TOTAL MAXIMUM DAILY LOADs (TMDLs)

FOR THE

UPPER RIO CHAMA WATERSHED
(El VADO RESERVOIR TO COLORADO BORDER)

September 9, 2003

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EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act requires states to develop Total Maximum Daily Load (TMDL) management plans for water bodies determined to be water quality limited. A TMDL documents the amount of a pollutant a water body can assimilate without violating a state's water quality standards. It also allocates that load capacity to known point sources and nonpoint sources at a given flow. TMDLs are defined in 40 CFR Part 130 as the sum of the individual Waste Load Allocations (WLA) for point sources and Load Allocations (LA) for nonpoint sources, including a margin of safety and natural background conditions.

The Upper Rio Chama watershed, defined as the Rio Chama watershed upstream of El Vado reservoir, is located in north central New Mexico. It is a sub-basin of the Rio Grande Basin. Stations were located throughout the Upper Rio Chama watershed during the 1998 intensive watershed survey performed by the New Mexico Environment Department (NMED) Surface Water Quality Bureau (SWQB) to evaluate the impact of tributary streams. As a result of this monitoring effort, several exceedences of New Mexico water quality standards for temperature were documented on the Rio Chama (Rio Brazos to Little Willow Creek), Chavez Creek (Rio Brazos to headwaters), Rio Brazos (Rio Chama to Chavez Creek), and Rito de Tierra Amarilla (Rio Chama to State Highway 64). Samples taken at the lower Rito de Tierra Amarilla station also exceeded numeric turbidity criterion and the narrative stream bottom deposits (SBD) standard. Several exceedences of chronic aluminum criterion were documented on the Rio Chamita (Rio Chama to Colorado border). This TMDL document addresses the above noted impairments. TMDLs for temperature, ammonia, total phosphorus, and fecal coliform were previously completed for Rio Chamita (SWQB/NMED 1999a, 1999b). Accordingly, these efforts have completed TMDLs that address all currently measured impairments.

An implementation plan containing pollution abatement strategies for nonpoint source (NPS) pollution in the Upper Rio Chama watershed is included in this document. The Surface Water Quality Bureau's Watershed Protection Section developed the details of this plan. Implementation of recommendations in this document will be done with participation of all interested and affected parties. During implementation, additional water quality data will be collected by NMED during the standard rotational period for intensive stream surveys. As a result, 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 indicate that the targets used in this analysis are not appropriate and/or if new standards are adopted, the load capacity will be adjusted accordingly. When water quality standards have been achieved, the reach will be removed from the TMDL list.

LIST OF ABBREVIATIONS

20.6.4 NMAC	New Mexico Water Quality Standards (as amended through October 11, 2002)
4Q3	4-day, 3-year low flow frequency
BMP	Best Management Practice
cfs	Cubic Feet per Second
CWA	Clean Water Act
CWAP	Clean Water Action Plan
CWF	Coldwater Fishery
EPA	Environmental Protection Agency
EPT	Ephemeroptera/Plecoptera/Tricoptera
FS	United States Department of Agriculture Forest Service
HQCWF	High Quality Coldwater Fishery
HBI	Hilsenhoff's Biotic Index
ISI	Interstitial Space Index
J/m2/s	joules/meters squared/second
LA	Load Allocation
LCD	Local Climatological Data
MGD	Million Gallons per Day
mg/L	Milligrams per Liter
MOS	Margin of Safety
MOU	Memorandum of Understanding
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NMDGF	New Mexico Department of Game and Fish
NMSHTD	New Mexico State Highway and Transportation Department
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NTU	Nephelometric Turbidity Units
QAPP	Quality Assurance Project Plan
SBD	Stream Bottom Deposits
SSTEMP	Stream Segment Temperature Model
SWQB	Surface Water Quality Bureau
TOC	Total Organic Carbon
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
µg/L	micrograms per liter
USGS	United States Geological Survey
UWA	Unified Watershed Assessment
WLA	Waste Load Allocation
WQLS	Water Quality Limited Segment
WQCC	New Mexico Water Quality Control Commission
WQS	Water Quality Standards (NMAC 20.6.4 as amended through October 11, 2002)
WRAS	Watershed Restoration Action Strategy
WWTP	Wastewater Treatment Plant

TOTAL MAXIMUM DAILY LOAD SUMMARY TABLES
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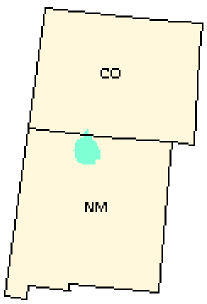
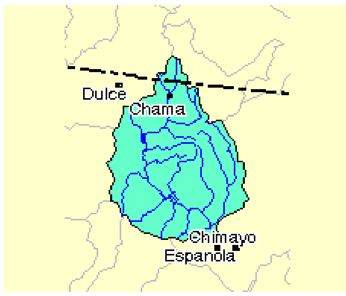
TOTAL MAXIMUM DAILY LOAD FOR CHRONIC ALUMINUM IN RIO CHAMITA (RIO CHAMA TO CO BORDER)





Summary Table

New Mexico Standards Segment	Rio Grande 20.6.4.119
Waterbody Identifier	Rio Chamita (Rio Chama to CO border) NM-2116.A_110 (formerly NM-URG2-30500), 13.58 miles
Parameters of Concern	Chronic Aluminum
Uses Affected	High Quality Coldwater Fishery
Geographic Location	Rio Chama USGS Hydrologic Unit Code 13020102
Scope/size of Watershed	38 mi^2
Land Type	Southern Rockies Ecoregion (21)
Land Use/Cover	Rangeland (33%), Forest (67%), Urban/Water (<1%), Agriculture (<1%)
Identified Sources	Flow Regulation/Modification, Removal of Riparian Vegetation, Municipal Point Sources, Natural Sources
Land Management	State land (94%), Private (6%)
Priority Ranking	2
Threatened and Endangered Species	None
TMDL for: Chronic Aluminum	WLA (0.4) + LA (9.8) + MOS (2.6)= **12.8 lbs/day**

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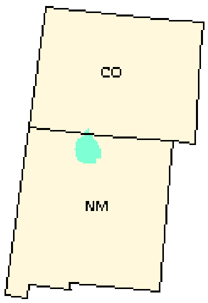
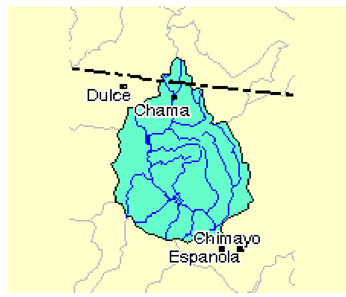
TOTAL MAXIMUM DAILY LOAD FOR TEMPERATURE IN RIO CHAMA (RIO BRAZOS TO LITTLE WILLOW CREEK)





Summary Table

New Mexico Standards Segment	Rio Grande 20.6.4.119
Waterbody Identifier	Rio Chama (Rio Brazos to Little Willow Creek) NM-2116.A_001 (formerly NM-URG2-30000), 11.72 miles
Parameters of Concern	Temperature
Uses Affected	High Quality Coldwater Fishery
Geographic Location	Rio Chama USGS Hydrologic Unit Code 13020102
Scope/size of Watershed	221 mi^2 (upstream of confluence with the Rio Brazos)
Land Type	Southern Rockies Ecoregion (21)
Land Use/Cover	Range (16%), Forest (80%), Agriculture (4%), Urban/Water (<1%)
Identified Sources	Range Grazing -- Riparian or Upland, Removal of Riparian Vegetation, Flow Regulation/Modification
Land Management	Private (85%), USFS (1%), State (14%)
Priority Ranking	4
Threatened and Endangered Species	None
TMDL for: Temperature	WLA (0) + LA (194.82) + MOS (22.38) = **217.20 joules/meter^2/second/day**

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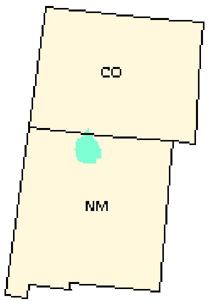
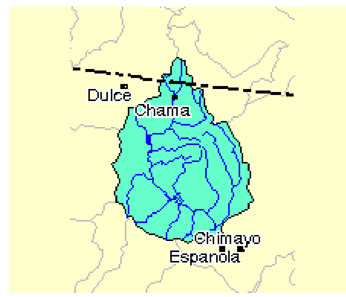
TOTAL MAXIMUM DAILY LOAD FOR TEMPERATURE IN CHAVEZ CREEK (RIO BRAZOS TO HEADWATERS)





Summary Table

New Mexico Standards Segment	Rio Grande 20.6.4.119
Waterbody Identifier	Chavez Creek (Rio Brazos to headwaters) NM-2116.A_081 (formerly NM-URG2-30210), 12.59 miles
Parameters of Concern	Temperature
Uses Affected	High Quality Coldwater Fishery
Geographic Location	Rio Chama USGS Hydrologic Unit Code 13020102
Scope/size of Watershed	25 mi^2
Land Type	Southern Rockies Ecoregion (21)
Land Use/Cover	Forest (92%), Rangeland (8%), Urban/Water (<1%), Agriculture (<1%)
Identified Sources	Range Grazing -- Riparian or Upland, Removal of Riparian Vegetation, Flow Regulation/Modification, Dredging, Gravel Mining
Land Management	Private (100%)
Priority Ranking	4
Threatened and Endangered Species	None
TMDL for: Temperature	WLA (0) + LA (173.52) + MOS (21.03) = **194.55 joules/meter^2/second/day**

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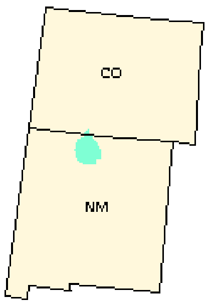
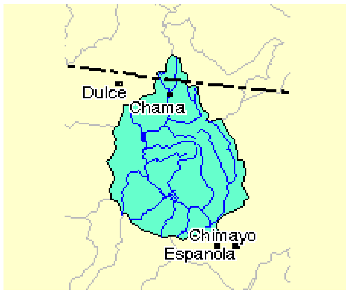
TOTAL MAXIMUM DAILY LOAD FOR TEMPERATURE IN RIO BRAZOS (RIO CHAMA TO CHAVEZ CREEK)





Summary Table

New Mexico Standards Segment	Rio Grande 20.6.4.119
Waterbody Identifier	Rio Brazos (Rio Chama to Chavez Creek) NM-2116.A_080 (formerly NM-URG2-30200), 3.52 miles
Parameters of Concern	Temperature
Uses Affected	High Quality Coldwater Fishery
Geographic Location	Rio Chama USGS Hydrologic Unit Code 13020102
Scope/size of Watershed	171 mi^2
Land Type	Southern Rockies Ecoregion (21)
Land Use/Cover	Forest (64%), Rangeland (30%), Agriculture (6%), Urban/Water (<1%)
Identified Sources	Range Grazing -- Riparian or Upland, Removal of Riparian Vegetation, Flow Regulation/Modification, Dredging, Gravel Mining, Channelization, Unmaintained Low Water Crossing
Land Management	Private (96%), USFS (4%)
Priority Ranking	4
Threatened and Endangered Species	None
TMDL for: Temperature	WLA (0) + LA (184.89) + MOS (20.54) = **205.43 joules/meter^2/second/day**

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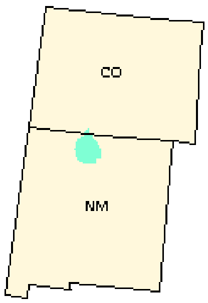
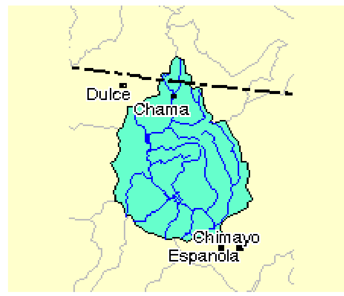
TOTAL MAXIMUM DAILY LOAD FOR
TURBIDITY, STREAM BOTTOM DEPOSITS, AND TEMPERATURE
IN
RITO DE TIERRA AMARILLA (RIO CHAMA TO HWY 64)





Summary Table

New Mexico Standards Segment	Rio Grande 20.6.4.119
Waterbody Identifier	Rito de Tierra Amarilla (Rio Chama to HWY 64) NM-2116.A_070 (formerly NM-URG2-30100), 15.8 mi
Parameters of Concern	Turbidity Stream Bottom Deposits Temperature
Uses Affected	High Quality Coldwater Fishery
Geographic Location	Rio Chama USGS Hydrologic Unit Code 13020102
Scope/size of Watershed	61.3 mi^2
Land Type	Southern Rockies Ecoregion (21)
Land Use/Cover	Forest (70%), Rangeland (25%), Agriculture (5%), Urban/Water (<1%)
Identified Sources	Range Grazing -- Riparian or Upland, Removal of Riparian Vegetation, Road Maintenance and Runoff, Flow Regulation/Modification, Agriculture
Land Management	Private (100%)
Priority Ranking	4
Threatened and Endangered Species	None
TMDL for: Turbidity (as TSS) Stream Bottom Deposits Temperature	 WLA(0) + LA(1296.4) + MOS(432.2)= **1728.6 lbs/day** WLA(0) + LA (15) + MOS(5)= **20% fines** WLA (0) + LA(150.85) + MOS (16.76) = **167.61 joules/meter^2/second/day**

1.0 BACKGROUND INFORMATION

1.1 Location Description and History

The Rio Chama watershed (USGS Hydrologic Unit Code 13020102) is a sub-basin of the Rio Grande Basin, located in north central New Mexico. The entire Rio Chama watershed encompasses 3,150 square miles. For practical purposes, the Rio Chama watershed was divided into upper and lower sampling units. SWQB/NMED defines the Upper Rio Chama watershed as the New Mexico portion of the Rio Chama watershed above El Vado Reservoir. Tributaries in the Upper Rio Chama watershed include Sixto Creek, Nabor Creek, Rio Chamita, Wolf Creek, Little Willow Creek, Cañones Creek, Rio Brazos, Chavez Creek, and Rito de Tierra Amarilla.

The majority of the Upper Rio Chama watershed is within the Tierra Amarilla land grant boundary. The Tierra Amarilla land grant was the largest and most controversial land grant in northwestern New Mexico (Quintana 1991). The first application for the Tierra Amarilla land grant was made by seventy-two Hispanic settlers of the lower Rio Chama valley in 1814 to start a tract of agricultural land primarily to raise sheep. Two other unsuccessful petitions were submitted in 1820 and 1824. In 1832, Manuel Martinez submitted a grant petition on behalf of himself and his family, requesting that access to pastures, roads, and watering places be limited to grantees in an attempt to acquire a private vs. communal grant. The Committee of the Territorial Deputation rejected the request for limited access and made the Tierra Amarilla grant a community grant (Quintana 1991).

There were no permanently inhabited Hispanic settlements in the area until 1860. In the same year, Congress changed the grant from a communal grant to a private grant for Martinez and his descendants. Although deeds supported settlers' claims to their rights on common lands, the grant was signed over to Thomas Benton Catron in 1881, one of the richest landowners in the country (Quintana 1991). In 1901, Catron received patent on the entire grant with small exceptions of the lands allotted to settlers. By 1904, the area between the Village of Chama and Tierra Amarilla was cleared of ponderosa pine by the Southwestern Lumber and Railway Company, leading to subsequent gully erosion and siltation of downstream surface waters (Quintana 1991). The first fences were installed in 1912, depriving settlers of their open range rights. The Alianza was launched in Northern New Mexico in 1966, believing that colonialism had denied them access to the resources of their ancestral lands and had destroyed their communities. They appealed for a Congressional investigation into the circumstances that had lead to this alienation of original land grantees. In 1967, the Alianza attempted a citizen's arrest of a district attorney at the Tierra Amarilla Courthouse. The incident erupted into a shootout, leading to a manhunt for Alianza leader Reies Lopez Tijerina. The episode at the courthouse lead to inquires by the Civil Liberties Union and to a resurrected sense of pride and identity with the land and associated culture (Quintana 1991).

Although the Alianza in now defunct, the issue of land ownership and management in the Tierra Amarilla land grant issue remains alive (Quintana 1991). The Upper Rio Chama watershed is currently dominated by private land with some US Forest Service and state wildlife land (Figure 1.1). Approximately 80 percent of the Upper Rio Chama watershed is private, the Forest Service manages 5 percent, 15 percent is managed by the State of New Mexico as the Edward Sargent

Fish and Wildlife Area. A large portion of the Little Willow Creek watershed is owned and managed by the Jicarilla Apache Tribe. Primary land uses in the Upper Rio Chama watershed include ranching, agriculture, gravel mining, silvaculture, recreation and tourism, and limited urban development. There are two permitted point sources in the Upper Rio Chama basin: The Village of Chama Wastewater Treatment Plant (NPDES Permit No. NM0027731) and the New Mexico Department of Game and Fish Parkview Fish Hatchery (NPDES Permit No. NM0030139). There are several active and abandoned gravel mines throughout the watershed. There are several active irrigation canals throughout the Upper Rio Chama watershed that divert surface water from streams to agricultural and rangeland fields. The main population centers are the Village of Chama and Tierra Amarilla. The Upper Rio Chama watershed was intensively sampled in 1998. Select follow-up monitoring was completed in 2002.

Precambrian sedimentary rocks form the Brazos Cliffs in the eastern portion of the Upper Rio Chama watershed (Figure 1.2 and Table 1.1). The Brazos Box is a dramatic 2000-foot-deep cliff-walled canyon that is three times deeper than the Rio Grande gorge near Taos. Small cinder cones are sources for lava that flowed down the Brazos Box into the Rio Chama basin to the west of Tierra Amarilla approximately 250,000 years ago. In places on these western slopes, glacial gravels overlie Mancos shale that is a particularly weak Cretaceous rock unit that is slippery when wet. Road construction through these areas has led to landslides over the years (Chronic 1987). The name Tierra Amarilla refers to the yellowish soil derived from Mancos shale. West of the Village of Chama off State Highway 64, the Mancos shale bluffs are capped with Mesa Verde group sandstone and shale. The Mancos shale floors the Chama syncline that extends to the south. The Cumbres Mountains to the north are composed of Precambrian granite and Tertiary volcanic rocks (Chronic 1987).

Table 1.1 Geologic unit definitions

Geologic Unit Code	Definition
J	Jurassic rocks, Middle and Upper, undivided
Jm	Morrison Formation; Upper Jurassic nonmarine rocks present only in northern one-third of state
Kd	Dakota Sandstone; includes Oak Canyon, Cubero, and Paguate Tongues plus Clay Mesa Tongue of Mancos Shale
Kl	Lower Cretaceous, undivided; in northern Lea and Roosevelt Counties includes equivalents of Tucumcari Shale
Km	Mancos Shale; divided into Upper and Lower parts by Gallup Sandstone
Kmv	Mesa Verde Group includes the Gallup Sandstone, Crevasse Canyon Formation
Pc	Castile Formation; dominantly anhydrite sequence; Upper Permian
Qb	Quaternary Basalt and andesite flows and locally vent deposits
Ql	Quaternary Landslide deposits and colluvium
Qm	Quaternary Moranil
Tbb	Tertiary Basalt
Tca	Carson conglomerate
Tp	Tertiary pediment deposit
TR	Triassic rocks, general

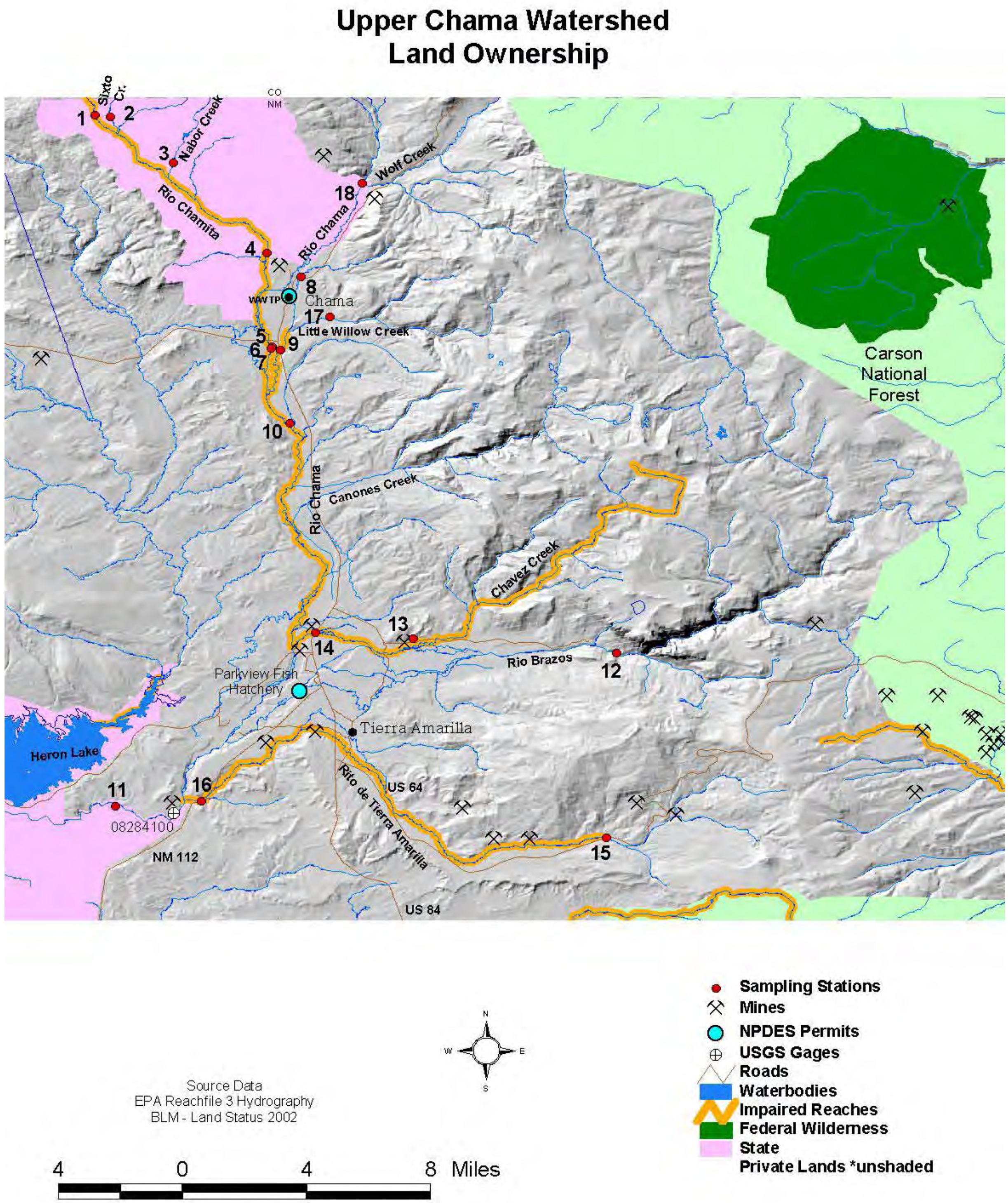


Figure 1.1 Upper Rio Chama Land Ownership and SWQB Sampling Stations

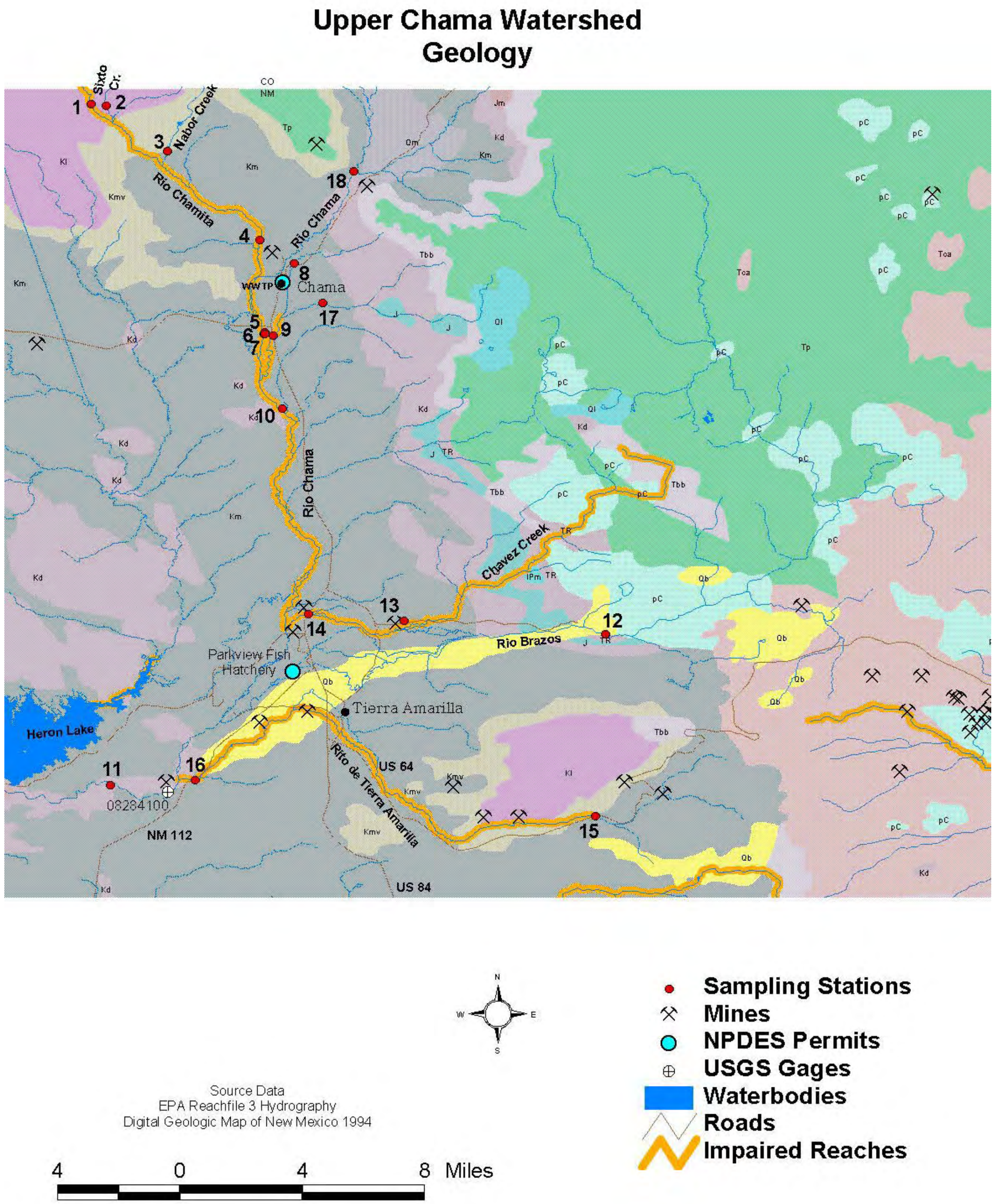


Figure 1.2 Upper Rio Chama Geology

1.2 Water Quality Standards

Water quality standards (WQS) for all assessment units in this document are set forth in sections 20.6.4.119 and 20.6.4.900 of the 2001 New Mexico Standards for Interstate and Intrastate Surface Waters (NMAC 20.6.4). NMAC 20.6.4.119 reads as follows:

> **RIO GRANDE BASIN**-All perennial reaches of tributaries to the Rio Chama above Abiquiu dam except the Rio Gallina and Rio Puerco de Chama north of state highway 96 and the main stem of the Rio Chama from the headwaters of El Vado reservoir upstream to the New Mexico-Colorado line.
>
> **A. Designated Uses**: domestic water supply, fish culture, high quality coldwater fishery, irrigation, livestock watering, wildlife habitat, and secondary contact.
>
> **B. Standards**:
>
> (1) In any single sample: conductivity shall not exceed 500 µmhos (1,000 µmhos for Coyote Creek), pH shall be within the range of 6.6 to 8.8, temperature shall not exceed 20 ºC (68 ºF), and turbidity shall not exceed 25 NTU. The use-specific numeric standards set forth in 20.6.4.900 NMAC are applicable to designated uses listed above in Subsection A of this section.
>
> (2) The monthly geometric mean of fecal coliform bacteria shall not exceed 100/100 mL; no single sample shall exceed 200/100 mL (see Subsection B of 20.6.4.13 NMAC.

1.3 Intensive Water Quality Sampling

The Upper Rio Chama watershed was intensively sampled by SWQB/NMED in 1998. Water quality samples were collected during spring (June 1-4), summer (August 18-19), and fall (October 20-21). Select follow-up monitoring was completed in October 2001 and June – September 2002. Surface water quality monitoring stations were selected to characterize water quality of the stream reaches (Table 1.2, Figure 1.1). Stations were located to evaluate the impact of tributary streams and to establish background conditions. Due to the large percentage of private land in the Upper Rio Chama watershed, selection of sampling stations was often limited to road/bridge right-of-way locations. The results of the survey were summarized in a water quality survey report (SWQB/NMED 2001a).

Table 1.2 SWQB/NMED 1998 Upper Rio Chama Sampling Stations

SWQB Station	STORET Reference	Station Location
1	URG116.020055	Rio Chamita upstream of confluence with Sixto Creek
2	URG116.020050	Sixto Creek upstream of confluence with Rio Chamita
3	URG116.020044	Nabor Creek upstream of confluence with Rio Chamita
4	URG116.020035	Rio Chamita at State Highway 29
5	URG116.020015	Rio Chamita above Village of Chama WWTP
6	URG116.020010	Village of Chama WWTP effluent discharge
7	URG116.020005	Rio Chamita downstream of the Village of Chama WWTP outfall
8	URG116.020510	Rio Chama upstream of the Village of Chama at State Highway 17
9	URG116.020505	Rio Chama at State Highway 84
10	URG116.019550	Rio Chama at NMG&F access downstream of confluence with Rio Chamita
11	URG116.016533	Rio Chama 2 miles downstream of the USGS gaging station at La Puente
12	URG116.018040	Rio Brazos upstream of Corkin's Lodge
13	URG116.018022	Chavez Creek upstream of confluence with Rio Brazos at County RD 512
14	URG116.008005	Rio Brazos at State Highway 84
15	URG116.017066	Rio Tierra Amarilla at State Highway 64
16	URG116.017005	Rito de Tierra Amarilla at State Highway 112
17	URG116.020506	Little Willow Creek upstream of confluence with Rio Chama
18	URG116.020570	Wolf Creek at State Highway 17

There is one active USGS gaging station in the Upper Rio Chama watershed: USGS 08284100 Rio Chama Near LaPuente, New Mexico (Figure 1.1). Minimum, mean, and maximum stream flows at this station are 11 cfs, 104 cfs, and 809 cfs, respectively, based on 46 years of record (1955 – 2001).

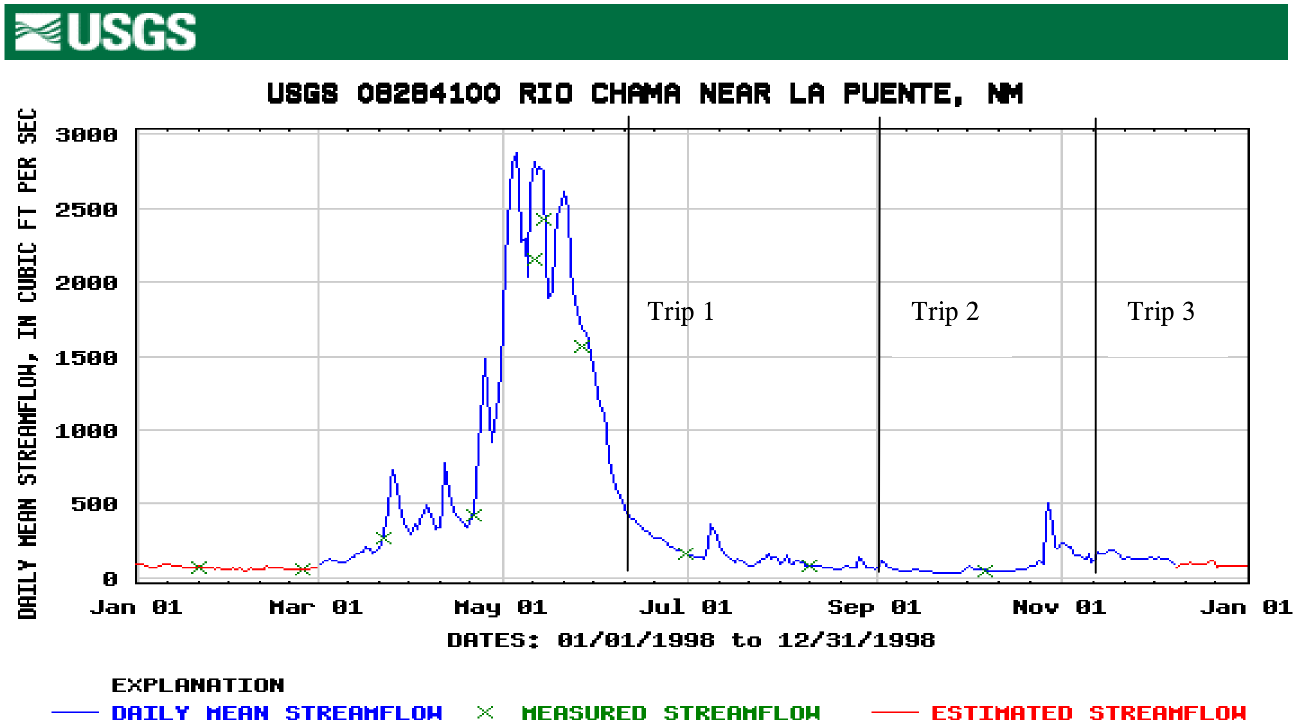


Figure 1.3 Daily flow of the Rio Chama Near LaPuente during the 1998 calendar year

All temperature, chemical/physical, and stream bottom deposits sampling and assessment techniques are detailed in the Quality Assurance Project Plan (SWQB/NMED 2001b). As a result of 1998 monitoring effort and subsequent assessment of results, several exceedences of New Mexico water quality standards for several streams were documented. Accordingly, these impairments were added to New Mexico's Clean Water Act §303 (d) list. This TMDL document addresses each assessment unit by constituent (or pollutant) whose standard(s) have been exceeded.

2.0 INDIVIDUAL WATERSHED DESCRIPTIONS

2.1 Rio Chamita

The Rio Chamita watershed is approximately 38 mi^2. Land ownership includes 94% State land and 6% privately held lands (Figure 2.1). An eight mile reach of the Rio Chamita, from the Chama village limit upstream to the Colorado state line is owned and managed by the New Mexico Department of Game and Fish (NMDGF) as part of the Edward Sargent Fish and Wildlife Area. This 20,400-acre wildlife area is used as a spring, summer, and fall range for elk, deer, and bear. The remaining portion of the Rio Chamita is within or adjacent to the Village of Chama (SWQB/NMED 2001a). Land use in this watershed is predominately forest (67%) and rangeland (33%). Approximately 15% of the watershed lies within Colorado (Figure 2.1). The Village of Chama Wastewater Treatment Plant (NPDES Permit No. NM0027731) effluent is discharged into the Rio Chamita approximately 1.5 miles upstream from the confluence with the Rio Chama.

The Rio Chamita is approximately 13.68 miles in length from the CO/NM border to the confluence with the Rio Chama (Photo 01). There were four sampling stations established on the Rio Chamita during the 1998 survey. Chemical, biological, and physical data were collected and assessed. The Rio Chamita was listed on the 2000-2002 Clean Water Act §303(d) list for temperature, ammonia, total phosphorus, fecal coliform, total organic carbon (TOC), and chronic aluminum. TMDLs for temperature, ammonia, total phosphorus, and fecal coliform were previously completed for Rio Chamita (SWQB/NMED 1999a, 1999b). The total phosphorus and TOC water quality standards for high quality coldwater fishery were subsequently removed from New Mexico's Water Quality Standards (NMAC 20.6.4). A level one plant nutrient assessment was performed on the Rio Chamita in June 2001 to confirm that there was no impairment of the narrative plant nutrient standard.

Photo 01. Rio Chamita below Sixto Creek, 07/20/98.

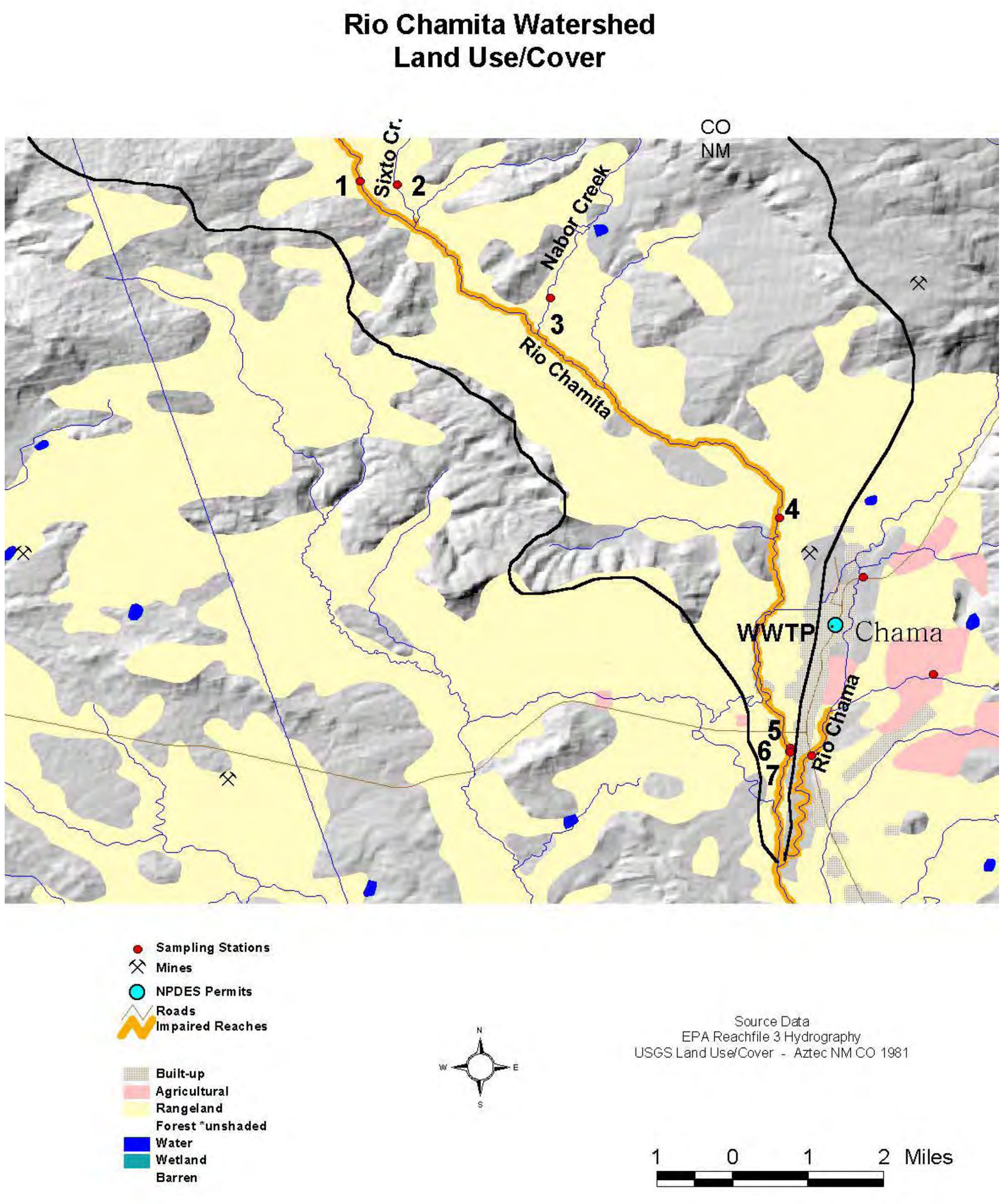


Figure 2.1 Rio Chamita Watershed Land Use and Sampling Stations

2.2 Rio Chama

The portion of the Rio Chama watershed upstream of Rio Brazos is approximately 221 mi^2 and includes Rio Chamita, Little Willow Creek, and Wolf Creek tributaries. Approximately 15% of the watershed lies within Colorado. Land ownership includes 14% State land and 85% privately held lands (Figure 1.1). Land use in this watershed is predominately forest (80%), rangeland (16%) and agriculture (4%) (Figure 2.2).

The Rio Chama from Rio Brazos to Little Willow Creek is approximately 11.72 miles in length (Photo 02). While access to the river along the majority of this reach is privately owned, there is a NMDGF access approximately two miles south of the Village of Chama. There were four sampling stations established on the Rio Chama during the 1998 survey. Additional thermograph data was collected at State Highway 95 in 2002. Chemical, biological, and physical data were collected and assessed. Rio Chama from the confluence with Rio Brazos to Little Willow Creek was listed on the 2000-2002 Clean Water Act §303(d) list for temperature.

Photo 02. Rio Chama upstream of confluence with Rio Brazos, 07/24/02.

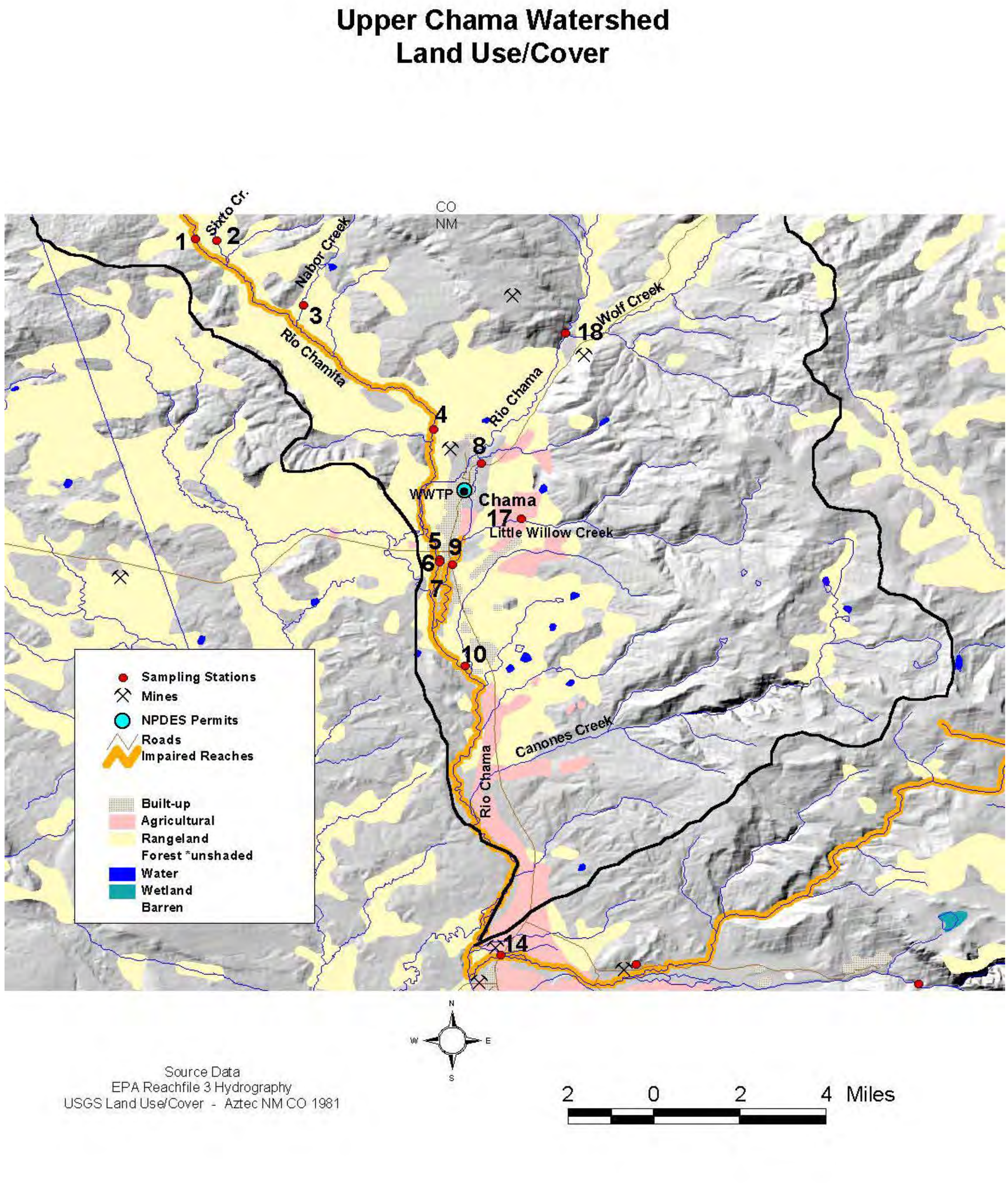


Figure 2.2 Rio Chama Watershed Land Use and Sampling Stations

2.3 Chavez Creek

The Chavez Creek watershed is approximately 25 mi^2. Land ownership is 100% private (Figure 1.1). Land use in this watershed is predominately forest (92%) rangeland (8%) (Figure 2.3). The Rocky Mountain Elk Foundation holds a Designated Conservation Easement on 395 acres along Chavez Creek. The middle portion of the watershed constricts into a box canyon.

Chavez Creek is approximately 12.59 miles in length (Photo 03). Due to private land access issues, only one sampling location was established on Chavez Creek during the 1998 survey. Chemical, biological, and habitat measurements were collected in 1998 and 2002 at this station. Chavez Creek from the confluence from the Rio Brazos to the headwaters was listed on the 2000-2002 Clean Water Act §303(d) list for temperature.

Photo 03. Chavez Creek at Country Road 512, 06/10/02.

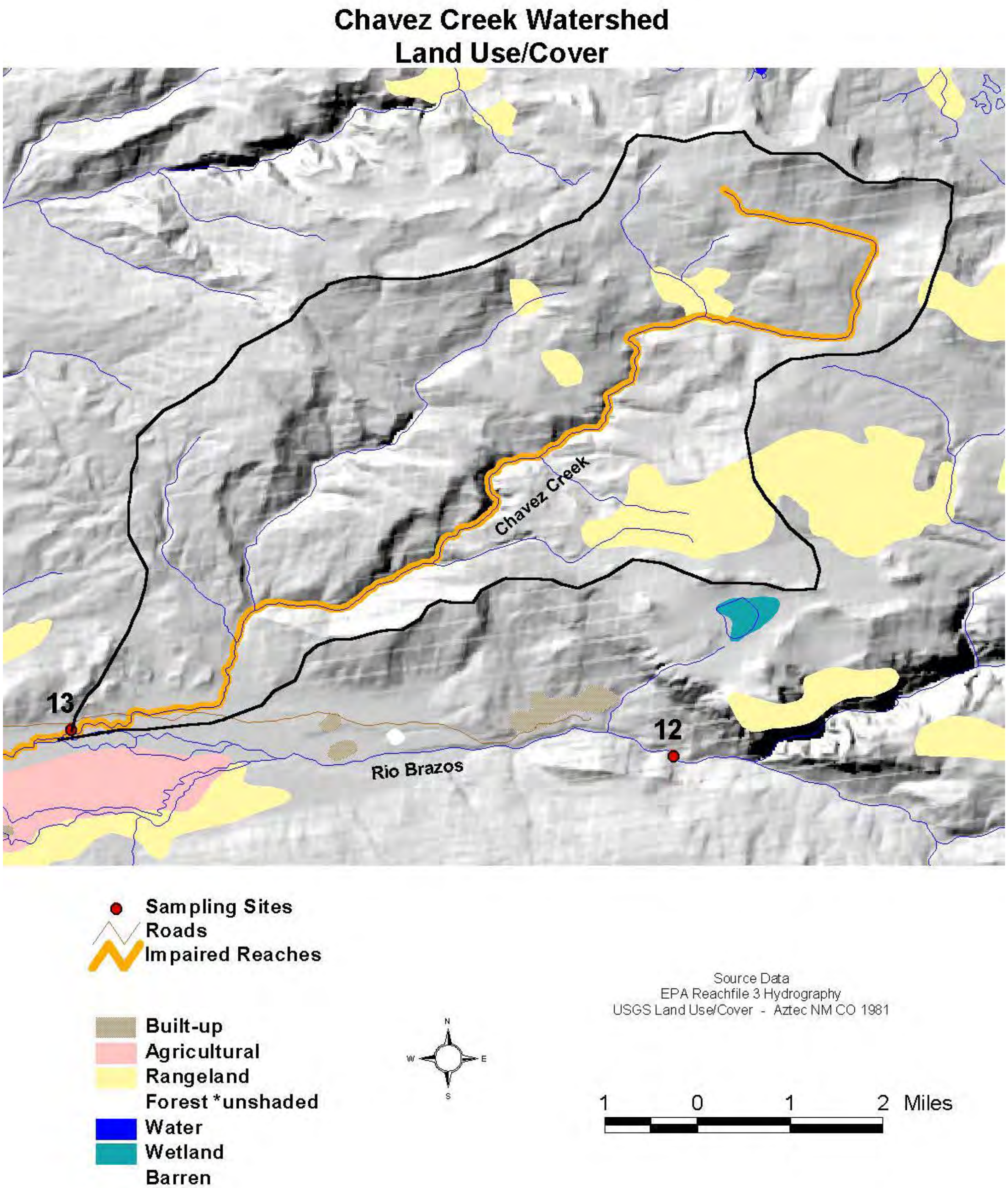


Figure 2.3 Chavez Creek Watershed Land Use and Sampling Stations

2.4 Rio Brazos

The Rio Brazos watershed is approximately 171 mi^2. Land ownership includes 4% USFS land and 96% privately held lands (Figure 1.1). Land use in this watershed is predominately forest (64%), rangeland (30%) and agriculture (6%) (Figure 2.4). The middle portion of the watershed is comprised of the Brazos Cliffs and Brazos Box.

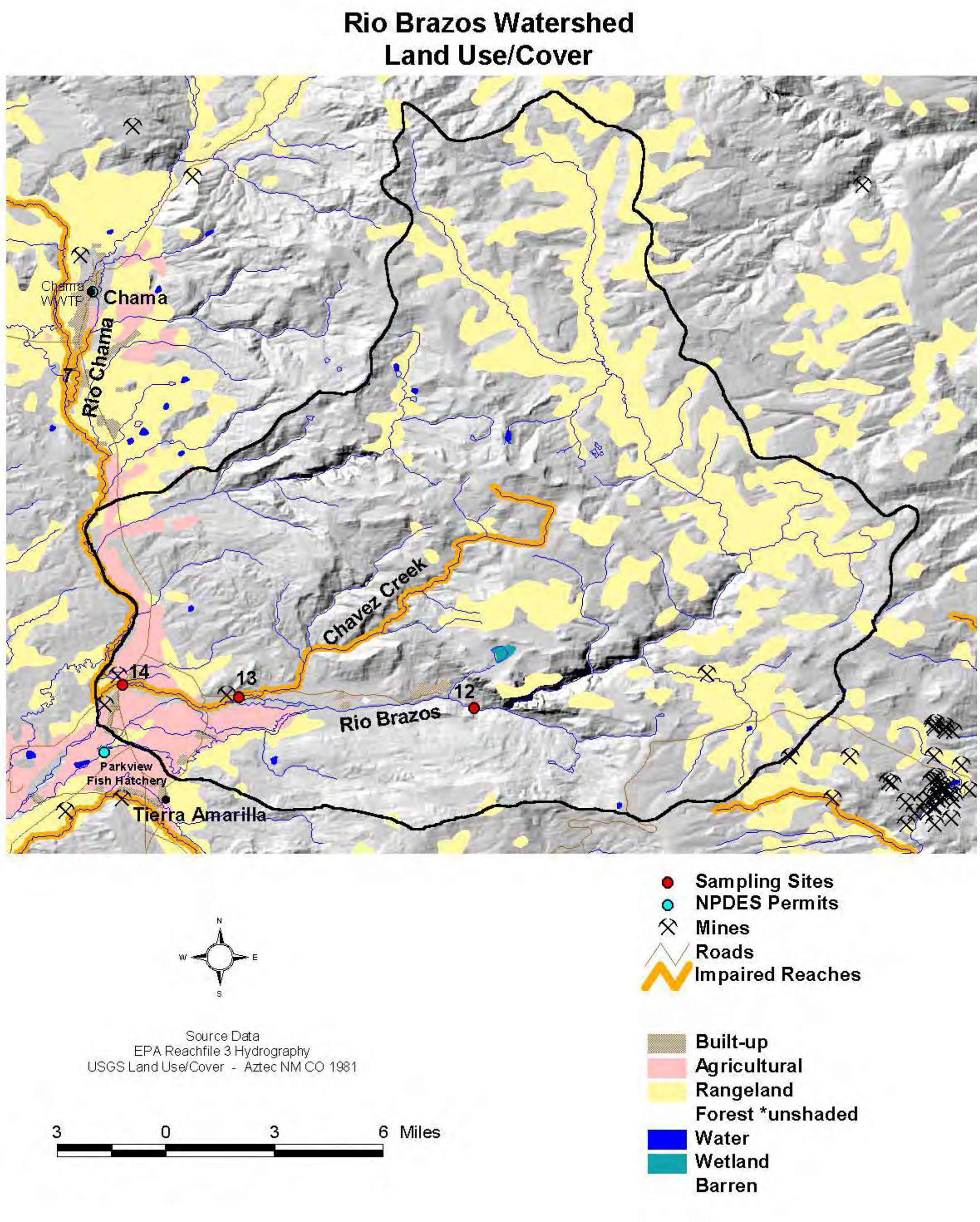


Figure 2.4 Rio Brazos Watershed Land Use and Sampling Stations

Rio Brazos from the Rio Chama to Chavez Creek is approximately 3.52 miles in length (Photo 04). There were two sampling stations established on the Rio Chama during the 1998 survey. Chemical, biological, and physical data were collected and assessed. An additional thermograph station was located at County Road 162 in 2002. Rio Brazos from the Rio Chama to Chavez Creek was listed on the 2000-2002 Clean Water Act §303(d) list for temperature.

Photo 04. Rio Brazos upstream of HWY 84 bridge, 07/23/02.

2.5 Rito de Tierra Amarilla

The Rito de Tierra Amarilla watershed is approximately 61.3 mi^2. Land ownership is 100% privately held lands (Figure 1.1). Land use in this watershed is predominately forest (70%), rangeland (25%), and agriculture (5%) (Figure 2.5).

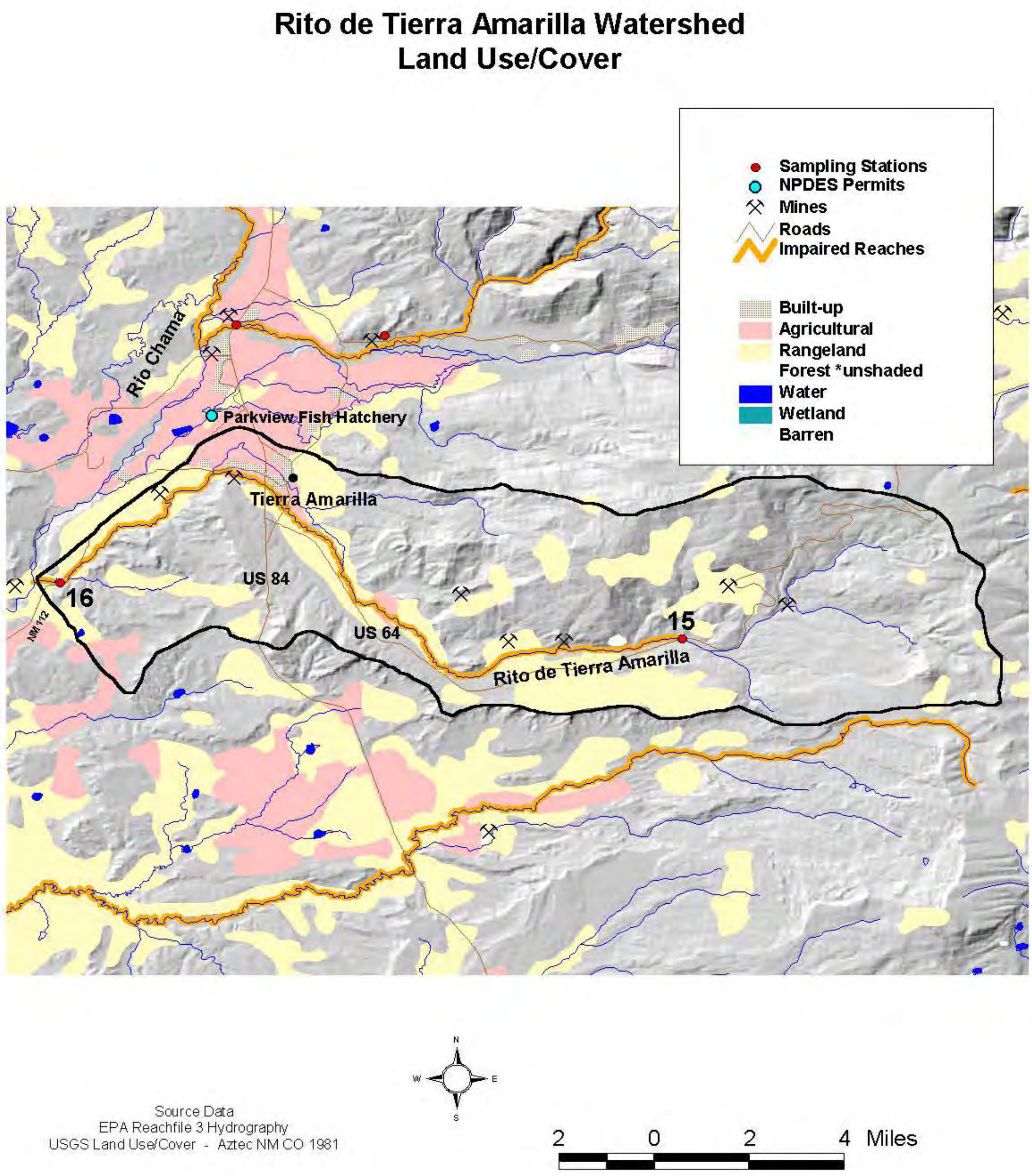


Figure 2.5 Rito de Tierra Amarilla Land Use and Sampling Stations

Rito de Tierra Amarilla from Rio Chama to State Highway 64 is approximately 15.8 miles in length (Photo 05). There were two sampling stations established on the Rio Chama during the 1998 survey. Chemical, biological, and physical data were collected and assessed. Additional data were collected in 2001 and 2002. Rito de Tierra Amarilla from Rio Chama to State Highway 64 was listed on the 2000-2002 Clean Water Act §303(d) list for turbidity, stream bottom deposits, and temperature.

Photo 05. Rito de Tierra Amarilla station 16 at Highway 112, 07/20/98.

3.0 TURBIDITY

3.1 Summary

During the SWQB 1998 intensive water quality survey in the Upper Rio Chama Watershed, several exceedences of the New Mexico water quality standard for turbidity were documented at the lower sampling station on Rito de Tierra Amarilla (SWQB Station 16). Consequently, the Rito de Tierra Amarilla from Rio Chama to State Highway 64 was listed on the 2000-2002 Clean Water Act §303(d) list for turbidity.

3.2 Endpoint Identification

Target Loading Capacity

Target values for this turbidity TMDL 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 turbidity are based on numeric criteria. This TMDL is also consistent with New Mexico's antidegradation policy.

According to the New Mexico Water Quality Standards (20.6.4 NMAC), the general narrative standard 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 state's standard leading to an assessment of use impairment is the numeric criteria for turbidity of 25 NTU for this specific High Quality Coldwater Fishery (HQCWF).

The total suspended solids (TSS) analytical method is a commonly used measurement of suspended material in surface water. This method was originally developed for use on wastewater samples, but has widely been used as a measure of suspended materials in stream samples because it is acceptable for regulatory purposes and is an inexpensive laboratory procedure. Since there are no wastewater treatment plants discharging into Rito de Tierra Amarilla, it is assumed that TSS measurements in these ambient stream samples are representative of erosional activities and thus comprised primarily of suspended sediment vs. any potential biosolids from wastewater treatment plant effluent.

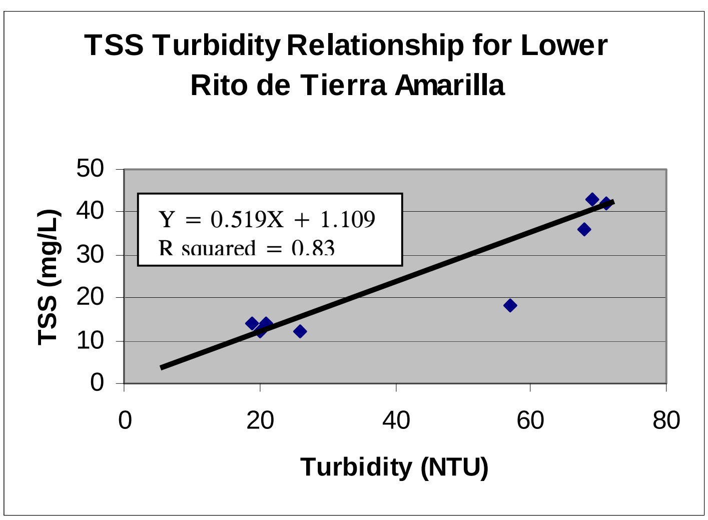
Turbidity levels can be inferred from studies that monitor suspended sediment concentrations. Extrapolation from these studies is possible when a site-specific relationship between concentrations of suspended sediments and turbidity is confirmed. Activities that generate varying amounts of suspended sediment will proportionally change or affect turbidity (USEPA 1991). The impacts of suspended sediment and turbidity are well documented in the literature. An increased sediment load is often the most important adverse effect of activities on streams, according to a monitoring guidelines report (USEPA 1991). This impact is largely a mechanical action that severely reduces the available habitat for macroinvertebrates and fish species that utilize the streambed in various life stages. An increase in suspended sediment concentration will reduce the penetration of light, decreases the ability of fish or fingerlings to capture prey, and reduce primary production (USEPA 1991). Specifically, increased turbidity by sediments can reduce stream primary production by reducing photosynthesis, physically abrading algae and other plants, and preventing attachment of autotrouphs to substrate surfaces (Van Nieuwenhuyse and LaPierre 1986, Brookes 1986).

At the lower sampling station on Rito de Tierra Amarilla, TSS and turbidity were measured during the 1998 survey (Table 3.1). The TSS target was derived using a regression equation developed using measured turbidity as the independent variable and measured TSS dependent variable. The equation and regression statistics are displayed below in Figure 3.1. A correlation (R^2=0.83) was found between TSS and turbidity for Rito de Tierra Amarilla.

Table 3.1 TSS and turbidity data from Rito de Tierra Amarilla at State Highway 112

Sample Date	TSS (mg/L)	Turbidity (NTU)
980601	14	19
980602	12	26*
980603	14	21
980604	12	20
980818	36	68*
980819	18	57*
981020	43	69*
981021	42	71*

* Exceedence of 25 NTU water quality criterion. Arithmetic mean of TSS values when measured turbidity exceeded the standard = 30.2 mg/L



SUMMARY OUTPUT	
Regression Statistics	
Multiple R	0.909114987
R Square	0.82649006
Adjusted R Square	0.797571736
Standard Error	6.254828273
Observations	8

Figure 3.1 Relationship between TSS and Turbidity at Rito de Tierra Amarilla

Flow

Sediment transport in a stream varies as a function of flow. As flow increases, the amount of sediment being transported increases. This TMDL is calculated for each reach at a specific flow. When available, US Geologic Survey gages are used to estimate flow. Where gages are absent, geomorphologic cross sectional information is taken at each site and the flows are modeled. Gaged streamflow data are not available for Rito de Tierra Amarilla. Cross sectional data was taken in order to estimate stream discharge using procedures from USGS Technical Paper 2193 (USGS 1982).

For perennial streams in areas with alpine regional-runoff characteristics and silt-clay or armored channel material characteristics, average annual discharge is calculated using the following regression equation (USGS 1982):

$Q_A = 64W_{ac}^{\ 1.88}$
Where Q_A = acre-feet/year and W_{ac} = width of the active channel (i.e., width at bankfull) in feet.

According to cross-section field data (see Appendix A), the width of Rito de Tierra at bankfull is 19.15 feet. Therefore,

RITO DE TIERRA AMARILLA --
$Q_A = 64W_{ac}^{\ 1.88} = 64\ (19.15\ \text{ft})^{1.88} = 16{,}468$ acre-feet/year
Q_A = 16,468 acre-feet/year (1 year/365 day) (1 day/86,400 sec) (43,560 ft3/acre-feet)
Q_A = 22.7 cfs

Q_A = 22.7 cfs (1 cfs/1.5473 mgd)
Q_A = 14.7 mgd

Average discharge is defined as that flow rate which would yield the observed annual volume of water if continued every day of the year. The average discharge usually fills a channel to approximately one-third of the channel depth and this flow rate is equaled or exceeded approximately 25% of the days in any given year (Leopold et al. 1964). Therefore, approximately 75% of the time, flows are less than then average discharge. The cross section of the channel and adjacent floodplain is key to predict velocity and water surface stage elevation during high and low flow events. 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 these systems the target load will vary based on the changing flow. Management of the load should set a goal at water quality standards attainment versus meeting the calculated target load.

Calculations

Target loads for turbidity (expressed as TSS) are calculated based on a flow, the current water quality standards, and a conversion factor (8.34) that is a used to convert mg/L units to lbs/day (see Appendix B for Conversion Factor Derivation). The target loading capacity is calculated using Equation 1. The results are shown in Table 3.2.

Equation 1. critical flow (mgd) x standard (mg/L) x 8.34 (conversion factor) = target loading capacity

Table 3.2 Calculation of target loads for turbidity (expressed as TSS)

Location	Flow+ (mgd)	TSS* (mg/L)	Conversion Factor	Target Load Capacity (lbs/day)
Rito de Tierra Amarilla	14.7	14.1	8.34	1728.6

+ Since USGS gages were unavailable, flows are modeled using cross-sectional field data in order to estimate average stream discharge using USGS technical paper 2193 (USGS 1982).
*The TSS value was calculated using the relationship established between TSS and turbidity in Figure 3.1 (Y=0.519X + 1.109, R^2=0.83) using the turbidity standard of 25 NTU for the X variable.

The measured loads for turbidity (expressed as TSS) were similarly calculated. In order to achieve comparability between the target and measured loads, the flows used were the same for both calculations. The arithmetic mean of corresponding TSS values when turbidity exceeded the standard was substituted for the standard in Equation 1. The same conversion factor of 8.34 was used. Results are presented in Table 3.3.

Table 3.3 Calculation of measured loads for turbidity (expressed as TSS)

Location	Flow+ (mgd)	TSS Arithmetic Mean * (mg/L)	Conversion Factor	Measured Load Capacity (lbs/day)
Rito de Tierra Amarilla	14.7	30.2	8.34	3702.5

+ Since USGS gages were unavailable, flows are modeled using cross-sectional field data in order to estimate average stream discharge using USGS technical paper 2193 (USGS 1982).
* Arithmetic mean of TSS values when measured turbidity exceeded the standard (see Table 3.1).

Waste Load Allocations and Load Allocations

•*Waste Load Allocation*
There are no point source contributions associated with this TMDL. The waste load allocation (WLA) is zero.

•*Load Allocation*

In order to calculate the Load Allocation (LA), the WLA and margin of safety (MOS) were subtracted from the target capacity (TMDL) following Equation 2.

Equation 2. $WLA + LA + MOS = TMDL$

The MOS is estimated to be 25% of the target load calculated in Table 3.2. Results are presented in Table 3.4. Additional details on the MOS chosen are presented in section 3.3 below.

Table 3.4 Calculation of TMDL for turbidity

Location	WLA (lbs/day)	LA (lbs/day)	MOS (25%) (lbs/day)	TMDL (lbs/day)
Rito de Tierra Amarilla	0	1296.4	432.2	1728.6

The extensive data collection and analyses necessary to determine background turbidity loads for the Rito de Tierra Amarilla watershed was 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 load reductions that would be necessary to meet the target loads were calculated to be the difference between the target load allocation (Table 3.2) and the measured load (Table 3.3), and are shown in Table 3.5.

Table 3.5 Calculation of load reduction for turbidity (expressed as TSS)

Location	Load Allocation (lbs/day)	Measured Load (lbs/day)	Load Reduction (lb/day)
Rito de Tierra Amarilla	1296.4	3702.5	2406.1

Identification and Description of pollutant source(s)

Pollutant sources that could contribute to each segment are listed in Table 3.6.

Table 3.6 Pollutant source summary for turbidity

Pollutant Sources	**Magnitude** (Load Allocation + MOS)	**Location**	**Potential Sources** (% from each)
Point: None	0	--------	0%
Nonpoint: Turbidity (expressed as TSS in lbs/day)		Rito de Tierra Amarilla	100% Range Grazing -- Riparian or Upland, Removal of Riparian Vegetation Road Maintenance and Runoff Flow Regulation/Modification Agriculture

Linkage of Water Quality and Pollutant Sources

Turbidity is an expression of the optical property in water that causes incident light to be scattered of absorbed rather than transmitted in straight lines. It is the condition resulting from suspended solids in the water, including silts, clays, and plankton. Such particles absorb heat in the sunlight, thus raising water temperature, which in turn lowers dissolved oxygen levels. It also prevents sunlight from reaching plants below the surface. This decreases the rate of photosynthesis, so less oxygen is produced by plants. Turbidity may harm fish and their larvae. Turbidity exceedences, historically, are generally attributable to soil erosion, excess nutrients, various wastes and pollutants, and the stirring of sediments up into the water column during high flow events. Turbidity increases, as observed in SWQB monitoring data, show turbidity values along this reach that exceed the State Standards for the protection of aquatic habitat, namely the high quality cold water fishery (HQCWF) designed use. Through monitoring, and pollutant source documentation, it has been observed that the most probable cause for these exceedences are due to the alteration of the stream's hydrograph and grazing impacts. Alterations can be historical or current in nature.

The components of a watershed continually change through natural ecological processes such as vegetation succession, erosion, and evolution of stream channels. Intrusive human activity often affects watershed function in ways that are inconsistent with the natural balance. These changes, often rapid and sometimes irreversible, occur when people:

- cut forests
- clear and cultivate land
- remove stream-side vegetation
- alter the drainage of the land
- channelize watercourses
- withdraw water for irrigation
- build towns and cities
- discharge pollutants into waterways.

Possible effects of these practices on aquatic ecosystems include:

1. Increased amount of sediment carried into water by soil erosion which may

    - increase turbidity of the water
    - reduce transmission of sunlight needed for photosynthesis
    - interfere with animal behaviors dependent on sight (foraging, mating, and escape from predators)
    - impede respiration (e.g., by gill abrasion in fish) and digestion
    - reduce oxygen in the water
    - cover bottom gravel and degrade spawning habitat cover eggs, which may suffocate or develop abnormally; fry may be unable to emerge from the buried gravel bed

2. Clearing of trees and shrubs from shorelines which may

- destabilize banks and promote erosion
- increase sedimentation and turbidity
- reduce shade and increase water temperature which could disrupt fish metabolism
- cause channels to widen and become more shallow

3. Land clearing, constructing drainage ditches, straightening natural water channels which may

   - create an obstacle to upstream movement of fish and suspend more sediment in the water due to increased flow
   - strand fish upstream and dry out recently spawned eggs due to subsequent low flows
   - reduce baseflows

Where available data are incomplete or where 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 (SWQB/NMED 1999c). The completed Pollutant Source(s) Documentation Protocol forms in Appendix C 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 3.6 (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 stream, which is predominantly privately held, but also to consider upland and upstream areas in a more holistic watershed approach to implementing this TMDL.

The primary sources of impairment for this reach identified in the state 303(d) list are range grazing, removal of riparian vegetation, road maintenance, flow regulation/modification, and agriculture. There were no turbidity exceedences observed at the upper Rito de Tierra Amarilla sampling station (SWQB station 15) during the 1998 survey. Increased turbidity at the lower station (SWQB station 16) likely results from a number of potential factors. There is a change in soil type and geology from the upper station to the lower station in the valley. The main sources of impairment along this lower reach appear to be from livestock grazing and removal of riparian vegetation in the floodplain upstream of the lower sampling stations. Agricultural practices such as grazing appear to have contributed to the removal of riparian vegetation and streambank destabilization. Field staff observed several horses, colts, and cattle while taking measurements at the lower sampling station. There are several small animal confinement pens, irrigation return flow, and poorly designed culverts at road crossings (SWQB/NMED 2001a). The reach flows through Tierra Amarilla in which all the above factors are concentrated (Photo 06). When the area was first settled, creating narrow strips from the road all the way to the stream so each family's livestock would have access to a water source broke up land. In many instances, these plots have been completely cleared of vegetation that would have filtered out sediments before reaching the stream. Direct access of livestock to the stream banks has caused streambank destabilization in many areas.

The channel appears to have an increased width-to-depth ratio throughout this lower portion of the Rito de Tierra Amarilla as a result of the above-mentioned landuse practices. Given the low valley slope at the lower station (0.0036), the channel should be narrower and deeper which would transport sediment more efficiently (Rosgen 1996).

Photo 06. Rito de Tierra Amarilla immediately upstream of HWY 84, 10/02/02.

3.3 Margin of Safety (MOS)

TMDLs should reflect a margin of safety based on the uncertainty or variability in the data, the point and nonpoint source load estimates, and the modeling analysis. For this TMDL, there will be no margin of safety for point sources since there are none in Rito de Tierra Amarilla. However, for the nonpoint sources the margin of safety is estimated to be an addition of **25%** of the TMDL. This margin of safety incorporates several factors:

•*Errors in calculating NPS loads*

A level of uncertainty does exist in the relationship between TSS and turbidity. In this case, the TSS measure does not include bedload and therefore does not account for a complete measure of sediment load. This does not influence the MOS because we need only be concerned with the turbidity portion of the sediment load, which is the basis for the standard. However, there is a potential to have errors in measurements of nonpoint source loads due to equipment accuracy, time of sampling, etc. Accordingly, a conservative margin of safety increases the TMDL by **15%**.

•*Errors in calculating flow*

Flow estimates were based on estimated mean average annual discharge using cross-section field data (Appendix A) and USGS Technical Paper 2193 (USGS 1982). To be conservative, an additional MOS of **10%** will be included to account for accuracy of flow computations.

3.4 Consideration of Seasonal Variation

Data used in the calculation of this TMDL were collected during spring, summer, and fall in order to ensure coverage of any potential seasonal variation in the system. Since the critical condition is set to estimate average stream discharge, all data collected throughout the seasons were used in determining the target capacities. Therefore, it is assumed that if critical conditions are met, coverage of any potential seasonal variation will also be met.

3.5 Future Growth

Estimations of future growth are not anticipated to lead to a significant increase for turbidity that cannot be controlled with best management practice implementation in this watershed.

4.0 STREAM BOTTOM DEPOSITS

4.1 Summary

During the 1998 SWQB intensive water quality survey in the Upper Rio Chama Watershed, impairment of the aquatic community due to excessive stream bottom deposits (SBD) was documented at the lower sampling station on Rito de Tierra Amarilla (SWQB Station 16). Consequently, the Rito de Tierra Amarilla from Rio Chama to State Highway 64 was listed on the 2000-2002 Clean Water Act §303(d) list for SBD.

4.2 Endpoint Identification

Target Loading Capacity

Target values for this SBD TMDL 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. This TMDL is also consistent with New Mexico's antidegradation policy.

According to the New Mexico water quality standards (20.6.4.12.A NMAC), the general criterion for SBD reads:

> Bottom Deposits
>
> Surface waters of the state shall be free of water contaminants from other than natural causes that will settle and damage or impair the normal growth, function, or reproduction of aquatic life or significantly alter the physical or chemical properties of the bottom.

The impact of fine sediment deposits is well documented in the literature. An increased sediment load is often the most important adverse effect of activities on streams, according to a monitoring guidelines report (USEPA 1991). This impact is largely a mechanical action that severely reduces the available habitat for macroinvertebrates and fish species that utilize the streambed in various life stages. Minshall (1984) cited the importance of substratum size to aquatic insects and found that substratum is a primary factor influencing the abundance and distribution of insects. Aquatic detritivores also can be affected when their food supply either is buried under sediments or diluted by increased inorganic sediment load and by increasing search time for food (Relyea et al., 2000).

The SWQB Sediment Workgroup evaluated a number of methods described in the literature that would provide information allowing a direct assessment of the impacts to the stream bottom substrate. As a result, SWQB/NMED compiled techniques to measure the level of sedimentation of a stream bottom in a SWQB/NMED draft Protocol for the Assessment of Stream Bottom Deposits in order to address the narrative criteria for SBD (SWQB/NMED 2001c). The purpose of the Protocol is to provide a reproducible quantification of the narrative criteria for SBD. A final set of monitoring procedures was implemented at a wide variety of sites during the 1998 monitoring season. These procedures included conducting pebble counts (to determine percent fines), stream bottom cobble embeddedness, geomorphologic measurements, and the collection and enumeration of benthic macroinvertebrates.

The target levels involved the examination of developed relationships between percent fines and biological score as compared to a reference site. Using existing data from New Mexico, a strong relationship (R^2=0.75) was established between embeddedness and the biological scores using data collected in 1998 (SWQB/NMED 2001c). A strong correlation (R^2= 0.719) was also found when relating embeddedness to percent fines. Although these correlations were based on a limited data set, TMDL studies on other reaches, including those in the Cimarron Basin, the Jemez Basin, and the Rio Guadalupe, have shown this relationship to be consistent. These relationships show that at the desired biological score of at least 70, the target embeddedness for fully supporting a designated use would be 45% and the target fines would be 20% (SWQB/NMED 2001c). Since this relationship is based on New Mexico streams, 20% was chosen for the target value for percent fines.

Rito de Tierra Amarilla at HWY 64 (SWQB station 15) was chosen as the benthic macroinvertebrate reference station for Rito de Tierra Amarilla at HWY 112 (SWQB station 16). They are both in ecoregion 21 and have similar geomorphic characteristics as displayed in Table 4.1 (see Appendix A for field data). Benthic macroinvertebrate samples and pebble counts were collected at both stations (Barbour et al. 1999, Wohlman 1954) (Photo 07).

Table 4.1 Geomorphic characteristics of benthic macroinvertebrate sampling sites

Dimensions	Station 15 (reference site)	Station 16 (study site)
x-section area (ft)	10.9	18.2
width (ft)	14.1	19.1
max depth (ft)	1.2	1.4
mean depth (ft)	0.76	1.0
width/depth ratio	18.6	20.0
entrenchment ratio	1.4	1.4

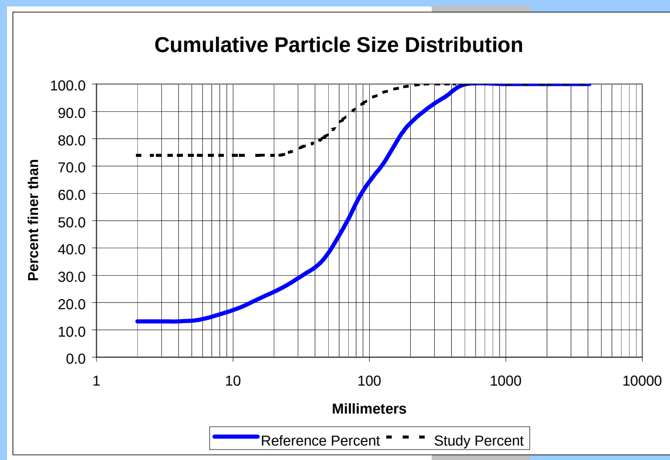
Collection of benthic macroinvertebrates involved the compositing of three individual kick net samples taken from a riffle at each sampling location. Each kick involved the disturbance of approximately one-third of a square meter of substrate for one minute into a 500-micron mesh net. The rapid bioassessment protocol metrics were applied to a 300-organism subsample of the composite sample at each site (Barbour et al. 1999). Selection of those metrics that are particularly suited to the delineation of sediment impacts highlights the degree of impairment. Ephemeroptera/ Plecoptera/ Tricoptera (EPT) Taxa, the number of sediment adapted organisms, taxa richness, and Hilsenhoff's Biotic Index (HBI) all indicate some degree of impairment attributable to sedimentation. Select results of the pebble count and benthic macroinvertebrate surveys are shown in Table 4.2 and Figure 4.1 (SWQB/NMED 2001a). See Appendix A for field data.

Table 4.2 Pebble count and benthic macroinvertebrate results

Results	Station 15 (reference)	Station 16 (study)	Percent of reference
Pebble count			
percent fines (< 2 mm)	26	74	285%
D50	69	na	
D84	186	55	
Benthic metrics			
Standing crop (#/m^2)	1480	133	
EPT taxa	20	5	
Taxa richness	30	18	
HBI	3.1	5.5	
Total biologic score	58	24	41%
Total habitat score (out of a possible 200)	179	99	55%

Photo 07. Substrate at Rito de Tierra Amarilla at HWY 112, 10/22/01.

Cumulative Distribution		
Size finer than (mm)	Reference Percent	Study Percent
2	13.1	74.0
2.8	13.1	74.0
4	13.1	74.0
5.6	13.6	74.0
8	15.7	74.0
11.3	18.2	74.0
16	21.7	74.0
22.6	25.3	74.0
32	29.8	77.0
45.3	35.4	80.0
64	47.0	87.0
90.5	61.1	93.0
128	71.2	97.0
181	83.3	99.0
256	90.4	100.0
362	95.5	100.0
512	100.0	100.0
1024	100.0	100.0
2048	100.0	100.0
4096	100.0	100.0



Histogram		
Size finer than (mm)	Reference Percent	Study Percent
2	13.1	74.0
2.8	0.0	0.0
4	0.0	0.0
5.6	0.5	0.0
8	2.0	0.0
11.3	2.5	0.0
16	3.5	0.0
22.6	3.5	0.0
32	4.5	3.0
45.3	5.6	3.0
64	11.6	7.0
90.5	14.1	6.0
128	10.1	4.0
181	12.1	2.0
256	7.1	1.0
362	5.1	0.0
512	4.5	0.0
1024	0.0	0.0
2048	0.0	0.0
4096	0.0	0.0

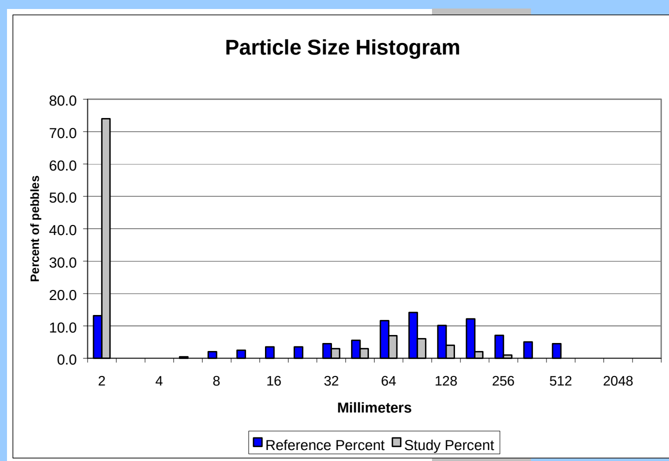


Figure 4.1 Comparison of pebble count data at stations 15 (reference) and 16 (study) (USFS 2001).

Calculations

No calculations were necessary because all loads are specified in percent fines.

The target loads for SBD are show in Table 4.3.

Table 4.3 Calculation of Target Loads for SBD

Location	SBD Standards* (% fines)	SBD Target Load Capacity (% fines)
Rito de Tierra Amarilla	20	20

*This value is based on a narrative standard. The background values for stream bottom deposits were taken from the SBD assessment protocol (SWQB/NMED 2001c).

Measured load was determined by a pebble count as described in the SBD assessment protocol (SWQB/NMED 2001c). Fines are defined as particles less than 2 mm in diameter. Results are displayed in Table 4.4 and Figure 4.1. See Appendix A for field data.

Table 4.4 Calculation of Measured Loads for SBD

Location	SBD (% fines)	SBD Measured Load (% fines)
Rito de Tierra Amarilla	74	74

Waste Load Allocations and Load Allocations

•*Waste Load Allocation*
There are no point source contributions associated with this TMDL. The waste load allocation (WLA) is zero.

•*Load Allocation*
In order to calculate the Load Allocation (LA), the WLA and margin of safety (MOS) were subtracted from the target capacity (TMDL) following Equation 2.

Equation 2. $WLA + LA + MOS = TMDL$

The MOS is estimated to be 25% of the target load calculated in Table 4.3. Results are presented in Table 4.5. Additional details on the MOS chosen are presented in section 4.3 below.

Table 4.5 Calculation of TMDL for Stream Bottom Deposits

Location	WLA (% fines)	LA (% fines)	MOS (25%) (% fines)	TMDL (% fines)
Rito de Tierra Amarilla	0	15	5	20

The extensive data collection and analyses necessary to determine background SBD loads for the Rito de Tierra Amarilla watershed was 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 load reductions that would be necessary to meet the target loads were calculated to be the difference between the target load allocation (Table 4.3 and 4.5) and the measured load (Table 4.4), and are shown in Table 4.6.

Table 4.6 Calculation of Load Reduction for Stream Bottom Deposits

Location	Load Allocation (% fines)	Measured Load (% fines)	Load Reduction (% fines)
Rito de Tierra Amarilla	15	74	59

Identification and Description of pollutant source(s)

Pollutant sources that could contribute to each segment are listed in Table 4.7.

Table 4.7 Pollutant source summary for Stream Bottom Deposits

Pollutant Sources	**Magnitude** (Load Allocation + MOS)	**Location**	**Potential Sources** (% from each)
Point: None	0	--------	0%
Nonpoint: Stream Bottom Deposits (expressed as percent fines)		Rito de Tierra Amarilla	100% Range Grazing -- Riparian or Upland, Removal of Riparian Vegetation Road Maintenance and Runoff Flow Regulation/Modification Agriculture

Linkage of Water Quality and Pollutant Sources

Where available data are incomplete or where 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 (SWQB/NMED 1999c). The completed Pollutant Source(s) Documentation Protocol forms in Appendix C 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 4.7 (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 stream, which is predominantly privately held, but also to consider upland and upstream areas in a more holistic watershed approach to implementing this TMDL.

A substantial and healthy benthic macroinvertebrate community exists at the upper Rito de Tierra Amarilla sampling station (SWQB station 15). An increase in percent fines and consequent reduction in biological score at the lower station (SWQB station 16) results from a number of potential factors. There is a change in soil type and geology from the upper station to the lower station in the valley. The main sources of impairment along this lower reach appear to be from livestock grazing and removal of riparian vegetation in the floodplain upstream of the lower sampling stations. Agricultural practices such as grazing appear to have contributed to the removal of riparian vegetation and streambank destabilization. Field staff observed several horses and cattle while taking measurements at the lower sampling station (Photo 08). There are several small animal confinement pens, irrigation return flows, and poorly designed culverts at road crossings (SWQB/NMED 2001a). The reach flows through Tierra Amarilla in which all the above factors are concentrated (Photo 06). When the area was first settled, creating narrow strips from the road all the way to the stream so each family's livestock would have access to a water source broke up land. In many instances, these plots have been completely cleared of vegetation that would have filtered out sediments before reaching the stream. Direct access of livestock to the stream banks has caused streambank destabilization in many areas.

Photo 08. Rito de Tierra Amarilla upstream of HWY 112, 06/11/02.

The channel appears to have an increased width-to-depth ratio throughout this lower portion of the Rito de Tierra Amarilla as a result of the above-mentioned landuse practices. Given the low valley slope at the lower station (0.0036), the channel should be narrower and deeper which would transport sediment more efficiently (Rosgen 1996). There are also irrigation ditches coming off of the Rito de Tierra Amarilla that at times divert the majority of the flow from the stream. Reductions in flow due to irrigation demands can greatly reduce a stream's ability to efficiently transport sediment. At present, the state of New Mexico does not have an "instream flow" mechanism in place whereby water would be left in a stream bed to be used to protect habitat and water quality for fish, wildlife, recreational, and/or aesthetic uses.

4.3 Margin of Safety (MOS)

TMDLs should reflect a margin of safety based on the uncertainty or variability in the data, the point and nonpoint source load estimates, and the modeling analysis. For this TMDL, there will be no margin of safety for point sources since there are none. However, the margin of safety is estimated to be an addition of **25%** for SBD caused by nonpoint sources, excluding background. This margin of safety incorporates several factors:

•*Errors in calculating NPS loads*

A level of uncertainty exists in the relationship between embeddedness, fines, and biological score. In this case, the percent fines are based on a narrative standard and there are also potential errors in measurement of nonpoint source loads due to equipment accuracy, time of sampling, and other factors. Accordingly, a conservative margin of safety for SBD increases the TMDL by **25%.**

•*Errors in calculating flow*

Flow estimates were not needed for the SBD calculations, thus do not warrant additional MOS.

4.4 Consideration of seasonal variation

Data used in the calculation of this TMDL were collected during the fall which is biological index period SWQB/NMED has determined is the best time to collect benthic macroinvertebrates in New Mexico (SWQB/NMED 2001b). Fall is a critical time in the life cycle stages of benthic macroinvertebrates in New Mexico. Fall is also generally the low-flow period of the mean annual hydrograph in New Mexico when bottom deposits are most likely to settle and cause impairment, after the summer monsoon season but before annual spring runoff. It is assumed that if critical conditions are met during this time, coverage of any potential seasonal variation will also be met.

4.5 Future Growth

Estimations of future growth are not anticipated to lead to a significant increase for SBD that cannot be controlled with best management practice (BMP) implementation in this watershed.

5.0 TEMPERATURE

5.1 Summary

During the 1998 SWQB sampling monitoring effort in the Upper Rio Chama Watershed, thermograph data recorded several exceedences of the New Mexico water quality standard for temperature throughout the watershed. Thermographs were set to record every 15 minutes for several weeks to months during the warmest time of the year (generally June through September). Thermograph data are assessed using the SWQB/NMED temperature protocol (SWQB/NMED 2001b). Rio Chamita, Rio Chama, Chavez Creek, Rio Brazos, and Rito de Tierra Amarilla were listed on the 2000-2002 Clean Water Act §303(d) list for temperature. A TMDL for temperature was previously completed for Rio Chamita (SWQB/NMED 1999b).

5.2 Endpoint Identification

Target Loading Capacity

Target values for these temperature 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 temperature are based on the reduction in solar radiation necessary to achieve numeric criteria as predicted by a temperature model. This TMDL is also consistent with New Mexico's antidegradation policy.

The New Mexico WQCC has adopted numeric water quality criteria for temperature to protect the designated use of HQCWF (20.6.4.900.C NMAC). These water quality standards have been set at a level to protect cold-water aquatic life such as trout. The HQCWF use designation requires that a stream reach must have water quality, streambed characteristics, and other attributes of habitat sufficient to protect and maintain a propagating coldwater fishery (i.e., a population of reproducing salmonids). The primary standard leading to an assessment of use impairment is the numeric criterion for temperature of 20 °C (68°F). The following TMDLs address the following reaches where temperatures exceeded the criterion (see Appendix D for graphical representation of thermograph data):

> RIO CHAMA -- Two thermographs were deployed on this reach in 1998. The upper thermograph was deployed under the HWY 17 bridge (SWQB station 8) and did not exceed the HQCWF criterion. The lower thermograph was deployed at the Rio Chama and Hwy 84 fishing access (SWQB station 9). Recorded temperatures exceeded the HQCWF criterion 363 of 1,704 times with a maximum temperature of 26°C. In 2002, a thermograph was deployed in the Rio Chama at under HWY 95 bridge immediately downstream of the listed reach for verification and model calibration purposes. Recorded temperatures exceeded the HQCWF criterion 912 of 2616 times with a maximum temperature of 27.9°C. A thermograph re-deployed at station 9 was destroyed either by vandals or while an in-channel irrigation diversion was being constructed.

CHAVEZ CREEK -- In 1998, one thermograph was deployed on Chavez Creek at the County RD 512 bridge (SWQB station 13). Recorded temperatures exceeded the HQCWF criterion 160 of 864 times with a maximum temperature of 26°C. In 2002, a thermograph was re-deployed at this location for verification and model calibration purposes. Recorded temperatures exceeded the HQCWF criterion 371 of 2616 times with a maximum temperature of 28.7°C.

RIO BRAZOS -- Two thermographs were deployed on this reach in 1998. The upper thermograph was deployed above Corkin's Lodge (SWQB station 12) and did not exceed the HQCWF criterion. The lower thermograph was deployed at the Rio Brazos and Hwy 84 bridge (SWQB station 14). Recorded temperatures exceeded the HQCWF criterion 463 of 1,752 times with a maximum temperature of 27°C. In 2002, a thermograph was re-deployed at this location for verification and model calibration purposes. Recorded temperatures exceeded the HQCWF criterion 944 of 2586 times with a maximum temperature of 29.2°C. An additional thermograph was deployed in the Rio Brazos at County Road 162 near the upstream end of the listed reach for verification and model calibration purposes.

RITO DE TIERRA AMARILLA -- Two thermographs were deployed on this reach in 1998. The upper thermograph was deployed at the HWY 64 bridge (SWQB station 15) and did not exceed the HQCWF criterion. The lower thermograph was deployed on the Rito de Tierra Amarilla at the Hwy 112 bridge (SWQB station 16) and exceeded the HQCWF criterion 194 of 864 times with a maximum temperature of 29.5°C. In 2002, a thermograph was re-deployed at the upper station location for verification and model calibration purposes. Recorded temperatures did not exceed the HQCWF criterion. It was not possible to re-deploy a thermograph at the lower station because channel flow was reduced to standing pools during the summer months in 2002.

Calculations

The Stream Segment Temperature (SSTEMP) version 2.0 was used to predict stream temperatures based on watershed geometry, hydrology, and meteorology. This model was developed by the USGS Biological Resource Division (Bartholow 2002). The model predicts minimum 24-hour temperatures, mean 24-hour temperatures, and maximum 24-hour stream temperatures for a given day, as well as a variety of intermediate values. The predicted temperature values are compared to actual thermograph readings measured in the field in order to calibrate the model. The SSTEMP model identifies current stream and/or watershed characteristics that control stream temperatures. The model also quantifies the maximum loading capacity of the stream to meet water quality criteria for temperature. This model is important for estimating the effect of changing controls or factors (such as riparian grazing, stream channel alteration, and reduced streamflow) on stream temperature. The model can also be used to help identify possible implementation activities to improve stream temperature by targeting those factors causing impairment to the stream.

Waste Load Allocations and Load Allocations

•Waste Load Allocation
There are no point source contributions associated with this TMDL. The waste load allocation (WLA) is zero.

•Load Allocation
Water temperature can be expressed as heat energy per unit volume. SSTEMP provides an estimate of heat energy per unit volume expressed in joules (the absolute meter kilogram-second unit of work or energy equal to 10^7 ergs or approximately 0.7375 foot pounds) per meter squared per second ($j/m^2/s$) and Langley's (a unit of solar radiation equivalent to one gram calorie per square centimeter of irradiated surface) per day. The following information relevant to the model runs used to determine temperature these TMDLs was copied from the user's manual (Bartholow 2002). Please refer directly to the user's manual for the complete text. Various notes have been added in parentheses to clarify local sources of input data.

DESCRIPTION OF LOGIC

SSTEMP version 2.0 integrates SSSOLAR version 1.6 and SSSHADE version 1.4 into one simple-to-use program. In general terms, SSTEMP calculates the heat gained or lost from a parcel of water as it passes through a stream segment. This is accomplished by simulating the various heat flux processes that determine temperature change. These physical processes include convection, conduction, evaporation, as well as heat to or from the air (long wave radiation), direct solar radiation (short wave), and radiation back from the water. SSTEMP first calculates the solar radiation and how much is intercepted by (optional) shading. This is followed by calculations of the remaining heat flux components for the stream segment. The details are just that: To calculate solar radiation, SSTEMP computes the radiation at the outer edge of the earth's atmosphere. This radiation is passed through the attenuating effects of the atmosphere and finally reflects off the water's surface depending on the angle of the sun. For shading, SSTEMP computes the day length for the level plain case, i.e., as if there were no local topographic influence. Next the local topography is factored in by computing the sunrise and sunset times based on the east and west-side topography. Thus, the local topography results in a percentage decrease in the level plain daylight hours. From this local sunrise/sunset, the program computes the percentage of light that is filtered out from the riparian vegetation. This filtering is the result of the size, position and density of the shadow-casting vegetation on both sides of the stream.

HYDROLOGY PARAMETERS

1. **Segment Inflow (cfs or cms)** -- Enter the mean daily flow at the top of the stream segment. If the segment begins at an effective headwater, the flow may be entered as zero; all accumulated flow will accrue from lateral inflow, both surface and groundwater.

If the segment begins at a reservoir, the flow will be the outflow from that reservoir. Remember that this model assumes steady-state flow conditions.

2. **Inflow Temperature (°F or °C)** -- Enter the mean daily water temperature at the top of the segment. If the segment begins at a true headwater, you may enter any water temperature, because zero flow has zero heat. If there is a reservoir at the inflow, use the reservoir release temperature. Otherwise, use the outflow from the upstream segment. [NOTE: Thermograph data from the top of the modeled reach is used to determine the inflow temperature.]

3. **Segment Outflow (cfs or cms)** -- The program calculates the lateral discharge by knowing the flow at the head and tail of the segment, subtracting to obtain the net difference, and dividing by segment length. The program assumes that lateral inflow (or outflow) is uniformly apportioned through the length of the segment. If any "major" tributaries enter the segment, you probably should divide the segment into two or more subsections. "Major" is defined as any stream contributing greater than 10% of the mainstem flow.
[NOTE: To be conservative, 4Q3 low flow values were used as the segment outflow. These critical low flows were used to decrease assimilative capacity of the stream to adsorb and disperse solar energy. See Appendix E for calculations.]

4. **Accretion Temperature (°F or °C)** -- 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. You can verify this by checking United States Geological Survey (USGS) well log temperatures. Exceptions may arise in areas of geothermal activity. If irrigation return flow makes up most of the lateral flow, it may be warmer than mean annual air temperature. Return flow may be approximated by equilibrium temperatures.
[NOTE: Mean annual air temperature data are found at the Western Regional Climate Center web site (www.wrcc.dri.edu).]

GEOMETRY PARAMETERS

1. **Latitude (decimal degrees or radians)** -- Latitude refers to the position of the stream segment on the earth's surface. It may be read off of any standard topographic map.
[NOTE: Latitude is generally determined in the field with a GPS unit.]

2. **Dam at Head of Segment (checked or unchecked)** -- If there is a dam at the upstream end of the segment with a constant, or nearly constant diel release temperature, check the box, otherwise leave it unchecked…Maximum daily water temperature is calculated by following a water column from solar noon to the end of the segment, allowing it to heat up towards the maximum equilibrium temperature. If there is an upstream dam within a half-day's travel time from the end of the segment, a parcel of water should only be allowed to heat for a shorter time/distance.

3. **Segment Length (miles or kilometers)** -- Enter the length of the segment for which you want to predict the outflowing temperature. Remember that all parameters will be assumed to remain constant for the entire segment. Length may be estimated from a topographic map, but a true measurement is best.
[NOTE: Segment length is determined with National Hydrographic Dataset Reach Indexing GIS tool.]

4. **Upstream Elevation (feet or meters)** -- Enter elevation as taken from a 7 ½ minute quadrangle map.
[NOTE: Upstream elevation is generally determined in the field with a GPS unit.]

5. **Downstream Elevation (feet or meters)** -- Enter elevation as taken from a 7 ½ minute quadrangle map. Do not enter a downstream elevation that is higher than the upstream elevation.
[NOTE: Downstream elevation is generally determined in the field with a GPS unit.]

6. **Width's A Term (seconds/foot^2 or seconds/meter^2)** -- This parameter may be derived by calculating the wetted width-discharge relationship… To conceptualize this, plot the width of the segment on the Y-axis and discharge on the X-axis of log-log paper…The relationship should approximate a straight line, the slope of which is the B term (the next parameter). Theoretically, the A term is the Y-intercept. However, the width vs. discharge relationship tends to break down at very low flows. Thus, it is best to calculate B as the slope and then solve for A in the equation:

$W = A * Q^B$
where:
Q is a known discharge
W is a known width
B is the power relationship

Regression analysis also may be used to develop this relationship. First transform the flow to natural log (flow) and width to natural log (width). Log (width) will be the dependent variable. The resulting X coefficient will be the B term and the (non-zero) constant will be the A term when exponentiated. That is:

A = e^constant from regression
where ^ represents exponentiation

As you can see from the width equation, width equals A if B is zero. Thus, substitution of the stream's actual wetted width for the A term will result if the B term is equal to zero. This is satisfactory if you will not be varying the flow, and thus the stream width, very much in your simulations. If, however, you will be changing the flow by a factor of 10 or so, you should go to the trouble of calculating the A and B terms more precisely. Width can be a sensitive factor under many circumstances.
[NOTE: After Width's B Term is determined (see note below), Width's A Term is calculated as displayed above.]

7. **Width's B Term (essentially dimensionless)** -- From the above discussion, you can see how to calculate the B term from the log-log plot. This plot may be in either English or international units. The B term is calculated by linear measurements from this plot. Leopold et al. (1964, p.244) report a variety of B values from around the world. A good default in the absence of anything better is 0.20; you may then calculate A if you know the width at a particular flow.
[NOTE: Width's B Term is calculated at the slope of the regression of the natural log of width and the natural log of flow. Width vs. flow data sets are determined by entering cross-section field data into WINXSPRO (USFS 1998). See Appendix E for details.]

8. **Manning's n (essentially dimensionless)** -- Manning's n is an empirical measure of the segment's "roughness." A generally acceptable default value is 0.035. This parameter is necessary only if you are interested in predicting the minimum and maximum daily fluctuation in temperatures. It is not used in the prediction of the mean daily water temperature.
[NOTE: Rosgen stream type is also taken into account when estimating Manning's n (Rosgen 1996).]

TIME OF YEAR

Month/Day (mm/dd) -- Enter the number of the month and day to be modeled. January is month 01, etc. This program's output is for a single day. To compute an average value for a longer period (up to one month), simply use the middle day of that period. The error encountered in so doing will usually be minimal. Note that any month in SSTEMP can contain 31 days.

METEOROLOGICAL PARAMETERS

1. **Air Temperature (°F or °C)** -- Enter the mean daily air temperature. This information may be measured (in the shade), and should be for truly accurate results; however, this and the other meteorological parameters may come from the Local Climatological Data (LCD) reports which can be obtained from the National Oceanic and Atmospheric Administration for a weather station near your site. The LCD Annual Summary contains monthly values, whereas the Monthly Summary contains daily values.

Use the adiabatic lapse rate to correct for elevational differences from the meteorological station:

$$Ta = To + Ct * (Z - Zo)$$

where:
Ta = air temperature at elevation E (°C)
To = air temperature at elevation Eo (°C)
Z = mean elevation of segment (m)
Zo = elevation of station (m)
Ct = moist-air adiabatic lapse rate (-0.00656 °C/m)

NOTE: Air temperature will usually be the single most important factor in determining water temperature.
[NOTE: Mean daily air temperature data are found at the Western Regional Climate Center web site (www.wrcc.dri.edu) or determined from air thermographs deployed in the shade near the instream thermograph locations. Regardless of the source, air temperatures are corrected for elevation using the above equation.]

2. **Maximum Air Temperature (°F or °C)** -- The maximum air temperature is a special case of an override condition. Unlike the other parameters where simply typing a value influences which parameters "take effect", the maximum daily air temperature overrides only if the check box is checked. If the box is not checked, the program continues to estimate the maximum daily air temperature from a set of empirical coefficients (Theurer et al. 1984) and will print the result in the grayed data entry box. You cannot enter a value in that box unless the box is checked. Note: maximum air temperature appears in the Intermediate Values portion of the screen, not with the other mean daily meteorology values.

3. **Relative Humidity (percent)** -- Obtain the mean daily relative humidity for your area by measurement or from LCD reports by averaging the four daily values given in the report. Correct for elevational differences by:

Rh = Ro * [1.0640 ^ (To-Ta)] * [(Ta+273.16)/(To+273.16)]
where:
Rh = relative humidity for temperature Ta (decimal)
Ro = relative humidity at station (decimal)
Ta = air temperature at segment (°C)
To = air temperature at station (°C)
^ = exponentiation

[NOTE: Relative humidity data are found at the Western Regional Climate Center web site (www.wrcc.dri.edu) or National Renewable Energy Laboratory (NREL) Solar Radiation Data Base web site (rredc.nrel.gov/solar/pubs/NSRDB). Regardless of the source, relative humidity data are corrected for elevation and temperature using the above equation.]

4. **Wind Speed (miles per hour or meters/second)** -- Obtainable from LCD reports. Wind speed also may be useful in calibrating the program to known outflow temperatures by varying it within some reasonable range. In the best of all worlds, SSTEMP would like wind speed to be right above the water's surface.
[NOTE: Wind speed data are found at the Western Regional Climate Center web site (www.wrcc.dri.edu) or NREL Solar Radiation Data Base web site (rredc.nrel.gov/solar/pubs/NSRDB).]

5. **Ground Temperature (°F or °C)** -- Use mean annual air temperature from LCD reports.
[NOTE: Mean annual air temperature is found at the Western Regional Climate Center web site (www.wrcc.dri.edu).]

6. **Thermal Gradient (Joules/Meter^2/Second/°C)** -- This elusive quantity is a measure of rate of thermal input (or outgo) from the streambed to the water. It is not a particularly sensitive parameter within a narrow range. This parameter may prove useful in calibration, particularly for the maximum temperature of small, shallow streams where it may be expected that surface waters interact with either the streambed or subsurface flows. In the absence of anything better, simply use the 1.65 default. Note that this parameter is measured in the same units regardless of the system of measurement used.

7. **Possible Sun (percent)** -- This parameter is an indirect measure of cloud cover. Measure with a pyrometer or use LCD Reports.
[NOTE: Percent possible sun is found at the Western Regional Climate Center web site (www.wrcc.dri.edu).]

8. **Dust Coefficient (dimensionless)** -- This value represents the amount of dust in the air. If you enter a value for the dust coefficient, SSTEMP will calculate the solar radiation. Representative values look like the following (TVA 1972):

Winter	6 to 13
Spring	5 to 13
Summer	3 to 10
Fall	4 to 11

If all other parameters are known for a given event, the dust coefficient may be calibrated by using known ground-level solar radiation data.

9. **Ground Reflectivity (percent)** -- The ground reflectivity is a measure of the amount of short-wave radiation reflected back from the earth into the atmosphere. If you enter a value for the ground reflectivity, SSTEMP will calculate the solar radiation.

Representative values look like the following (TVA 1972, Gray 1970):

Meadows and fields	14
Leaf and needle forest	5 to 20
Dark, extended mixed forest	4 to 5
Heath	10
Flat ground, grass covered	15 to 33
Flat ground, rock	12 to 15
Flat ground, tilled soil	15 to 30
Sand	10 to 20
Vegetation, early summer	19
Vegetation, late summer	29
Fresh snow	80 to 90
Old snow	60 to 80
Melting snow	40 to 60

Ice	40	to 50
Water	5	to 15

10. Solar Radiation (Langley's/day or Joules/meter^2/second) -- Measure with a pyrometer, or refer to Cinquemani et al. (1978) for reported values of solar radiation. If you do not calculate solar radiation within SSTEMP, but instead rely on an external source of ground level radiation, you should assume that about 90% of the ground-level solar radiation actually enters the water. Thus, multiply the recorded solar measurements by 0.90 to get the number to be entered. If you enter a value for solar radiation, SSTEMP will ignore the dust coefficient and ground reflectivity and "override' the internal calculation of solar radiation, graying out the unused input boxes.

SHADE PARAMETER

Total Shade (percent) -- This parameter refers to how much of the segment is shaded by vegetation, cliffs, etc. If 10% of the water surface is shaded through the day, enter 10. As a shortcut, you may think of the shade factor as being the percent of water surface shaded at noon on a sunny day. In actuality however, shade represents the percent of the incoming solar radiation that does not reach the water. If you enter a value for total shade, the optional shading parameters are ignored.
[NOTE: There is a set of Optional Shading Parameters that can also be used to calculate Total Shade in SSTEMP. In 2002, Optional Shading Parameters and concurrent densiometer readings were measured at seventeen Upper Chama stations in order to compared modeling results from the use of these more extensive data sets to modeling results using densiometer readings as an estimate of Total Shade. The estimated value for Total Shade was within 15% of the calculated value in all cases. Estimated values for Maximum Temperatures differed by less than 0.5% in all cases. The Optional Shading Parameters are dependent on the exact vegetation at each cross section, thus requiring multiple cross sections to determine an accurate estimate for vegetation at a reach scale. Densiometer readings are less variable and less inclined to measurement error in the field. Therefore, densiometer readings are used to determine Total Shade for each modeled reach. Aerial photos are also examined and considered whenever available.]

OUTPUT

The program will predict the minimum, mean, and maximum daily water temperature for the set of parameters you provide (Figure 5.1). The theoretical basis for the model is strongest for the mean daily temperature. The maximum is largely an estimate and likely to vary widely with the maximum daily air temperature. The minimum is computed by subtracting the difference between maximum and mean from the mean; but the minimum is always positive. Other output includes the intermediate parameters average width, average depth and slope, maximum daily air temperature (all calculated from the input parameters), and the mean daily heat flux components.

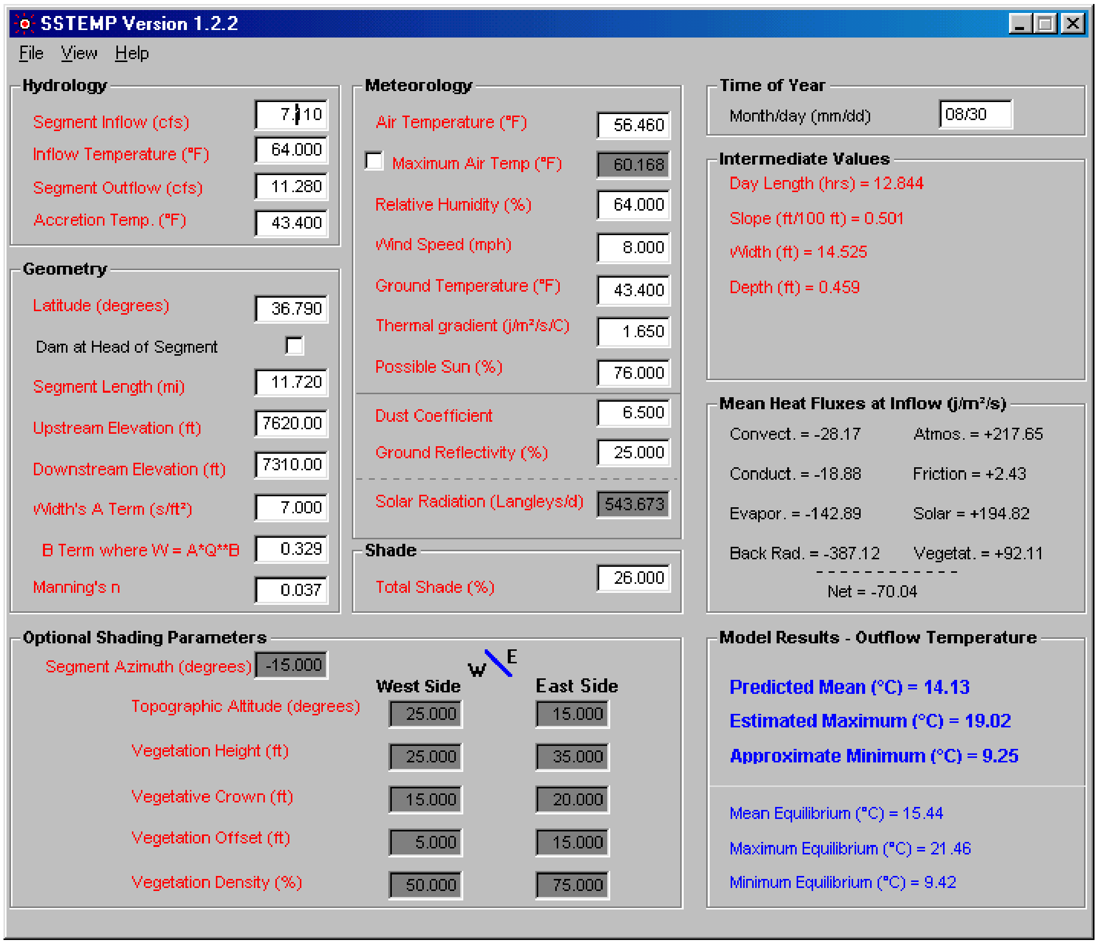


Figure 5.1 Example of SSTEMP input and output for Rio Chama.

The mean heat flux components are abbreviated as follows:

Convect. = convection component
Conduct. = conduction component
Evapor. = evaporation component
Back Rad. = water's back radiation component
Atmos. = atmospheric radiation component
Friction = friction component
Solar = solar radiation component
Vegetat. = vegetative and topographic radiation component
Net = sum of all the above flux values

The sign of these flux components indicates whether or not heat is entering (+) or exiting (-) the water. The units are in joules/meter^2/second. In essence, these flux components are the best indicator of the relative importance of the driving forces in heating and cooling the water from inflow to outflow. SSTEMP produces two sets of values, one based on the inflow to the segment and one based on the outflow. The user may toggle from one to the other by double clicking on the frame containing the values. In doing so, you will find that the first four flux values change as a function of water temperature which varies along the segment. In contrast, the last four flux values do not change because they are not a function of water temperature but of constant air temperature and channel attributes. For a more complete discussion of heat flux, please refer to Theurer et al. (1984).

SENSITIVITY ANALYSIS

SSTEMP may be used to compute a one-at-a-time sensitivity of a set of input values (Figure 5.2). Use View|Sensitivity Analysis or the scale toolbar button to initiate the computation. This simply increases and decreases most active input (i.e., non-grayed out values) by 10% and displays a screen for changes to mean and maximum temperatures. The schematic graph that accompanies the display gives an indication of which variables most strongly influence the results. This version does not compute any interactions between input values.

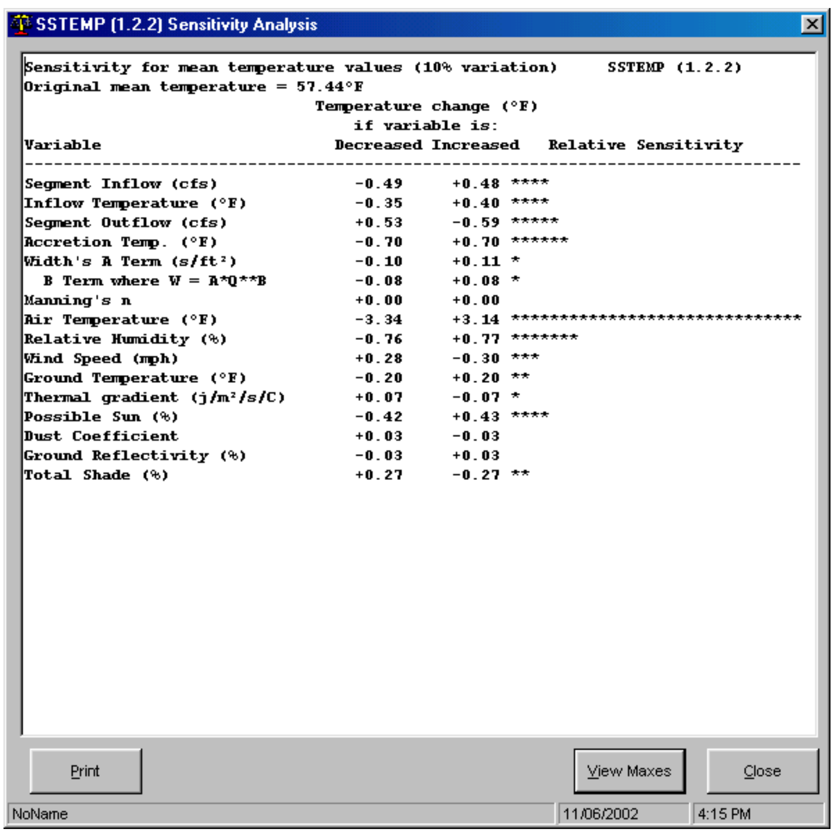


Figure 5.2 Example of SSTEMP sensitivity analysis for Rio Chama

UNCERTAINTY ANALYSIS

Previous versions of SSTEMP were deterministic; you supplied the "most likely" estimate of input variables and the model predicted the "most likely" thermal response. But choosing this "most likely" approach is like putting on blinders. There is variability in the natural system and inherent inaccuracy in the model. The previous model did not reflect variance in measured or estimated input variables (e.g., air temperature, streamflow, stream width) or parameter values (e.g., Bowen ratio, specific gravity of water); therefore they could not be used to estimate the uncertainty in the predicted temperatures. This version (2.0) adds an uncertainty feature that may be useful in estimating uncertainty in the water temperature estimates, given certain caveats.

The built-in uncertainty routine uses Monte Carlo analysis, a technique that gets its name from the seventeenth century study of the casino games of chance. The basic idea behind Monte Carlo analysis is that model input values are randomly selected from a distribution that describes the set of values composing the input. That is, instead of choosing one value for mean daily air temperature, the model is repeatedly run with several randomly selected estimates for air temperature in combination with random selections for all other relevant input values. The distribution of input values may be thought of as representing the variability in measurement and extrapolation error, estimation error, and a degree of spatial and temporal variability throughout the landscape. In other words, we may measure a single value for an input variable, but we know that our instruments are inaccurate to a degree and we also know that the values we measure might have been different if we had measured in a different location along or across the stream, or on a different day.

SSTEMP is fairly crude in its method of creating a distribution for each input variable. There are two approaches in this software: a percentage deviation and an absolute deviation. The percentage deviation is useful for variables commonly considered to be reliable only within a percentage difference. For example, USGS commonly describes stream flow as being accurate plus or minus 10%. The absolute deviation, as the name implies, allows entry of deviation values in the same units as the variable (*and always in international units*). A common example would be water temperature where we estimate our ability to measure temperature plus or minus maybe 0.2 degrees. Ultimately, SSTEMP converts all of the deviation values you enter to the percent representation before it computes a sample value in the range. No attempt is made to allow for deviations of the date, but all others are fair game, with three exceptions. First, the deviation on stream width is applied only to the A-value, not the B-term. If you want to be thorough, set the width to a constant by setting the B-term to zero. Second, if after sampling, the upstream elevation is lower than the downstream elevation, the upstream elevation is adjusted to be slightly above the downstream elevation. Third, you may enter deviations only for the values being used on the main screen.

The sampled value is chosen from either 1) a uniform (rectangular) distribution plus or minus the percent deviation, or 2) a normal (bell-shaped) distribution with its mean equal to the original value and its standard deviation equal to 1.96 times the deviation so that it represents 95% of the samples drawn from that distribution. If in the process of sampling from either of these two distributions, a value is drawn that is either above or below the "legal" limits set in SSTEMP, a new value is drawn from the distribution. For example, let's assume that you had a relative humidity of 99% and a deviation of 5 percent. If you were using a uniform distribution, the sample range would be 94.05 to 103.95; but you cannot have a relative humidity greater than 100%. Rather than prune the distribution at 100%, SSTEMP resamples to avoid over-specifying 100% values. No attempt has been made to account for correlation among variables, even though we know there is some. I have found little difference in using the uniform versus normal distributions, except that the normal method produces somewhat tighter confidence intervals.

SSTEMP's random sampling is used to estimate the average temperature response, both for mean daily and maximum daily temperature, and to estimate the entire dispersion in predicted temperatures. You tell the program how many *trials* to run (minimum of 11) and how many *samples* per trial (minimum of two). Although it would be satisfactory to simply run many individual samples, the advantage to this trial-sample method is twofold. First, by computing the average of the trial means, it allows a better, tighter estimate of that mean value. This is analogous to performing numerous "experiments" each with the same number of data points used for calibration. Each "experiment" produces an estimate of the mean. Second, one can gain insight as to the narrowness of the confidence interval around the mean depending on how many samples there are per trial. This is analogous to knowing how many data points you have to calibrate the model with and the influence of that. For example, if you have only a few days' worth of measurements, your confidence interval will be far broader than if you had several months' worth of daily values. But this technique does little to reduce the overall spread of the resulting predicted temperatures.

The deviations you control are arranged along the left side of the dialog box. The program uses default values that are meant to be representative of real-world values, but as always you need to scrutinize all of them for appropriateness for your situation. Grayed out items were unused on the main screen and therefore cannot be used on this screen. Display type, distribution type, number of trials and number of samples are on the top right. You may toggle the display between percent and absolute as often as you choose. Once satisfied with your values, pressing *Run* initiates the simulations. You can watch the variables change during the simulations on the main screen behind this dialog if you wish, though you will see this happen only periodically. You will also note that the routine uses whatever units (International or English) were on the main screen as it runs. The model is run a total of Trials * Samples per Trial times, and the results collected. If need be, you may press the *Stop* button to terminate the process.

Once the analysis is complete, a summary of the temperature output appears in whatever units you had chosen on the main screen. (More information is also contained in the file UNCERTAINTY.TXT that may be found in the installation folder for SSTEMP.) The best estimate of the mean and maximum temperatures are shown; these should be nearly identical to the results from the deterministic model given on SSTEMP's main screen, but you may find that they do differ somewhat. These mean estimates are accompanied by the best estimate of their standard deviation (SD) and 95% confidence interval (1.96 * SD). These are followed by the "full" estimate of the standard deviation for the full range of model predictions. These are always considerably broader than the estimates of the mean. If you have chosen more than 10 samples per trial, you will get an exceedence table displaying the probabilities of equaling or exceeding the stated temperature. Finally, you may plot a bar graph showing the frequency of trialaverage results.

If you want to estimate the mean temperature, the 95% confidence interval is recommended. This would be 1.96 times the SD of the estimate of the mean, 0.34°F in the above example. If you want to estimate the variability in the full model predictions, use 1.96 times the full distribution value, 1.21°F in the above example. As you can see, these two estimates can be widely different, though this depends on the number of trials and samples per trial. Remember that there is no magic in these statistics; they simply characterize the distributions of the data. The graphs may be more understandable to those who like figures rather than numbers, and do a good job of illustrating any skewness.

Huge data collection efforts might provide more accurate estimates for each of our input variables, but we rarely have the money to do this. We could always rely on "worst case" estimates for the input variables, where worst case is defined as that set of estimates producing the highest predicted temperatures. The probability of the worst case is too low to be practical. It is better simply to understand and acknowledge the uncertainty, but continue to make decisions based on our best estimate of the average predictions with 95% confidence intervals given.

ASSUMPTIONS

a. Water in the system is instantaneously and thoroughly mixed at all times. Thus there is no lateral temperature distribution across the stream channel, nor is there any vertical gradient in pools.

b. All stream geometry (e.g., slope, shade, friction coefficient) is characterized by mean conditions. This applies to the full travel distance upstream to solar noon, unless there is a dam at the upstream end.

c. Distribution of lateral inflow is uniformly apportioned throughout the segment length.

d. Solar radiation and the other meteorological and hydrological parameters are 24-hour means. You may lean away from them for an extreme case analysis, but you risk violating some of the principles involved. For example, you may alter the relative humidity to be more representative of the early morning hours. If you do, the mean water temperature may better approximate the early morning temperature, but the maximum and minimum temperatures would be meaningless.

e. Each parameter has certain built-in upper and lower bounds to prevent outlandish input errors. These limits are not unreasonable; however, the user should look to see that what he or she types actually shows up on the screen. The screen image will always contain the values that the program is using.

f. This model does not allow either Manning's n or travel time to vary as a function of flow.

g. The program should be considered valid only for the Northern Hemisphere below the Arctic Circle. One could theoretically "fast forward" six months for the Southern Hemisphere's shade calculations, but this has not been tested. The solar radiation calculations would, however, be invalid due to the asymmetrical elliptical nature of the earth's orbit around the sun.

h. The representative time period must be long enough for water to flow the full length of the segment. Remember that SSTEMP is a model that simulates the mean (and maximum) water temperature for some period of days. (One day is the minimum time period, and theoretically, there is no maximum, although a month is likely the upper pragmatic limit.) SSTEMP looks at the world as if all the inputs represent an average day for the time period. For this reason, SSTEMP also assumes that a parcel of water entering the top of the study segment will have the opportunity to be exposed to a full day's worth of heat flux by the time it exits the downstream end. If this is not true, the time period must be lengthened.

For example, suppose your stream has an average velocity of 0.5 meters per second and you want to simulate a 10 km segment. With 86,400 seconds in a day, that water would travel 43 km in a day's time. As this far exceeds your 10 km segment length, you can simulate a single day if you wish. But if your stream's velocity were only 0.05 mps, the water would only travel 4.3 km, so the averaging period for your simulation must be at least 3 days to allow that water to be fully influenced by the average conditions over that period. If, however, most conditions (flow, meteorology) are really relatively stable over the 3 days, you can get by with simulating a single day. Just be aware of the theoretical limitation.

i. Remember that SSTEMP does not and can not deal with cumulative effects. For example, suppose you are gaming with the riparian vegetation shade's effect on stream temperature. Mathematically adding or deleting vegetation is not the same as doing so in real life, where such vegetation may have subtle or not so subtle effects on channel width or length, air temperature, relative humidity, wind speed, and so on.

Temperature Allocations as Determined by % Total Shade and Width-to-Depth Ratios

Tables 5.1 through 5.4 detail model run outputs for Rio Chama, Chavez Creek, Rio Brazos, and Rito de Tierra Amarilla, respectively (see Appendix F for model runs). SSTEMP is first calibrated against thermograph data to determine the standard error of the model. Initial conditions are determined. As the percent Total Shade is increased and the Width's A Term is decreased, the maximum 24-hour temperature decreases until the segment specific standard of 20ºC is achieved. The calculated 24-hour Solar Radiation Component is the maximum solar load that can occur in order to meet the water quality standard (i.e., the target capacity). In order to calculate the actual Load Allocation (LA), the WLA and margin of safety (MOS) were subtracted from the target capacity (TMDL) following Equation 2.

Equation 2. $WLA + LA + MOS = TMDL$

For Rio Chama, the water quality standard for temperature is achieved when the percent total shade is 17.5% and the Width's A term is reduced to 7.0, thus simulating a decrease in the width-to-depth ratio of the channel. According to the model runs, the actual load allocation (LA) of 194.82 joules/meter2/second/day is achieved when the shade is further increased to 26% (Table 5.1).

Table 5.1 SSTEMP model results for Rio Chama

<table>
<tr><th>Rosgen Channel Type</th><th>WQS (HQCWF)</th><th>Model Run Dates</th><th>Segment Length (mi)</th><th>Solar Radiation Component per 24-Hours (+/-)</th><th>% Total Shade</th><th>Width's A Term</th><th>Modeled Temperature °C (24 hour)</th></tr>
<tr><td>B/C</td><td>20°C (68°F)</td><td>8/30/98</td><td>11.72</td><td>Current Field Condition
+233.52 joules/meter^2/ second</td><td>11.3</td><td>9.14</td><td>Minimum 9.19
Mean 15.19
Maximum 21.18</td></tr>
<tr><td colspan="4" rowspan="3">Stream Segment Temperature Model (SSTEMP) Results

TEMPERATURE ALLOCATIONS
FOR
RIO CHAMA (Rio Brazos to Little Willow Creek)

* DENOTES 24-HOUR ACHIEVEMENT OF SURFACE WQS FOR TEMPERATURE

♦ DENOTES 24-HOUR LOAD ALLOCATION (LA) NEEDED TO ACHIEVE SURFACE WQS WITH A 10% MARGIN OF SAFETY

Actual reduction in solar radiation necessary to meet surface WQS for temperature:

233.52 joules/meter^2/second (current condition) –
194.82 joules/meter^2/second (LA) =

38.7 joules/meter^2/second</td><td>+205.35 joules/meter^2/second</td><td>22.0</td><td>9.14</td><td>Minimum 9.12
Mean 14.54
Maximum 19.96</td></tr>
<tr><td>*+217.20 joules/meter^2/second</td><td>17.5</td><td>7.0</td><td>Minimum 9.27
Mean 14.61
Maximum 19.96</td></tr>
<tr><td>Actual Load Allocation
♦+194.82 joules/meter^2/second</td><td>26.0</td><td>7.00</td><td>Minimum 9.25
Mean 14.13
Maximum 19.02</td></tr>
</table>

For Chavez Creek, the water quality standard for temperature is achieved when the percent total shade is 26% and the Width's A term is reduced to 8.5, thus simulating a decrease in the width-to-depth ratio of the channel. According to the model runs, the actual load allocation (LA) of 173.52 joules/meter2/second/day is achieved when the shade is further increased to 34% (Table 5.2).

Table 5.2 SSTEMP model results for Chavez Creek

<table>
<tr><th>Rosgen Channel Type</th><th>WQS (HQCWF)</th><th>Model Run Dates</th><th>Segment Length (mi)</th><th>Solar Radiation Component per 24-Hours (+/-)</th><th>% Total Shade</th><th>Width's A Term</th><th>Modeled Temperature °C (24 hour)</th></tr>
<tr><td>B</td><td>20°C (68°F)</td><td>8/30/02</td><td>12.59</td><td>Current Field Condition
+236.61 joules/meter^2/second</td><td>10.0</td><td>16.1</td><td>Minimum 6.93
Mean 14.58
Maximum 22.22</td></tr>
<tr><td colspan="4" rowspan="3">Stream Segment Temperature Model (SSTEMP) Results

TEMPERATURE ALLOCATIONS
FOR
CHAVEZ CREEK (Rio Brazos to headwaters)

* DENOTES 24-HOUR ACHIEVEMENT OF SURFACE WQS FOR TEMPERATURE

♦ DENOTES 24-HOUR LOAD ALLOCATION (LA) NEEDED TO ACHIEVE SURFACE WQS WITH A 10% MARGIN OF SAFETY

Actual reduction in solar radiation necessary to meet surface WQS for temperature:

236.61 joules/meter^2/second (current condition) – 173.52 joules/meter^2/second (LA) =

63.1 joules/meter^2/second</td><td>+189.29 joules/meter^2/second</td><td>28.0</td><td>16.1</td><td>Minimum 6.66
Mean 13.32
Maximum 19.97</td></tr>
<tr><td>*+194.55 joules/meter^2/second</td><td>26.0</td><td>8.5</td><td>Minimum 6.02
Mean 12.99
Maximum 19.96</td></tr>
<tr><td>Actual Load Allocation
♦+173.52 joules/meter^2/second</td><td>34.0</td><td>8.5</td><td>Minimum 6.00
Mean 12.45
Maximum 18.90</td></tr>
</table>

For Rio Brazos, the water quality standard for temperature is achieved when the percent total shade is 22% and the Width's A term is reduced to 8.3, thus simulating a decrease in the width-to-depth ratio of the channel. According to the model runs, the actual load allocation (LA) of 184.89 joules/meter2/second/day is achieved when the shade is further increased to 29.8% (Table 5.3).

Table 5.3 SSTEMP model results for Rio Brazos

<table>
<tr><th>Rosgen Channel Type</th><th>WQS (HQCWF)</th><th>Model Run Dates</th><th>Segment Length (mi)</th><th>Solar Radiation Component per 24-Hours (+/-)</th><th>% Total Shade</th><th>Width's A Term</th><th>Modeled Temperature °C (24 hour)</th></tr>
<tr><td>B</td><td>20°C (68°F)</td><td>8/30/02</td><td>3.52</td><td>Current Field Condition
+223.87
joules/meter^2/
second</td><td>15.0</td><td>12.3</td><td>Minimum 8.72
Mean 14.98
Maximum 21.23</td></tr>
<tr><td colspan="4" rowspan="3">Stream Segment Temperature Model (SSTEMP) Results

TEMPERATURE ALLOCATIONS
FOR
RIO BRAZOS (Rio Chama to Chavez Creek)

* DENOTES 24-HOUR ACHIEVEMENT OF SURFACE WQS FOR TEMPERATURE

♦ DENOTES 24-HOUR LOAD ALLOCATION (LA) NEEDED TO ACHIEVE SURFACE WQS WITH A 10% MARGIN OF SAFETY

Actual reduction in solar radiation necessary to meet surface WQS for temperature:

223.87 joules/meter^2/second (current condition) –
184.89 joules/meter^2/second (LA) =

38.98 joules/meter^2/second</td><td>+190.95
joules/meter^2/second</td><td>27.5</td><td>12.3</td><td>Minimum 9.08
Mean 14.52
Maximum 19.97</td></tr>
<tr><td>*+205.43
joules/meter^2/second</td><td>22.0</td><td>8.3</td><td>Minimum 9.42
Mean 14.6
Maximum 19.96</td></tr>
<tr><td>Actual Load Allocation
♦+184.89
joules/meter^2/second</td><td>29.8</td><td>8.3</td><td>Minimum 9.52
Mean 14.38
Maximum 19.25</td></tr>
</table>

For Rito de Tierra Amarilla, the water quality standard for temperature is achieved when the percent total shade is 36%. According to the model runs, the actual load allocation (LA) of 150.85 joules/meter2/second/day is achieved when the shade is further increased to 42.5% (Table 5.4).

Table 5.4 SSTEMP model results for Rito de Tierra Amarilla

<table>
<tr><th>Rosgen Channel Type</th><th>WQS (HQCWF)</th><th>Model Run Dates</th><th>Segment Length (mi)</th><th>Solar Radiation Component per 24-Hours (+/-)</th><th>% Total Shade</th><th>Width's A Term</th><th>Modeled Temperature °C (24 hour)</th></tr>
<tr><td>E/C</td><td>20°C (68°F)</td><td>8/30/98</td><td>15.8</td><td>Current Field Condition
+248.79
joules/meter^2/ second</td><td>5.0</td><td>10.8</td><td>Minimum 9.64
Mean 16.64
Maximum 23.63</td></tr>
<tr><td colspan="4" rowspan="3">Stream Segment Temperature Model (SSTEMP) Results

TEMPERATURE ALLOCATIONS
FOR
RITO DE TIERRA AMARILLA
(Rio Chama to HWY 64)

* DENOTES 24-HOUR ACHIEVEMENT OF SURFACE WQS FOR TEMPERATURE

♦ DENOTES 24-HOUR LOAD ALLOCATION (LA) NEEDED TO ACHIEVE SURFACE WQS WITH A 10% MARGIN OF SAFETY

Actual reduction in solar radiation necessary to meet surface WQS for temperature:

248.79 joules/meter^2/second (current condition) –
150.85 joules/meter^2/second (LA) =

97.94 joules/meter^2/second</td><td>+209.51
joules/meter^2/second</td><td>20</td><td>10.8</td><td>Minimum 9.28
Mean 15.6
Maximum 21.93</td></tr>
<tr><td>*+167.61
joules/meter^2/second</td><td>36</td><td>10.8</td><td>Minimum 8.94
Mean 14.46
Maximum 19.98</td></tr>
<tr><td>Actual Load Allocation
♦+150.85
joules/meter^2/second</td><td>42.5</td><td>10.8</td><td>Minimum 8.83
Mean 13.99
Maximum 19.15</td></tr>
</table>

According to the Sensitivity Analysis feature of the Rito de Tierra Amarilla model runs, the Width's A term was not sensitive in these model runs due to the low inflow and outflow values (< 1.5 cfs). Therefore, reducing Width's A term had an insignificant effect on the predicted maximum temperature. Rito de Tierra Amarilla flows through a broad valley from Highway 84 to the confluence with the Rio Chama. The channel through this section should be more like an E channel (small width-to-depth ratio, sinuous) (Rosgen 1996). A healthy riparian system through this portion would consist of grassy overhanging banks. To achieve a Total Shade component of 42.5% through this valley with grassy vegetation vs. woody vegetation, the channel would need to be narrower and deeper even though the model was not sensitive to the Width's A Term.

Target loads as determined by the modeling runs are summarized in Tables 5.1-5.4.
The MOS is estimated to be 10% of the target load calculated by the modeling runs. Results are presented in Table 5.5. Additional details on the MOS chosen are presented in Section 5.3 below.

Table 5.5 Calculation of TMDL for temperature

Location	WLA (J/m2/s)	LA (J/m2/s)	MOS (10%)* (J/m2/s)	TMDL (J/m2/s)
Rio Chama	0	194.82	22.38	217.20
Chavez Creek	0	173.52	21.03	194.55
Rio Brazos	0	184.89	20.54	205.43
Rito de Tierra Amarilla	0	150.85	16.76	167.61

* Actual MOS values may be slightly greater than 10% because the final MOS is back calculated after the Total Shade value is increased enough to reduce the modeled solar radiation component to a value less than the target load minus 10%.

The load reductions that would be necessary to meet the target loads were calculated to be the difference between the calculated target load allocation and the measured load (i.e., current field condition in Tables 5.1-5.4), and are shown in Table 5.6.

Table 5.6 Calculation of load reduction for temperature

Location	Load Allocation (J/m2/s)	Measured Load (J/m2/s)	Load Reduction (J/m2/s)
Rio Chama	194.82	233.52	38.70
Chavez Creek	173.52	236.61	63.09
Rio Brazos	184.89	223.87	38.98
Rito de Tierra Amarilla	150.85	248.79	97.94

Identification and Description of pollutant source(s)

Pollutant sources that could contribute to each segment are listed in Table 5.7.

Table 5.7 Pollutant source summary for Temperature

Pollutant Sources	**Magnitude** (Load Allocation + MOS)	**Location**	**Potential Sources** (% from each)
Point: None	0	--------	0%
Nonpoint: Temperature (expressed as solar radiation)		Rio Chama	100% Range Grazing -- Riparian or Upland, Removal of Riparian Vegetation Road Maintenance and Runoff Flow Regulation/Modification
		Chavez Creek	100% Range Grazing -- Riparian or Upland, Removal of Riparian Vegetation Road Maintenance and Runoff Gravel Mining Flow Regulation/Modification
		Rio Brazos	100% Unmaintained Low Water Crossing Range Grazing -- Riparian or Upland, Removal of Riparian Vegetation Road Maintenance and Runoff Gravel Mining Flow Regulation/Modification
		Rito de Tierra Amarilla	100% Range Grazing -- Riparian or Upland, Removal of Riparian Vegetation Road Maintenance and Runoff Flow Regulation/Modification Agriculture

Linkage of Water Quality and Pollutant Sources

Water temperature influences the metabolism, behavior, and mortality of fish and other aquatic organisms that affect fish. Natural temperatures of a waterbody fluctuate daily and seasonally. These natural fluctuations do not eliminate indigenous populations, but may affect existing community structure and geographical distribution of species. In fact, such temperature cycles are often necessary to induce reproductive cycles and may regulate other aspects of life history (Mount 1969). Behnke and Zarn (1976) in a discussion of temperature requirements for endangered western native trout recognized that populations cannot persist in waters where maximum temperatures consistently exceed 21-22°C, but they may survive brief daily periods of higher temperatures (25.5-26.7°C). Anthropogenic impacts can lead to modifications of these natural temperature cycles, often leading to deleterious impacts on the fishery. Such modifications may contribute to changes in geographical distribution of species and their ability to persist in the presence of introduced species. Of all the environmental factors affecting aquatic organisms in a waterbody, many either present or not present, temperature is always a factor. Heat, which is a quantitative measure of energy of molecular motion that is dependent on the mass of an object or body of water is fundamentally different that temperature, which is a measure (unrelated to mass) of energy intensity. Organisms respond to temperature, not heat.

Temperature increases, as observed in SWQB thermograph data, show temperatures along this reach that exceed the State Standards for the protection of aquatic habitat, namely the High Quality Cold Water Fishery (HQCWF) designed use. Through monitoring, and pollutant source documentation, it has been observed that the most probable cause for these temperature exceedences are due to the alteration of the stream's hydrograph, removal of riparian vegetation, and livestock grazing. Alterations can be historical or current in nature.

A variety of factors impact stream temperature (Figure 5.3). Decreased effective shade levels result from reduction of riparian vegetation. When canopy densities are compromised, thermal loading increases in response to the increase in incident solar radiation. Likewise, it is well documented that many past hydromodification activities have lead to channel widening. Wider stream channels also increase the stream surface area exposed to sunlight and heat transfer. Riparian area and channel morphology disturbances are attributed to past and to some extent current rangeland grazing practices that have resulted in reduction of riparian vegetation and streambank destabilization. These nonpoint sources of pollution primarily affect the water temperature through increased solar loading by: (1) increasing stream surface solar radiation and (2) increasing stream surface area exposed to solar radiation.

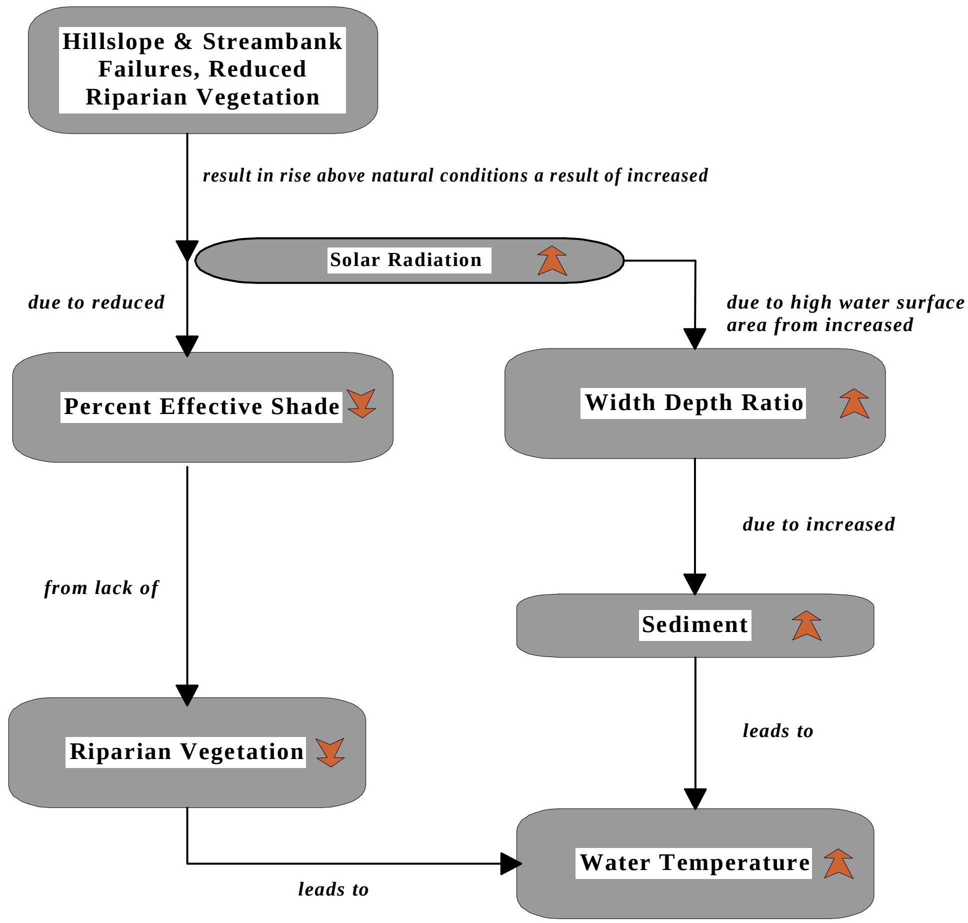


Figure 5.3 Factors That Impact Water Temperature

Riparian vegetation, stream morphology, hydrology, climate, geographic location, and aspect influence stream temperature. Although climate, geographic location, and aspect are outside of human control, the condition of the riparian area, channel morphology and hydrology can be affected by land use activities. Specifically, the elevated summertime stream temperatures attributable to anthropogenic causes in the Upper Chama watershed result from the following conditions:

1. Channel widening (i.e., increased width to depth ratios) that has increased the stream surface area exposed to incident solar radiation,
2. Riparian vegetation disturbance that has reduced stream surface shading, riparian vegetation height and density, and
3. Reduced summertime base flows that result from instream withdrawals and/or inadequate riparian vegetation. Base flows are maintained with a functioning riparian system so that loss of a functioning riparian system may lower and sometimes eliminate baseflows. Although removal of upland vegetation has been shown to increase water yield, studies show that removal of riparian vegetation along the stream channel subjects the water surface and adjacent soil surfaces to wind and solar radiation, partially offsetting the reduction in transpiration with evaporation. In losing stream reaches, increased

temperatures can result in increased streambed infiltration which can result in lower base flow (Constantz et al. 1994).

Analyses presented in these TMDLs demonstrate that defined loading capacities will ensure attainment of New Mexico water quality standards. Specifically, the relationship between shade, channel dimensions, solar radiation, and water quality attainment was demonstrated. Vegetation density increases will provide necessary shading, as well as encourage bank-building processes in severe hydrologic events.

Where available data are incomplete or where 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 (SWQB/NMED 1999c). The completed Pollutant Source(s) Documentation Protocol forms in Appendix C 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 5.7 (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 stream, which is predominantly privately held, but also to consider upland and upstream areas in a more holistic watershed approach to implementing this TMDL.

RIO CHAMA -- There is a large instream diversion structure in the Rio Chama near the NMDGF access area (SWQB station 10) that is diverting a large percentage of the flow into an irrigation canal (Photo 09). Reduced baseflows impact riparian vegetation, reduce the depth of the water, and therefore, increase solar gain. There are also areas where riparian vegetation has been altered, thus reducing the amount of total shade on the stream (Photo 10).

Photo 09. Instream withdrawal for irrigation on Rio Chama near the NMDGF access station, 10/02/02.

Photo 10. Densiometer reading on Rio Chama near the NMDGF access station, 06/24/02. Note lack of stream shading and widened channel without pool features.

CHAVEZ CREEK -- Approximately 200 meters downstream of the bridge, upstream of the confluence with the Rio Brazos, a large portion of the flow in Chavez Creek is diverted into an irrigation canal. The riparian area immediately upstream of this sampling location is heavily grazed by livestock (Photo 11). At the time of the 1998 survey, illegal dredge and fill operations were observed on Chavez Creek in this same area. A large gravel mining operation is active on the Rio Brazos upstream of and adjacent to Chavez Creek. Several of the cottonwoods in the Chavez Creek riparian area near the gravel operation are dead and/or dying. The gravel operation may be contributing to this problem by lowering the local water table. According to an aerial photograph taken in 1997, there is an approximately one mile long section of Chavez Creek about 1.5 miles upstream of the sampling station that is completely devoid of riparian vegetation. This is a result of several years of intensive gravel mining according to SWQB survey staff.

Photo 11. Grazing impacts on Chavez Creek upstream of County RD 512 bridge, 06/10/02. Note collapsed streambanks and loss of riparian vegetation to shade the stream.

RIO BRAZOS -- Upstream of the confluence with Chavez Creek, there is an irrigation diversion that diverts a large portion of Rio Brazos water into the Park View Ditch. This ditch splits and passes by the communities of Los Ojos and Rito de Tierra Amarilla. Return flow enters the Rio Chama near La Puente. There is a large gravel mining operation on the Rio Brazos upstream of the confluence with Chavez Creek. There are additional smaller active and inactive gravel mining sites along the Rio Brazos. According to an aerial photograph taken in 1997, the Rio Brazos is braided with an increased width-to-depth ratio in several reaches between the Rio Chama and Chavez Creek (Photo 12). Riparian vegetation is sparse in these areas as well, leading to increased solar radiation. There is also a low water crossing at County Road 162 that has resulted in a wide, shallow, braided reach in this section of the stream (Photo 13).

Photo 12. Looking downstream from the HWY 84 bridge on the Rio Brazos, 06/11/02.

Photo 13. Looking towards left bank at the Rio Brazos low water crossing at County RD 331, 06/11/02.

RITO DE TIERRA AMARILLA --
There is an irrigation diversion that diverts a large portion of Rito de Tierra Amarilla. This ditch travels along the on the southwest side of the community of Tierra Amarilla. The main sources of impairment along this lower reach appear to be from livestock grazing and removal of riparian vegetation in the floodplain upstream of the lower sampling station. Agricultural practices such as grazing appear to have contributed to the removal of riparian vegetation and streambank destabilization. Field staff observed several horses and cattle while at the lower sampling station

(Photo 14). There are several small animal confinement pens, increased irrigation return flows, and poorly designed culverts at road crossings. The reach flows through Tierra Amarilla in which all the above factors are concentrated (Photo 06). When the area was first settled, creating narrow strips from the road all the way to the stream so each family's livestock would have access to a water source broke up land. In many instances, these plots have been completely cleared of vegetation that would have provided shade and filtered out sediments before reaching the stream. Direct access of livestock to the stream banks has caused streambank destabilization in many areas.

Photo 14. Upstream of the lower station on the Rito de Tierra Amarilla, 10/21/01.

5.3 Margin of Safety (MOS)

The Federal Clean Water Act (CWA) requires that each TMDL be calculated with a margin of safety (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 TMDL, there will be no margin of safety for point sources since there are none.
In order to develop this temperature TMDL, the following conservative assumptions were used to parameterize the model:

- Data from the warmest time of the year were used in order to capture the seasonality of temperature exceedences.

- Critical upstream and downstream low flows were used because assimilative capacity of the stream to absorb and disperse solar heat is decreased during these flow conditions.
- Low flow was modeled using two formulas developed by the USGS. One formula (USGS 1993) is recommended when the ratio between the gaged watershed area and the ungaged watershed area is between 0.5 and 1.5. When the ratio is outside of this range, a different regression formula is used (Borland, 1970). See Appendix E for details.

As detailed in section 5.2, a variety of high quality hydrologic, geomorphologic, and meteorological data were used to parameterize the SSTEMP model. Because of the high quality of data and information that was put into this model and the continuous field monitoring data used to verify these model outputs, an explicit MOS of **10%** is assigned to this TMDL.

5.4 Consideration of seasonal variation

Section 303(d)(1) of the CWA requires TMDLs to be "established at a level necessary to implement the applicable water quality standard with seasonal variation." Both stream temperature and flow vary seasonally and from year to year. Water temperatures are coolest in winter and early spring months.

Thermograph records show that temperatures exceed State of New Mexico water quality standards in summer and early fall. Warmest stream temperatures corresponded to prolonged solar radiation exposure, warmer air temperature, and low flow conditions. These conditions occur during late summer and early fall and promote the warmest seasonal instream temperatures. It is assumed that if critical conditions are met, coverage of any potential seasonal variation will also be met.

5.5 Future Growth

Estimations of future growth are not anticipated to lead to a significant increase in stream temperature that cannot be controlled with best management practice (BMP) implementation in this watershed.

6.0 ALUMINUM

6.1 Summary

During the 1998 SWQB intensive water quality survey in the Upper Rio Chama Watershed, exceedences of the New Mexico water quality standard for chronic aluminum were documented at two sampling stations on Rio Chamita (SWQB Stations 4 and 7). Consequently, the Rio Chamita from Rio Chama to the Colorado border was listed on the 2000-2002 Clean Water Act §303(d) list for chronic aluminum.

The Village of Chama WWTP discharges into the Rio Chamita at SWQB station 6. The WWTP has a design capacity of 0.3 MGD average discharge and serves a population of approximately 400 persons. The plant is a lagoon system with chlorination and dechlorination that is monitored through NPDES permit #NM0027731 (SWQB/NMED 1999a). The current permit expires June 30, 2005. Because high instream concentrations of aluminum were noted during the 1998 study, the permit includes reference to a reopener clause that will allow the permit to be reopened to include aluminum limits once the TMDL is established and approved.

6.2 Endpoint Identification

Target Loading Capacity

Target values for this chronic aluminum TMDL 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 New Mexico water quality standards (20.6.4.900.M NMAC), the dissolved aluminum chronic criterion is 87 µg/L and the dissolved aluminum acute criterion is 750 µg/L for aquatic life uses.

High chronic levels of dissolved aluminum can be toxic to fish, benthic invertebrates, and some single-celled plants. Aluminum concentrations from 100 to 300 µg/L increase mortality, retard growth, gonadal development and egg production of fish (http://h2osparc.wq.ncsu.edu). To be conservative, these TMDLs were drafted for chronic aluminum and, therefore, should also protect against any acute exceedences.

Data was collected from the Rio Chamita at the Highway 29 crossing (SWQB station 4) and from the Rio Chamita below the Village of Chama Wastewater Treatment Plant (WWTP) (SWQB station 7) eight times between June 1 and October 21, 1998 (Table 6.1). Dissolved aluminum concentrations exceeded the chronic criterion for aluminum during spring sampling. The calculated dissolved aluminum 4-day average during the spring sampling run was 92.5 µg/L at station 4 and 145 µg/L at station 7. Aluminum was not detected at these two stations during the summer and fall seasons in 1998. Concurrently collected total suspended solids (TSS) data reported in Table 6.1 will be discussed in the Linkage(s) section below.

Table 6.1 Dissolved aluminum (Al) and total suspended solids (TSS) concentrations in the Rio Chamita

Sample Date	SWQB Station 4		SWQB Station 7	
	Dissolved Al (μg /L)	TSS (mg/L)	Dissolved Al (μg /L)	TSS (mg/L)
980601	120*	15	190*	15
980602	140*	14	130*	28
980603	70	21	70	25
980604	40	18	190*	22
980818	10K	12	10K	18
980819	10K	13	10K	not available
981020	10K	10	10K	6
981021	not available	3K	10K	not available

K = reported as "below detection limit"
* Exceedence of 87 µg /L dissolved aluminum chronic water quality criterion.

Flow

TMDLs are calculated for the Rio Chamita 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. In this case, flow was measured on the Rio Chamita at SWQB station 5 (upstream of the WWTP) during the spring sampling run using standard USGS procedures (SWQB/NMED 2001a). The measured flow value was 27.0 cfs. Therefore,

RIO CHAMITA critical flow --
Q_{MSR} = 27.0 cfs (1 cfs/1.5473 mgd)
Q_{MSR} = 17.4 mgd

The combined flow is calculated by adding the critical flow and the average design flow contribution from any point sources. The WWTP has a design capacity of 0.3 MGD average discharge. Therefore,

RIO CHAMITA combined flow –
$Q_{MSR} + Q_{DESIGN}$ = 17.4 mgd + 0.3 mgd = 17.7 mgd

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 these 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. Meeting the calculated target load may be a difficult objective.

Calculations

A target load for chronic 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 B for Conversion Factor Derivation). The target loading capacity is calculated using Equation 1. The results are shown in Table 6.2.

Equation 1. *combined flow (mgd) x standard (mg/L) x 8.34 (conversion factor) = target loading capacity*

Table 6.2 Calculation of target loads for chronic dissolved aluminum

Location	Combined Flow+ (mgd)	Dissolved Al chronic criterion (mg/L)	Conversion Factor	Target Load Capacity (lbs/day)
Rio Chamita	17.7	0.087	8.34	12.8

+ Since USGS gages were unavailable, flow was measured during the 1998 spring sampling run (SWQB/NMED 2001a). This value was added to the design flow of the WWTP to estimate the combined instream flow below the WWTP.

The measured loads for dissolved aluminum were similarly calculated. The arithmetic mean of the data from the site downstream of the WWTP (station 7) collected during the spring run was substituted for the standard in Equation 1. Dissolved aluminum concentrations were not measured at the WWTP outlet (station 6) during the 1998 survey. Concentrations at station 7 include any potential contributions to the measured load from the WWTP. The calculated dissolved aluminum 4-day average during the spring sampling run was 145 µg /L (0.145 mg/L) at station 7. The same conversion factor of 8.34 was used. Results are presented in Table 6.3.

Table 6.3 Calculation of measured loads for chronic dissolved aluminum

Pollutant sources in Rio Chamita	Flow (mgd)	Dissolved Al Arithmetic Mean * (mg/L)	Conversion Factor	Measured Load Capacity (lbs/day)
Rio Chamita	17.7	0.145	8.34	21.4

* Arithmetic mean of dissolved aluminum concentration at station 7 during the spring sampling run (see Table 6.1).

Waste Load Allocations and Load Allocations

•*Waste Load Allocation*

There is one point source contributor associated with this TMDL. As noted above, the Village of Chama WWTP discharges into the Rio Chamita at SWQB station 6 and is monitored through NPDES permit #NM0027731 (SWQB/NMED 1999a). There is currently no discharge limit for dissolved aluminum in the permit. Because high instream concentrations of aluminum were noted during the 1998 study, the permit includes reference to a reopener clause that will allow the permit to be reopened to include aluminum limits once the TMDL is established and approved.

Because the WWTP discharges into a stream reach that is listed for dissolved aluminum, they are required to monitor and report on dissolved aluminum limits once per quarter as stated in their NPDES permit. The plant operators have sampled aluminum during two quarters, but the lab analyzed for total aluminum instead of dissolved aluminum. SWQB staff sampled the WWTP effluent in October of 2002 as part of an NPDES compliance sampling inspection. The concentration of dissolved aluminum during this sampling event was 0.14 mg/L. This is only available data point available to determine a potential dissolved aluminum waste load allocation for the WWTP. Given a design flow of 0.3 MGD, a concentration of 0.14 mg/L, and the conversion factor of 8.34, a WLA of 0.4 lbs/day was calculated.

•*Load Allocation*
In order to calculate the Load Allocation (LA), the WLA and margin of safety (MOS) were subtracted from the target capacity (TMDL) following Equation 2.

Equation 2. $WLA + LA + MOS = TMDL$

The MOS is estimated to be 20% of the target load calculated in Table 6.2. Results are presented in Table 6.4. Additional details on the MOS chosen are presented in section 6.3 below.

Table 6.4 Calculation of TMDL for chronic dissolved aluminum

Location	WLA (lbs/day)	LA (lbs/day)	MOS (20%) (lbs/day)	TMDL (lbs/day)
Rio Chamita	0.4	9.8	2.6	12.8

The extensive data collection and analyses necessary to determine background dissolved aluminum loads for the Rio Chamita watershed was 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 load reductions that would be necessary to meet the target loads were calculated to be the difference between the calculated target load allocation (Tables 6.2 and 6.4) and the measured load (Table 6.3), and are shown in Table 6.5.

Table 6.5 Calculation of load reduction for chronic dissolved aluminum

Location	Target Load (lbs/day)	Measured Load (lbs/day)	Load Reduction (lb/day)
Rio Chamita	12.8	21.4	8.6

Identification and Description of pollutant source(s)

Pollutant sources that could contribute to each segment are listed in Table 6.6.

Table 6.6 Pollutant source summary for chronic dissolved aluminum

Pollutant Sources	Magnitude	Location	Potential Sources (% from each)
<u>Point</u>: Village of Chamita WWTP	0.4	Rio Chamita	4% Municipal Point Source
<u>Nonpoint</u>:	9.8	Rio Chamita	96% Elk Range Grazing Road Maintenance and Runoff Natural Sources/ Geology

Linkage of Water Quality and Pollutant Sources

Where available data are incomplete or where 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 (SWQB/NMED 1999c). The completed Pollutant Source(s) Documentation Protocol forms in Appendix C 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 stream, which is predominantly state and privately managed land, but also to consider upland and upstream areas in a more holistic watershed approach to implementing this TMDL.

Aluminum is the most common metal in the Earth's crust and the third most common element. Aluminum comprises, on average, about eight percent of the Earth's crust. 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 in the Rio Chamita as evidenced by the fact that there is not a relationship between dissolved aluminum and total suspended solids concentrations (TSS) at station 4 according to the 1998 sampling data (Table 6.1, Figure 6.1). The TSS method is a commonly used measurement of suspended material in surface water. This method was originally developed for use on wastewater samples, but has widely been used as a measure of suspended materials in stream samples because it is acceptable for regulatory purposes and is an inexpensive laboratory procedure. Since there are no wastewater treatment plants discharging into Rio Chamita above station 4, it is assumed that TSS measurements at this station are representative of erosional activities and thus comprised primarily of suspended sediment vs. any potential biosolids from wastewater treatment plant effluent.

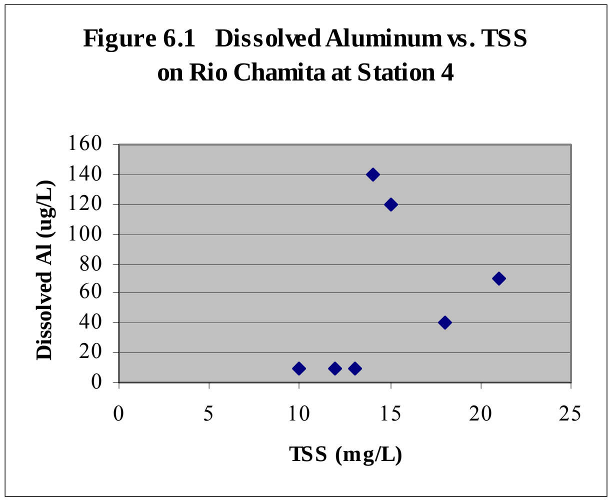


Figure 6.1 Relationship between Dissolved Aluminum and TSS in Rio Chamita at station 4 (above the WWTP)

High aluminum is characteristic of the spring snowmelt/runoff period and is not pronounced during baseflow conditions in the Rio Chamita. 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 high dissolved aluminum concentrations were measured during the spring sampling run as opposed to below detection limit concentrations during summer and 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.

The predominant geologic formation in the lower to middle portions of the watershed is Mancos Shale (see figure 1.2). The middle portion contains a band from the Mesa Verde group. Lower Cretaceous formations occupy the upper portion of the watershed. Although volcanic formations in the watershed would provide a stronger explanation for elevated aluminum, Mancos Shale can be an accumulation unit for metals transported from volcanic activity in the surrounding area. The Mesa Verde group could also contain beach sand components resulting from surrounding volcanic activity.

Also, approximately 32 mi^2 of the upper watershed area are protected within the Edward Sargent Fish and Wildlife Area that was established in 1978 and is managed by NMDGF. Domestic livestock grazing is excluded and public access is restricted to foot and horseback traffic. Impacts are limited to elk herds that reside in the area. There are no known existing or historic aluminum mines in the watershed. In the absence of identifiable degraded uplands, anthropogenic sources of aluminum, poor streambank condition, or land use impacts to explain high levels of sedimentation that may have led to high aluminum concentrations, the largest probable source for high aluminum concentrations measured during snowmelt runoff appears to be local watershed bedrock and natural surface geology processes.

The potential waste load allocation of aluminum from the WWTP (0.35 lbs/day) is negligible compared to total measured load contributed during spring runoff (21.4 lbs/day). Even during baseflow conditions, input from the WWTP does not appear to exceed the assimilative capacity of the Rio Chamita based on the 1998 survey data because all baseflow concentrations of aluminum in the Rio Chamita were below the detection limit (<0.01 mg/L) at station 7. Additionally, the Village of Chama WWTP operators have begun discussing the possibility of re-directing their outfall from the Rio Chamita to the Rio Chama to take advantage of the increased assimilative capacity of the Rio Chama. During the October 2002, SWQB staff noted several potential sources of aluminum, such as aluminum weirs, screens, and gates. They may consider installing non-aluminum replacement fixtures to eliminate these potential sources of aluminum at the WWTP.

6.3 Margin of Safety (MOS)

TMDLs should reflect a margin of safety based on the uncertainty or variability in the data, the point and nonpoint source load estimates, and the modeling analysis. For this TMDL, there will be no margin of safety for point sources, since there are none. However, for nonpoint sources the margin of safety is estimated to be an addition of **20%** for aluminum in this case, excluding background. This margin of safety incorporates several factors:

- *Errors in calculating NPS loads*
  A level of uncertainty exists in sampling nonpoint sources of pollution. Techniques used for measuring metals concentrations in stream water are $\pm$15% accurate according to the QAPP (SWQB/NMED 2001b). Accordingly, a conservative margin of safety for metals increases the TMDL by **15%.**

- *Errors in calculating flow*
  Flow estimates were based on one measurement during the spring sampling run. Instrument and operator error can lead to inaccuracy in flow measurements. Accordingly, a conservative margin of safety increases the TMDL by an additional **5%.**

6.4 Consideration of Seasonal Variation

Data used in the calculation of this TMDL were collected during the spring, summer, and fall of 1998 in order to ensure coverage of any potential seasonal variation in the system. Critical condition is set to high flow for dissolved aluminum because data exceedences were observed during high spring flows. A flow measurement taken during the spring sampling run was used in the calculations.

6.5 Future Growth

Estimations of future growth are not anticipated to lead to a significant increase for chronic aluminum that cannot be controlled with best management practice (BMP) implementation in this watershed. According to the US Census bureau, the population of Rio Arriba county was reduced by 141 persons (0.34 %) between July 1, 2000, and July 1, 2002. Therefore, a growth allocation was not included in the waste load allocation.

7.0 MONITORING PLAN

Pursuant to Section 106(e)(1) of the Federal Clean Water Act, 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, 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 utilizes a rotating basin system approach to water quality monitoring. In this system, a select number of watersheds are intensively monitored each year with an established return frequency of every five to seven years. The SWQB maintains current quality assurance and quality control plans to cover all monitoring activities. This document called the Quality Assurance Project Plan (QAPP) is updated and certified annually by US EPA Region 6 (SWQB/NMED 2001b). 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. Short-term efforts will be directed toward those waters that are on the EPA TMDL consent decree list (Forest Guardians and Southwest Environmental Center v. Carol Browner, Administrator, US EPA, Civil Action 96-0826 LH/LFG, 1997).

Once assessment monitoring is completed, those reaches showing impacts and requiring a TMDL will be targeted for more intensive monitoring. The methods of data acquisition include fixed-station monitoring, intensive surveys of priority assessment units (including biological assessments), and compliance monitoring of industrial, federal and municipal dischargers, as specified in the SWQB Assessment Protocols (SWQB/NMED 2000).

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

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

It should be noted that a basin would not be ignored during the years in between intensive sampling. The rotating basin program will be supplemented with other data collection efforts such as the funding of long-term USGS water quality gaging stations for long-term trend data. 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 305(b) report and 303(d) listing processes.

The following draft schedule covers sampling seasons 1998 through 2004 and will be followed in a consistent manner to support the New Mexico Unified Watershed Assessment (UWA) and the Nonpoint Source Management Program. This sampling regime allows characterization of seasonal variation and thorough sampling in spring, summer, and fall for each of the watersheds. Revisions to the schedule may be occasionally necessary based on staff and monetary resources that fluctuate on an annual basis.

- 1998 Jemez Watershed, Upper Chama Watershed (El Vado to CO border), Cimarron Watershed, Santa Fe River, San Francisco Watershed
- 1999 Lower Chama Watershed (Rio Grande to El Vado), Red River Watershed, Middle Rio Grande, Gila River Watershed (summer and fall), Santa Fe River
- 2000 Gila River Watershed (spring), Dry Cimarron Watershed, Upper Rio Grande 1 (Pilar to CO border)
- 2001 Upper Rio Grande 2 (Cochiti Reservoir to Pilar), Upper Pecos Watershed (Ft. Sumner to headwaters)
- 2002 Canadian River 1, San Juan River Watershed, Mimbres Watershed
- 2003 Lower Pecos Watershed (TX border to Ft. Sumner), Rio Ruidoso Watershed
- 2004 Rio Puerco Watershed, Lower Rio Grande (TX border to Isleta Pueblo boundary)

8.0 IMPLEMENTATION PLANS

Purpose

The purpose of this implementation plan is to outline appropriate steps to achieve the load capacities developed for the pollutants specified in this TMDL document. It is also a plan of action to protect and maintain surface water quality throughout the Upper Rio Chama watershed. Many of the activities that cause water quality impairments (for example, the removal of riparian vegetation) are the cumulative effects of practices causing degradation of the watershed and the affected streams. Some of these impacts have their origins in past events and are compounded by inappropriate land management practices today. The key to changing these practices and improving the condition of the entire watershed is education. An understanding of the attributes of a quality stream environment and a healthy watershed, and how important clean water is to the future of all stakeholders, is an integral part of the process.

This plan for the Upper Rio Chama watershed focuses on prevention and remediation for non-point source pollution – that is pollution that cannot be attributed to a single source such as the outfall pipe of a factory. Previously, individual or discrete projects to address non-point sources of pollution have had limited long-term success. Non-point source pollution control projects are most effective when multiple sources are addressed and activities are coordinated with a watershed plan throughout the affected area. This is because the watershed approach integrates land use, climate, hydrology, drainage, and vegetation effects on water quality. The watershed approach also calls for all stakeholders in the watershed to participate.

Strategy

The mission of the SWQB Watershed Protection Section is to implement progressive watershed-based restoration and protection programs to reduce human-induced pollutants from non-point sources in order to meet water quality standards and beneficial uses of surface water and ground water resources. In recent years, the SWQB Watershed Protection Section has focused its resources to promote a collaborative approach to identifying and reducing the impact of priority non-point sources of pollution.

The first step of this approach is to engage local interest and involvement in locating and defining the problems and implementing the solutions on the land. Table 8.1 lists potential stakeholders in the Upper Rio Chama watershed.

Table 8.1 Potential Stakeholders in the Upper Rio Chama Watershed

Upper Rio Chama Watershed Stakeholders
Land Owners
Ranchers
Crop producers
Homeowners
Businesses
Land Management Agencies
Carson National Forest
Jicarilla Apache Tribe
Bureau of Land Management Taos Ranger District
New Mexico Department of Game and Fish
New Mexico State Parks
US Department of the Army, Corps of Engineers
Government Agencies Providing Technical Expertise And Other Resources
New Mexico Environment Department
Natural Resources Conservation Service
Interstate Stream Commission Regional Water Planning
Rio Arriba County
Village of Chama
Village of Tierra Amarilla
NMSU Cooperative Extension Service
Soil And Water Conservation District
US Geological Survey Water Resources Division
USDI Fish and Wildlife Service
USDA Farm Service Agency
Environmental Protection Agency, Region 6
Interest Groups
Acequia Associations
Rocky Mountain Elk Foundation
Trout Unlimited
Sierra Club
Quivira Coalition
Meridian Institute
New Mexico Cattle Grower's Association
Rio Grande Restoration
Los Rios River Runners
Northern New Mexico Community College
Youth Groups
Boy Scouts and Girl Scouts
Rocky Mountain Youth Corps
Youth Conservation Corps
Local Schools

Ranchers, crop producers, and other private interests own a substantial portion of the Upper Rio Chama watershed. In addition, the Jicarilla Apache Tribe have land holdings and land is also under the jurisdiction of the Carson National Forest, the Bureau of Land Management Taos Ranger District, the New Mexico Department of Game and Fish, New Mexico State Parks and US Department of the Army, Corps of Engineers. The collaborative approach also includes the involvement of agencies and interest groups that can provide technical expertise, knowledge of the watershed, volunteer labor and other needed resources. Local schools and students and other community organizations and environmental groups can also provide volunteer time and labor.

After all stakeholders are located and provided information about crucial water quality impairments and degradation of the watershed, the next critical step is to engage stakeholders in joining forces to restore the watershed, and identify the "sparkplugs" -- those individuals with the time and the drive to address the challenges concerning the relationship of the community, landholders, and groups to the Rio Chama watershed. These diverse factions are ultimately brought together to form a watershed alliance.

The next logical step will be the development of a locally accepted remediation plan that efficiently achieves pollution load reductions and then maintains and protects water quality from future impairments. This remediation plan or "Watershed Restoration Action Strategy" will document past remedial actions and future restoration projects and activities that will improve the condition of the watershed to meet water quality goals. The involvement of all interests and stakeholders in the development of this plan and unification of community activities through a watershed approach will likely achieve far-reaching and long-term results.

Watershed Goals

The Upper Rio Chama Watershed poses a unique set of conditions that set the stage for restoration. The first and foremost is that the Upper Rio Chama from the headwaters of El Vado reservoir upstream to the New Mexico-Colorado line, and all perennial reaches of tributaries to the Rio Chama above Abiquiu Dam (except the Rio Gallina and the Rio Puerco de Chama), are designated high quality cold water fisheries. This designated use applies to all the impaired stream reaches mentioned in this document. The significance of this designation is that the standards that apply to these surface waters support a superior coldwater fishery habitat and watershed restoration efforts should be focused on this goal.

Perennial tributaries in the Upper Rio Chama watershed include Sixto Creek, Nabor Creek, Rio Chamita, Wolf Creek, Little Willow Creek, Cañones Creek, Rio Brazos, Chavez Creek, and Rito de Tierra Amarilla. Several stream reaches sampled have been characterized as meeting water quality standards (Photo 15). Local landowners can use stream stretches that are identified as meeting water quality standards and designated uses as models or reference condition for restoration goals.

Other designated uses that apply to these streams include domestic water supply, fish culture, irrigation, livestock watering, wildlife habitat and recreational uses such as fishing, wading and other limited seasonal contact activities. Most of the criteria that applies to these designated uses will be met if those of the high quality coldwater fishery are achieved. The water quality criteria and anti-degradation policy that applies to these stream reaches ultimately protects all of these uses.

Photo 15. Stretch of the Rito de Tierra Amarilla upstream of HWY 64 meeting all water quality standards and designated uses.

Photo 16. Stretch of Rio Chama showing stable streambank vegetation.

Management Measures

Management measures are "economically achievable measures for the control of the addition of pollutants from existing and new categories and classes of nonpoint sources of pollution, which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint source pollution control practices, technologies, processes, siting criteria, operating methods, or other alternatives" (USEPA, 1993). A combination of best management practices (BMPs) will be used to implement this TMDL.

A general implementation plan for activities to be established in the watershed is included in this document. The Surface Water Quality Bureau's Watershed Protection Section will further develop the details of this plan. Implementation of recommendations in this document will be done with full participation of all interested and affected parties. Stakeholder and public outreach and involvement in the implementation of this TMDL will be ongoing. Stakeholder participation will include choosing and installing BMPs, as well as potential volunteer monitoring.

During implementation, additional water quality data will be generated. As a result, targets will be re-examined and potentially revised; this document is considered to be an evolving management plan. In the event that new data indicate that the targets used in this analysis are not appropriate or if new standards are adopted, the load capacity will be adjusted accordingly. When water quality standards have been achieved, the reach will be removed from the 303(d) list of impaired waters.

8.1 Turbidity

Introduction

Turbidity is the reduction of the penetration of light through natural waters and appears as cloudy water. Suspended solids such as clay, silt, ash, plankton, and organic materials cause turbidity in surface waters. Some level of turbidity is a function of a stream's natural process of moving water and sediment. However, land surface disturbance activities and removal of vegetation can create an environment for erosion of fine soil material that washes into a stream and causes excessive turbidity. Turbidity can harm aquatic life by decreasing light available for plant growth, increasing water temperature, clogging the gills of aquatic fauna, and covering habitat. The turbidity standard addresses excessive sedimentation, which can also lead to the formation of excessive stream bottom deposits that can impact the aquatic ecosystem. Turbidity is a qualitative measure of water clarity or opacity and is reported in Nephelometric turbidity units (NTU). The measured loads for turbidity are expressed in lbs/day of total suspended solids (TSS). The calculated load reduction of TSS to meet water quality standards in Rito de Tierra Amarilla is 1569.3 lbs/day or 48%.

Examples of sources that can cause excessive turbidity include:

- runoff from exposed soil (such as construction sites),
- improperly maintained dirt roads and embankments,
- eroded streambanks,
- activities occurring within a stream channels that re-suspend sediments (such as gravel mining and low water crossings),
- removal of riparian vegetation, and
- naturally occurring situations, in some cases.

Process

Excessive turbidity occurs in the lower Rito de Tierra Amarilla as indicated by samples taken at the lower Rito de Tierra Amarilla station. The Pollutant Source Summary (Table 3.6) lists the land activities in the Rito de Tierra Amarilla watershed that are potentially contributing to excessive turbidity. The potential pollution sources and the resulting degradation to the stream are described further in the Linkage of Water Quality and Pollutant Sources (Section 3.2).

Photo 18. Note plume of turbid water discharging into the Rio Chama from the mouth of the Rito de Tierra Amarilla.

Using the information given in these previous sections and with further reconnaissance by stakeholders and landowners in the watershed, a land treatment strategy should be developed to guide the selection and implementation of Best Management Practices (BMPs) to reduce turbidity. Additionally, because time and funding are critical elements of implementing a plan, critical areas within a watershed or land treatments with the potential to produce significant results should be prioritized.

Agricultural practices have a significant effect on water quality in the floodplain of the lower Rito de Tierra Amarilla. Some of the ways in which agriculture can potentially cause turbidity include contributing sediment-laden runoff from land cleared for farming and in irrigation return flows, overgrazing and trampling of uplands that leads to loss of grass cover and increased bare ground, and removing or trampling of streambank (riparian) vegetation by domestic animals that may lead to bank erosion.

Landowners in the watershed can reverse the erosion process and loss of topsoil by using improved grazing management that lead to more continuous grass cover and less bare ground. Laser leveling of irrigated croplands and the use of buffer strips will reduce sediment-laden runoff from irrigation return flows. With help and technical guidance that members of a watershed alliance can provide, landowners can work to restore appropriate channel sinuosity and stable streambank environments through the installation of vegetative and other in-stream structures. Restoring riparian vegetation not only stabilizes soils along streambanks and floodplains but also attenuates erosive stream power and flood flows. The implementation of practices such as these that reduce turbidity will improve water quality and also benefit the landowner through the improvement of long-term soil productivity, increased organic litter, improved moisture retention, enhanced water infiltration, and reduced soil compaction.

Other strategies that will contribute to reducing turbidity include proper road maintenance practices and drainage controls, relocation of recreation trails away from riparian areas, riparian plantings along streambanks, and hydrogeomorphic river restoration. The SWQB will work with private landowners and community organizations to develop and implement a watershed-wide plan.

Additional sources of information for BMPs to address turbidity are listed below in the Agriculture, Forestry, Riparian and Streambank Stabilization, Roads, Stormwater, and Miscellaneous portions of section 8.5 below. Some of these documents are available for viewing at the New Mexico Environment Department, Surface Water Quality Bureau, Watershed Protection Section Library, 1190 St. Francis Drive, Santa Fe, New Mexico.

Performance Targets

Interim load reduction targets will be used to determine if control actions implemented are successful and standards attained. The interim load reduction targets will be established by the number and kind of BMPs implemented, the number of stream reach miles treated or positively affected by treatment of related areas, and the time it normally takes to see the results of the implemented BMPs. For example, interim load reduction targets for turbidity will be decreased turbidity values as a result of items such as:

- decreased erosion from streambanks,
- increased amount and health of riparian vegetation,
- increased vegetative cover in contributing upland areas, and
- increased miles of properly maintained roads.

In some cases, the results of implementation and maintenance of the most effective BMPs may likely take years to a decade to achieve.

Interim load reduction targets will be established by SWQB staff and will be re-evaluated periodically, depending on type and timing of BMP implementation. Furthermore, these interim load reduction targets will become part of the watershed remediation plan (WRAS). As additional information becomes available during the identification and quantification of the sources of pollution, the targets, load capacity, and allocations may need to be changed. In the event that new data or information show that changes are warranted, TMDL revisions will be made with assistance of the Upper Rio Chama watershed stakeholders. The re-examination process will involve monitoring pollutant loading, tracking implementation and effectiveness of controls, assessing water quality trends in the waterbody, and re-evaluating the TMDL for attainment of water quality standards. Although specific targets and allocations are identified in the TMDL, the ultimate success of the TMDL is not whether these targets and allocations are met, but whether beneficial uses and water quality standards are achieved.

8.2 Stream Bottom Deposits

Introduction

Stream bottom deposits in rivers are the result of excessive sediment carried either from watershed erosion or from eroding riverbanks. Stream bottom deposits become a concern when substantial amount of fine sediment settles on the channel bottom and are not fully flushed out of a river system during storm events (The Georgia Conservancy, TMDL Technical Advisory Group, 2002). Excessive stream bottom deposits fill in and eliminate pool habitat in streams, smothers riffle areas and reduces the overall habitat complexity of the stream. Excessive sediment deposits negatively affect aquatic life. Bottom deposit TMDLs are primarily intended to protect biota and habitat from the physical impacts of sediment.

Stream bottom deposits are measured using a number of monitoring procedures to quantify the narrative standard. Target levels use relationships between percent fines (material < 2mm diameter) and biological score as compared to a reference site. The measured loads for stream bottom deposits are expressed in % fines of the particle distribution within a stream segment. The calculated load reduction of % fines to meet water quality standards is 59% in Rita de Tierra Amarilla.

Clean stream bottom substrates are essential habitat for many fish and aquatic insect communities. Many macroinvertebrates such as aquatic insects and insect larvae, must adhere to hard surfaces such as coarse substrate to live, and/or depend on hard surfaces for feeding. If fine sediment cover the coarser sediment and block the interstitial spaces, macroinvertebrates can be affected by habitat reduction, increased drift during low flow and storm events, and decreased respiration. The result is an alteration of the macroinvertebrate community composition. Riffles tend to be very productive areas for the macroinvertebrates upon which fish feed. If riffles are covered by fine sediment or disturbed too frequently, macroinvertebrate productivity declines with direct effects on fish (The Georgia Conservancy, TMDL Technical Advisory Group, 2002).

The productivity of many fish species is correlated closely to the amount of pool habitat in a stream. Fish tend to congregate in pool areas because the lower water velocities reduce their metabolic requirements and because the deeper water provides cover against predators outside the stream. Bottom deposits can smother eggs and choke spawning habitats of some fish species.

The following are examples of sources of sedimentation that result in stream bottom deposits:

- runoff from construction activities,
- poorly constructed or maintained roads especially those located in riparian areas,
- poorly constructed culverts, bridges and other river crossings that cause erosion, and act as direct conduits of sediment into the river,
- removal of riparian vegetation causing streambank destabilization and loss of natural vegetative sediment traps,
- recreation areas located alongside rivers, and
- excessive stormwater runoff from urbanized areas
- silvicultural practices leading to unstable unprotected slopes
- straightening of river channels causing erosion by higher velocity flows

Historically, a major contributor to accelerated erosion is due to the destruction of beaver dams and extermination of the beaver. Sediment can become mobilized when beaver dams are breached causing erosion of channel bottoms and banks.

Photo 19. Beaver dam on the Rio Brazos

Process

Excessive stream bottom deposits occurs in the lower Rito de Tierra Amarilla as indicated by samples taken at the lower Rito de Tierra Amarilla station. The Pollutant Source Summary (Table 4.7) lists the land activities in the Rito de Tierra Amarilla watershed that are potentially contributing to excessive stream bottom deposits. The potential pollution sources and the resulting degradation to the stream are described further in the Linkage of Water Quality and Pollutant Sources (Section 4.2).

Many of the strategies that reduce turbidity in a stream also can be effective in reducing the sources of stream bottom deposits. However, sediment such as sand is normally retained within the system longer than finer particles such as clay that are carried as suspended material in the water column. This situation is exacerbated when normal flows that would continue to remove stream bottom deposits are reduced because of irrigation needs. Recovery of biota from the effects of stream bottom deposits may take longer to occur and should be considered when monitoring the effectiveness of BMP implementation.

There are a number of BMPs that can be utilized to address stream bottom deposits, depending on the source of the sediment. Such BMPs include:

- Minimize land use activities in riparian areas that can tear up existing protective ground cover and expose soils to erosion. For example, ruts from vehicles can channelize the flow of water causing gully formation and increased erosion and sedimentation into the adjacent river. (Soil and Water Conservation Practices Handbook, USDA Forest Service, Southwestern Region.).
- Develop water sources for livestock away from riparian areas and stream channels to prevent trampling, and overgrazing and to prevent the animals from disturbing the channel bottom. Also fence streamside areas to allow existing vegetation to recover.
- Promote maintenance and protection of riparian and wetland buffer strips of vegetation between roads and watercourses. In addition to the benefits of riparian areas for shading and bank stabilization, sufficiently wide buffers within the floodplain of the watercourse act as filters to prevent sediment from reaching watercourses during runoff events. (Water Quality Protection Guidelines for Forestry Operations in New Mexico, 1983, New Mexico Natural Resources Department, Forestry Division, 1983).
- Removal of forest and shrub land overgrowth in watersheds allows for the regeneration of a healthy groundcover of grasses. Without these healthy grasslands to provide a surface for water to infiltrate, watersheds can contribute large amounts of sediment that is washed from the land surface or scoured from eroding gullies that drain into watercourses (Watershed Restoration Through Integrated Resource Management on Public and Private Rangelands, Goodloe, Sid. and Alexander, Susan).
- Use water-catchment and water-harvesting techniques in urbanized areas. Catching and storing rainwater through the use of berms, detention ponds, and catchments from gutters and canales can enhance local supplies of water for domestic and agricultural use, can recharge the local water table, can water homeowner's gardens and vegetation, and can prevent sediment and other impurities from entering nearby water bodies. When used

extensively by a community, urban stormwater runoff and the sediment is carries can be significantly reduced.

Additional sources of information for BMPs to address stream bottom deposits are listed below in the Agriculture, Forestry, Riparian and Streambank Stabilization, Roads, Stormwater, and Miscellaneous portions of section 8.5 below. Some of these documents are available for viewing at the New Mexico Environment Department, Surface Water Quality Bureau, Watershed Protection Section Library, 1190 St. Francis Drive, Santa Fe, New Mexico.

Performance Targets

Interim load reduction targets will be used to determine if control actions implemented are successful and standards attained. The interim load reduction targets will be established by the number and kind of BMPs implemented, the number of stream reach miles treated or positively affected by treatment of related areas, and the time it normally takes to see the results of the implemented BMPs. For example, interim load reduction targets will be a lower percentage of fines in the stream bed as a result of items such as:

- a decrease in cobble embeddedness,
- removal of a poorly constructed dirt road from a riparian area, and
- successful bank stabilization efforts in a given reach of river.

In some cases, the results of implementation and maintenance of the most effective BMPs may likely take years to a decade to achieve.

Interim load reduction targets will be established by SWQB staff and will be re-evaluated periodically, depending on type and timing of BMP implementation. Furthermore, these interim load reduction targets will become part of the watershed remediation plan (WRAS). As additional information becomes available during the identification and quantification of the sources of pollution, the targets, load capacity, and allocations may need to be changed. In the event that new data or information show that changes are warranted, TMDL revisions will be made with assistance of the Upper Rio Chama watershed stakeholders. The re-examination process will involve monitoring pollutant loading, tracking implementation and effectiveness of controls, assessing water quality trends in the waterbody, and re-evaluating the TMDL for attainment of water quality standards. Although specific targets and allocations are identified in the TMDL, the ultimate success of the TMDL is not whether these targets and allocations are met, but whether beneficial uses and water quality standards are achieved.

8.3 Temperature

Introduction

Water temperature influences the metabolism, behavior, and mortality of fish and other aquatic organisms. Temperature affects the amount of oxygen that can be dissolved in water, the rate of photosynthesis of algae and other aquatic plants, the rates of growth, reproduction and decomposition of aquatic life, and the sensitivity of organisms to toxic wastes, parasites, and diseases. Normal water temperature varies both seasonally and throughout the day. Local indigenous aquatic communities are adapted to these natural daily and seasonal temperature fluctuations. However, changes to the normal temperature regime of a stream can eliminate indigenous populations, affect existing community structure and geographical distribution of species, and can support colonization of other species not found in the existing aquatic community.

Human-related pollution can change water temperature to the detriment of the aquatic community. The numeric water quality criterion for temperature of 20 °C (68°F) is applied to streams sampled in this study to maintain the designated use of a high quality cold water fishery and to protect cold-water aquatic life. Recorded maximum temperatures were higher than the criterion on the Rio Chama, Rio Brazos, Chavez Creek and the Rito de Tierra Amarilla by up to nearly 10 degrees Celsius. This temperature increase may kill many of the aquatic organisms that live in these streams. In order to meet the water quality standard, maximum stream temperatures must be reduced on all of these streams. Temperature load reductions expressed in joules/meter2/second are given in Table 5.6.

Some factors that can significantly increase water temperature include summer urban runoff, shallow stream depth, point sources of pollution, turbidity, insufficient shading, decreased base flow, ambient air temperature, and stream orientation (north/south or east/west). The following are examples of causes of temperature increases in aquatic ecosystems:

- reduction of shade caused by removal of streamside vegetation,
- collapse of undercut banks where fish and water are protected from incident sunlight,
- reduction of ground water discharge to the stream caused by reduced infiltration to the local water table,
- excessive turbidity that absorbs sunlight,
- alterations in stream geomorphology leading to a higher width/depth ratio and thus wider/shallower streams, and
- stormwater that flows across hot surfaces such as streets and enters a stream increasing water temperatures

Process

The Pollutant Source Summary (Table 5.7) lists the land activities that are potentially contributing to higher stream temperatures in the stream reaches mentioned above. The potential pollution sources and the resulting degradation that impacts each stream are described further in the Linkage of Water Quality and Pollutant Sources (Section 5.2).

There are a number of BMPs that address temperature, depending on the source of the problem. Many of the same impacts that can contribute to turbidity and stream bottom deposits also contribute to higher temperatures in streams. Below are some remedial actions that may address temperature:

- Reestablishment of appropriate woody and grassy riparian and wetland species applicable to the affected area provides canopy cover and shading for temperature control and helps prevent streambank collapse. Riparian and wetland vegetation can be restored by planting and seeding and by fencing riparian exclosures, and/or by promoting infiltration that raises the local water table.

- River restoration involving such actions as reconfiguration of the river's sinuosity and/or altering the processes of degradation and aggradation returns the river to a natural and stable morphology which incorporates a lower width-to-depth ratio. This lowered ratio means that the stream has become narrower and deeper and pools have reestablished. Thus, the stream can maintain cooler temperatures with the increased channel depth and reduced water surface exposed to solar radiation.
- Collection of stormwater runoff in detention ponds and reduction of the percentage of impervious surfaces in urban settings can reduce thermal pollution in runoff and can promote infiltration to the local water table where water temperatures are cooled and returned to recharge local streams as base flow.
- Limiting in-stream diversion to maintain adequate in-stream flow and stream depth will reduce water temperature extremes.
- Gravel operations that widen stream channels and/or lower stream bed elevation, thereby leaving adjacent riparian and wetland vegetation "high-and-dry", should be stopped. In New Mexico, most activities that result in fill material (ie. sand, gravel, etc.) entering waters of the U.S. are regulated. The Corps of Engineers and EPA regard the use of mechanized earth-moving equipment to conduct land-clearing, ditching, channelization, in-stream mining and gravel operations, or other earth-moving activity in waters of the United States as resulting in a discharge of dredged material, unless project-specific evidence shows that the activity results in only incidental fallback (33 CFR Ch II part 323.2). Permits are required from the Corps of Engineers and certification from the SWQB to conduct activities in the waters of the U.S.

The number of beneficial or designated uses usually decreases with declining water quality. Surface water quality temperature criteria are assigned to protect beneficial and designated uses. Temperature modifications from human activities associated with one use, such as livestock watering or in-stream withdrawals, should not compromise the protective needs of other uses within the same stream classification. Moreover, it is critically important that cumulative effects of human activities/uses on water temperature be considered holistically and not individually. A holistic approach is more readily feasible using the watershed geographical area and when all those with an interest in the river are involved. Stream uses and impacts should also be evaluated within an ecosystem context. To be acceptable, all beneficial uses must fit within the temperature regimes provided in nature.

A critical role of the watershed approach is to provide a forum to convey the benefits to the landowner and other stakeholders that will entice them to voluntarily implement modifications to activities and uses of the river already taking place that are causing impairments. Watershed-wide collaborations are a means to implement strategies benefiting users, activities and water quality. Incentives such as improved sport fishing and the influx of recreation dollars into the local economy, enhancement of grazing resources, and increased property values can be demonstrated to promote stewardship of local water resources.

Additional sources of information for BMPs to address temperature are listed below in the Agriculture, Forestry, Riparian and Streambank Stabilization, Roads, Stormwater, and Miscellaneous portions of section 8.5 below. Some of these documents are available for viewing at the New Mexico Environment Department, Surface Water Quality Bureau, Watershed Protection Section Library, 1190 St. Francis Drive, Santa Fe, New Mexico.

Performance Targets

Interim load reduction targets will be used to determine if control actions implemented are successful and standards attained. The interim load reduction targets will be established by the number and kind of BMPs implemented, the number of stream reach miles treated or positively affected by treatment of related areas, and the time it normally takes to see the results of the implemented BMPs. For example, interim load reduction targets will be decreased in stream temperature values as a result of items such as:

- percent success of riparian plantings,
- an increase in the percentage of stream canopy cover, and
- a decrease in the width-to-depth ratio of the stream.

In some cases, the results of implementation and maintenance of the most effective BMPs may likely take years to a decade to achieve.

Interim load reduction targets will be established by SWQB staff and will be re-evaluated periodically, depending on type and timing of BMP implementation. Furthermore, these interim load reduction targets will become part of the watershed remediation plan (WRAS). As additional information becomes available during the identification and quantification of the sources of pollution, the targets, load capacity, and allocations may need to be changed. In the event that new data or information show that changes are warranted, TMDL revisions will be made with assistance of the Upper Rio Chama watershed stakeholders. The re-examination process will involve monitoring pollutant loading, tracking implementation and effectiveness of controls, assessing water quality trends in the waterbody, and re-evaluating the TMDL for attainment of water quality standards. Although specific targets and allocations are identified in the TMDL, the ultimate success of the TMDL is not whether these targets and allocations are met, but whether beneficial uses and water quality standards are achieved.

8.4 Chronic Aluminum

Introduction

The uptake and transport of metals in surface waters can pose a considerable nonpoint source pollution problem. Metals such as aluminum, lead, copper, iron, zinc and others can occur naturally in watersheds in amounts ranging from trace to highly mineralized deposits. Some metals are essential to life at low concentrations but are toxic at higher concentrations. Metals such as cadmium, lead, mercury, nickel, and beryllium represent known hazards to human health. The metals are continually released into the aquatic environment through natural processes, including weathering of rocks, landscape erosion, geothermal or volcanic activity. The metals may be introduced into a waterway via headcuts, gullies or roads. Depending on the characteristics of the metal, it can be dissolved in water, deposited in the sediments or both. Metals become dissolved metals in water as a function of the pH of a water system. In urban settings, stormwater runoff can increase the mobilization of many metals into streams.

Examples of sources that can cause metals contamination:

- activities such as resource extraction, recreation, some agricultural activities and erosion can contribute to nonpoint source pollution of surface water by metals, and
- stormwater runoff in industrial areas may have elevated metals in both sediments and the water column.

Process

For the Rio Chamita, one of the primary focuses will be on the control of aluminum to the extent possible.

During the TMDL process in this watershed, point sources have been reviewed. Monitoring data from the Village of Chama WWTP have indicated that the facility is potentially contributing aluminum to the Rio Chamita. The WWTP has begun discussing the possibility of moving the discharge to the Rio Chama. SWQB NPDES staff will continue to work with the WWTP to encourage this transfer. During the October 2002, SWQB staff noted several potential sources of aluminum, such as aluminum weirs, screens, and gates. SWQB NPDES staff will encourage the WWTP to replace these fixtures with non-aluminum fixtures to eliminate these potential sources of aluminum.

The nonpoint source contributions will need to address aluminum exceedences through BMP implementation. BMPs can be implemented to address and remediate metal contamination. They include, but are not limited to:

- Improving the pH in a stream -- Neutral to alkaline pH waters will generally not pose a metal exceedence problem. An acidic pH will dissolve available metals. In such a case, a remedy for metals contamination could be an adjustment of the pH of runoff before it enters the water body. An approach may be the construction of an anoxic alkaline drain to raise the pH and precipitate the contained metals. An anoxic alkaline drain is constructed by placing a high pH material in a trench between runoff and the stream to be used as a buffer (Red River Groundwater Investigation- NMED-SWQB-Nonpoint Source Pollution Section, D. Slifer, 1996).

- Installing constructed wetlands -- Wetlands are used to filter runoff water and sediment from source areas in the watershed. Metals may be bound up in the root systems of wetlands vegetation, preventing them from entering a waterway. (The Use of Wetlands for Improving Water Quality to Meet Established Standards, Filas and Wildeman, 1992.)

- Improved stormwater control and construction BMPs -- Stormwater and construction BMPs can be used to divert flows off metal-producing areas directing them away from streams into areas where the flows may infiltrate, evaporate, or accumulate in sediment retention basins. (Conservation Design for Stormwater Management: A Design

Approach to Reduce Stormwater Impacts from Land Development and Achieve Multiple Objectives Related to Land Use, Delaware Department of Natural Resources and Environmental Control, Sediment and Stormwater Program & the Environment Management Center, Brandywine Conservancy, 1997.)

Additional sources of information for BMPs to address chronic aluminum are listed below in the Mining, Riparian and Streambank Stabilization, Stormwater/Urban, and Miscellaneous portions of section 8.5 below. Some of these documents are available for viewing at the New Mexico Environment Department, Surface Water Quality Bureau, Watershed Protection Section Library, 1190 St. Francis Drive, Santa Fe, New Mexico.

Performance Targets

Interim load reduction targets will be used to determine if control actions implemented are successful and standards attained. The interim load reduction targets will be established by the number and kind of BMPs implemented, the number of stream reach miles treated or positively affected by treatment of related areas, and the time it normally takes to see the results of the implemented BMPs. For example, interim load reduction targets will be decreased aluminum values as a result of items such as:

- increases in wetland areas to filter associated reductions in metals concentrations found in the stream,
- increases in stabilized streambanks and enhanced riparian areas to decrease erosion and potential loading of sediment associated with metals into a stream, and
- re-design/upgrades to the current WWTP.

Interim load reduction targets will be established by SWQB staff and will be re-evaluated periodically, depending on type and timing of BMP implementation. Furthermore, these interim load reduction targets will become part of the watershed remediation plan (WRAS). As additional information becomes available during the identification and quantification of the sources of pollution, the targets, load capacity, and allocations may need to be changed. In the event that new data or information show that changes are warranted, TMDL revisions will be made with assistance of the Upper Rio Chama watershed stakeholders. The re-examination process will involve monitoring pollutant loading, tracking implementation and effectiveness of controls, assessing water quality trends in the waterbody, and re-evaluating the TMDL for attainment of water quality standards. Although specific targets and allocations are identified in the TMDL, the ultimate success of the TMDL is not whether these targets and allocations are met, but whether beneficial uses and water quality standards are achieved.

8.5 Additional BMP references and sources of information

Additional sources of information for BMPs to address a variety of landuse practices and concerns are listed below. Some of these documents are available for viewing at the New Mexico Environment Department, Surface Water Quality Bureau, Watershed Protection Section Library, 1190 St. Francis Drive, Santa Fe, New Mexico:

Agriculture

Internet websites -- http://www.nm.nrcs.usda.gov/

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Forestry

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State of Alabama. 1993. Alabama's Best Management Practices for Forestry.

Mining

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Cohen, R.R.H., and S. W. Staub, 1992, Technical Manual for the Design and Operation of a Passive Mine Drainage Treatment System. U.S. Bureau of Land Management and U.S. Bureau of Reclamation, Denver, CO.

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Kleinmann, R.L.P., 1989, Acid Mine Drainage: U.S. Bureau of Mines, Research and Developments, Controlling Methods for Both Coal and Metal Mines. Engineering Mining Journal 190:16i-n.

Machemer, S.D., 1992, Measurements and Modeling of the Chemical Processes in a Constructed Wetland Built to Treat Acid Mine Drainage. Colorado School of Mines Thesis T-4074, Golden, CO.

Metish, J.J. and others, 1998, Treating Acid Mine Drainage From Abandoned Mines in Remote Areas. USDA Forest Service Technology and Development Program, AMD Study 7E72G71, Missoula, MT, US Govt. Printing Office: 1998-789-283/15001.

Royer, M.D., and L. Smith, 1995, Contaminants and Remedial Options at Selected Metal-Contaminated Sites: Battelle Memorial Institute-Columbus Division, under contract # 68-CO-0003-WA41 to Natl. Risk Management Lab-Office of Research and Development, USEPA. EPA/540/R-95/512.

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State of Tennessee, 1995, Riparian Restoration and Streamside Erosion Control Handbook, Nonpoint Source Water Pollution Management Program.

Roads

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9.0 OTHER IMPLEMENTATION ITEMS

9.1 Coordination

In this watershed public awareness and involvement will be crucial to the successful implementation of these plans and improved water quality. Staff from the SWQB will work with stakeholders to provide the guidance in developing the Watershed Management Plan (WMP). The WMP 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 impacts to water quality. This long-range strategy will become instrumental in coordinating and achieving constituent levels consistent with the New Mexico State Standards, and will be used to prevent water quality impacts in the watershed.

SWQB staff will assist with any technical assistance such as selection and application of BMPs needed to meet WMP goals. Implementation of BMPs within the watershed to reduce pollutant loading from nonpoint sources will be on a voluntary basis. Reductions from point sources will be addressed in revisions to discharge permits. Stakeholder public outreach and involvement in the implementation of this TMDL will be ongoing. Stakeholders in this process will include SWQB, and other members of the WMP. With assistance from SWQB, stakeholders are encourage to develop watershed groups in order to identify the following components of a successful WMP:

- The public outreach method(s) and structure that will be used to engage and maintain public and governmental involvement including local, state, federal, and tribal governments. This should include a process for cross-agency coordination and a process for continuous public involvement.
- Any monitoring and evaluation activities based on water quality goals and outcomes needed to refine the problems or assess progress towards achieving water quality goals. If monitoring is required to clarify/refine the water quality problems and sources, it should be done following a specific plan including concise goals and targeting, specific performance measures and a firm end date.
- The specific water quality problems to be addressed, the sources of pollution and the relative contribution of sources. WMPs should support a comprehensive approach to addressing all nonpoint sources in a targeted watershed. The WMP should also assure that water quality benefits are demonstrated in the short term. One mechanism that can be used in such a strategy is having individuals serving as watershed coordinators/evaluators.
- A blueprint of the actions to be taken and desired water quality goals and outcomes, i.e., implementation of pollution control and natural resource restoration measures. This may include implementation of tasks identified in source water protection programs and/or actions to implement TMDLs. This should include a discussion within the WMP as to how all program components will be applied (technical, financial and educational) to the water quality program.

- A schedule for implementation of needed restoration measures and identification of appropriate lead agencies to oversee implementation, maintenance, monitoring and evaluation.
- Funding needs to support the implementation and maintenance of restoration measures. This should include funding that would be available through federal assistance programs, state funds and other resources.

9.2 Time Line

The following table details the proposed implementation timeline (Table 9.1).

Table 9.1 Proposed Implementation Timeline

Implementation Actions	Year 1	Year 2	Year 3	Year 4	Year 5
Public Outreach and Involvement	X	X X X X			
Establish Performance Targets	X				
Secure Funding	X		X		
Implement Management Measures (BMPs)		X	X		
Monitor BMPs		X	X X		
Determine BMP Effectiveness		X			X
Re-evaluate Performance Targets		X			X

9.3 Clean Water Act §319(h) Funding Opportunities

The Watershed Protection Section of the SWQB provides USEPA §319(h) funding to assist in implementation of BMPs to address water quality problems on reaches listed on the §303(d) list or which are located within Category I Watersheds as identified under the Unified Watershed Assessment of the Clean Water Action Plan. 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 by applicants through a Request for Proposal (RFP) process and require a non-federal match of 40% of the total project cost consisting of funds and/or in-kind services. Further information on funding from the Clean Water Act §319 (h) can be found at the New Mexico Environment Department website: http://www.nmenv.state.nm.us.

9.4 Assurances

New Mexico's Water Quality Act (Act) does authorize the Water Quality Control Commission to "promulgate and publish regulation to prevent or abate water pollution in the state" and to require permits. The Act authorizes a constituent agency to take enforcement action against any person who violates a water quality standard. Several statutory provisions on nuisance law could also be applied to nonpoint source water pollution. The Water Quality Act also states in §74-6-12(a):

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

In addition, the State of New Mexico Surface Water Quality Standards (see Section 1100E and Section 1105C) (NMWQCC 1995b) states:

> *These water quality standards do not grant the Commission or any other entity the power to create, take away or modify property rights in water.*

New Mexico policies are in accordance with the federal Clean Water Act §101(g):

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

New Mexico's Clean Water Action Plan has been developed in a coordinated manner with the State's 303(d) process. All Category I watersheds identified in New Mexico's Unified Watershed Assessment process are totally coincidental with the impaired waters lists for 1996 and 1998 as approved by EPA. The State has given a high priority for funding, assessment, and restoration activities to these watersheds.

The New Mexico Water Quality Act authorizes the Water Quality Commission to "promulgate and publish regulations to prevent or abate water pollution in the state" and to require permits. Several statutory provisions on nuisance law could also be applied to nonpoint source water pollution. As a constituent agency, NMED has the authority under Chapter 74, Article 6-10 NMSA 1978 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. NMED nonpoint source water quality management program has historically strived for and will continue to promote voluntary compliance to nonpoint source water pollution concerns by utilizing a voluntary, cooperative approach. The State provides technical support and grant monies for implementation of BMPs and other NPS prevention mechanisms through §319 of the Clean Water Act. 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. The Watershed Protection Program coordinates with the Nonpoint Source Taskforce. The Nonpoint Source Taskforce is the New Mexico statewide focus group representing Federal and State agencies, local governments, tribes and pueblos, soil and water conservation districts, environmental organizations, industry, and the public. This group meets on a quarterly basis to provide input on the §319 program process, to disseminate information to other stakeholders and the public regarding nonpoint source issues, to identify complementary programs and sources of funding, and to help review and rank §319 proposals.

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 Forest Service and the Bureau of Land Management. MOUs have also been developed with other State agencies, such as the New Mexico State Highway and Transportation Department. These MOUs provide for coordination and consistency in dealing with nonpoint source issues.

New Mexico’s Clean Water Action Plan has been developed in a coordinated manner with the State’s §303(d) process. All Category I watersheds identified in New Mexico’s Unified Watershed Assessment process are totally coincident with the impaired waters list for 1996 and 1998 approved by EPA. The State has given a high priority for funding assessment and restoration activities to these watersheds.

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 members of the Watershed Restoration Action Strategy. The cooperation of the Upper Rio Chama watershed stakeholders will be pivotal in the implementation of these TMDLs as well.

10.0 PUBLIC PARTICIPATION

Public participation was solicited in development of this TMDL (see Appendix G). The draft TMDL was made available for a 30-day comment period starting July 15, 2003. Response to comments is attached as Appendix H of this document. The draft document notice of availability was extensively advertised via newsletters, email distribution lists, webpage postings (http://www.nmenv.state.nm.us), and press releases to area newspapers.

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APPENDICES

Appendix A: Cross-section Survey, Pebble Count, and Habitat Field Data

Appendix B: Conversion Factor Derivation

Appendix C: Pollutant Source(s) Documentation Protocol Forms

Appendix D: Thermograph Summary Data and Graphics

Appendix E: Hydrology, Geometry, and Meteorological Input Data for SSTEMP

Appendix F: SSTEMP Model Run Output

Appendix G: Public Participation Process Flowchart

Appendix H: Response to Comments

Appendix A: Cross-section Surveys, Pebble Counts, and Habitat Field Data

**Gary K is scanning in an additional 13 pages

SITE: Chama blw Chama At G&F Date: 981019

Location:

Party / Notes:

Distance; Point; or STATION Ft.	Elevation ~~Back-Sight~~ B S Ft.	Height of Instrument H I Ft.	Fore-Sight F S Ft.	Height; Depth; or Elevation Ft.	NOTES COMMENT REMARKS

Adjusted Distance	Height	Adjusted Height	Notes
0.0	3.27	100.00	LBP
2.5	3.62	99.65	
5.0	3.92	99.35	
8.0	4.22	99.05	
10.6	5.23	98.04	Bank Edge
10.9	5.75	97.52	LBF
11.1	6.55	96.72	
12.0	6.80	96.47	
13.0	7.06	96.21	LWE
14.6	7.56	95.71	
16.0	7.84	95.43	
17.8	7.81	95.46	
19.8	8.11	95.16	
22.3	8.49	94.78	Thalwag
23.8	8.43	94.84	Thalwag
25.2	8.46	94.81	Thalwag
29.5	8.23	95.04	
33.2	7.88	95.39	
36.3	8.04	95.23	
39.0	7.81	95.46	
42.8	7.59	95.68	
45.8	7.57	95.70	
48.7	6.99	96.28	
50.8	7.08	96.19	RWE
54.0	6.68	96.59	
58.0	6.36	96.91	
61.0	6.22	97.05	
64.2	6.20	97.07	
66.5	6.19	97.08	
68.8	6.30	96.97	
70.0	6.16	97.11	
72.1	5.75	97.52	RBF
74.0	5.19	98.08	
74.6	4.55	98.72	
75.8	3.38	99.89	
77.0	2.78	100.49	
79.0	2.21	101.60	
81.0	1.62	101.65	
83.0	1.62	101.65	RBP

Item	STATION	B S	H I	F S	Elevation
33	71.9	6.55			0.8
34	72.1	5.75			0
35	72.4	5.23			

GPS File N10198OB

BF = 2.74

ENTRENCHMENT

- Thalwag

- Bankfull

= Entrenchment Elevation

$\bar{X} = 1.43$

SURVEY DATA ⟹ CROSS - SECTION

SITE: Part

Date:

Item	STATION Ft.	B S Ft.	H I Ft.	F S Ft.	Elevation Ft.	NOTES COMMENT REMARKS
36	7Cn	11.72				
37						
38						
39	LP03					
40						
41						
42						
43						L3
44						
45						
46						
47						
48						
49						
50						
51						
52						
53						
54						
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57						
58						
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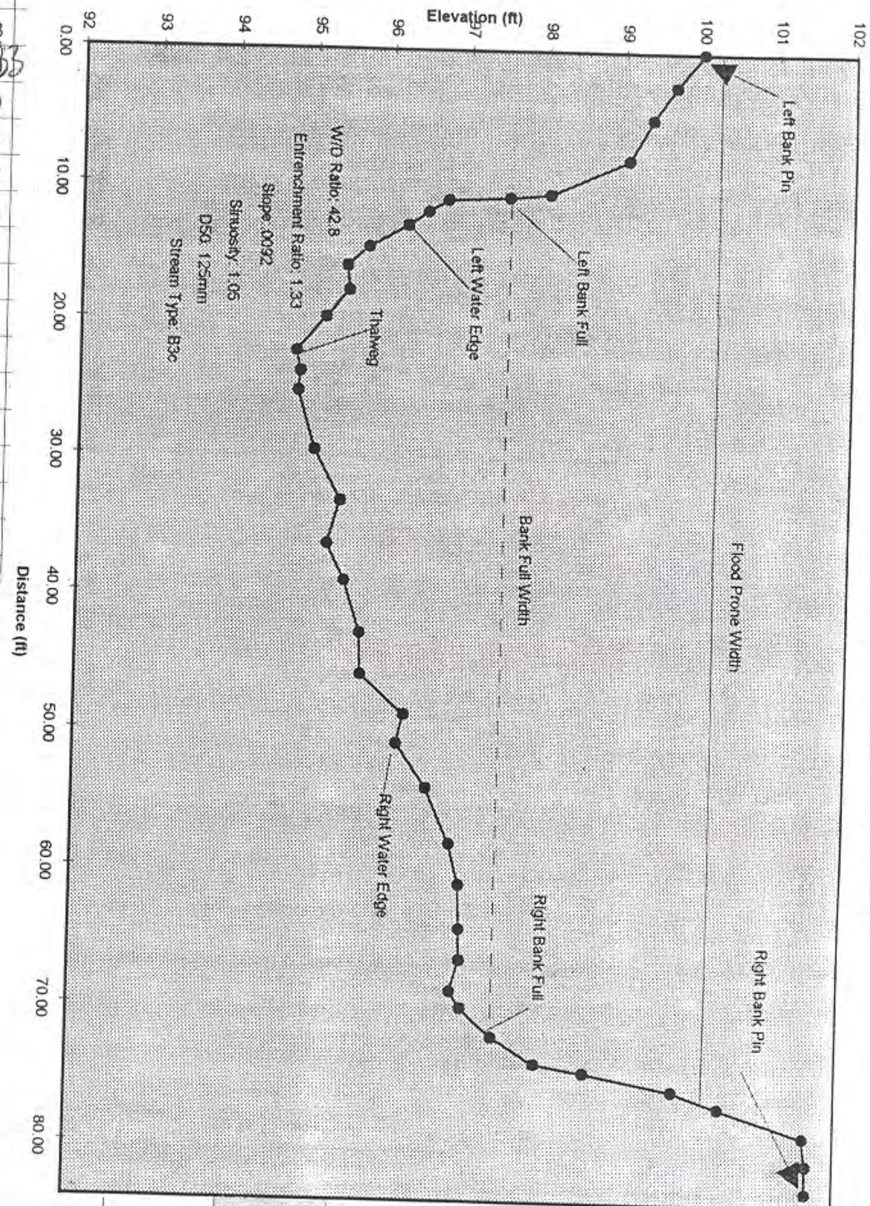
74						

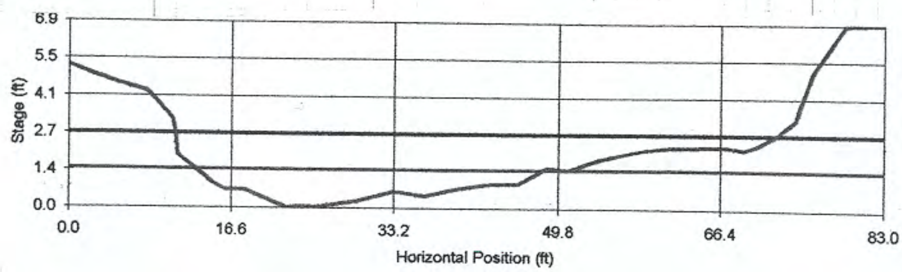


WINXSPRO results

Resistance Method: Thorne and Zevenbergen
D84: 195.000 mm

STAGE (ft)	#SEC	AREA (sq ft)	PERIM (ft)	WIDTH (ft)	R (ft)	DHYD (ft)	SLOPE (ft/ft)	n	VAVG (ft/s)	Q (cfs)	SHEAR (psf)
1.42	T	30.24	35.54	35.30	0.85	0.86	0.009	0.065	1.94	58.61	0.48
1.44	T	30.95	36.41	36.16	0.85	0.86	0.009	0.065	1.94	60.12	0.48
1.46	T	31.69	37.28	37.02	0.85	0.86	0.009	0.065	1.95	61.69	0.48
1.48	T	32.43	38.15	37.89	0.85	0.86	0.009	0.065	1.95	63.33	0.48
1.50	T	33.20	39.02	38.75	0.85	0.86	0.009	0.065	1.96	65.05	0.48
1.52	T	33.98	39.26	38.99	0.87	0.87	0.009	0.064	2.00	67.79	0.49
1.54	T	34.76	39.51	39.23	0.88	0.89	0.009	0.064	2.03	70.60	0.49
1.56	T	35.55	39.75	39.46	0.89	0.90	0.009	0.064	2.07	73.46	0.50
1.58	T	36.34	39.99	39.70	0.91	0.92	0.009	0.063	2.10	76.37	0.51
1.60	T	37.13	40.23	39.94	0.92	0.93	0.009	0.063	2.14	79.35	0.52
1.62	T	37.94	40.47	40.18	0.94	0.94	0.009	0.062	2.17	82.38	0.53
1.64	T	38.74	40.71	40.42	0.95	0.96	0.009	0.062	2.21	85.47	0.53
1.66	T	39.55	40.96	40.65	0.97	0.97	0.009	0.062	2.24	88.62	0.54
1.68	T	40.37	41.20	40.89	0.98	0.99	0.009	0.061	2.27	91.82	0.55
1.70	T	41.19	41.44	41.13	0.99	1.00	0.009	0.061	2.31	95.09	0.56
1.72	T	42.01	41.68	41.37	1.01	1.02	0.009	0.061	2.34	98.41	0.57
1.74	T	42.84	41.92	41.60	1.02	1.03	0.009	0.060	2.38	101.80	0.57
1.76	T	43.68	42.16	41.84	1.04	1.04	0.009	0.060	2.41	105.24	0.58
1.78	T	44.51	42.40	42.07	1.05	1.06	0.009	0.060	2.44	108.74	0.59
1.80	T	45.36	42.64	42.31	1.06	1.07	0.009	0.060	2.48	112.30	0.60
1.82	T	46.21	42.92	42.59	1.08	1.08	0.009	0.059	2.51	115.82	0.60
1.84	T	47.06	43.25	42.91	1.09	1.10	0.009	0.059	2.53	119.30	0.61
1.86	T	47.92	43.57	43.23	1.10	1.11	0.009	0.059	2.56	122.83	0.62
1.88	T	48.79	43.90	43.55	1.11	1.12	0.009	0.059	2.59	126.43	0.62
1.90	T	49.67	44.22	43.88	1.12	1.13	0.009	0.058	2.62	130.09	0.63
1.92	T	50.55	44.55	44.20	1.13	1.14	0.009	0.058	2.65	133.80	0.64
1.94	T	51.43	44.87	44.52	1.15	1.16	0.009	0.058	2.67	137.58	0.64
1.96	T	52.33	45.15	44.78	1.16	1.17	0.009	0.058	2.71	141.56	0.65
1.98	T	53.22	45.42	45.03	1.17	1.18	0.009	0.057	2.74	145.59	0.66
2.00	T	54.13	45.69	45.29	1.18	1.20	0.009	0.057	2.77	149.69	0.67
2.02	T	55.03	45.96	45.54	1.20	1.21	0.009	0.057	2.80	153.85	0.67
2.04	T	55.95	46.23	45.80	1.21	1.22	0.009	0.057	2.83	158.07	0.68
2.06	T	56.87	46.50	46.05	1.22	1.23	0.009	0.057	2.85	162.34	0.69
2.08	T	57.79	46.77	46.31	1.24	1.25	0.009	0.056	2.88	166.68	0.69
2.10	T	58.72	47.05	46.56	1.25	1.26	0.009	0.056	2.91	171.08	0.70
2.12	T	59.65	47.32	46.82	1.26	1.27	0.009	0.056	2.94	175.54	0.71
2.14	T	60.59	47.68	47.16	1.27	1.28	0.009	0.056	2.97	179.79	0.71
2.16	T	61.54	48.13	47.59	1.28	1.29	0.009	0.056	2.99	183.81	0.72
2.18	T	62.49	48.58	48.03	1.29	1.30	0.009	0.056	3.01	187.90	0.72
2.20	T	63.46	49.32	48.75	1.29	1.30	0.009	0.056	3.01	191.10	0.72
2.22	T	64.45	50.36	49.77	1.28	1.29	0.009	0.056	3.00	193.45	0.72
2.24	T	65.45	51.40	50.80	1.27	1.29	0.009	0.055	2.99	195.92	0.72
2.26	T	66.48	52.44	51.82	1.27	1.28	0.009	0.055	2.99	198.52	0.71
2.28	T	67.53	54.84	54.21	1.23	1.25	0.009	0.056	2.92	197.05	0.69
2.30	T	68.66	59.34	58.69	1.16	1.17	0.009	0.056	2.77	190.31	0.65
2.32	T	69.83	59.58	58.90	1.17	1.19	0.009	0.056	2.81	196.00	0.66
2.34	T	71.01	59.74	59.05	1.19	1.20	0.009	0.056	2.84	201.98	0.67
2.36	T	72.19	59.86	59.15	1.21	1.22	0.009	0.056	2.88	208.13	0.68
2.38	T	73.38	59.99	59.26	1.22	1.24	0.009	0.055	2.92	214.37	0.69
2.40	T	74.56	60.11	59.37	1.24	1.26	0.009	0.055	2.96	220.69	0.70
2.42	T	75.75	60.24	59.48	1.26	1.27	0.009	0.055	3.00	227.09	0.71
2.44	T	76.94	60.36	59.58	1.27	1.29	0.009	0.055	3.04	233.58	0.72
2.46	T	78.13	60.49	59.69	1.29	1.31	0.009	0.055	3.07	240.15	0.73
2.48	T	79.33	60.61	59.80	1.31	1.33	0.009	0.054	3.11	246.80	0.74
2.50	T	80.53	60.74	59.91	1.33	1.34	0.009	0.054	3.15	253.53	0.74
2.52	T	81.72	60.86	60.01	1.34	1.36	0.009	0.054	3.19	260.34	0.75
2.54	T	82.93	60.99	60.12	1.36	1.38	0.009	0.054	3.22	267.24	0.76
2.56	T	84.13	61.11	60.23	1.38	1.40	0.009	0.054	3.26	274.22	0.77
2.58	T	85.33	61.24	60.34	1.39	1.41	0.009	0.054	3.30	281.27	0.78
2.60	T	86.54	61.36	60.44	1.41	1.43	0.009	0.053	3.33	288.41	0.79
2.62	T	87.75	61.49	60.55	1.43	1.45	0.009	0.053	3.37	295.63	0.80
2.64	T	88.96	61.61	60.66	1.44	1.47	0.009	0.053	3.41	302.93	0.81
2.66	T	90.18	61.73	60.76	1.46	1.48	0.009	0.053	3.44	310.31	0.82
2.68	T	91.39	61.86	60.87	1.48	1.50	0.009	0.053	3.48	317.77	0.83
2.70	T	92.61	61.98	60.98	1.49	1.52	0.009	0.053	3.51	325.31	0.84
2.72	T	93.83	62.11	61.09	1.51	1.54	0.009	0.052	3.55	332.93	0.85
2.74	T	95.05	62.23	61.19	1.53	1.55	0.009	0.052	3.58	340.63	[illegible]

STAGE	ALPHA	FROUDE
1.42	1.00	0.37
1.44	1.00	0.37
1.46	1.00	0.37
1.48	1.00	0.37
1.50	1.00	0.37
2.64	1.00	0.50
2.66	1.00	0.50
2.68	1.00	0.50
2.70	1.00	0.50
2.72	1.00	0.50
2.74	1.00	0.51



URVEY DATA ⟹ CROSS - SECTION Part I

AGE: No:

ocation: Chavery CK @ 512 bridge Date: 6/10/02

arty / Notes: L Stevens, S Strine, J Tsanos

istance; Point; or STATION Ft.	Back-Sight B S Ft.	Height of Instrument H I Ft.	Fore-Sight F S Ft.	Height; Depth; or Elevation Ft.	NOTES COMMENT REMARKS
1	10.59				RBF
2.5	10.83				slope break
4.3	10.95				slope break
6.8	11.72				Right Edge of active channel
14.0	11.92				Right wetted Edge
20.2	12.14				Thalweg
~~25.2~~	~~11.66~~				Left wetted Edge
23.6	11.92				" " "
26.3	11.55				slope break
33.5	11.32				slope break
36.0	10.46				Slope Break
~~36.2~~	~~9.54~~				~~LBF~~
36.2	10.58				LBF
	11.94				16.4' upstream of tape
	12.24				16.4' downstream of tape

$$\text{Slope} = \frac{0.30\text{ ft}}{32.8\text{ ft}} = 0.009$$

$= 0.9\%$

SURVEY DATA ⟹ CROSS - SECTION Part II

GAGE: No: Date:

Item	STATION Ft.	B S Ft.	H I Ft.	F S Ft.	Elevation Ft.	NOTES COMMENT REMARKS
36						
37						
38						
39						
40						
41						
42						
43						
44						
45						
46						
47						
48						
49						
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51						
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58						
59						
60						
61						
62						
63						
64						
65						
66						
67						
68						
69						
70						
71						
72						

```
********************************WinXSPRO**********************************
chavez.out
Input File:            C:\MYDOCU~1\WXSPRO20\CHAVEZ.DAT
Run Date:              10/30/02
Analysis Procedure:    Hydraulics & Regression
Cross Section Number:  1
Survey Date:           6/10/02

Subsections/Dividing stations
A /  36.19/ @

Resistance Method:     Thorne and Zevenbergen
           D84:        84.000 mm
```

STAGE (ft)	#SEC	AREA (sq ft)	PERIM (ft)	WIDTH (ft)	R (ft)	DHYD (ft)	SLOPE (ft/ft)	n	VAVG (ft/s)	Q (cfs)
0.10	T	0.22	4.46	4.45	0.05	0.05	0.009	0.116	0.16	0.04
0.20	T	0.89	8.92	8.91	0.10	0.10	0.009	0.096	0.32	0.28
0.30	T	2.02	13.66	13.65	0.15	0.15	0.009	0.086	0.46	0.92
0.40	T	3.62	18.48	18.46	0.20	0.20	0.009	0.080	0.59	2.15
0.50	T	5.60	20.69	20.66	0.27	0.27	0.009	0.070	0.85	4.75
0.60	T	7.75	22.36	22.30	0.35	0.35	0.009	0.058	1.20	9.31
0.70	T	10.11	24.96	24.89	0.40	0.41	0.009	0.054	1.43	14.45
0.80	T	12.72	27.56	27.47	0.46	0.46	0.009	0.051	1.64	20.92
0.90	T	15.54	28.79	28.68	0.54	0.54	0.009	0.049	1.92	29.81
1.00	T	18.46	29.69	29.55	0.62	0.62	0.009	0.047	2.19	40.46
1.10	T	21.45	30.58	30.42	0.70	0.71	0.009	0.045	2.45	52.63
1.20	T	24.54	31.59	31.40	0.78	0.78	0.009	0.044	2.69	66.11
1.30	T	27.78	33.56	33.35	0.83	0.83	0.009	0.044	2.86	79.54
1.40	T	31.16	34.40	34.13	0.91	0.91	0.009	0.043	3.10	96.63
1.50	T	34.61	35.15	34.83	0.98	0.99	0.009	0.042	3.34	115.43
1.56	T	36.71	35.55	35.19	1.03	1.04	0.009	0.042	3.48	127.60 *

STAGE	ALPHA	FROUDE
0.10	1.00	0.13
0.20	1.00	0.18
0.30	1.00	0.21
0.40	1.00	0.24
0.50	1.00	0.29
0.60	1.00	0.36
0.70	1.00	0.40
0.80	1.00	0.43
0.90	1.00	0.46
1.00	1.00	0.49
1.10	1.00	0.51
1.20	1.00	0.54
1.30	1.00	0.55
1.40	1.00	0.57
1.50	1.00	0.59
1.56	1.00	0.60

```
Q = aR^b     a=138.796295  b=2.659834  r^2=0.996922  n=16
Q = aZ^b     a=37.388386  b=3.004  r^2=0.998462  n=16
```

*******************************WinXSPRO*********************************

C:\WXSPRO20\TEMPLET.OUT

Input File: C:\WXSPRO20\SAMPLE.DAT
Run Date: 06/17/02
Analysis Procedure: Hydraulics
Cross Section Number: 1
Survey Date: 08/17/00

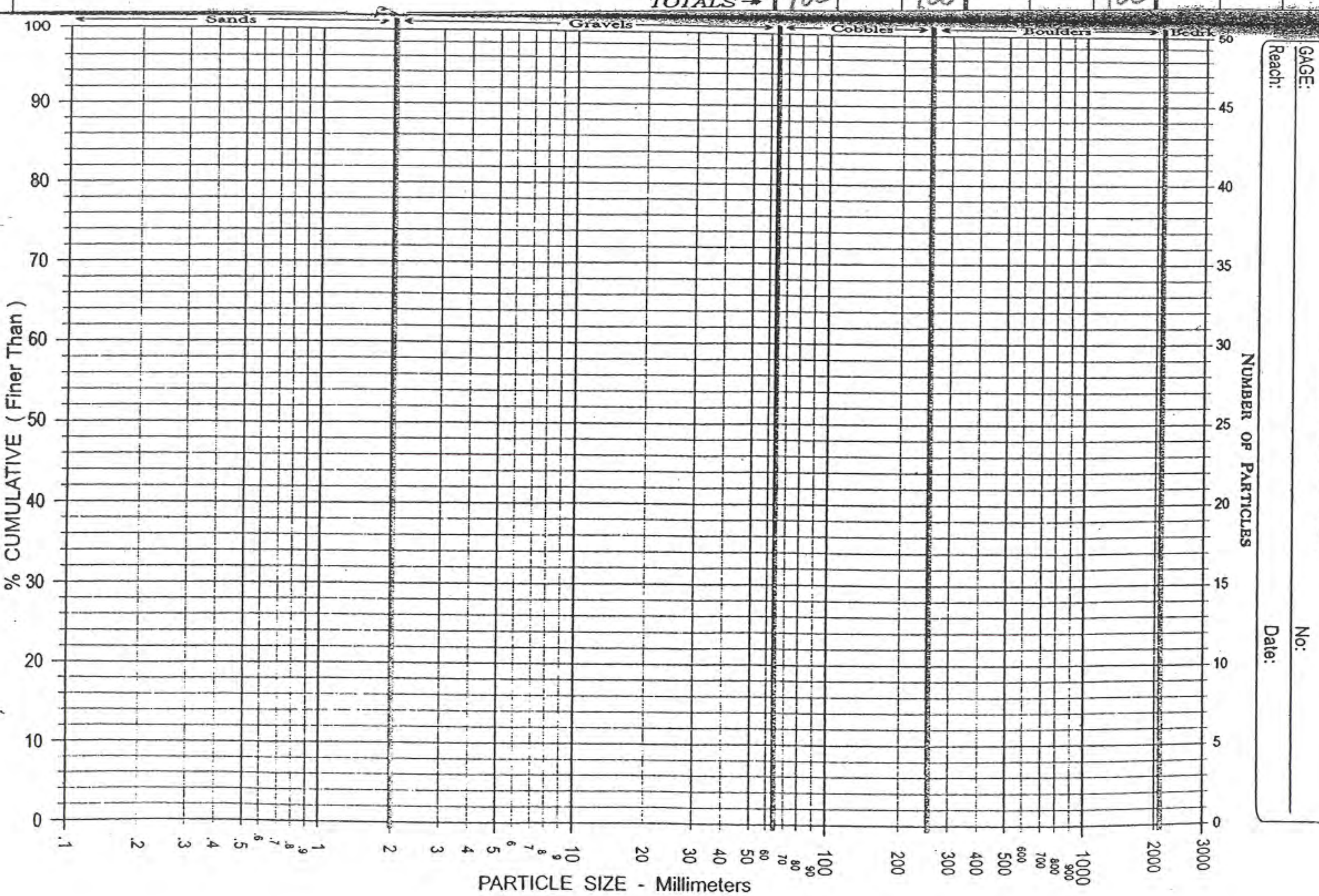
Subsections/Dividing stations
A / 121.00/ @

Resistance Method: Thorne and Zevenbergen
D84: 300.000 mm

STAGE (ft)	#SEC	AREA (sq ft)	PERIM (ft)	WIDTH (ft)	R (ft)	DHYD (ft)	SLOPE (ft/ft)	n	VAVG (ft/s)	Q (cfs)
0.10	T	0.10	2.02	2.00	0.05	0.05	0.012	0.447	0.05	0.00
0.20	T	0.40	4.03	4.00	0.10	0.10	0.012	0.292	0.12	0.05
0.30	T	1.03	8.59	8.55	0.12	0.12	0.012	0.184	0.22	0.22
0.40	T	2.11	13.16	13.10	0.16	0.16	0.012	0.155	0.31	0.66
0.50	T	3.49	14.53	14.45	0.24	0.24	0.012	0.150	0.42	1.48
0.60	T	5.00	15.90	15.81	0.31	0.32	0.012	0.138	0.55	2.76
0.70	T	6.65	17.27	17.16	0.38	0.39	0.012	0.126	0.69	4.61
0.80	T	8.43	18.65	18.52	0.45	0.46	0.012	0.115	0.84	7.12
0.90	T	10.35	20.02	19.87	0.52	0.52	0.012	0.106	1.00	10.40
1.00	T	12.41	21.39	21.23	0.58	0.58	0.012	0.098	1.17	14.53
1.10	T	14.60	22.76	22.58	0.64	0.65	0.012	0.091	1.34	19.63
1.20	T	16.92	24.13	23.94	0.70	0.71	0.012	0.086	1.52	25.80
1.30	T	19.38	25.51	25.29	0.76	0.77	0.012	0.081	1.71	33.14
1.40	T	21.98	26.88	26.64	0.82	0.82	0.012	0.076	1.90	41.77
1.50	T	24.71	28.25	28.00	0.87	0.88	0.012	0.073	2.10	51.79
1.60	T	27.85	35.09	34.83	0.79	0.80	0.012	0.083	1.72	48.05
1.70	T	31.43	36.93	36.66	0.85	0.86	0.013	0.079	1.89	59.43
1.80	T	35.19	38.78	38.50	0.91	0.91	0.013	0.076	2.06	72.48
1.90	T	39.13	40.62	40.33	0.96	0.97	0.013	0.073	2.23	87.33
2.00	T	43.25	42.47	42.16	1.02	1.03	0.013	0.077	2.20	95.04
2.10	T	47.56	44.31	44.00	1.07	1.08	0.013	0.075	2.34	111.35
2.20	T	52.01	45.22	44.88	1.15	1.16	0.013	0.073	2.53	131.58
2.30	T	56.54	46.13	45.77	1.23	1.24	0.013	0.071	2.71	153.50
2.40	T	61.16	47.03	46.65	1.30	1.31	0.013	0.069	2.90	177.11
2.50	T	65.87	47.94	47.54	1.37	1.39	0.013	0.068	3.07	202.43
2.60	T	70.66	48.64	48.21	1.45	1.47	0.013	0.066	3.26	230.29
2.70	T	75.51	49.34	48.88	1.53	1.54	0.013	0.065	3.44	259.91
2.80	T	80.43	50.04	49.55	1.61	1.62	0.013	0.064	3.62	291.30
2.90	T	85.42	50.74	50.22	1.68	1.70	0.013	0.063	3.80	324.46
3.00	T	90.47	51.44	50.89	1.76	1.78	0.013	0.062	3.97	359.39
3.10	T	95.60	52.14	51.56	1.83	1.85	0.013	0.061	4.14	396.11
3.20	T	100.79	52.84	52.23	1.91	1.93	0.013	0.061	4.31	434.63

STAGE	ALPHA	FROUDE
0.10	1.00	0.04
0.20	1.00	0.07
0.30	1.00	0.11
0.40	1.00	0.14
0.50	1.00	0.15
0.60	1.00	0.17
0.70	1.00	0.20
0.80	1.00	0.22
0.90	1.00	0.25
1.00	1.00	0.27
1.10	1.00	0.29
1.20	1.00	0.32
1.30	1.00	0.34
1.40	1.00	0.37
1.50	1.00	0.39
1.60	1.00	0.34
1.70	1.00	0.36
1.80	1.00	0.38
1.90	1.00	0.40
2.00	1.00	0.38
2.10	1.00	0.40
2.20	1.00	0.41
2.30	1.00	0.43
2.40	1.00	0.45
2.50	1.00	0.46
2.60	1.00	0.47
2.70	1.00	0.49
2.80	1.00	0.50
2.90	1.00	0.51
3.00	1.00	0.52
3.10	1.00	0.54
3.20	1.00	0.55

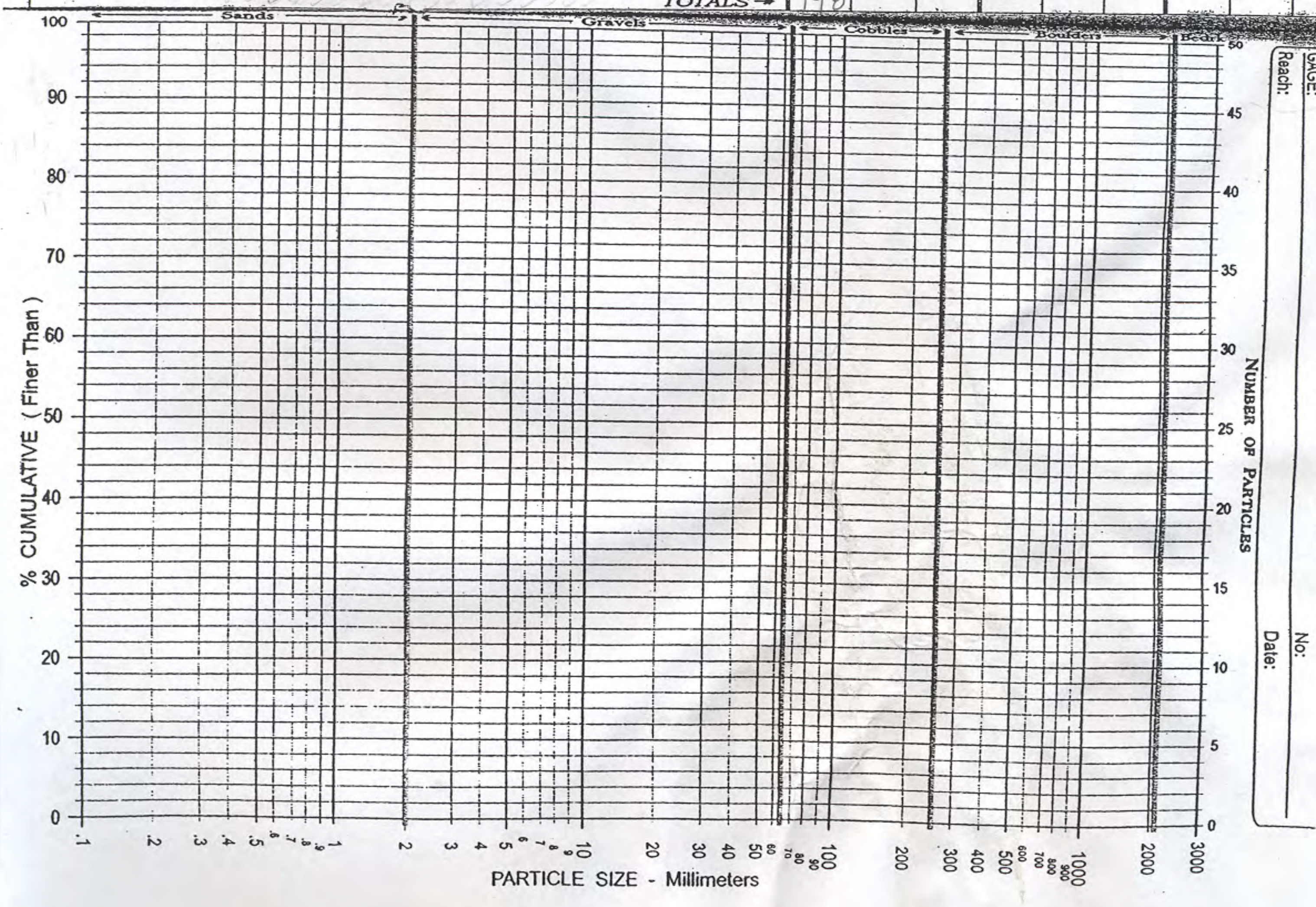
Site: Rito TAmarilla				Reach: ~100 yds u/s of Confl w/ Chama				Reach: U/s of Hwy			Reach: 112		
Party: L. Smolka L. Stevens				Date: 10/22/01 1045				Date: 10/22/01			Date:		
Inches	PARTICLE	Millimeters		PARTICLE COUNT 1 2 3	TOT #	ITEM %	% CUM	TOT #	ITEM %	% CUM	TOT #	ITEM %	% CUM
	Silt / Clay	< .062	S/C		59		59	73		73			
	Very Fine	.062 - .125	SAND		1		60						
	Fine	.125 - .25	SAND										
	Medium	.25 - .50	SAND										
	Coarse	.50 - 1.0	SAND										
.04 - .08	Very Coarse	1.0 - 2	SAND					1		74			
.08 - .16	Very Fine	2 - 4	GRAVEL		1		61						
.16 - .22	Fine	4 - 5.7	GRAVEL		2		63						
.22 - .31	Fine	5.7 - 8	GRAVEL		2		65						
.31 - .44	Medium	8 - 11.3	GRAVEL		1		66						
.44 - .63	Medium	11.3 - 16	GRAVEL										
.63 - .89	Coarse	16 - 22.6	GRAVEL		1		67						
.89 - 1.26	Coarse	22.6 - 32	GRAVEL		2		69	3		77			
1.26 - 1.77	Very Coarse	32 - 45	GRAVEL		5		74	3		80			
1.77 - 2.5	Very Coarse	45 - 64	GRAVEL		5		79	7		87			
2.5 - 3.5	Small	64 - 90	COBBLE		6		85	6		93			
3.5 - 5.0	Small	90 - 128	COBBLE		3		88	4		97			
5.0 - 7.1	Large	128 - 180	COBBLE		4		92	2		99			
7.1 - 10.1	Large	180 - 256	COBBLE		2		94	1		100			
10.1 - 14.3	Small	256 - 362	BOULDER		3		97						
14.3 - 20	Small	362 - 512	BOULDER		3		100						
20 - 40	Medium	512 - 1024	BOULDER										
40 - 80	Large-Vry Large	1024 - 2048	BOULDER										
	Bedrock		BDRK										
				TOTALS →	100		100			100			



Site: R Tierra Amarilla Reach: @ Hwy 64

Party: LS, JT, SS[illegible] Date: 6/11/02 1130

Inches	PARTICLE	Millimeters		PARTICLE COUNT 1 2 3	TOT #	ITEM %	% CUM	Reach: Date: TOT #	ITEM %	% CUM	Reach: Date: TOT #	ITEM %	% CUM
	Silt / Clay	< .062	S/C		21								
	Very Fine	.062 - .125	SAND										
	Fine	.125 - .25	SAND										
	Medium	.25 - .50	SAND		1								
	Coarse	.50 - 1.0	SAND										
.04 - .08	Very Coarse	1.0 - 2	SAND		4								
.08 - .16	Very Fine	2 - 4 3	GRAVEL										
.16 - .22	Fine	4 - 5.7 5.6	GRAVEL		1			-Alders, willows,					
.22 - .31	Fine	5.7 - 8 7	GRAVEL		4			shaded					
.31 - .44	Medium	8 - 11.3	GRAVEL		5								
.44 - .63	Medium	11.3 - 16 15	GRAVEL		7								
.63 - .89	Coarse	16 - 22.6	GRAVEL		7								
.89 - 1.26	Coarse	22.6 - 32 31	GRAVEL		9								
1.26 - 1.77	Very Coarse	32 - 45 44	GRAVEL		11								
1.77 - 2.5	Very Coarse	45 - 64 63	GRAVEL		23								
2.5 - 3.5	Small	64 - 90 89	COBBLE		28								
3.5 - 5.0	Small	90 - 128 127	COBBLE		20								
5.0 - 7.1	Large	128 - 180 179	COBBLE		24								
7.1 - 10.1	Large	180 - 256 255	COBBLE		14								
10.1 - 14.3	Small	256 - 362 361	BOULDER		10								
14.3 - 20	Small	362 - 512 511	BOULDER		9								
20 - 40	Medium	512 - 1024 3	BOULDER										
40 - 80	Large-Vry Large	1024 - 2048	BOULDER										
	Bedrock		BDRK										
				TOTALS →	198								



RB Breached Earthen Dam u/s of lower site

Silt veneer on all submerged substrate

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME Rita T Amarillo	LOCATION ~100 y u/s of confl w/ Chama O =
STATION # RIVERMILE	STREAM CLASS / = u/s of HWY 112
LAT LONG	RIVER BASIN
STORET #	AGENCY SWQB / NMED
INVESTIGATORS L. Smolka, L. Stevens	
FORM COMPLETED BY L. Stevens / L. Smolka	DATE 10/22/01 TIME 1100 AM PM
REASON FOR SURVEY	

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration * u/s breached earthen dam	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream. *u/s outside bends are contributing	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score ________

0 = RTA ~100 y u/s of Chamita = 121/200

1 = RTA @ 112 = 99/200

Cattle grazin

(FP mostly R. brush)

10/21/1998

Note: Chamita @ Sexto Creek = 148/200

Chamita a/s WWTP = 136/200

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION R ITO TA @ 64	
STATION # ______ RIVERMILE ______	STREAM CLASS	
LAT ______ LONG ______	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY SMOLKA	DATE 981020 TIME ______ AM PM	REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

p-1Y

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score 179

*use topo for LB topo alt. (RB = meadow)

SURVEY DATA ⟹ CROSS - SECTION Part I

GAGE: Rito de Tierra Amarilla No:

Location: @ HWY 112 ~60 yds u/s of bridge Date: 7/24/02

Party / Notes: LS, JT, MM

Distance; Point; or STATION Ft.	Back-Sight BS Ft.	Height of Instrument HI Ft.	Fore-Sight FS Ft.	Height; Depth; or Elevation Ft.	NOTES COMMENT REMARKS
0				5.79	Left Pin
2.0				6.24	
4.4				6.78	L BNK FULL
5.85				8.13	LEW
7.30				8.26	thalweg
10.0				7.85	mid bar
12.0				8.05	
13.55				8.10	REW
15.3				7.81	
17.0				7.71	
19.0				7.67	
21.65				7.59	
23.55				6.92	R BNKFULL
23.75				6.44	
24.3				5.76	
26.0				5.23	
28.0				5.1	Right Pin

slope → u/s LEW elev = 8.20

d/s LEW elev = 8.52

Dist = 90 ft.

Slope = 0.32 ft/90 ft = 0.0036

Q = ~1 cfs (trickle) at time of msmt.

ELEV = 7152 ft

SURVEY DATA ⟹ CROSS - SECTION Part II

GAGE: No: Date:

Item	STATION Ft.	BS Ft.	HI Ft.	FS Ft.	Elevation Ft.	NOTES COMMENT REMARKS
36						
37						
38						
39						
40						
41						
42						
43						
44						
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50						
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71						
72						

*******************************WinXSPRO*******************************
rta_112.out
Input File: C:\MYDOCU~1\WXSPRO20\RTA_112.DAT
Run Date: 10/30/02
Analysis Procedure: Hydraulics & Regression
Cross Section Number: 1
Survey Date: 7/24/02

Subsections/Dividing stations
A / 27.98/ @

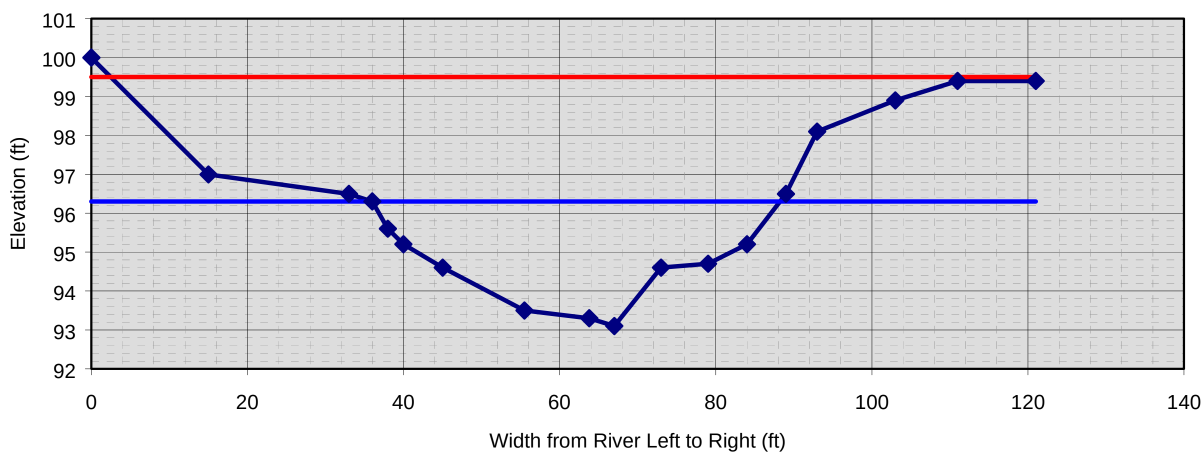
Resistance Method: Thorne and Zevenbergen
D84: 55.000 mm

STAGE (ft)	#SEC	AREA (sq ft)	PERIM (ft)	WIDTH (ft)	R (ft)	DHYD (ft)	SLOPE (ft/ft)	n	VAVG (ft/s)	Q (cfs)	
0.10	T	0.09	1.75	1.73	0.05	0.05	0.004	0.123	0.10	0.01	
0.20	T	0.35	4.36	4.31	0.08	0.08	0.004	0.087	0.20	0.07	
0.30	T	0.92	6.99	6.88	0.13	0.13	0.004	0.068	0.36	0.33	
0.40	T	1.73	9.41	9.24	0.18	0.19	0.004	0.057	0.53	0.92	
0.50	T	2.72	10.87	10.65	0.25	0.25	0.004	0.050	0.74	2.02	
0.60	T	3.91	14.21	13.95	0.28	0.28	0.004	0.048	0.84	3.28	
0.70	T	5.47	16.81	16.51	0.33	0.33	0.004	0.045	0.99	5.42	
0.80	T	7.14	17.26	16.90	0.41	0.42	0.004	0.042	1.23	8.81	
0.90	T	8.85	17.71	17.30	0.50	0.51	0.004	0.041	1.46	12.91	
1.00	T	10.60	18.16	17.69	0.58	0.60	0.004	0.039	1.67	17.70	
1.10	T	12.39	18.61	18.09	0.67	0.68	0.004	0.038	1.87	23.16	
1.20	T	14.22	19.06	18.48	0.75	0.77	0.004	0.038	2.06	29.27	
1.30	T	16.08	19.51	18.87	0.82	0.85	0.004	0.037	2.24	36.01	
1.40	T	17.99	19.84	19.12	0.91	0.94	0.004	0.036	2.42	43.55	
1.50	T	19.91	20.16	19.34	0.99	1.03	0.004	0.036	2.60	51.70	
1.60	T	21.87	20.73	19.83	1.05	1.10	0.004	0.036	2.74	59.99	
1.70	T	23.87	21.29	20.31	1.12	1.18	0.004	0.035	2.88	68.87	
1.80	T	25.93	21.85	20.80	1.19	1.25	0.004	0.035	3.02	78.35	
1.90	T	28.03	22.43	21.31	1.25	1.32	0.004	0.035	3.15	88.39	
2.00	T	30.19	23.01	21.83	1.31	1.38	0.004	0.034	3.28	99.03	
2.10	T	32.40	23.59	22.35	1.37	1.45	0.004	0.034	3.40	110.28	
2.20	T	34.66	24.17	22.86	1.43	1.52	0.004	0.034	3.52	122.16	
2.30	T	36.97	24.75	23.38	1.49	1.58	0.004	0.034	3.64	134.66	
2.40	T	39.34	25.33	23.90	1.55	1.65	0.004	0.034	3.76	147.80	
2.50	T	41.75	25.80	24.28	1.62	1.72	0.004	0.033	3.88	162.03	*
2.60	T	44.19	26.23	24.61	1.68	1.80	0.004	0.033	4.00	177.00	*
2.70	T	46.67	26.67	24.93	1.75	1.87	0.004	0.033	4.13	192.56	*
2.80	T	49.18	27.11	25.25	1.81	1.95	0.004	0.033	4.24	208.71	*
2.90	T	51.72	27.54	25.57	1.88	2.02	0.004	0.033	4.36	225.45	*
3.00	T	54.29	27.98	25.89	1.94	2.10	0.004	0.033	4.47	242.78	*
3.10	T	56.93	29.26	27.06	1.95	2.10	0.004	0.033	4.49	255.75	*
3.16	T	58.58	30.24	27.98	1.94	2.09	0.004	0.033	4.49	262.78	*

STAGE	ALPHA	FROUDE
0.10	1.00	0.08
0.20	1.00	0.13
0.30	1.00	0.17
0.40	1.00	0.22
0.50	1.00	0.26
0.60	1.00	0.28
0.70	1.00	0.30
0.80	1.00	0.33
0.90	1.00	0.36
1.00	1.00	0.38
1.10	1.00	0.40
1.20	1.00	0.41
1.30	1.00	0.43
1.40	1.00	0.44
1.50	1.00	0.45
1.60	1.00	0.46
1.70	1.00	0.47
1.80	1.00	0.48
1.90	1.00	0.48
2.00	1.00	0.49
2.10	1.00	0.50
2.20	1.00	0.50
2.30	1.00	0.51
2.40	1.00	0.52
2.50	1.00	0.52
2.60	1.00	0.53
2.70	1.00	0.53
2.80	1.00	0.54
2.90	1.00	0.54
3.00	1.00	0.54
3.10	1.00	0.55

Cross Section

XS 1 @ 225 feet Riffle Rio Brazos at County road 573



section:	**XS 1 @ 225 feet**
	Riffle
stream:	Rio Brazos at County road 573
location:	132 square miles
description:	Moody et al 06/16/1999
height of instrument (ft):	**100.00**

notes	omit pt.	distance (ft)	FS (ft)	elevation
		0	**0**	100
		15	**3**	97
		33	**3.5**	96.5
LBF		**36**	**3.7**	96.3
		38	**4.4**	95.6
		40	**4.8**	95.2
		45	**5.4**	94.6
		55.5	**6.5**	93.5
		63.8	**6.7**	93.3
TW		**67**	**6.9**	93.1
	# #	**73**	**5.4**	94.6
	# #	**79**	**5.3**	94.7
RBF?	# #	**84**	**4.8**	95.2
	# #	**89**	**3.5**	96.5
	# #	**93**	**1.9**	98.1
	# #	**103**	**1.1**	98.9
	# #	**111**	**0.6**	99.4
	# #	**121**	**0.6**	99.4
	# #			
	# #			
	# #			
	# #			

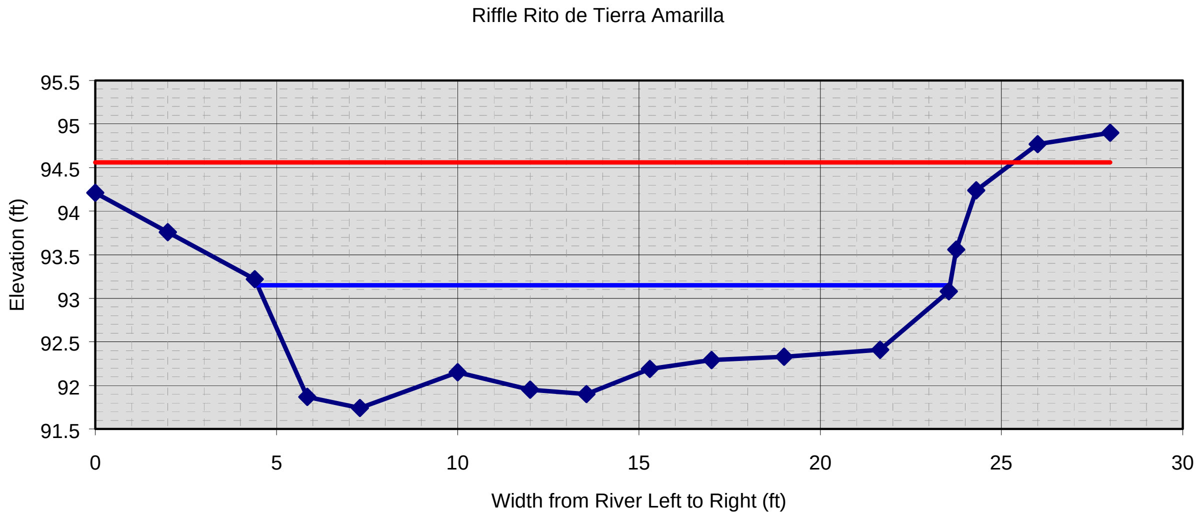
FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
3.7	**3.5**	**200.0**	**1.25**	**0.065**
96.3	96.5			

dimensions			
100.8	x-section area	1.9	d mean
52.2	width	52.8	wet P
3.2	d max	1.9	hyd radi
3.4	bank ht	27.1	w/d ratio
200.0	W flood prone area	3.8	ent ratio

hydraulics	
3.9	velocity (ft/sec)
396.2	discharge rate, Q (cfs)
1.49	shear stress ((lbs/ft sq)
0.88	shear velocity (ft/sec)
5.917	unit stream power (lbs/ft/sec)
0.25	Froude number
4.5	friction factor u/u*
157.3	threshold grain size (mm)

check from channel material			
300	measured D84 (mm)		
2.0	relative roughness	4.5	fric. factor
0.065	Manning's n from channel material		

Cross Section



section:	Riffle
stream:	Rito de Tierra Amarilla
location:	at HWY 112 Watershed size 66 sq miles
description:	taken 7/24/02 appox 60 m u/s of bridge
height of instrument (ft):	100.00

notes	omit pt.	distance (ft)	FS (ft)	elevation
Left pin	# ✓ #	0	5.79	94.21
	# ✓ #	2	6.24	93.76
LBF	# #	4.4	6.78	93.22
LEW	# #	5.85	8.13	91.87
thalweg	# #	7.3	8.26	91.74
mid bar	# #	10	7.85	92.15
	# #	12	8.05	91.95
REW	# #	13.55	8.1	91.9
	# #	15.3	7.81	92.19
	# #	17	7.71	92.29
	# #	19	7.67	92.33
	# #	21.65	7.59	92.41
RBF	# #	23.55	6.92	93.08
	# ✓ #	23.75	6.44	93.56
	# ✓ #	24.3	5.76	94.24
	# ✓ #	26	5.23	94.77
Right bin	# ✓ #	28	5.1	94.9
	# #			
	# #			
	# #			
	# #			
	# #			
	# #			
	# #			
	# #			

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
6.85		26.0	0.36	0.037
93.15	---			

dimensions			
18.2	x-section area	1.0	d mean
19.1	width	19.8	wet P
1.4	d max	0.9	hyd radi
0.0	bank ht	20.0	w/d ratio
26.0	W flood prone area	1.4	ent ratio

hydraulics	
2.3	velocity (ft/sec)
41.4	discharge rate, Q (cfs)
0.21	shear stress ((lbs/ft sq)
0.33	shear velocity (ft/sec)
0.488	unit stream power (lbs/ft/sec)
0.17	Froude number
7.0	friction factor u/u*
11.9	threshold grain size (mm)

check from channel material			
55	measured D84 (mm)		
5.3	relative roughness	7.0	fric. factor
0.037	Manning's n from channel material		

Appendix B: Conversion Factor Derivation

Flow and concentration values must be multiplied by a conversion factor in order to express the load in the units “pounds/day.” The following expressions detail how the conversion factor was determined:

$$Flow\left(\frac{million\,gallons}{day}\right)\times concentration\left(\frac{milligrams}{Liter}\right)\times CF = Load\left(\frac{pounds}{day}\right)$$

$$10^6\,\frac{gal}{day}\times\frac{mg}{L}\times\left(\frac{3.785L}{gal}\times\frac{lb}{454000\,mg}\right) \quad = \quad \frac{lb}{day}$$

$$10^6\times\frac{3.785\,L}{gal}\times\frac{lb}{454000\,mg}=8.34\,\frac{L-lb}{gal-mg}$$

$$CF = 8.34\frac{L-lb}{gal-mg}$$

$$CF = 8.34$$

Appendix C: Pollutant Source(s) Documentation Protocol Forms

This protocol was designed to support federal regulations and guidance requiring states to document and include probable source(s) of pollutant(s) in their §303(d) Lists as well as the States §305(b) Report to Congress.

The following procedure should be used when sampling crews are in the field conducting water quality surveys or at any other time field staff are collecting data.

Pollutant Source Documentation Steps:

1). Obtain a copy of the most current §303(d) List.

2). Obtain copies of the ***Field Sheet for Assessing Designated Uses and Nonpoint Sources of Pollution***.

3). Obtain 35mm camera that has time/date photo stamp on it. **DO NOT USE A DIGITAL CAMERA FOR THIS PHOTODOCUMENTATION**

4). Identify the reach(s) and probable source(s) of pollutant in the §303(d) List associated with the project that you will be working on.

5). Verify if current source(s) listed in the §303(d) List are accurate.

6). Check the appropriate box(s) on the field sheet for source(s) of nonsupport and estimate percent contribution of each source.

7). Photodocument probable source(s) of pollutant.

8). Create a folder for the TMDL files, insert field sheet and photodocumentation into the file.

This information will be used to update §303(d) Lists and the States §305(b) Report to Congress.

**Gary K is scanning in the filled out forms

FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

CODES FOR USES NOT FULLY SUPPORTED

☒	HQCWF	=	HIGH QUALITY COLDWATER FISHERY
☐	CWF	=	COLDWATER FISHERY
☐	MCWF	=	MARGINAL COLDWATER FISHERY
☐	WWF	=	WARMWATER FISHERY
☐	LWWF	=	LIMITED WARMWATER FISHERY
☐	DWS	=	DOMESTIC WATER SUPPLY
☐	PC	=	PRIMARY CONTACT
☐	IRR	=	IRRIGATION
☐	LW	=	LIVESTOCK WATERING
☐	WH	=	WILDLIFE HABITAT

Fish culture, secondary contact and municipal and industrial water supply and storage are also designated in particular stream reaches where these uses are actually being realized. However, no numeric standards apply uniquely to these uses.

REACH NAME: Rio Chamita (Rio Chama to CO border)

SEGMENT NUMBER: 2116.A_110

BASIN: Rio Chama

PARAMETER: Chronic Al

STAFF MAKING ASSESSMENT: LS, JT, MM

DATE: 7/24/02

CODES FOR SOURCES OF NONSUPPORT (CHECK ALL THAT APPLY)

- ☐ <u>0100</u> <u>INDUSTRIAL POINT SOURCES</u>
- ☒ <u>0200</u> <u>MUNICIPAL POINT SOURCES</u>
- ☐ 0201 DOMESTIC POINT SOURCES
- ☐ <u>0400</u> <u>COMBINED SEWER OVERFLOWS</u>
- ☐ <u>1000</u> AGRICULTURE
- ☐ 1100 NONIRRIGATED CROP PRODUCTION
- ☐ 1200 IRRIGATED CROP PRODUCTION
- ☐ 1201 IRRIGATED RETURN FLOWS
- ☐ 1300 SPECIALTY CROP PRODUCTION (e.g., truck farming and orchards)
- ☐ 1400 PASTURELAND
- ☐ 1500 RANGELAND
- ☐ 1600 FEEDLOTS - ALL TYPES
- ☐ 1700 AQUACULTURE
- ☐ 1800 ANIMAL HOLDING/MANAGEMENT AREAS
- ☐ 1900 MANURE LAGOONS
- ☐ <u>2000</u> <u>SILVICULTURE</u>
- ☐ 2100 HARVESTING, RESTORATION, RESIDUE MANAGEMENT
- ☐ 2200 FOREST MANAGEMENT
- ☐ 2300 ROAD CONSTRUCTION or MAINTENANCE
- ☐ <u>3000</u> <u>CONSTRUCTION</u>
- ☐ 3100 HIGHWAY/ROAD/BRIDGE
- ☐ 3200 LAND DEVELOPMENT
- ☐ 3201 RESORT DEVELOPMENT
- ☐ 3300 HYDROELECTRIC
- ☐ <u>4000</u> <u>URBAN RUNOFF/STORM SEWERS</u>
- ☐ 5000 <u>RESOURCES EXTRACTION</u>
- ☐ 5100 SURFACE MINING
- ☐ 5200 SUBSURFACE MINING
- ☐ 5300 PLACER MINING
- ☐ 5400 DREDGE MINING
- ☐ 5500 PETROLEUM ACTIVITIES
- ☐ 5501 PIPELINES
- ☐ 5600 MILL TAILINGS
- ☐ 5700 MINE TAILINGS
- ☐ 5800 ROAD CONSTRUCTION/MAINTENANCE 8400
- ☐ 5900 SPILLS
- ☐ <u>6000</u> <u>LAND DISPOSAL</u>
- ☐ 6100 SLUDGE
- ☐ 6200 WASTEWATER
- ☐ 6300 LANDFILLS
- ☐ 6400 INDUSTRIAL LAND TREATMENT
- ☐ 6500 ONSITE WASTEWATER SYSTEMS (septic tanks, etc.)
- ☐ 6600 HAZARDOUS WASTE
- ☐ 6700 SEPTAGE DISPOSAL
- ☐ 6800 UST LEAKS
- ☐ <u>7000</u> <u>HYDROMODIFICATION</u>
- ☐ 7100 CHANNELIZATION
- ☐ 7200 DREDGING
- ☐ 7300 DAM CONSTRUCTION/REPAIR
- ☒ 7400 FLOW REGULATION/MODIFICATION
- ☐ 7500 BRIDGE CONSTRUCTION
- ☒ 7600 REMOVAL OF RIPARIAN VEGETATION
- ☐ 7700 STREAMBANK MODIFICATION OR DESTABILIZATION
- ☐ 7800 DRAINING/FILLING OF WETLANDS
- ☐ <u>8000</u> <u>OTHER</u>
- ☐ 8010 VECTOR CONTROL ACTIVITIES
- ☐ 8100 ATMOSPHERIC DEPOSITION
- ☐ 8200 WASTE STORAGE/STORAGE TANK LEAKS
- ☐ 8300 ROAD MAINTENANCE or RUNOFF
- ☐ 8400 SPILLS
- ☐ 8500 IN-PLACE CONTAMINANTS
- ☒ 8600 NATURAL
- ☐ 8700 RECREATIONAL ACTIVITIES
- ☐ 8701 ROAD/PARKING LOT RUNOFF
- ☐ 8702 OFF-ROAD VEHICLES
- ☐ 8703 REFUSE DISPOSAL
- ☐ 8704 WILDLIFE IMPACTS
- ☐ 8705 SKI SLOPE RUNOFF
- ☐ 8800 UPSTREAM IMPOUNDMENT
- ☐ 8900 SALT STORAGE SITES
- ☐ <u>9000</u> <u>SOURCE UNKNOWN</u>

FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

CODES FOR USES NOT FULLY SUPPORTED

- ☒ HQCWF = HIGH QUALITY COLDWATER FISHERY
- ☐ CWF = COLDWATER FISHERY
- ☐ MCWF = MARGINAL COLDWATER FISHERY
- ☐ WWF = WARMWATER FISHERY
- ☐ LWWF = LIMITED WARMWATER FISHERY
- ☐ DWS = DOMESTIC WATER SUPPLY
- ☐ PC = PRIMARY CONTACT
- ☐ IRR = IRRIGATION
- ☐ LW = LIVESTOCK WATERING
- ☐ WH = WILDLIFE HABITAT

Fish culture, secondary contact and municipal and industrial water supply and storage are also designated in particular stream reaches where these uses are actually being realized. However, no numeric standards apply uniquely to these uses.

REACH NAME: Rio Chama (Rio Brazos to Little Willow Creek)
SEGMENT NUMBER: 2116.A_001
BASIN: Rio Chama
PARAMETER: Temperature
STAFF MAKING ASSESSMENT: LS, JT, MM
DATE: 7/24/02

CODES FOR SOURCES OF NONSUPPORT (CHECK ALL THAT APPLY)

- ☐ <u>0100</u> <u>INDUSTRIAL POINT SOURCES</u>
- ☐ <u>0200</u> <u>MUNICIPAL POINT SOURCES</u>
- ☐ 0201 DOMESTIC POINT SOURCES
- ☐ <u>0400</u> <u>COMBINED SEWER OVERFLOWS</u>
- ☐ <u>1000</u> AGRICULTURE
- ☐ 1100 NONIRRIGATED CROP PRODUCTION
- ☐ 1200 IRRIGATED CROP PRODUCTION
- ☐ 1201 IRRIGATED RETURN FLOWS
- ☐ 1300 SPECIALTY CROP PRODUCTION (e.g., truck farming and orchards)
- ☐ 1400 PASTURELAND
- ☒ 1500 RANGELAND
- ☐ 1600 FEEDLOTS - ALL TYPES
- ☐ 1700 AQUACULTURE
- ☐ 1800 ANIMAL HOLDING/MANAGEMENT AREAS
- ☐ 1900 MANURE LAGOONS
- ☐ <u>2000</u> <u>SILVICULTURE</u>
- ☐ 2100 HARVESTING, RESTORATION, RESIDUE MANAGEMENT
- ☐ 2200 FOREST MANAGEMENT
- ☐ 2300 ROAD CONSTRUCTION or MAINTENANCE
- ☐ <u>3000</u> <u>CONSTRUCTION</u>
- ☐ 3100 HIGHWAY/ROAD/BRIDGE
- ☐ 3200 LAND DEVELOPMENT
- ☐ 3201 RESORT DEVELOPMENT
- ☐ 3300 HYDROELECTRIC
- ☐ <u>4000</u> <u>URBAN RUNOFF/STORM SEWERS</u>
- ☐ 5000 <u>RESOURCES EXTRACTION</u>
- ☐ 5100 SURFACE MINING
- ☐ 5200 SUBSURFACE MINING
- ☐ 5300 PLACER MINING
- ☐ 5400 DREDGE MINING
- ☐ 5500 PETROLEUM ACTIVITIES
- ☐ 5501 PIPELINES
- ☐ 5600 MILL TAILINGS
- ☐ 5700 MINE TAILINGS
- ☐ 5800 ROAD CONSTRUCTION/MAINTENANCE 8400
- ☐ 5900 SPILLS
- ☐ <u>6000</u> <u>LAND DISPOSAL</u>
- ☐ 6100 SLUDGE
- ☐ 6200 WASTEWATER
- ☐ 6300 LANDFILLS
- ☐ 6400 INDUSTRIAL LAND TREATMENT
- ☐ 6500 ONSITE WASTEWATER SYSTEMS (septic tanks, etc.)
- ☐ 6600 HAZARDOUS WASTE
- ☐ 6700 SEPTAGE DISPOSAL
- ☐ 6800 UST LEAKS
- ☐ <u>7000</u> <u>HYDROMODIFICATION</u>
- ☐ 7100 CHANNELIZATION
- ☐ 7200 DREDGING
- ☐ 7300 DAM CONSTRUCTION/REPAIR
- ☒ 7400 FLOW REGULATION/MODIFICATION
- ☐ 7500 BRIDGE CONSTRUCTION
- ☒ 7600 REMOVAL OF RIPARIAN VEGETATION
- ☐ 7700 STREAMBANK MODIFICATION OR DESTABILIZATION
- ☐ 7800 DRAINING/FILLING OF WETLANDS
- ☐ <u>8000</u> <u>OTHER</u>
- ☐ 8010 VECTOR CONTROL ACTIVITIES
- ☐ 8100 ATMOSPHERIC DEPOSITION
- ☐ 8200 WASTE STORAGE/STORAGE TANK LEAKS
- ☐ 8300 ROAD MAINTENANCE or RUNOFF
- ☐ 8400 SPILLS
- ☐ 8500 IN-PLACE CONTAMINANTS
- ☐ 8600 NATURAL
- ☐ 8700 RECREATIONAL ACTIVITIES
- ☐ 8701 ROAD/PARKING LOT RUNOFF
- ☐ 8702 OFF-ROAD VEHICLES
- ☐ 8703 REFUSE DISPOSAL
- ☐ 8704 WILDLIFE IMPACTS
- ☐ 8705 SKI SLOPE RUNOFF
- ☐ 8800 UPSTREAM IMPOUNDMENT
- ☐ 8900 SALT STORAGE SITES
- ☐ <u>9000</u> <u>SOURCE UNKNOWN</u>

FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

CODES FOR USES NOT FULLY SUPPORTED

[x]	HQCWF =	HIGH QUALITY COLDWATER FISHERY		[ ]	DWS =	DOMESTIC WATER SUPPLY
[ ]	CWF =	COLDWATER FISHERY		[ ]	PC =	PRIMARY CONTACT
[ ]	MCWF =	MARGINAL COLDWATER FISHERY		[ ]	IRR =	IRRIGATION
[ ]	WWF =	WARMWATER FISHERY		[ ]	LW =	LIVESTOCK WATERING
[ ]	LWWF =	LIMITED WARMWATER FISHERY		[ ]	WH =	WILDLIFE HABITAT

Fish culture, secondary contact and municipal and industrial water supply and storage are also designated in particular stream reaches where these uses are actually being realized. However, no numeric standards apply uniquely to these uses.

REACH NAME: Chavez Creek (Rio Brazos to headwaters)
SEGMENT NUMBER: 2116.A_081
BASIN: Rio Chama
PARAMETER: Temperature
STAFF MAKING ASSESSMENT: LS, JT, MM
DATE: 7/24/02

CODES FOR SOURCES OF NONSUPPORT (CHECK ALL THAT APPLY)

- [ ] 0100 INDUSTRIAL POINT SOURCES
- [ ] 0200 MUNICIPAL POINT SOURCES
- [ ] 0201 DOMESTIC POINT SOURCES
- [ ] 0400 COMBINED SEWER OVERFLOWS
- [x] 1000 AGRICULTURE
- [ ] 1100 NONIRRIGATED CROP PRODUCTION
- [ ] 1200 IRRIGATED CROP PRODUCTION
- [ ] 1201 IRRIGATED RETURN FLOWS
- [ ] 1300 SPECIALTY CROP PRODUCTION (e.g., truck farming and orchards)
- [ ] 1400 PASTURELAND
- [x] 1500 RANGELAND
- [ ] 1600 FEEDLOTS - ALL TYPES
- [ ] 1700 AQUACULTURE
- [ ] 1800 ANIMAL HOLDING/MANAGEMENT AREAS
- [ ] 1900 MANURE LAGOONS
- [ ] 2000 SILVICULTURE
- [ ] 2100 HARVESTING, RESTORATION, RESIDUE MANAGEMENT
- [ ] 2200 FOREST MANAGEMENT
- [ ] 2300 ROAD CONSTRUCTION or MAINTENANCE
- [ ] 3000 CONSTRUCTION
- [ ] 3100 HIGHWAY/ROAD/BRIDGE
- [ ] 3200 LAND DEVELOPMENT
- [ ] 3201 RESORT DEVELOPMENT
- [ ] 3300 HYDROELECTRIC
- [ ] 4000 URBAN RUNOFF/STORM SEWERS
- [ ] 5000 RESOURCES EXTRACTION
- [ ] 5100 SURFACE MINING
- [ ] 5200 SUBSURFACE MINING
- [ ] 5300 PLACER MINING
- [ ] 5400 DREDGE MINING
- [ ] 5500 PETROLEUM ACTIVITIES
- [ ] 5501 PIPELINES
- [ ] 5600 MILL TAILINGS
- [ ] 5700 MINE TAILINGS
- [ ] 5800 ROAD CONSTRUCTION/MAINTENANCE 8400
- [ ] 5900 SPILLS
- [x] Gravel Mining
- [ ] 6000 LAND DISPOSAL
- [ ] 6100 SLUDGE
- [ ] 6200 WASTEWATER
- [ ] 6300 LANDFILLS
- [ ] 6400 INDUSTRIAL LAND TREATMENT
- [ ] 6500 ONSITE WASTEWATER SYSTEMS (septic tanks, etc.)
- [ ] 6600 HAZARDOUS WASTE
- [ ] 6700 SEPTAGE DISPOSAL
- [ ] 6800 UST LEAKS
- [ ] 7000 HYDROMODIFICATION
- [ ] 7100 CHANNELIZATION
- [x] 7200 DREDGING
- [ ] 7300 DAM CONSTRUCTION/REPAIR
- [x] 7400 FLOW REGULATION/MODIFICATION
- [ ] 7500 BRIDGE CONSTRUCTION
- [x] 7600 REMOVAL OF RIPARIAN VEGETATION
- [ ] 7700 STREAMBANK MODIFICATION OR DESTABILIZATION
- [ ] 7800 DRAINING/FILLING OF WETLANDS
- [ ] 8000 OTHER
- [ ] 8010 VECTOR CONTROL ACTIVITIES
- [ ] 8100 ATMOSPHERIC DEPOSITION
- [ ] 8200 WASTE STORAGE/STORAGE TANK LEAKS
- [ ] 8300 ROAD MAINTENANCE or RUNOFF
- [ ] 8400 SPILLS
- [ ] 8500 IN-PLACE CONTAMINANTS
- [ ] 8600 NATURAL
- [ ] 8700 RECREATIONAL ACTIVITIES
- [ ] 8701 ROAD/PARKING LOT RUNOFF
- [ ] 8702 OFF-ROAD VEHICLES
- [ ] 8703 REFUSE DISPOSAL
- [ ] 8704 WILDLIFE IMPACTS
- [ ] 8705 SKI SLOPE RUNOFF
- [ ] 8800 UPSTREAM IMPOUNDMENT
- [ ] 8900 SALT STORAGE SITES
- [ ] 9000 SOURCE UNKNOWN

FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

CODES FOR USES NOT FULLY SUPPORTED

☒	HQCWF	=	HIGH QUALITY COLDWATER FISHERY
☐	CWF	=	COLDWATER FISHERY
☐	MCWF	=	MARGINAL COLDWATER FISHERY
☐	WWF	=	WARMWATER FISHERY
☐	LWWF	=	LIMITED WARMWATER FISHERY
☐	DWS	=	DOMESTIC WATER SUPPLY
☐	PC	=	PRIMARY CONTACT
☐	IRR	=	IRRIGATION
☐	LW	=	LIVESTOCK WATERING
☐	WH	=	WILDLIFE HABITAT

Fish culture, secondary contact and municipal and industrial water supply and storage are also designated in particular stream reaches where these uses are actually being realized. However, no numeric standards apply uniquely to these uses.

REACH NAME: Rio Brazos (Rio Chama to Chavez Creek)
SEGMENT NUMBER: 2116.A_080
BASIN: Rio Chama
PARAMETER: Temperature
STAFF MAKING ASSESSMENT: LS, JT, MM
DATE: 7/24/02

CODES FOR SOURCES OF NONSUPPORT (CHECK ALL THAT APPLY)

☐	<u>0100</u>	<u>INDUSTRIAL POINT SOURCES</u>
☐	<u>0200</u>	<u>MUNICIPAL POINT SOURCES</u>
☐	0201	DOMESTIC POINT SOURCES
☐	<u>0400</u>	<u>COMBINED SEWER OVERFLOWS</u>
☐	<u>1000</u>	AGRICULTURE
☐	1100	NONIRRIGATED CROP PRODUCTION
☐	1200	IRRIGATED CROP PRODUCTION
☐	1201	IRRIGATED RETURN FLOWS
☐	1300	SPECIALTY CROP PRODUCTION (e.g., truck farming and orchards)
☐	1400	PASTURELAND
☒	1500	RANGELAND
☐	1600	FEEDLOTS - ALL TYPES
☐	1700	AQUACULTURE
☐	1800	ANIMAL HOLDING/MANAGEMENT AREAS
☐	1900	MANURE LAGOONS
☐	<u>2000</u>	<u>SILVICULTURE</u>
☐	2100	HARVESTING, RESTORATION, RESIDUE MANAGEMENT
☐	2200	FOREST MANAGEMENT
☐	2300	ROAD CONSTRUCTION or MAINTENANCE
☐	<u>3000</u>	<u>CONSTRUCTION</u>
☐	3100	HIGHWAY/ROAD/BRIDGE
☐	3200	LAND DEVELOPMENT
☐	3201	RESORT DEVELOPMENT
☐	3300	HYDROELECTRIC
☐	<u>4000</u>	<u>URBAN RUNOFF/STORM SEWERS</u>
☐	5000	<u>RESOURCES EXTRACTION</u>
☐	5100	SURFACE MINING
☐	5200	SUBSURFACE MINING
☐	5300	PLACER MINING
☐	5400	DREDGE MINING
☐	5500	PETROLEUM ACTIVITIES
☐	5501	PIPELINES
☐	5600	MILL TAILINGS
☐	5700	MINE TAILINGS
☐	5800	ROAD CONSTRUCTION/MAINTENANCE 8400
☐	5900	SPILLS
X		Gravel Mining (u/s)
☐	<u>6000</u>	<u>LAND DISPOSAL</u>
☐	6100	SLUDGE
☐	6200	WASTEWATER
☐	6300	LANDFILLS
☐	6400	INDUSTRIAL LAND TREATMENT
☐	6500	ONSITE WASTEWATER SYSTEMS (septic tanks, etc.)
☐	6600	HAZARDOUS WASTE
☐	6700	SEPTAGE DISPOSAL
☐	6800	UST LEAKS
☐	<u>7000</u>	<u>HYDROMODIFICATION</u>
☒	7100	CHANNELIZATION
☒	7200	DREDGING
☐	7300	DAM CONSTRUCTION/REPAIR
☒	7400	FLOW REGULATION/MODIFICATION
☐	7500	BRIDGE CONSTRUCTION
☒	7600	REMOVAL OF RIPARIAN VEGETATION
☐	7700	STREAMBANK MODIFICATION OR DESTABILIZATION
☐	7800	DRAINING/FILLING OF WETLANDS
☐	<u>8000</u>	<u>OTHER</u>
☐	8010	VECTOR CONTROL ACTIVITIES
☐	8100	ATMOSPHERIC DEPOSITION
☐	8200	WASTE STORAGE/STORAGE TANK LEAKS
☐	8300	ROAD MAINTENANCE or RUNOFF
☐	8400	SPILLS
☐	8500	IN-PLACE CONTAMINANTS
☐	8600	NATURAL
☐	8700	RECREATIONAL ACTIVITIES
☐	8701	ROAD/PARKING LOT RUNOFF
☐	8702	OFF-ROAD VEHICLES
☐	8703	REFUSE DISPOSAL
☐	8704	WILDLIFE IMPACTS
☐	8705	SKI SLOPE RUNOFF
☐	8800	UPSTREAM IMPOUNDMENT
☐	8900	SALT STORAGE SITES
X		~~Road~~ Unmaintained Low Water Crossing
☐	<u>9000</u>	<u>SOURCE UNKNOWN</u>

FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

REACH NAME: Rito de Tierra Amarilla (Rio Chama to HWY 64)
SEGMENT NUMBER: 2116.A_070
BASIN: Rio Chama
PARAMETER: Turbidity, Temp, SBD
STAFF MAKING ASSESSMENT: JT, LS, MM
DATE: 7/24/02

CODES FOR USES NOT FULLY SUPPORTED

☒	HQCWF	=	HIGH QUALITY COLDWATER FISHERY
☐	CWF	=	COLDWATER FISHERY
☐	MCWF	=	MARGINAL COLDWATER FISHERY
☐	WWF	=	WARMWATER FISHERY
☐	LWWF	=	LIMITED WARMWATER FISHERY
☐	DWS	=	DOMESTIC WATER SUPPLY
☐	PC	=	PRIMARY CONTACT
☐	IRR	=	IRRIGATION
☐	LW	=	LIVESTOCK WATERING
☐	WH	=	WILDLIFE HABITAT

Fish culture, secondary contact and municipal and industrial water supply and storage are also designated in particular stream reaches where these uses are actually being realized. However, no numeric standards apply uniquely to these uses.

CODES FOR SOURCES OF NONSUPPORT (CHECK ALL THAT APPLY)

☐ 0100 INDUSTRIAL POINT SOURCES

☐ 0200 MUNICIPAL POINT SOURCES
☐ 0201 DOMESTIC POINT SOURCES

☐ 0400 COMBINED SEWER OVERFLOWS

☒ 1000 AGRICULTURE
☐ 1100 NONIRRIGATED CROP PRODUCTION
☐ 1200 IRRIGATED CROP PRODUCTION
☐ 1201 IRRIGATED RETURN FLOWS
☐ 1300 SPECIALTY CROP PRODUCTION (e.g., truck farming and orchards)
☐ 1400 PASTURELAND
☒ 1500 RANGELAND
☐ 1600 FEEDLOTS - ALL TYPES
☐ 1700 AQUACULTURE
☐ 1800 ANIMAL HOLDING/MANAGEMENT AREAS
☐ 1900 MANURE LAGOONS

☐ 2000 SILVICULTURE
☐ 2100 HARVESTING, RESTORATION, RESIDUE MANAGEMENT
☐ 2200 FOREST MANAGEMENT
☐ 2300 ROAD CONSTRUCTION or MAINTENANCE

☐ 3000 CONSTRUCTION
☐ 3100 HIGHWAY/ROAD/BRIDGE
☐ 3200 LAND DEVELOPMENT
☐ 3201 RESORT DEVELOPMENT
☐ 3300 HYDROELECTRIC

☐ 4000 URBAN RUNOFF/STORM SEWERS

☐ 5000 RESOURCES EXTRACTION
☐ 5100 SURFACE MINING
☐ 5200 SUBSURFACE MINING
☐ 5300 PLACER MINING
☐ 5400 DREDGE MINING
☐ 5500 PETROLEUM ACTIVITIES
☐ 5501 PIPELINES
☐ 5600 MILL TAILINGS
☐ 5700 MINE TAILINGS
☐ 5800 ROAD CONSTRUCTION/MAINTENANCE 8400
☐ 5900 SPILLS

☐ 6000 LAND DISPOSAL
☐ 6100 SLUDGE
☐ 6200 WASTEWATER
☐ 6300 LANDFILLS
☐ 6400 INDUSTRIAL LAND TREATMENT
☐ 6500 ONSITE WASTEWATER SYSTEMS (septic tanks, etc.)
☐ 6600 HAZARDOUS WASTE
☐ 6700 SEPTAGE DISPOSAL
☐ 6800 UST LEAKS

☐ 7000 HYDROMODIFICATION
☐ 7100 CHANNELIZATION
☐ 7200 DREDGING
☐ 7300 DAM CONSTRUCTION/REPAIR
☒ 7400 FLOW REGULATION/MODIFICATION
☐ 7500 BRIDGE CONSTRUCTION
☒ 7600 REMOVAL OF RIPARIAN VEGETATION
☐ 7700 STREAMBANK MODIFICATION OR DESTABILIZATION
☐ 7800 DRAINING/FILLING OF WETLANDS

☐ 8000 OTHER
☐ 8010 VECTOR CONTROL ACTIVITIES
☐ 8100 ATMOSPHERIC DEPOSITION
☐ 8200 WASTE STORAGE/STORAGE TANK LEAKS
☒ 8300 ROAD MAINTENANCE or RUNOFF
☐ 8400 SPILLS
☐ 8500 IN-PLACE CONTAMINANTS
☐ 8600 NATURAL
☐ 8700 RECREATIONAL ACTIVITIES
☐ 8701 ROAD/PARKING LOT RUNOFF
☐ 8702 OFF-ROAD VEHICLES
☐ 8703 REFUSE DISPOSAL
☐ 8704 WILDLIFE IMPACTS
☐ 8705 SKI SLOPE RUNOFF
☐ 8800 UPSTREAM IMPOUNDMENT
☐ 8900 SALT STORAGE SITES

☐ 9000 SOURCE UNKNOWN

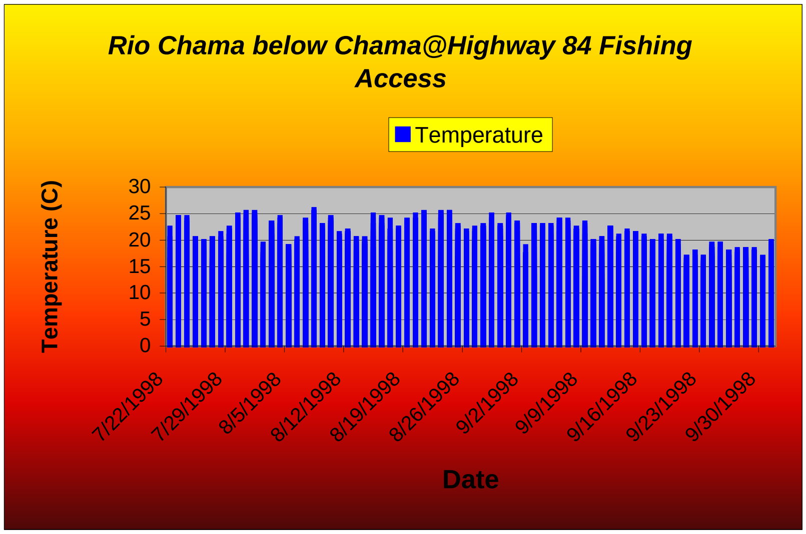
Appendix D: Thermograph Summary Data and Graphics

Rio Chama below Chama@Highway 84 Fishing Access

Date/Time	Temperature
	>20

Total Readings	1704
Max. Temp.	26
# Values>20	***363***
% Values>20	***21.3***
Avg. Temp.	16.9
Min. Temp.	7
Variance	14.2

8/30/1998	
Avg. Temp	17.8
Max. Temp	23.0
Min. Temp	13.5



Date/Time	Temperature
7/22/1998 13:57	16.5
7/22/1998 14:57	15.5
7/22/1998 15:57	15
7/22/1998 16:57	14.5
7/22/1998 17:57	14.5
7/22/1998 18:57	14.5
7/22/1998 19:57	15
7/22/1998 20:57	16.5
7/22/1998 21:57	18.5
7/22/1998 22:57	***20.5***
7/22/1998 23:57	***22.5***
7/23/1998 0:57	***22.5***
7/23/1998 1:57	***23***
7/23/1998 2:57	***24.5***
7/23/1998 3:57	***24.5***
7/23/1998 4:57	***23.5***
7/23/1998 5:57	***22.5***
7/23/1998 6:57	***21.5***
7/23/1998 7:57	***20.5***
7/23/1998 8:57	19.5
7/23/1998 9:57	18.5
7/23/1998 10:57	17.5
7/23/1998 11:57	17
7/23/1998 12:57	16.5
7/23/1998 13:57	16.5
7/23/1998 14:57	16
7/23/1998 15:57	15.5
7/23/1998 16:57	15
7/23/1998 17:57	15
7/23/1998 18:57	14.5
7/23/1998 19:57	15.5
7/23/1998 20:57	16.5
7/23/1998 21:57	18.5
7/23/1998 22:57	***20.5***
7/23/1998 23:57	***21.5***
7/24/1998 0:57	***23***
7/24/1998 1:57	***23.5***
7/24/1998 2:57	***24.5***
7/24/1998 3:57	***24***
7/24/1998 4:57	***23.5***
7/24/1998 5:57	***23***
7/24/1998 6:57	***21.5***
7/24/1998 7:57	***20.5***
7/24/1998 8:57	19.5
7/24/1998 9:57	18.5
7/24/1998 10:57	18
7/24/1998 11:57	17
7/24/1998 12:57	16.5
7/24/1998 13:57	16
7/24/1998 14:57	16
7/24/1998 15:57	15.5
7/24/1998 16:57	15
7/24/1998 17:57	15
7/24/1998 18:57	15
7/24/1998 19:57	15.5

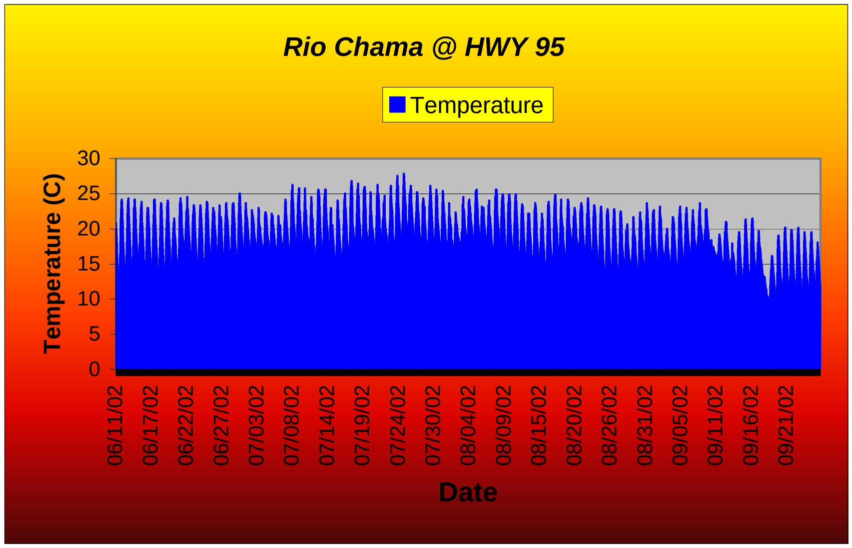
Rio Chama @ HWY 95

Date/Time	Temperature
	>20

Total Readings	2586
Max.Temp.	27.88
# Values>20	***912***
% Values>20	***34.7***
Avg. Temp.	18.5
Min. Temp.	9.47
Variance	12.4

8/30/2002	
Avg. Temp	17.1
Max. Temp	22.3
Min. Temp	12.6

9/27/2002	
Avg. Temp	14.2
Max. Temp	18.1
Min. Temp	11.3



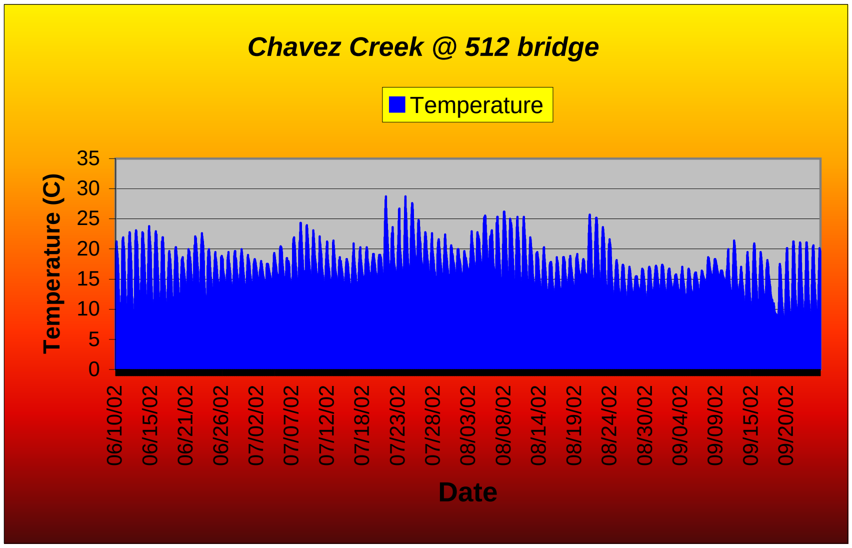
Date/Time	Temperature
06/11/02 19:39:24.	***20.83***
06/11/02 20:39:24.	19.86
06/11/02 21:39:24.	19.05
06/11/02 22:39:24.	17.92
06/11/02 23:39:24.	16.8
06/12/02 00:39:24.	15.86
06/12/02 01:39:24.	14.9
06/12/02 02:39:24.	14.12
06/12/02 03:39:24.	13.35
06/12/02 04:39:24.	12.58
06/12/02 05:39:24.	11.96
06/12/02 06:39:24.	11.34
06/12/02 07:39:24.	11.64
06/12/02 08:39:24.	13.19
06/12/02 09:39:24.	14.74
06/12/02 10:39:24.	16.33
06/12/02 11:39:24.	18.24
06/12/02 12:39:24.	***20.02***
06/12/02 13:39:24.	***21.49***
06/12/02 14:39:24.	***22.83***
06/12/02 15:39:24.	***23.85***
06/12/02 16:39:24.	***24.19***
06/12/02 17:39:24.	***23.85***
06/12/02 18:39:24.	***22.83***
06/12/02 19:39:24.	***21.16***
06/12/02 20:39:24.	***20.51***
06/12/02 21:39:24.	19.37
06/12/02 22:39:24.	18.08
06/12/02 23:39:24.	17.12
06/13/02 00:39:24.	16.01
06/13/02 01:39:24.	15.06
06/13/02 02:39:24.	14.12
06/13/02 03:39:24.	13.35
06/13/02 04:39:24.	12.58
06/13/02 05:39:24.	11.96
06/13/02 06:39:24.	11.49
06/13/02 07:39:24.	11.64
06/13/02 08:39:24.	13.19
06/13/02 09:39:24.	14.58
06/13/02 10:39:24.	16.33
06/13/02 11:39:24.	18.08
06/13/02 12:39:24.	***20.02***
06/13/02 13:39:24.	***22.16***
06/13/02 14:39:24.	***23.51***
06/13/02 15:39:24.	***24.02***
06/13/02 16:39:24.	***24.37***
06/13/02 17:39:24.	***23.85***
06/13/02 18:39:24.	***22.83***
06/13/02 19:39:24.	***21.66***
06/13/02 20:39:24.	***20.67***
06/13/02 21:39:24.	19.53
06/13/02 22:39:24.	18.41
06/13/02 23:39:24.	17.28
06/14/02 00:39:24.	16.48
06/14/02 01:39:24.	15.69

Chavez Creek @ 512 bridge

Date/Time	Temperature >20

Total Readings	2616
Max.Temp.	28.72
# Values>20	***371***
% Values>20	***14.1***
Avg. Temp.	16.3
Min. Temp.	7.26
Variance	12.9

8/30/02	
Avg. Temp	14.0
Max. Temp	17.1
Min. Temp	11.1



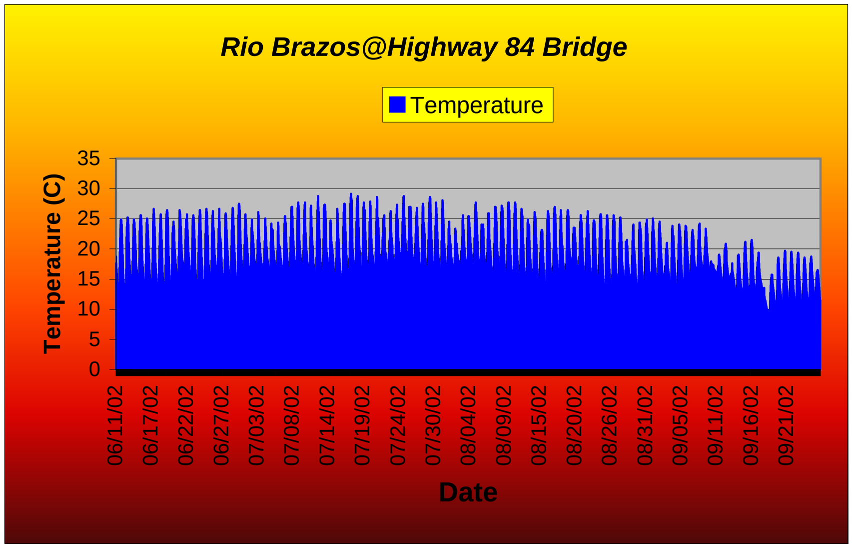
Date/Time	*Temperature*
06/10/02 12:40:14.	18.02
06/10/02 13:40:14.	19.79
06/10/02 14:40:14.	***20.93***
06/10/02 15:40:14.	***21.27***
06/10/02 16:40:14.	***21.27***
06/10/02 17:40:14.	***20.44***
06/10/02 18:40:14.	19.63
06/10/02 19:40:14.	19.15
06/10/02 20:40:14.	18.5
06/10/02 21:40:14.	17.38
06/10/02 22:40:14.	15.95
06/10/02 23:40:14.	14.53
06/11/02 00:40:14.	13.29
06/11/02 01:40:14.	12.21
06/11/02 02:40:14.	11.12
06/11/02 03:40:14.	10.35
06/11/02 04:40:14.	9.57
06/11/02 05:40:14.	8.96
06/11/02 06:40:14.	8.34
06/11/02 07:40:14.	8.03
06/11/02 08:40:14.	8.49
06/11/02 09:40:14.	9.88
06/11/02 10:40:14.	12.21
06/11/02 11:40:14.	14.84
06/11/02 12:40:14.	18.02
06/11/02 13:40:14.	19.96
06/11/02 14:40:14.	***21.43***
06/11/02 15:40:14.	***21.77***
06/11/02 16:40:14.	***21.93***
06/11/02 17:40:14.	***21.1***
06/11/02 18:40:14.	***20.44***
06/11/02 19:40:14.	19.96
06/11/02 20:40:14.	18.99
06/11/02 21:40:14.	17.86
06/11/02 22:40:14.	16.27
06/11/02 23:40:14.	14.53
06/12/02 00:40:14.	13.29
06/12/02 01:40:14.	12.06
06/12/02 02:40:14.	10.82
06/12/02 03:40:14.	9.88
06/12/02 04:40:14.	9.11
06/12/02 05:40:14.	8.34
06/12/02 06:40:14.	7.73
06/12/02 07:40:14.	7.42
06/12/02 08:40:14.	7.88
06/12/02 09:40:14.	9.26
06/12/02 10:40:14.	12.21
06/12/02 11:40:14.	15.79
06/12/02 12:40:14.	18.34
06/12/02 13:40:14.	***20.93***
06/12/02 14:40:14.	***22.27***
06/12/02 15:40:14.	***22.77***
06/12/02 16:40:14.	***22.6***
06/12/02 17:40:14.	***21.93***
06/12/02 18:40:14.	***21.1***

Rio Brazos@Highway 84 Bridge

Date/Time	Temperature >20

Total Readings	2586
Max.Temp.	29.17
# Values>20	944
% Values>20	36.3
Avg. Temp.	19.9
Min. Temp.	9.17
Variance	17.6

8/30/2002	
Avg. Temp	18.1
Max. Temp	24.4
Min. Temp	12.7



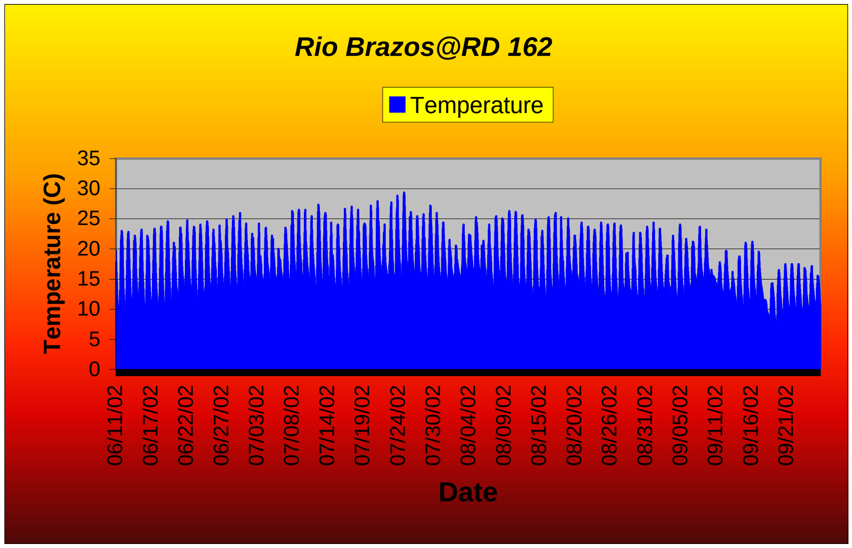
Date/Time	Temperature
06/11/02 20:41:32.	18.74
06/11/02 21:41:32.	17.61
06/11/02 22:41:32.	16.66
06/11/02 23:41:32.	15.87
06/12/02 00:41:32.	15.07
06/12/02 01:41:32.	14.44
06/12/02 02:41:32.	13.82
06/12/02 03:41:32.	13.36
06/12/02 04:41:32.	12.9
06/12/02 05:41:32.	12.43
06/12/02 06:41:32.	12.12
06/12/02 07:41:32.	12.43
06/12/02 08:41:32.	14.29
06/12/02 09:41:32.	16.82
06/12/02 10:41:32.	19.56
06/12/02 11:41:32.	21.84
06/12/02 12:41:32.	23.36
06/12/02 13:41:32.	24.04
06/12/02 14:41:32.	24.73
06/12/02 15:41:32.	24.9
06/12/02 16:41:32.	24.73
06/12/02 17:41:32.	24.04
06/12/02 18:41:32.	22.51
06/12/02 19:41:32.	20.69
06/12/02 20:41:32.	19.07
06/12/02 21:41:32.	17.77
06/12/02 22:41:32.	16.66
06/12/02 23:41:32.	15.71
06/13/02 00:41:32.	14.92
06/13/02 01:41:32.	14.29
06/13/02 02:41:32.	13.67
06/13/02 03:41:32.	13.06
06/13/02 04:41:32.	12.74
06/13/02 05:41:32.	12.28
06/13/02 06:41:32.	11.97
06/13/02 07:41:32.	12.28
06/13/02 08:41:32.	14.13
06/13/02 09:41:32.	16.66
06/13/02 10:41:32.	19.39
06/13/02 11:41:32.	22.01
06/13/02 12:41:32.	23.69
06/13/02 13:41:32.	24.38
06/13/02 14:41:32.	25.25
06/13/02 15:41:32.	25.25
06/13/02 16:41:32.	24.9
06/13/02 17:41:32.	24.04
06/13/02 18:41:32.	22.68
06/13/02 19:41:32.	21.02
06/13/02 20:41:32.	19.72
06/13/02 21:41:32.	18.26
06/13/02 22:41:32.	17.29
06/13/02 23:41:32.	16.34
06/14/02 00:41:32.	15.71
06/14/02 01:41:32.	15.07
06/14/02 02:41:32.	14.6

Rio Brazos@RD 162

Date/Time	Temperature >20

Total Readings	2586
Max.Temp.	29.37
# Values>20	***632***
% Values>20	***24.3***
Avg. Temp.	16.6
Min. Temp.	6.7
Variance	18.8

8/30/2002	
Avg. Temp	15.5
Max. Temp	22.7
Min. Temp	10.3



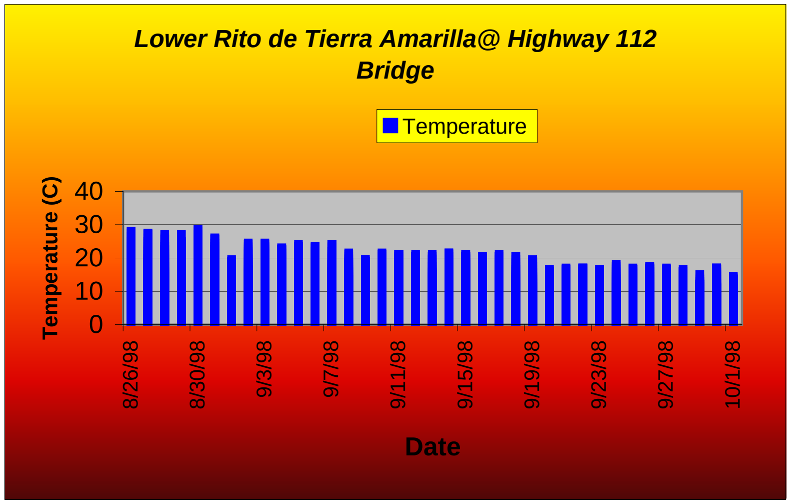
Date/Time	Temperature
06/11/02 18:40:41.	19.72
06/11/02 19:40:41.	17.78
06/11/02 20:40:41.	16.18
06/11/02 21:40:41.	14.6
06/11/02 22:40:41.	13.36
06/11/02 23:40:41.	12.28
06/12/02 00:40:41.	11.5
06/12/02 01:40:41.	10.73
06/12/02 02:40:41.	10.11
06/12/02 03:40:41.	9.48
06/12/02 04:40:41.	9.02
06/12/02 05:40:41.	8.56
06/12/02 06:40:41.	8.24
06/12/02 07:40:41.	9.02
06/12/02 08:40:41.	10.42
06/12/02 09:40:41.	13.06
06/12/02 10:40:41.	15.71
06/12/02 11:40:41.	17.94
06/12/02 12:40:41.	***20.04***
06/12/02 13:40:41.	***21.52***
06/12/02 14:40:41.	***22.18***
06/12/02 15:40:41.	***23.02***
06/12/02 16:40:41.	***22.68***
06/12/02 17:40:41.	***21.85***
06/12/02 18:40:41.	***20.37***
06/12/02 19:40:41.	18.26
06/12/02 20:40:41.	16.66
06/12/02 21:40:41.	14.76
06/12/02 22:40:41.	13.36
06/12/02 23:40:41.	12.28
06/13/02 00:40:41.	11.34
06/13/02 01:40:41.	10.57
06/13/02 02:40:41.	9.95
06/13/02 03:40:41.	9.33
06/13/02 04:40:41.	8.86
06/13/02 05:40:41.	8.4
06/13/02 06:40:41.	8.09
06/13/02 07:40:41.	9.02
06/13/02 08:40:41.	10.26
06/13/02 09:40:41.	13.06
06/13/02 10:40:41.	15.55
06/13/02 11:40:41.	18.1
06/13/02 12:40:41.	***20.04***
06/13/02 13:40:41.	***21.68***
06/13/02 14:40:41.	***22.52***
06/13/02 15:40:41.	***22.86***
06/13/02 16:40:41.	***22.52***
06/13/02 17:40:41.	***21.52***
06/13/02 18:40:41.	***20.04***
06/13/02 19:40:41.	18.26
06/13/02 20:40:41.	16.5
06/13/02 21:40:41.	14.92
06/13/02 22:40:41.	13.52
06/13/02 23:40:41.	12.59
06/14/02 00:40:41.	11.97

Lower Rito de Tierra Amarilla@Highway 112 Bridge

Date/Time	Temperature
	>20

Total Readings	864
Max.Temp.	29.5
# Values>20	***194***
% Values>20	***22.5***
Avg. Temp.	17.0
Min. Temp.	1.5
Variance	18.3

8/30/02	
Avg. Temp	21.9
Max. Temp	29.5
Min. Temp	15.5



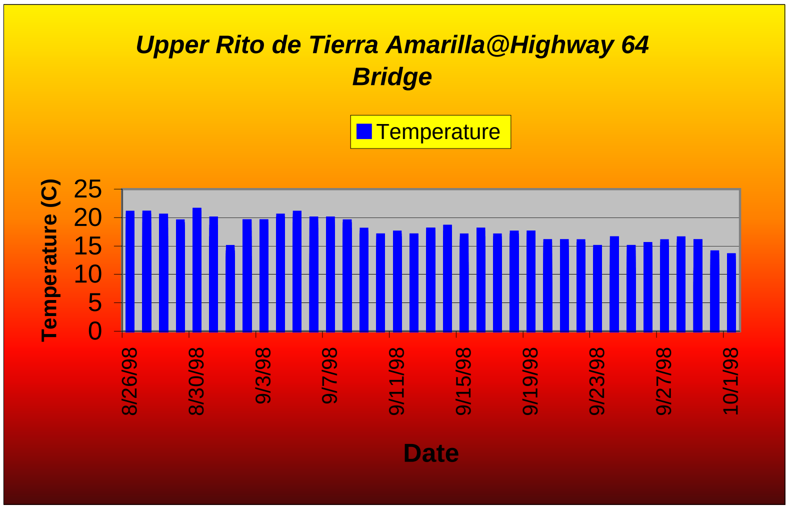
Date/Time	Temperature
8/26/1998 14:59	**29**
8/26/1998 15:59	**29**
8/26/1998 16:59	**28.5**
8/26/1998 17:59	**27.5**
8/26/1998 18:59	**26**
8/26/1998 19:59	**24.5**
8/26/1998 20:59	**23.5**
8/26/1998 21:59	**22**
8/26/1998 22:59	**21**
8/26/1998 23:59	20
8/27/1998 0:59	19.5
8/27/1998 1:59	18.5
8/27/1998 2:59	18
8/27/1998 3:59	17.5
8/27/1998 4:59	17
8/27/1998 5:59	16
8/27/1998 6:59	15.5
8/27/1998 7:59	15.5
8/27/1998 8:59	17
8/27/1998 9:59	19
8/27/1998 10:59	**21**
8/27/1998 11:59	**23.5**
8/27/1998 12:59	**26**
8/27/1998 13:59	**26**
8/27/1998 14:59	**28**
8/27/1998 15:59	**28.5**
8/27/1998 16:59	**28**
8/27/1998 17:59	**27**
8/27/1998 18:59	**25.5**
8/27/1998 19:59	**24.5**
8/27/1998 20:59	**23**
8/27/1998 21:59	**22**
8/27/1998 22:59	**21**
8/27/1998 23:59	20
8/28/1998 0:59	19.5
8/28/1998 1:59	18.5
8/28/1998 2:59	18
8/28/1998 3:59	17
8/28/1998 4:59	16.5
8/28/1998 5:59	16
8/28/1998 6:59	15.5
8/28/1998 7:59	15.5
8/28/1998 8:59	16.5
8/28/1998 9:59	18.5
8/28/1998 10:59	**21**
8/28/1998 11:59	**23.5**
8/28/1998 12:59	**24.5**
8/28/1998 13:59	**24.5**
8/28/1998 14:59	**26.5**
8/28/1998 15:59	**28**
8/28/1998 16:59	**28**
8/28/1998 17:59	**27**
8/28/1998 18:59	**25**
8/28/1998 19:59	**23.5**

Upper Rito de Tierra Amarilla@Highway 64 Bridge

Date/Time	Temperature >20

Total Readings	864
Max.Temp.	21.5
# Values>20	*16*
% Values>20	*1.9*
Avg. Temp.	13.5
Min. Temp.	7
Variance	9.8

8/30/98	
Avg. Temp	16.4
Max. Temp	21.5
Min. Temp	12.5

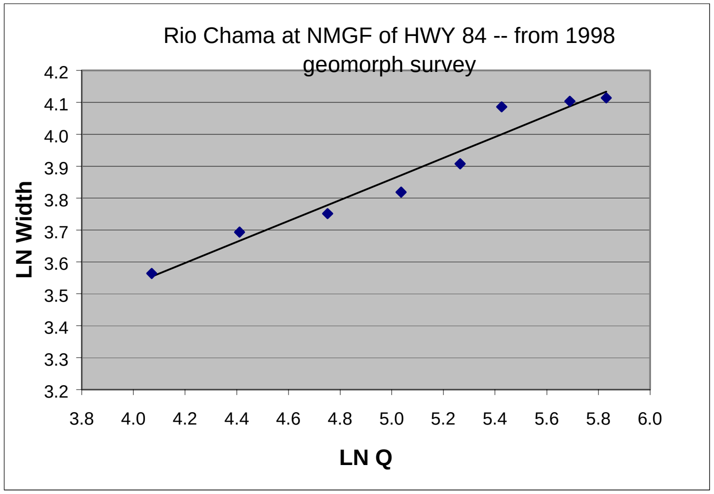


Date/Time	Temperature
8/26/1998 15:59	**21**
8/26/1998 16:59	**20.5**
8/26/1998 17:59	19.5
8/26/1998 18:59	18.5
8/26/1998 19:59	18
8/26/1998 20:59	17
8/26/1998 21:59	16
8/26/1998 22:59	15.5
8/26/1998 23:59	15
8/27/1998 0:59	14.5
8/27/1998 1:59	14.5
8/27/1998 2:59	14
8/27/1998 3:59	13.5
8/27/1998 4:59	13.5
8/27/1998 5:59	13
8/27/1998 6:59	13
8/27/1998 7:59	13
8/27/1998 8:59	13.5
8/27/1998 9:59	14.5
8/27/1998 10:59	16.5
8/27/1998 11:59	19
8/27/1998 12:59	**20.5**
8/27/1998 13:59	**20.5**
8/27/1998 14:59	**21**
8/27/1998 15:59	**21**
8/27/1998 16:59	**20.5**
8/27/1998 17:59	20
8/27/1998 18:59	19
8/27/1998 19:59	18
8/27/1998 20:59	17
8/27/1998 21:59	16
8/27/1998 22:59	15.5
8/27/1998 23:59	15
8/28/1998 0:59	14.5
8/28/1998 1:59	14.5
8/28/1998 2:59	14
8/28/1998 3:59	14
8/28/1998 4:59	13.5
8/28/1998 5:59	13.5
8/28/1998 6:59	13
8/28/1998 7:59	13
8/28/1998 8:59	14
8/28/1998 9:59	15
8/28/1998 10:59	16.5
8/28/1998 11:59	18
8/28/1998 12:59	20
8/28/1998 13:59	19.5
8/28/1998 14:59	20
8/28/1998 15:59	**20.5**
8/28/1998 16:59	19.5
8/28/1998 17:59	18.5
8/28/1998 18:59	18
8/28/1998 19:59	17

Appendix E: Hydrology, Geometry, and Meteorological Input Data for SSTEMP

Rio Chama at NMGF of HWY 84 -- from 1998 geomorph survey

W	Q	LN(W)	LN(Q)	Predicted LN(W)	
35.3	58.61	3.5639	4.0709	3.5539	**
40.18	82.36	3.6934	4.4111	3.6659	
42.59	115.82	3.7516	4.7520	3.7783	
45.54	153.85	3.8186	5.0360	3.8718	
49.77	193.45	3.9074	5.2650	3.9473	
59.48	227.09	4.0856	5.4253	4.0001	
60.55	295.63	4.1035	5.6891	4.0870	
61.19	340.63	4.1140	5.8308	4.1337	



Date : 05/13/2002

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.976669215
R Square	0.953882755
Adjusted R Square	0.946196548
Standard Error	0.048238136
Observations	8

ANOVA

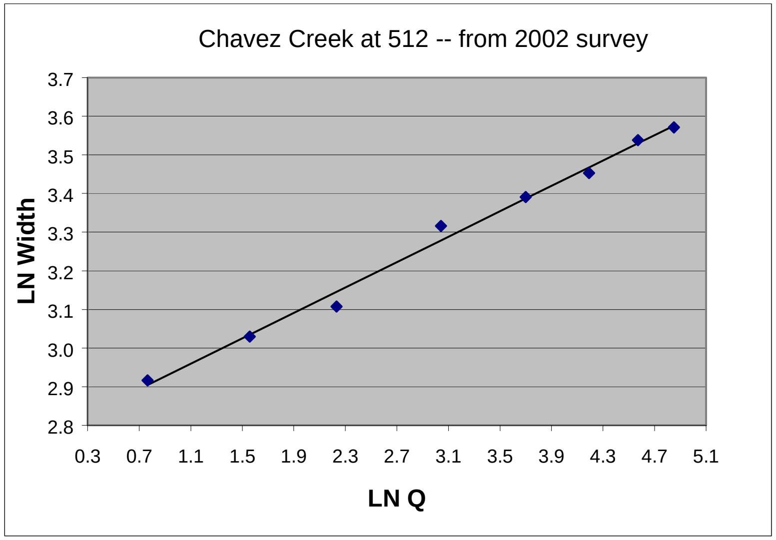
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.28877788	0.288778	124.10318	3.11959E-05
Residual	6	0.013961506	0.002327		
Total	7	0.302739386			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	2.212585945	0.150621813	14.68968	6.251E-06	1.844027376	2.581144515
X Variable 1	0.329475914	0.029575509	11.14016	3.12E-05	0.257107198	0.40184463

B term = X variable =	0.329475914
A term = e^ intercept =	9.139319643

Chavez Creek at HWY 512 -- from 2002 survey data

W	Q	LN(W)	LN(Q)	Predicted LN(W)	
18.48	2.15	2.9167	0.7655	2.9044	**
20.69	4.75	3.0297	1.5581	3.0347	
22.36	9.31	3.1073	2.2311	3.1453	
27.56	20.92	3.3164	3.0407	3.2784	
29.69	40.46	3.3908	3.7003	3.3868	
31.59	66.11	3.4528	4.1913	3.4675	
34.4	96.63	3.5381	4.5709	3.5299	
35.55	127.6	3.5709	4.8489	3.5756	



Date : 10/30/2002

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.99594626
R Square	0.99190896
Adjusted R Square	0.99056045
Standard Error	0.02375224
Observations	8

ANOVA

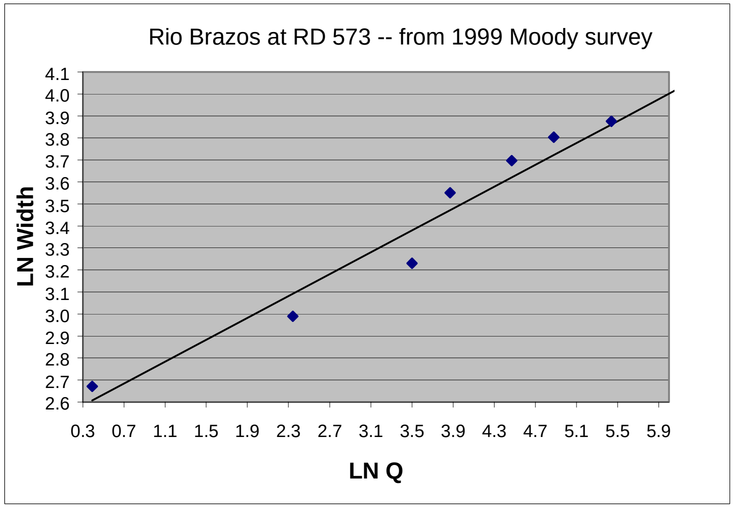
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.414980312	0.41498	735.5606	1.6603E-07
Residual	6	0.003385013	0.000564		
Total	7	0.418365325			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	2.77855783	0.020654014	134.5287	1.14E-11	2.728019238	2.829096
X Variable 1	0.16437915	0.006060905	27.12122	1.66E-07	0.149548638	0.17921

B term = X variable =	0.16437915
A term = e^ intercept =	16.09579127

Rio Brazos at RD 573 -- from Moody survey and WINXSPRO

W	Q	LN(W)	LN(Q)	Predicted LN(W)	
14.45	1.48	2.6707	0.3920	2.6069	**
19.87	10.4	2.9892	2.3418	3.0915	
25.29	33.14	3.2304	3.5007	3.3795	
34.83	48.05	3.5505	3.8722	3.4719	
40.33	87.33	3.6971	4.4697	3.6204	
44.88	131.58	3.8040	4.8796	3.7223	
48.21	230.29	3.8756	5.4393	3.8614	
52.23	434.63	3.9557	6.0745	4.0193	



Date : 10/30/2002

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.979840766
R Square	0.960087926
Adjusted R Square	0.953435914
Standard Error	0.099802651
Observations	8

ANOVA

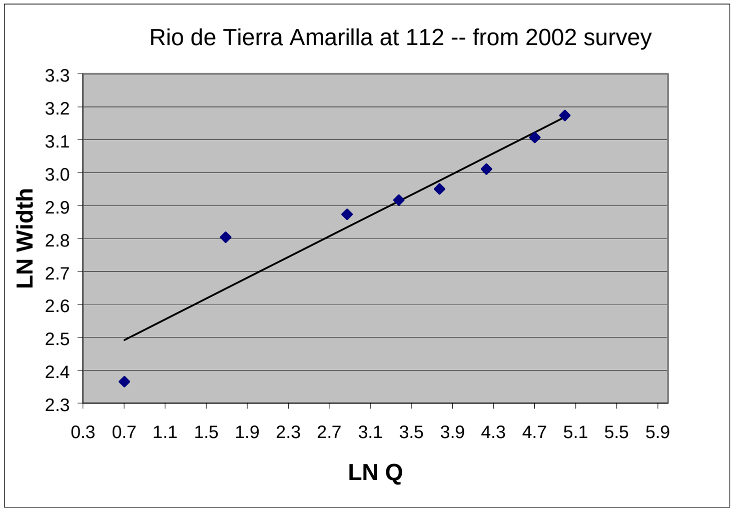
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1.437613416	1.437613	144.33045	2.01731E-05
Residual	6	0.059763414	0.009961		
Total	7	1.49737683			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	2.509409098	0.087522025	28.67174	1.192E-07	2.295250262	2.723567935
X Variable 1	0.248557912	0.020689434	12.01376	2.017E-05	0.197932654	0.29918317

B term = X variable =	0.248557912
A term = e^ intercept =	12.29766121

Rito de Tierra Amarilla at 112 -- from 2002 survey and WINXSPRO

W	Q	LN(W)	LN(Q)	Predicted LN(W)	
10.65	2.02	2.3656	0.7031	2.4918	**
16.51	5.42	2.8040	1.6901	2.6474	
17.69	17.7	2.8730	2.8736	2.8340	
18.48	29.27	2.9167	3.3766	2.9133	
19.12	43.55	2.9507	3.7739	2.9760	
20.31	68.87	3.0111	4.2322	3.0482	
22.35	110.28	3.1068	4.7030	3.1224	
23.9	147.8	3.1739	4.9959	3.1686	



Date : 10/30/2002

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.94695354
R Square	0.896721007
Adjusted R Square	0.879507842
Standard Error	0.085888994
Observations	8

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.384301104	0.384301	52.095067	0.000358483
Residual	6	0.044261516	0.007377		
Total	7	0.42856262			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	2.380968382	0.07808787	30.49089	8.259E-08	2.189894108	2.572043
X Variable 1	0.157657814	0.021843247	7.217691	0.0003585	0.104209274	0.211106

B term = X variable =	0.157657814
A term = e^ intercept =	10.8153712

Air temp corrections: **using air thermograph data collected 2002**

13.79	C	=air temp at Brazos@84 on 8/30/02'	=To	12.6 C	=air temp at Brazos@84 on 9/27/02'
7367	ft	=elevation at Brazos air station'	=Zo		
2245	m				
-0.00656	C/m	=Ct			

Ta = To + Ct * (Z-Zo)

		u/s	d/s	Z mid (ft)	mid (m)	Ta air temp (C)	air temp (F)	30-Aug avg '71 - '00	August avg '71 - '00	
Chavez		10500	7570	9035	2754	10.45	50.81			
Brazos		7570	7367	7469	2276	13.58	56.45			
Chama		7620	7310	7465	2275	13.59	56.46	59	61.3	Chama, NM
RTA		8290	7150	7720	2353	13.08	55.55	62.6	65.3	El Vado Dam
Chama cal temp		7620	7310	7465	2275	12.40	54.32			

Relative humidity corrections: **using 30-year data from 1971-2000**

Rh = Ro * [1.0640 ^(To-Ta)] * [(Ta+273.16)/(To+273.16)]

57	%	=RH late Aug at Alamosa station	=Ro
15.6	C	=avr air temp late Aug at Alamosa	=To

		Ta air temp(C)	Rh RH corrected
Chavez		10.45	0.77
Brazos		13.58	0.64
Chama		13.59	0.64
RTA		13.08	0.66

4Q3 Derivations for ungaged Upper Chama streams

4Q3 ungaged = 7.3287 X 10^(-5) X DA^0.70 X Pw^3.58 X S^1.35 Reference: USGS 2002
where
4Q3 = 4-day, 3-year, low flow frequency (cfs)
DA = drainage area (mi2)
Pw = average basin mean winter precipitation 1961-1990 (in)
S = average basin slope

Parameter	Brazos at Chama	Brazos at Chavez	Chavez at Brazos	RTA at Chama	RTA at HWY 64
Pw	20.9	20.67	15.92	13.57	14.93
DA	171	125	25.2	61.3	49.6
Slope	0.178	0.192	0.229	0.136	0.144
Elevation	10075	10010	9724	8412	8770
4Q3 (cfs)	13.88	11.86	1.93	1.00	1.31
4Q3 (mgd)	**8.97**	**7.67**	**1.24**	**0.65**	**0.85**

4Q3 derivations for portions of gaged Upper Chama streams

When ratio between the two watershed areas is between 0.5 and 1.5:
4Q3 ungaged = Qt(u) = Qt(g) X (Au/Ag)^0.566 Reference: USGS 1993
where
4Q3 = 4-day, 3-year, low flow frequency (cfs)
Qt(g) = 4Q3 at the gaged site (cfs)
Au = drainage area at the ungaged site (mi2)
Ag = drainage area at the gaged site (mi2)
Qt(u) = area weighted 4Q3 at the ungaged site (cfs)

When ratio between the two watershed areas is < 0.5 or > 1.5:
7Q2(u) = 1.36 X 10^(-4) X Au^0.566 X Pw^3.32 Reference: USGS 1970
7Q2 = 7-day, 2-year, low flow frequency (cfs)
Pw = average basin mean winter precipitation 1961-1990 (in)
4Q3(u) = 7Q2(u) x [4Q3(g)/7Q2(g)]

4Q3(g) for Rio Chama at LaPuente gage based on Log Pearson Type III plot = 17.5 cfs
7Q2(g) for Rio Chama at LaPuente gage based on Log Pearson Type III plot = 22.0 cfs

Parameter	Chama at LaPuente (gage location)	Chama at Brazos (ungaged portion)	Chama at Little Willow (ungaged portion)
Ag	480		
Au		221	95
Au/Ag		0.46	0.20
Qt(u)		11.28	NA because outside of range
Pw			13
7Q2	22		8.94
4Q3(g)/7Q2(g)	0.80		
4Q3 (cfs)	17.5		7.11
4Q3 (mgd)		**7.29**	**4.59**

Appendix F: SSTEMP Model Run Output

Rio Chama Calibration Run for 9/27/02

```
"SSTEMP (1.2.2)  ","10/31/2002  11:51 am"
"NoName"
"English",         "Segment Inflow (cfs)",             "7.110"
"English",         "Inflow Temperature (°F)",          "57.000"
"English",         "Segment Outflow (cfs)",            "11.280"
"English",         "Accretion Temp. (°F)",             "43.400"
"English",         "Latitude (degrees)",               "36.790"
"English",         "Segment Length (mi)",              "11.720"
"English",         "Upstream Elevation (ft)",          "7620.00"
"English",         "Downstream Elevation (ft)",        "7310.00"
"English",         "Width's A Term (s/ft²)",           "9.140"
"English",         "  B Term where W = A*Q**B",        "0.329"
"English",         "Manning's n",                      "0.037"
"English",         "Air Temperature (°F)",             "54.320"
"English",         "Relative Humidity (%)",            "64.000"
"English",         "Wind Speed (mph)",                 "8.000"
"English",         "Ground Temperature (°F)",          "43.400"
"English",         "Thermal gradient (j/m²/s/C)",      "1.650"
"English",         "Possible Sun (%)",                 "76.000"
"English",         "Dust Coefficient",                 "6.500"
"English",         "Ground Reflectivity (%)",          "25.000"
"English",         "Solar Radiation (Langleys/d)",     "439.069"
"English",         "Total Shade (%)",                  "11.300"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Enabled"
"Month/day","09/27"
         "Predicted Mean (°F) = 55.31"
         "Estimated Maximum (°F) = 65.80"
         "Approximate Minimum (°F) = 44.82"
```

From thermograph data at Rio Chama @ HWY 95:
Actual mean temp (°F) 9/27/02 = 57.6   Error = ± 4.0%
Acutal max temp (°F) 9/27/02 = 64.6   Error = ± 1.9%
Actual min temp (°F) 9/27/02 = 52.3   Error = ± 14.3%

Rio Chama Run 1 for 8/30/98 -- initial run

```
"SSTEMP (1.2.2)  ","10/31/2002  02:17 pm"
"NoName"
"English",         "Segment Inflow (cfs)",            "7.110"
"English",         "Inflow Temperature (°F)",         "64.000"
"English",         "Segment Outflow (cfs)",           "11.280"
"English",         "Accretion Temp. (°F)",            "43.400"
"English",         "Latitude (degrees)",              "36.790"
"English",         "Segment Length (mi)",             "11.720"
"English",         "Upstream Elevation (ft)",         "7620.00"
"English",         "Downstream Elevation (ft)",       "7310.00"
"English",         "Width's A Term (s/ft²)",          "9.140"
"English",         "  B Term where W = A*Q**B",       "0.329"
"English",         "Manning's n",                     "0.037"
"English",         "Air Temperature (°F)",            "56.460"
"English",         "Relative Humidity (%)",           "64.000"
"English",         "Wind Speed (mph)",                "8.000"
"English",         "Ground Temperature (°F)",         "43.400"
"English",         "Thermal gradient (j/m²/s/C)",     "1.650"
"English",         "Possible Sun (%)",                "76.000"
"English",         "Dust Coefficient",                "6.500"
"English",         "Ground Reflectivity (%)",         "25.000"
"English",         "Solar Radiation (Langleys/d)",    "543.673"
"English",         "Total Shade (%)",                 "11.300"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Enabled"
"Month/day","08/30"
         "Predicted Mean (°F) = 59.34"
         "Estimated Maximum (°F) = 70.12"
         "Approximate Minimum (°F) = 48.55"
```

Rio Chama Run 2 for 8/30/98 -- change Total Shade to 22.0%

```
"SSTEMP (1.2.2)  ","10/31/2002  02:29 pm"
"NoName"
"English",         "Segment Inflow (cfs)",            "7.110"
"English",         "Inflow Temperature (°F)",         "64.000"
"English",         "Segment Outflow (cfs)",           "11.280"
"English",         "Accretion Temp. (°F)",            "43.400"
"English",         "Latitude (degrees)",              "36.790"
"English",         "Segment Length (mi)",             "11.720"
"English",         "Upstream Elevation (ft)",         "7620.00"
"English",         "Downstream Elevation (ft)",       "7310.00"
"English",         "Width's A Term (s/ft²)",          "9.140"
"English",         "  B Term where W = A*Q**B",       "0.329"
"English",         "Manning's n",                     "0.037"
"English",         "Air Temperature (°F)",            "56.460"
"English",         "Relative Humidity (%)",           "64.000"
"English",         "Wind Speed (mph)",                "8.000"
"English",         "Ground Temperature (°F)",         "43.400"
"English",         "Thermal gradient (j/m²/s/C)",     "1.650"
"English",         "Possible Sun (%)",                "76.000"
"English",         "Dust Coefficient",                "6.500"
"English",         "Ground Reflectivity (%)",         "25.000"
"English",         "Solar Radiation (Langleys/d)",    "543.673"
"English",         "Total Shade (%)",                 "22.000"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Enabled"
"Month/day","08/30"
         "Predicted Mean (°F) = 58.18"
         "Estimated Maximum (°F) = 67.93"
         "Approximate Minimum (°F) = 48.42"
```

Rio Chama Run 3 for 8/30/98 -- change Total Shade to 17.5% and Width's A Term to 7.0

```
"SSTEMP (1.2.2)  ","10/31/2002  02:28 pm"
"NoName"
"English",         "Segment Inflow (cfs)",            "7.110"
"English",         "Inflow Temperature (°F)",         "64.000"
"English",         "Segment Outflow (cfs)",           "11.280"
"English",         "Accretion Temp. (°F)",            "43.400"
"English",         "Latitude (degrees)",              "36.790"
"English",         "Segment Length (mi)",             "11.720"
"English",         "Upstream Elevation (ft)",         "7620.00"
"English",         "Downstream Elevation (ft)",       "7310.00"
"English",         "Width's A Term (s/ft²)",          "7.000"
"English",         "  B Term where W = A*Q**B",       "0.329"
"English",         "Manning's n",                     "0.037"
"English",         "Air Temperature (°F)",            "56.460"
"English",         "Relative Humidity (%)",           "64.000"
"English",         "Wind Speed (mph)",                "8.000"
"English",         "Ground Temperature (°F)",         "43.400"
"English",         "Thermal gradient (j/m²/s/C)",     "1.650"
"English",         "Possible Sun (%)",                "76.000"
"English",         "Dust Coefficient",                "6.500"
"English",         "Ground Reflectivity (%)",         "25.000"
"English",         "Solar Radiation (Langleys/d)",    "543.673"
"English",         "Total Shade (%)",                 "17.500"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Enabled"
"Month/day","08/30"
         "Predicted Mean (°F) = 58.30"
         "Estimated Maximum (°F) = 67.92"
         "Approximate Minimum (°F) = 48.69"
```

Rio Chama Run FINAL for 8/30/98 -- Total Shade to 17.5% and Width's A Term to 7.0 (to include 10% MOS in solar radiation component)

```
"SSTEMP (1.2.2)  ","10/31/2002  04:16 pm"
"NoName"
"English",         "Segment Inflow (cfs)",            "7.110"
"English",         "Inflow Temperature (°F)",         "64.000"
"English",         "Segment Outflow (cfs)",           "11.280"
"English",         "Accretion Temp. (°F)",            "43.400"
"English",         "Latitude (degrees)",              "36.790"
"English",         "Segment Length (mi)",             "11.720"
"English",         "Upstream Elevation (ft)",         "7620.00"
"English",         "Downstream Elevation (ft)",       "7310.00"
"English",         "Width's A Term (s/ft²)",          "7.000"
"English",         "  B Term where W = A*Q**B",       "0.329"
"English",         "Manning's n",                     "0.037"
"English",         "Air Temperature (°F)",            "56.460"
"English",         "Relative Humidity (%)",           "64.000"
"English",         "Wind Speed (mph)",                "8.000"
"English",         "Ground Temperature (°F)",         "43.400"
"English",         "Thermal gradient (j/m²/s/C)",     "1.650"
"English",         "Possible Sun (%)",                "76.000"
"English",         "Dust Coefficient",                "6.500"
"English",         "Ground Reflectivity (%)",         "25.000"
"English",         "Solar Radiation (Langleys/d)",    "543.673"
"English",         "Total Shade (%)",                 "26.000"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Enabled"
"Month/day","08/30"
         "Predicted Mean (°F) = 57.44"
         "Estimated Maximum (°F) = 66.23"
         "Approximate Minimum (°F) = 48.64"
```

Chavez Creek Calibration Run for 8/30/02

```
"SSTEMP (1.2.2)  ","10/31/2002  10:35 am"
"NoName"
"English",         "Segment Inflow (cfs)",             "0.000"
"English",         "Inflow Temperature (°F)",          "32.000"
"English",         "Segment Outflow (cfs)",            "1.930"
"English",         "Accretion Temp. (°F)",             "43.400"
"English",         "Latitude (degrees)",               "36.740"
"English",         "Segment Length (mi)",              "12.590"
"English",         "Upstream Elevation (ft)",          "10500.0"
"English",         "Downstream Elevation (ft)",        "7570.00"
"English",         "Width's A Term (s/ft²)",           "16.100"
"English",         "  B Term where W = A*Q**B",        "0.164"
"English",         "Manning's n",                      "0.037"
"English",         "Air Temperature (°F)",             "50.810"
"English",         "Relative Humidity (%)",            "77.000"
"English",         "Wind Speed (mph)",                 "8.000"
"English",         "Ground Temperature (°F)",          "43.400"
"English",         "Thermal gradient (j/m²/s/C)",      "1.650"
"English",         "Possible Sun (%)",                 "76.000"
"English",         "Dust Coefficient",                 "6.500"
"English",         "Ground Reflectivity (%)",          "18.000"
"English",         "Solar Radiation (Langleys/d)",     "542.907"
"English",         "Total Shade (%)",                  "10.000"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Enabled"
"Month/day","08/30"
         "Predicted Mean (°F) = 58.24"
         "Estimated Maximum (°F) = 72.00"
         "Approximate Minimum (°F) = 44.48"
```

From thermograph data at Chavez @ HWY 512:
Actual mean temp (°F) 8/30/02 = 57.2   Error = ± 1.8%
Acutal max temp (°F) 8/30/02 = 62.8   Error = ± 14.6%
Actual min temp (°F) 8/30/02 = 52.0   Error = ± 14.6%

Chavez Creek Run 2 for 8/30/02 -- change Total Shade to 28%

```
"SSTEMP (1.2.2)  ","10/31/2002  02:31 pm"
"NoName"
"English",         "Segment Inflow (cfs)",            "0.000"
"English",         "Inflow Temperature (°F)",         "32.000"
"English",         "Segment Outflow (cfs)",           "1.930"
"English",         "Accretion Temp. (°F)",            "43.400"
"English",         "Latitude (degrees)",              "36.740"
"English",         "Segment Length (mi)",             "12.590"
"English",         "Upstream Elevation (ft)",         "10500.0"
"English",         "Downstream Elevation (ft)",       "7570.00"
"English",         "Width's A Term (s/ft²)",          "16.100"
"English",         "  B Term where W = A*Q**B",       "0.164"
"English",         "Manning's n",                     "0.037"
"English",         "Air Temperature (°F)",            "50.810"
"English",         "Relative Humidity (%)",           "77.000"
"English",         "Wind Speed (mph)",                "8.000"
"English",         "Ground Temperature (°F)",         "43.400"
"English",         "Thermal gradient (j/m²/s/C)",     "1.650"
"English",         "Possible Sun (%)",                "76.000"
"English",         "Dust Coefficient",                "6.500"
"English",         "Ground Reflectivity (%)",         "18.000"
"English",         "Solar Radiation (Langleys/d)",    "542.907"
"English",         "Total Shade (%)",                 "28.000"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Enabled"
"Month/day","08/30"
         "Predicted Mean (°F) = 55.97"
         "Estimated Maximum (°F) = 67.95"
         "Approximate Minimum (°F) = 44.00"
```

Chavez Creek Run 3 for 8/30/02 -- change Total Shade to 26% and Width's A Term to 8.6

```
"SSTEMP (1.2.2)  ","10/31/2002  03:40 pm"
"NoName"
"English",          "Segment Inflow (cfs)",             "0.000"
"English",          "Inflow Temperature (°F)",          "32.000"
"English",          "Segment Outflow (cfs)",            "1.930"
"English",          "Accretion Temp. (°F)",             "43.400"
"English",          "Latitude (degrees)",               "36.740"
"English",          "Segment Length (mi)",              "12.590"
"English",          "Upstream Elevation (ft)",          "10500.0"
"English",          "Downstream Elevation (ft)",        "7570.00"
"English",          "Width's A Term (s/ft²)",           "8.500"
"English",          "  B Term where W = A*Q**B",        "0.164"
"English",          "Manning's n",                      "0.037"
"English",          "Air Temperature (°F)",             "50.810"
"English",          "Relative Humidity (%)",            "77.000"
"English",          "Wind Speed (mph)",                 "8.000"
"English",          "Ground Temperature (°F)",          "43.400"
"English",          "Thermal gradient (j/m²/s/C)",      "1.650"
"English",          "Possible Sun (%)",                 "76.000"
"English",          "Dust Coefficient",                 "6.500"
"English",          "Ground Reflectivity (%)",          "18.000"
"English",          "Solar Radiation (Langleys/d)",     "542.907"
"English",          "Total Shade (%)",                  "26.000"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Enabled"
"Month/day","08/30"
         "Predicted Mean (°F) = 55.38"
         "Estimated Maximum (°F) = 67.93"
         "Approximate Minimum (°F) = 42.84"
```

Chavez Creek Run FINAL for 8/30/02 -- Total Shade to 34% and Width's A Term to 8.6 (to include 10% MOS in solar radiation component)

```
"SSTEMP (1.2.2)  ","10/31/2002  04:25 pm"
"NoName"
"English",         "Segment Inflow (cfs)",            "0.000"
"English",         "Inflow Temperature (°F)",         "32.000"
"English",         "Segment Outflow (cfs)",           "1.930"
"English",         "Accretion Temp. (°F)",            "43.400"
"English",         "Latitude (degrees)",              "36.740"
"English",         "Segment Length (mi)",             "12.590"
"English",         "Upstream Elevation (ft)",         "10500.0"
"English",         "Downstream Elevation (ft)",       "7570.00"
"English",         "Width's A Term (s/ft²)",          "8.500"
"English",         "  B Term where W = A*Q**B",       "0.164"
"English",         "Manning's n",                     "0.037"
"English",         "Air Temperature (°F)",            "50.810"
"English",         "Relative Humidity (%)",           "77.000"
"English",         "Wind Speed (mph)",                "8.000"
"English",         "Ground Temperature (°F)",         "43.400"
"English",         "Thermal gradient (j/m²/s/C)",     "1.650"
"English",         "Possible Sun (%)",                "76.000"
"English",         "Dust Coefficient",                "6.500"
"English",         "Ground Reflectivity (%)",         "18.000"
"English",         "Solar Radiation (Langleys/d)",    "542.907"
"English",         "Total Shade (%)",                 "34.000"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Enabled"
"Month/day","08/30"
         "Predicted Mean (°F) = 54.41"
         "Estimated Maximum (°F) = 66.02"
         "Approximate Minimum (°F) = 42.80"
```

Rio Brazos Calibration Run for 8/30/02

```
"SSTEMP (1.2.2)  ","11/18/2002  11:46 am"
"NoName"
"English",          "Segment Inflow (cfs)",             "11.900"
"English",          "Inflow Temperature (°F)",          "59.900"
"English",          "Segment Outflow (cfs)",            "13.900"
"English",          "Accretion Temp. (°F)",             "43.400"
"English",          "Latitude (degrees)",               "36.750"
"English",          "Segment Length (mi)",              "3.520"
"English",          "Upstream Elevation (ft)",          "7570.00"
"English",          "Downstream Elevation (ft)",        "7367.00"
"English",          "Width's A Term (s/ft²)",           "12.300"
"English",          "  B Term where W = A*Q**B",        "0.249"
"English",          "Manning's n",                      "0.039"
"English",          "Air Temperature (°F)",             "56.450"
"English",          "Relative Humidity (%)",            "64.000"
"English",          "Wind Speed (mph)",                 "8.000"
"English",          "Ground Temperature (°F)",          "43.400"
"English",          "Thermal gradient (j/m²/s/C)",      "1.650"
"English",          "Possible Sun (%)",                 "76.000"
"English",          "Dust Coefficient",                 "6.500"
"English",          "Ground Reflectivity (%)",          "25.000"
"English",          "Solar Radiation (Langleys/d)",     "543.884"
"English",          "Total Shade (%)",                  "15.000"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Enabled"
"Month/day","08/30"
         "Predicted Mean (°F) = 58.96"
         "Estimated Maximum (°F) = 70.22"
         "Approximate Minimum (°F) = 47.70"
```

<u>From thermograph data at Brazos @ HWY 84:</u>
Actual mean temp (°F) 8/30/02 = 65.6   Error = ± 10.0%
Acutal max temp (°F) 8/30/02 = 75.9   Error = ± 7.5%
Actual min temp (°F) 8/30/02 = 54.9   Error = ± 13.1%

Rio Brazos Run 2 for 8/30/02 -- change Total Shade to 27.5%

```
"SSTEMP (1.2.2)  ","11/18/2002  11:48 am"
"NoName"
"English",         "Segment Inflow (cfs)",            "11.900"
"English",         "Inflow Temperature (°F)",         "59.900"
"English",         "Segment Outflow (cfs)",           "13.900"
"English",         "Accretion Temp. (°F)",            "43.400"
"English",         "Latitude (degrees)",              "36.750"
"English",         "Segment Length (mi)",             "3.520"
"English",         "Upstream Elevation (ft)",         "7570.00"
"English",         "Downstream Elevation (ft)",       "7367.00"
"English",         "Width's A Term (s/ft²)",          "12.300"
"English",         "  B Term where W = A*Q**B",       "0.249"
"English",         "Manning's n",                     "0.039"
"English",         "Air Temperature (°F)",            "56.450"
"English",         "Relative Humidity (%)",           "64.000"
"English",         "Wind Speed (mph)",                "8.000"
"English",         "Ground Temperature (°F)",         "43.400"
"English",         "Thermal gradient (j/m²/s/C)",     "1.650"
"English",         "Possible Sun (%)",                "76.000"
"English",         "Dust Coefficient",                "6.500"
"English",         "Ground Reflectivity (%)",         "25.000"
"English",         "Solar Radiation (Langleys/d)",    "543.884"
"English",         "Total Shade (%)",                 "27.500"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Enabled"
"Month/day","08/30"
         "Predicted Mean (°F) = 58.14"
         "Estimated Maximum (°F) = 67.94"
         "Approximate Minimum (°F) = 48.34"
```

Rio Brazos Run 3 for 8/30/02 -- change Total Shade to 22% and Width's A Term to 8.3

```
"SSTEMP (1.2.2)  ","11/18/2002  11:49 am"
"NoName"
"English",         "Segment Inflow (cfs)",            "11.900"
"English",         "Inflow Temperature (°F)",         "59.900"
"English",         "Segment Outflow (cfs)",           "13.900"
"English",         "Accretion Temp. (°F)",            "43.400"
"English",         "Latitude (degrees)",              "36.750"
"English",         "Segment Length (mi)",             "3.520"
"English",         "Upstream Elevation (ft)",         "7570.00"
"English",         "Downstream Elevation (ft)",       "7367.00"
"English",         "Width's A Term (s/ft²)",          "8.300"
"English",         "  B Term where W = A*Q**B",       "0.249"
"English",         "Manning's n",                     "0.039"
"English",         "Air Temperature (°F)",            "56.450"
"English",         "Relative Humidity (%)",           "64.000"
"English",         "Wind Speed (mph)",                "8.000"
"English",         "Ground Temperature (°F)",         "43.400"
"English",         "Thermal gradient (j/m²/s/C)",     "1.650"
"English",         "Possible Sun (%)",                "76.000"
"English",         "Dust Coefficient",                "6.500"
"English",         "Ground Reflectivity (%)",         "25.000"
"English",         "Solar Radiation (Langleys/d)",    "543.884"
"English",         "Total Shade (%)",                 "22.000"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Enabled"
"Month/day","08/30"
         "Predicted Mean (°F) = 58.29"
         "Estimated Maximum (°F) = 67.94"
         "Approximate Minimum (°F) = 48.63"
```

Rio Brazos Run FINAL for 8/30/02 -- Total Shade to 29.8% and Width's A Term to 8.3 (to include 10% MOS in solar radiation component)

```
"SSTEMP (1.2.2)  ","11/18/2002  11:51 am"
"NoName"
"English",          "Segment Inflow (cfs)",             "11.900"
"English",          "Inflow Temperature (°F)",          "59.900"
"English",          "Segment Outflow (cfs)",            "13.900"
"English",          "Accretion Temp. (°F)",             "43.400"
"English",          "Latitude (degrees)",               "36.750"
"English",          "Segment Length (mi)",              "3.520"
"English",          "Upstream Elevation (ft)",          "7570.00"
"English",          "Downstream Elevation (ft)",        "7367.00"
"English",          "Width's A Term (s/ft²)",           "8.300"
"English",          "  B Term where W = A*Q**B",        "0.249"
"English",          "Manning's n",                      "0.039"
"English",          "Air Temperature (°F)",             "56.450"
"English",          "Relative Humidity (%)",            "64.000"
"English",          "Wind Speed (mph)",                 "8.000"
"English",          "Ground Temperature (°F)",          "43.400"
"English",          "Thermal gradient (j/m²/s/C)",      "1.650"
"English",          "Possible Sun (%)",                 "76.000"
"English",          "Dust Coefficient",                 "6.500"
"English",          "Ground Reflectivity (%)",          "25.000"
"English",          "Solar Radiation (Langleys/d)",     "543.884"
"English",          "Total Shade (%)",                  "29.800"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Enabled"
"Month/day","08/30"
         "Predicted Mean (°F) = 57.89"
         "Estimated Maximum (°F) = 66.65"
         "Approximate Minimum (°F) = 49.13"
```

Rito de Tierra Amarilla Calibration Run for 8/30/98

```
"SSTEMP (1.2.2)  ","11/18/2002  01:51 pm"
"NoName"
"English",         "Segment Inflow (cfs)",             "1.310"
"English",         "Inflow Temperature (°F)",          "61.520"
"English",         "Segment Outflow (cfs)",            "1.000"
"English",         "Accretion Temp. (°F)",             "43.400"
"English",         "Latitude (degrees)",               "36.660"
"English",         "Segment Length (mi)",              "15.800"
"English",         "Upstream Elevation (ft)",          "8290.00"
"English",         "Downstream Elevation (ft)",        "7150.00"
"English",         "Width's A Term (s/ft²)",           "10.820"
"English",         "  B Term where W = A*Q**B",        "0.158"
"English",         "Manning's n",                      "0.037"
"English",         "Air Temperature (°F)",             "55.550"
"English",         "Relative Humidity (%)",            "66.000"
"English",         "Wind Speed (mph)",                 "8.000"
"English",         "Ground Temperature (°F)",          "43.400"
"English",         "Thermal gradient (j/m²/s/C)",      "1.650"
"English",         "Possible Sun (%)",                 "76.000"
"English",         "Dust Coefficient",                 "6.500"
"English",         "Ground Reflectivity (%)",          "18.000"
"English",         "Solar Radiation (Langleys/d)",     "540.810"
"English",         "Total Shade (%)",                  "5.000"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Enabled"
"Month/day","08/30"
         "Predicted Mean (°F) = 61.94"
         "Estimated Maximum (°F) = 74.54"
         "Approximate Minimum (°F) = 49.35"
```

From thermograph data at Rito de Tierra Amarilla @ HWY 112:

Actual mean temp (°F) 8/30/02 = 71.42   Error = ± 13.3%
Acutal max temp (°F) 8/30/02 = 85.10   Error = ± 12.4%
Actual min temp (°F) 8/30/02 = 59.9   Error = ± 17.6%

Rito de Tierra Amarilla Run 2 for 8/30/98 -- change Total Shade to 20%

```
"SSTEMP (1.2.2)  ","11/18/2002  02:38 pm"
"NoName"
"English",         "Segment Inflow (cfs)",             "1.310"
"English",         "Inflow Temperature (°F)",          "61.520"
"English",         "Segment Outflow (cfs)",            "1.000"
"English",         "Accretion Temp. (°F)",             "43.400"
"English",         "Latitude (degrees)",               "36.660"
"English",         "Segment Length (mi)",              "15.800"
"English",         "Upstream Elevation (ft)",          "8290.00"
"English",         "Downstream Elevation (ft)",        "7150.00"
"English",         "Width's A Term (s/ft²)",           "10.820"
"English",         "  B Term where W = A*Q**B",        "0.158"
"English",         "Manning's n",                      "0.037"
"English",         "Air Temperature (°F)",             "55.550"
"English",         "Relative Humidity (%)",            "66.000"
"English",         "Wind Speed (mph)",                 "8.000"
"English",         "Ground Temperature (°F)",          "43.400"
"English",         "Thermal gradient (j/m²/s/C)",      "1.650"
"English",         "Possible Sun (%)",                 "76.000"
"English",         "Dust Coefficient",                 "6.500"
"English",         "Ground Reflectivity (%)",          "18.000"
"English",         "Solar Radiation (Langleys/d)",     "540.810"
"English",         "Total Shade (%)",                  "20.000"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Enabled"
"Month/day","08/30"
         "Predicted Mean (°F) = 60.09"
         "Estimated Maximum (°F) = 71.48"
         "Approximate Minimum (°F) = 48.70"
```

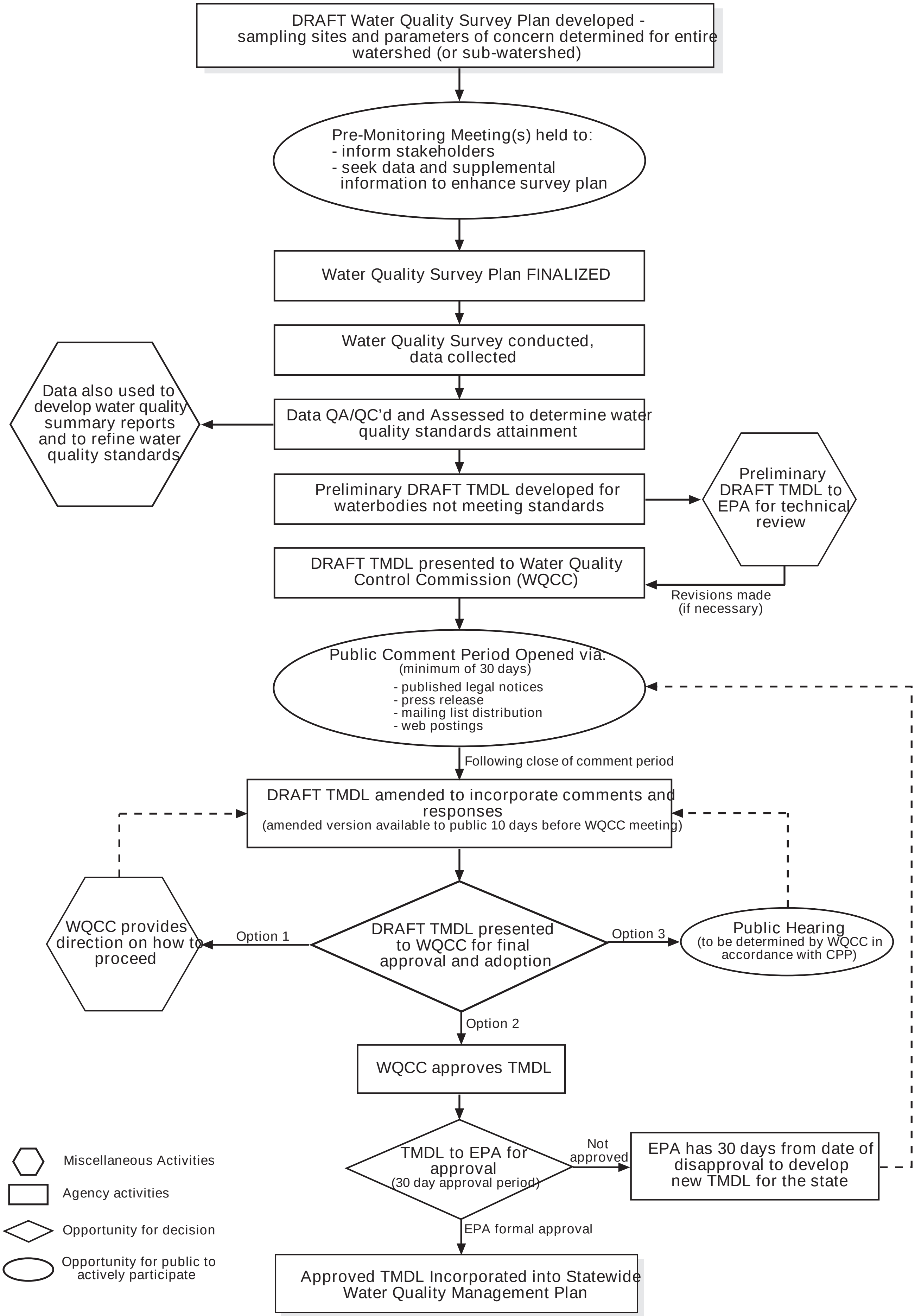
Rito de Tierra Amarilla Run 3 for 8/30/98 -- change Total Shade to 36%

```
"SSTEMP (1.2.2)  ","11/18/2002  02:18 pm"
"NoName"
"English",         "Segment Inflow (cfs)",            "1.310"
"English",         "Inflow Temperature (°F)",         "61.520"
"English",         "Segment Outflow (cfs)",           "1.000"
"English",         "Accretion Temp. (°F)",            "43.400"
"English",         "Latitude (degrees)",              "36.660"
"English",         "Segment Length (mi)",             "15.800"
"English",         "Upstream Elevation (ft)",         "8290.00"
"English",         "Downstream Elevation (ft)",       "7150.00"
"English",         "Width's A Term (s/ft²)",          "10.820"
"English",         "  B Term where W = A*Q**B",       "0.158"
"English",         "Manning's n",                     "0.037"
"English",         "Air Temperature (°F)",            "55.550"
"English",         "Relative Humidity (%)",           "66.000"
"English",         "Wind Speed (mph)",                "8.000"
"English",         "Ground Temperature (°F)",         "43.400"
"English",         "Thermal gradient (j/m²/s/C)",     "1.650"
"English",         "Possible Sun (%)",                "76.000"
"English",         "Dust Coefficient",                "6.500"
"English",         "Ground Reflectivity (%)",         "18.000"
"English",         "Solar Radiation (Langleys/d)",    "540.810"
"English",         "Total Shade (%)",                 "36.000"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Enabled"
"Month/day","08/30"
         "Predicted Mean (°F) = 58.03"
         "Estimated Maximum (°F) = 67.97"
         "Approximate Minimum (°F) = 48.10"
```

Rito de Tierra Amarilla Run FINAL for 8/30/98 -- Total Shade to 42.5% (to include 10% MOS in solar radiation component)

```
"SSTEMP (1.2.2)  ","11/18/2002  04:38 pm"
"NoName"
"English",         "Segment Inflow (cfs)",             "1.310"
"English",         "Inflow Temperature (°F)",          "61.520"
"English",         "Segment Outflow (cfs)",            "1.000"
"English",         "Accretion Temp. (°F)",             "43.400"
"English",         "Latitude (degrees)",               "36.660"
"English",         "Segment Length (mi)",              "15.800"
"English",         "Upstream Elevation (ft)",          "8290.00"
"English",         "Downstream Elevation (ft)",        "7150.00"
"English",         "Width's A Term (s/ft²)",           "10.820"
"English",         "  B Term where W = A*Q**B",        "0.158"
"English",         "Manning's n",                      "0.037"
"English",         "Air Temperature (°F)",             "55.550"
"English",         "Relative Humidity (%)",            "66.000"
"English",         "Wind Speed (mph)",                 "8.000"
"English",         "Ground Temperature (°F)",          "43.400"
"English",         "Thermal gradient (j/m²/s/C)",      "1.650"
"English",         "Possible Sun (%)",                 "76.000"
"English",         "Dust Coefficient",                 "6.500"
"English",         "Ground Reflectivity (%)",          "18.000"
"English",         "Solar Radiation (Langleys/d)",     "540.810"
"English",         "Total Shade (%)",                  "42.500"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Enabled"
"Month/day","08/30"
         "Predicted Mean (°F) = 57.18"
         "Estimated Maximum (°F) = 66.46"
         "Approximate Minimum (°F) = 47.89"
```

Appendix G: Public Participation Process Flowchart



Appendix H: Response to Comments