8$ | $2.43 \times 10^8$ | $1.21 \times 10^9$ |
| La Jara Creek (East Fork Jemez to headwaters) | 0 | $1.42 \times 10^7$ | $3.56 \times 10^6$ | $1.78 \times 10^7$ |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) | 0 | $7.36 \times 10^7$ | $1.84 \times 10^7$ | $9.20 \times 10^7$ |

## 6.4 Identification and Description of Pollutant Sources

SWQB fieldwork includes an assessment of the probable sources of impairment in the AU drainage area, according to Standard Operating Procedure 4.1, Probable Source(s) Determination (https://www.env.nm.gov/surface-water-quality/sop/; **Appendix C**). Probable Source Sheets are filled out by SWQB monitoring staff during watershed surveys. The sheets are then reviewed by watershed protection staff familiar with the location, and the TMDL writer conducts a search of aerial imagery, GIS files, and other available resources. 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. Pollutant sources that may contribute to each impairment were determined by field reconnaissance and evaluation (**Table 6.6**). Probable sources of temperature impairments will be evaluated, refined, and changed as necessary through the Watershed Based Plans.

Table 6.6 Probable sources of excessive temperature

| Assessment Unit | Probable Source(s) |
|---|---|
| American Creek (Rio de las Palomas to headwaters) | Grazing in riparian zone; Rangeland grazing; Wildlife other than waterfowl |
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | Crop production; Dams/diversion; Irrigated crop production; Onsite treatment systems; Roads/bridges; Wildlife other than waterfowl |
| La Jara Creek (East Fork Jemez to headwaters) | Other recreational pollution; Rangeland grazing; Wildlife other than waterfowl |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) | Other recreational pollution sources; Rangeland grazing; Roads/bridges; Wildlife other than waterfowl |

## 6.5 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. Water temperatures are coolest in the winter and early spring months. Future climate change is expected to increase air temperatures and decrease streamflow, potentially causing increases in maximum water temperature.

The warmest stream temperatures correspond to prolonged solar radiation exposure, warmer air temperature, and low flow conditions. Maximum temperatures were recorded in the TMDL AUs from late June to late August, in 2021 and 2022.

## 6.6 Future Growth

SWQB acknowledges the projected impact of climate change on the state's water resources. Climate change will put additional stress on New Mexico's water resources and make attainment of water quality standards more difficult to achieve. In addition, shifting temperature and precipitation patterns affect vegetative composition and density and increase wildfire intensity and the propensity for wildfire in non-fire adapted ecosystems. In 2019, Governor Lujan Grisham signed Executive Order 2019-003 on Addressing Climate Change and Energy Waste Prevention. Executive order 2019-003 directs all State agencies to evaluate the impacts of climate change on their programs and operations and integrate climate change mitigation and adaptation practices into their programs and operations.

In general, the strongest influence on in-stream water temperature is the ambient air temperature. Stakeholders should explore options to determine the most appropriate approach for each particular watershed or project, with the ultimate goal being that the stream meets the WQS. The SWQB encourages implementation practitioners to design projects to reduce water temperature well below the WQS, such that currently impaired AUs will be likely to meet WQS standards in the future with sufficient resiliency to warmer air temperatures and potentially lower flows.

Studies (GPS) (https://gps.unm.edu/pop/population-projections.html, accessed 1/27/2025). The estimates project growth to the year 2050. Almost the entirety of the Jemez Watershed is within the boundary of Sandoval County, and the small section of HUC 13020202 that extends into Rio Arriba County is largely unpopulated. GPS projects Sandoval County population to grow until the year 2040, and then begin declining, as detailed in **Table 5.9**. These projections account for the 2020 census results, also accessed through GPS (https://gps.unm.edu/pop/population-estimates.html, accessed 1/27/2025). TMDL implementation planners should seek out the most current projections, if the information is relevant to their project.

**Table 6.7 Sandoval County population estimates**

| 2020 (Census)[B] | 2025 | 2030 | 2035 | 2040 | 2045 | 2050[A] | % Increase |
|---|---|---|---|---|---|---|---|
| 148,834 | 157,468 | 164,648 | 169,117 | 170,460 | 169,575 | 166,753 | 12.04 |

*% Increase: [ (A – B) / B ] × 100*

Estimates of future growth are not anticipated to lead to a significant increase in in-stream temperatures 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.

# 7.0 TURBIDITY

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 a condition resulting from suspended solids in the water, including silts, clays, and plankton. Such particles absorb heat in the sunlight, thus increasing 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 scientific literature. An EPA monitoring guideline 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."

## 7.1 Target Loading Capacity

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…"*

The assessment approach used to determine impairments of the narrative turbidity standard is described in detail in the Comprehensive Assessment and Listing Methodology (NMED/SWQB, 2025). 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 affects 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.

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 7.1**, 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 7.2**. AUs discussed in this section and the respective maximum turbidity observation are listed in **Table 7.1**.

**Equation 7.1:** $x = 37{,}382y^{-1.9887}$

Where:

$x$ = duration (hours)

$y$ = turbidity (NTU)

Applicable for durations between 7 and 720 hours.

**Table 7.1 Turbidity impaired AUs and date of maximum turbidity measurement**

| Assessment Unit | Date of Maximum Observation | Maximum Turbidity (NTU) |
|---|---|---|
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | 10/18/2022 | 474.7 |
| Rio Cebolla (Fenton Lake to headwaters) | 5/10/2022 | 19.7 |
| Vallecito Ck (Perennial Prt Div abv Ponderosa to headwaters) | 7/21/2022 | 65.3 |

**Table 7.2 Impairment thresholds & 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*

## 7.2 Flow

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 (4) consecutive day flow that occurs with a frequency of at least once every three (3) years.

Critical flow for the Jemez River (Jemez Pueblo bnd to Rio Guadalupe) was determined from daily discharge data, capturing at least 20 years of flow data, from 2003 through 2024 at the gage USGS 08324000 Jemez River Near Jemez, NM. USGS Hydrologic Toolbox was the software used to calculate 4Q3. The calculated 4Q3 is 7.33 cfs.

Because all AUs discussed in this section are ungaged, an analysis method developed by USGS in partnership with NMED, authored by Bell and Tillery (2023) was used to estimate the critical low flow. In the Bell & Tillery analysis, six regression equations for estimating 4Q3 were developed based on physiographic regions of New Mexico and stream basin characteristics (i.e., statewide and mountainous regions above 8,000 ft in elevation, or basins with less than 75 square mile drainage areas). The average elevation of all impaired AUs in the Jemez watershed are above 8,000 ft and are not the San Juan River nor tributaries to the San Juan, so the 4Q3-1a statewide regression equation was used. The following regression equation is based on data from 44 gaging stations with non-zero discharge (Bell, 2023):

**Equation 7.2:** $4Q3 = DA^{1.08} \times E^{12.20} \times e^{-115.37}$

Where:

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

$DA$ = drainage area ($mi^2$)

$E$ = mean basin elevation (ft)

$e$ = mathematical constant, Euler's number

The 4Q3 values calculated using Bell & Tillery's method are presented in **Table 7.3**. Parameters used in the calculation were obtained using the StreamStats online GIS application developed by the USGS (https://streamstats.usgs.gov/ss/). The 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 instream water quality is the goal of SWQB efforts.

**Table 7.3 Critical flow for turbidity impaired AUs**

| Assessment Unit | Drainage Area ($mi^2$) | Average Elevation (ft) | 4Q3 (cfs) | 4Q3 (mgd) |
|---|---|---|---|---|
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe)[ab] | -- | -- | 7.35 | 4.75 |
| Rio Cebolla (Fenton Lake to headwaters)[b] | 43.7 | 8783 | 3.28 | 2.12 |
| Vallecito Ck (Perennial Prt Div abv Ponderosa to headwaters) | 16.4 | 8066 | 0.07 | 0.05 |

*a) Calculated using USGS gage data.*

*b) Combined flow of permitted facility design capacity flow and 4Q3*

## 7.3 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. These TMDLs were developed using the turbidity/duration thresholds identified in the SWQB turbidity assessment protocol (NMED/SWQB, 2025), the site-specific relationship between turbidity and TSS, the 4Q3 flow condition, and a unit conversion factor to correct the TMDL units into pounds per day (lbs/day).

First, using the regression equations shown in **Appendix B**, TSS concentrations for each turbidity threshold were calculated (**Table 7.4**). Then, the 4Q3 critical low flow from Section 7.2, above, and the TSS threshold values were substituted into **Equation 7.3** to determine the TMDL at each turbidity/duration threshold (**Table 7.4**). Note that each TMDL is for a particular turbidity/duration pairing. It should not be extrapolated to longer or shorter durations.

**Equation 7.3** *WQS (mg/L) x Critical Flow (4Q3) x Conversion Factor (8.34) = TMDL (lbs/day)*

**Table 7.4 Turbidity TMDL calculations**

| Assessment Unit | Turbidity (NTU) | TSS (mg/L) | TSS TMDL (lbs/day) | Duration (consecutive days) |
|---|---|---|---|---|
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | 23 | 26.58 | 1053.14 | 3 |
| | 20 | 24.13 | 955.81 | 4 |
| | 18 | 22.49 | 890.93 | 5 |
| | 16 | 20.85 | 826.05 | 6 |
| | 15 | 20.03 | 793.61 | 7 |
| | 11 | 16.76 | 663.85 | 14 |
| | 7 | 13.48 | 534.09 | 30 |
| **Assessment Unit** | **Turbidity (NTU)** | **TSS (mg/L)** | **TSS TMDL (lbs/day)** | **Duration (consecutive days)** |
| Rio Cebolla (Fenton Lake to headwaters) | 23 | 36.65 | 648.06 | 3 |
| | 20 | 32.38 | 572.48 | 4 |
| | 18 | 29.53 | 522.09 | 5 |
| | 16 | 26.68 | 471.70 | 6 |
| | 15 | 25.25 | 446.51 | 7 |
| | 11 | 19.55 | 345.74 | 14 |
| | 7 | 13.85 | 244.96 | 30 |
| **Assessment Unit** | **Turbidity (NTU)** | **TSS (mg/L)** | **TSS TMDL (lbs/day)** | **Duration (consecutive days)** |
| Vallecito Ck (Perennial Prt Div abv Ponderosa to headwaters) | 23 | 32.75 | 13.66 | 3 |
| | 20 | 29.60 | 12.34 | 4 |
| | 18 | 27.49 | 11.46 | 5 |
| | 16 | 25.39 | 10.59 | 6 |
| | 15 | 24.34 | 10.15 | 7 |
| | 11 | 20.13 | 8.39 | 14 |
| | 7 | 15.92 | 6.64 | 30 |

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

**Equation 7.4:** *WLA + LA + MOS = TMDL*

### 7.3.1 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 turbidity TMDL, the MOS was developed using a combination of conservative assumptions and explicit allocations. Therefore, this MOS is the sum of the following elements:

- *Conservative assumptions:*
    - TSS is a conservative parameter that does not settle out of the water column.
- *Explicit recognition of potential errors:*
    - Uncertainty exists in the relationship between TSS and turbidity. A conservative MOS for this element is **5%**.
    - There is inherent error in flow estimation, a conservative MOS for this element in ungaged streams is **10 %**.

The total MOS for this TMDL is **15%**.

### 7.3.2 Waste Load Allocation

There are National Pollution Discharge Elimination System (NPDES) permits for a wastewater treatment plant (WWTP) on the Jemez River (Jemez Pueblo bnd to Rio Guadalupe), and a discharge permit for a fish hatchery on the Rio Cebolla (Fenton Lake to headwaters). The Jemez Valley Public Schools hold a permit, no. NM0028479, for a small WWTP with one outfall that is authorized to discharge to the Jemez River. The New Mexico Department of Game & Fish (NMDGF) Seven Springs State Fish Hatchery holds a permit, no. NM0030112, with two outfalls that authorizes the discharge of wastewater into the Rio Cebolla above Fenton Lake. The table below outlines the permitted facilities, design capacity flow, and effluent limits.

The Jemez Valley Public Schools, (NM0028479), is currently authorized to discharge TSS at 2.503 lbs/day for a 30-day average or 30 mg/L, and 3.755 lbs/day for a 7-day average or 45 mg/L to the Jemez River (Jemez Pueblo bnd to Rio Guadalupe). Their DMR from 2015 to 2019 has a 30-day average discharge of 0.32 lbs/day ranging from 0.2-0.88 lbs/day. SWQB monitoring staff took two samples from effluent in June 2021, and March 2022, with TSS observations being 4mg/L and 3mg/L respectively. There are no examples of this facility exceeding the current permit limits, and the WLAs presented are intended to account for a portion of the load allocation that would not be included in the “background load”. The WLA in **Table 7.6** is not intended to change the TSS permit limits of 30 and 45 mg/L.

The Seven Springs Fish Hatchery, (NM0030112), is currently authorized to discharge TSS at a daily maximum of 96 lbs/day or 15 mg/L to Rio Cebolla (Fenton Lake to headwaters). The 2015-2019 DMR average TSS values are 10.35 lbs/day and 3 mg/L ranging from 8.2-14 lbs/day. There are no records of

SWQB monitoring of effluent from the hatchery. There are no examples of this facility exceeding the current permit limits, and the WLAs presented are intended to account for a portion of the load allocation that would not be included in the "background load". The WLA in **Table 7.6** is not intended to change the TSS permit limits of 30 and 45 mg/L.

**Table 7.5 NPDES discharge limits for TSS**

| Assessment Unit | Permit | Design Flow | TSS Permit Limit |
|---|---|---|---|
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | Jemez Valley Public School NM0028479 | 0.01 mgd | 30 mg/L (30-day avg)<br>45 mg/L (7-day avg) |
| Rio Cebolla (Fenton Lake to headwaters) | Seven Springs State Fish Hatchery NM0030112 Outfall 001 | 0.77 mgd | 10 mg/L (30-day avg)<br>15 mg/L (daily max) |

**Table 7.6 TSS waste load allocations**

| Assessment Unit | Duration (consecutive days) | TSS (mg/L) | TSS WLA (lbs/day) |
|---|---|---|---|
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | 3 | 26.58 | 2.22 |
| | 4 | 24.13 | 2.01 |
| | 5 | 22.49 | 1.88 |
| | 6 | 20.85 | 1.74 |
| | 7 | 20.03 | 1.67 |
| | 14 | 16.76 | 1.40 |
| | 30 | 13.48 | 1.12 |
| **Assessment Unit** | **Duration (consecutive days)** | **TSS (mg/L)** | **TSS WLA (lbs/day)** |
| Rio Cebolla (Fenton Lake to headwaters) | 3 | 36.65 | 235.38 |
| | 4 | 32.38 | 207.93 |
| | 5 | 29.53 | 189.63 |
| | 6 | 26.68 | 171.33 |
| | 7 | 25.25 | 162.18 |
| | 14 | 19.55 | 125.57 |
| | 30 | 13.85 | 88.97 |

*[WLA] = [TSS (**Table 7.4**)] × [design flow (**Table 7.3**)] × [conversion factor (8.34)]*

*See **Appendix B** for TSS/Turbidity regression equations*

### 7.3.3 Load Allocation

Load allocation is pollution from any nonpoint source(s) or natural background and is addressed through Best Management Practices (BMPs). To calculate the LA, the WLA and the MOS were subtracted from the TMDL using **Equation 7.4**, as shown on **Table 7.7**. The MOS was developed using a combination of conservative assumptions and explicit recognition of potential errors (see **Section 7.3.1** for details).

**Table 7.7 TSS load allocations for turbidity impaired AUs**

| Assessment Unit | Duration (consecutive days) | WLA (lbs/day)* | MOS (15%) | LA (lbs/day) | TMDL (lbs/day) |
|---|---|---|---|---|---|
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | 3 | 2.22 | 157.97 | 892.95 | 1053.14 |
| | 4 | 2.01 | 143.37 | 810.43 | 955.81 |
| | 5 | 1.88 | 133.64 | 755.42 | 890.93 |
| | 6 | 1.74 | 123.91 | 700.41 | 826.05 |
| | 7 | 1.67 | 119.04 | 672.90 | 793.61 |
| | 14 | 1.40 | 99.58 | 562.87 | 663.85 |
| | 30 | 1.12 | 80.11 | 452.85 | 534.09 |
| **Assessment Unit** | **Duration (consecutive days)** | **WLA** | **MOS (15%)** | **LA** | **TSS TMDL (lbs/day)** |
| Rio Cebolla (Fenton Lake to headwaters) | 3 | 235.38 | 97.21 | 315.47 | 648.06 |
| | 4 | 207.93 | 85.87 | 278.68 | 572.48 |
| | 5 | 189.63 | 78.31 | 254.15 | 522.09 |
| | 6 | 171.33 | 70.76 | 229.62 | 471.70 |
| | 7 | 162.18 | 66.98 | 217.36 | 446.51 |
| | 14 | 125.57 | 51.86 | 168.30 | 345.74 |
| | 30 | 88.97 | 36.74 | 119.25 | 244.96 |
| **Assessment Unit** | **Duration (consecutive days)** | **WLA** | **MOS (15%)** | **LA** | **TSS TMDL (lbs/day)** |
| Vallecito Ck (Perennial Prt Div abv Ponderosa to headwaters) | 3 | 0 | 2.05 | 11.61 | 13.66 |
| | 4 | 0 | 1.85 | 10.49 | 12.34 |
| | 5 | 0 | 1.72 | 9.74 | 11.46 |
| | 6 | 0 | 1.59 | 9.00 | 10.59 |
| | 7 | 0 | 1.52 | 8.63 | 10.15 |
| | 14 | 0 | 1.26 | 7.13 | 8.39 |
| | 30 | 0 | 1.00 | 5.64 | 6.64 |

** See section 9.1.1 for discussion of TSS WLA and permit NM0028479 and NM0030112*

## 7.4 Identification and Description of Pollutant Sources

SWQB fieldwork includes an assessment of the probable sources of impairment in the AU drainage area, according to Standard Operating Procedure 4.1, Probable Source(s) Determination (https://www.env.nm.gov/surface-water-quality/sop/; **Appendix C**). Probable Source Sheets are filled out by SWQB monitoring staff during watershed surveys. The sheets are then reviewed by watershed protection staff familiar with the location, and the TMDL writer conducts a search of aerial imagery, GIS files, and other available resources. 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. Pollutant sources that may contribute to each impairment were determined by field reconnaissance and evaluation (**Table 7.8**). Probable sources of impairments will be evaluated, refined, and changed as necessary through the Watershed Based Plans.

**Table 7.8 Probable sources of excessive turbidity**

| Assessment Unit | Probable Source(s) |
|---|---|
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | Crop production; Dams/diversion; Irrigated crop production; Onsite treatment systems; Roads/bridges; Wildlife other than waterfowl |
| Rio Cebolla (Fenton Lake to headwaters) | Deer; Illegal dumps or other inappropriate waste disposal; Grazing in riparian zone; Other recreational pollution sources; Onsite fishery; Roads/bridges; Waterfowl |
| Vallecito Ck (Perennial Prt Div abv Ponderosa to headwaters) | Other recreational pollution sources; Rangeland grazing; Roads/bridges; Wildlife other than waterfowl |

## 7.5 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. 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.

## 7.6 Future Growth

Studies (GPS) (https://gps.unm.edu/pop/population-projections.html, accessed 1/27/2025). The estimates project growth to the year 2050. Almost the entirety of the Jemez Watershed is within the boundary of Sandoval County, and the small section of HUC 13020202 that extends into Rio Arriba County is largely unpopulated. GPS projects Sandoval County population to grow until the year 2040, and then begin declining, as detailed in **Table 7.9**. These projections account for the 2020 census results, also accessed through GPS (https://gps.unm.edu/pop/population-estimates.html, accessed 1/27/2025). TMDL implementation planners should seek out the most current projections, if the information is relevant to their project.

**Table 7.9 Sandoval County population estimates**

| 2020 (Census)[B] | 2025 | 2030 | 2035 | 2040 | 2045 | 2050[A] | % Increase |
|---|---|---|---|---|---|---|---|
| 148,834 | 157,468 | 164,648 | 169,117 | 170,460 | 169,575 | 166,753 | 12.04 |

*% Increase: [ (A – B) / B ] × 100*

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.

# 8.0 MONITORING PLAN

Pursuant to CWA Section 106(e)(1), 33 U.S.C. § 1256(e)(1), 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 through -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. The SWQB revised its 10-year monitoring and assessment strategy (NMED/SWQB, 2016a) and submitted it to USEPA Region 6 for review in June of 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 to ten years. The next scheduled monitoring date for the Jemez watershed is 2031-2032.

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, 2024), 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 priorities for monitoring in the SWQB 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).

Once assessment monitoring is completed, those reaches showing impairment 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.

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.

# 9.0 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.

## 9.1 Point Sources

### 9.1.1 Individual NPDES Permits

There are three individual NPDES permits discussed in these TMDLs. Two are on the Jemez River - Jemez River (Jemez Pueblo bnd to Rio Guadalupe), and Jemez River (Rio Guadalupe to Soda Dam nr Jemez Springs). There is one NPDES permit on the Rio Cebolla (Fenton Lake to headwaters). Discussion of these permits is separated into the following sections. These AUs and permitted facilities are discussed in **Section 2.0 ALUMINUM, Section 4.0 PLANT NUTRIENTS, Section 6.0 TEMPERATURE or Section 7.0 TURBIDITY.**

#### 9.1.1.A Jemez Valley Public Schools NM0028479

The Jemez Valley Public Schools located by the Jemez Pueblo has a small privately owned sanitary wastewater treatment facility, (NM0028479), that serves a population of 350 people. The discharge from this facility is located 70 ft from the Jemez River. The assigned nutrient WLA concentrations are high at 111.56mg/L TN and 7.14mg/L TP. It is recommended that this facility begin monitoring TN/TP data and reporting TN/TP data in the next permit cycle. Further data collection and reporting of temperature is needed as well.

This facility has had no record of exceeding turbidity permit limits, and SWQB is not recommending any changes to the permit regarding turbidity. The WLAs in **Section 7.3.2** are calculated using the TSS/Turbidity regression equations presented in the turbidity data portion of **Appendix B**. These are not equal to permit limits already in place due to the nature of using a regression equation to determine target TSS values that are based on field measured turbidity values. The WLAs are to account for a portion of the load that is not considered "background load".

#### 9.1.1.B Village of Jemez Springs NM0028011

The Village of Jemez Springs has a small publicly owned treatment works, permit number NM0028011, serving a community of 375 people. The WWTP discharges to the Jemez River which flows through the Jemez Pueblo, Zia Pueblo, and Santa Ana Pueblo. The phased plant nutrient TMDL approach outlined in **Section 4.0 PLANT NUTRIENTS, 4.3.2 Waste Load Allocation** should be incorporated in future NPDES permits.

#### 9.1.1.C Seven Springs Fish Hatchery NM0030112

State of New Mexico Department of Game & Fish Seven Springs State Fish Hatchery holds a permit (NM0030112) for an industrial facility near the village of Jemez Springs that hatches and raises Rio Grande cutthroat trout. The water sources are the Calaveras, Cebolla, Coldwater and Seven Springs. The facility has three ponds, including a settling pond and a kid fishing pond, and two outfalls for discharge. Wastewater is discharged to the fishing pond, where Outfall 001 is located, where wastewater at the fishing pond is routed to a surrounding wetland, and is also discharged to the Rio Cebolla. Outfall 002 is a discharge point to the settling pond, which is then routed to the Rio Cebolla. At this time, SWQB is not recommending any alterations to the permit for total aluminum. Plant nutrient monitoring is recommended in order to refine the WLA for the next permit cycle. This facility has had no record of exceeding turbidity permit limits, and SWQB is not recommending any changes to the permit regarding TSS limits.

## 9.2 Nonpoint Sources

### 9.2.1 WBP and BMP Coordination

Public awareness and involvement will be crucial to the successful implementation of these plans and improved water quality. A Watershed Based Plan (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. This long-range strategy will become instrumental in coordinating efforts to achieve water quality standards in the watershed. The WBP is essentially the Implementation Plan, or Phase Two of the TMDL process. 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. 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. Additional information about the reduction of nonpoint source pollution can be found online at: https://www.epa.gov/polluted-runoff-nonpoint-source-pollution.

### 9.2.2 Clean Water Act Section 319(h) Funding

The Watershed Protection Section of the SWQB may potentially be able to provide CWA 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), 33 U.S.C. § 1329, can be found at the SWQB website: https://www.env.nm.gov/surface-water-quality/.

### 9.2.3 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 are 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 Solicitation for Applications (SFA) process. *See* 33 U.S.C. § 1384. The SWQB requests quotes from regional public comprehensive planning organizations to conduct water quality management planning as defined under Sections 205(j) and 303(e) and the CWA. *See* 33 U.S.C. §§ 1285 and 1313. 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 New Mexico Legislature appropriated $2,250,000 in state funds for the River Stewardship Program as of 2025. 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 (RFP) will be conducted to select projects for the funding at https://www.env.nm.gov/requests-for-proposals/. 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/watershed-protection-section/.

## 9.3 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. 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 during a single day (Bartholow, 2002). Each AU was modeled on the date of the maximum recorded water temperature on the thermograph record which was used to assess impairment. 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.

SWQB collects physical habitat data using Standard Operating Procedure 5.0 (https://www.env.nm.gov/surface-water-quality/sop/). Sufficient physical habitat data was available to conduct SSTEMP modeling for the AUs American Creek (Rio de las Palomas to headwaters), Jemez River (Jemez Pueblo bnd to Rio Guadalupe), La Jara Creek (East Fork Jemez to headwaters) and Rio Cebolla (Rio de las Vacas to Fenton Lake).

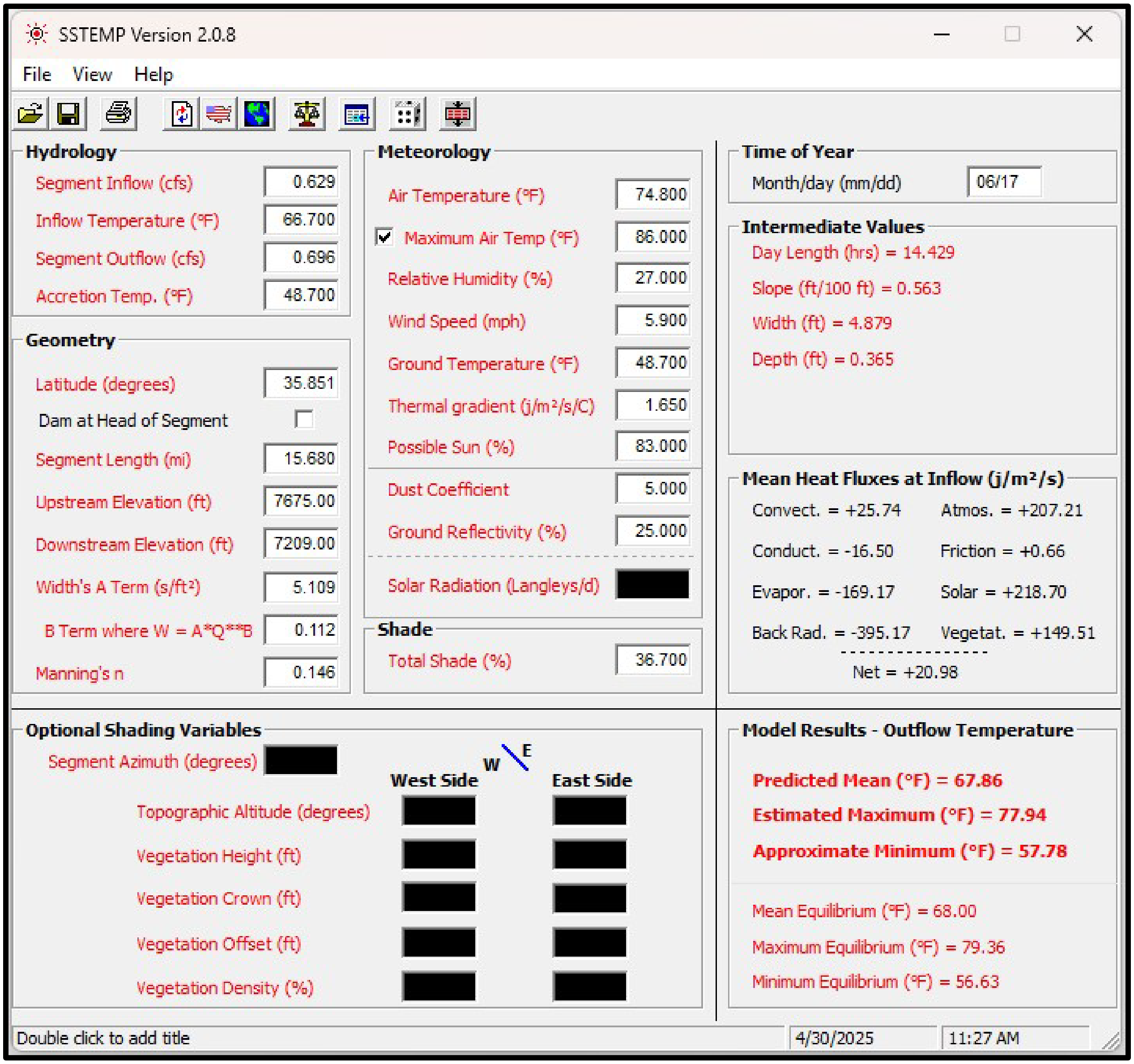


**Figure 9.1 SSTEMP Example output for Rio Cebolla (Rio de las Vacas to Fenton Lake)**

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. A complete list of assumptions and model deficiencies is presented in 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).

Sources for the SSTEMP input variables are shown in **Appendix E**. The SSTEMP predicted maximum temperature was calibrated against thermograph data. **Table E.1** shows input values for the calibrated model. Percent total shade was then increased until the maximum 24-hour temperature decreased to the applicable temperature criterion. Width's A term (a measure of relative width-to-depth ratio) was then decreased, at the calibrated percent shade, until the $T_{MAX}$ criterion was reached. **Table 8.1** details model outputs for the TMDL AUs.

**Table 9.1 SSTEMP model results for Jemez watershed temperature impaired AUs**

| Assessment Unit | Estimated % Shade [(a)] | WQS % Shade [(b)] | Shade Increase (%) [(c)] |
|---|---|---|---|
| American Creek (Rio de las Palomas to headwaters) | 48.23 | 58.00 | 20.23 |
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | 33.50 | 73.80 | 120.29 |
| La Jara Creek (East Fork Jemez to headwaters) | 59.66 | 62.25 | 4.35 |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) | 36.70 | 55.20 | 50.41 |

[(a)] *Shade is collected via densitometer during SWQB habitat monitoring (see Appendix E).*
[(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.*

For the Rio Cebolla AU, shade was increased from the densitometer recorded 26.7% to 36.7% This increase is justified by comparing the monitoring location to the full length of the AU. The monitoring location is near a road in a clearing, while much of the AU is wooded, as well the stream is between ~100ft topographic features on the east and west that would prevent direct sunlight for the entirety of the modeled day length of 14.4 hours. For the AUs Jemez River (Jemez Pueblo bnd to Rio Guadalupe) and La Jara Creek (East Fork Jemez to headwaters), field densitometer recordings were used for the shade values. The most recent field operations at the AU American Creek (Rio de las Palomas to headwaters) occurred in July of 2025. At that time, there was no flow at the station 31Americ003.4 (roughly the mid-point between the headwaters and outflow).

The SSTEMP model does not consider any impact 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.

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 9.2**. Meteorological variables will always have the greatest impact on predicted maximum temperature. For the San Francisco River, the sensitivity analysis indicates that maximum water temperature is relatively insensitive to variables other than the meteorological conditions.

Sensitivity Analysis - SSTEMP (2.0.8)

```
Sensitivity for mean temperature values (10% variation)     SSTEMP (2.0.8)
Original mean temperature = 55.00°F
                              Temperature change (°F)
                                  if variable is:
Variable                        Decreased Increased   Relative Sensitivity
--------------------------------------------------------------------------------
Segment Inflow (cfs)              +0.00     +0.00
Inflow Temperature (°F)           -0.01     +0.01
Segment Outflow (cfs)             +0.21     -0.23 ***
Accretion Temp. (°F)              -2.57     +2.57 ******************************
Width's A Term (s/ft²)            -0.59     +0.64 *******
  B Term where W = A*Q**B         +1.06     -1.11 *************
Manning's n                       +0.00     +0.00
Air Temperature (°F)              -2.51     +2.24 *****************************
Relative Humidity (%)             -0.36     +0.36 ****
Wind Speed (mph)                  +0.01     -0.01
Ground Temperature (°F)           -0.19     +0.19 **
Thermal gradient (j/m²/s/C)       +0.06     -0.06 *
Possible Sun (%)                  -0.33     +0.33 ****
Dust Coefficient                  +0.02     -0.02
Ground Reflectivity (%)           -0.02     +0.02
Total Shade (%)                   +0.55     -0.56 ******
 Maximum Air Temp (°F)            +0.00     +0.00
```

**A**

Sensitivity Analysis - SSTEMP (2.0.8)

Sensitivity for mean temperature values (10% variation)     SSTEMP (2.0.8)

Original mean temperature = 74.01°F

| Variable | Temperature change (°F) if variable is: Decreased | Increased | Relative Sensitivity |
|---|---|---|---|
| Segment Inflow (cfs) | -0.09 | +1.35 | ******* |
| Inflow Temperature (°F) | -5.27 | +5.48 | ****************************** |
| Segment Outflow (cfs) | +1.28 | -0.13 | ******* |
| Accretion Temp. (°F) | -0.04 | +0.04 | |
| Width's A Term (s/ft²) | -0.04 | +0.04 | |
| B Term where W = A*Q**B | -0.01 | +0.01 | |
| Manning's n | +0.00 | +0.00 | |
| Air Temperature (°F) | -1.21 | +1.08 | ******* |
| Relative Humidity (%) | -0.20 | +0.20 | * |
| Wind Speed (mph) | +0.03 | -0.03 | |
| Ground Temperature (°F) | -0.11 | +0.11 | * |
| Thermal gradient (j/m²/s/C) | +0.03 | -0.03 | |
| Possible Sun (%) | -0.19 | +0.20 | * |
| Dust Coefficient | +0.01 | -0.01 | |
| Ground Reflectivity (%) | -0.01 | +0.01 | |
| Total Shade (%) | +0.18 | -0.18 | * |
| Maximum Air Temp (°F) | +0.00 | +0.00 | |

**B**

Sensitivity Analysis - SSTEMP (2.0.8)

Sensitivity for mean temperature values (10% variation)     SSTEMP (2.0.8)

Original mean temperature = 59.26°F

| Variable | Temperature change (°F) if variable is: Decreased | Increased | Relative Sensitivity |
|---|---|---|---|
| Segment Inflow (cfs) | +0.00 | +0.00 | |
| Inflow Temperature (°F) | -0.01 | +0.02 | |
| Segment Outflow (cfs) | +0.21 | -0.20 | ** |
| Accretion Temp. (°F) | -0.85 | +0.85 | ******* |
| Width's A Term (s/ft²) | -0.32 | +0.37 | *** |
| B Term where W = A*Q**B | +0.38 | -0.36 | *** |
| Manning's n | +0.00 | +0.00 | |
| Air Temperature (°F) | -3.87 | +3.69 | ****************************** |
| Relative Humidity (%) | -0.55 | +0.56 | **** |
| Wind Speed (mph) | +0.11 | -0.12 | * |
| Ground Temperature (°F) | -0.29 | +0.29 | ** |
| Thermal gradient (j/m²/s/C) | +0.12 | -0.12 | * |
| Possible Sun (%) | -0.42 | +0.43 | *** |
| Dust Coefficient | +0.02 | -0.02 | |
| Ground Reflectivity (%) | -0.02 | +0.02 | |
| Total Shade (%) | +1.11 | -1.10 | ********* |
| Maximum Air Temp (°F) | +0.00 | +0.00 | |

**C**

Sensitivity Analysis - SSTEMP (2.0.8)

Sensitivity for mean temperature values (10% variation) SSTEMP (2.0.8)

Original mean temperature = 70.34°F

| Variable | Temperature change (°F) if variable is: Decreased | Increased | Relative Sensitivity |
|---|---|---|---|
| Segment Inflow (cfs) | -0.15 | +0.15 | * |
| Inflow Temperature (°F) | -0.02 | +0.02 | |
| Segment Outflow (cfs) | +0.16 | -0.15 | * |
| Accretion Temp. (°F) | -0.03 | +0.03 | |
| Width's A Term (s/ft²) | -0.01 | +0.01 | |
| B Term where W = A*Q**B | +0.00 | 0.00 | |
| Manning's n | +0.00 | +0.00 | |
| Air Temperature (°F) | -4.12 | +4.02 | ****************************** |
| Relative Humidity (%) | -0.59 | +0.61 | **** |
| Wind Speed (mph) | +0.46 | -0.49 | **** |
| Ground Temperature (°F) | -0.27 | +0.27 | ** |
| Thermal gradient (j/m²/s/C) | +0.12 | -0.12 | * |
| Possible Sun (%) | -0.67 | +0.70 | ***** |
| Dust Coefficient | +0.04 | -0.04 | |
| Ground Reflectivity (%) | -0.03 | +0.03 | |
| Total Shade (%) | +0.43 | -0.43 | *** |
| Maximum Air Temp (°F) | +0.00 | +0.00 | |

D

**Figure 9.2 SSTEMP Sensitivity outputs: A) American Creek (Rio de las Palomas to Headwaters, B) Jemez River (Jemez Pueblo bnd to Rio Guadalupe), C) La Jara Creek (East Fork Jemez to headwaters), D) Rio Cebolla (Rio de las Vacas to Fenton Lake)**

## 9.4 QWET Modeling Overview

Lake nutrient TMDLs were developed with the support of the Watershed Ecosystems Tool (WET), a graphical user interface (GUI) for the coupled one-dimensional hydrodynamic-ecosystems model GOTM-FABM-PCLake, which was developed by Aarhus University in Denmark to model a multitude of ecosystem parameters in lakes and reservoirs (Anders, 2017). WET can be accessed through the QGIS plugin QWET, which allows model creators to build the WET model within QGIS. Data needed to create a WET model range from simple loading estimates to continuous time series datasets. Detailed information on specific input data for each lake model is available in **Appendix F**. QWET models were created for San Gregorio Lake and Fenton Lake to address impairment for nutrients.

### 9.4.1 QWET Nutrient Modeling

The QWET nutrient models for San Gregorio Lake and Fenton Lake were created using various physical, chemical, and meteorological input data that is described in depth in **Appendix F**. The models were manually calibrated using grab sample measurements collected during two water quality surveys, the 2011-2013 Jemez survey and the 2021-2023 Jemez survey. Details on calibrated data can be found in **Appendix F**. The models were run from 2010 to 2020 to predict average daily total phosphorus and total nitrogen levels for the lakes named above. Numerous inputs are used to calculate the lake nutrient concentration in the WET model, including nutrient loading values, model coefficients, lake volume and area, and meteorological conditions. QWET allows the model user to create different nutrient loading scenarios to evaluate the impacts non-point source nutrient increases or decreases will have to the overall total nitrogen (TN) and total phosphorus (TP) concentration values. Five nutrient parameters can be manipulated, organic phosphorus, phosphate, organic nitrogen, nitrate, and ammonia.

Nutrient reduction scenarios were created for each lake and for each TMDL and target concentration value specified in Chapter 4 of this document. To reach desired TN concentrations, organic nitrogen, nitrate, and ammonia values were reduced and to reach desired TP concentrations, organic phosphorus, and phosphate were reduced.

### 9.4.2 QWET Nutrient Results

Nutrient reduction scenarios were explored until modeled lake nutrient concentrations met both the TMDL and the target concentration values.

For Fenton Lake, a reduction in TP loading of 33% will result in achieving the TMDL of 0.025 mg/L, and a 38% reduction in TP loading will result in achieving the target load of 0.021 mg/L. For Fenton Lake, a reduction in TN loading of 38% will result in achieving the TMDL of 0.387 mg/L, and a 45% reduction in TN loading will result in achieving the target load of 0.33 mg/L.

For San Gregorio Lake, a reduction in TP loading of 32% will result in achieving the TMDL of 0.03mg/L, and a 42% reduction in TP loading will result in achieving the target load of 0.027mg/L. For San Gregorio Lake, a reduction in TN loading of 35% will result in achieving the TMDL of 0.025 mg/L, and a 41% reduction in TN loading will result in achieving the target load of 0.027mg/L.

# 10.0 APPLICABLE REGULATIONS AND REASONABLE ASSURANCES

New Mexico's Water Quality Act, NMSA 1978, §§ 74-6-1 through -17 (Act), authorizes the WQCC to "adopt rules to prevent or abate water pollution in the state" and to require permits. *See* NMSA 1978, § 74-6-4(E). The Act authorizes a constituent agency, such as NMED, to take enforcement action against any person who violates a water quality standard. *See* NMSA 1978, § 74-6-10. Several statutory provisions on nuisance law could also be applied to NPS water pollution. The Act also states in Section 74-6-12(a):

> *The Water Quality Act 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 at 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.* 33 U.S.C. § 1251.

New Mexico's CWA Section 319 Program has been developed in a coordinated manner with the State's CWA Section 303(d) process. *See* 33 U.S.C. §§ 1329 and 1313. 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 an NPS. The NMED NPS water quality management program has historically strived for and will continue to promote voluntary compliance with NPS water pollution concerns by utilizing a voluntary, cooperative approach. The State provides technical support and grant money for implementation of BMPs and other NPS prevention mechanisms through Section 319 of the CWA. *See* 33 U.S.C. § 1329. 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.

# 11.0 PUBLIC PARTICIPATION

Public participation was solicited in development of this TMDL. Pursuant to 40 C.F.R. § 130.7(a), the public participation will be conducted in accordance with Section XIV of the WQMP/CPP (NMED/SWQB, 2020b), and as outlined in Section IV.C of the WQMP/CPP. The draft TMDL was made available for a 30-day comment period beginning March 16, 2026, and ending on April 14, 2026. The draft document notice of availability included information on comment submittal and dates/times of the public meetings. It was advertised via email distribution lists and webpage postings. Public meetings were held using virtual meeting technology. Three sets of public comments were submitted. A response to public comments have been added to this TMDL document as **Appendix G**. The TMDL document was approved by the NM WQCC on DATE and EPA Region 6 on DATE.

Following WQCC and EPA approval, 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.

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# APPENDIX A
# THREATENED AND ENDAGERED SPECIES
# KNOWN TO OCCUR IN THE PROJECT AREA

Biota Information System of New Mexico — NATURAL HERITAGE NEW MEXICO

# Federal or State Threatened/Endangered Species
## Sandoval

| Taxonomic Group | # Species | Taxonomic Group | # Species |
|---|---|---|---|
| Amphibians | 1 | Birds | 15 |
| Fish | 1 | Lepidoptera; moths and butterflies | 1 |
| Mammals | 3 | Molluscs | 2 |

**TOTAL SPECIES: 23**

| Common Name | Scientific Name | NMGF | US FWS | Critical Habitat | SGCN | Photo |
|---|---|---|---|---|---|---|
| Spotted Bat | Euderma maculatum | T | | | Y | View |
| Pacific Marten | Martes caurina | T | | | Y | View |
| New Mexico Jumping Mouse | Zapus hudsonius luteus | E | E | Y | Y | View |
| Yellow-billed Cuckoo (western pop) | Coccyzus americanus occidentalis | | T | Y | Y | View |
| Costa's Hummingbird | Calypte costae | T | | | Y | View |
| Broad-billed Hummingbird | Cynanthus latirostris | T | | | Y | View |
| Whooping Crane | Grus americana | E | E | | | No Photo |
| Neotropic Cormorant | Phalacrocorax brasilianus | T | | | Y | View |
| Brown Pelican | Pelecanus occidentalis | E | | | | View |
| Bald Eagle | Haliaeetus leucocephalus | T | | | Y | View |
| Common Black Hawk | Buteogallus anthracinus | T | | | Y | View |
| Mexican Spotted Owl | Strix occidentalis lucida | | T | Y | Y | View |
| Peregrine Falcon | Falco peregrinus | T | | | Y | View |
| Northern Beardless-Tyrannulet | Camptostoma imberbe | E | | | Y | View |
| Southwestern Willow Flycatcher | Empidonax traillii extimus | E | E | Y | Y | View |
| Bell's Vireo | Vireo bellii | T | | | Y | View |
| Gray Vireo | Vireo vicinior | T | | | Y | View |
| Baird's Sparrow | Centronyx bairdii | T | | | Y | View |
| Jemez Mountains Salamander | Plethodon neomexicanus | E | E | Y | Y | View |
| Rio Grande Silvery Minnow | Hybognathus amarus | E | E | Y | Y | View |
| Wrinkled Marshsnail | Stagnicola caperata | E | | | Y | View |
| Monarch | Danaus plexippus | | P | | | View |
| Paper Pondshell | Utterbackia imbecillis | E | | | Y | View |

# APPENDIX B
# WATER QUALITY DATA

## Total Recoverable Aluminum data

Exceedances of the applicable criteria are shown in bold red font. MDP indicates a missing data point.

Calaveras Creek (Rio Cebolla to headwaters)
Monitoring station(s): CALAVERAS CREEK ABOVE RIO CEBOLLA ON NM 126 - 31Calave001.1

| Date | Hardness (mg/L) | Acute Criterion (mg/L) | Chronic Criterion (mg/L) | TR Al (mg/L) | Flow (cfs) | pH |
|---|---|---|---|---|---|---|
| 4/6/2021 | 31.00 | 0.69 | 0.28 | **0.84** | 0.24 | 7.54 |
| 8/10/2022 | 37.00 | 0.88 | 0.35 | **0.86** | 0.03 | 7.62 |
| 10/19/2022 | 36.00 | 0.84 | 0.34 | **1.00** | 0.01 | 7.19 |
| 5/17/2023 | 33.00 | 0.75 | 0.30 | **1.50** | 3.00 | 7.74 |

Clear Creek (Rio de las Vacas to San Gregorio Lake)
Monitoring station(s): Clear Creek at NM 126 - 31ClearC002.3

| Date | Hardness (mg/L) | Acute Criterion (mg/L) | Chronic Criterion (mg/L) | TR Al (mg/L) | Flow (cfs) | pH |
|---|---|---|---|---|---|---|
| 4/6/2021 | 22.00 | 0.43 | 0.17 | **2.20** | 9.76 | 6.75 |
| 5/12/2021 | 38.00 | 0.91 | 0.36 | **0.61** | 1.86 | MDP |
| 6/16/2021 | 116.00 | 4.19 | 1.68 | 0.08 | 0.01 | 8.27 |
| 8/10/2022 | 95.00 | 3.19 | 1.28 | 0.14 | 0.14 | 7.95 |
| 10/19/2022 | 43.00 | 1.08 | 0.43 | **0.75** | 0.82 | 6.74 |

Clear Creek (San Gregorio Lake to headwaters)
Monitoring station(s): Clear Creek abv San Gregorio Lake - 31ClearC009.2

| Date | Hardness (mg/L) | Acute Criterion (mg/L) | Chronic Criterion (mg/L) | TR Al (mg/L) | Flow (cfs) | pH |
|---|---|---|---|---|---|---|
| 5/23/2013 | 19.00 | 0.35 | 0.14 | **0.64** | MDP | 7.31 |
| 6/19/2013 | 24.00 | 0.48 | 0.19 | **0.40** | MDP | 7.17 |
| 7/31/2013 | 24.00 | 0.48 | 0.19 | **0.38** | MDP | 7.41 |
| 8/21/2013 | 27.00 | 0.57 | 0.23 | **0.43** | MDP | 6.49 |

East Fork Jemez (San Antonio Creek to VCNP bnd)
Monitoring station(s): East Fork Jemez above confluence with San Antonio Creek - 31EFkJem000.1

| Date | Hardness (mg/L) | Acute Criterion (mg/L) | Chronic Criterion (mg/L) | TR Al (mg/L) | Flow (cfs) | pH |
|---|---|---|---|---|---|---|
| 3/23/2021 | 32.00 | 0.72 | 0.29 | 0.24 | 8.65 | 8.20 |
| 5/11/2021 | 32.00 | 0.72 | 0.29 | 0.23 | 4.85 | 7.98 |
| 10/5/2021 | 31.00 | 0.69 | 0.28 | 0.25 | 3.98 | 8.31 |
| 3/31/2022 | 24.00 | 0.48 | 0.19 | **1.20** | 16.00 | 8.02 |
| 10/20/2022 | 30.00 | 0.66 | 0.26 | **3.00** | 30.00 | 7.61 |

East Fork Jemez (VCNP to headwaters)
Monitoring station(s): East Fork Jemez below La Jara Creek - 31EFkJem020.7

| Date | Hardness (mg/L) | Acute Criterion (mg/L) | Chronic Criterion (mg/L) | TR Al (mg/L) | Flow (cfs) | pH |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| 4/14/2021 | 20.00 | 0.38 | 0.15 | **0.53** | 2.00 | 7.39 |
| 5/13/2021 | 23.00 | 0.46 | 0.18 | **0.29** | 2.88 | 7.37 |
| 6/16/2022 | 20.00 | 0.38 | 0.15 | **0.54** | 1.18 | 8.93 |
| 7/19/2022 | 32.00 | 0.72 | 0.29 | 0.15 | 0.50 | 7.36 |
| 9/7/2022 | 32.00 | 0.72 | 0.29 | 0.23 | 2.02 | 7.50 |
| 10/20/2022 | 26.00 | 0.54 | 0.22 | **2.60** | 9.17 | 7.09 |

Jaramillo Creek (East Fork Jemez to headwaters)
Monitoring station(s): Jaramillo Creek abv road VC 02 - 31Jarami006.0

| Date | Hardness (mg/L) | Acute Criterion (mg/L) | Chronic Criterion (mg/L) | TR Al (mg/L) | Flow (cfs) | pH |
|---|---|---|---|---|---|---|
| 4/14/2021 | 19.00 | 0.35 | 0.14 | **0.88** | 1.35 | 7.54 |
| 5/13/2021 | 25.00 | 0.51 | 0.21 | **0.76** | 0.42 | 7.51 |
| 6/17/2021 | 34.00 | 0.78 | 0.31 | **0.56** | 0.14 | 7.50 |
| 6/16/2022 | 34.00 | 0.78 | 0.31 | **2.10** | 0.03 | 7.72 |
| 7/19/2022 | 33.00 | 0.75 | 0.30 | **0.50** | 0.25 | 6.98 |
| 9/7/2022 | 31.00 | 0.69 | 0.28 | **0.40** | 1.17 | 7.60 |

La Jara Creek (East Fork Jemez to headwaters)
Monitoring station(s): La Jara above headquarters (VCNP 15) - 31LaJara005.0

| Date | Hardness (mg/L) | Acute Criterion (mg/L) | Chronic Criterion (mg/L) | TR Al (mg/L) | Flow (cfs) | pH |
|---|---|---|---|---|---|---|
| 4/14/2021 | 15.00 | 0.25 | 0.10 | **0.38** | 0.37 | 7.94 |
| 5/13/2021 | 15.00 | 0.25 | 0.10 | **0.31** | 0.14 | 7.77 |
| 6/17/2021 | 15.00 | 0.25 | 0.10 | **0.44** | 0.09 | 8.02 |
| 6/16/2022 | 15.00 | 0.25 | 0.10 | **0.26** | 0.06 | 7.96 |
| 7/19/2022 | 18.00 | 0.33 | 0.13 | **0.28** | 0.20 | 7.62 |
| 9/7/2022 | 20.00 | 0.38 | 0.15 | **0.20** | 0.97 | 7.64 |

Rio Cebolla (Fenton Lake to headwaters)
Monitoring station(s): Rio Cebolla ~0.5 mile above Fenton Lake - 31RCebol011.4
Rio Cebolla at campground abv Seven Springs hatchery - 31RCebol017.9

| Date | Hardness (mg/L) | Acute Criterion (mg/L) | Chronic Criterion (mg/L) | TR Al (mg/L) | Flow (cfs) | pH |
|---|---|---|---|---|---|---|
| 4/6/2021 | 32.00 | 0.72 | 0.29 | 0.26 | 3.88 | 8.09 |
| 6/2/2021 | 33.00 | 0.75 | 0.30 | 0.25 | 2.61 | 7.88 |
| 4/7/2022 | 31.00 | 0.69 | 0.28 | 0.18 | 3.57 | 8.31 |
| 10/19/2022 | 34.00 | 0.78 | 0.31 | **0.37** | 3.90 | 7.59 |
| 4/14/2021 | 28.00 | 0.60 | 0.24 | **0.33** | 1.36 | 7.87 |
| 5/12/2021 | 27.00 | 0.57 | 0.23 | **0.35** | 1.11 | MDP |
| 5/10/2022 | 25.00 | 0.51 | 0.21 | **0.59** | 0.96 | 8.07 |
| 8/10/2022 | 28.00 | 0.60 | 0.24 | 0.09 | 1.63 | 7.62 |
| 10/18/2022 | 28.00 | 0.60 | 0.24 | **0.31** | 2.10 | 7.65 |

Rio de las Vacas (Clear Creek to headwaters)
Monitoring station(s): Rio de Las Vacas at SR 126 - 31RVacas023.7

| Date | Hardness (mg/L) | Acute Criterion (mg/L) | Chronic Criterion (mg/L) | TR Al (mg/L) | Flow (cfs) | pH |
|---|---|---|---|---|---|---|
| 4/6/2021 | 19.00 | 0.35 | 0.14 | **1.60** | 28.22 | 6.90 |
| 6/16/2021 | 21.00 | 0.40 | 0.16 | 0.12 | 0.48 | 7.78 |
| 8/10/2022 | 21.00 | 0.40 | 0.16 | **0.46** | 11.74 | 6.49 |
| 10/19/2022 | 21.00 | 0.40 | 0.16 | **0.50** | 7.11 | 5.81 |

Rito de los Indios (San Antonio Creek to headwaters)
Monitoring station(s): Rito de los Indios above San Antonio Creek - 31RIndio000.2

| Date | Hardness (mg/L) | Acute Criterion (mg/L) | Chronic Criterion (mg/L) | TR Al (mg/L) | Flow (cfs) | pH |
|---|---|---|---|---|---|---|
| 5/13/2021 | 21.00 | 0.40 | 0.16 | **0.90** | 0.27 | 7.26 |
| 6/17/2021 | 18.00 | 0.33 | 0.13 | **0.45** | 0.41 | 7.50 |
| 10/7/2021 | 21.00 | 0.40 | 0.16 | **0.21** | 0.53 | 7.62 |
| 6/16/2022 | 17.00 | 0.30 | 0.12 | **0.47** | 0.13 | 7.95 |
| 7/19/2022 | 27.00 | 0.57 | 0.23 | 0.09 | 0.30 | 8.17 |
| 10/20/2022 | 30.00 | 0.66 | 0.26 | **0.41** | 0.85 | 6.99 |

San Antonio Creek (East Fork Jemez to VCNP bnd)
Monitoring station(s): San Antonio Creek abv confl w East Fork Jemez River - 31SanAnt000.1

| Date | Hardness (mg/L) | Acute Criterion (mg/L) | Chronic Criterion (mg/L) | TR Al (mg/L) | Flow (cfs) | pH |
|---|---|---|---|---|---|---|
| 3/23/2021 | 49.00 | 1.29 | 0.52 | **1.20** | 8.73 | 8.00 |
| 5/11/2021 | 42.00 | 1.04 | 0.42 | 0.29 | 6.06 | 8.08 |
| 3/31/2022 | 50.00 | 1.32 | 0.53 | **1.10** | 10.44 | 8.24 |
| 10/18/2022 | 57.00 | 1.58 | 0.63 | **1.30** | 25.00 | 7.65 |

San Antonio Creek (VCNP bnd to headwaters)
Monitoring station(s): San Antonio Creek abv VCNP boundary - 31SanAnt017.7

| Date | Hardness (mg/L) | Acute Criterion (mg/L) | Chronic Criterion (mg/L) | TR Al (mg/L) | Flow (cfs) | pH |
|---|---|---|---|---|---|---|
| 5/13/2021 | 27.00 | 0.57 | 0.23 | **0.45** | 3.90 | 7.55 |
| 6/17/2021 | 27.00 | 0.57 | 0.23 | 0.18 | 3.03 | 8.43 |
| 7/19/2022 | 27.00 | 0.57 | 0.23 | 0.15 | 0.15 | 7.55 |
| 9/7/2022 | 28.00 | 0.60 | 0.24 | 0.22 | 3.50 | 7.86 |
| 10/20/2022 | 38.00 | 0.91 | 0.36 | **0.76** | 8.51 | 7.61 |

## Dissolved Aluminum data

Exceedances of the applicable criteria are shown in bold red font.

Redondo Creek (Sulphur Creek to headwaters)
Monitoring station(s): Redondo Creek Above Sulphur Creek - 31Redond000.1
Redondo Creek above VCNP boundary - 31Redond001.2

| Date | Hardness (mg/L) | Acute Criterion (mg/L) | Chronic Criterion (mg/L) | Dissolved Al (mg/L) | Flow (cfs) | pH |
|---|---|---|---|---|---|---|
| 9/7/2022 | 48.00 | 0.75 | 0.087 | 0.14 | 0.90 | 7.34 |
| 10/7/2021 | 145.00 | 0.75 | 0.087 | **4.70** | 0.01 | 4.57 |
| 4/14/2021 | 53.00 | 0.75 | 0.087 | 0.32 | 0.08 | 6.51 |
| 5/13/2021 | 65.00 | 0.75 | 0.087 | **0.27** | 0.03 | 5.96 |
| 10/20/2022 | 33.00 | 0.75 | 0.087 | 0.01 | 1.60 | 7.32 |

Sulphur Creek (Redondo Creek to headwaters)
Monitoring station(s): Sulphur Creek Above Redondo Creek - 31Sulphu001.3

| Date | Hardness (mg/L) | Acute Criterion (mg/L) | Chronic Criterion (mg/L) | Dissolved Al (mg/L) | Flow (cfs) | pH |
|---|---|---|---|---|---|---|
| 4/14/2021 | 220.00 | 0.75 | 0.087 | **16.00** | 0.37 | 3.60 |
| 5/13/2021 | 220.00 | 0.75 | 0.087 | **11.00** | 0.05 | 3.05 |
| 3/30/2022 | 220.00 | 0.75 | 0.087 | **28.00** | 0.71 | 3.31 |
| 10/20/2022 | 42.00 | 0.75 | 0.087 | 0.11 | 1.28 | 6.75 |

Sulphur Creek (San Antonio Creek to Redondo Creek)
Monitoring station(s): Sulphur Creek blw Redondo Creek - 31Sulphu001.2
Sulphur Creek at Hwy 4 - 31Sulphu000.9

| Date | Hardness (mg/L) | Acute Criterion (mg/L) | Chronic Criterion (mg/L) | Dissolved Al (mg/L) | Flow (cfs) | pH |
|---|---|---|---|---|---|---|
| 4/6/2021 | 215.00 | 0.75 | 0.087 | **15.00** | 0.69 | 4.00 |
| 5/13/2021 | 171.00 | 0.75 | 0.087 | **2.30** | 0.04 | 4.35 |
| 3/30/2022 | 205.00 | 0.75 | 0.087 | **18.00** | 0.63 | 3.60 |
| 5/10/2022 | 176.00 | 0.75 | 0.087 | **2.70** | 0.03 | 4.37 |
| 10/20/2022 | 89.00 | 0.75 | 0.087 | **3.50** | 2.84 | 4.89 |
| 7/21/2022 | 220.00 | 0.75 | 0.087 | **2.80** | 0.10 | 4.67 |

## *E. Coli* data

Exceedances of the applicable criteria are shown in bold red font. MPN is the most probable number of colony forming units and is equivalent to cfu in the New Mexico WQS. These Assessment Units have segment-specific single sample criteria of 235 cfu/100 mL or less (20.6.4.108 NMAC). MDP indicates a missing data point.

American Creek (Rio de las Palomas to headwaters)
Monitoring station(s): American Creek at FR 69C - 31Americ001.5
American Creek at FR 69 abv American Park - 31Americ006.4
American Creek at southern end of American Park - 31Americ003.4

| Date | E. Coli (MPN/100mL) | Flow (cfs) |
|---|---|---|
| 5/12/2021 | 1 | 0.11 |

| | | |
|---|---|---|
| 6/16/2021 | **352.54** | 0.01 |
| 5/10/2022 | 7.38 | 0.334 |
| 8/10/2022 | **325.54** | 0.2 |

Jaramillo Creek (East Fork Jemez to headwaters)
Monitoring station(s): Jaramillo Creek abv road VC 02 - 31Jarami006.0

| Date | E. Coli (MPN/100mL) | Flow (cfs) |
|---|---|---|
| 4/14/2021 | 1 | 1.346 |
| 5/13/2021 | 5.21 | 0.42 |
| 6/17/2021 | **230.2** | 0.135 |
| 6/16/2022 | **613.14** | 0.033 |
| 7/19/2022 | 90.75 | 0.25 |
| 9/7/2022 | 22.81 | 1.165 |
| 10/20/2022 | 6.26 | 5.219 |
| 5/17/2023 | 2.02 | MDP |

Rio Cebolla (Rio de las Vacas to Fenton Lake)
Monitoring station(s): Rio Cebolla above the Rio de las Vacas - 31RCebol000.1
Rio Cebolla at Hal Baxter Trail - 31RCebol009.6
Rio Cebolla at Lake Fork Canyon- 31RCebol007.0

| Date | E. Coli (MPN/100mL) | Flow (cfs) |
|---|---|---|
| 5/12/2021 | 193.49 | 3.41 |
| 6/2/2021 | 88.59 | 2.486 |
| 6/2/2021 | 135.4 | 2.608 |
| 6/2/2021 | **273.3** | 2.866 |
| 4/7/2022 | 1 | 3.844 |
| 7/21/2022 | **325.54** | 1.934 |
| 7/21/2022 | **488.44** | 2.037 |
| 9/8/2022 | 69.68 | 2.403 |
| 10/19/2022 | 13.5 | 5.624 |
| 5/17/2023 | 2.02 | MDP |

Rito Penas Negras (Rio de las Vacas to headwaters)
Monitoring station(s): Rito Penas Negras 3.2km above Rio de las Vacas - 31RPNegr003.2
Rito Penas Negras at NM Hwy 126 - 31RPNegr000.1

| Date | E. Coli (MPN/100mL) | Flow (cfs) |
|---|---|---|
| 4/6/2021 | 10.78 | 4.11 |
| 5/12/2021 | 12.11 | 0.61 |
| 5/10/2022 | 20.34 | 0.312 |
| 8/10/2022 | **435.17** | 0.13 |
| 9/8/2022 | **461.11** | 0.2 |
| 9/20/2022 | 198.9 | 0.176 |
| 8/3/2023 | 16.13 | MDP |

## Plant Nutrients data

Separate tables with 2013-2014 Jemez Watershed Monitoring Survey data are presented for the following AUs:

Rio Cebolla (Fenton Lake to headwaters)
Rito de los Indios (San Antonio Creek to headwaters)
San Antonio Creek (VCNP bnd to headwaters)

This is because these AUs were originally listed as impaired in the 2016 Integrated List but have not had sufficient data to de-list.
Exceedances are highlighted in red.

Jemez River (Jemez Pueblo bnd to Rio Guadalupe)
Monitoring Station(s): Jemez River below Rio Guadalupe - 31JemezR048.7
JEMEZ RIVER NEAR CANON, BELOW MUNICIPAL SCHOOL - 31JemezR046.6
Applicable Thresholds: TN(Moderate) 0.42 mg/L, TP (High-Volcanic) 0.105 mg/L, Delta DO 5.02 mg/L

| Monitoring Station | Date | TN (mg/L) | TP (mg/L) |
|---|---|---|---|
| 31JemezR046.6 | 3/23/2021 | 0.28 | 0.01 |
| 31JemezR048.7 | 3/23/2021 | 0.25 | 0.049 |
| 31JemezR046.6 | 5/11/2021 | 0.39 | 0.033 |
| 31JemezR048.7 | 5/11/2021 | MDP | 0.041 |
| 31JemezR046.6 | 6/15/2021 | 1.23 | 0.02 |
| 31JemezR048.7 | 6/15/2021 | 1.72 | 0.032 |
| 31JemezR046.6 | 10/5/2021 | 0.25 | 0.071 |
| 31JemezR048.7 | 10/5/2021 | 0.32 | 0.052 |
| 31JemezR046.6 | 3/30/2022 | 0.89 | 0.129 |
| 31JemezR048.7 | 3/30/2022 | 0.78 | 0.157 |
| 31JemezR046.6 | 6/16/2022 | 0.28 | 0.04 |
| 31JemezR048.7 | 8/23/2022 | 0.78 | 0.241 |
| 31JemezR046.6 | 9/7/2022 | 0.41 | MDP |
| 31JemezR046.6 | 10/18/2022 | 1.38 | 0.287 |
| **Median TN:** | | 0.41 | |
| **Median TP:** | | 0.049 | |
| **Max Delta DO:** | | 0.95 | |

Jemez River (Rio Guadalupe to Soda Dam nr Jemez Springs)
Monitoring Station(s): Jemez River above Rio Guadalupe - 31JemezR049.2
Jemez R. blw Jemez Spr. WWTP - 31JemezR057.4
Jemez R. abv. Jemez Springs WWTP - 31JemezR058.6
Applicable Thresholds: TN(Moderate) 0.42 mg/L, TP (High-Volcanic) 0.105 mg/L, Delta DO 5.02 mg/L

| Monitoring Station | Date | TN (mg/L) | TP (mg/L) |
|---|---|---|---|
| 31JemezR049.2 | 3/23/2021 | 0.25 | 0.064 |
| 31JemezR057.4 | 3/23/2021 | 0.31 | 0.067 |
| 31JemezR058.6 | 3/23/2021 | 0.35 | 0.064 |

| | | | |
|---|---|---|---|
| 31JemezR049.2 | 5/11/2021 | 0.27 | 0.045 |
| 31JemezR057.4 | 5/11/2021 | 1.53 | 0.11 |
| 31JemezR058.6 | 5/11/2021 | 0.29 | 0.051 |
| 31JemezR049.2 | 6/15/2021 | 1.45 | 0.034 |
| 31JemezR057.4 | 6/15/2021 | 0.29 | 0.049 |
| 31JemezR058.6 | 6/15/2021 | 0.25 | 0.039 |
| 31JemezR049.2 | 10/5/2021 | 0.27 | 0.076 |
| 31JemezR057.4 | 10/5/2021 | 0.31 | 0.165 |
| 31JemezR058.6 | 10/5/2021 | 0.33 | 0.104 |
| 31JemezR057.4 | 2/25/2022 | 0.25 | 0.032 |
| 31JemezR058.6 | 2/25/2022 | 0.25 | 0.042 |
| 31JemezR049.2 | 3/30/2022 | 0.88 | 0.169 |
| 31JemezR057.4 | 3/31/2022 | 0.81 | 0.11 |
| 31JemezR058.6 | 3/31/2022 | 0.7 | 0.108 |
| 31JemezR057.4 | 5/10/2022 | 0.39 | 0.045 |
| 31JemezR057.4 | 8/23/2022 | 0.86 | 0.197 |
| 31JemezR049.2 | 8/23/2022 | 0.87 | 0.315 |
| 31JemezR057.4 | 10/18/2022 | 1.29 | 0.276 |
| 31JemezR058.6 | 10/18/2022 | 1.22 | 0.263 |
| 31JemezR049.2 | 10/18/2022 | 1.28 | 0.303 |
| **Median TN:** | | 0.35 | |
| **Median TP:** | | 0.076 | |
| **Max Delta DO:** | | 2.07 | |

Rio Cebolla (Fenton Lake to headwaters)
Monitoring Station(s): Rio Cebolla ~0.5 mile above Fenton Lake - 31RCebol011.4
Rio Cebolla at campground abv Seven Springs hatchery - 31RCebol017.9
Applicable Thresholds: TN(Moderate) 0.42 mg/L, TP (High-Volcanic) 0.105 mg/L, Delta DO 5.02 mg/L

| Monitoring Station | Date | TN (mg/L) | TP (mg/L) |
|---|---|---|---|
| 31RCebol011.4 | 4/6/21 | 0.25 | 0.03 |
| 31RCebol017.9 | 4/14/21 | 0.3 | 0.032 |
| 31RCebol017.9 | 5/12/21 | 0.25 | 0.055 |
| 31RCebol011.4 | 6/2/21 | 0.35 | 0.024 |
| 31RCebol017.9 | 6/16/21 | 0.25 | 0.023 |
| 31RCebol011.4 | 4/7/22 | 0.27 | 0.03 |
| 31RCebol017.9 | 5/10/22 | **0.66** | 0.065 |
| 31RCebol017.9 | 8/10/22 | 0.29 | 0.05 |
| 31RCebol017.9 | 10/18/22 | 0.26 | 0.065 |
| 31RCebol011.4 | 10/19/22 | 0.3 | 0.077 |
| **Median TN:** | | 0.28 | |
| **Median TP:** | | 0.041 | |
| **Max Delta DO:** | | MDP | |

Rio Cebolla (Fenton Lake to headwaters) 2013-2014 data

| Monitoring Station | Date | TN (mg/L) | TP (mg/L) |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 31RCebol011.4 | 3/26/13 | 0.3 | **0.032** |
| 31RCebol011.4 | 5/15/13 | 0.3 | **0.046** |
| 31RCebol017.9 | 6/19/13 | **1.19** | **0.051** |
| 31RCebol011.4 | 6/19/13 | **1.46** | **0.061** |
| 31RCebol011.4 | 7/9/13 | 0.3 | **0.061** |
| 31RCebol017.9 | 7/11/13 | **1.08** | **0.1** |
| 31RCebol011.4 | 7/17/13 | 0.3 | **0.047** |
| 31RCebol017.9 | 7/17/13 | 0.3 | **0.046** |
| 31RCebol011.4 | 8/8/13 | **0.56** | **0.043** |
| 31RCebol011.4 | 8/28/13 | 0.3 | **0.032** |
| 31RCebol017.9 | 8/28/13 | 0.3 | **0.034** |
| 31RCebol011.4 | 10/9/13 | 0.3 | **0.026** |
| 31RCebol011.4 | 6/10/14 | 0.3 | **0.071** |
| 31RCebol017.9 | 9/17/14 | 0.3 | **0.051** |
| 31RCebol011.4 | 9/17/14 | 0.3 | **0.052** |
| 31RCebol011.4 | 9/17/14 | 0.3 | **0.052** |
| 31RCebol017.9 | 9/30/14 | 0.3 | **0.039** |
| 31RCebol011.4 | 9/30/14 | 0.3 | **0.024** |

Rito de los Indios (San Antonio Creek to headwaters)
Monitoring Station(s): Rito de los Indios above San Antonio Creek - 31RIndio000.2
Applicable Thresholds: TN(Moderate) 0.42 mg/L, TP (High-Volcanic) 0.105 mg/L, Delta DO 5.02 mg/L

| Monitoring Station | Date | TN (mg/L) | TP (mg/L) |
|---|---|---|---|
| 31RIndio000.2 | 5/13/21 | 0.25 | 0.092 |
| 31RIndio000.2 | 6/17/21 | **0.78** | 0.045 |
| 31RIndio000.2 | 10/7/21 | 0.25 | 0.035 |
| 31RIndio000.2 | 6/16/22 | 0.35 | 0.089 |
| 31RIndio000.2 | 7/19/22 | 0.3 | 0.051 |
| 31RIndio000.2 | 10/20/22 | 0.29 | 0.087 |
| **Median TN:** | | 0.33 | |
| **Median TP:** | | 0.07 | |
| **Max Delta DO:** | | 3.52 | |

Rito de los Indios (San Antonio Creek to headwaters) 2013-2014 data

| Monitoring Station | Date | TN (mg/L) | TP (mg/L) |
|---|---|---|---|
| 31RIndio000.2 | 4/24/13 | **3.06** | **0.343** |
| 31RIndio000.2 | 5/21/13 | 0.3 | **0.061** |
| 31RIndio000.2 | 7/2/13 | 0.3 | **0.1** |
| 31RIndio000.2 | 10/10/13 | 0.3 | **0.043** |

San Antonio Creek (VCNP bnd to headwaters)
Monitoring Station(s): San Antonio Creek abv VCNP boundary - 31SanAnt017.7

Applicable Thresholds: TN(Moderate) 0.42 mg/L, TP (High-Volcanic) 0.105 mg/L, Delta DO 5.02 mg/L

| Monitoring Station | Date | TN (mg/L) | TP (mg/L) |
|---|---|---|---|
| 31SanAnt017.7 | 5/13/21 | 0.25 | 0.033 |
| 31SanAnt017.7 | 6/17/21 | 0.25 | 0.037 |
| 31SanAnt017.7 | 10/7/21 | 0.25 | 0.025 |
| 31SanAnt017.7 | 7/19/22 | 0.35 | 0.074 |
| 31SanAnt017.7 | 9/7/22 | **0.43** | 0.068 |
| 31SanAnt017.7 | 10/20/22 | **0.51** | 0.095 |
| **Median TN:** | | 0.30 | |
| **Median TP:** | | 0.05 | |
| **Max Delta DO:** | | 3.21 | |

San Antonio Creek (VCNP bnd to headwaters) 2013-2014 data

| Monitoring Station | Date | TN (mg/L) | TP (mg/L) |
|---|---|---|---|
| 31SanAnt017.7 | 4/24/13 | **1.53** | **0.075** |
| 31SanAnt023.4 | 4/24/13 | 0.3 | **0.064** |
| 31SanAnt034.6 | 4/24/13 | 0.3 | 0.019 |
| 31SanAnt017.7 | 5/21/13 | 0.3 | **0.07** |
| 31SanAnt023.4 | 5/21/13 | 0.3 | **0.047** |
| 31SanAnt034.6 | 5/21/13 | 0.3 | 0.014 |
| 31SanAnt034.6 | 7/2/13 | 0.3 | **0.1** |
| 31SanAnt023.4 | 7/3/13 | **0.7** | **0.1** |
| 31SanAnt017.7 | 7/3/13 | **0.74** | **0.1** |
| 31SanAnt017.7 | 10/10/13 | **0.39** | **0.029** |
| 31SanAnt023.4 | 10/10/13 | **0.38** | **0.041** |
| 31SanAnt034.6 | 10/10/13 | **0.56** | 0.01 |

Fenton Lake

Monitoring Station(s): Fenton Lake at dam - 31FentonLkDam

Applicable Causal Thresholds: Cold Lake Group – TN 0.387 mg/L, TP 0.025 mg/L

| Monitoring Station | Date | TN (mg/L) | TP (mg/L) |
|---|---|---|---|
| 31FentonLkDam | 2013-05-22 15:00:00 | 0.3 | **0.027** |
| 31FentonLkDam | 2013-07-09 10:30:00 | 0.3 | **0.068** |
| 31FentonLkDam | 2013-08-08 10:40:00 | **1.6** | **0.07** |
| 31FentonLkDam | 2013-10-09 10:30:00 | 0.3 | **0.026** |
| 31FentonLkDam | 2013-10-09 10:30:00 | 0.3 | **0.026** |
| 31FentonLkDam | 2014-06-10 10:00:00 | **0.76** | **0.043** |
| 31FentonLkDam | 2014-08-08 14:15:00 | 0.38 | **0.066** |
| 31FentonLkDam | 2021-06-03 10:20:00 | **0.65** | 0.014 |
| 31FentonLkDam | 2022-04-07 11:57:00 | 0.28 | **0.027** |
| **Median TN:** | | **0.56** | |
| **Median TP:** | | **0.047** | |

San Gregorio Lake
Monitoring Station(s): San Gregorio Deep - 33SanGregorLk
Applicable Causal Thresholds: Cold Lake Group – TN 0.387 mg/L, TP 0.025 mg/L

| Monitoring Station | Date | TN (mg/L) | TP (mg/L) |
|---|---|---|---|
| 33SanGregorLk | 2013-05-23 10:30:00 | 0.3 | **0.03** |
| 33SanGregorLk | 2013-07-31 09:30:00 | 0.3 | **0.03** |
| 33SanGregorLk | 2013-10-08 12:00:00 | 0.3 | **0.312** |
| 33SanGregorLk | 2014-08-08 10:00:00 | **0.9** | **0.052** |
| 33SanGregorLk | 2014-09-22 12:45:00 | **0.95** | **0.036** |
| **Median TN:** | | **0.55** | |
| **Median TP:** | | **0.092** | |

**SWQB TN/TP Effluent Monitoring Data**

Jemez Velley Public Schools wastewater treatment plant, permit no. NM0028479

| Date | Parameter | Reported Value (mg/L) |
|---|---|---|
| 6-10-2013 | Total Nitrogen | 70.8 |
| | Total Phosphorus | 7.14 |
| 10-4-2013 | Total Nitrogen | 135.5 |
| | Total Phosphorus | 6.62 |
| 12-19-2013 | Total Nitrogen | 95.4 |
| | Total Phosphorus | 7.15 |
| 6-15-2021 | Total Nitrogen | 37.5 |
| | Total Phosphorus | 2.21 |
| 3-30-2022 | Total Nitrogen | 95.6 |
| | Total Phosphorus | 4.8 |

Jemez Springs wastewater treatment plant, permit no. NM0028011

| Date | Parameter | Reported Value (mg/L) |
|---|---|---|
| 2-25-2022 | Total Nitrogen | 4.2 |
| | Total Phosphorus | 0.481 |
| 3-31-2022 | Total Nitrogen | 2.04 |
| | Total Phosphorus | 0.296 |
| 8-23-2022 | Total Nitrogen | 6.68 |
| | Total Phosphorus | 0.171 |
| 10-18-2022 | Total Nitrogen | 0.37 |
| | Total Phosphorus | 0.216 |

## Sedimentation data

Exceedances of the applicable indicator thresholds are shown in bold red font. Threshold values are shown on **Table 5.4** of this report.

Jaramillo Creek (East Fork Jemez to headwaters)
Monitoring Station(s): Jaramillo Creek abv road VC 02 - 31Jarami006.0
Applicable TSS indicator threshold: 8.75 mg/L

| Date | TSS (mg/L) | Turbidity (NTU) | Flow (cfs) |
|---|---|---|---|
| 4/14/2021 | 4 | 6.4 | 1.35 |
| 5/13/2021 | 9 | 27 | 0.42 |
| 6/17/2021 | **13** | 9.8 | 0.14 |
| 6/16/2022 | **15** | 16.7 | 0.03 |
| 7/19/2022 | 3 | 18.7 | 0.25 |
| 9/7/2022 | 4 | 4.1 | 1.17 |
| 10/20/2022 | 6 | 16.1 | 5.22 |

Vallecito Ck (Perennial Prt Div abv Ponderosa to headwaters)
Monitoring Station(s): Vallecito Ck abv Ponderosa diversion - 31RValle012.2
Applicable TSS indicator threshold: 16.12 mg/L

| Date | TSS (mg/L) | Turbidity (NTU) | Flow (cfs) |
|---|---|---|---|
| 3/23/2021 | **25** | 21.4 | 0.54 |
| 5/11/2021 | **36** | 12.3 | 0.38 |
| 6/15/2021 | **23** | 25.5 | 0.21 |
| 3/31/2022 | **65** | 44.7 | 0.43 |
| 6/16/2022 | **31** | 26.3 | 0.30 |
| 7/21/2022 | **77** | 65.3 | 0.91 |

## Temperature data

Exceedances of the applicable criteria are shown in bold red font.

| AU Name – Thermograph Location | Designated ALU | Chronic Criterion (°C) | Measured Chronic (°C) | $T_{MAX}$ Criterion (°C) | Date of Measured $T_{MAX}$ | Measured $T_{MAX}$ (°C) |
|---|---|---|---|---|---|---|
| American Creek (Rio de las Palomas to headwaters) - 31Americ006.4 | HQCWAL | 20 (4T3) | 17.51 | 23 | 8/27/2021 | 22.35 |
| American Creek (Rio de las Palomas to headwaters) - 31Americ003.4 | HQCWAL | 20 (4T3) | **21.15** | 23 | 7/18/2022 | **25.36** |
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) - 31JemezR046.6 | CWAL | 20 (6T3) | **30.02** | 25 | 5/30/2021 | **29.32** |
| La Jara Creek (East Fork Jemez to headwaters) - 31LaJara006.1 | HQCWAL | 20 (4T3) | 12.56 | 23 | 6/16/2022 | 16.82 |

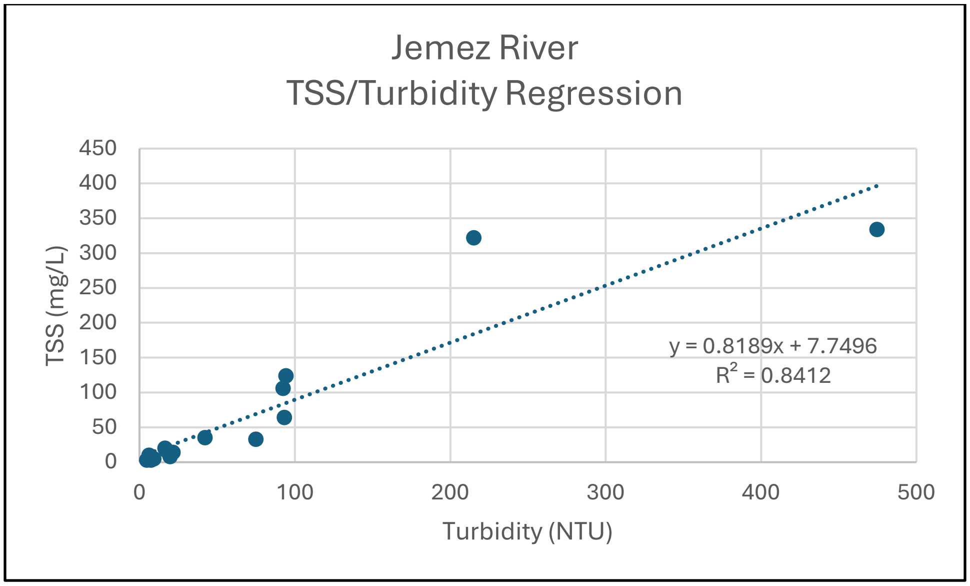
| | | | | | | |
|---|---|---|---|---|---|---|
| La Jara Creek (East Fork Jemez to headwaters) - 31LaJara002.0 | HQCWAL | 20 (4T3) | **21.29** | 23 | 7/6/2022 | **23.45** |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) - 31RCebol000.1 | HQCWAL | 20 (4T3) | 19.98 | 23 | 6/18/2021 | **23.33** |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) - 31RCebol007.0 | HQCWAL | 20 (4T3) | **22.15** | 23 | 6/17/2021 | **25.21** |

## Turbidity data

MDP is a missing data point

Jemez River (Jemez Pueblo bnd to Rio Guadalupe)
Monitoring Station(s): Jemez River below Rio Guadalupe - 31JemezR048.7
Jemez River near Canon, below municipal school - 31JemezR046.6

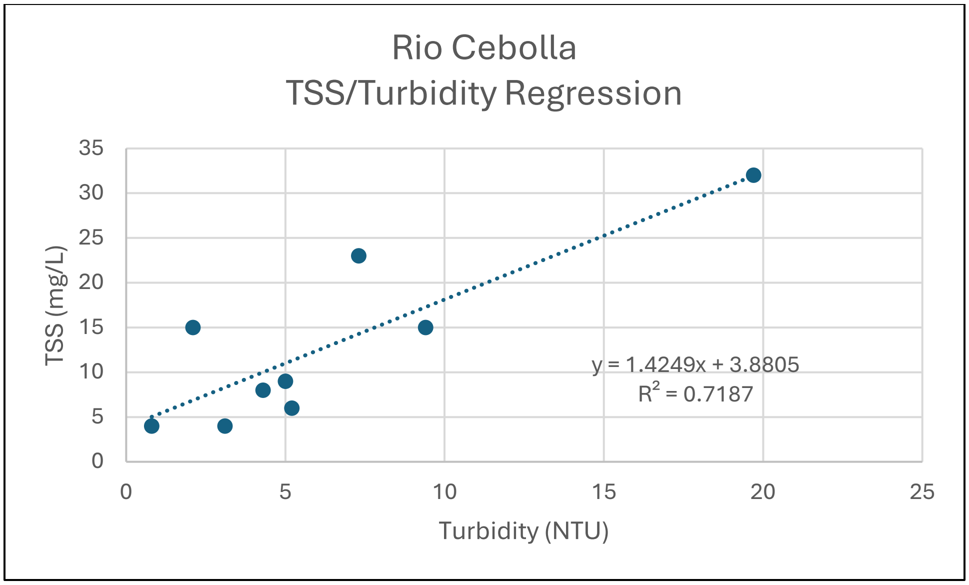
| Date | TSS (mg/L) | Turbidity (NTU) | Flow (cfs) |
|---|---|---|---|
| 3/23/2021 | 20 | 16.4 | 46.0 |
| 3/23/2021 | 14 | 21.5 | 35.6 |
| 5/11/2021 | 17 | 17.2 | 49.8 |
| 5/11/2021 | 8 | 19.6 | 39.1 |
| 6/15/2021 | 3 | 7.4 | MDP |
| 6/15/2021 | 4 | 5.5 | MDP |
| 6/15/2021 | 10 | 6.2 | 6.1 |
| 10/5/2021 | 64 | 93.3 | 16.2 |
| 10/5/2021 | 33 | 74.9 | 16.2 |
| 3/30/2022 | 106 | 92.3 | 78.5 |
| 3/30/2022 | 3 | 4.6 | MDP |
| 3/30/2022 | 124 | 94.3 | 76.1 |
| 6/16/2022 | 5 | 9.2 | 9.5 |
| 8/23/2022 | 322 | 215.1 | 48.5 |
| 9/7/2022 | 35 | 42.1 | 28.9 |
| 10/18/2022 | 334 | 474.7 | 92.9 |




Rio Cebolla (Fenton Lake to headwaters)

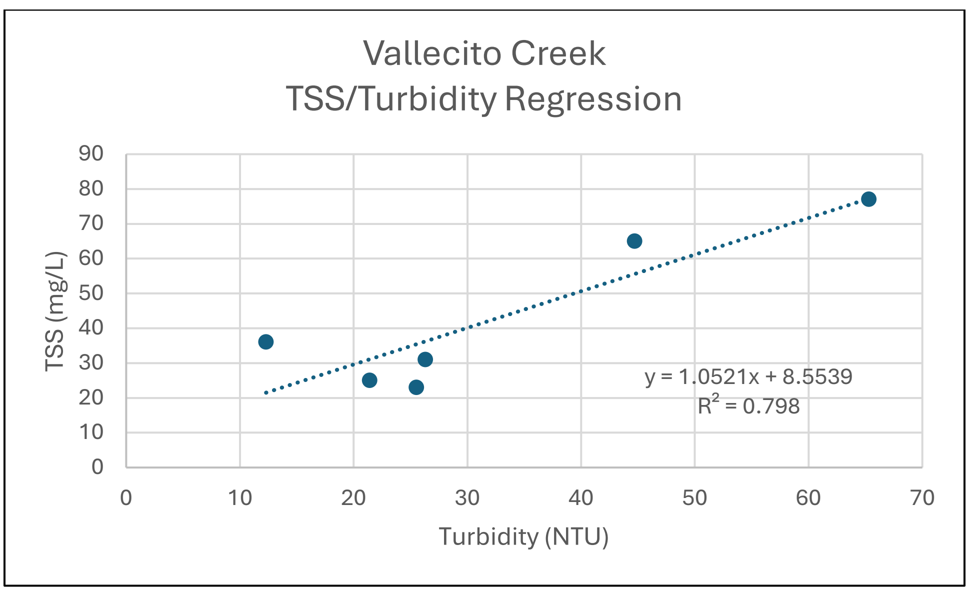
Monitoring Station(s): Rio Cebolla ~0.5 mile above Fenton Lake - 31RCebol011.4
Rio Cebolla at campground abv Seven Springs hatchery - 31RCebol017.9

| Date | TSS (mg/L) | Turbidity (NTU) | Flow (cfs) |
|---|---|---|---|
| 4/6/2021 | 15 | 9.4 | 3.88 |
| 4/14/2021 | 15 | 2.1 | 1.359 |
| 6/2/2021 | 9 | 5 | 2.61 |
| 6/16/2021 | 8 | 4.3 | 0.756 |
| 4/7/2022 | 6 | 5.2 | 3.569 |
| 5/10/2022 | 32 | 19.7 | 0.962 |
| 8/10/2022 | 4 | 0.8 | 1.626 |
| 10/18/2022 | 4 | 3.1 | 2.098 |
| 10/19/2022 | 23 | 7.3 | 3.893 |




Vallecito Ck (Perennial Prt Div abv Ponderosa to headwaters)
Monitoring Station(s): Vallecito Ck abv Ponderosa diversion - 31RValle012.2

| Date | TSS (mg/L) | Turbidity (NTU) | Flow (cfs) |
|---|---|---|---|
| 3/23/2021 | 25 | 21.4 | 0.54 |
| 5/11/2021 | 36 | 12.3 | 0.38 |
| 6/15/2021 | 23 | 25.5 | 0.21 |
| 3/31/2022 | 65 | 44.7 | 0.432 |
| 6/16/2022 | 31 | 26.3 | 0.3 |
| 7/21/2022 | 77 | 65.3 | 0.911 |



# APPENDIX C
# SOURCE DOCUMENTATION

The approach for identifying probable sources of impairment is documented in SWQB Standard Operating Procedure (SOP) 4.1, Probable Source(s) Determination (https://www.env.nm.gov/surface-water-quality/sop/ ). "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, which are supported by evidence strong enough to establish presumption but not proof. Probable Source categories are selected from Appendix A of SOP 4.1, which was adapted from the EPA ATTAINS database.

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), (D), and (E) (USEPA, 1997). The list of "Probable Sources" is not intended to single out any particular landowner or single land management activity and has therefore been labeled "Probable" and generally includes several sources for each known impairment.

Any new impairment listing will be assigned a Probable Source of "Source Unknown." During sampling events, Monitoring Team staff select applicable Probable Sources from a drop-down menu on the Stream/River Field Data Form. Information gathered by the Monitoring Team is used to generate a draft Probable Source list in consequent TMDL planning documents. The TMDL writer then revises the list using aerial imagery, Geographic Information System data, and other available records. The list is also reviewed by Watershed Protection Section staff with knowledge of the AU and watershed. 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 Probable Source list in the approved TMDL will be used to update the subsequent Integrated List.

Data on Probable Sources gathered by Monitoring and Assessment Section staff and Watershed Protection Section staff during water quality surveys and watershed restoration projects is housed in the NMED Surface Water Quality Information Database (SQUID). 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.

Literature Cited:

USEPA. 1997. Guidelines for preparation of the comprehensive state water quality assessments (305(b) reports) and electronic uptakes. EPA-841-B-97-002A. Washington, D.C.

# APPENDIX D
# 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 by 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 [**ºC**] x [**cfs]** x 1.023E+07 = TMDL (kJ/day)

Input variables in **bold**, Δ**ºC** = (WQC - 0**ºC)** and **cfs** = critical flow

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

# APPENDIX E
# SSTEMP INPUT DATA

## E 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. Each AU was modeled on the date of the maximum recorded water temperature on the thermograph record, which was used to assess impairment, shown below in **Table E.1.**

**Table E.1 Assessment units and modeled dates**

| Assessment Unit | Assessment Unit ID | $T_{MAX}$ Date (Modeled Date) |
|---|---|---|
| American Creek (Rio de las Palomas to headwaters) | NM-2106.A_44 | 7/18/2022 |
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | NM-2105_71 | 5/30/2021 |
| La Jara Creek (East Fork Jemez to headwaters) | NM-2106.A_11 | 7/6/2022 |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) | NM-2106.A_50 | 6/17/2021 |

## E 2.0 HYDROLOGY

### E 2.1 Segment Inflow and Outflow

This parameter is the mean daily flow 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.

Discharges for ungaged sites on gaged streams were estimated based on methods published by Thomas et. Al. (1997). If the drainage area of the ungaged site is between 50 and 150 percent of the drainage area of the gaged site, **Equation E.1** is used. Only one AU, Jemez River (Jemez Pueblo bnd to Rio Guadalupe), falls into this category. The Jemez River AU has one USGS gage, USGS 08324000 Jemez River near Jemez, NM, in the middle of the AU. Gaged flow was determined using the USGS Hydrologic Toolbox software.

**Equation E.1:** $Q_u = Q_g \times \left(\frac{A_u}{A_g}\right)^{0.5}$

Where:

$Q_u$ = area weighted 4Q3 at the ungaged site (cfs)

$Q_g$ = 4Q3 at gaged site (cfs)

$A_u$ = drainage area of ungaged site ($mi^2$)

$A_g$ = drainage area of gaged site ($mi^2$)

Discharges for ungaged streams were determined using Bell & Tillery's statewide regression equations (2023). The 4Q3 inflow and outflow were determined for the AUs American Creek (Rio de las Palomas to headwaters), La Jara Creek (East Fork Jemez to headwaters) and Rio Cebolla (Rio de las Vacas to Fenton Lake) using the 4Q3-1a, **Equation E.2**, statewide regression equation. For AUs who's inflow are headwaters, American Creek (Rio de las Palomas to headwaters) and La Jara Creek (East Fork Jemez to headwaters), the inflow is equal to zero.

**Equation E.2:** $4Q3 = DA^{1.08} \times E^{12.20} \times e^{-115.37}$

Where:

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

$DA$ = drainage area ($mi^2$)

$E$ = mean basin elevation (ft)

$e$ = mathematical constant, Euler's number

The 4Q3 values for inflow and outflow are presented in **Table E.2**. Parameters used in the calculations were obtained using the StreamStats online GIS application developed by the USGS (https://streamstats.usgs.gov/ss/). Inflow and outflow were determined by delineating basins at the top and bottom of the AUs, respectively.

The inflow of Rio Cebolla is at the dammed Fenton Lake. There is no outflow data available for the Fenton Lake dam, but it is an overflow dam, so an assumption was made that the outflow from the lake would be similar to a calculated 4Q3 using Bell & Tillery's regression equation.

The Jemez River AU has an active NPDES permit for the Jemez Valley Public Schools – permit number NM0028479. The wastewater treatment plant discharges near the outflow of the AU. The permitted final effluent limits are a design flow of 0.01 million gallons per day. Dividing by 0.646 to convert to cfs is 0.015cfs. This effluent limit has been incorporated into the outflow 4Q3.

**Table E.2 4Q3 Inflow & outflow**

| Assessment Unit | Inflow 4Q3 (cfs) | Outflow 4Q3 (cfs) |
|---|---|---|
| American Creek (Rio de las Palomas to headwaters) | -- | 0.126 |
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | 7.31 | 7.37 |
| La Jara Creek (East Fork Jemez to headwaters) | -- | 0.135 |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) | 0.629 | 0.696 |

### E 2.2 Inflow Temperature

This parameter represents the mean water temperature at the top of the segment on the modeled date.

For AUs whose inflows begin at a headwater, any number can be entered for inflow temperature. Zero flow is equivalent to zero heat.

The Rio Cebolla AU begins at the outflow of Fenton Lake. There is a lack of long-term thermograph data at the lake or nearby monitoring stations, so an alternative method was used to estimate inflow temperatures. An assumption was made that the ratio between air temperature and surface water temperature is the same at the top of the AU and the monitoring location used for assessment of the AU. Mean daily air temperatures were acquired from New Mexico Climate Center website (https://wrcc.dri.edu/wraws/nmF.html). The adiabatic lapse rate was used to correct for elevational differences at both the monitoring station and the inflow location. This same process was also performed for the Jemez River AU to obtain inflow temperature due to lack of thermograph data. Mean daily air temperature for the AU and the adiabatic lapse rate equation are presented later in section **E 4.1**.

**Table E.3 Mean daily inflow temperature**

| Assessment Unit | Inflow Temp (°C) | Inflow Temp (°F) |
|---|---|---|
| American Creek (Rio de las Palomas to headwaters) | -- | -- |
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | 19.5 | 67.1 |
| La Jara Creek (East Fork Jemez to headwaters) | -- | -- |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) | 19.3 | 66.7 |

### E 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 were acquired from the New Mexico Climate Center website (https://wrcc.dri.edu/wraws/nmF.html). The adiabatic lapse rate (**Equation E.4** – presented in section **E 4.1)** was used to correct for elevational differences between the AUs and weather stations. Weather stations were chosen by relative elevation and geographic area of the AUs.

**Table E.4 Mean annual air temperature as estimates for accretion temperature**

| Assessment Unit | Mean Annual Air Temp (°C) | Mean Annual Air Temp (°F) |
|---|---|---|
| American Creek (Rio de las Palomas to headwaters) | 6.8 | 44.3 |
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | 14.4 | 57.9 |
| La Jara Creek (East Fork Jemez to headwaters) | 5.7 | 42.2 |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) | 9.3 | 48.7 |

## E 3.0 GEOMETRY

### E 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. Latitudes are presented in **Table E.5**.

### E 3.2 Dam at Head of Segment

The AU Rio Cebolla (Rio de las Vacas to Fenton Lake) has a dam at the inflow, coming from Fenton Lake.

### E 3.3 Segment Length

Segment length was obtained from the SWQB Surface Water Quality Database. Segment lengths are presented in **Table E.5**.

### E 3.4 Upstream and Downstream Elevation

Elevations were obtained from Google Earth. Elevations are presented in **Table E.5**.

**Table E.5 Geometric parameters**

| Assessment Unit | Latitude | Segment Length (mi) | Upstream Elevation (ft) | Downstream Elevation (ft) |
|---|---|---|---|---|
| American Creek (Rio de las Palomas to headwaters) | 36.023 | 4.99 | 9533 | 8142 |
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | 35.660 | 1.98 | 5658 | 5610 |
| La Jara Creek (East Fork Jemez to headwaters) | 35.867 | 5.4 | 10487 | 8493 |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) | 35.851 | 15.68 | 7675 | 7209 |

### E 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 (https://www.env.nm.gov/surface-water-quality/sop/). 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:

**Equation E.3:** $W = A \times Q^B$

Where:

$W$ = Known width (feet)

$A$ = Width's A Term (seconds per square foot)

$Q$ = Known discharge (cfs)

$B$ = Width's B Term (unitless)

It should be noted that the physical habitat monitoring of the AUs La Jara Creek (East Fork Jemez to headwaters) and Rio Cebolla (Rio de las Vacas to Fenton Lake) were conducted as part of a probabilistic water quality survey. As such, the exact monitoring locations were chosen at random, rather than having been selected as representative of the AU and therefore may not meet all the SOP requirements for site selection. There were three probabilistic monitoring sites in La Jara Creek (East Fork Jemez to headwaters) and three sites at Rio Cebolla (Rio de las Vacas to Fenton Lake). **Table E.6** summarizes width A & B terms for the temperature impaired assessment units. The following **Figures E.1 – E.4** presents the calculations for the width A term.

**Table E.6 Width A & B terms**

| Assessment Unit | Width A Term | Width B Term |
|---|---|---|
| American Creek (Rio de las Palomas to headwaters) | 1.295 | 0.659 |
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | 9.386 | 0.110 |
| La Jara Creek (East Fork Jemez to headwaters) | 3.372 | 0.402 |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) | 5.109 | 0.112 |

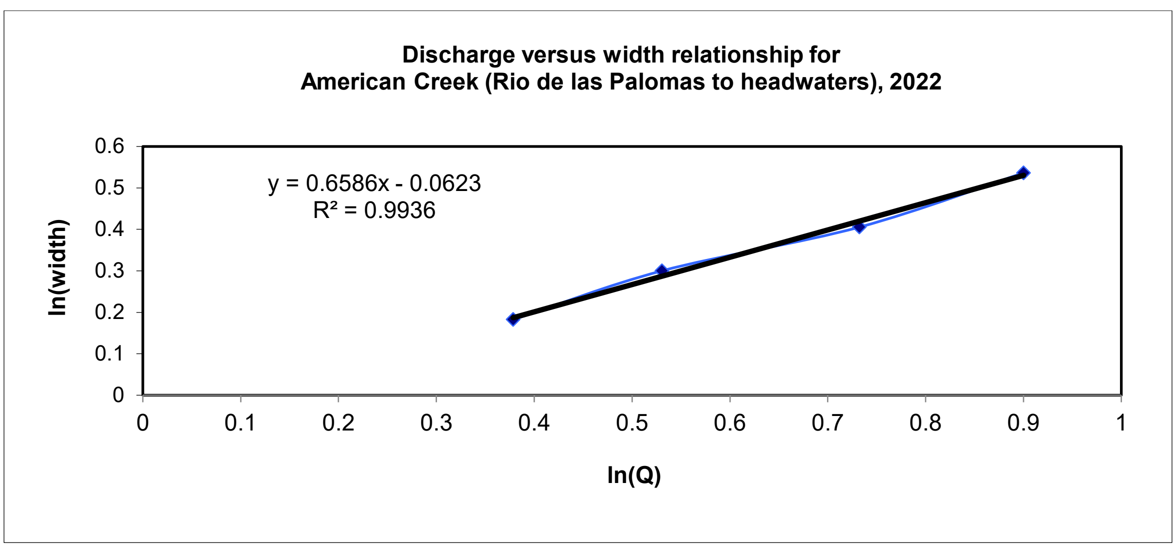



**Figure E.1 Discharge vs. Width Relationship**
**American Creek (Rio de las Palomas to headwaters)**

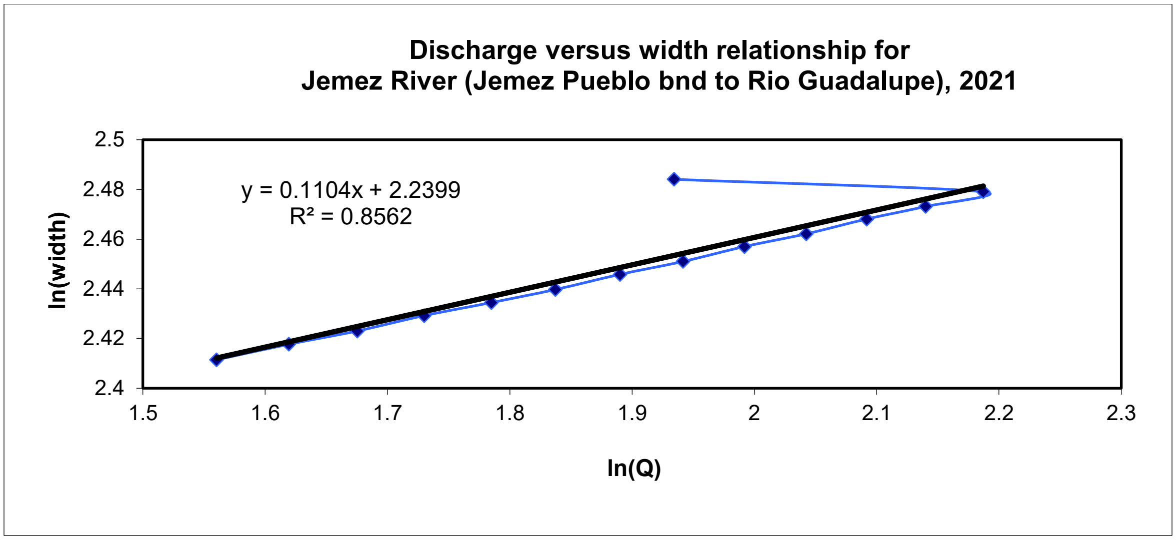



**Figure E.2 Discharge vs. Width Relationship**
**Jemez River (Jemez Pueblo bnd to Rio Guadalupe)**

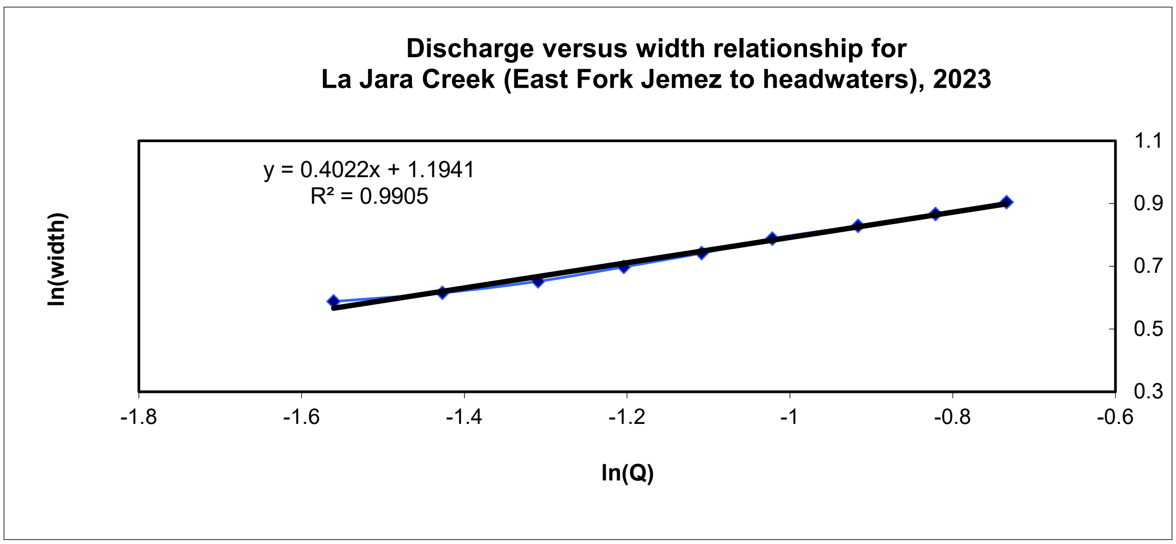



**Figure E.3 Discharge vs. Width Relationship**
**La Jara Creek (East Fork Jemez to headwaters)**

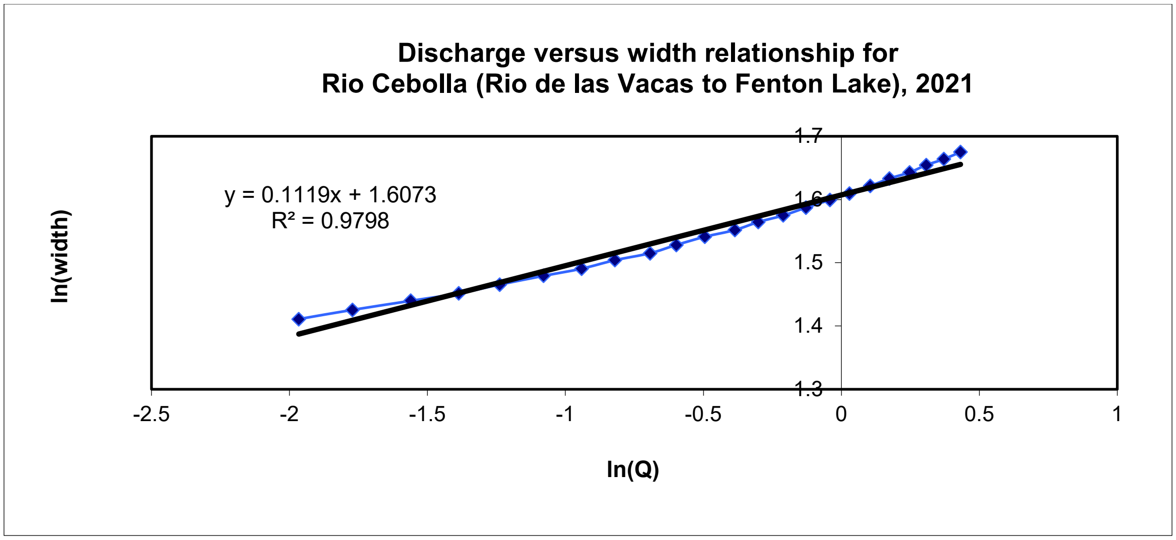



**Figure E.4 Discharge vs. Width Relationship**
**Rio Cebolla (Rio de las Vacas to Fenton Lake)**

### E 3.6 Manning's n or Travel Time

Site and stage-specific geometry were modeled by the WinXSPro program described above. WinXSPro uses Thorne and Zevenbergen's equation as the default Manning's n estimator. 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 flow being modelled was selected.

In the case of the Jemez River and Rio Cebolla AUs, the modeled flow using Thorne and Zevenbergen's equation was not consistent with data observed in the field. The option of "User Supplied Manning's n" was used instead. This requires the user to input at least two values for the program to interpolate. Manning's n is calculated and recorded in habitat monitoring surveys. The value from the habitat survey reports of these AUs was input, which provided a more accurate representation of recorded flow values.

**Table E.7 Manning's n values**

| Assessment Unit | Manning's n |
|---|---|
| American Creek (Rio de las Palomas to headwaters) | 0.026 |
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | 0.064 |
| La Jara Creek (East Fork Jemez to headwaters) | 0.035 |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) | 0.146 |

## E 4.0 METEOROLOGICAL PARAMETERS

### E 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 Western Regional Climate Center Remote Automatic Weather Station (RAWS) website (https://raws.dri.edu/nmF.html). Air temperature for the American Creek and La Jara Creek AUs was the temperature at the RAWS at Coyote New Mexico. Air temperature for the Jemez River AU was the RAWS station Tower New Mexico. Air temperature for the Rio Cebolla AU was the RAWS station Santa Fe Watershed New Mexico. The adiabatic lapse rate, **Equation E.4**, was used to correct for elevational differences between the AUs and weather stations. Adjusted mean daily air temperatures for temperature impaired AUs are presented in **Table E.6**. Weather stations were chosen by relative elevation and geographic area of the AUs.

**Equation E.4:** $T_a = T_o + C_t \times (Z - Z_o)$

Where:

$T_a$ = air temperature at elevation E (°C)

$T_o$ = air temperature at elevation $E_o$ (°C)

$C_t$ = moist-air adiabatic lapse rate (-0.00656 °C/m)

$Z$ = mean elevation of segment (m)

$Z_o$ = elevation of weather station (m)

**Table E.8 Adjusted mean daily air temperature**

| Assessment Unit | Mean Elevation of AU (m) | Elevation of Weather Station (m) | Weather Station Mean Daily Air Temp (°C) | AU Adjusted Mean Daily Air Temp (°C) | AU Adjusted Mean Daily Air Temp (°F) |
|---|---|---|---|---|---|
| American Creek (Rio de las Palomas to headwaters) | 2694 | 2682 | 21.9 | 21.8 | 71.3 |
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | 1717 | 1981 | 19.0 | 20.7 | 69.3 |
| La Jara Creek (East Fork Jemez to headwaters) | 2895 | 2682 | 22.0 | 20.6 | 69.1 |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) | 2255 | 2339 | 23.2 | 23.8 | 74.8 |

### E 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 the same weather stations used for mean daily air temperature, above.

### E 4.3 Relative Humidity

Mean relative humidity on the modelled date was obtained from the same weather stations used for mean and maximum daily air temperature, above. Data was corrected for elevation and temperature using **Equation E.5**:

**Equation E.5:** $$R_h = R_o \times \left(1.064^{(T_o - T_a)}\right) \times \left(\frac{T_a + 273.16}{T_o + 273.16}\right)$$

Where:

$T_a$ = air temperature at elevation E (°C)

$T_o$ = air temperature at elevation $E_o$ (°C)

$C_t$ = moist-air adiabatic lapse rate (-0.00656 °C/m)

$Z$ = mean elevation of segment (m)

$Z_o$ = elevation of weather station (m)

### E 4.4 Wind Speed

Mean wind speed on the modelled date was obtained from the same weather stations used for mean and maximum daily air temperature, above. Since wind can be variable, and the conditions of the weather stations are not equivalent to the AUs, and wind speed likely being lower at the water's surface compared to an exposed weather station, this parameter was adjusted for model calibration.

### E 4.5 Ground Temperature

Same as Accretion Temperature, above.

### E 4.6 Thermal Gradient

The software default value is 1.65 joules/meter$^2$/second/°C.

### E 4.7 Possible Sun

This variable is an indirect and inverse measure of cloud cover. Percent possible sun was obtained from the Western Regional Climate Center (https://wrcc.dri.edu/cgi-bin/clilcd.pl?nm23050). The nearest location with monthly possible sun data is Albuquerque. Bartholow (2002) recommends using possible sun as a calibration parameter. Maximum air temperature, relative humidity, wind speed, ground temperature and possible sun are presented in **Table E.7:**

**Table E.9 Meteorological Parameters**

| Assessment Unit | Maximum Air Temperature (°F) | Relative Humidity (%) | Wind Speed (mph) | Ground Temperature (°F) | Possible Sun (%) |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| American Creek (Rio de las Palomas to headwaters) | 84.9 | 38 | 4.0 | 44.3 | 76 |
| Jemez River (Jemez Pueblo bnd to Rio Guadalupe) | 82.6 | 52 | 9.5 | 57.9 | 83 |
| La Jara Creek (East Fork Jemez to headwaters) | 90.0 | 34 | 3.9 | 42.2 | 76 |
| Rio Cebolla (Rio de las Vacas to Fenton Lake) | 86.0 | 27 | 4.9 | 48.7 | 83 |

### E 4.8 Dust Coefficient

The software default value of 5 was used.

### E 4.9 Ground Reflectivity

The software default value of 25% was used.

### E 4.10 Solar Radiation

SSTEMP calculates solar radiation internally when a dust coefficient is entered. Weather station values may not represent the on-site solar radiation since the stations are remote from the AU.

### E 5.0 SHADE

Shade % data is collected during habitat surveys using a densiometer. These values have been confirmed or adjusted by viewing google earth and ArcGIS maps.

# APPENDIX F
# QWET INPUT DATA

## F 1.0 INTRODUCTION

This appendix provides lake specific physical, flow and nutrient loading, and meteorological data for input into the QWET model. Physical input data includes lake surface area, coordinates of the lake center, bathymetric data if available, and maximum lake depth. QWET requires either continuous flow and nutrient loading data or estimated constant loading values. Nutrient loading parameters needed are organic phosphorus, phosphate, organic nitrogen, nitrate, and ammonia. Meteorological inputs for the QWET model are formatted at a daily timestep and include air pressure, cloud cover fraction, dew point, temperature, and wind speed. Observation data can also be used for calibration purposes. In the following sections, data sources for these parameters are discussed for each lake to be modeled using QWET.

## F 2.0 Physical Input Data

### F 2.1 Surface Area

The surface area of the lakes was obtained from the USGS NHD+ GIS geodatabase. Within the geodatabase, the polygons of the lakes have their surface area stated in the attribute table. The surface area is in acres in the geodatabase and must be converted to meters squared for the QWET model.

### F 2.2 Bathymetric Data

If there is bathymetric data available, then that is the preferred method for the QWET physical configuration. However, it is very unlikely that lakes and reservoirs in New Mexico will have bathymetric data. There was no bathymetric data available for the lakes included in this TMDL, so a different method using only the lake's max depth was used.

### F 2.3 Coordinates

The longitude and latitude of the center of the lake are required. To obtain these values, polygons of the lakes from the USGS NHD+ GIS geodatabase were projected to the WQS84 geographic projection. Then, the coordinates at the polygon's centroid were calculated within the layer's attribute table. QWET requires the polygons to be projected into WQS84 before determining the coordinates.

### F 2.4 Maximum Depth

The maximum depth of lakes in this document was calculated from lake depth profiles collected during water quality surveys conducted by the NMED SWQB monitoring team. All recorded maximum depths taken during relevant monitoring surveys were averaged for one lake depth value per lake. This depth value is used as the maximum depth in QWET. The value must be converted from feet to meters.

## F 3.0 Flow and Nutrient Loading Data

## F 3.1 Flow Data

Continuous flow data is preferred for the QWET model, however if that method is chosen there must also be continuous nutrient loading data. Most lakes in New Mexico do not have continuous nutrient loading data, so a constant flow rate method was established. The constant flow rate for a lake is the average daily water inflow in cubic feet per second.

San Gregorio and Fenton do not have Office of the State Engineer or USGS stream gages at their lake inlets. The NMED SWQB monitoring team has collected some flow data at the lake inlets during water quality surveys, but not enough data to create a constant flow value. A commonly used method for determining flow of ungaged streams/watersheds is the drainage area ratio method, which uses the flow of a gaged watershed along with watershed area to estimate flow in another watershed whose area is within 50% to 150% of the area. The nearest gaged watershed is on the Jemez River. Both San Gregorio and Fenton lakes do not meet the criteria for the drainage area ratio method, having too small of watershed areas (3.35 and 47.3 square miles respectively, compared to 472 square miles for the gaged Jemez River watershed. These watersheds were delineated using the USGS StreamStats tool https://streamstats.usgs.gov/ss/).

The USGS StreamStats tool provides an estimated 4Q3, which is used in calculating TMDLs. An alternative method using the ratio of the 4Q3 and mean flow of the Jemez River gage was used to estimate a constant flow rate for the ungaged lake watersheds.

$$Q_u = 4Q3_u \, (Q_g / 4Q3_g)$$

$Q_u$ = Flow at ungaged watershed

$4Q3_u$ = 4Q3 at ungaged watershed

$Q_g$ = Flow at gaged watershed

$4Q3_g$ = 4Q3 at gaged watershed

The 4Q3 flow for the Jemez River is 7.35cfs, and the mean flow is 49cfs, resulting in a ratio of 6.67. Using this ratio to determine an estimated mean flow for San Gregorio Lake inflow, whose 4Q3 is 0.15cfs, results in a mean flow of 1.0cfs. Using this ratio to estimate the mean flow for Fenton Lake, whose 4Q3 is 2.35 cfs, results in a mean flow of 7.35cfs.

## F 3.2 Nutrient Loading Data

There is limited nutrient loading data for most lakes in New Mexico, and for the lakes included in this TMDL there are only a handful of samples collected by the NMED SWQB monitoring team. For this reason, a constant value approach was taken. The Water Quality Portal (WQP) was used to create average loading values for organic phosphorus, phosphate, organic nitrogen, nitrate, and ammonia. The WQP collates publicly available water-quality data from the USGS, EPA and over 400 state, federal, tribal, and local agencies.

Water quality data can be downloaded from the WQP based on a radius from a given point. For this project, a radius of 20 miles around San Gregorio Lake and Fenton Lake was used. This radius was used because it coincides with the Level III EPA Ecoregion(s) that are encompassed by the lake watersheds. The water quality data within the 20-mile radius was used to create the average nutrient loading values for the lakes. The water quality data ranges from the year 2000 to the present day.

### F 4.0 Meteorological Data

QWET requires meteorological data at a daily time step. The model creator can use pre-defined meteorological time series data from the European Center for Medium-Range Weather Forecasts (ECMWF) as a minimum requirement or meteorological time series data can be created from more detailed sources for more accurate modeling. The later method was chosen for the models used in this TMDL, using data from NOAA ASOS (automated surface observing systems) and AWOS weather stations.

### F 4.1 Air Pressure

Air pressure (hPa) is required for the QWET model. For San Gregorio and Fenton lakes an average monthly value was used. The average monthly value was calculated from the Santa Fe Airport Western Regional Climate Center weather station. An average monthly value was used because of significant data gaps from the weather station. No other nearby weather stations have reliable air pressure data for the time period needed.

### F 4.2 Cloud Cover Fraction

Cloud cover fraction (0-1) is required for the QWET model. For San Gregorio and Fenton lakes an average monthly value was used. The period of record for this weather station is 1961 to 1990. Percent possible sun was obtained from the Western Regional Climate Center (https://wrcc.dri.edu/cgi-bin/clilcd.pl?nm23050). The nearest location with monthly possible sun data is Albuquerque.

### F 4.3 Temperature, Dew Point & Wind

Temperature (°C), dew point (°C) and wind speed (meter/second) is required for the QWET model. Daily values for all three of these variables are included in the AWOS and ASOS Albuquerque airport weather station. The Albuquerque station was chosen due to being the only nearby weather station with continuous daily data currently available.

### F 5.0 Observation Data

Model calibration was conducted for each QWET model using water quality data collected by the NMED SWQB monitoring team. Lake sampling procedures are described in depth in SOP 12.1 (Lake Sampling). NMED SWQB SOPs can be found at https://www.env.nm.gov/surface-water-quality/sop/. Measured data used to calibrate the QWET models are temperature, total nitrogen, and total phosphorus. The observation data was collected during the 2011-2013 and 2021-2023 water quality surveys in the lake watersheds. The tables below contain detailed information on the observation data used to calibrate the QWET models.

## D 6.0 Calibration

QWET can be calibrated using the Parallel Sensitivity Analysis and Calibration (ParSAC) tool written in the python programming language. A few parameters were calibrated using this tool, along with manual calibration due to the hardware demands of ParSAC. QWET does not specify the amount of data points needed for a successful calibration, however there is strong evidence that three or more years of continuous or regular data samples are needed to conduct a thorough calibration of a hydrologic model (Shen et al., 2022; Moriasi et al., 2015). The number of available calibration data points is significantly below the standard recommendation of three or more years; six points for San Gregorio, and eight points for Fenton. One data point for San Gregorio Lake was excluded in the calibration data, due to being a significant outlier (2013-10-08; TP=0.312). With so few data points, one point being a factor of 10 greater than the others caused extreme error in the fit of predicted data. The lack of data complicated the calibration process and adds significant levels of uncertainty to the model output. However, only general trends of the model output are being analyzed, not specific model output values.

The performance measure used to evaluate these calibrations was Pearson's coefficient of determination ($R^2$). $R^2$ values can range from 0 to 1, with values closer to 1 generally indicating a better preforming model and $R^2$ values above 0.60 considered satisfactory for most hydrologic models (Moriasi *et al*. 2015). Performance measures can be skewed by lack of data, so in addition to $R^2$ these models are also evaluated by visually comparing the model output and the calibration data points. In the case of Fenton Lake, $R^2$=0.6 (n=7), and for San Gregorio $R^2$=0.5 (n=5). With the severe lack of data, and exploring various scenarios, this was the best fit scenario for both lakes.

**Table F.1 Model input data used for QWET nutrient modeling**

| Variable | Fenton Lake | San Gregorio Lake |
|---|---|---|
| **Physical Variables** | | |
| Surface Area ($m^2$) | 119499.92 | 145390.27 |
| Latitude (deg) | 35.883 | 36.040 |
| Longitude (deg) | -106.726 | -106.849 |
| Max Depth (m) | 3.9 | 4.5 |
| **Flow and Nutrient Loading Values** | | |
| Flow ($m^3$/s) | 0.444 | 0.028 |
| Organic Phosphorus (mg/L) | 0.030 | 0.035 |
| Phosphate (mg/L) | 0.300 | 0.109 |
| Organic Nitrogen (mg/L) | 0.352 | 0.386 |
| Nitrate (mg/L) | 0.355 | 0.365 |
| Ammonia (mg/L) | 0.909 | 0.100 |

**Table F.2 Calibration Data used for QWET nutrient models**

| San Gregorio Lake Nutrient Calibration Data | | |
|---|---|---|
| **Date** | **Total Nitrogen (mg/L)** | **Total Phosphorus (mg/L** |
| 2011-08-03 | 0.37 | 0.035 |
| 2011-11-03 | 0.3 | 0.035 |
| 2013-05-23 | 0.3 | 0.03 |
| 2013-07-31 | 0.3 | 0.03 |
| 2014-08-08 | 0.9 | 0.052 |
| 2014-09-22 | 0.95 | 0.036 |
| **Fenton Lake Nutrient Calibration Data** | | |
| **Date** | **Total Nitrogen (mg/L)** | **Total Phosphorus (mg/L** |
| 2013-05-22 | 0.3 | 0.027 |
| 2013-07-09 | 0.3 | 0.068 |
| 2013-08-08 | 1.6 | 0.07 |
| 2013-10-09 | 0.3 | 0.026 |
| 2014-06-10 | 0.76 | 0.043 |
| 2014-08-08 | 0.38 | 0.066 |
| 2021-06-03 | 0.65 | 0.014 |
| 2022-04-07 | 0.28 | 0.027 |

# APPENDIX G
# RESPONSE TO COMMENTS