6.0 ALUMINUM

During the 1999 SWQB intensive water quality survey in the Red River basin, there were several exceedences of the New Mexico water quality standards for dissolved aluminum documented in Bitter Creek, Placer Creek, and Red River. Consequently, these three waterbodies were listed on the 2004-2006 Integrated CWA §303(d)/§305(b) list for aluminum.

6.1 Target Loading Capacity

Target values for these aluminum TMDLs will be determined based on 1) the presence of numeric criteria, 2) the degree of experience in applying the indicator, and 3) the ability to easily monitor and produce quantifiable and reproducible results. For this TMDL document, target values for dissolved aluminum are based on numeric criteria. This TMDL is also consistent with New Mexico's antidegradation policy.

According to the current New Mexico water quality standards (20.6.4.900.M NMAC), the dissolved aluminum chronic criterion is 0.087 mg/L and the dissolved aluminum acute criterion is 0.75 mg/L for aquatic life uses. According to the SWQB assessment protocol, impairment is determined by comparing the arithmetic mean of the measured concentrations of consecutive-day samples to the chronic criterion of 0.087 mg/L. The measured concentrations are also compared to the acute criterion of 0.75 mg/L; and more than one exceedence is considered not supporting. The acute criterion was exceeded 9 times in the lower Red River assessment unit (i.e. Red River [Rio Grande to Placer Creek]), 3 times in Bitter Creek, and 4 times in Placer Creek during the 1999 survey (see Appendix B). All of these acute criterion exceedences occurred in May 1999 during spring runoff. Average dissolved aluminum concentrations for the SWQB Red River stations are presented in Figure 6.1. Concurrently collected TSS and turbidity data reported in the tables in Appendix B will be discussed in the Linkage(s) section below.

The SWQB and other states are currently reviewing the appropriateness of the chronic aluminum criterion of 0.087 mg/L and SWQB is considering proposing changes to this criterion for the Red River Watershed. This area has very high naturally occurring levels of aluminum and exceedences of the chronic criterion were measured during spring runoff in the upstream background site (SWQB Site 3). Because this review is ongoing SWQB has decided to postpone the preparation of chronic aluminum TMDLs for the Red River Watershed until a new chronic standard is developed. This document therefore contains acute aluminum TMDLs for Red River (Rio Grande to Placer Creek), Bitter Creek (Red River to headwaters), and Placer Creek (Red River to headwaters). When a new standard is in place then the Red River data will reassessed and any necessary chronic aluminum TMDLs will be prepared. SWQB recognizes that acute aluminum TMDLs are not protective of the water quality of the Red River against chronic effects of aluminum and every effort will be made to develop new chronic aluminum standards and resulting TMDLs in a timely manner.

One of the studies conducted by the USGS, *Low-Flow (2001) and Snowmelt (2002) Synoptic/Tracer Water Chemistry for the Red River, New Mexico* (McCleskey *et al* 2003), reported water analyses for 259 samples collected from the Red River and tributaries during periods of both low-flow and snowmelt. Aluminum results from this study are included in

Appendix B. The goal of the 2002 snowmelt synoptic study "was to obtain information about metal and acid loading to the Red River from snowmelt draining altered areas on the north side of the basin and from the mine area" (McCleskey *et al* 2003). However it is important to remember that snowpack and snowmelt in 2002 was well below average and the 1999 snowmelt sampled by SWQB. The total and dissolved aluminum concentrations from stream samples collected during the 2002 snowmelt tracer study are presented in Figure 6.2. USGS also collected water samples from surface inflows (tributaries, springs, and seeps) the aluminum concentrations from these samples are presented in Figure 6.3. Figures 6.2 shows the total aluminum concentrations in the Red River are higher than the dissolved aluminum concentrations. The dissolved aluminum concentrations increase slightly from the top of the study, which is just above the Town of Red River (i.e., RR-0), downstream to below the mine site. All of the dissolved aluminum 2002 snowmelt samples were below the acute aluminum criteria, but the majority of the concentrations were above the chronic aluminum criteria (Appendix B). The increase in the total aluminum concentrations from upstream to downstream is much greater than the increase observed in the dissolved aluminum concentrations, especially within and below the Molycorp Mine (i.e. >10,000 meters downstream from RR-0).

High chronic levels of dissolved aluminum can be toxic to fish, benthic invertebrates, and some single-celled plants. Aluminum concentrations from 0.1 to 0.3 mg/L increase mortality, retard growth, gonadal development, and egg production of fish (http://www.bae.ncsu.edu/programs/extension/wqg/). High acute levels of dissolved aluminum can be especially detrimental to aquatic life increasing mortality rates for many species of fish and benthic macroinvertebrates.

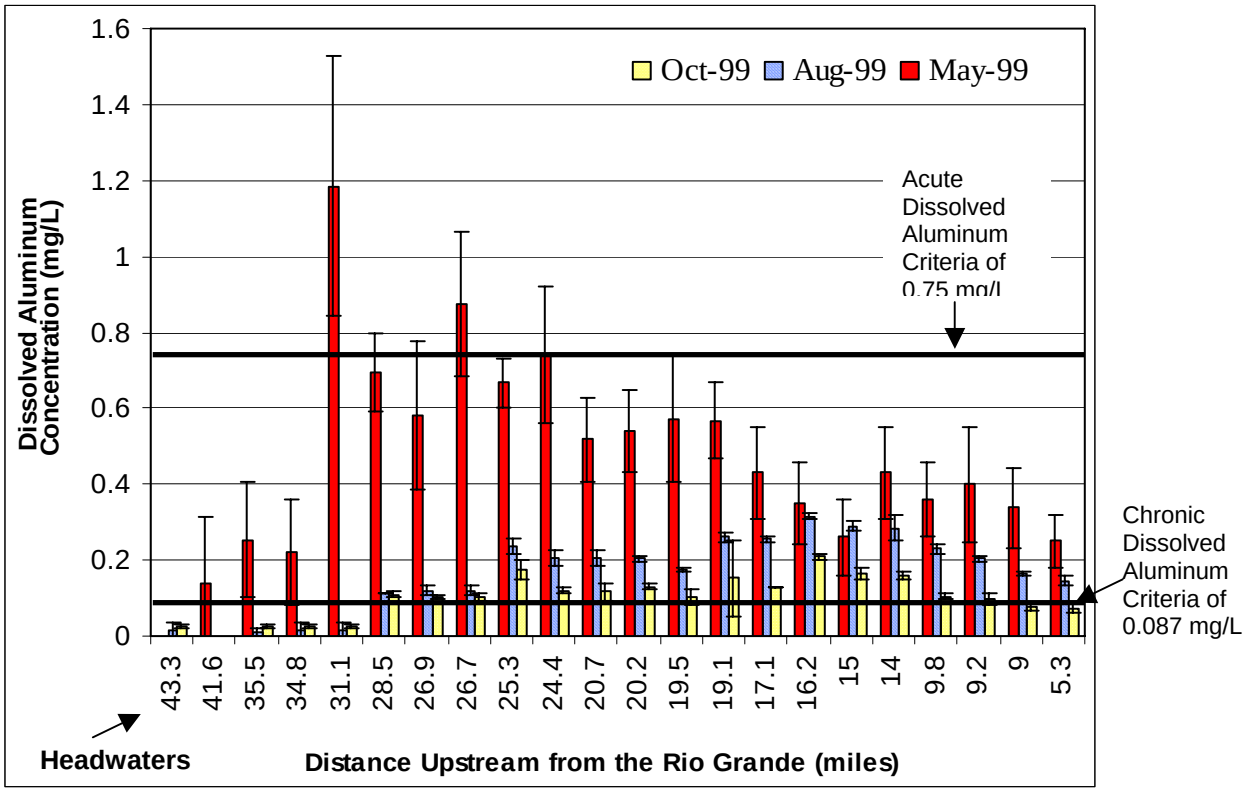

Figure 6.1 SWQB 1999 Average Dissolved Aluminum Concentrations from the Headwaters to the Confluence with the Rio Grande

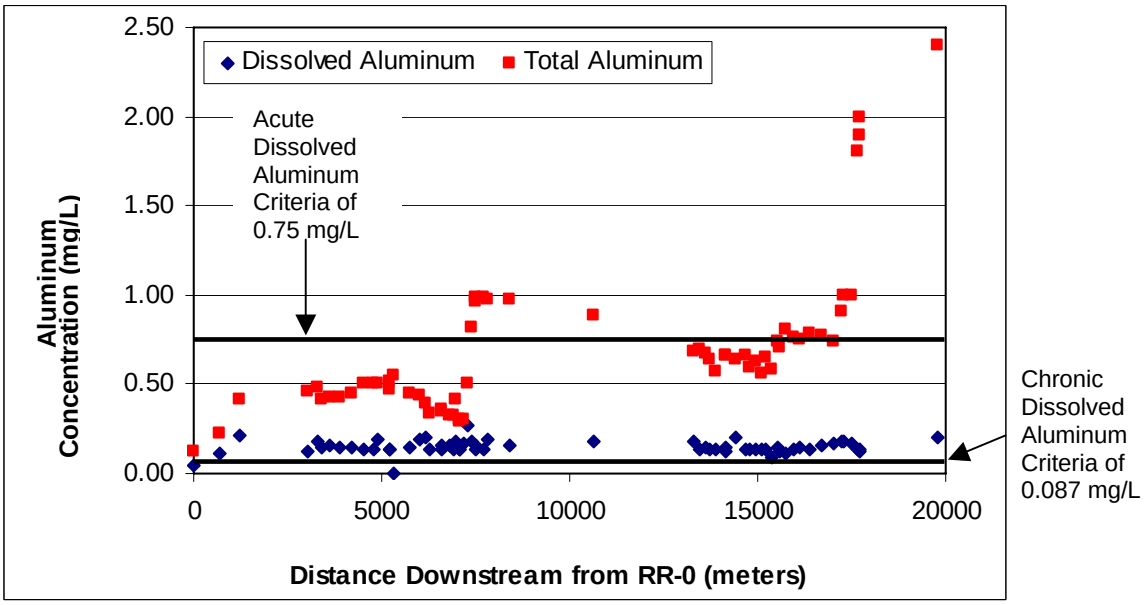

Figure 6.2 USGS 2002 In-stream Snowmelt Tracer Study Aluminum Concentrations

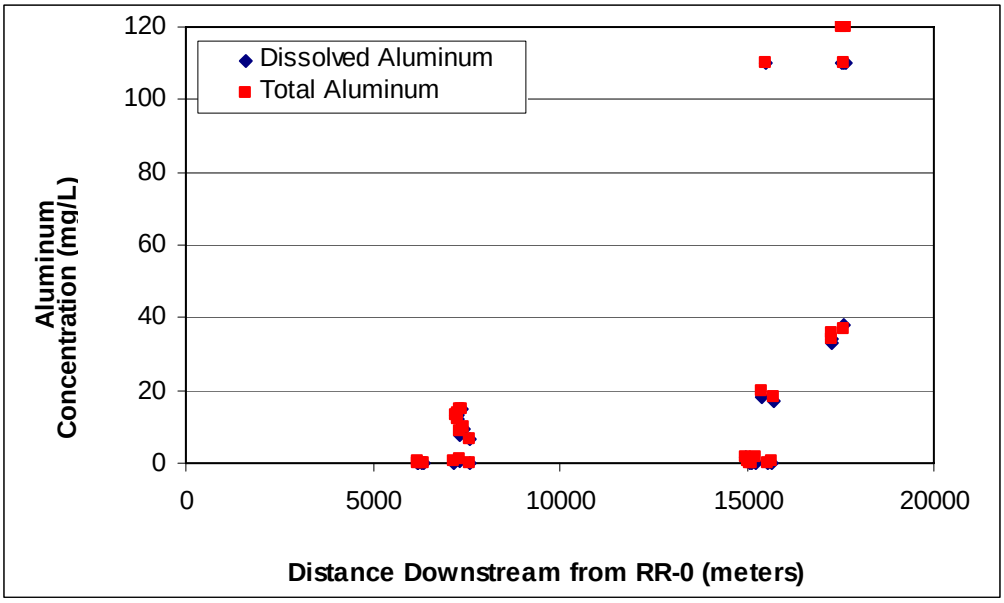

Figure 6.3 USGS 2002 Bank (i.e. Tributaries, Seeps, and Springs) Snowmelt Tracer Study Aluminum Concentrations

6.2 Flow

TMDLs are calculated for the Red River Watershed at a specific flow. Metal concentrations in a stream vary as a function of flow. As flow increases the concentration of metals can increase. When available, USGS gages are used to estimate flow. Where gages are absent, geomorphologic cross section field data are collected at each site and flows are modeled or actual flow measurements are taken. There are two active USGS gages on the Red River, both

of which are located in the lower Red River assessment unit. Since all of the exceedences of the acute aluminum criterion were measured during spring runoff, the average flow for May 1999 at the furthest downstream USGS gage (i.e. 08266820, Red River below Fish Hatchery, near Questa, NM) will be used. Therefore, the flow value for the Red River (Rio Grande to Placer Creek) used in this TMDL is 192 cubic feet per second (cfs).

This flow value for the Red River was converted from cfs to units of mgd as follows:

$$192\frac{ft^3}{\sec}\times 7.48\frac{gal}{ft^3}\times 86{,}400\frac{\sec}{day}\times 10^{-6}=124mgd$$

There are no USGS gage stations for either Bitter Creek or Placer Creek and flow was not recorded during the 1999 sampling events, therefore flow had to be estimated for May from the Red River Watershed flow model developed by Daniel B. Stephens & Associates, Inc. (Appendix C). The estimated May 1999 flow values for Bitter Creek and Placer Creek based on this model are 6.7 and 1.6 mgd, respectively.

It is important to remember that the TMDL is a planning tool to be used to achieve water quality standards. Since flows vary throughout the year in all natural surface water systems, the target load will vary based on the changing flow. Management of the load to improve stream water quality should be a goal to be attained.

6.3 Calculations

A target load for dissolved aluminum is calculated based on a flow, the current water quality criterion, and a conversion factor (8.34) that is a used to convert mg/L units to lbs/day (see Appendix D for Conversion Factor Derivation). The target loading capacity is calculated using **Equation 1**. The results are shown in Table 6.1.

Critical Flow (mgd) x Standard (mg/L) x 8.34 = Target Loading Capacity (Eq. 1)

Table 6.1 Calculation of target loads for dissolved aluminum

Location	**Flow (mgd)**	**Dissolved Aluminum (mg/L)**	**Conversion Factor**	**Target Load Capacity (lbs/day)**
Red River (Rio Grande to Placer Creek)	124	0.750	8.34	776*
Bitter Creek (Red River to Headwaters)	6.70+	0.750	8.34	41.9*
Placer Creek (Red River to Headwaters)	1.60+	0.750	8.34	10.0*

NOTES: + Since USGS gages were unavailable and direct measurements were not obtained, flow was estimated using a model (see Appendix C).
* Values rounded to three significant figures.

The measured loads for dissolved aluminum were similarly calculated. The arithmetic mean of the data used to determine the impairment (see Appendix B) was substituted for the standard in **Equation 1**. The same conversion factor of 8.34 was used. Results are presented in Table 6.2.

Table 6.2 Calculation of Measured Loads for Dissolved Aluminum

Location	Flow (mgd)	Dissolved Aluminum Arithmetic Mean+ (mg/L)	Conversion Factor	Measured Load (lbs/day)
Red River (Rio Grande to Placer Creek)	124	1.13	8.34	1,170*
Bitter Creek (Red River to Headwaters)	6.70	1.27	8.34	71.0*
Placer Creek (Red River to Headwaters)	1.60	1.08	8.34	14.4*

Notes: + Arithmetic mean of May 1999 dissolved aluminum concentrations (see Appendix B).
* Values rounded to three significant figures.

6.4 Waste Load Allocations and Load Allocations

6.4.1 Waste Load Allocation

There are no point source contributions associated with the TMDLs for Bitter Creek and Placer Creek, therefore the WLA for both of these streams is zero. There are three point sources on the Red River (Rio Grande to Placer Creek). From upstream to downstream they are the wastewater treatment plant (WWTP) for the Town of Red River, the Molycorp Mine, and the Red River Fish Hatchery. The outfall locations for these sources are shown on Figure 2.1. The Town of Questa operates WWTP lagoons along the Red River, but this facility does not have a discharge permit and does not discharge into the Red River, therefore no WLA will be assigned to the Questa WWTP. The Red River WWTP and the fish hatchery have one outfall each. The Molycorp Mine has four permitted outfalls (#1, #2, #4, and #5); however, only outfall #2 has continuous discharge (from the tailings interceptor system). The other three outfalls are intermittent, containing process water and storm water. Monitoring records indicate that Molycorp has not discharged from outfall #1 since 1990 and has never discharged water from outfalls #4 and #5.

As an additional BMP in the Molycorp Questa Mine's NPDES permit, Molycorp was required to "install seepage interception systems to prevent discharges of process-related groundwater to the Red River at Spring 13 and Spring 39. The permittee shall also install a ground water withdrawal well below the toe of the Sugar Shack South deposit at a location approximately 100 yards south west of the old mill site." (USEPA 2000). The locations of Springs 13 and 39 and the seepage interception system are shown in Figure 2.1. Photo 6.1 shows the Spring 13 area and white aluminum precipitation in the Red River before installation of the interception system.

Molycorp's permit states "the permittee shall install the following seepage interception and management system to comply with the prohibition against discharge to the Red River of pollutants traceable to point source mine operations except in trace amounts." Therefore, no WLA is assigned to Springs 13 and 39 or any other springs or seeps located along the Red River. If future studies determine there are additional point sources attributable to the Molycorp Questa Mine or other entities then this TMDL will be revisited and the WLAs will be adjusted accordingly.

The monthly average discharge limits for total aluminum at the Red River WWTP, the Molycorp Mine outfalls, and the fish hatchery are listed in Table 6.3. The current permit for the fish hatchery does not include a discharge limit for total aluminum. Since the fish hatchery uses water obtained from the Red River in their operations, water discharged from the fish hatchery will contain aluminum concentrations similar to ambient river concentrations. No reduction in aluminum concentrations from the fish hatchery discharge is required in their permit or this TMDL.

The monthly average aluminum loading allowable under the Molycorp permit is 2.075 lbs/day for outfall #1 and 0.169 lb/day from outfall #2 after the first two years of the five-year permit. The total aluminum discharge limit for the Red River WWTP permit has interim and final limits based on a compliance schedule, with the highest limit being 2.63 lbs/day during the first two years (2001 through 2002), but decreasing to 0.305 lbs/day after 2002.

The discharge limit for each of the permitted point sources is well below the target loads for aluminum, and impairment of the Red River from these sources is assumed to be negligible. Therefore, the WLAs for the Red River will be the discharge limits as set in the NPDES permits. To account for potential permitted discharges from Molycorp's outfalls #4 and #5 the WLA was increased by 1.35 lb/day, which corresponds to a combined flow value of 0.5 cfs. This portion of the WLA is not directly allocated to outfalls #4 and #5, but is a set-aside value to allow for permitted discharges without violating the TMDL.

Table 6.3 NPDES Permitted Point Source Discharge Limits for Total Aluminum

Outfall	Permit No.	Effective Date	Expiration Date	Discharge Limit (monthly average)
Red River WWTP	NM0024899	9/1/2000	8/31/2005*	0.305 lbs/day
Molycorp Mine #1	NM0022306	2/1/2001	1/31/2006	2.075 lbs/day
Molycorp Mine #2				0.169 lbs/day
Molycorp Mine #4				0.5 mg/L+
Molycorp Mine #5				0.5 mg/L+
Fish Hatchery	NM0030147	11/1/2001	9/30/2005*	no limit specified

+ There is no flow value in the NPDES permit associated with Outfalls 4 and 5, therefore a loading valve is not included in the permit. Since there has been no discharge measured for Outfalls 4 and 5 and the potential flow is unknown, a WLA could not be calculated for these outfalls.

* These NPDES permits are currently in the process of being reissued by the USEPA Region 6.

Photo 6.1. Spring 13 Area Before Installation of the Interception System (note white aluminum precipitation in the River).

6.4.2 Load Allocation

In order to calculate the LA, the WLA and MOS were subtracted from the target capacity (TMDL) following **Equation 2**.

$$WLA + LA + MOS = TMDL \qquad \text{(Eq. 2)}$$

The MOS is estimated to be 25% of the target load calculated in Table 6.1. Results are presented in Table 6.4. Additional details on the MOS chosen are presented in Section 6.7 below.

Table 6.4 Calculation of TMDL for Dissolved Aluminum

Location	WLA (lbs/day)	LA (lbs/day)	MOS (25%) (lbs/day)	TMDL (lbs/day)
Red River (Rio Grande to Placer Creek)	3.90*	578*	194	776*
Bitter Creek (Red River to Headwaters)	0	31.4	10.5	41.9*
Placer Creek (Red River to Headwaters)	0	7.50	2.50	10.0*

* Values rounded to three significant figures.

The extensive data collection and analyses necessary to determine background dissolved aluminum for the Bitter Creek and Placer Creek watersheds was beyond the resources available for this study. There are several ongoing studies being conducted in the Red River to determine the amount of aluminum coming from background, nonpoint source, and point sources, but exact values were not available at the time this TMDL was prepared. It is therefore assumed that a portion of the load allocation for Red River, Bitter Creek, and Placer Creek is made up of natural background loads and potentially also includes presently unidentified or uncontrolled point sources for the Red River.

The nonpoint source and background load reductions that would be necessary to meet the target loads were calculated to be the difference between the target load (Table 6.4) and the measured load (Table 6.2), and are shown in Table 6.5. These load reduction tables are presented for informational purposes only.

Table 6.5 Calculation of Load Reduction for Dissolved Aluminum

Location	**Target Load[(a)] (lbs/day)**	**Measured Load (lbs/day)**	**Load Reduction (lbs/day)**	**Percent Reduction[(b)]**
Red River (Rio Grande to Placer Creek)	582*	1,170*	588	50.3%
Bitter Creek (Red River to Headwaters)	31.4*	71.0*	39.6	55.8%
Placer Creek (Red River to Headwaters)	7.50*	14.4*	6.90	47.9%

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

6.5 Identification and Description of Pollutant Source(s)

Probable nonpoint pollutant sources that may be contributing to observed dissolved aluminum loads are displayed in Table 6.6.

A variety of potential point and nonpoint sources of pollutants are located in the Red River watershed. The area includes three point-source dischargers regulated through NPDES permits issued by the USEPA:

- The Town of Red River wastewater treatment plant discharges its treated effluent near the Elephant Rock Campground (NPDES Permit NM0024899).

Table 6.6 Pollutant Source Summary for Dissolved Aluminum

Pollutant Sources	Magnitude[(a)] (lbs/day)	Assessment Unit	Potential Sources[(b)]
Point:			
Aluminum	3.90[(c)]	Red River (Rio Grande to Placer Creek)	0.3%[(c)] Mill Tailings Mine Tailings Acid Mine Drainage
	None	Bitter Creek (Red River to Headwaters)	0%
	None	Placer Creek (Red River to Headwaters)	0%
Nonpoint:			
Aluminum	1,166.1[(c)]	Red River (Rio Grande to Placer Creek)	99.6%[(c)] Highway/Road/Bridge Runoff (Non-construction Related) Impacts from Abandoned Mine Lands (Inactive) Natural Sources Acid Mine Drainage
	71.0	Bitter Creek (Red River to Headwaters)	100% Acid Mine Drainage Highway/Road/Bridge Runoff (Non-construction Related) Natural Sources Other Recreational Pollution Sources Surface Mining
	14.4	Placer Creek (Red River to Headwaters)	100% Habitat Modification – other than Hydromodification Loss of Riparian Habitat Natural Sources Placer Mining Recreational Pollution Sources (Off Highway vehicles (OHV)

Notes:
(a) Measured load.
(b) From the 2004-2006 Integrated CWA 303(d)/305(b) list. This list of probable sources is based on staff observation and known land use activities in the watershed. These sources are not confirmed or quantified at this time.
(c) The exact amount of the measured load for the Red River attributed to point sources, background, and nonpoint sources is yet to be determined, studies currently being conducted are attempting to resolve this issue.

- The Red River Fish Hatchery is located near the confluence of the Rio Grande. The hatchery discharges return water from its raceways (NPDES Permit NM0030147).

- A large molybdenum (Molycorp) mine operates along the middle 10 miles of the river. The mill tailings from the mine are deposited in tailing ponds located just west of the town of Questa. There are four permitted discharge points, but only one has continual discharge of collected tailing dam seepage (NPDES Permit NM0022306). Also, a series of waste rock piles have been placed in drainages located within the Molycorp property

boundary along Highway 38, which parallels the Red River.

Based on the relatively low allowable discharge limits and compliance monitoring, it seems likely that the nonpoint source areas within the watershed are the primary cause of aluminum impacts to the Red River. The following nonpoint sources have been identified:

- Natural alteration scars are located along the river from the Molycorp Mine upstream to the town of Red River. The scar areas contribute to decreased water quality in the Red River under two conditions. During runoff events, large amounts of sediment and acidic runoff are released from these areas, often coloring the river a mustard yellow. The scar areas also release acid rock drainage that enters the Red River as groundwater seepage. This groundwater seepage has low pH, elevated aluminum content and a suite of other metals, and appears to be a major factor in the impairment of the river.

- There are also several scar areas located within the Molycorp Mine property land holdings that contribute to nonpoint source pollution. These areas are adjacent to mineralized rocks exposed and/or disturbed during the mining process. Some of the scar material was placed in a series of waste rock piles. The *Molycorp Questa Mine Site-Wide Comprehensive Hydrologic Characterization Report* (URS 2001) describes the potential nonpoint source pollution source areas at the Molycorp Mine.

- Road maintenance along Highway 38 has led to changes in the course of the Red River, resulting in increased sediment erosion in certain areas.

- The Red River Ski Area and the Town of Red River are located upstream of the mine; the township stretches for 1.5 miles along the river downstream from Placer Creek. The ski area is developed on mineralized rock and soil.

- Numerous access roads have been constructed on the steep slopes that adjoin the river and its tributaries. Some road cuts expose mineralized bedrock and acidic scar debris. In addition, dwellings with individual septic systems are also located along these roads.

6.6 Link Between Water Quality and Pollutant Sources

Where data gaps exist or the level of uncertainty in the characterization of sources is large, the recommended approach to TMDL assignments requires the development of allocations based on estimates utilizing the best available information.

SWQB fieldwork includes an assessment of the potential sources of impairment (NMED/SWQB 1999b). The Pollutant Source(s) Documentation Protocol form and Potential Sources Summary Table in Appendix A provide documentation of a visual analysis of probable sources along an impaired reach. Although this procedure is subjective, SWQB feels that it provides the best available information for the identification of potential sources of impairment in this watershed. Table 6.6 (Pollutant Source Summary) identifies and quantifies potential sources of nonpoint source impairments along each reach as determined by field reconnaissance and assessment. It is

important to consider not only the land directly adjacent to the impaired assessment unit, but also on the upland and upstream areas in a more holistic watershed approach to implementing this TMDL.

In general, increased metals in the water column can commonly be linked to sediment transport and accumulation, where the metals are a constituent part of the sediment. This does not appear to be the case for either the Red River or Bitter Creek as evidenced by the fact that there is a very weak relationship between dissolved aluminum and TSS concentrations according to the data used to determine the impairment (Figures 6.4 and 6.5). There appears to be a correlation between TSS and dissolved aluminum in Placer Creek (Figure 6.6) with an R^2 value of 0.57.

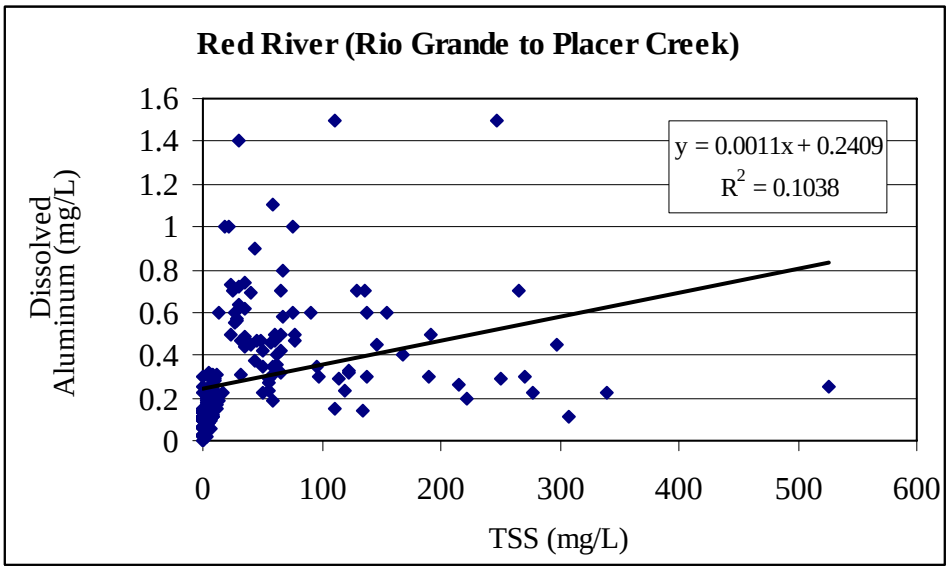

Figure 6.4 Relationship between Dissolved Aluminum and TSS in the Red River

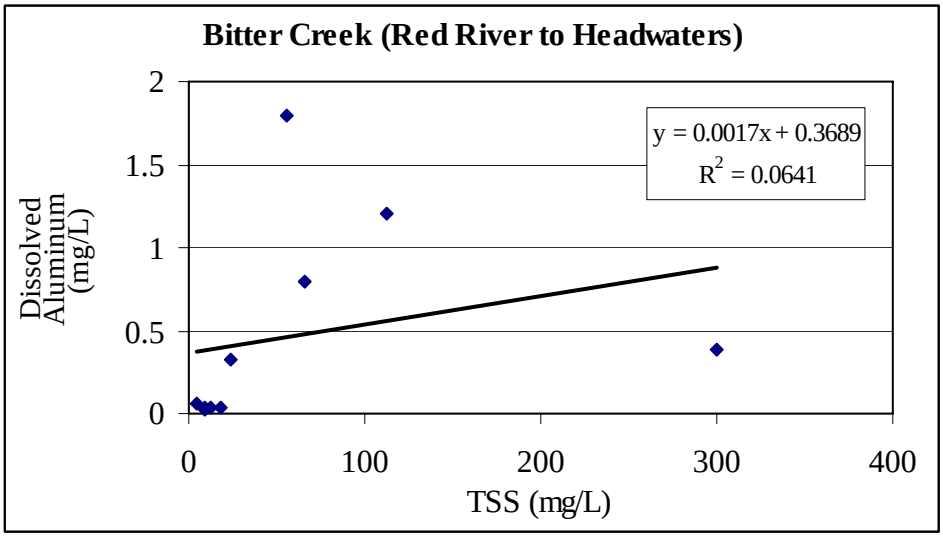

Figure 6.5 Relationship between Dissolved Aluminum and TSS in Bitter Creek

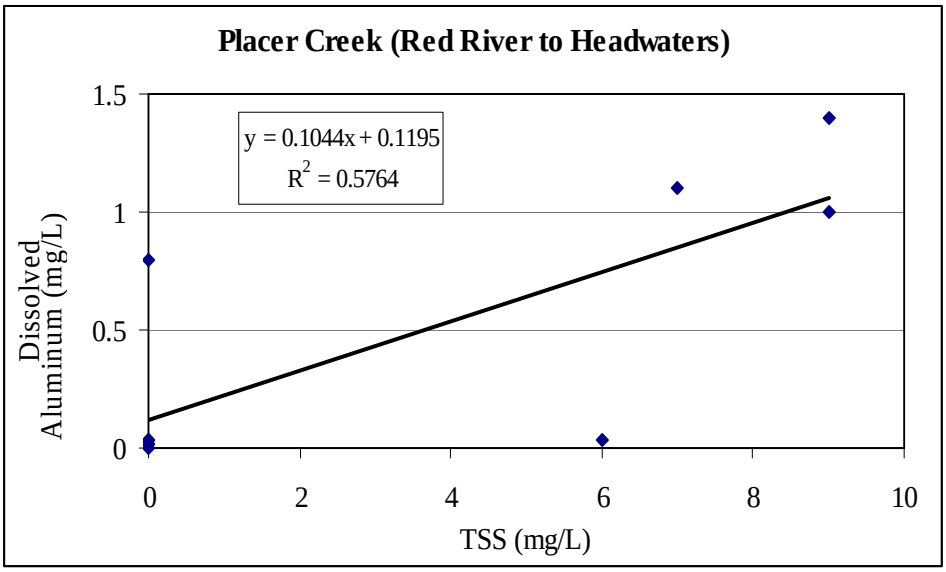

Figure 6.6 Relationship between Dissolved Aluminum and TSS in Placer Creek

Extremely high aluminum is characteristic of the spring snowmelt/runoff period and is not pronounced during baseflow conditions in the Red River, Bitter Creek, or Placer Creek. Normal aqueous chemical processes, enhanced by the slight natural acidity of snow and rain, are capable of rendering some of this abundant, naturally-occurring aluminum available to the stream system. The fact that dissolved aluminum concentrations above the acute aluminum criterion were measured during the spring sampling run as opposed to lower concentrations during fall sampling runs are indicative of a landscape source. Acidic anions as well as carbonic acid carried in snow are released into the soil as the snow melts and bring aluminum species into solution. Thus, aluminum concentrations are often high during spring runoff in many areas in New Mexico despite the expected diluting effects of high flow.

There are several known existing and historic mines in this watershed which are also contributing to the high levels of aluminum during baseflow. The most likely source for the higher aluminum concentrations in Bitter Creek and the Red River during spring runoff/snowmelt are the large alterations scars located along Bitter Creek (Figure 2.4). All of the exceedences of the acute aluminum criterion were in samples collected below Bitter Creek (SWQB Station 11) downstream to the sampling location below Columbine Creek (SWQB Station 25). These alteration scars are naturally occurring geological features, but the amount of eroded material being washed into Bitter Creek during snowmelt and other runoff events has been accelerated in areas by Bitter Creek Road which runs along the creek, a sand and gravel operation, and land development along the creek.

The source of the acute aluminum exceedences in Placer Creek are likely caused by the channelization/alteration of the creek channel in the Town of Red River. The bottom ½ mile of Placer Creek runs parallel to a National Forest Service road and eventually the creek runs down the middle of the road delivering high sediment loads to the Red River. There are also several

historic abandoned mines with exposed waste rock piles and acid rock drainage in the Placer Creek Watershed which may be releasing aluminum to surface water.

6.7 Margin of Safety

TMDLs should reflect a MOS based on the uncertainty or variability in the data, the point and nonpoint source load estimates, and the modeling analysis. For this TMDL the MOS is estimated to be an addition of **25%** for the Red River, Bitter Creek, and Placer Creek. This MOS incorporates several factors:

- *Errors in calculating nonpoint source loads*

  A level of uncertainty exists in sampling nonpoint sources of pollution. Techniques used for measuring metals concentrations in stream water can lead to inaccuracies in the data. Therefore, a conservative MOS for metals increases the TMDL by **15%.**

- *Errors in calculating flow*

  Flow estimates were based on USGS gages and modeling calculations. There is a potential to have errors in measurements of flow due to equipment accuracy, time of sampling, etc. To be conservative, an additional MOS of **10%** will be included to account for accuracy of flow computations.

6.8 Consideration of Seasonal Variation

Data used in the calculation of this TMDL were collected during the spring, summer, fall, and winter between 1999 and 2002 in order to ensure coverage of any potential seasonal variation in the system. Critical condition was set to the flow estimate determined during snowmelt in May 1999.

6.9 Future Growth

Based on the lack of point sources in Placer Creek and Bitter Creek, the overwhelming source of aluminum loading in these two creeks is from nonpoint sources The point sources located on the Red River are contributing only a very minor portion of the acute aluminum load during the critical flow period. Therefore, estimates of future growth are not anticipated to lead to a significant increase in aluminum concentrations that cannot be controlled with BMP implementation in this watershed. Since future projections indicate the potential that nonpoint sources will increase as this region continues to grow and develop, it is imperative that BMPs continue to be utilized and improved upon in this watershed while continuing to improve road conditions and adhering to SWPPP requirements related to construction activities for sites greater than one acre.