TOTAL MAXIMUM DAILY LOAD (TMDL)

FOR THE

UPPER RIO GRANDE WATERSHED (PART 1)

PILAR, NM, TO COLORADO BORDER

NOVEMBER 9, 2004

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LIST OF ABBREVIATIONS

4Q3	4-Day, 3-year low-flow frequency
BLM	Bureau of Land Management
BMP	Best management practices
CFR	Code of Federal Regulations
cfs	Cubic feet per second
cms	Cubic meters per second
CO	Colorado
CWA	Clean Water Act
CWF	Coldwater Fishery
EID	Environmental Improvement Division
EMNRD	New Mexico Energy, Minerals, and Natural Resources Department
EPA	U.S. Environmental Protection Agency
EPT	Ephemeroptera/Plecoptera/Tricoptera
FISRWG	Federal Interagency Stream Restoration Working Group
FR	Forest Road
GIS	Geographic Information Systems
GPS	Global Positioning System
HBI	Hilsenhoff's Biotic Index
HQCWF	High quality cold water fishery
HUC	Hydrologic unit code
IOWDM	Input and Output for Watershed Data Management
$j/m^2/s$	Joules per square meter per second
LA	Load allocation
lb/day	Pounds per Day
mg/L	Milligrams per Liter
mi^2	Square miles
mL	Milliliters

mm	Millimeters
MOS	Margin of safety
MOU	Memoranda of Understanding
NM	New Mexico
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NPDES	National Pollution Discharge Elimination System
NPS	National Park Service
NTU	Nephelometric turbidity units
^{o}C	Degrees Celcius
^{o}F	Degrees Farenheit
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
QAPP	Quality Assurance Project Plan
RBP	Rapid Bioassessment Protocol
RFP	Request for proposal
SBD	Stream bottom deposits
SC	Specific Conductance
SEE	Standard Error of the Estimate
SSTEMP	Stream Segment Temperature Model
SVOC	Semivolatile organic chemical
SWQB	Surface Water Quality Bureau
SWSTAT	Surface Water Statistics
TDS	Total Dissolved Solids
TMDL	Total maximum daily load
TSS	Total suspended sediment
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
UWA	Unified Watershed Assessment
WLA	Waste load allocation
WQCC	Water Quality Control Commission
WQS	Water quality standards (NMAC 20.6.4 as amended through October 11, 2002)
WRAS	Watershed Restoration Action Strategy
WWTP	Waste water treatment plant
μmhos	Micromhos
μmhos/cm	Micromhos per centimeter

EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act requires states to develop Total Maximum Daily Load management plans for water bodies determined to be water quality limited. A total maximum daily load 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. Total maximum daily loads are defined in 40 Code of Federal Regulations Part 130 as the sum of the individual Waste Load Allocations for point sources and Load Allocations for nonpoint sources, including a margin of safety and natural background conditions.

The Upper Rio Grande watershed is located in north central New Mexico. For practical purposes, the Upper Rio Grande watershed was divided into two investigations (i.e., Part 1 and Part 2). The Upper Rio Grande watershed from Pilar, New Mexico to the New Mexico-Colorado border is Part 1 of the Upper Rio Grande investigation and is addressed in this document. Stations were located throughout the Upper Rio Grande watershed during an intensive watershed survey performed by the New Mexico Environment Department Surface Water Quality Bureau in 2000 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 Comanche Creek (Costilla Creek to Little Costilla Creek), Costilla Creek (Diversion above Costilla to Comanche Creek), Rio de los Pinos (Colorado border to headwaters), Rio Fernando de Taos (Rio Pueblo de Taos to headwaters), Rio Grande (Red River to New Mexico-Colorado border), Rio Hondo (Rio Grande to US Forest Service boundary), Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo), Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho), Rio Pueblo de Taos (Rio Grande del Rancho to Taos Pueblo Boundary), and Rio San Antonio (Montoya Canyon to headwaters). Exceedences of the conductivity[1] criterion were documented on the Rio Fernando de Taos (Rio Pueblo de Taos to headwaters), and Rio Grande del Rancho (Rio Pueblo de Taos to Hwy 518). Conditions at Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho) do not meet the narrative stream bottom deposits standard. This total maximum daily load document addresses the above noted impairments. The impaired assessment units and total maximum daily loads are summarized below. A total maximum daily load for stream bottom deposits was previously completed for Cordova Creek (Costilla Creek to headwaters) (New Mexico Environment Department/Surface Water Quality Bureau 1999a). Accordingly, this effort provides total maximum daily loads that address all the above noted impairments.

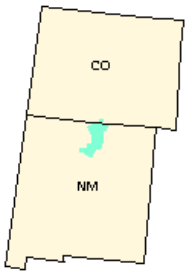
Additional water quality data will be collected by New Mexico Environment Department during the standard rotational period for intensive stream surveys. As a result, targets will be re-examined and potentially revised as this document is considered to be an evolving management plan. In the event that new data indicate that the targets used in this analysis are not appropriate

[1] The current water quality standards erroneously refer to "conductivity" when the intention was "specific conductance." Specific conductance means conductivity adjusted to 25 degrees C. SWQB proposed changing all references from conductivity to specific conductance at the recent (February 2004) trienniel review hearing. This proposal is expected to be accepted by the WQCC and EPA. Therefore, the term specific conductance is used throughout this TMDL document.

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 moved to the appropriate category on the Clean Water Act Integrated §303(d)/§305(b) list of waters.

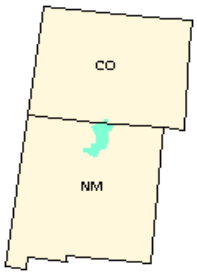
The Surface Water Quality Bureau's Watershed Protection Section has and will continue to work with watershed groups to develop Watershed Restoration Action Strategies to develop and implement strategies to attempt to correct the water quality impairments detailed in this document. Implementation of items detailed in Watershed Restoration Action Strategies will be done with participation of all interested and affected parties.

TOTAL MAXIMUM DAILY LOAD FOR TEMPERATURE
COMANCHE CREEK (COSTILLA CREEK TO LITTLE COSTILLA CREEK)



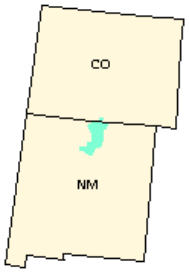
New Mexico Standards Segment	Rio Grande 20.6.4.123
Waterbody Identifier	Comanche Creek (Costilla Creek to Little Costilla Creek) NM-2120.A_827 (formerly NM-URG1-30500)
Segment Length	10.3 miles
Parameters of Concern	Temperature
Uses Affected	High Quality Coldwater Fishery
Geographic Location	Rio Grande USGS Hydrologic Unit Code 13020101
Scope/size of Watershed	43 mi^2
Land Type	Southern Rockies Ecoregion (21)
Land Use/Cover	Rangeland (33%), Forest (66%), Agriculture (<1%), Built-up/Water (<1%)
Identified Sources	Range grazing, silviculture (historic), road construction/maintenance, placer mining (historic), removal of riparian vegetation, streambank modification or destabilization
Land Management	U.S. Forest Service (99%), Private (<1%)
Priority Ranking	3
Threatened and Endangered Species	None
TMDL for: Temperature	WLA (0) + LA (115.1) + MOS (12.8) = **127.9 j/m^2/sec/day**

TOTAL MAXIMUM DAILY LOAD FOR TEMPERATURE
COSTILLA CREEK (DIVERSION ABOVE COSTILLA TO COMANCHE CREEK)



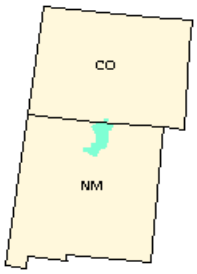
New Mexico Standards Segment	Rio Grande 20.6.4.123
Waterbody Identifier	Costilla Creek (Diversion above Costilla to Comanche Creek) NM-2120.A_820 (formerly NM-URG1-30000)
Segment Length	18.0 miles
Parameters of Concern	Temperature
Uses Affected	High Quality Coldwater Fishery
Geographic Location	Rio Grande USGS Hydrologic Unit Code 13020101
Scope/size of Watershed	230 mi^2
Land Type	Southern Rockies Ecoregion (22)
Land Use/Cover	Rangeland (14%), Forest (80%), Agriculture (2%), Barren/Tundra (4%), Built-up/Water (<1%)
Identified Sources	Range grazing (riparian and/or upland); hydromodification; highway maintenance and runoff; flow regulation/modification; channelization
Land Management	U.S. Forest Service (28%), Private (72%)
Priority Ranking	3
Threatened and Endangered Species	None
TMDL for: Temperature	WLA (0) + LA (70.7) + MOS (7.9) = **78.6 j/m^2/sec/day**

TOTAL MAXIMUM DAILY LOAD FOR TEMPERATURE
RIO DE LOS PINOS (COLORADO BORDER TO HEADWATERS)



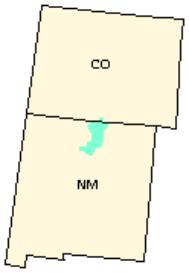
New Mexico Standards Segment	Rio Grande 20.6.4.123
Waterbody Identifier	Rio de los Pinos (Colorado border to headwaters) NM-2120.A_900 (formerly NM-URG1-50000)
Segment Length	20.9 miles
Parameters of Concern	Temperature
Uses Affected	High Quality Coldwater Fishery
Geographic Location	Rio Grande USGS Hydrologic Unit Code 13010005
Scope/size of Watershed	160 mi^2
Land Type	Southern Rockies Ecoregion (21/22)
Land Use/Cover	Rangeland (39%), Forest (61%), Agriculture (<1%), Built-up/Water (<1%)
Identified Sources	Range grazing, removal of riparian vegetation, streambank modification or destabilization, natural, unknown
Land Management	Bureau of Land Management (7%), U.S. Forest Service (91%), Private (2%)
Priority Ranking	3
Threatened and Endangered Species	None
TMDL for: Temperature	WLA (0) + LA (135.7) + MOS (15.4) = **151.1 j/m^2/sec/day**

TOTAL MAXIMUM DAILY LOADS FOR SPECIFIC CONDUCTANCE AND TEMPERATURE RIO FERNANDO DE TAOS (RIO PUEBLO DE TAOS TO HEADWATERS)



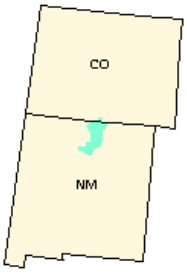
New Mexico Standards Segment	Rio Grande 20.6.4.123
Waterbody Identifier	Rio Fernando de Taos (Rio Pueblo de Taos to headwaters) NM-2120.A_512 (formerly NM-URG1-20210)
Segment Length	21.6 miles
Parameters of Concern	Specific Conductance, Temperature
Uses Affected	High Quality Coldwater Fishery
Geographic Location	Rio Grande USGS Hydrologic Unit Code 13020101
Scope/size of Watershed	63 mi^2
Land Type	Southern Rockies Ecoregion (21/22)
Land Use/Cover	Rangeland (3%), Forest (90%), Agriculture (3%), Built-up/Water (4%)
Identified Sources	Recreation and tourism activities (other than boating); range grazing (riparian and/or upland); natural sources; land disposal; land development; highway maintenance and runoff; habitat modification (other than hydromodification); construction; bank or shoreline modification/destabilization
Land Management	Tribal lands (2%), U.S. Forest Service (81%), Private (17%)
Priority Ranking	3
Threatened and Endangered Species	None
TMDL for:	
Specific Conductance	WLA (0) + LA (111) + MOS (20) = **131 lbs/day**
Temperature	WLA (0) + LA (59.3) + MOS (6.59) = **65.9 j/m^2/sec/day**

TOTAL MAXIMUM DAILY LOAD FOR TEMPERATURE
RIO GRANDE (RED RIVER TO NEW MEXICO-COLORADO BORDER)



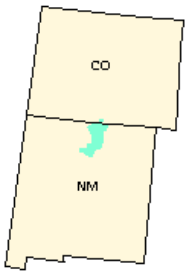
New Mexico Standards Segment	Rio Grande 20.6.4.122
Waterbody Identifier	Rio Grande (Red River to New Mexico-Colorado Border) NM-2119_05 (formerly NM-URG1-20000 [split])
Segment Length	27.75 miles
Parameters of Concern	Temperature
Uses Affected	Coldwater Fishery
Geographic Location	Rio Grande USGS Hydrologic Unit Code 13020101
Scope/size of Watershed	5,660 mi^2
Land Type	Southern Rockies Ecoregion (22)
Land Use/Cover	Rangeland (42%), Forest (46%), Agriculture (11%), Barren/Tundra (1%), Built-up/Water (<1%)
Identified Sources	Watershed runoff following forest fire; removal of riparian vegetation; recreation and tourism activities (other than boating); hydromodification; habitat modification (other than hydromodification); flow regulation/modification
Land Management	State land (10%), U.S. Forest Service (28%), Bureau of Land Management (30%), Private (32%)
Priority Ranking	2
Threatened and Endangered Species	None
TMDL for: Temperature	WLA (0) + LA (82.0) + MOS (9.11) = **91.1 $j/m^2/sec/day$**

TOTAL MAXIMUM DAILY LOAD FOR SPECIFIC CONDUCTANCE
RIO GRANDE DEL RANCHO (RIO PUEBLO DE TAOS TO HIGHWAY 518)



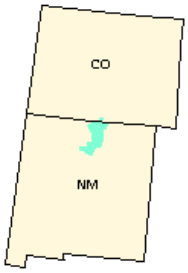
New Mexico Standards Segment	Rio Grande 20.6.4.123
Waterbody Identifier	Rio Grande del Rancho (Rio Pueblo de Taos to Hwy 518) NM-2120.A_501 (formerly NM-URG1-20110)
Segment Length	11.5 miles
Parameters of Concern	Specific Conductance
Uses Affected	High Quality Coldwater Fishery
Geographic Location	Rio Grande USGS Hydrologic Unit Code 13020101
Scope/size of Watershed	142 mi^2
Land Type	Southern Rockies Ecoregion (21/22)
Land Use/Cover	Rangeland (4%), Forest (92%), Agriculture (2%), Built-up/Water (2%)
Identified Sources	Range grazing (riparian and/or upland); natural sources; land disposal; hydromodification; highway/road/bridge construction; highway maintenance and runoff; habitat modification (other than hydromodification); flow regulation/modification; construction; channelization; bank or shoreline modification/destabilization
Land Management	U.S. Forest Service (93%), Private (7%)
Priority Ranking	4
Threatened and Endangered Species	None
TMDL for: Specific Conductance	WLA (0) + LA (3,743) + MOS (660) = **4,403 lbs/day**

TOTAL MAXIMUM DAILY LOAD FOR TEMPERATURE
RIO HONDO (RIO GRANDE TO U.S. FOREST SERVICE BOUNDARY)



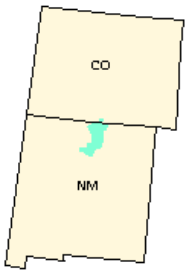
New Mexico Standards Segment	Rio Grande 20.6.4.123
Waterbody Identifier	Rio Hondo (Rio Grande to US Forest Service Boundary) NM-2120.A_600 (formerly NM-URG1-20300)
Segment Length	8.5 miles
Parameters of Concern	Temperature
Uses Affected	High Quality Coldwater Fishery
Geographic Location	Rio Grande USGS Hydrologic Unit Code 13020101
Scope/size of Watershed	72 mi^2
Land Type	Southern Rockies Ecoregion (22)
Land Use/Cover	Rangeland (7%), Forest (78%), Agriculture (10%), Built-up/Water (3%), Barren/Tundra (2%)
Identified Sources	Removal of riparian vegetation; pasture grazing (riparian and/or upland); irrigated crop production; highway maintenance and runoff; habitat modification (other than hydromodification); crop-related sources; bank or shoreline modification/destabilization
Land Management	Tribal lands (1%), U.S. Forest Service (61%), Private (38%)
Priority Ranking	4
Threatened and Endangered Species	None
TMDL for: Temperature	WLA (0) + LA (91.7) + MOS (10.2) = **101.9 j/m^2/sec/day**

TOTAL MAXIMUM DAILY LOAD FOR TEMPERATURE
RIO PUEBLO DE TAOS (RIO GRANDE TO ARROYO DEL ALAMO)



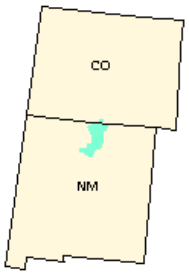
New Mexico Standards Segment	Rio Grande 20.6.4.123
Waterbody Identifier	Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo) NM-2119_20 (formerly NM-URG1-20100 [split])
Segment Length	6.4 miles
Parameters of Concern	Temperature
Uses Affected	High Quality Coldwater Fishery
Geographic Location	Rio Grande USGS Hydrologic Unit Code 13020101
Scope/size of Watershed	418 mi^2
Land Type	Southern Rockies Ecoregion (22)
Land Use/Cover	Rangeland (15%), Forest (76%), Agriculture (5%), Built-up/Water (3%), Barren/Tundra (1%)
Identified Sources	Recreation and tourism activities (other than boating); range grazing (riparian and/or upland); pasture grazing (riparian and/or upland); irrigated crop production; hydromodification; highway maintenance and runoff; habitat modification (other than hydromodification); grazing related sources; flow regulation/modification; crop-related sources; bank or shoreline modification/destabilization
Land Management	Tribal land (32%), U.S. Forest Service (47%), Private (21%)
Priority Ranking	2
Threatened and Endangered Species	None
TMDL for: Temperature	WLA (0) + LA (23.1) + MOS (2.57) = **25.7 j/m^2/sec/day**

TOTAL MAXIMUM DAILY LOADS FOR TEMPERATURE
AND STREAM BOTTOM DEPOSITS
RIO PUEBLO DE TAOS (ARROYO DEL ALAMO TO RIO GRANDE DEL RANCHO)



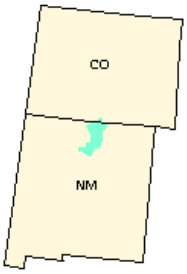
New Mexico Standards Segment	Rio Grande 20.6.4.122
Waterbody Identifier	Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho) NM-2119_30 (formerly NM-URG1-20100 [split])
Segment Length	1.2 miles
Parameters of Concern	Temperature, Stream bottom deposits (sedimentation/siltation)
Uses Affected	High Quality Coldwater Fishery
Geographic Location	Rio Grande USGS Hydrologic Unit Code 13020101
Scope/size of Watershed	401 mi^2
Land Type	Southern Rockies Ecoregion (22)
Land Use/Cover	Rangeland (14%), Forest (77%), Agriculture (5%), Built-up/Water (3%), Barren/Tundra (1%)
Identified Sources	Range grazing (riparian and/or upland); onsite wastewater systems (septic tanks); municipal point sources; land disposal; highway/road/bridge construction; highway maintenance and runoff; grazing related sources; crop-related sources; construction; agriculture
Land Management	Tribal land (33%), U.S. Forest Service (48%), Private (19%)
Priority Ranking	2
Threatened and Endangered Species	None
TMDL for:	
Temperature	WLA (0) + LA (10.7) + MOS (1.19) = **11.9 j/m^2/sec/day**
Stream bottom deposits	WLA (0) + LA (15) + MOS (5) = **20 percent fines**

TOTAL MAXIMUM DAILY LOADS FOR TEMPERATURE
RIO PUEBLO DE TAOS (RIO GRANDE DEL RANCHO TO TAOS PUEBLO BOUNDARY)



New Mexico Standards Segment	Rio Grande 20.6.4.123
Waterbody Identifier	Rio Pueblo de Taos (Rio Grande del Rancho to Taos Pueblo bdy) NM-2120.A_511 (formerly NM-URG1-20200)
Segment Length	2.8 miles
Parameters of Concern	Temperature
Uses Affected	High Quality Coldwater Fishery
Geographic Location	Rio Grande USGS Hydrologic Unit Code 13020101
Scope/size of Watershed	214 mi^2
Land Type	Southern Rockies Ecoregion (22)
Land Use/Cover	Rangeland (7%), Forest (78%), Agriculture (9%), Built-up/Water (5%), Barren/Tundra (1%)
Identified Sources	Removal of riparian vegetation; pasture grazing (riparian and/or upland); irrigated crop production; habitat modification (other than hydromodification); grazing related sources; crop-related sources; bank or shoreline modification/destabilization; agriculture
Land Management	Tribal lands (56%), U.S. Forest Service (30%), Private (14%)
Priority Ranking	4
Threatened and Endangered Species	None
TMDL for: Temperature	WLA (0) + LA (64.7) + MOS (7.19) = **71.9 j/m^2/sec/day**

TOTAL MAXIMUM DAILY LOAD FOR TEMPERATURE
RIO SAN ANTONIO (MONTOYA CANYON TO HEADWATERS)



New Mexico Standards Segment	Rio Grande 20.6.4.123
Waterbody Identifier	Rio San Antonio (Montoya Canyon to headwaters) NM-2120.A_901 (formerly NM-URG1-50100)
Segment Length	12.9 miles
Parameters of Concern	Temperature
Uses Affected	High Quality Coldwater Fishery
Geographic Location	Rio Grande USGS Hydrologic Unit Code 13010005
Scope/size of Watershed	125 mi^2
Land Type	Southern Rockies Ecoregion (21/22)
Land Use/Cover	Rangeland (63%), Forest (37%), Agriculture (<1%), Built-up/Water (<1%)
Identified Sources	Range grazing, removal of riparian vegetation, streambank modification or destabilization, natural, unknown
Land Management	U.S. Forest Service (86%), Bureau of Land Management (12%), State Land (1%), Private (1%)
Priority Ranking	3
Threatened and Endangered Species	None
TMDL for: Temperature	WLA (0) + LA (147.48) + MOS (16.4) = **163.88 j/m^2/sec/day**

1.0 INTRODUCTION

Under Section 303 of the Clean Water Act (CWA), states establish water quality standards, which are submitted and subject to the approval of the U.S. Environmental Protection Agency (EPA). Under Section 303(d)(1) of the CWA, states are required to develop a list of waters within a state that are impaired and establish a total maximum daily load (TMDL) for each pollutant. A TMDL is defined as "*a written plan and analysis established to ensure that a waterbody will attain and maintain water quality standard including consideration of existing pollutant loads and reasonably foreseeable increases in pollutant loads*" (EPA 1999). A TMDL documents the amount of a pollutant a waterbody 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 Code of Federal Regulations (CFR) Part 130 as the sum of the individual Waste Load Allocations (WLAs) for point sources and Load Allocations (LAs) for nonpoint sources, including a margin of safety (MOS) and natural background conditions. This document provides TMDLs for assessment units within the Upper Rio Grande (Part 1) that have been determined to be impaired based on a comparison of measured concentrations and conditions with water quality criteria.

In addition to this introductory Section 1.0, this document is divided into eleven main sections. Section 2.0 provides background information on the location and history of the Upper Rio Grande watershed, provides applicable water quality standards for the assessment units addressed in this document, and briefly discusses the intensive water quality survey that was conducted in the Upper Rio Grande watershed (Part 1) in 2000. Section 3.0 provides detailed descriptions of the individual watersheds for which TMDLs were developed. Section 4.0 presents the TMDLs developed for specific conductance in the Upper Rio Grande watershed (Part 1). Section 5.0 presents the TMDL developed for stream bottom deposits in the Upper Rio Grande watershed (Part 1). Section 6.0 provides temperature TMDLs. Pursuant to Section 106(e)(1) of the Federal CWA, Section 7.0 provides a monitoring plan in which methods, systems, and procedures for data collection and analysis are discussed. Section 8.0 discusses implementation of TMDLs (phase two) and the relationship with Watershed Restoration Action Strategies. Section 9.0 discusses assurance, section 10.0 public participation in the TMDL process, and Section 11.0 provides references.

2.0 UPPER RIO GRANDE (PART 1) BACKGROUND

For practical purposes, the Upper Rio Grande watershed was divided into two investigations (i.e., Parts 1 and 2). The Upper Rio Grande (Part 1) was intensively sampled by the New Mexico Environment Department/Surface Water Quality Bureau (NMED/SWQB) from May to October, 2000 and is addressed in this document. Surface water quality monitoring stations were selected to characterize water quality of the stream reaches (Table 2.1, Figure 2.1). Most of all the perennial tributaries to the Rio Grande in New Mexico (NM) can be found within the Upper Rio Grande. The Red River subwatershed was excluded from the 2000 investigation, as that portion of the Upper Rio Grande was surveyed in a separate intensive study during 1999.

2.1 Location Description and History

The Upper Rio Grande (Part 1) watershed (US Geological Survey [USGS] Hydrologic Unit Codes [HUCs] 13020101 and 13010005) is located in north central NM. The entire Upper Rio Grande watershed encompasses approximately 7,500 square miles (mi^2) and extends over portions of seven counties including Rio Arriba, Taos, Santa Fe, Los Alamos, Sandoval, Mora, and San Miguel. The Upper Rio Grande (Part 1) includes the main stem of the Rio Grande between Pilar, NM, and the NM-Colorado (CO) border, as well as tributaries that enter the Rio Grande in that reach.

Several land grants were established along the Upper Rio Grande and its tributaries because water for domestic and irrigation purposes was necessary to the early settlers. The establishment of land grants also protected Upper Rio Grande towns and Spanish missions from attack by nomadic tribes (Westphall 1983). Because the archives of NM were destroyed during the Pueblo Revolt, little information is available regarding land grants prior to 1680 (Ebright 1994). The first recorded (lasting) land grant in the Taos Valley following the reconquest by Diego de Vargas in 1692 was to Captain Cristobal de la Serna (1715) for land in the Ranchos de Taos-Talpa area (Martinez 1968). Many of the Northern Pueblo lands became occupied by Spanish settlers following the reconquest by de Vargas. Spanish settlers moved to Taos Pueblo for safety from the Comanche Indians and other Plains tribes (Westphall 1983). Sixty-three families settled and built the Taos Plaza in 1797-98 under the Don Fernando de Taos Grant (Martinez 1968), and Taos became the center of the fur trade in the 17th century (Westphall 1983). Other Taos Valley grants included the Quijosa Grant (1715), Martinez or Godoi Grant (1716), Antoine Leroux Grant I (1742), Las Trampas Grant (1751), Rancho del Rio Grande Grant (1795), Don Fernando de Taos and Santa Barbara Grants (1796), and Arroyo Hondo Grant (1815). Nearly one-third of the 1.5-million acres of Taos county was contained in gifts or grants from either Spain or Mexico (Martinez 1968).

In an 1815 lawsuit, the Taos Pueblo petitioned the local alcalde (mayor) asking him to measure the land to which the Pueblo was entitled (Ebright 1994). Taos Pueblo and Picuris Pueblo were eventually recognized by the Mexican government and formally identified by surveys confirmed by the United States government in 1858 (Carlson 1975). During the last half of the 1800s, Spanish-Americans acquired much of the irrigable cropland within the eight Northern Pueblo

Indian Grants of the Upper Rio Grande Valley and received titles following hearings by the Pueblo Lands Board (Carlson 1975). Today, much of the Taos Valley is still used for agriculture (Figure 2.1).

The geology of the Upper Rio Grande watershed consists of a complex distribution of Precambrian metamorphic rocks, Paleozoic sedimentary rocks and Tertiary volcanics (Table 2.2, Figure 2.2). Smaller deposits of intrusives, ash flows and unaltered igneous rocks are also present. The Upper Rio Grande river bisects the two distinct geologic areas. The area west of the Rio Grande mainly consists of late Quaternary to Tertiary basalts formed as a result of the Rio Grande Rift tectonic events. The Tertiary volcanics (mainly basalt flows) are interbedded with sands and gravels, which were deposited during periods of erosion between volcanic events. The Rio Grande River has incised a deep canyon through these basalt flows, which extends from the CO border to Velarde. Immediately east of the Rio Grande recent alluvial deposits cover these basalt deposits. The source of this alluvial material is the Sangre de Cristo Mountains, which parallel the river in a north-south direction. The Sangre de Cristo mountains mainly consist of Precambrian metamorphic rocks (amphibolites, granite, gneiss, and mica schist) and granitic stocks. Dikes of rhyolite, monzonite porphyry, latite and andesite are also common. Not as common, but still notable, are the scattered deposits of Pennsylvanian sediments including conglomerates, sandstones, shales and limestones. This portion of the Sangre de Cristo range is highly mineralized and heavily mined, as a result.

Table 2.1 SWQB/NMED 2000 Upper Rio Grande (Part 1) Sampling Stations

Station	Latitude, decimal degrees	Longitude, decimal degrees	Elevation, feet	Station Location
1	36.981944	-106.074166	8,044	Los Pinos at USGS gage
2	36.962200	-106.156100	8,155	Los Pinos above NMDGF area at FS bridge
3	36.993611	-106.038333	8,036	Rio San Antionio at NM-CO border in Ortiz
4	36.857777	-106.129444	8,809	Rio San Antonio at FR 87 bridge
5	36.942222	-105.454444	8,150	Ute Creek above Costilla Creek at Hwy 196 in Amalia
6	36.831944	-105.318611	8,960	Costilla Creek below Comanche Creek
7	37.001111	-105.722222	7,485	Rio Grande at NM-CO border at USGS gage in CO
8	36.534444	-105.709444	6,545	Rio Grande below Rio Pueblo de Taos at USGS gage
9	36.000000	-105.415100	6,616	Rio Grande below Red River at Lama
10	36.418138	-105.342713	8,917	Rio Fernando de Taos at Hwy 64 bridge
11	36.779167	-105.275278	9,220	Comanche below upper exclosure
12	36.834166	-105.343611	8,900	Costilla Creek at Costilla-Vermejo boundary
13	36.897417	-105.260583	9,400	Casias Creek above Costilla Reservoir
14	36.338918	-105.729667	6,099	Rio Pueblo de Taos at Rio Grande
15	36.380380	-105.663770	6,665	Rio Pueblo de Taos 20m below Taos effluent channel
16	36.377222	-105.668611	6,670	Rio Pueblo de Taos 20m above Taos effluent channel
17	36.298939	-105.581830	7,270	Rio Grande del Rancho at USGS gage
18	36.276111	-105.576388	7,400	Rito de la Olla at bridge on Hwy 518
19	36.260706	-105.575417	7,498	Rio Grande del Rancho at Hwy 518 bridge
20	36.332200	-105.578600	7,223	Rio Chiquito at USGS gage
21	36.387777	-105.631388	6,730	Rio Grande del Rancho below Rio Chiquito
22	36.390000	-105.630555	6,730	Rio Pueblo de Taos near Los Cordovas
23	36.394875	-105.605471	6,818	Rio Fernando de Taos near Lower Ranchito
24	36.421000	-105.579700	8,051	Rio Lucero above Rio Pueblo de Taos
24a	36.508300	-105.530200	8,051	Rio Lucero at USGS gage on Taos Pueblo
25	36.375555	-105.549166	7,175	Rio Fernando de Taos at USGS gage
26	36.352500	-105.395100	7,162	San Cristobal Creek
27	36.398611	-105.609920	6,792	Rio Pueblo de Taos near Lower Ranchito
28	36.535833	-105.708333	7,000	Rio Hondo at Rio Grande confluence
29	36.534166	-105.710000	6,550	Rio Grande below Rio Hondo
30	36.541666	-105.556388	7,700	Rio Hondo 1.5 miles above Valdez
31	36.596000	-105.449000	9,899	North Fork Rio Hondo at Taos Ski Valley Parking Lot
32	36.831944	-105.318611	8,960	Comanche Creek at mouth on Rio Costilla
33	36.596388	-105.453611	9,343	Rio Hondo 50 feet above WWTP
34	36.847222	-105.380000	8,746	Latir Creek at Costilla Creek
35	36.864900	-105.449900	9,467	Cordova Creek 300 m upstream from Day Lodge
36	36.900278	-105.432500	8,588	Cordova Creek above Costilla Creek above Hwy 196
37	36.922777	-105.446944	8,180	Sanchez Creek above Costilla Creek
38	36.919166	-105.446388	8,190	Costilla Creek above Amalia at Hwy 196 culvert bridge
39	36.966666	-105.507500	7,950	Costilla Creek above Costilla at Hwy 196 bridge
40	36.831944	-105.318611	8,960	Costilla Creek above Comanche

Table 2.2 Geologic Unit Definitions for the Upper Rio Grande (Part 1)

Geologic Unit Code	Definition
IP	Pennsylvanian (age) rocks
J	Jurassic rocks, Middle and Upper, undivided
J_{sr}	San Rafael Group; consists of Entrada Sandstone, Todilto and Summerville Formations
K	Cretaceous rocks, undivided
K_d	Dakota Sandstone; includes Oak Canyon, Cubero, and Paguate Tongues plus Clay Mesa Tongue of Mancos Shale
K_{kf}	Kirtland and Fruitland Formations; coal-bearing, coal primarily in the Fruitland; Campanian to Maastrichtian
K_m	Mancos Shale; divided into Upper and Lower parts by Gallup Sandstone
MD	Mississippian and Devonian rocks, undivided; includes the Lake Valley Limestone
MD_pc	Mississippian and Devonian rocks, undivided; includes the Lake Valley Limestone; Precambrian
pC	Precambrian
P_c	Castile Formation; dominantly anhydrite sequence; Upper Permian
P_d	Permian (age), unknown formation
P_g	Glorieta Sandstone; texturally and mineralogically mature, high-silica quartz sandstone
PIP	Combination of Permian and Pennsylvanian (age) rock units
Q_{ab}	Alluvium; upper and middle Quaternary; Basalt and andesite flows and locally vent deposits
Q_{al}	Alluvium; upper and middle Quaternary
Q_b	Quaternary Basalt and andesite flows and locally vent deposits
QT_b	Basaltic and andesitic volcanics interbedded with Pleistocene and Pliocene sedimentary units
QT_p	Older piedmont alluvial deposits and shallow basin fill
QT_s	Upper Santa Fe Group
SOC	Silurian through Cambrian rocks, undivided
T_{bb}	Tertiary Basalt
T_{ca}	Carson conglomerate
TK	Combination of Tertiary and Cretaceous (age) rock units
TK_i	Paleogene and Upper Cretaceous intrusive rocks
T_p	Tertiary pediment deposit
T_{pi}	Tertiary (age) pyroclastic and intrusive rocks (volcanic rocks of varying compositions)
TR	Triassic rocks, general
T_{sa}	Tertiary (age), unknown formation
T_v	Middle Tertiary volcanic rocks, undifferentiated

Figure 2.1 SWQB/NMED 2000 Upper Rio Grande (Part 1) Sampling Stations

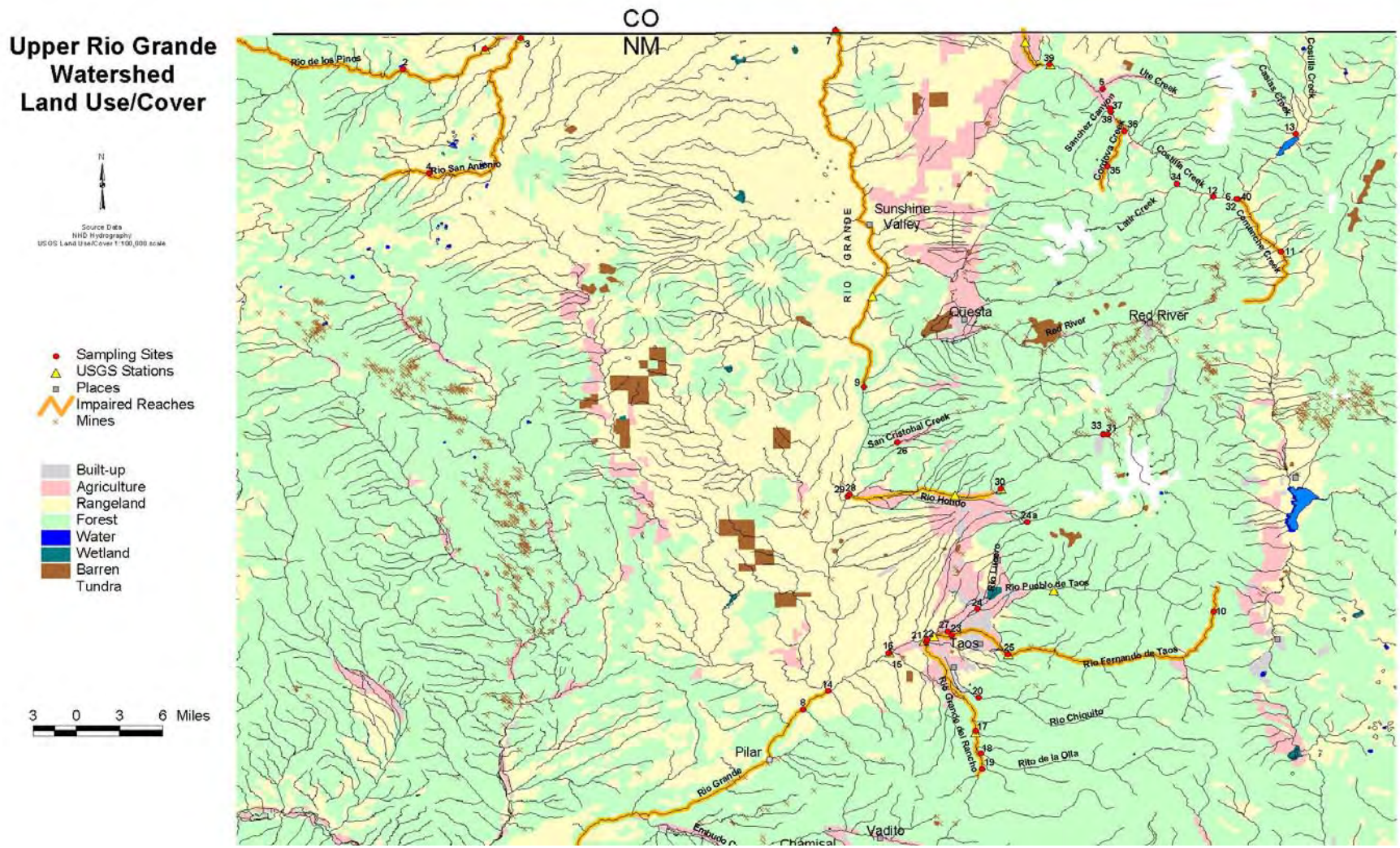
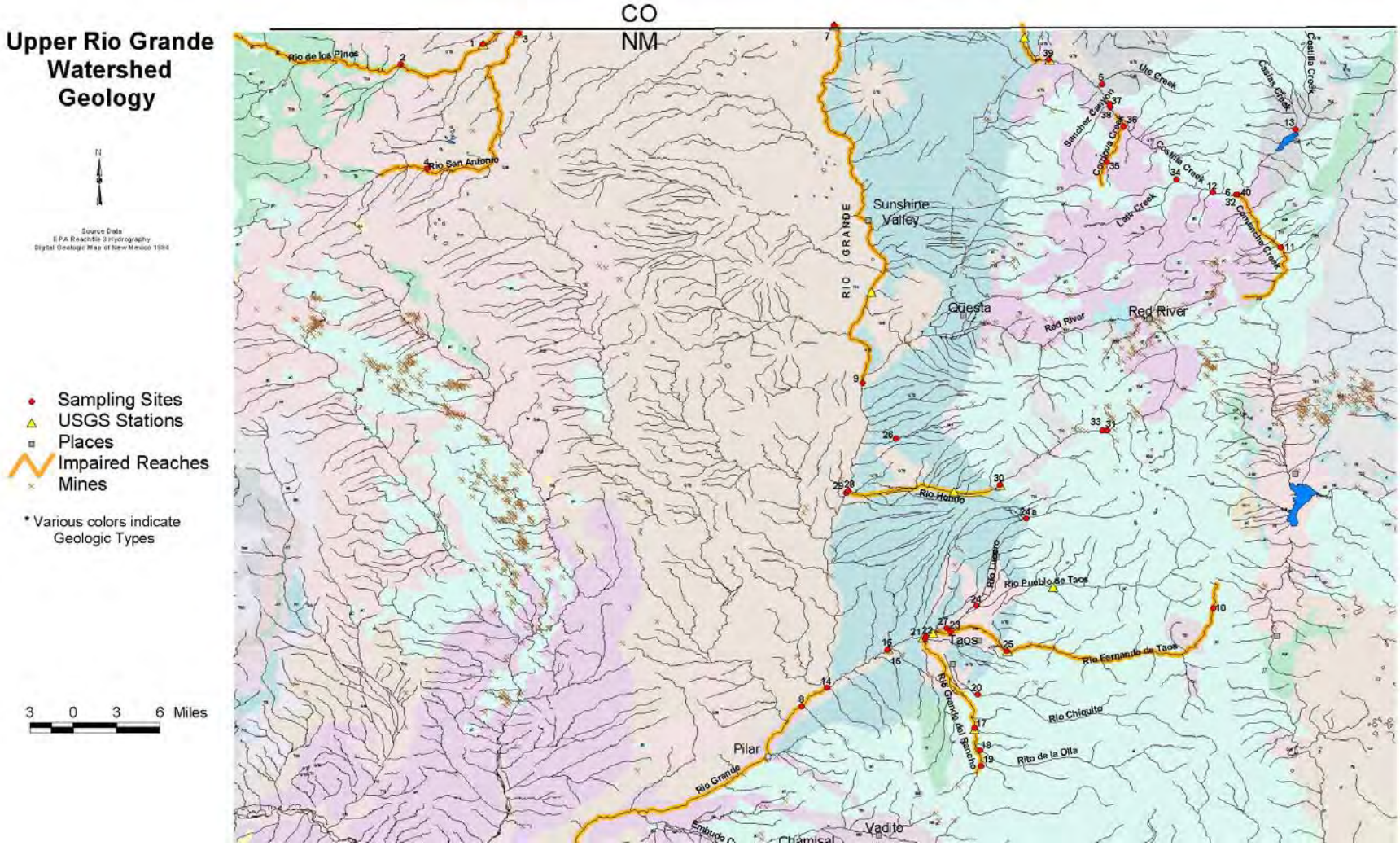


Figure 2.2 Upper Rio Grande (Part 1) Geology



2.2 Water Quality Standards

Water quality standards (WQS) for all assessment units in this document are set forth in sections 20.6.4.12, 20.6.4.122, 20.6.4.123, and 20.6.4.900 of the 2002 NM Standards for Interstate and Intrastate Surface Waters (NM Administrative Code [NMAC] 20.6.4). NMAC 20.6.4.122 reads as follows:

> **RIO GRANDE BASIN**-The main stem of the Rio Grande from Taos Junction bridge upstream to the NM-CO line, the Red river from its mouth on the Rio Grande upstream to the mout of Placer creek, and the Rio Pueblo de Taos from its mouth on the Rio Grande upstream to the mouth of the Rio Grande del Rancho.
>
> **A. Designated Uses**: coldwater fishery, fish culture, irrigation, livestock watering, wildlife habitat, and primary contact.
>
> **B. Standards**:
>
> (1) In any single sample: pH shall be within the range of 6.6 to 8.8, temperature shall not exceed 20 degrees Celcius (^{o}C) (68 degrees Farenheit [^{o}F]), and turbidity shall not exceed 50 Nephelometric Turbidity Units (NTU). The use-specific numeric standards set forth in 20.6.4.900 NMAC are applicable to the designated uses listed above in Subsection A of this section.
>
> (2) The monthly geometric mean of fecal coliform bacteria shall not exceed 100/100 milliliters (mL); no single sample shall exceed 200/100 mL (see Subsection B of 20.6.4.13 NMAC).

NMAC 20.6.4.123 reads as follows:

> **RIO GRANDE BASIN**-The Red river upstream of the mouth of Placer creek, all tributaries to the Red river, and all other perennial reaches of tributaries to the Rio Grande in Taos and Rio Arriba counties unless included in other segments.
>
> **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[2] shall not exceed 400 micromhos (μmhos) (500 μmhos for the Rio Fernando de Taos), pH shall be within the range of 6.6 to 8.8, temperature shall not exceed 20°C (68°F), and turbidity shall not exceed 25 NTU. The use-specific numeric standards set forth in 20.6.4.900 NMAC are applicable to the 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).

[2] The current water quality standards erroneously refer to "conductivity" when the intention was "specific conductance." Specific conductance means conductivity adjusted to 25 degrees C. SWQB proposed changing all references from conductivity to specific conductance at the recent (February 2004) trienniel review hearing. This proposal is expected to be accepted by the WQCC and EPA. Therefore, the term specific conductance is used throughout this TMDL document.

NMAC 20.6.4.900 provides standards applicable to attainable or designated uses unless otherwise specified in 20.6.4.101 through 20.6.4.899. NMAC 20.6.4.12 lists general standards that apply to all surface waters of the state at all times, unless a specified standard is provided elsewhere in NMAC.

2.3 Intensive Water Quality Sampling

The Upper Rio Grande (Part 1) watershed was intensively sampled by the SWQB/NMED in 2000. A brief summary of the survey and the hydrologic conditions during the sampling events is provided in the following subsections.

2.3.1 Survey Design

Water quality samples were collected during three seasons (spring, summer, and fall) in 2000. Temperature data were collected in 2000 and again in 2002 because some data collected during the 2000 survey were lost. Follow-up monitoring for temperature was completed in July to September, 2003. Surface water quality monitoring stations were selected to characterize water quality of the stream reaches. Table 2.1 and Figure 2.1 present the SWQB water quality monitoring station locations sampled in 2000. Figure 2.3 shows thermograph locations from the follow-up monitoring for temperature in 2003. Stations were located to evaluate the impact of tributary streams and to determine ambient water quality conditions. The results of the survey were summarized in a water quality survey report (SWQB/NMED 2000a).

All temperature, chemical/physical, and stream bottom deposits (SBD) sampling and assessment techniques are detailed in the *Quality Assurance Project Plan* (QAPP, SWQB/NMED 2000b). As a result of the 2000 monitoring effort and subsequent assessment of results, several exceedences of NM WQS for several streams were documented. Accordingly, these impairments were added to NM's 2002-2004 CWA §303 (d) list (SWQB/NMED 2002).

2.3.2 Hydrologic Conditions

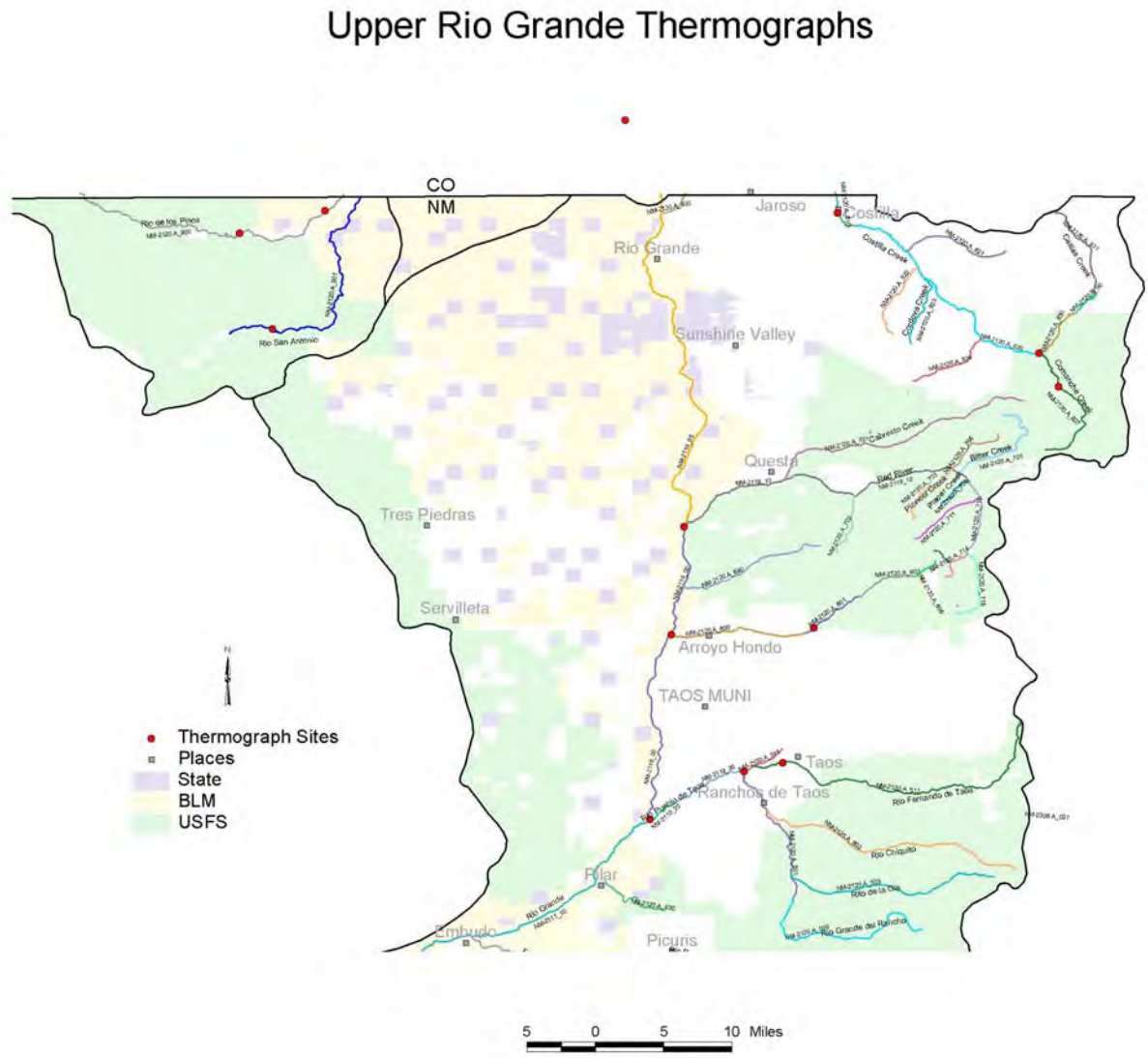
Stream discharge, measured by SWQB/NMED staff in spring, summer, and/or fall at thirteen stations, is summarized in Table 2.3.

Table 2.3 Stream Discharge Measured or Estimated by SWQB/NMED (2000), Upper Rio Grande (Part 1)

Station	May 16-17 Discharge (cfs)	July 16-17 Discharge (cfs)	Jul 31–Aug 1 Discharge (cfs)
4 (Rio San Antonio)	11.3[(a)]	2.5[(a)]	0[(b)]
5 (Ute Creek above Costilla Creek @ Hwy 196 in Amalia)	<1.0[(b)]	0.1[(b)]	<0.25[(b)]
10 (Rio Fernando de Taos)	0.27[(a)]	0.1[(b)]	0.1[(b)]
12 (Costilla Creek @ Costilla-Vermejo boundary)	113	3.84	111.5
14 (Rio Pueblo de Taos)	12.7[(a)]	7.3	4.1[(a)]
17 (Rio Grande del Rancho)	27.3	3.6[(a)]	3.25
19 (Rio Grande del Rancho)	15.1[(a)]	1.9[(a)]	1.3[(a)]
22 (Rio Pueblo de Taos)	3.7[(a)]	2.9	0.98[(a)]
23 (Rio Fernando de Taos)	1.6[(a)]	0.36[(a)]	0.23[(a)]
25 (Rio Fernando de Taos)	3.7[(a)]	0.29[(a)]	0.38[(a)]
26 (San Cristobal Creek)	<1.0[(b)]	0.26[(a)]	0.304[(a)]
27 (Rio Pueblo de Taos)	2.1	1.6[(a)]	1.2[(a)]
28 (Rio Hondo)	7.7	8.6	7.5[(a)]
31 (North Fork Rio Hondo)	4.5[(b)]	2.6[(a)]	1.0[(a)]
32 (Comanche Creek)	5.4[(a)]	1.4[(a)]	1.6[(a)]
33 (Rio Hondo)	18.2	5.0	5.1[(a)]
34 (Latir Creek @ Costilla Creek)	9.45[(a)]	2.08[(a)]	3.38[(a)]
36 (Cordova Creek above Costilla Creek @ Hwy 196)	<1.0[(b)]	<0.1[(b)]	<0.25[(b)]

Notes:
[(a)] Estimated flow (fewer than 20 measurements across the channel)
[(b)] Visual estimation (no measurements)
cfs = Cubic feet per second

Figure 2.3 Upper Rio Grande (Part 1) Thermograph Locations (2003)



There are also 14 USGS gaging stations in the Upper Rio Grande (Part 1) watershed (Table 2.4), nine of which are active. USGS gage locations are presented in Figure 2.1. Minimum, mean, and maximum stream flows for the periods of record at these stations are also provided in Table 2.4. Daily streamflows for active USGS gages are presented graphically in Figures 2.4 through 2.11 for the 2000 calendar year. Gage data are not provided for Rio Grande del Rancho near Talpa, NM because all flows were estimated for the 2000 calendar year.

Streamflows at these gage locations during the spring (May 16 to May 17), summer (July 31 to August 2), and fall (October 17 to October 19) sampling events are as follows:

- Streamflow was 124 cubic feet per second (cfs) on May 16 and 126 cfs on May 17 on Costilla Creek near Costilla, NM (Figure 2.4). During the summer sampling event at this location, streamflows were 87 cfs (July 31), 97 cfs (August 1), and 100 cfs (August 2). During the fall sampling event, streamflows were 9.6 cfs (October 17), 9.3 cfs (October 18), and 8.6 cfs (October 19);

- Streamflow was 27 cfs on May 16 and 22 cfs on May 17 on Costilla Creek near Garcia, CO (Figure 2.5). During the summer sampling event, streamflows were less than 1 cfs (July 31) and zero cfs on August 1 and 2. During the fall sampling event, streamflow was 2.6 cfs (October 17). Data are unavailable for October 18 to 19 at this location;

- Streamflow was 167 cfs on May 16 and 149 cfs on May 17 on Los Pinos River near Ortiz, CO (Figure 2.6). During the summer sampling event, streamflows were 11 cfs, 12 cfs, and 11 cfs on July 31, August 1, and August 2, respectively. During the fall sampling event, streamflows were 16 cfs, 15 cfs, and 16 cfs on October 17 through October 19, respectively;

- Streamflow was 235 cfs on May 16 and 206 cfs on May 17 on Rio Grande near Cerro, NM (Figure 2.7). During the summer sampling event, streamflows were 61 cfs, 59 cfs, and 59 cfs on July 31, August 1, and August 2, respectively. During the fall sampling event, streamflows were 86 cfs, 81 cfs, and 77 cfs on October 17 through October 19, respectively;

- Streamflow was 30 cfs on May 16 and May 17 on Rio Hondo near Valdez, NM (Figure 2.8). During the summer sampling event, streamflows were 10 cfs, 9.8 cfs, and 9.5 cfs on July 31, August 1, and August 2, respectively. During the fall sampling event, streamflows were 12 cfs, 11 cfs, and 11 cfs on October 17 through October 19, respectively;

- Streamflow was 13 cfs on May 16 and May 17 on Rio Pueblo de Taos below Los Cordovas, NM (Figure 2.9). During the summer sampling event, streamflows were 4.4 cfs, 3.9 cfs, and 3.8 cfs on July 31, August 1, and August 2, respectively. During the fall sampling event, streamflows were 9.7 cfs, 9.1 cfs, and 9.9 cfs on October 17 through October 19, respectively;

- Streamflow was 16 cfs on May 16 and May 17 on Rio Pueblo de Taos near Taos, NM (Figure 2.10). During the summer sampling event, streamflows were 5.0 cfs, 4.7 cfs, and 4.6 cfs on July 31, August 1, and August 2, respectively. During the fall sampling event, streamflow was 4.7 cfs on October 17 through October 19;

- Streamflows were 9.7 cfs and 9.1 cfs, respectively, on May 16 and May 17 on San Antonio River at Ortiz, CO (Figure 2.11). During the summer sampling event (July 31, August 1, and August 2), streamflow was zero cfs. During the fall sampling event, streamflows were 1.9 cfs, 2.0 cfs, and 2.2 cfs on October 17 through October 19, respectively.

Table 2.4 USGS Upper Rio Grande (Part 1) Gage Stations

Station	Latitude, decimal degrees	Longitude, decimal degrees	Elevation, feet	Mininum Annual Flow, cfs	Maximum Annual Flow, cfs	Mean Annual Flow[a], cfs	Station Location (Period of Record)
08255500	36.966944	105.506389	7,900	16	87	44.7	Costilla Creek near Costilla, NM (1936 – 2002)
08261000	36.989167	105.531667	7,758	0	444	15.3	Costilla Creek near Garcia, CO (1965 – 2002)
08248000	36.982222	106.073056	8,040	18	231	118	Los Pinos River near Ortiz, CO (1915 – 2002)
08275000	36.375556	105.548611	7,140	1.1	20	5.11	Rio Fernando de Taos near Taos, NM (1963 – 1980)
08252000	37.000833	105.721944	7,390	78	858	345	Rio Grande at CO-NM State Line (1953 – 1982)
08275500	36.297777	105.581944	7,238	5.4	45	20.9	Rio Grande del Rancho near Talpa, NM (1952 – 2002)
08263500	36.734722	105.684722	7,110	121	1,238	461	Rio Grande near Cerro, NM (1948 – 2002)
08268200	36.535278	105601944	7,254	14	36	24.8	Rio Hondo at Damsi at Valdez, NM (1963 – 1966)
08267500	36.541667	105.555833	7,650	13	72	35.4	Rio Hondo near Valdez, NM (1934 – 2002)
08276000	36.388889	105.633333	6,709	14	197	59.0	Rio Pueblo de Taos at Los Cordovas, NM (1910 – 1965)
08276300	36.377500	105.668056	6,652	12	194	64.6	Rio Pueblo de Taos below Los Cordovas, NM (1957 – 2002)
08275300	36.393889	105.623056	6,747	7.7	110	29.3	Rio Pueblo de Taos near Ranchito, NM (1957 – 1980)
08269000	36.439444	105.503056	7,380	7.0	73	29.2	Rio Pueblo de Taos near Taos, NM (1913 – 2002)
08247500	36.993056	106.038056	7,970	2.4	62	25.2	San Antonio River at Ortiz, CO (1919 – 2002)

Notes:
Shading identifies gages that are not currently active.
cfs = Cubic feet per second
[a]Unweighted average for period of record.

Figure 2.4 USGS Average Daily Streamflow, Costilla Creek near Costilla, NM (2000)

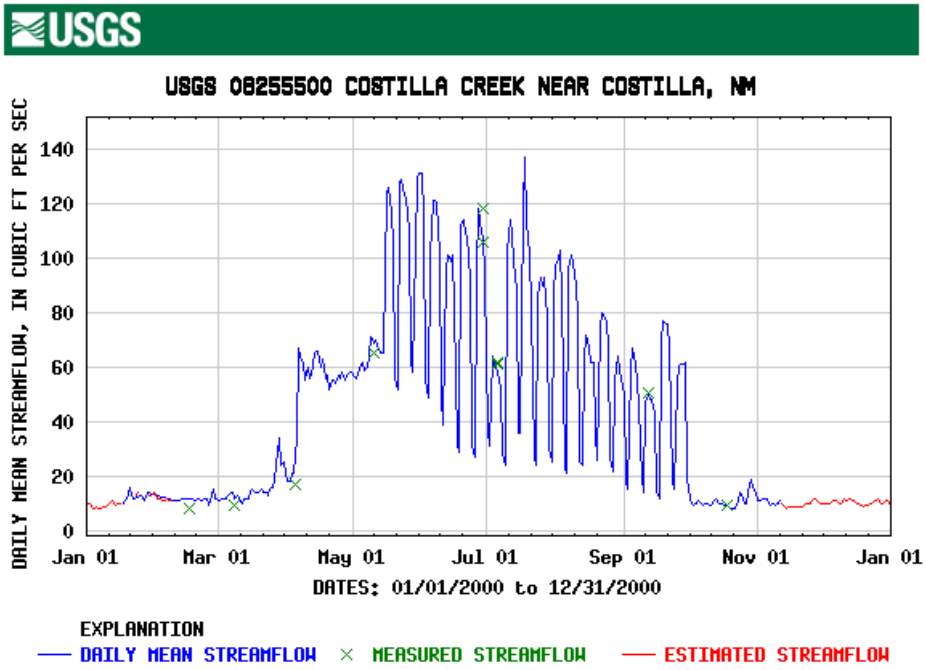


Figure 2.5 USGS Average Daily Streamflow, Costilla Creek near Garcia, CO (2000)

Figure 2.6 USGS Average Daily Streamflow, Los Pinos River near Ortiz, CO (2000)

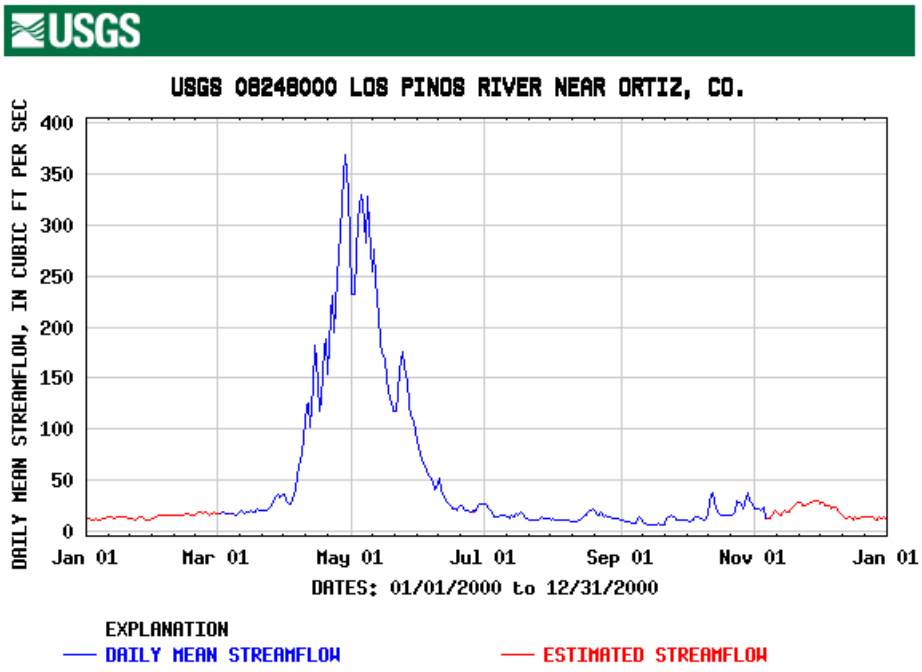


Figure 2.7 USGS Average Daily Streamflow, Rio Grande near Cerro, NM (2000)

Figure 2.8 USGS Average Daily Streamflow, Rio Hondo near Valdez, NM (2000)

Figure 2.9 USGS Average Daily Streamflow, Rio Pueblo de Taos below Los Cordovas, NM (2000)

Figure 2.10 USGS Average Daily Streamflow, Rio Pueblo de Taos near Taos, NM (2000)

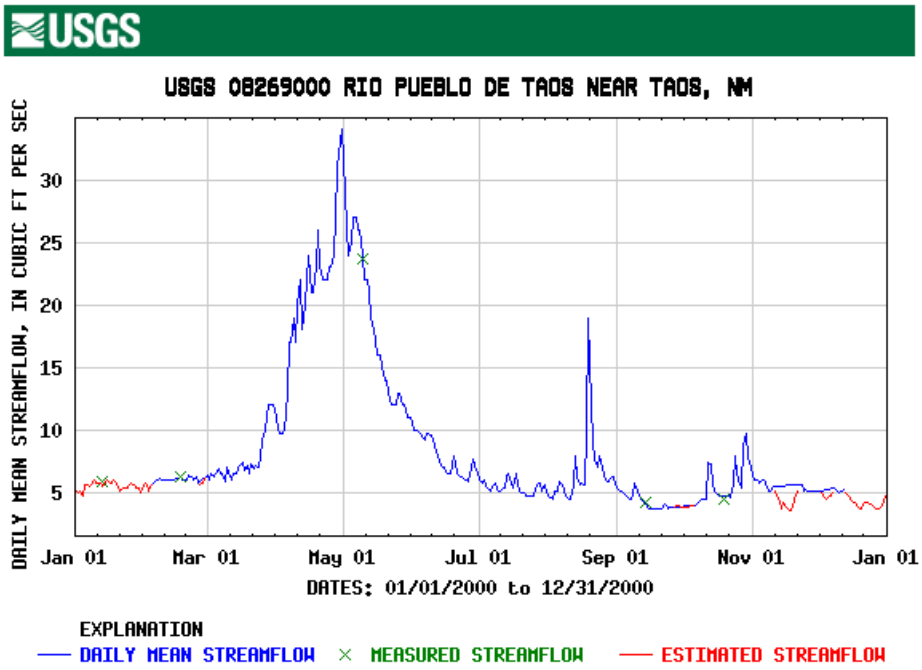
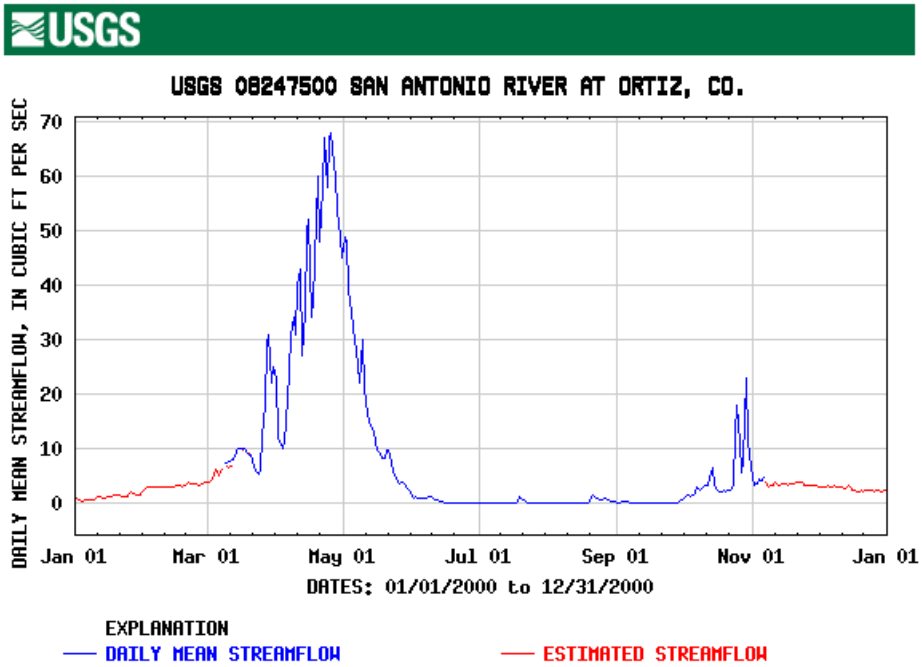


Figure 2.11 USGS Average Daily Streamflow, San Antonio River at Ortiz, CO (2000)



3.0 INDIVIDUAL WATERSHED DESCRIPTIONS

TMDLs were developed for each assessment unit for which constituent (or pollutant) concentrations measured during the 2000 water quality survey indicated impairment. Because characteristics of each watershed, such as geology, land use, and land ownership provide insight into probable sources of impairment, they are presented in this section for the individual watersheds within the Upper Rio Grande (Part 1) basin. In addition, the sampling stations established for the 2000 intensive water quality survey are presented in detail, and the 2002-2004 §303(d) listings within the Upper Rio Grande (Part 1) river/stream reaches are discussed.

3.1 Rio Costilla

Rio Costilla (Costilla Creek) originates in CO in the Sangre de Christo range and flows into NM and then back into CO. Costilla Creek then flows back into NM where it joins the Rio Grande just south of the state line. Approximately 33 miles of the Rio Costilla are within the NM border. Water only flows to the Rio Grande occasionally because of diversions in the two states and the high loss rate in the stream channel (Vandiver 1999). The Valle Vidal Wildlife Management Unit is a 100,000 acre parcel of wilderness below the Costilla reservoir dam. Costilla Creek watershed is approximately 230 mi^2 and includes Cordova Creek, Casias Creek, Latir Creek, Ute Creek, Sanchez Creek, and Comanche Creek tributaries. As presented in Figure 3.1, land ownership is 72% private and 28% U.S. Forest Service (USFS). Land use includes 80% forest, 14% rangeland, 4% barren tundra, 2% agriculture, and less than 1% built-up land (Figure 3.2).

The geology of the Costilla Creek watershed consists of a complex distribution of Precambrian metamorphic rocks, and Tertiary volcanics. Smaller deposits of intrusives, ash flows, and unaltered igneous rocks are also present. Costilla Creek bisects two distinct geologic areas. The area south of the CO-NM State line mainly consists of Precambrian igneous and metamorphic rocks of the Sangre de Cristo Range. Metamorphic rocks in this area mainly consist of amphibolites, granite gneiss, and mica schist. The less abundant igneous rocks consist of granitic stocks. The upper portions of the watershed are also highly faulted as a result of Rio Grande Rift tectonics. Tertiary volcanics are the predominant rock type in the lower portions of the watershed, north of the state line. These volcanics consist of basalt flows that are interbedded with sands and gravels, which were deposited during periods of erosion between volcanic events. Varying thicknesses of alluvial material cover much of these basalt flows, especially near the base of the Sangre de Cristos.

Thirteen sampling stations were established in the Costilla Creek watershed during the 2000 survey (Table 2.1, Figure 3.1). Surface water grab samples from all of the above stations were analyzed for a variety of chemical/physical parameters. The chemical data were collected, assessed, and summarized in a water quality survey report (SWQB/NMED 2000a). Data results from grab sampling have been uploaded to USEPA's STORET database. Costilla Creek (Diversion above Costilla to Comanche Creek) was included on the 2002-2004 CWA §303(d) list for temperature and requires a TMDL. Violations of the temperature criterion in Comanche Creek (Costilla Creek to Little Costilla Creek) were also observed based on 2002 monitoring

data. No TMDLs have previously been completed for Costilla Creek or Comanche Creek. Cordova Creek (Costilla Creek to headwaters) was included on the 2002-2004 §303(d) list for SBD (NMED/SWQB 2002); however, a TMDL for SBD was previously completed for this assessment unit (SWQB/NMED 1999a). Therefore, TMDLs were developed for the following assessment units in the Rio Costilla watershed:

- ***Temperature***: Costilla Creek (Diversion above Costilla to Comanche Creek)
- ***Temperature***: Comanche Creek (Costilla Creek to Little Costilla Creek)

Photo 3.1 Rio Costilla at Colorado Border (downstream) – May 2000

Photo 3.2 Comanche Creek above Rio Costilla - July 2003

Photo 3.3 Comanche Creek below Upper Exclosure – May 2000

Figure 3.1 Rio Costilla Land Ownership and Sampling Stations

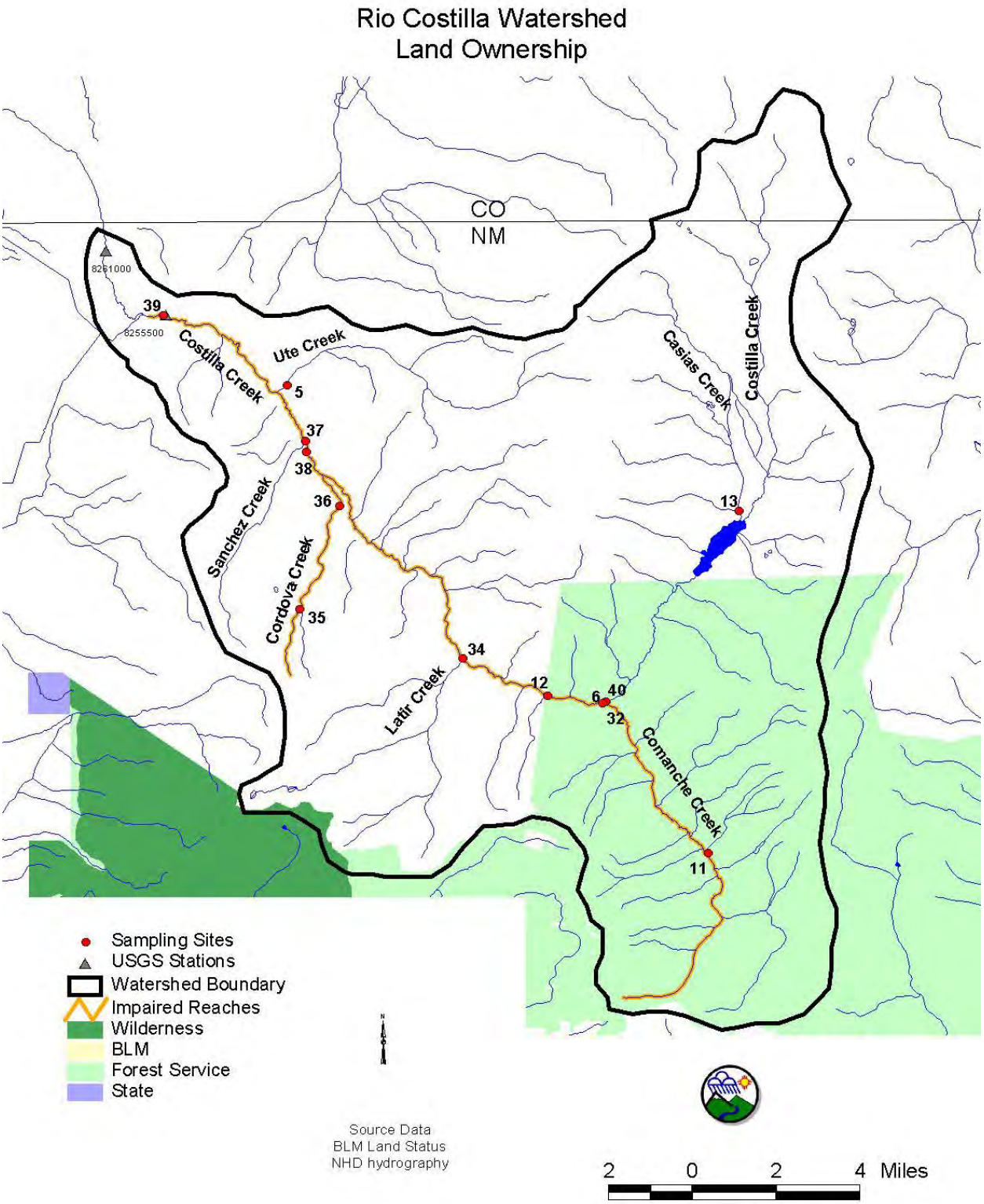
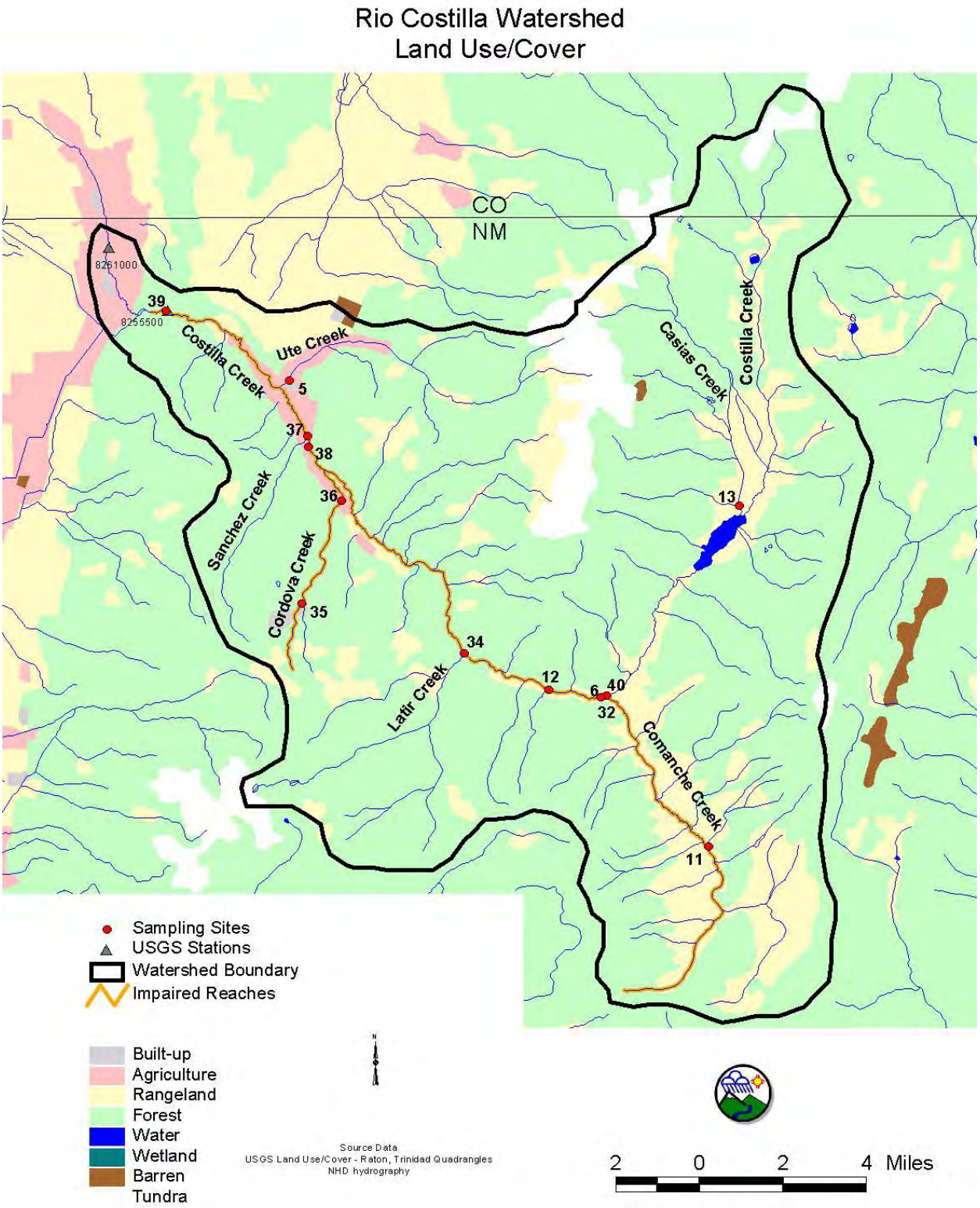


Figure 3.2 Rio Costilla Watershed Land Use and Sampling Stations



3.2 Rio de los Pinos and Rio San Antionio

The Rio de los Pinos originates in the San Juan Mountains in southern CO. The stream flows south and then east through NM for about 20 miles then crosses the CO border again near Ortiz, CO. The Rio de los Pinos watershed is approximately 160 mi^2. Approximately 28% of the Rio de los Pinos watershed lies within CO. As presented in Figure 3.3, land ownership in the Rio de los Pinos watershed is USFS (91%), Bureau of Land Management (BLM) (7%), and private (2%). As shown in Figure 3.4, land use in the Rio de los Pinos watershed is predominately forest (61%), rangeland (39%), agriculture (less than 1%), and built-up lands (less than 1%).

The geology of the Rio de los Pinos and Rio San Antonio watersheds consists primarily of Precambrian igneous and metamorphic rocks and Tertiary volcanics related to the Rio Grande Rift tectonic events. The Precambrian rocks, which are not abundant in the area, occur mainly near the headwaters of the watershed. These Precambrian rocks consist of gneiss, schist and amphibolite which are intruded by granite and aplite. Tertiatary-aged volcanic units are the next oldest rocks present. The oldest of the tertiary units consists of breccias, mudflows, tuffs and basaltic andesites. These units were derived, in part, from the erosion of older volcanic rocks. Small amounts of sandstone and conglomerate were deposited between volcanic events, and are interbedded throughout these units. Conglomerate clasts consist various volcanic rocks. These older Tertairy units are overlaid by three primary basalt flows. These flows create the cap-rock for many of the mesas in the area. The two youngest basalt flows are of varying thicknesses and lithologies and together make up the Hinsdale Volcanic Series. Quaternary deposits present in the watershed include stream, fan and talus deposits.

The Rio de los Pinos (NM reaches) is approximately 20.9 miles in length. Two sampling stations were established in the Rio de los Pinos watershed during the 2000 survey (Table 2.1, Figure 3.3). Surface water grab samples from all of the above stations were analyzed for a variety of chemical/physical parameters. The chemical data were collected, assessed, and summarized in a water quality survey report (SWQB/NMED 2000a). Data results from grab sampling have been uploaded to USEPA's STORET database. 2002 monitoring data for temperature at these locations indicate non-support for the temperature criterion of 20^oC. Rio de los Pinos was not listed for temperature in the 2002-2004 §303(d) list (NMED/SWQB 2002) because some temperature data from the 2000 monitoring were lost. Follow-up temperature monitoring was conducted in 2002 and 2003 for the purpose of developing TMDLs. The following TMDLs have been developed for the Rio de Los Pinos assessment unit:

- ***Temperature***: Rio de los Pinos (CO border to headwaters)

The Rio San Antonio headwaters are located in the Carson National Forest northwest of Tres Piedras and northeast of Tierra Amarilla, NM. Approximately 4% of the Rio San Antonio watershed lies within CO. Land ownership in the Rio San Antonio watershed is USFS (86%), BLM (12%), state land (1%), and private (1%). Land use in the Rio San Antonio watershed is rangeland (63%), forest (37%), agriculture (less than 1%), and built-up lands (less than 1%).

The Rio San Antonio (NM reaches) is approximately 19.1 miles in length. Two sampling stations were established in the Rio San Antonio watershed during the 2000 survey (Table 2.1,

Figure 3.3). Surface water grab samples from all of the above stations were analyzed for a variety of chemical/physical parameters. The chemical data were collected, assessed, and summarized in a water quality survey report (SWQB/NMED 2000a). Data results from grab sampling have been uploaded to USEPA's STORET database. 2002 monitoring data for temperature at these locations indicate non-support for the temperature criterion of 20°C. Rio San Antonio was not listed for temperature in the 2002-2004 §303(d) list (NMED/SWQB 2002) because some of the 2000 results for temperature were lost. Follow-up temperature monitoring was conducted in 2002 and 2003 for the purpose of developing TMDLs. The following TMDLs have been developed for the Rio San Antonio assessment unit:

- ***Temperature***: Rio San Antonio (Montoya Canyon to headwaters)

Photo 3.4 Rio de los Pinos at USFS Bridge – May 2000

Photo 3.5 Rio San Antonio near USGS Gage near Ortiz, CO – May 2000

Figure 3.3 Rio San Antonio/Rio de los Pinos Watersheds Land Ownership

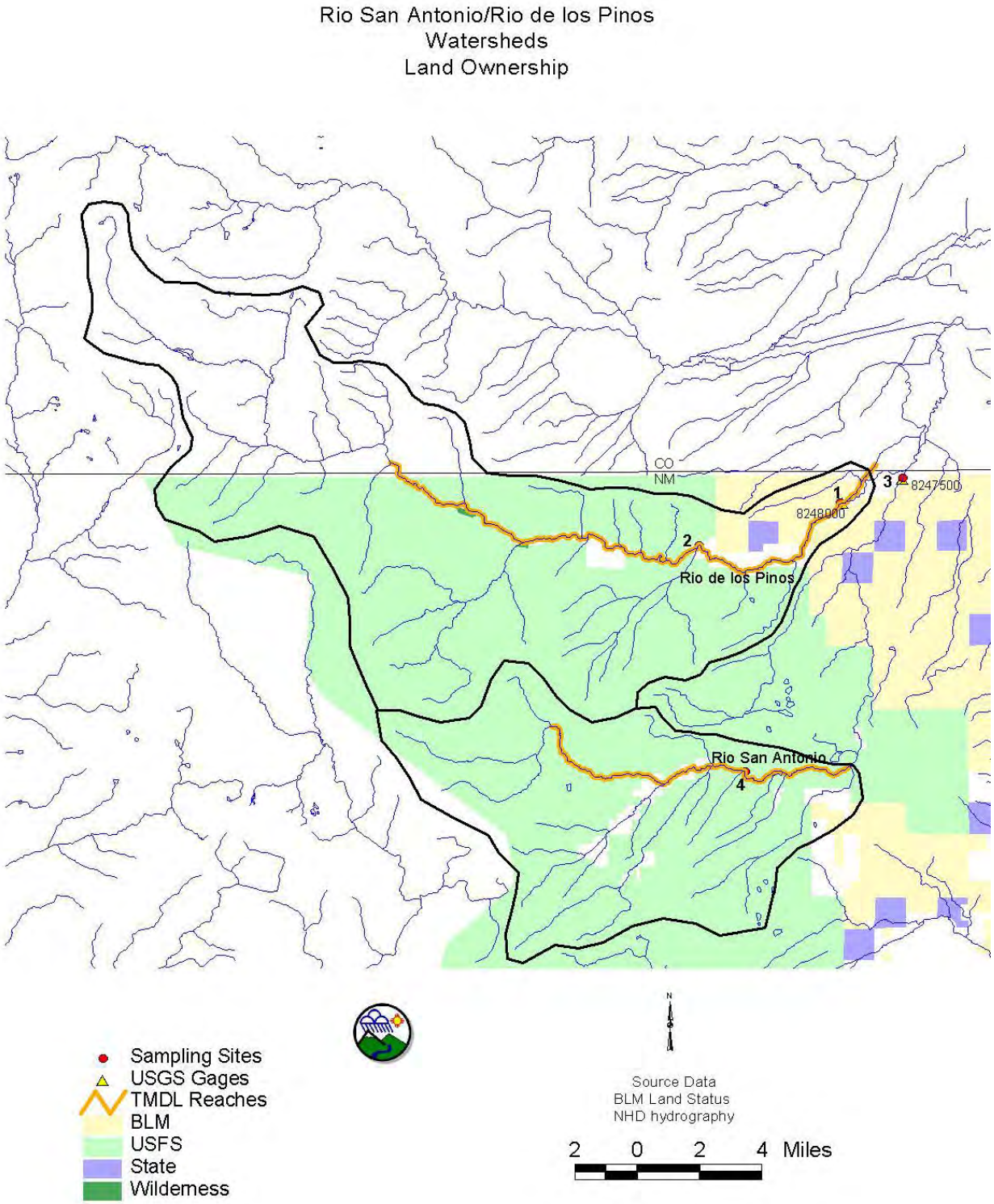
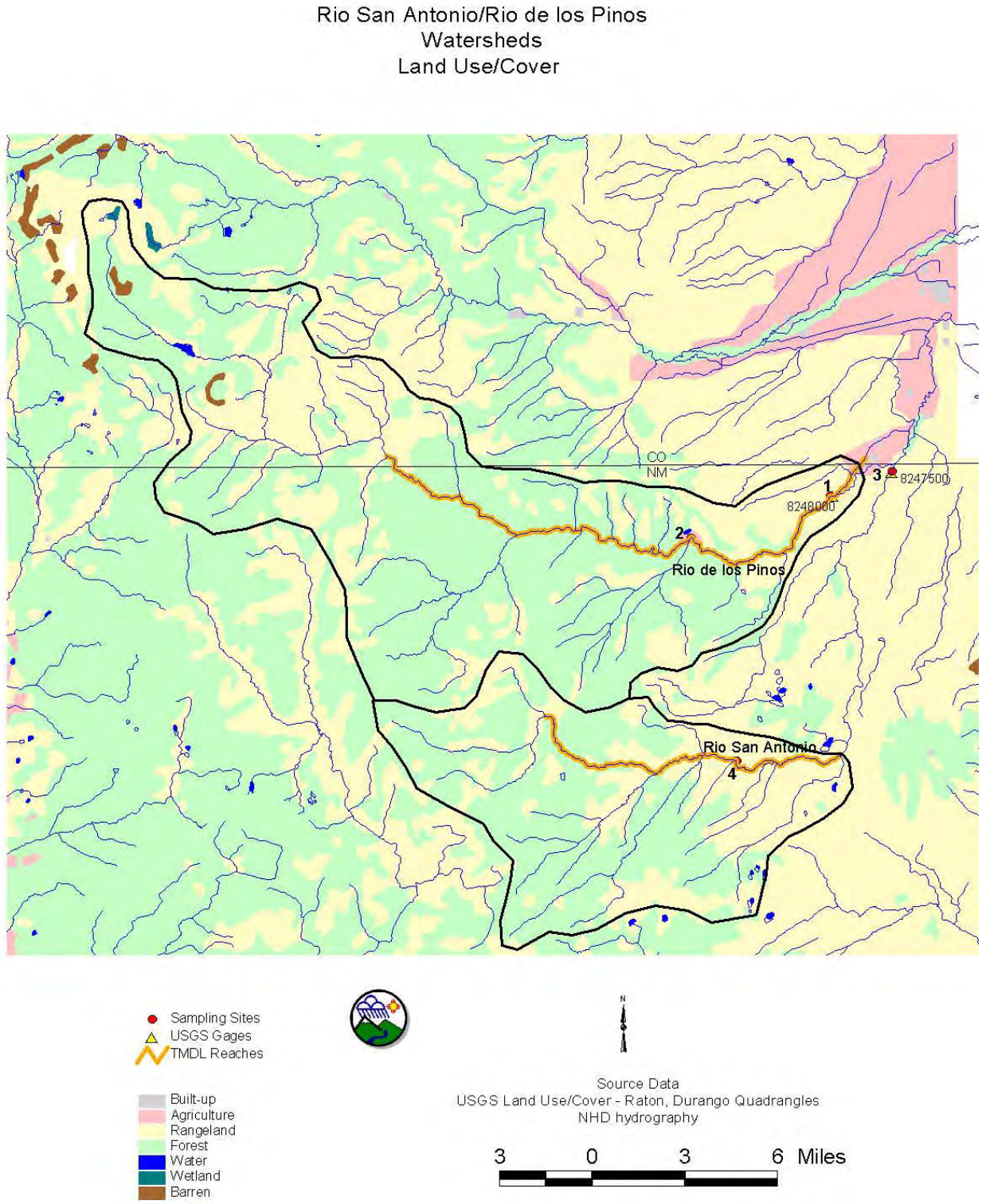


Figure 3.4 Rio de los Pinos and Rio San Antonio Watersheds Land Use and Sampling Stations



3.3 Upper Rio Grande

The Rio Grande originates at 12,000 feet above sea level in the San Juan Mountains west of Creede, CO. The Rio Grande and Red River of northern NM were among the original eight rivers designated by Congress as Wild and Scenic in 1968 (National Park Service [NPS] 2002). The Upper Rio Grande watershed is roughly 5,660 mi^2. As shown in Figure 3.5, land ownership is 32% private, 30% BLM, , 28% USFS, and 10% state land. Figure 3.6 presents the land use in this watershed, which is predominately forest (46%), rangeland (42%), agriculture (11%), barren tundra (1%), and built-up lands (less than 1%).

The geology of the Upper Rio Grande watershed consists of a complex distribution of Precambrian metamorphic rocks, Paleozoic sedimentary rocks and Tertiary volcanics (Table 2.2, Figure 2.2). Smaller deposits of intrusives, ash flows and unaltered igneous rocks are also present. The Upper Rio Grande river bisects the two distinct geologic areas. The area west of the Rio Grande mainly consists of late Quaternary to Tertiary basalts formed as a result of the Rio Grande Rift tectonic events. The Tertiary volcanics (mainly basalt flows) are interbedded with sands and gravels, which were deposited during periods of erosion between volcanic events. The Rio Grande River has incised a deep canyon through these basalt flows, which extends from the CO border to Velarde. Immediately east of the Rio Grande recent alluvial deposits cover these basalt deposits. The source of this alluvial material is the Sangre de Cristo Mountains, which parallel the river in a north-south direction. The Sangre de Cristo mountains mainly consist of Precambrian metamorphic rocks (amphibolites, granite, gneiss, and mica schist) and granitic stocks. Dikes of rhyolite, monzonite porphyry, latite and andesite are also common. Not as common, but still notable, are the scattered deposits of Pennsylvanian sediments including conglomerates, sandstones, shales and limestones. This portion of the Sangre de Cristo range is highly mineralized and heavily mined, as a result.

The Rio Grande from the Red River to the NM-CO border is approximately 27.75 miles in length and from the Rio Pueblo de Taos to Red River is approximately 23.35 miles in length. Four sampling stations were established in the Upper Rio Grande watershed during the 2000 survey (Table 2.1, Figure 3.5). Surface water grab samples from all of the above stations were analyzed for a variety of chemical/physical parameters. The chemical data were collected, assessed, and summarized in a water quality survey report (SWQB/NMED 2000a). Data results from grab sampling have been uploaded to USEPA's STORET database. The Red River subwatershed was excluded from the 2000 investigation, as that portion of the Upper Rio Grande was surveyed in a separate intensive study during 1999. Follow-up temperature monitoring was conducted in 2003 for the purpose of developing TMDLs. The following TMDLs were developed for this watershed:

Temperature: Rio Grande (CO border to headwaters);

Photo 3.6 Rio Grande above Red River – July 2003

Figure 3.5 Upper Rio Grande Watershed Land Ownership and Sampling Stations

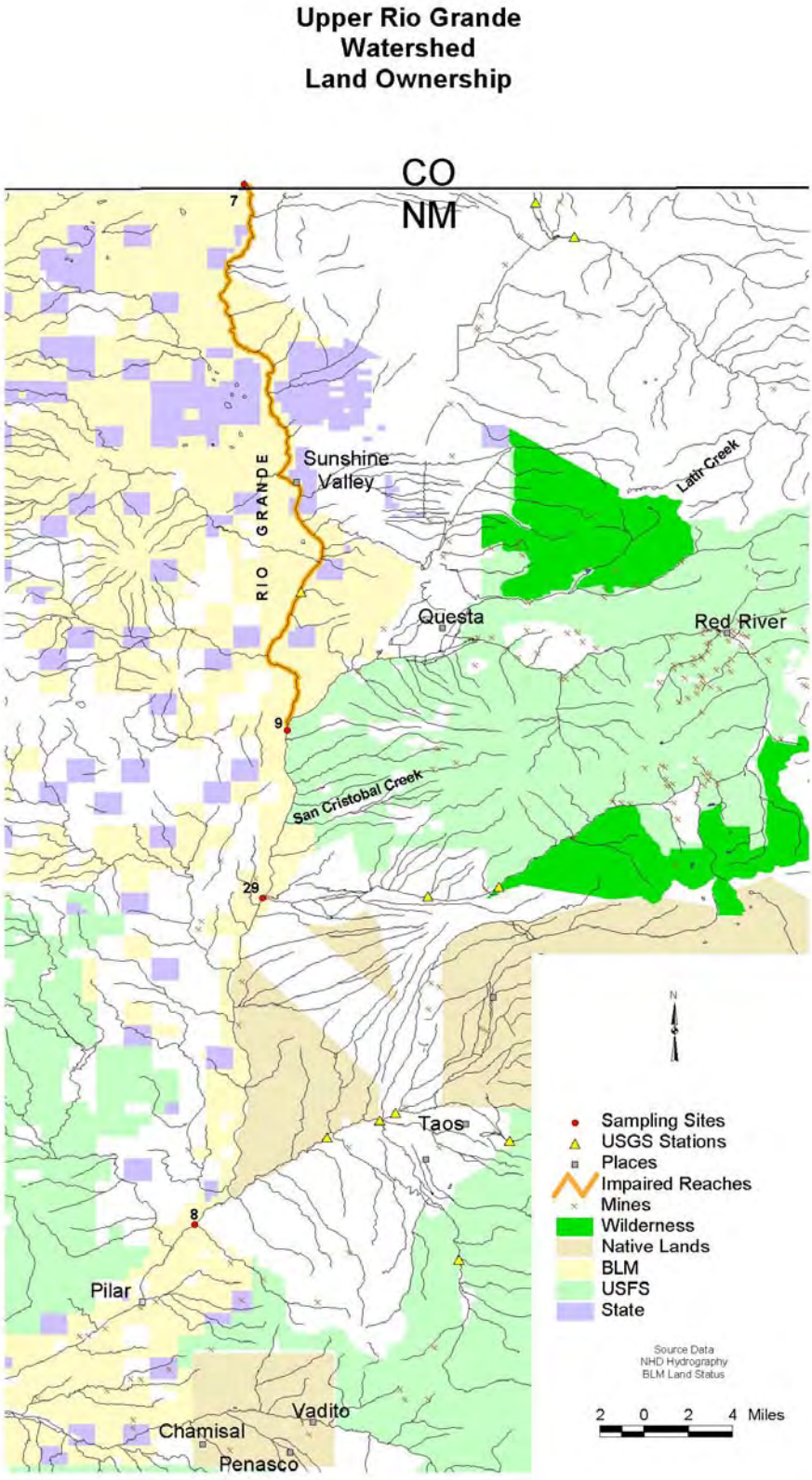
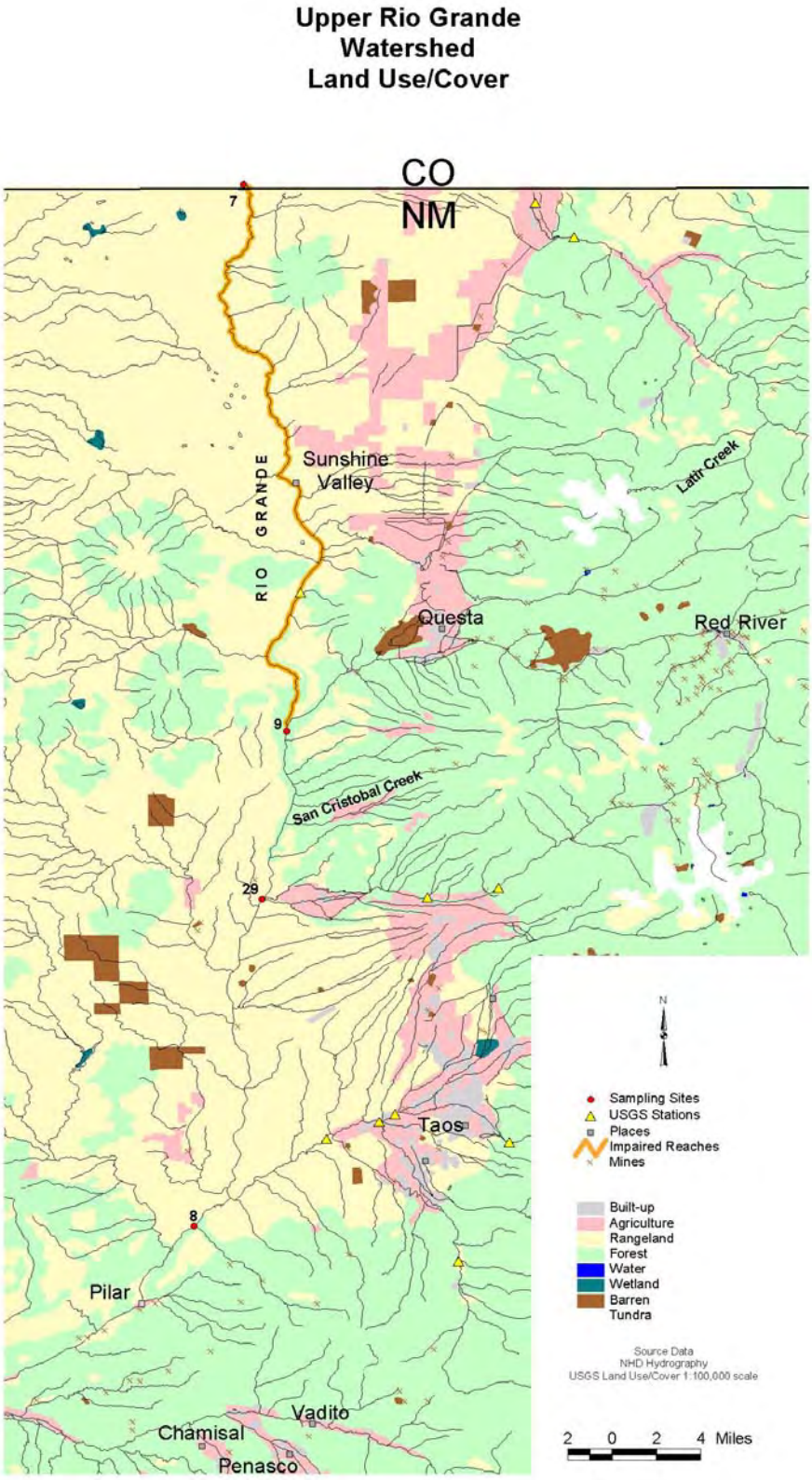


Figure 3.6 Upper Rio Grande Watershed Land Use and Sampling Stations



3.4 Rio Hondo

The Village of Taos Ski Valley is situated near the headwaters of the Rio Hondo in the Sangre de Cristo mountains of northern NM. The Rio Hondo watershed is roughly 72 mi^2. As shown in Figure 3.7, land ownership is 61% USFS, 38% private, and 1% tribal land. Figure 3.8 presents the land use in this watershed, which is predominately forest (78%), agriculture (10%), rangeland (7%), built-up lands (3%), and barren tundra (2%).

The geology of the Rio Hondo watershed consists of a complex distribution of Precambrian igneous and metamorphic rocks, Pennsylvanian sedimentary rocks, Tertiary intrusives. The lower portions of the watershed also contain Quaternary deposits including volcanics and various alluvial materials. The Rio Hondo bisects two distinct geologic areas. The area east of Valdez consists mainly of Precambrian metamorphic (schist, gneiss and quartzite) and igneous rocks (granite, andesite, porphyry). This area may also contain small deposits of Pennsylvanian sedimentary rocks including arkosic shales, sandstones and conglomerates. The area west of Valdez consists mainly of Quaternary alluvial materials (including stream, fan and glacial deposits) and basalt flows interbedded with sands and gravels, which were deposited during periods of erosion between volcanic events.

Rio Hondo from the Rio Grande to USFS boundary is approximately 8.5 miles in length. Four sampling stations were established in the Rio Hondo watershed during the 2000 survey (Table 2.1, Figure 3.7). Surface water grab samples from all of the above stations were analyzed for a variety of chemical/physical parameters. The chemical data were collected, assessed, and summarized in a water quality survey report (SWQB/NMED 2000a). Data results from grab sampling have been uploaded to USEPA's STORET database. Rio Hondo (Rio Grande to USFS boundary) was included on the 2002-2004 CWA §303(d) list for temperature. Field measurements for temperature from the 2000 survey indicate non-support for the temperature criterion of 20^oC. The following TMDLs were developed for this watershed:

Temperature: Rio Hondo (Rio Grande to US Forest Service boundary).

A TMDL for nutrients was previously completed for Rio Hondo (New Mexico Environmental Improvement Division [EID] 1981). SWQB is implemented a special study in 2004 to prepare for a revision of this nutrient TMDL because the Twinings WWTP is proposing to increase the amount of effluent discharged into the stream.

Photo 3.7 Rio Hondo at Taos Ski Valley – May 2000

Figure 3.7 Rio Hondo Watershed Land Ownership and Sampling Stations

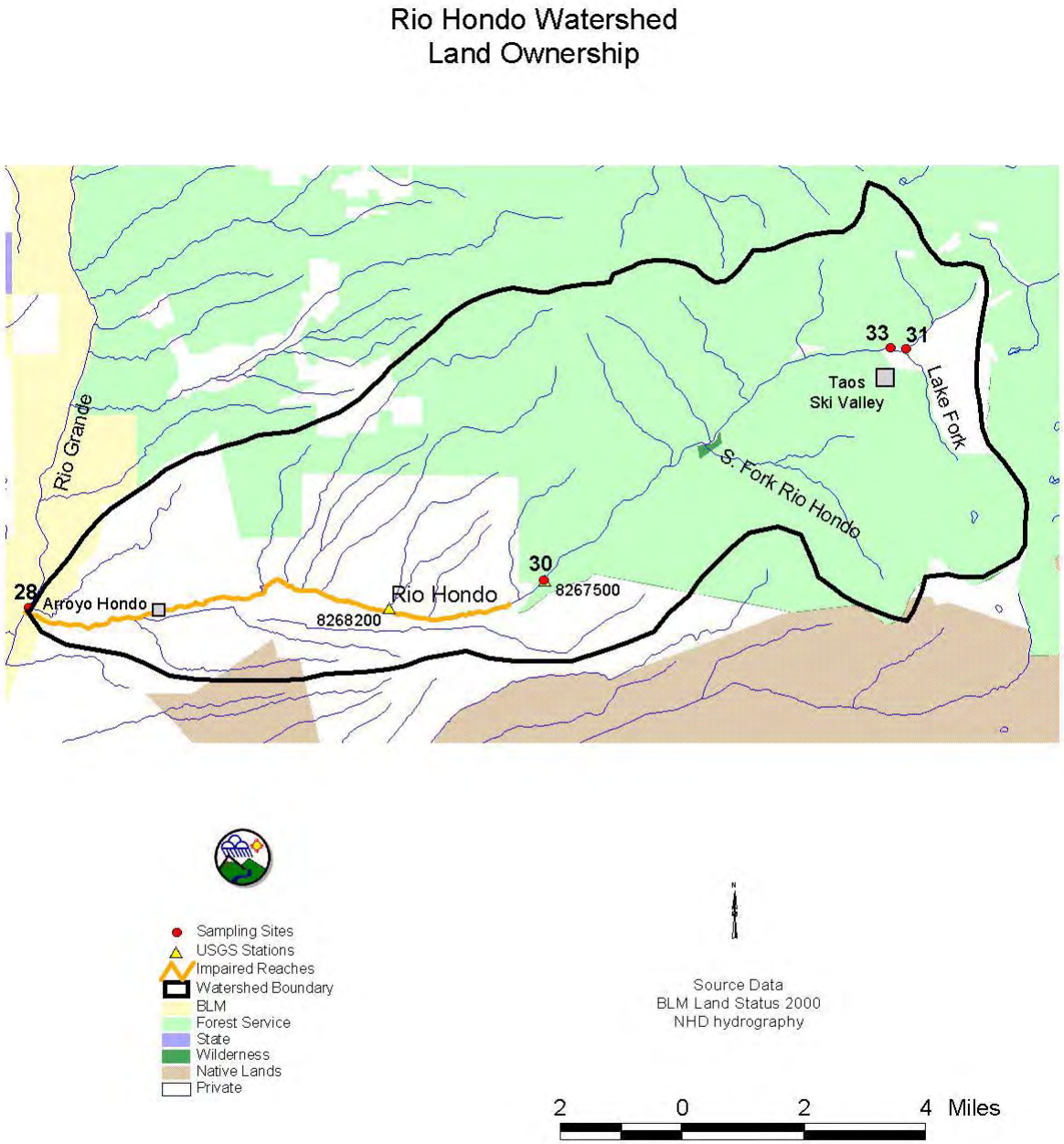
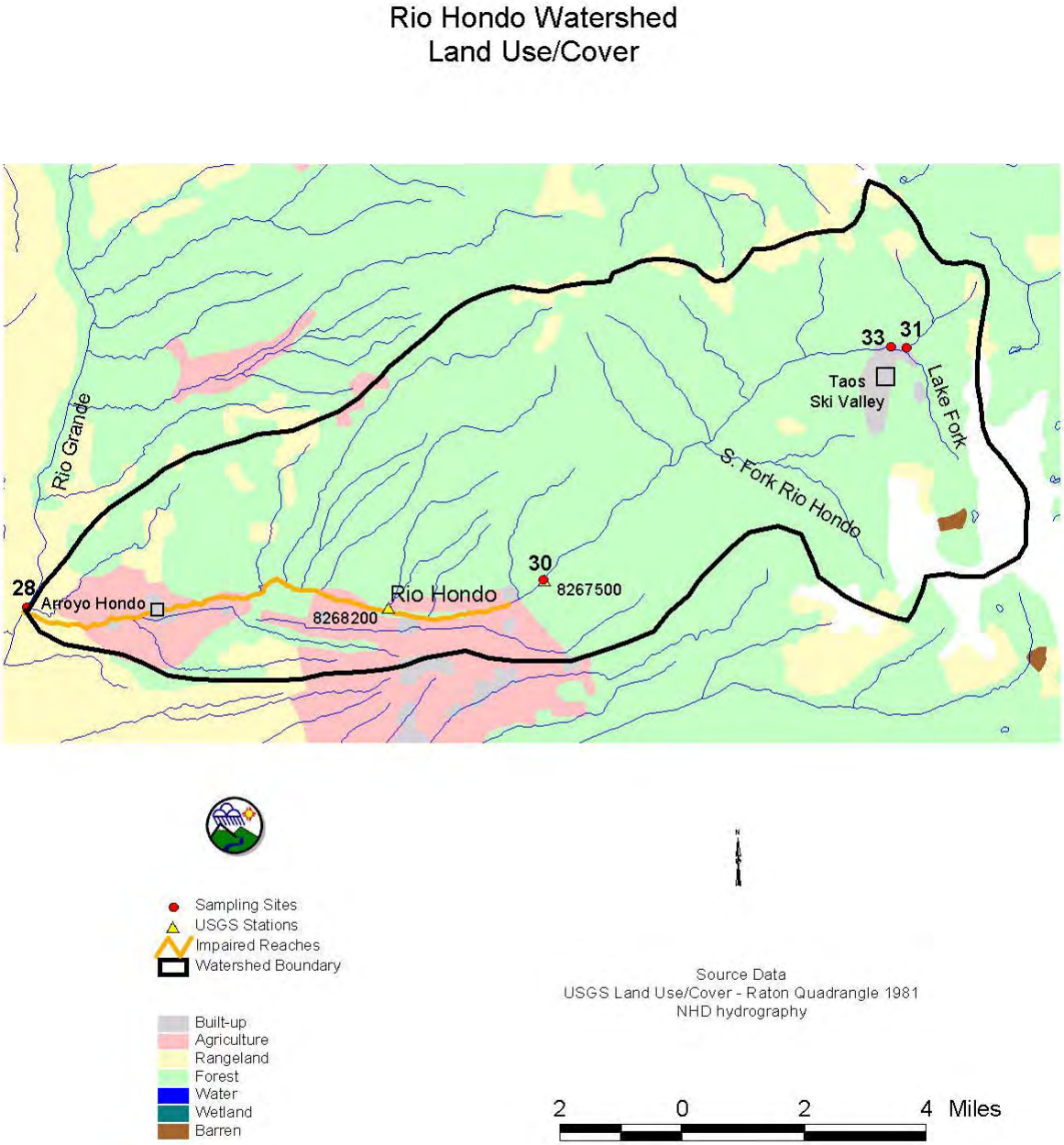


Figure 3.8 Rio Hondo Watershed Land Use and Sampling Stations



3.5 Rio Pueblo de Taos

The Rio Pueblo de Taos, which originates in the Sangre de Cristo mountains at Blue Lake, is used by the Taos Pueblo for irrigation and domestic purposes. There is currently one active National Pollution Discharge Elimination System (NPDES) permit on the Rio Pueblo de Taos issued to the Town of Taos (NM0024066).

The Rio Pueblo de Taos watershed is roughly 400 mi^2 and includes Rio Chiquito, Rito de la Olla, Rio Fernando de Taos, and Rio Grande del Rancho tributaries. As shown in Figure 3.9, land ownership is 56% tribal lands, 30% USFS, and 14% private land. Figure 3.10 presents the land use in this watershed, which is predominately forest (78%), agriculture (9%), rangeland (7%), built-up lands (5%), and barren tundra (1%). Fifteen sampling stations were established in the Rio Pueblo de Taos watershed during the 2000 survey (Table 2.1, Figure 3.9). Surface water grab samples from all of the above stations were analyzed for a variety of chemical/physical parameters. The chemical data were collected, assessed, and summarized in a water quality survey report (SWQB/NMED 2000a). Data results from grab sampling have been uploaded to USEPA's STORET database. Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho) was included on the 2002-2004 CWA §303(d) list for temperature and SBD. Rio Pueblo de Taos (Rio Grande del Rancho to headwaters) was included on the 2002-2004 CWA §303(d) list for temperature and specific conductance (SC). Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo) was included on the 2002-2004 CWA §303(d) list for temperature. Rio Fernando de Taos (Rio Pueblo de Taos to headwaters) was included on the 2002-2004 CWA §303(d) list for temperature and conductivity. Rio Grande del Rancho (Rio Pueblo de Taos to Hwy 518) was included on the 2002-2004 CWA §303(d) list for conductivity. The following TMDLs were developed for the Rio Pueblo de Taos watershed:

Temperature:	Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo)
	Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho)
	Rio Pueblo de Taos (Rio Grande del Rancho to headwaters)
	Rio Fernando de Taos (Rio Pueblo de Taos to headwaters)
SBD:	Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho)
Specific Conductance:	Rio Fernando de Taos (Rio Pueblo de Taos to headwaters)
	Rio Grande del Rancho (Rio Pueblo de Taos to Hwy 518)

Photo 3.8 Rio Pueblo de Taos below Taos WWTF – May 2000

Photo 3.9 Rio Pueblo de Taos near Los Cordovas, NM – May 2000

Photo 3.10 Rio Fernando de Taos at USGS Gage – May 2000

Photo 3.11 Rio Grande del Rancho at Highway 518 Bridge – May 2000

Figure 3.9 Rio Pueblo de Taos Land Ownership and Sampling Stations

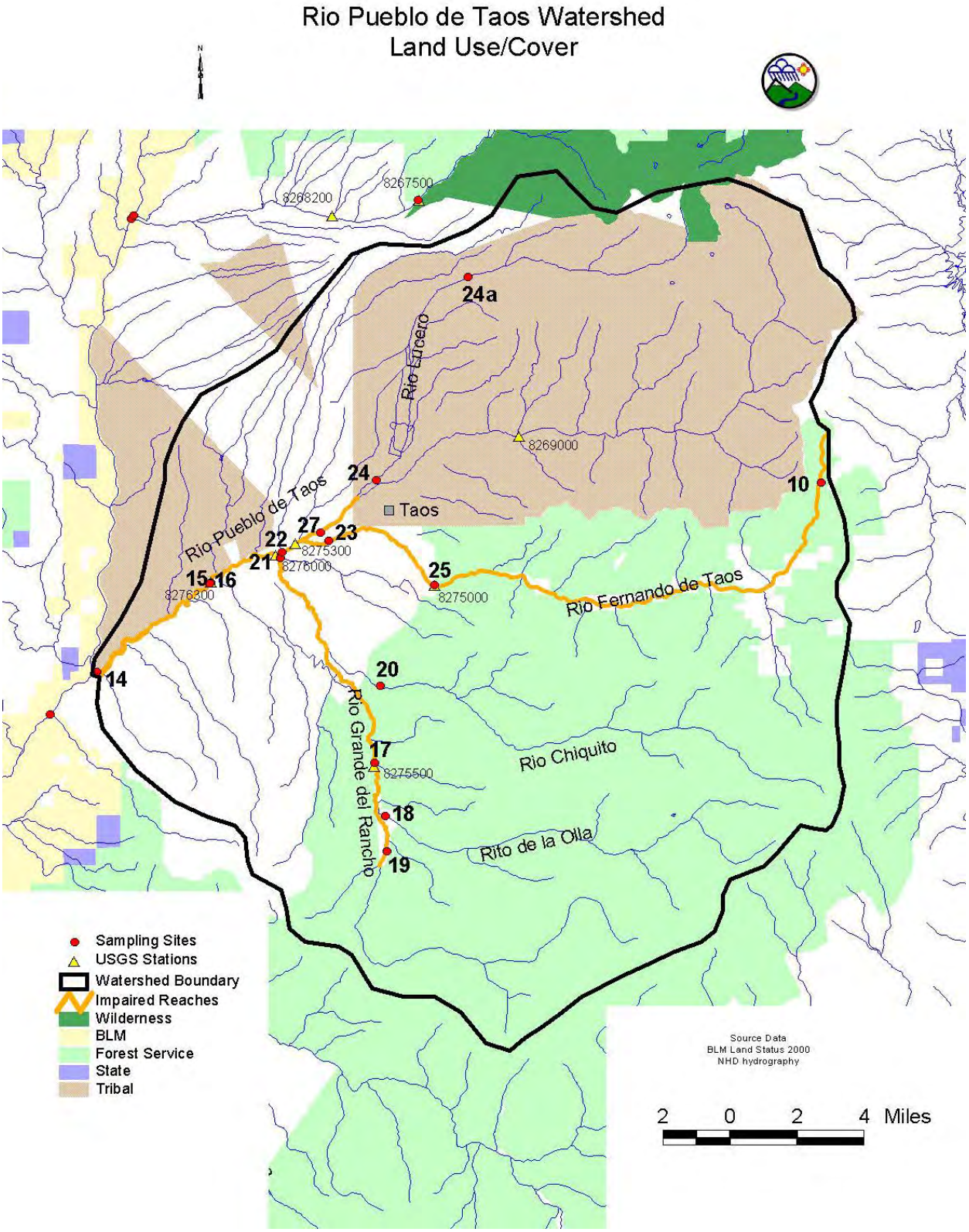
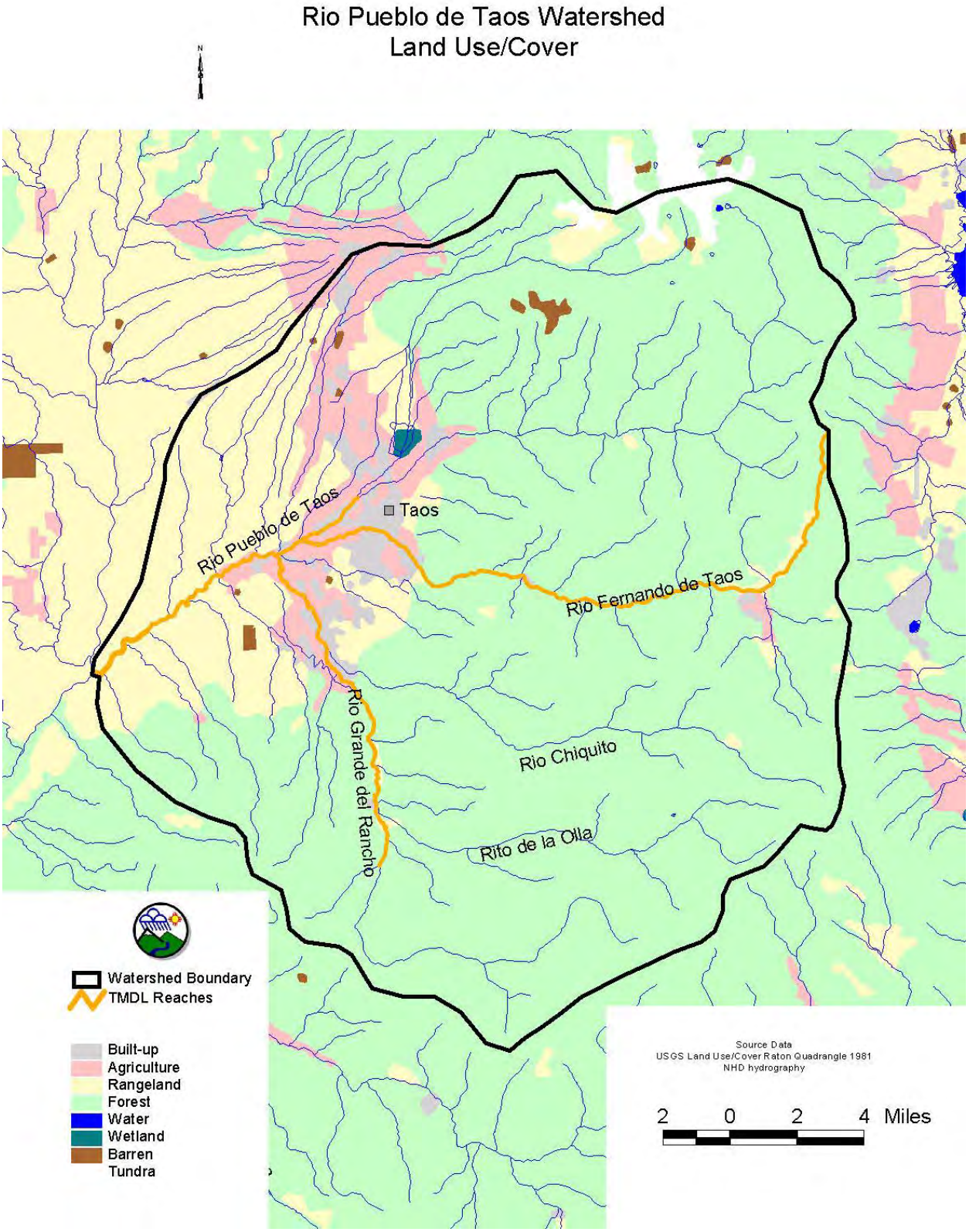


Figure 3.10 Rio Pueblo de Taos Land Use and Sampling Stations



4.0 SPECIFIC CONDUCTANCE

During the 2000 SWQB intensive water quality survey, exceedences of the NM water quality criteria for SC were documented in the following assessment units (20.6.4.123 NMAC):

- Rio Grande del Rancho (Rio Pueblo de Taos to Highway 518)
- Rio Fernando de Taos (Rio Pueblo de Taos to headwaters)

According to the NM WQS (20.6.4.123 NMAC), the standard for SC reads:

> *In any single sample: conductivity shall not exceed 400 µmhos (500 µmhos for the Rio Fernando de Taos). . .*

The following subsections present the SC TMDLs for these two assessment units.

4.1 Target Loading Capacity

Target values for these SC 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 SC are based on the reduction in total dissolved solids (TDS) necessary to achieve numeric SC criteria. This TMDL is also consistent with New Mexico's antidegradation policy.

The NM Water Quality Control Commission (WQCC) has adopted a numeric water quality criterion for SC to protect the designated use of High Quality Coldwater Fishery (HQCWF). The water quality criterion has been set at a level to protect coldwater aquatic life. The HQCWF use designation requires that a stream have water quality, streambed characteristics, and other attributes of habitat sufficient to protect and maintain a HQCWF. The primary standard leading to an assessment of use impairment is the numeric criteria for SC of 400 µmhos (500 µmhos for the Rio Fernando de Taos).

4.2 Flow

SC in a stream can vary as a function of flow. As flow decreases, the concentration of total dissolved solids (TDS) can increase, thereby increasing the SC. Similarly, as flows decline, temperatures have a tendency to increase, thus affecting SC values. These TMDLs are calculated for each reach at a specific flow.

The flow values used to calculate the TMDL for SC on these assessment units were obtained using a 4-day, 3-year low-flow frequency (4Q3) regression model. The 4Q3 is the annual lowest 4 consecutive day period discharge that will not fall below that discharge at least every 3 years (Waltemeyer 2002). Low flow was chosen as the critical flow because the exceedances of the SC standard occurred from May to October 2000.

The 4Q3 for Rio Grande del Rancho (Rio Pueblo de Taos to Highway 518) is based on USGS gage data. USGS gage at Rio Grande del Rancho near Talpa, NM (08275500) was used to estimate the 4Q3. The 4Q3 was estimated using a log Pearson Type III distribution through "*Input and Output for Watershed Data Management*" (IOWDM) software, Version 4.1 (USGS 2002a) and "*Surface-Water Statistics*" (SWSTAT) software, Version 4.1 (USGS 2002b). The 4Q3 is as follows:

- Rio Grande del Rancho (Rio Pueblo de Taos to Highway 518): 4Q3 = 3.051 cfs

The 4Q3 value for Rio Grande del Rancho was converted from cfs to units of million gallons per day (MGD) as follows:

$$3.051\,\frac{ft^3}{\sec} \times 1{,}728\,\frac{in^3}{ft^3} \times 0.004329\,\frac{gal}{in^3} \times 86{,}400\,\frac{\sec}{day} \times 10^{-6} = 1.97\,MGD$$

It is often necessary to calculate a critical flow for a portion of a watershed where there is no active flow gage as in Rio Fernando de Taos. 4Q3 derivations for ungaged streams were based on analysis methods described by Waltemeyer (2002). In this analysis, two regression equations for estimating 4Q3 were developed based on physiographic regions of NM (i.e., statewide and mountainous regions above 7,500 feet in elevation). The following statewide regression equation is based on data from 50 gaging stations with non-zero discharge (Waltemeyer 2002):

$$4Q3 \quad = \quad 1.2856 \times 10^{-4}\ DA^{0.42}\ P_w^{\ 3.16} \qquad \text{(Eq. 1)}$$

where,

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

The average standard error of estimate (SEE) and coefficient of determination are 126 and 48 percent, respectively, for this regression equation (Waltemeyer 2002). The following regression equation for mountainous regions above 7,500 feet in elevation is based on data from 40 gaging stations with non-zero discharge (Waltemeyer 2002):

$$4Q3 \quad = \quad 7.3287 \times 10^{-5}\ DA^{0.70}\ P_w^{\ 3.58}\ S^{1.35} \qquad \text{(Eq. 2)}$$

where,

S = Average basin slope (percent)

The average SEE and coefficient of determination are 94 and 66 percent, respectively, for this regression equation (Waltemeyer 2002). The 4Q3 for Rio Fernando de Taos was estimated using

the regression equation for mountainous regions (above 7,500 feet in elevation) because the mean elevation for the assessment unit is 7,640 feet in elevation (based on measurements from three stations).

Equation 2 above was used to estimate the 4Q3. Based on an average basin winter mean precipitation of 9.3 inches, drainage area of 67.914 mi^2, and slope of 0.268, the 4Q3 is:

$$4Q3 \quad = \quad 7.3287 \times 10^{-5} \times 67.914^{0.42} \times 9.3^{3.58} \times 0.268^{1.35} = 0.214\,cfs$$

The 4Q3 value for Rio Fernando de Taos was converted from cfs to units of MGD as follows:

$$0.214\,\frac{ft^3}{\sec} \times 1{,}728\,\frac{in^3}{ft^3} \times 0.004329\,\frac{gal}{in^3} \times 86{,}400\,\frac{\sec}{day} \times 10^{-6} = 0.0425\,MGD$$

It is important to remember that the TMDL itself is a value calculated at a defined critical condition, and is calculated as part of planning process designed to achieve water quality standards. Since flows vary throughout the year in these systems, the actual load at any given time will vary based on the changing flow. Management of the load to improve stream water quality should be a goal to be attained. Meeting the calculated TMDL may be a difficult objective.

4.3 Calculations

SC (SC) may be used to estimate the total ion concentration of a surface water sample, and is often used as an alternative measure of dissolved solids. In order to calculate a load in pounds per day (lb/day), TDS is used as a surrogate for SC. The TDS to SC ratio ranges from 0.5 to 0.9 milligrams per liter (mg/L)/microhos per centimeter (µmhos/cm) (American Public Health Association [APHA] 1998). Specific correlation should be derived by site, if TDS values are available.

TDS values were obtained for these assessment units during the 2000 SWQB/NMED sampling season. These values as well as the SC values are located on Table 4.6 at the end of this section. The TDS to SC ratio values were calculated, and averaged, resulting in TDS:SC ratios of

- Rio Grande del Rancho (Rio Pueblo de Taos to Highway 518): TDS:SC = 0.69
- Rio Fernando de Taos (Rio Pueblo de Taos to headwaters): TDS:SC = 0.74

State WQS to protect the designated HQCWF use states that SC shall not exceed 400µmhos/cm (500 µmhos for the Rio Fernando de Taos). Using the above mentioned reference ratios to estimate the TDS required to achieve State WQS,

$$\text{TDS (mg/L)} \cong \text{SC (µmhos/cm)} \times \text{(ratio)} \qquad \text{(Eq. 3)}$$

The SC to achieve state standards is 400 µmhos/cm (500 µmhos for the Rio Fernando de Taos). Using **Equation 3**, the TDS concentration required to achieve State standards is:

- Rio Grande del Rancho (Rio Pueblo de Taos to Highway 518):

$$400\ \mu\text{mhos/cm} \times (0.67) \cong 268\ \text{mg/L of TDS}$$

- Rio Fernando de Taos (Rio Pueblo de Taos to headwaters):

$$500\ \mu\text{mhos/cm} \times (0.74) \cong 370\ \text{mg/L of TDS}$$

For the purpose of TMDL development, these TDS criteria were used. The TMDLs were developed based on simple dilution calculations using 4Q3 flow and the TDS criteria above (from **Equation 3**). The TMDL calculation includes WLAs, LAs, and a MOS.

Target loads for TDS are calculated based on the 4Q3 flow, the current WQS, and a conversion factor of 8.34, that is used to convert mg/L units to lb/day (see **Appendix A** for conversion factor derivation).

Critical Flow (MGD) x Standard (mg/L) x 8.34 = Target Loading Capacity (Eq. 4)

The target loads (TMDLs) predicted to attain standards were calculated using **Equation 4** and are shown in Table 4.1.

Table 4.1 Calculation of Target Loads

Location	**Flow[(a)] (MGD)**	**Standard[(b)] TDS (mg/L)**	**Conversion Factor[(c)]**	**Target Load Capacity (lb/day)**
Rio Grande del Rancho	1.97	268	8.34	4,403
Rio Fernando de Taos	0.0425	370	8.34	131

Notes:
[(a)] Flow is the 4Q3 value calculated on the previous pages converted from cfs to million gallons per day.
[(b)] TDS is used as a surrogate measure for SC in order to calculate a load in lb/day.
[(c)] Conversion factor used to convert mg/L to lb/day (See **Appendix A**).
MGD = Million gallons per day
mg/L = Milligrams per liter
lb/day = Pounds per day

Background loads were not possible to calculate in this watershed. A reference reach, having similar stream channel morphology and flow, was not found. It is assumed that all or a portion of the LA is made up of natural background loads. In future water quality surveys, finding a suitable reference reach will be a priority.

The measured loads were also calculated using **Equation 4**. In order to achieve comparability between the target and measured loads, the flow rate used was the same for both calculations. The same conversion factor of 8.34 was used. Results are presented in Table 4.2.

Table 4.2 Calculation of Measured Loads

Location	Flow[(a)] (MGD)	Field TDS (mg/L) [(b)]	Conversion Factor[(c)]	Measured Load (lb/day)
Rio Grande del Rancho	1.97	428	8.34	7,032
Rio Fernando de Taos	0.0425	493	8.34	175

Notes:
[(a)] Flow is the 4Q3 value calculated on the previous pages converted from cfs to million gallons per day.
[(b)] The field measurement is the arithmetic mean of the SC exceedances, converted to TDS (see Table 4.6).
[(c)] Conversion factor used to convert mg/L to lb/day (See **Appendix A**).
MGD = Million gallons per day
mg/L = Milligrams per liter
lb/day = Pounds per day

4.4 Waste Load Allocations and Load Allocations

4.4.1 Waste Load Allocation

There are no individually permitted point source facilities or MS4 storm water permits in these assessment units. TDS may be a component of some (primarily construction) storm water discharges so these discharges should be addressed.

In contrast to discharges from other industrial storm water and individual process wastewater permitted facilities, storm water discharges from construction activities are transient because they occur mainly during the construction itself, and then only during storm events. Coverage under the NPDES construction general storm water permit (CGP) requires preparation of a Storm Water Pollution Prevention Plan (SWPPP) that includes identification and control of all pollutants associated with the construction activities to minimize impacts to water quality. In addition, the current CGP also includes state specific requirements to implement best management practices that are designed to prevent to the maximum extent practicable, an increase in sediment, or a parameter that addresses sediment (e.g., total suspended solids, turbidity, siltation, stream bottom deposits, etc.) and flow velocity during and after construction compared to pre-construction conditions. In this case, compliance with a SWPPP that meets the requirements of the CGP is generally assumed to be consistent with this TMDL.

Other industrial storm water facilities are generally covered under the current NPDES Multi Sector General Storm Water Permit (MSGP). This permit also requires preparation of an SWPPP that includes identification and control of all pollutants associated with the industrial activities to minimize impacts to water quality. In addition, the current MSGP also includes state specific requirements to further limit (or eliminate) pollutant loading to water quality impaired/water quality limited waters from facilities where there is a reasonable potential to contain pollutants for which the receiving water is impaired. In this case, compliance with a

SWPPP that meets the requirements of the MSGP is generally assumed to be consistent with this TMDL.

Individual waste load allocations for the General Permits were not possible to calculate at this time in this watershed using available tools. Loads that are in compliance with the General Permits from facilities covered are therefore currently calculated as part of the watershed load allocation.

4.4.2 Load Allocation

In order to calculate the LA, the WLA and MOS were subtracted from the target capacity (TMDL), as shown below in **Equation 5**.

$$WLA + LA + MOS = TMDL \qquad \text{(Eq. 5)}$$

Results using a MOS of 15% (as explained in Section 4.7), are presented in Table 4.3.

Table 4.3 Calculation of TMDL for TDS (SC Surrogate)

Location	WLA (lb/day)	LA (lb/day)	MOS (15%) (lb/day)	TMDL (Target Load Capacity) (lb/day)
Rio Grande del Rancho	0	3,743	660	4,403
Rio Fernando de Taos	0	111	20	131

Notes:
WLA = Waste load allocation
LA = Load allocation
MOS = Margin of safety
TMDL = Total maximum daily load
lb/day = Pounds per day

The load reduction that would be necessary to meet the target load was calculated to be the difference between the LA (Table 4.3) and the measured load (Table 4.2), and is shown in Table 4.4.

Table 4.4 Calculation of Load Reduction for TDS (SC Surrogate)

Location	LA (lb/day)	Measured Load (lb/day)	Load Reduction (lb/day)
Rio Grande del Rancho	3,743	7,032	3,289
Rio Fernando de Taos	111	175	64

Notes:
lb/day = Pounds per day

4.5 Identification and Description of Pollutant Source(s)

Pollutant sources that could contribute to these waterbodies are listed in Table 4.5.

Table 4.5 Pollutant Source Summary

Pollutant	Magnitude[(a)] (lb/day)	Location	Potential Sources (% from each)
Point Source			
None	0	---	0
Nonpoint Source			
TDS	4,403	Rio Grande del Rancho	100% Unknown and Natural
TDS	131	Rio Fernando de Taos	100% Unknown and Natural

Notes:
TDS = Total dissolved solids
lb/day = Pounds per day
[(a)] WLA + LA + MOS = TMDL

4.6 Link Between 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 TMDLs 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 1999b). The Pollutant Source(s) Documentation Protocol, shown as **Appendix B**, provides an approach for a visual analysis of a pollutant source along an impaired reach. Although this procedure is subjective, SWQB feels that it provides the best available information for the identification of potential sources of impairment in this watershed. Table 4.5 identifies and quantifies potential sources of nonpoint source impairments along each reach as determined by field reconnaissance and assessment. The sources of impairment to these waterbodies are considered to be natural.

4.7 Margin of Safety

TMDLs should reflect a MOS based on the uncertainty or variability in the data, the point and nonpoint source load estimates, and the modeling analysis. For this TMDL, there is no MOS for point sources, since there are none. However, for the nonpoint sources the MOS for SC is estimated to be an addition of 15 percent of the TMDL. This MOS incorporates several factors:

- Errors in calculating nonpoint source loads

  A level of uncertainty exists in sampling nonpoint sources of pollution. Accordingly, a conservative MOS increases the TMDL by 10 percent.

- Errors in calculating flow

Flow estimates were based on the estimation of the 4Q3 for gaged and ungaged streams and compared to actual flows and cross-sectional information taken in the field. Techniques used for measuring flow in water have a ±5 percent precision. Accordingly, a conservative MOS increases the TMDL by 5 percent.

4.8 Consideration of Seasonal Variation

Data used in the calculation of this TMDL were collected during high and low flow seasons in order to ensure coverage of any potential seasonal variation in the system. As shown in Table 4.6, exceedences were observed from May through October, which are months that capture the spring runoff and summer monsoonal rains. The critical condition used for calculating the TMDL was low flow. Data that exceeded the standard for SC were used in the calculation of the measured loads and can be found in Table 4.6 at the end of this section.

4.9 Future Growth

Estimates of future growth are not anticipated to lead to a significant increase in SC that cannot be controlled with BMP implementation in this watershed.

Table 4.6 Specific Conductance Results from 2000 Sampling Effort

Location	Activity Start Date	SC (µmhos/cm)	TDS (mg/L)	Site-Specific TDS to SC Ratio
Rio Fernando de Taos at Hwy 64 bridge	05-16-2000	206	154	0.75
	05-17-2000	212	208	0.98
	07-31-2000	***558****	282	0.51
	08-01-2000	373	312	0.84
	08-02-2000	***532****	348	0.65
	10-17-2000	430	286	0.66
	10-18-2000	426	274	0.64
	10-19-2000	429	270	0.63
Rio Fernando de Taos at USGS gage	05-16-2000	409	276	0.67
	05-17-2000	415	286	0.69
	07-31-2000	***707****	344	0.49
	08-01-2000	466	388	0.83
	08-02-2000	***548****	400	0.73
	10-17-2000	***605****	420	0.69
	10-18-2000	***592****	398	0.67
	10-19-2000	***584****	416	0.71
Rio Fernando de Taos near Lower Ranchito	05-16-2000	***721****	476	0.66
	05-17-2000	***703****	484	0.69
	07-31-2000	***605****	414	0.68
	08-01-2000	218	420	1.93
	08-02-2000	***695****	454	0.65
	10-17-2000	***786****	504	0.64
	10-18-2000	***842****	580	0.69
	10-19-2000	***856****	566	0.66
			Average	**0.74**
Arithmetic Mean of Exceedances Converted to TDS = 667 x 0.74 = 493 mg/L				
Rio Grande del Rancho at USGS gage	05-16-2000	248	166	0.67
	07-31-2000	344	216	0.63
	10-17-2000	377	268	0.71
Rio Grande del Rancho below Rio Chiquito	05-16-2000	***577 ****	392	0.68
	07-31-2000	***644 ****	400	0.62
	10-17-2000	***700 ****	488	0.70
			Average	**0.67**
Arithmetic Mean of Exceedances Converted to TDS = 640 x 0.67 = 428 mg/L				

Notes:
* = Exceeds water quality criterion for SC.
µmhos/cm = microhos per centimeter
mg/L = Milligrams per liter
TDS = Total dissolved solids
SC = Specific conductance

5.0 STREAM BOTTOM DEPOSITS

During the 2000 SWQB intensive water quality survey in the Upper Rio Grande Watershed (Part 1), impairment of the aquatic community due to excessive SBD was documented at Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho) (SWQB Stations 15 and 16). Consequently, this assessment unit was listed on the 2002-2004 CWA §303(d) list for SBD. Cordova Creek (Costilla Creek to headwaters) was listed for SBD on the 2002-2004 CWA §303(d) list. The SBD TMDL for this assessment unit was previously completed (NMED/SWQB 1999a).

5.1 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 NM WQS (20.6.4 NMAC), the general narrative standard for SBD reads:

> 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 (EPA 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. In order to address the narrative criteria for SBD, SWQB/NMED compiled techniques to measure the level of sedimentation of a stream bottom. These procedures are presented in Appendix D of the *State of New Mexico Procedures for Assessing Standards Attainment for the Integrated §303(d)/§305(b) Water Quality Monitoring and Assessment Report* (NMED/SWQB 2004), which is online at http://www.nmenv.state.nm.us/swqb/links.html. 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 2000 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 NM, a strong relationship (r^2=0.75) was established between embeddedness and the biological scores using data collected in 1998 (SWQB/NMED 2004). 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 2004). Since this relationship is based on NM streams, 20% was chosen for the target value for percent fines.

The Red River below the fish hatchery was chosen as the benthic macroinvertebrate reference station for the Rio Pueblo de Taos 20 meters below the Taos WWTF effluent channel (SWQB Station 15). They are both in ecoregion 22 and have similar geomorphic characteristics as displayed in Table 5.1 (see **Appendix C** for field data). Benthic macroinvertebrate samples and pebble counts were collected at both stations (Barbour et al. 1999, Wohlman 1954).

Table 5.1 Geomorphic Characteristics of Benthic Macroinvertebrate Sampling Sites

Dimensions	Reference Site[(a)]	Study Site[(b)]
Cross-section Area (feet)	61.0	69.0
Width (feet)	33.5	41.0
Maximum Depth (feet)	2.75	2.30
Mean Depth (feet)	1.81	1.70
Width:Depth Ratio	18.5	24.4
Entrenchment Ratio	3.88	2.24

Notes:
[(a)] Reference Site = Red River below Fish Hatchery
[(b)] Study Site = Rio Pueblo de Taos 20 meters below the Taos WWTF effluent channel

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 (RBP) 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 (Table 5.2). Select results of the pebble count and benthic macroinvertebrate surveys are shown in Table 5.2 and Figure 5.1. **Appendix C** of this document contains field data.

Table 5.2 Pebble Count and Benthic Macroinvertebrate Results

Results	Reference Site[(a)]	Study Site[(b)]	Percent of Reference
Pebble count			
Percent Fines (< 2 mm)	17%	85%	500%
D50	56 mm	<0.062 mm	—
D84	180 mm	0.50 mm	—
Benthic metrics			
Standing Crop (number/square meter)	2,609	11,790	—
Ephemeroptera/ Plecoptera/ Tricoptera Taxa	13	8	—
Taxa Richness	28	27	—
Hilsenhoff's Biotic Index	4.4	6.18	—
Total Biologic Score	54	38	70%
Total Habitat Score (out of a possible 200)	180	107	59%

Notes:
[(a)] Reference Site = Red River below Fish Hatchery
[(b)] Study Site = Rio Pueblo de Taos 20 meters below the Taos WWTF effluent channel
mm = Millimeters
— = Not applicable

Figure 5.1 Comparison of Pebble Count Data at Reference and Study Sites (USDA 1998).

Contingency Tables

The following is a summary of the data you entered in the Data Input Worksheet. Summary data are presented as (1) total number of pebbles counted that were less than and greater than the designated particle size criterion and (2) percentage of pebbles counted that were less than the designated particle size criterion. Also presented is a p-value for each particle size criterion. A small p-value indicates the proportion of particles less than the criterion is statistically different between your reference and study reaches. For example, p-values <0.10 indicate a significant difference at the 10% level of significance (90% confidence level); p-values <0.05 indicate a significant difference at the 5% level of significance (95% confidence level); and p-values <0.01 indicate a significant difference at the 1% level of significance (99% confidence level).

User-selected size criterion: <ctrl-u>

2mm

	<	> or =	Total
Reference	17	83	100
Study	85	15	100
Total	102	98	200

Reference <	Study <	Average <	Average >=
17.0%	85.0%	51.0%	49.0%

p-value	<.0001

4 mm

	<	> or =	Total
Reference	18	82	100
Study	85	15	100
Total	103	97	200

Reference <	Study <	Average <	Average >=
18.0%	85.0%	51.5%	48.5%

p-value	<.0001

8 mm

	<	> or =	Total
Reference	19	81	100
Study	85	15	100
Total	104	96	200

Reference <	Study <	Average <	Average >=
19.0%	85.0%	52.0%	48.0%

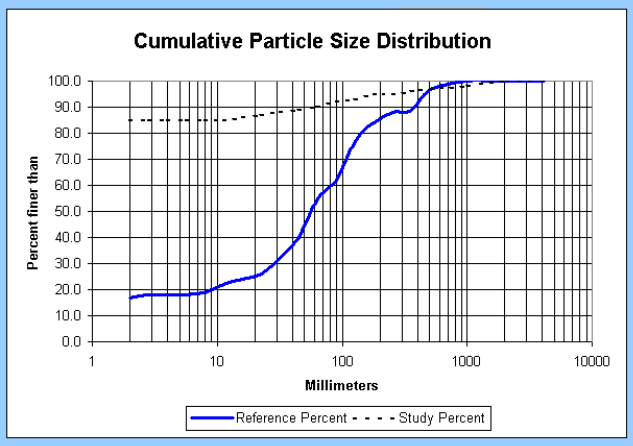
p-value	<.0001

Graphs

The following is a graphical output of the data you entered in the Data Input Worksheet. Presented are a cumulative distribution table and graph, and a histogram table and graph.

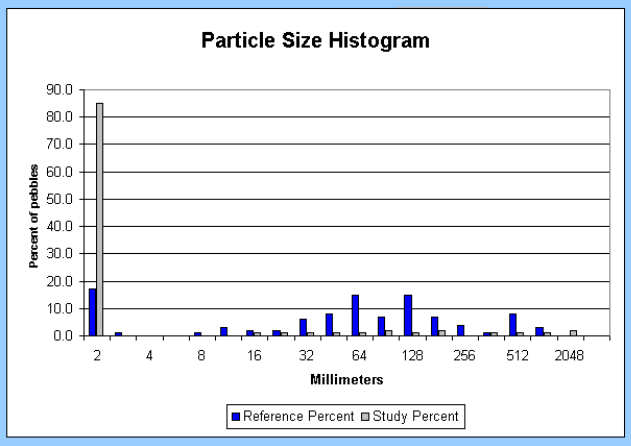
Cumulative Distribution

Size finer than (mm)	Reference Percent	Study Percent
2	17.0	85.0
2.8	18.0	85.0
4	18.0	85.0
5.6	18.0	85.0
8	19.0	85.0
11.3	22.0	85.0
16	24.0	86.0
22.6	26.0	87.0
32	32.0	88.0
45.3	40.0	89.0
64	55.0	90.0
90.5	62.0	92.0
128	77.0	93.0
181	84.0	95.0
256	88.0	95.0
362	89.0	96.0
512	97.0	97.0
1024	100.0	98.0
2048	100.0	100.0
4096	100.0	100.0



Histogram

Size finer than (mm)	Reference Percent	Study Percent
2	17.0	85.0
2.8	1.0	0.0
4	0.0	0.0
5.6	0.0	0.0
8	1.0	0.0
11.3	3.0	0.0
16	2.0	1.0
22.6	2.0	1.0
32	6.0	1.0
45.3	8.0	1.0
64	15.0	1.0
90.5	7.0	2.0
128	15.0	1.0
181	7.0	2.0
256	4.0	0.0
362	1.0	1.0
512	8.0	1.0
1024	3.0	1.0
2048	0.0	2.0
4096	0.0	0.0



5.2 Flow

No streamflow data are necessary because all loads are specified in percent fines.

5.3 Calculations

No calculations were necessary because all loads are specified in percent fines. The target loads for SBD are shown in Table 5.3.

Table 5.3 Calculation of Target Loads for SBD

Location	SBD Standards[(a)] (% fines)	SBD Target Load Capacity (% fines)
Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho)	20	20

Notes:
[(a)] This value is based on a narrative standard. The background values for SBD were taken from the SBD Assessment Protocol (SWQB/NMED 2004).

Measured load was determined by a pebble count as described in the SBD Assessment Protocol (SWQB/NMED 2004). Fines are defined as particles less than 2 millimeters (mm) in diameter. Results are displayed in Table 5.4 and Figure 5.1. **Appendix C** of this document contains field data.

Table 5.4 Calculation of Measured Loads for SBD

Location	SBD (% fines)	SBD Measured Load (% fines)
Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho)	85	85

Notes:
SBD = Stream bottom deposits

5.4 Waste Load Allocations and Load Allocations

5.4.1 Waste Load Allocation

The Taos WWTF is located within this assessment unit and discharges into the Rio Pueblo de Taos. The NPDES permit (Permit No. NM0024066) has total suspended solids (TSS) limits of 30 mg/L (30-day average) and 45 mg/L (7-day average) that are based on the Secondary Treatment Rule 40 CFR 133. There is some debate regarding whether or not TSS from WWTPs has an impact on SBD. TSS sampling in ambient streams typically measures suspended sediment from erosional processes. Since TSS sampling in WWTP effluent typically measures

biosolids, which are less inclined to settle on the stream bottom, EPA contends that TSS from WWTPs have no impact on SBD. Therefore, the WLA is zero.

5.4.2 Load Allocation

In order to calculate the LA, the WLA and MOS were subtracted from the target capacity TMDL following **Equation 5**:

$$TMDL = WLA + LA + MOS \qquad \text{(Eq. 5)}$$

The MOS is estimated to be 25 percent of the target load calculated in Table 5.3. Results are presented in Table 5.5. Additional details on the MOS chosen are presented in Section 5.7.

Table 5.5 TMDL for Stream Bottom Deposits

Location	WLA (% fines)	LA (% fines)	MOS (25%) (% fines)	TMDL (% fines)
Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho)	0	15	5	20

Notes:
WLA = Waste load allocation
LA = Load allocation
MOS = Margin of safety
TMDL = Total maximum daily load

The extensive data collection and analyses necessary to determine background SBD loads for the Rio Pueblo de Taos watershed was beyond the resources available for this study. Therefore, it is assumed that a portion of the LA is made up of natural background loads. The load reduction necessary to meet the target load was estimated as the difference between the target LA (Table 5.3) and the measured load (Table 5.4), shown in Table 5.6.

Table 5.6 Calculation of Load Reduction for Stream Bottom Deposits

Location	LA (% fines)	Measured Load (% fines)	Load Reduction (% fines)
Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho)	15	85	70

5.5 Identification and Description of Pollutant Source(s)

Nonpoint pollutant sources that could contribute to the observed load include range grazing (riparian and/or upland); municipal point sources; land disposal; highway/road/bridge construction; highway maintenance and runoff; crop-related sources; construction. The point source contributions associated with this TMDL were not considered to be applicable.

5.6 Linkage of Water Quality and Pollutant Sources

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

SWQB fieldwork includes an assessment of the potential sources of impairment (SWQB/NMED 1999b). The completed *Pollutant Source(s) Documentation Protocol* forms in **Appendix B** 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. Staff completing these forms identify and quantify 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 Red River below the fish hatchery. An increase in percent fines and consequent reduction in biological score at Rio Pueblo de Taos below the Taos WWTF 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.

There are irrigation ditches coming off of the Rio Pueblo de Taos 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 NM 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. It is possible that the increased sediment is due to population growth and road construction, in addition to flow reduction, irrigation, and climatic change. However, the sediment that was present in 2000 (85 percent) appears to have been substantially reduced based on visual observations in 2003. Measurments of percent fines from 1998 were 46 percent. It is possible that the increase in 2000 was due to an episodic event, either from a side arroyo or main channel.

5.7 Margin of Safety (MOS)

TMDLs should reflect a MOS based on the uncertainty or variability in the data, the point and nonpoint source load estimates, and the modeling analysis. For this TMDL, there will be no MOS for point sources since none that were accounted for. However, the MOS is estimated to be an addition of 25% for SBD caused by nonpoint sources, excluding background. This MOS is based on the uncertainty 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 MOS for SBD increases the TMDL by 25%. Because flow estimates were not needed for the SBD TMDL, an additional MOS is not warranted.

5.8 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 NM (SWQB/NMED 2004b). Fall is a critical time in the life cycle stages of benthic macroinvertebrates in NM. Fall is also generally the low-flow period of the mean annual hydrograph in NM 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.

5.9 Future Growth

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

6.0 TEMPERATURE

Monitoring for temperature was conducted in 2000, 2002, and 2003. Follow-up monitoring for temperature was conducted in 2002 and 2003 because results from some of the 2000 stations were lost. Based on available data, several exceedences of the NM WQS for temperature were noted throughout the watershed. Thermographs were set to record once every hour for several months during the warmest time of the year (generally June through September). Thermograph data are assessed using Appendix C of the *State of New Mexico Procedures for Assessing Standards Attainment for the Integrated §303(d)/§305(b) Water Quality Monitoring and Assessment Report* (SWQB/NMED 2004). Based on 2000 data, Rio Fernando de Taos (Rio Pueblo de Taos to headwaters), Rio Grande (Red River to CO border), Rio Hondo (Rio Grande to USFS boundary), Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho), Rio Pueblo de Taos (Rio Grande del Rancho to Taos Pueblo Boundary), and Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo) were included on the 2002-2004 CWA §303(d) list for temperature. Based on the 2002 sampling event, the following assessment units also had measurements that violated the temperature criterion: Comanche Creek (Costilla Creek to Little Costilla Creek), Costilla Creek (Diversion above Costilla to Comanche Creek), Rio de los Pinos (CO border to headwaters), and Rio San Antonio (Montoya Canyon to headwaters). Although these assessment units were not included on the 2002-2004 CWA §303(d) list, temperature TMDLs were also developed based on 2002 temperature data. Temperature data from 2003 were used to develop TMDLs.

6.1 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 NM WQCC has adopted numeric water quality criteria for temperature to protect the designated use of HQCWF (20.6.4.900.C NMAC). These WQS 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 (**Appendix D** of this document provides a graphical representation of thermograph data):

> *Comanche Creek (Costilla Creek to Little Costilla Creek)*: One thermograph was deployed on this reach in 2002 at SWQB Station 11 (below upper exclosure). Recorded temperatures from July 2 (18:46) through August 31, 2002 exceeded the HQCWF criterion 202 of 1,446

times (14%) with a maximum temperature of 27.1°C. In 2003, two thermographs were deployed in Comanche Creek above Rio Costilla and below Little Costilla Creek for verification and model calibration purposes. Recorded temperatures above Rio Costilla (downstream location) from July 2 (18:00) through August 31, 2003 exceeded the HQCWF criterion 276 of 1,446 times (19%) with a maximum temperature of 26.9°C. Recorded temperatures below Little Costilla Creek (upstream location) exceeded the HQCWF criterion 32 of 1,446 times (2%) with a maximum temperature of 21.5°C.

Costilla Creek (Diversion above Costilla to Comanche Creek): One thermograph was deployed on this reach in 2002 at SWQB Station 39 (above Costilla). Recorded temperatures from July 2 (18:38) through August 31, 2002 exceeded the HQCWF criterion 330 of 1,464 times (23%) with a maximum temperature of 25.8°C. In 2003, one thermograph was deployed in Costilla Creek at Highway 522 for verification and model calibration purposes. However, based on USGS streamflow data from gage 08261000 (Costilla Creek near Garcia, CO), this location likely went dry on July 3, 2003. Temperature measurements from July 2, 2003 range from 16.9 to 21.7 ^{o}C.

Rio Fernando de Taos (Rio Pueblo de Taos to headwaters):-- One thermograph was deployed on this reach in 2000 at SWQB Station 23 (near lower Ranchito, downstream). In 2002, one thermograph was deployed at Highway 64 (Station 10, upstream). In 2003, one thermograph was deployed at Fred Baca Park in Taos, NM (downstream) for verification and model calibration purposes. Recorded temperatures in 2000 (near lower Ranchito) from July 3 (12:00) through August 31, 2000 exceeded the HQCWF criterion 576 of 1,428 times (40%) with a maximum temperature of 24.5°C. In 2002 at Highway 64, recorded temperatures from July 3 (12:24) through August 31, 2002 exceeded the HQCWF criterion 43 of 1,428 times (3%) with a maximum temperature of 30.3°C. In 2003 at Fred Baca Park in Taos, NM, recorded temperatures from July 3 (12:00) through August 31, 2002 exceeded the HQCWF criterion 7 of 1,428 times (0.5%) with a maximum temperature of 22.8°C

Rio Grande (Red River to CO border):-- In 2003, two thermographs were deployed on Rio Grande at the NM-CO border in CO (Station 7) and above the confluence with Red River. At the NM-CO border, recorded temperatures from July 2 (18:00) through August 31, 2003 exceeded the HQCWF criterion 422 of 1,446 times (29%) with a maximum temperature of 26.6°C. Above the confluence with Red River, recorded temperatures from July 2 (18:00) through August 31, 2003 exceeded the HQCWF criterion 314 of 1,446 times (22%) with a maximum temperature of 22.5°C.

Rio Hondo (Rio Grande to USFS boundary):-- In 2003, two thermographs were deployed on Rio Hondo at the Rio Grande confluence (Station 28, downstream) and Rio Hondo above Valdez, NM (Station 30, upstream). At the Rio Grande confluence, recorded temperatures from July 3 (12:00) through August 31, 2003 exceeded the HQCWF criterion 307 of 1,428 times (21%) with a maximum temperature of 25.4°C. Above Valdez, NM, recorded temperatures from July 3 (12:00) through August 31, 2003 exceeded the HQCWF criterion zero of 1,428 times (0%) with a maximum temperature of 15.6°C.

Rio de los Pinos (CO border to headwaters): In 2002, two thermographs were deployed on Rio de los Pinos at USGS gage (Station 1, downstream) and Rio de los Pinos at the USFS bridge (Station 2, upstream). At the USGS gage, recorded temperatures from July 2 (18:36) through August 31, 2002 exceeded the HQCWF criterion 508 of 1,446 times (35%) with a maximum temperature of 29.8°C. At the USFS bridge in 2002, recorded temperatures from July 2 (18:31) through August 31, 2003 exceeded the HQCWF criterion 344 of 1,446 times (24%) with a maximum temperature of 27.7°C. In 2003, two thermographs were deployed on Rio de los Pinos at USGS gage (Station 1, downstream) and Rio de los Pinos at the USFS bridge (Station 2, upstream). At the USGS gage, recorded temperatures from July 2 (18:00) through August 31, 2002 exceeded the HQCWF criterion 246 of 1,446 times (17%) with a maximum temperature of 25.3°C. At the USFS bridge in 2003, recorded temperatures from July 2 (18:00) through August 31, 2003 exceeded the HQCWF criterion 387 of 1,446 times (27%) with a maximum temperature of 27.1°C.

Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo):-- One thermograph was deployed on this reach in 2000 at the Rio Grande confluence (Station 14, downstream) and one thermograph was deployed in the same location in 2003. Recorded temperatures from July 3 (14:00) through August 31, 2000 exceeded the HQCWF criterion 682 of 1,426 times (48%) with a maximum temperature of 25.1°C. In 2003, recorded temperatures from July 3 (14:00) through August 31 at this location exceeded the HQCWF criterion 634 of 1,426 times (44%) with a maximum temperature of 25.4°C.

Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho): One thermograph was deployed on this reach in 2000 below Taos WWTF effluent channel (Station 15, mid-stream) and one thermograph was deployed at Highway 240 (upstream) in 2003. In 2000 below Taos WWTF, recorded temperatures from July 3 (14:00) through August 31, 2000 exceeded the HQCWF criterion 745 of 1,426 times (52%) with a maximum temperature of 28.3°C. In 2003, recorded temperatures from July 3 (14:00) through August 31 at Highway 240 exceeded the HQCWF criterion 693 of 1,426 times (49%) with a maximum temperature of 30.8°C.

Rio Pueblo de Taos (Rio Grande del Rancho to Taos Pueblo Boundary): One thermograph was deployed on this reach in 2000 near lower Ranchito (Station 27, downstream). In 2002, one thermograph was deployed near Los Cordovas (Station 22, downstream), and one thermograph was deployed at Highway 240 (downstream) in 2003. In 2000 near lower Ranchito, recorded temperatures from July 3 (14:00) through August 31, 2000 exceeded the HQCWF criterion 410 of 1,426 times (29%) with a maximum temperature of 27.2°C. In 2002, recorded temperatures from July 3 (14:12) through August 31 at Los Cordovas exceeded the HQCWF criterion 648 of 1,426 times (45%) with a maximum temperature of 30.1°C. In 2003, recorded temperatures from July 3 (14:00) through August 31 at Highway 240 exceeded the HQCWF criterion 693 of 1,426 times (49%) with a maximum temperature of 30.8°C.

Rio San Antonio (Montoya Canyon to headwaters): One thermograph was deployed on this reach in 2002 near FR 87 bridge (Station 4, mid-stream). In 2003, one thermograph was deployed in the same location. In 2002, recorded temperatures from July 2 (18:44) through

August 31, 2000 exceeded the HQCWF criterion 255 of 1,446 times (18%) with a maximum temperature of 27.1°C. In 2003, recorded temperatures from July 2 (18:00) through August exceeded the HQCWF criterion 350 of 1,446 times (24%) with a maximum temperature of 27.6°C.

6.2 Calculations

The Stream Segment Temperature (SSTEMP) Model, Version 2.0 (Bartholow 2002) 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 mean, minimum, and maximum daily water temperatures throughout a stream reach by estimating the heat gained or lost from a parcel of water as it passes through a stream segment (Bartholow 2002). The 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.

6.3 Waste Load Allocations and Load Allocations

6.3.1 Waste Load Allocation

With the exception of Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo), there are no point source contributions associated with these TMDLs.

The Taos WWTF discharges into assessment unit Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo), and the Twinings WWTP discharges into and discharges into Rio Hondo. There is some debate regarding whether or not effluent from WWTPs has an impact on temperature. Neither NPDES permits have limitations or monitoring requirements for temperature. WWTP effluent has never been noted to be a significant source contributor of temperature impairment. There are no data available to determine whether or not the Taos WWTP is contributing to elevated temperatures in the respective receiving waters. SWQB has been conducting a special study of the Rio Hondo watershed in anticipation of revising the existing nutrient TMDL (1981). Data indicate that the WWTP is not contributing to elevated temperature in the Rio Hondo. In fact, both the mean (=5.37 degrees C) and median (= 4.90 degrees C) of ambient temperature measurements taken at station “Rio Hondo 50 feet above WWTP” are very similar to the mean (= 4.92 degrees C) and median (= 5.13 degrees C) of measurements taken at station “Rio Hondo 300 yards below WWTP.” Therefore, the WLA is zero.

6.3.2 Load Allocation

Water temperature can be expressed as heat energy per unit volume. SSTEMP provides an estimate of heat energy expressed in joules per square meter per second (j/m^2/s) and Langley's per day. The following information relevant to the model runs used to determine temperature TMDLs is taken from the SSTEMP documentation (Bartholow 2002). Please refer to the SSTEMP User's Manual for complete text. Various notes have been added below in brackets to clarify local sources of input data.

Description of Logic:
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 that 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, sunrise and sunset times are computed by factoring in local 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 by 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 VARIABLES

. . . 1. Segment Inflow (cfs or cms [cubic meters per second]) -- 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 so that all accumulated flow will accrue from accretions, both surface water 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.

If the inflow to the segment is the result of mixing two streams, you may use the mixing equation to compute the combined temperature:

$$T_j = \frac{(Q_1 \times T_1) + (Q_2 \times T_2)}{Q_1 + Q_2}$$

where

T_j = Temperature below the junction
Q_n = Discharge of source n
T_n = Temperature of source n

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 next upstream segment.

3. Segment Outflow (cfs or cms) -- The program calculates the lateral discharge accretion rate 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 should divide the segment into two or more subsections. "Major" is defined as any

stream contributing greater than 10% of the mainstem flow, particularly if there are major discontinuities in stream temperature.

[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.

GEOMETRY VARIABLES

. . . 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 global positioning system (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 parcel from solar noon to the end of the segment, allowing it to heat towards the maximum equilibrium temperature. If there is an upstream dam within a half-day's travel time from the end of the segment, a parcel of water should only be allowed to heat for a shorter time/distance. By telling SSTEMP that there is a dam at the top, it will know to heat the water only from the dam downstream. . . Just to confuse the issue, be aware that if there is no dam SSTEMP will assume that the stream segment’s meterology and geometry also apply upstream from that point a half-day’s travel time from the end of the segment. If conditions are vastly different upstream, this is one reason that the maximum temperature estimate can be inaccurate.

3. Segment Length (miles or kilometers) -- Enter the length of the segment for which you want to predict the outflowing temperature. Remember that all variables 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 Geographic Information System (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 variable). Theoretically, the A term is the untransformed 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 (USDA 1998). See **Appendix E** for details.]

8. Manning's n or Travel Time (seconds/mile or seconds/kilometer) -- 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 1, 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, e.g., July 15. 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 of course be measured (in the shade), and should be for truly accurate results; however, this and the other (following) 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. The Internet is another obvious source of data today. If only scooping-level analyses are required, you may refer to sources of general meterology for the United States, such as USDA (1941) ir USDC (1968).

Use the adiabatic lapse rate to correct for elevational differences from the met 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 mean daily water temperature. . .

[NOTE: Mean daily air temperature data were determined from air thermographs deployed in the shade near the instream thermograph locations or found at the New Mexico Climate Center web site (http://weather.nmsu.edu/data/data.htm). 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. Unlike the other variables where simply typing a value influences which variables "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.

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:

$$Rh = Ro \times \left[1.0640 ** (To - Ta)\right] \times \left(\frac{Ta + 273.16}{To + 273.16}\right)$$

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)
** = exponentation
0 <= Rh <= 1.0

[NOTE: Relative humidity data are found at the New Mexico Climate Center web site (http://weather.nmsu.edu/data/data.htm). 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 the LCD. 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, wind speed should be measured right above the water's surface.

[NOTE: Wind speed data are found at the New Mexico Climate Center web site (http://weather.nmsu.edu/data/data.htm).]

5. Ground Temperature (°F or °C) – In the absence of measured data, use mean annual air temperature from the LCD.

[NOTE: Mean annual air temperature is found at the New Mexico Climate Center web site (http://weather.nmsu.edu/data/data.htm).]

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 variable 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 and inverse measure of cloud cover. Measure with a pyrometer or use the LCD for historical data. Unfortunately, cloud cover is no longer routinely measured by NOAA weather stations. That means that one must "back calculate" this value or use it as a calibration parameter.

[NOTE: Percent possible sun is found at the New Mexico Climate Center web site (http://weather.nmsu.edu/data/data.htm).]

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 well 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, and 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.

[NOTE: Solar radiation data are found at the New Mexico Climate Center web site (http://weather.nmsu.edu/data/data.htm).]

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 will be grayed out and ignored. You may find it to your advantage to use the Optional Shading Variables to more accurately calculate stream shading. . .

[NOTE: In a 2002 study, Optional Shading Parameters and concurrent densiometer readings were measured at seventeen stations in order to compare 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. Aerial photos are examined and considered whenever available.]

OUTPUT

The program will predict the minimum, mean, and maximum daily water temperature for the set of variables you provide. . . 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. The mean daily equilibrium temperature is that temperature that the daily mean water temperature will approach, but never reach, if all conditions remain the same (forever) as you go downstream. (Of course, all conditions cannot remain the same, e.g., the elevation changes immediately.) The maximum daily equilibrium temperature is that temperature that the daily maximum water temperature will approach. . . Other output includes the intermediate parameters average width, and average depth and slope (all calculated from the input variables), and the mean daily heat flux components.

. . . 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. You 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). . .

The program will predict the total segment shading for the set of variables you provide. The program will also display how much of the total shade is a result of topography and how much is a result of vegetation. The topographic shade and vegetative shade are merely added to get the total shade. Use the knowledge that the two shade components are additive to improve your understanding about how SSTEMP deals with shade in toto.

SENSITIVITY ANALYSIS

SSTEMP may be used to compute a one-at-a-time sensitivity of a set of input values. 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.

FLOW/DISTANCE MATRIX

The **View|Flow/DistanceMatrix** option allows you to look at a variety of flow and distance combinations from your stream segment. You may enter up to five flows and five distances for further examination. The program will supply a default set of each, with flows ranging from 33% to 166% of that given on the main screen, and distances regularly spaced along the segment. After making any changes you may need, you may choose to view the results in simple graphs either as a function of distance (X) or discharge (Q). The units for discharge, distance and temperature used on the matrix and the graph are a function of those from the main form. The graph is discrete, i.e., does not attempt to smooth between points, and does not currently scale the X-axis realistically.

Note that changing the flow only changes the flow <u>through</u> the segment. That is, the accretion rate per unit distance will remain the same. Flow does impact shading (if active) and all other dependent calculations. . .

Note that you may enter distances beyond your segment length, but if you do so you are assuming that everything remains homogeneous farther downstream, just as you have assumed for the segment itself. *If you try to look at distances very close to the top of the segment, you may get mathematical instability*. . .

UNCERTAINTY ANALYSIS

SNTEMP and previous versions of SSTEMP were deterministic; you supplied the "most likely" estimate of input variables and the model predicted the "most likely" thermal response. This approach was comforting and easy to understand. But choosing this "most likely" approach is like putting on blinders. We know 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. Do not be fooled with input variables whose units are themselves percent, like shade. In this case, if you are in the percentage mode and shade is 50% as an example, entering a value

of 5% would impose a deviation of ±2.5 percent (47.5-52.5%), but if you were in the absolute mode, the same 5% value would impose a deviation of ±5 percent (45-55%). 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, lets 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. . .

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 variable 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 likely 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, like SNTEMP, 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.

. . . 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 cannot 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. . .

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

Tables 6.1 through 6.10 detail model run outputs for segments on Comanche Creek, Costilla Creek, Rio Fernando de Taos, Rio Grande, Rio Hondo, Rio de los Pinos, Rio Pueblo de Taos, and Rio San Antonio (see **Appendix F** for model runs). SSTEMP was first calibrated against thermograph data to determine the standard error of the model. Initial conditions were determined. As the percent total shade was increased and the Width's A term was decreased, the maximum 24-hour temperature decreased until the segment-specific standard of 20ºC was achieved. The calculated 24-hour solar radiation component is the maximum solar load that can occur in order to meet the WQS (i.e., the target capacity). In order to calculate the actual LA, the WLA and MOS were subtracted from the target capacity (TMDL) following **Equation 5**.

$$WLA + LA + MOS = TMDL \qquad \text{(Eq. 5)}$$

Temperature allocations for each assessment unit requiring a temperature TMDL are provided in the following subsections.

Temperature Load Allocation for Comanche Creek (Costilla Creek to Little Costilla Creek)
For Comanche Creek, the WQS for temperature is achieved when the percent total shade is increased to 52%. According to the SSTEMP model, the actual LA of 115.1 $j/m^2/s$ is achieved when the shade is further increased to 56.8% (Table 6.1).

Table 6.1 SSTEMP Model Results for Comanche Creek (Costilla Creek to Little Costilla Creek)

Rosgen Channel Type	WQS (HQCWF)	Model Run Dates	Segment Length (miles)	Solar Radiation Component per 24-Hours (+/-)	% Total Shade	Width's A Term	Modeled Temperature °C (24 hour)
C4/E4	20°C (68°F)	8/04/03	10.3	**Current Field Condition** +254.4 joules/m^2/s	4.5	6.681	Minimum: 12.6 Mean: 19.3 Maximum: 26.0
TEMPERATURE ALLOCATIONS FOR Comanche Creek (Costilla to Little Costilla Creek) [(a)] **24-HOUR ACHIEVEMENT OF SURFACE WQS FOR TEMPERATURE** [(b)] 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: Current Condition – Load Allocation = 254.4 joules/m^2/s – 115.1 joules/m^2/s **= 139.3 joules/m^2/s**				**Run 1** +133.2 joules/m^2/s	50.0	6.681	Minimum: 11.1 Mean: 15.7 Maximum: 20.3
				Run 2 + 127.9[(a)] joules/m^2/s	52.0	6.681	Minimum: 11.0 Mean: 15.5 Maximum: 20.0
				Actual LA +115.1 [(b)] joules/m^2/s	56.8	6.681	Minimum: 10.9 Mean: 15.1 Maximum: 19.3

Temperature Load Allocation for Costilla Creek (Diversion above Costilla to Comanche Creek

For Costilla Creek, the WQS for temperature is achieved when the percent total shade is increased to 70% and the Width's A term is reduced by 20 percent to 7.579. According to the SSTEMP model, the actual LA of 70.7 j/m^2/s is achieved when the shade is further increased to 73% (Table 6.2).

Table 6.2 SSTEMP Model Results for Costilla Creek (Diversion above Costilla to Comanche Creek

Rosgen Channel Type	WQS (HQCWF)	Model Run Dates	Segment Length (miles)	Solar Radiation Component per 24-Hours (+/-)	% Total Shade	Width's A Term	Modeled Temperature °C (24 hour)
C4/F4	20°C (68°F)	7/31/02	18.0	**Current Field Condition** +164.96 joules/m^2/s	37.0	9.474	Minimum: 15.1 Mean: 20.0 Maximum: 24.9
TEMPERATURE ALLOCATIONS FOR Costilla Creek (Diversion above Costilla to Comanche Creek) [(a)] **24-HOUR ACHIEVEMENT OF SURFACE WQS FOR TEMPERATURE** [(b)] 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: Current Condition – Load Allocation = 164.96 joules/m^2/s – 70.70 joules/m^2/s **= 94.26 joules/m^2/s**				**Run 1** +78.55 joules/m^2/s	70.0	9.474	Minimum: 14.3 Mean: 17.2 Maximum: 20.2
				Run 2 +78.55 [(a)] joules/m^2/s	70.0	7.579	Minimum: 14.3 Mean: 17.1 Maximum: 20.0
				Actual LA 70.70 [(b)] joules/m^2/s	73.0	7.579	Minimum: 14.2 Mean: 16.9 Maximum: 19.5

Temperature Load Allocation for Rio Fernando de Taos (Rio Pueblo de Taos to headwaters)
For Rio Fernando de Taos, the WQS for temperature is achieved when the percent total shade is increased to 76.8% and the Width's A term is reduced by 25 percent to 2.448. According to the SSTEMP model, the actual LA of 59.32 j/m^2/s is achieved when the shade is further increased to 79.2% (Table 6.3).

Table 6.3 SSTEMP Model Results for Rio Fernando de Taos (Rio Pueblo de Taos to headwaters)

Rosgen Channel Type	WQS (HQCWF)	Model Run Dates	Segment Length (miles)	Solar Radiation Component per 24-Hours (+/-)	% Total Shade	Width's A Term	Modeled Temperature °C (24 hour)
E6/B4/ Eb5	20°C (68°F)	7/31/00	21.6	**Current Field Condition** +142.06 joules/m^2/s	50.0	3.624	Minimum: 14.4 Mean: 19.8 Maximum: 25.1
TEMPERATURE ALLOCATIONS FOR Rio Fernando de Taos (Rio Pueblo de Taos to headwaters) [(a)] **24-HOUR ACHIEVEMENT OF SURFACE WQS FOR TEMPERATURE** [(b)] 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: Current Condition – Load Allocation = 142.06 joules/m^2/s – 59.32 joules/m^2/s **= 82.74 joules/m^2/s**				**Run 1** +82.39 joules/m^2/s	71.0	3.624	Minimum: 14.0 Mean: 17.7 Maximum: 21.5
				Run 2 +65.91 [(a)] joules/m^2/s	76.8	2.448	Minimum: 13.7 Mean: 16.9 Maximum: 20.0
				Actual LA +59.32 [(b)] joules/m^2/s	79.2	2.448	Minimum: 13.7 Mean: 16.6 Maximum: 19.6

Temperature Load Allocation for Rio Grande (Red River to NM-CO border)

For Rio Grande, the WQS for temperature is achieved when the percent total shade is increased to 71.6% and the Width's A term is reduced by 50 percent to 8.205. According to the SSTEMP model, the actual LA of 82.0 j/m^2/s is achieved when the shade is further increased to 74.5% (Table 6.4).

Table 6.4 SSTEMP Model Results for Rio Grande (Red River to NM-CO border)

Rosgen Channel Type	WQS (HQCWF)	Model Run Dates	Segment Length (miles)	Solar Radiation Component per 24-Hours (+/-)	% Total Shade	Width's A Term	Modeled Temperature °C (24 hour)
Upstream: C4/B4 Downstream: B3/B4	20°C (68°F)	7/05/03	27.8	**Current Field Condition** +160.38 joules/m^2/s	50.0	16.410	Minimum: 15.9 Mean: 19.5 Maximum: 23.1
TEMPERATURE ALLOCATIONS FOR Rio Grande (Red River to NM-CO border) [(a)] **24-HOUR ACHIEVEMENT OF SURFACE WQS FOR TEMPERATURE** [(b)] 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: Current Condition – Load Allocation = 160.38 joules/m^2/s – 82.0 joules/m^2/s **= 78.4 joules/m^2/s**				**Run 1** +178.20 joules/m^2/s	50.0	8.205	Minimum: 17.1 Mean: 19.9 Maximum: 22.7
				Run 2 +91.1 [(a)] joules/m^2/s	71.6	8.205	Minimum: 16.4 Mean: 18.2 Maximum: 20.0
				Actual LA +82.0 [(b)] joules/m^2/s	74.5	8.205	Minimum: 16.3 Mean: 18.0 Maximum: 19.6

Temperature Load Allocation for Rio Hondo (Rio Grande to USFS boundary)

For Rio Hondo, the WQS for temperature is achieved when the percent total shade is increased to 65.8% and the Width's A term is reduced by 50 percent to 5.431. According to the SSTEMP model, the actual LA of 91.70 j/m^2/s is achieved when the shade is further increased to 69.3% (Table 6.5).

Table 6.5 SSTEMP Model Results for Rio Hondo (Rio Grande to USFS boundary)

Rosgen Channel Type	WQS (HQCWF)	Model Run Dates	Segment Length (miles)	Solar Radiation Component per 24-Hours (+/-)	% Total Shade	Width's A Term	Modeled Temperature °C (24 hour)
Cb4	20°C (68°F)	7/08/03	8.5	**Current Field Condition** +169.82 joules/m^2/s	43.0	10.862	Minimum: 13.7 Mean: 18.5 Maximum: 23.3
TEMPERATURE ALLOCATIONS FOR Rio Hondo (Rio Grande to USFS boundary) [a] **24-HOUR ACHIEVEMENT OF SURFACE WQS FOR TEMPERATURE** [b] 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: Current Condition – Load Allocation = 169.82 joules/m^2/s – 91.70 joules/m^2/s **= 78.12 joules/m^2/s**				**Run 1** +119.17 joules/m^2/s	60.0	10.862	Minimum: 13.2 Mean: 17.1 Maximum: 21.0
				Run 2 +101.89 [a] joules/m^2/s	65.8	5.431	Minimum: 13.0 Mean: 17.1 Maximum: 20.0
				Actual LA +91.70 [b] joules/m^2/s	69.3	5.431	Minimum: 13.0 Mean: 16.2 Maximum: 19.5

Temperature Load Allocation for Rio de los Pinos (CO border to headwaters)

For Rio de los Pinos, the WQS for temperature is achieved when the percent total shade is increased to 53% and the Width's A term is reduced by 20 percent to 11.570. According to the SSTEMP model, the actual LA of 135.74 j/m^2/s is achieved when the shade is further increased to 58.6% (Table 6.6).

Table 6.6 SSTEMP Model Results for Rio de los Pinos (CO border to headwaters)

Rosgen Channel Type	WQS (HQCWF)	Model Run Dates	Segment Length (miles)	Solar Radiation Component per 24-Hours (+/-)	% Total Shade	Width's A Term	Modeled Temperature °C (24 hour)
C4/Bc3	20°C (68°F)	7/03/03	20.9	**Current Field Condition** +262.19 joules/m^2/s	20.0	14.463	Minimum: 10.6 Mean: 18.6 Maximum: 26.7
TEMPERATURE ALLOCATIONS FOR Rio de los Pinos (CO border to headwaters) [a] **24-HOUR ACHIEVEMENT OF SURFACE WQS FOR TEMPERATURE** [b] 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: Current Condition – Load Allocation = 262.19 joules/m^2/s – 135.74 joules/m^2/s **= 126.45 joules/m^2/s**				**Run 1** +163.87 joules/m^2/s	50.0	14.463	Minimum: 9.7 Mean: 15.4 Maximum: 21.2
				Run 2 +154.04 [a] joules/m^2/s	53.0	11.570	Minimum: 9.3 Mean: 14.6 Maximum: 20.0
				Actual LA 135.74 [b] joules/m^2/s	58.6	11.570	Minimum: 9.2 Mean: 14.0 Maximum: 18.9

Temperature Load Allocation for Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo)
For Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo), the WQS for temperature is achieved when the percent total shade is increased to 92% and the Width's A term is reduced by 50 percent to 3.241. According to the SSTEMP model, the actual LA of 23.13 j/m^2/s is achieved when the shade is further increased to 92.8% (Table 6.7).

Table 6.7 SSTEMP Model Results for Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo)

Rosgen Channel Type	WQS (HQCWF)	Model Run Dates	Segment Length (miles)	Solar Radiation Component per 24-Hours (+/-)	% Total Shade	Width's A Term	Modeled Temperature °C (24 hour)
Ba2	20°C (68°F)	7/10/03	6.4	**Current Field Condition** +269.81 joules/m^2/s	16.0	6.482	Minimum: 16.4 Mean: 21.1 Maximum: 25.8
TEMPERATURE ALLOCATIONS FOR Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo) [(a)] **24-HOUR ACHIEVEMENT OF SURFACE WQS FOR TEMPERATURE** [(b)] 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: Current Condition – Load Allocation = 269.81 joules/m^2/s – 23.13 joules/m^2/s **= 246.68 joules/m^2/s**				**Run 1** +128.48 joules/m^2/s	60.0	6.482	Minimum: 16.2 Mean: 18.9 Maximum: 21.6
				Run 2 +25.70 [(a)] joules/m^2/s	92.0	3.241	Minimum: 18.2 Mean: 19.1 Maximum: 20.0
				Actual LA +23.13 [(b)] joules/m^2/s	92.8	3.241	Minimum: 18.2 Mean: 19.1 Maximum: 19.9

Temperature Load Allocation for Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho)

For Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho), the WQS for temperature is achieved when the percent total shade is increased to 96.3 percent. According to the SSTEMP model, the actual LA of 10.69 j/m^2/s is achieved when the shade is further increased to 96.7% (Table 6.8).

Table 6.8 SSTEMP Model Results for Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho)

Rosgen Channel Type	WQS (HQCWF)	Model Run Dates	Segment Length (miles)	Solar Radiation Component per 24-Hours (+/-)	% Total Shade	Width's A Term	Modeled Temperature °C (24 hour)
Ba2	20°C (68°F)	7/10/03	1.2	**Current Field Condition** +305.14 joules/m^2/s	5.0	10.437	Minimum: 15.8 Mean: 21.5 Maximum: 27.1
TEMPERATURE ALLOCATIONS FOR Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho) [(a)] **24-HOUR ACHIEVEMENT OF SURFACE WQS FOR TEMPERATURE** [(b)] 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: Current Condition – Load Allocation = 305.14 joules/m^2/s – 10.69 joules/m^2/s **= 294.45 joules/m^2/s**				**Run 1** +80.30 joules/m^2/s	75.0	10.437	Minimum: 18.3 Mean: 19.8 Maximum: 21.4
				Run 2 +11.88 [(a)] joules/m^2/s	96.3	10.437	Minimum: 18.7 Mean: 19.4 Maximum: 20.0
				Actual LA +10.69 [(b)] joules/m^2/s	96.7	10.437	Minimum: 18.7 Mean: 19.3 Maximum: 20.0

Temperature Load Allocation for Rio Pueblo de Taos (Rio Grande del Rancho to Taos Pueblo Boundary)

For Rio Pueblo de Taos (Rio Grande del Rancho to Taos Pueblo), the WQS for temperature is achieved when the percent total shade is increased to 74.7 percent and the Width's A term is decreased by 50 percent to 3.718. According to the SSTEMP model, the actual LA of 64.69 j/m^2/s is achieved when the shade is further increased to 77.3% (Table 6.9).

Table 6.9 SSTEMP Model Results for Rio Pueblo de Taos (Rio Grande del Rancho to Taos Pueblo Boundary)

Rosgen Channel Type	WQS (HQCWF)	Model Run Dates	Segment Length (miles)	Solar Radiation Component per 24-Hours (+/-)	% Total Shade	Width's A Term	Modeled Temperature °C (24 hour)
Ba2	20°C (68°F)	7/31/00	2.8	**Current Field Condition** +264.22 joules/m^2/s	7.0	7.436	Minimum: 15.0 Mean: 22.2 Maximum: 29.4
TEMPERATURE ALLOCATIONS FOR Rio Pueblo de Taos (Rio Grande del Rancho to Taos Pueblo Boundary) [a] **24-HOUR ACHIEVEMENT OF SURFACE WQS FOR TEMPERATURE** [b] 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: Current Condition – Load Allocation = 264.22 joules/m^2/s – 64.69 joules/m^2/s **= 199.53 joules/m^2/s**				**Run 1** +85.23 joules/m^2/s	70.0	7.436	Minimum: 15.2 Mean: 18.1 Maximum 20.9
				Run 2 +71.88 [a] joules/m^2/s	74.7	3.718	Minimum: 16.0 Mean: 18.0 Maximum: 20.0
				Actual LA +64.69 [b] joules/m^2/s	77.3	3.718	Minimum: 16.1 Mean: 17.9 Maximum: 19.7

Temperature Load Allocation for Rio San Antonio (Montoya Canyon to headwaters)

For Rio San Antonio (Montoya Canyon to headwaters), the WQS for temperature is achieved when the percent total shade is increased to 50 percent and the Width's A term is decreased to 10.75. According to the SSTEMP model, the actual LA of 147.48 j/m^2/s is achieved when the shade is further increased to 55 percent (Table 6.10).

Table 6.10 SSTEMP Model Results for Rio San Antonio (Montoya Canyon to headwaters)

Rosgen Channel Type	WQS (HQCWF)	Model Run Dates	Segment Length (miles)	Solar Radiation Component per 24-Hours (+/-)	% Total Shade	Width's A Term	Modeled Temperature °C (24 hour)
Ba2	20°C (68°F)	07/03/03	9.1	**Current Field Condition** +275.30 joules/m^2/s	16.0	14.57	Minimum: 11.3 Mean: 19.1 Maximum: 27.0
TEMPERATURE ALLOCATIONS FOR Rio San Antonio (Montoya Canyon to headwaters) [(a)] **24-HOUR ACHIEVEMENT OF SURFACE WQS FOR TEMPERATURE** [(b)] 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: Current Condition – Load Allocation = 275.30 joules/m^2/s – 147.48 joules/m^2/s **= 127.82 joules/m^2/s**				**Run 1** +163.87 joules/m^2/s	50.0	14.57	Minimum: 10.0 Mean: 15.5 Maximum: 20.9
				Run 2 +163.87 [(a)] joules/m^2/s	50.0	10.75	Minimum: 49.5 Mean: 58.7 Maximum: 68.0
				Actual LA +147.48 [(b)] joules/m^2/s	55.0	10.75	Minimum: 9.6 Mean: 14.3 Maximum: 19.0

According to the Sensitivity Analysis feature of the model runs, mean daily air temperature had the greatest influence on the predicted outflow temperatures. In addition, total shade values have the greatest influence on temperature reduction. The estimate of total shade used in the model calibration was based on densiometer readings and examination of aerial photographs (see **Appendix E**). Target loads as determined by the modeling runs are summarized in Tables 6.1 through 6.10. The MOS is estimated to be 10% of the target load calculated by the modeling runs. Results are summarized in Table 6.11. Additional details on the MOS chosen are presented in Section 6.7 below.

Table 6.11 Calculation of TMDLs for Temperature

Assessment Unit	WLA ($j/m^2/s$)	LA ($j/m^2/s$)	MOS (10%)[(a)] ($j/m^2/s$)	TMDL ($j/m^2/s$)
Comanche Creek (Costilla Creek to Little Costilla Creek	0	115.1	12.79	127.9
Costilla Creek (Diverson above Costilla to Comanche Creek)	0	70.70	7.86	78.55
Rio Fernando de Taos (Rio Pueblo de Taos to headwaters)	0	59.32	6.59	65.91
Rio Grande (Red River to NM-CO border)	0	82.00	9.11	91.1
Rio Hondo (Rio Grande to USFS boundary)	0	91.70	10.19	101.89
Rio de los Pinos (CO border to headwaters)	0	135.7	15.40	154.04
Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo)	0	23.13	2.57	25.70
Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho)	0	10.69	1.19	11.88
Rio Pueblo de Taos (Rio Grande del Rancho to Taos Pueblo boundary)	0	64.69	7.19	71.88
Rio San Antonio (Montoya Canyon to headwaters)	0	147.48	16.39	163.87

Notes:
[(a)] 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 LA and the measured load (i.e., current field condition in Tables 6.1 through 6.10), and are shown in Table 6.12.

Table 6.12 Calculation of Load Reduction for Temperature

Location	LA ($j/m^2/s$)	Measured Load ($j/m^2/s$)	Load Reduction ($j/m^2/s$)
Comanche Creek (Costilla Creek to Little Costilla Creek	115.1	254.40	139.30
Costilla Creek (Diverson above Costilla to Comanche Creek)	70.70	164.96	94.26
Rio Fernando de Taos (Rio Pueblo de Taos to headwaters)	59.32	142.06	82.74
Rio Grande (Red River to NM-CO border)	82.00	160.38	78.40
Rio Hondo (Rio Grande to USFS boundary)	91.70	169.82	78.12
Rio de los Pinos (CO border to headwaters)	135.7	262.19	126.45
Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo)	23.13	269.81	246.68
Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho)	10.69	305.14	294.45
Rio Pueblo de Taos (Rio Grande del Rancho to Taos Pueblo boundary)	64.69	264.22	199.53
Rio San Antonio (Montoya Canyon to headwaters)	147.48	275.30	127.82

6.4 Identification and Description of pollutant source(s)

Pollutant sources that could contribute to each segment are listed in Table 6.13.

Table 6.13 Pollutant source summary for Temperature

Pollutant Sources	Magnitude[a]	Location	Potential Sources[b] (% from each)
Point:			
None or NA	0	--------	0%
Nonpoint:			
Temperature[c]	115.1	Comanche Creek	100% Silviculture (historic) Placer Mining (historic) Road Maintenance and Runoff Range Grazing -- Riparian or Upland Removal of Riparian Vegetation Streambank Modification or Destabilization
	70.70	Costilla Creek	100% Irrigated Return Flows Silviculture (historic) Draining or Filling of Wetlands Road Maintenance and Runoff Range Grazing -- Riparian or Upland Removal of Riparian Vegetation Streambank Modification or Destabilization Flow Regulation/Modification
	59.32	Rio Fernando de Taos	100% Road Maintenance and Runoff Range Grazing -- Riparian or Upland Removal of Riparian Vegetation Streambank Modification or Destabilization Flow Regulation/Modification
	82.0	Rio Grande	100% Streambank Modification or Destabilization (upstream) Natural Unknown
	91.7	Rio Hondo	100% Range Grazing -- Riparian or Upland Removal of Riparian Vegetation Streambank Modification or Destabilization Natural Unknown
	135.74	Rio de los Pinos	100% Range Grazing -- Riparian or Upland Removal of Riparian Vegetation Streambank Modification or Destabilization Natural Unknown
Temperature[c]	23.13	Rio Pueblo de	100%

Pollutant Sources	Magnitude[(a)]	Location	Potential Sources[(b)] (% from each)
		Taos (Rio Grande to Arroyo del Alamo)	Range Grazing -- Riparian or Upland Removal of Riparian Vegetation Streambank Modification or Destabilization Natural Unknown
	10.69	Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande Del Rancho)	100% Range Grazing -- Riparian or Upland Road Construction or Maintenance Flow Regulation/Modification Removal of Riparian Vegetation Streambank Modification or Destabilization
	64.69	Rio Pueblo de Taos (Rio Grande Del Rancho to Taos Pueblo Boundary)	100% Range Grazing -- Riparian or Upland Road Construction or Maintenance Flow Regulation/Modification Removal of Riparian Vegetation Streambank Modification or Destabilization
	147.48	Rio San Antonio	100% Range Grazing -- Riparian or Upland Flow Regulation/Modification Removal of Riparian Vegetation Streambank Modification or Destabilization

Notes:
NA = Not applicable
[(a)] LA + MOS as $j/m^2/s$
[(b)] From the 2002-2004 303(d) list unless otherwise noted.
[(c)] Expressed as solar radiation.

6.5 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 that exceed the State Standards for the protection of aquatic habitat, namely the HQCWF and Cold Water Fishery (CWF) designed uses. 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. For example, historical cattle grazing along Comanche Creek has adversely impacted riparian vegetation and resulted in geomorphological stream channel instabilities (Photo 6.1). There have been a variety of efforts to stabilize and improve habitat along Comanche Creek (Bionomics Southwest 2003). Cattle and elk exclosures constructed in the 1980s and 1990s have improved riparian vegetation to conditions presented in Photo 6.2 (Bionomics Southwest 2003).

A variety of factors impact stream temperature (Figure 6.1). 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.

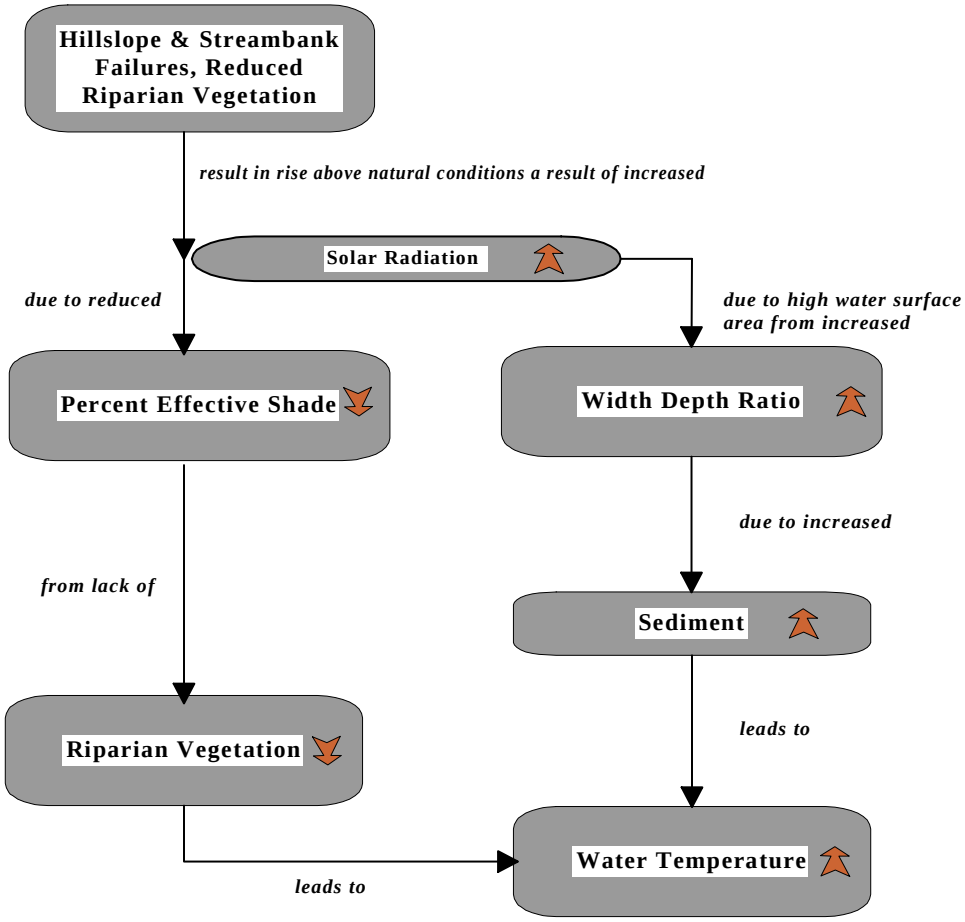
Riparian vegetation, stream morphology, hydrology, climate, geographic location, and aspect influence stream temperature. Although climate, geographic location, and aspect are outside of human control, the condition of the riparian area, channel morphology and hydrology can be affected by land use activities. Specifically, the elevated summertime stream temperatures attributable to anthropogenic causes in the Upper Rio Grande (Part 1) 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).

Figure 6.1 Factors That Impact Water Temperature



Analyses presented in these TMDLs demonstrate that defined loading capacities will ensure attainment of NM WQS. 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 1999b). The completed Pollutant Source(s) Documentation Protocol forms in **Appendix B** 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 6.13 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.

Photo 6.1 Grazing impacts on Comache Creek upstream. Note collapsed streambanks and loss of riparian vegetation to shade the stream, May 2000

Photo 6.2 Woody Riparian Vegetation Growing within Cattle and Elk Exclosure built in the 1990s, August 2002

6.6 Margin of Safety (MOS)

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

For this TMDL, there were no MOS adjustments 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 formulas developed by the USGS. One formula (Thomas et al. 1997) 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 (Waltemeyer 2002). See **Appendix E** for details.

As detailed in **Appendix E,** 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.

6.7 Uncertainty

Previous versions of SSTEMP were deterministic, meaning the user 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. Version 2.0 of SSTEMP 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 percent. 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 percent 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 percent 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 percent. Rather than prune the distribution at 100 percent, SSTEMP resamples to avoid over-specifying 100 percent 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 percent 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 percent 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 percent confidence intervals given.

6.8 Consideration of seasonal variation

Section 303(d)(1) of the CWA requires TMDLs to be “established at a level necessary to implement the applicable WQS with seasonal 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 NM WQS 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.

6.9 Future Growth

Estimations of future growth are not anticipated to lead to a significant increase for temperature that cannot be controlled with BMP implementation in this watershed. Because Taos County, Taos Valley Ski Basin, Angel Fire Resort have been growing rapidly over the last few decades, it is imperative that BMPs continue to be utilized and improved upon in this watershed.

7.0 MONITORING PLAN

Pursuant to Section 106(e)(1) of the Federal CWA, 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 NM. In accordance with the NM 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 approximately every seven years. The next scheduled monitoring date for the Upper Rio Grande watershed is 2008. The SWQB maintains current quality assurance and quality control plans to cover all monitoring activities. This document, called the QAPP, is updated and certified annually by EPA Region 6 (SWQB/NMED 2000b). 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 (U.S. District Court for the District of New Mexico 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 2004).

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 approximately every 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.

SWQB is in the process of developing a 10-year monitoring strategy for submittal to USEPA by September 30, 2004. Once developed, it will be available at the SWQB website: http://www.nmenv.state.nm.us/swqb/swqb.html. The strategy will detail both the extent of monitoring that can be accomplished with existing resources plus expanded monitoring strategies that could be implemented given additional resources. According to the draft proposed 8-year rotational cycle, which assumes the existing level of resources, the next time SWQB will intensive sample the Upper Rio Grande watershed is the year 2008.

It should be noted that a watershed 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 State's Integrated §303(d)/§305(b) listing process for waters requiring TMDLs.

8.0 IMPLEMENTATION OF TMDLS

8.1 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 Restoration Action Strategy (WRAS). The WRAS 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. The WRAS is essentially the Implementation Plan, or Phase Two of the TMDL process.

SWQB staff will assist with any technical assistance such as selection and application of BMPs needed to meet WRAS goals. 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 Watershed Restoration Action Strategy.

Implementation of BMPs within the watershed to reduce pollutant loading from nonpoint sources will be encouraged. Reductions from point sources will be addressed in revisions to discharge permits.

8.2 Time Line

The following table details the proposed implementation timeline (**Table 8.1**).

Table 8.1 Proposed Implementation Timeline

Implementation Actions	Year 1	Year 2	Year 3	Year 4	Year 5
Public Outreach and Involvement	X	X	X	X	X
Form watershed groups	X	X			
WRAS Development		X	X	X	
Establish Performance Targets		X			
Secure Funding		X	X		
Implement Management Measures (BMPs)		X	X	X	

Monitor BMPs		X	X	X	
Determine BMP Effectiveness				X	X
Re-evaluate Performance Targets				X	X

8.3 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 two times a year 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. Funding is available for both watershed group formation (which includes WRAS development) and on-the-ground projects to improve surface water quality and associated habitat. Further information on funding from the CWA §319 (h) can be found at the NM Environment Department website: http://www.nmenv.state.nm.us.

9.0 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 NMAC 20.6.4.10.C) (NMAC 2002) 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 319 Program has been developed in a coordinated manner with the State's 303(d) process. All 319 watersheds that are targeted in the annual request for proposals (RFP) process coincidental with the State's biennial impaired waters list as approved by EPA. The State has given a high priority for funding, assessment, and restoration activities to these watersheds.

As a constituent agency, NMED has the authority under 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 including a violation caused by a nonpoint source. The 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.

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.

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 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 August 10, 2004. 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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APPENDIX A
CONVERSION FACTOR DERIVATION

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Flow (as million gallons per day [MGD]) and concentration values (milligrams per liter [mg/L]) must be multiplied by a conversion factor in order to express the load in units "pounds per day." The following expressions detail how the conversion factor was determined:

TMDL Calculation:

$$Flow\left(MGD\right)\times Concentration\left(\frac{mg}{L}\right)\times CF\left(\frac{L-lb}{gal-mg}\right)=Load\left(\frac{lb}{day}\right)$$

Conversion Factor Derivation:

$$CF = 10^{6}\times\frac{3.785\,L}{gal}\times\frac{1lb}{454{,}000\,mg}=8.34\,\frac{L-lb}{gal-mg}$$

APPENDIX B
POLLUTANT SOURCE(S) DOCUMENTATION PROTOCOL

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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.

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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 Grande (Red River to NM-CO border)

SEGMENT NUMBER: NM-2119-05

BASIN: Upper Rio Grande

PARAMETER: Temperature

STAFF MAKING ASSESSMENT:

DATE: 02/04/04

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 (upstream)
- ☐ 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	☐	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: Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo)

SEGMENT NUMBER: NM-2119_20

BASIN: Upper Rio Grande

PARAMETER: Temperature

STAFF MAKING ASSESSMENT:

DATE: 02/04/04

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

FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

CODES FOR USES NOT FULLY SUPPORTED

☐	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: Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho)
SEGMENT NUMBER: NM-2119_30
BASIN: Upper Rio Grande
PARAMETER: Stream Bottom Dep.
STAFF MAKING ASSESSMENT: JS AF
DATE: 02/04/04

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

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☒	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: Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho)
SEGMENT NUMBER: NM-2119.30
BASIN: Upper Rio Grande
PARAMETER: Temperature
STAFF MAKING ASSESSMENT: JS AF
DATE: 02/04/04

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

FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

CODES FOR USES NOT FULLY SUPPORTED

☒	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: Rio Pueblo de Taos (Rio Grande del Rancho to Taos Pueblo bdy)
SEGMENT NUMBER: NM-2120.A_511
BASIN: Upper Rio Grande
PARAMETER: Temperature
STAFF MAKING ASSESSMENT: AF
DATE: 02/04/04

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

FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

CODES FOR USES NOT FULLY SUPPORTED

☑	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: Rio Grande del Rancho (Rio Pueblo de Taos to Hwy 518)

SEGMENT NUMBER: NM-2120.A_501

BASIN: Upper Rio Grande

PARAMETER: Conductivity

STAFF MAKING ASSESSMENT:

DATE: 02/04/04

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

FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

CODES FOR USES NOT FULLY SUPPORTED

☒	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: Rio Fernando de Taos (Rio Pueblo de Taos to headwaters)
SEGMENT NUMBER: NM-2120.A-512
BASIN: Upper Rio Grande
PARAMETER: Temperature
STAFF MAKING ASSESSMENT: AF
DATE: 02/04/04

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

FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

CODES FOR USES NOT FULLY SUPPORTED

☒	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: Rio Fernando de Taos (Rio Pueblo de Taos to headwaters)

SEGMENT NUMBER: NM-2120.A_512

BASIN: Upper Rio Grande

PARAMETER: Conductivity

STAFF MAKING ASSESSMENT: AF

DATE: 02/04/04

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

FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

CODES FOR USES NOT FULLY SUPPORTED

- [x] 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 Hondo (Rio Grande to USFS boundary)

SEGMENT NUMBER: NM-2120.A_600

BASIN: Upper Rio Grande

PARAMETER: Temperature

STAFF MAKING ASSESSMENT:

DATE: 02/04/04

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)
- [x] 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
- [ ] 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
- [x] 7600 REMOVAL OF RIPARIAN VEGETATION
- [x] 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
- [x] 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] 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	☐	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: Costilla Creek (Diversion above Costilla to Comanche Creek)
SEGMENT NUMBER: NM-2120.A_820
BASIN: Upper Rio Grande
PARAMETER: Temperature
STAFF MAKING ASSESSMENT: MM
DATE: 02/04/04

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 (historic)
☐	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

FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

CODES FOR USES NOT FULLY SUPPORTED

☑	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: Rio de los Pinos (Colorado border to headwaters)

SEGMENT NUMBER: NM-2120.A_900

BASIN: Upper Rio Grande

PARAMETER: Temperature

STAFF MAKING ASSESSMENT:

DATE: 02/04/04

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

FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

CODES FOR USES NOT FULLY SUPPORTED

☒	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: Comanche Creek (Costilla Creek to Little Costilla Creek)
SEGMENT NUMBER: NM-2120.A_827
BASIN: Upper Rio Grande
PARAMETER: Temperature
STAFF MAKING ASSESSMENT: MM
DATE: 02/04/04

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 (historic)
☐	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 (historic)
☐	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

FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

CODES FOR USES NOT FULLY SUPPORTED

- [x] 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 San Antonio

SEGMENT NUMBER: NM-2120.A_901

BASIN: Upper Rio Grande

PARAMETER: Temperature

STAFF MAKING ASSESSMENT:

DATE: 02/12/04

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
- [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
- [ ] 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
- [x] 7600 REMOVAL OF RIPARIAN VEGETATION
- [x] 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
- [x] 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] 9000 SOURCE UNKNOWN

APPENDIX C
CROSS-SECTION SURVEY, PEBBLE COUNT, AND HABITAT FIELD DATA

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BF 1870
CFS

Rio Grande @ Cerro (above Red River)

* DATE * TIME *	WIDTH *	DISCHARGE * CFS
10/4/1988	52	79.6
11/16/1988	113	478
12/21/1988	114	429
1/25/1989	102	375
3/9/1989	110	643
4/26/1989	116	707
6/6/1989	97	282
7/19/1989	97	102
10/12/1989	104	111
11/16/1989	94	128
2/14/1990	99	273
3/14/1990	120	436
4/12/1990	92	129
6/7/1990	118	405
7/19/1990	100	289
8/9/1990	93	163
9/20/1990	88	83.5
10/17/1990	96	323
12/19/1990	90.6	276
1/23/1991	90	372
2/13/1991	112	352
7/17/1991	94	309
8/21/1991	90	231
10/3/1991	88	152
10/16/1991	85	131
1/6/1992	95	376
5/19/1992	107	272
7/14/1992	94	168
8/11/1992	96	195
9/15/1992	94	135
10/14/1992	101	122
11/12/1992	110	281
1/6/1993	111	331
2/24/1993	114	414
7/20/1993	103	302
8/18/1993	102	170
9/28/1993	106	205
11/2/1993	122	297
12/6/1993	110	280
7/19/1994	93	93.3
8/23/1994	99	77.8
11/29/1995	96	231
3/29/1996	100	305
6/19/1996	89	114
10/17/1996	60	76.9
11/12/1996	86	138
12/18/1996	52	111
2/5/1997	98	403
3/5/1997	91	427

- 97

5/5/1997	99	368
7/11/1997	98	465
8/7/1997	96	462
1/12/1998	94	380
2/24/1998	96	494
4/20/1998	96	329
5/4/1998	94	663
5/19/1998	95	558
6/25/1998	92	267
7/29/1998	69	192
9/3/1998	62	88.6
10/28/1998	96	177
1/5/1999	93	380
2/3/1999	91	345
3/9/1999	93	472
1/12/2000	93	343
2/16/2000	95	454
4/5/2000	94	329
7/5/2000	60	91.6
8/17/2000	45	55.7
8/17/2000	44	52.8
10/13/2000	48	65.6
10/13/2000	48	67.2
2/21/2001	94	333
4/27/2001	95	275
8/1/2001	93	156
10/4/2001	54	80.9
11/15/2001	95	157
4/23/2002	61	108
6/1/2002	54	67.5
7/10/2002	32	48
7/10/2002	50	50.6
8/23/2002	45	45.7
10/2/2002	50	65.9
11/13/2002	53	83.4
12/5/2002	98	225
2/12/2003	91	238
3/11/2003	96	215
4/16/2003	51	81.6
5/15/2003	62	106
6/5/2003	67	197
7/10/2003	60	90.2
8/12/2003	61.5	55.1

Rio Grande @ Colorado Border

Width	Discharge
100	272
87	320
156	437
184	737
77	187
97	173
101	246
48	37
46	54
46	36
72	139
99	309
85	309
94	318
102	422
210	1010
265	1760
271	963
187	897
191	519
177	512
66	92
40	46
45	36
38	39
124	66
68	119
122	187
82	213
166	314
77	100
87	176
242	1030
232	1830
87	192
130	191
115	169
110	91
105	88
107	71
139	242
130	168
113	264
104	283
139	430
157	487
168	1050
153	459
272	1390
277	1540
177	1210

175	1240
140	229
110	55
123	90
110	94
158	268
81	258
168	1050
270	1440
160	528
117	158
122	91
134	127
118	86
123	119
135	242
130	245
142	289
125	335
160	738
175	1170
272	1500
275	1400
262	1160
129	104
268	1240
130	118
142	236
160	483
141	380
129	302
143	484
132	304
141	342
275	1590
152	290
66	48
44	35.2
42	31
119	110
154	433
150	417
148	427
158	581
147	399
158	832
162	876
273	1680
110	278
98	166
130	174
136	188

119	195
123	374
129	385
152	508
130	230
139	223
108	65
110	55
32	15
39	37
42	38
115	114
115	162
124	331
116	343
104	383
164	745
142	461
169	1070
139	233
108	65
110	55
32	15
39	37
42	39
115	114
115	162
124	331
116	343
104	383
156	386
164	745
142	461
168	1150
149	495
152	502
168	1040
169	1020
160	654
150	445
158	441
152	372
158	624
143	479
166	1010
52	95
60	114
49	62
43	55
125	168
144	274
144	335

135	378
148	417
126	136
155	560
273	1500
186	1010
157	765
204	1010
170	646
144	442
142	502
150	346
140	318
151	408
134	230
140	334
142	259
55	51
61	15
28	9
80	17
122	84
132	165
108	209
85	215
144	340
164	577
159	582
235	2040
232	1910
81	117
82	109
64	43
64	53
134	291
64	43
64	53
134	291
118	273
90	252
96	260
136	300
64	27
62	23
62	18
24	4.63
24	7.81
90	21
61	21
128	129
60	110
127	197

126	177
112	85
80	75
139	246
119	93
43	14
31	11
58	11
58	16
88	34

**********WinXSPRO**********
templet.out
Input File: C:\WXSPRO20\TEMPLET.DAT
Run Date: 11/06/03
Analysis Procedure: Hydraulics
Cross Section Number: 1
Survey Date: 11/04/03

Rio Pueblo de Taos
(Rio Grande To
Arroyo de Alamo

Subsections/Dividing stations
A

Resistance Method: Manning's n

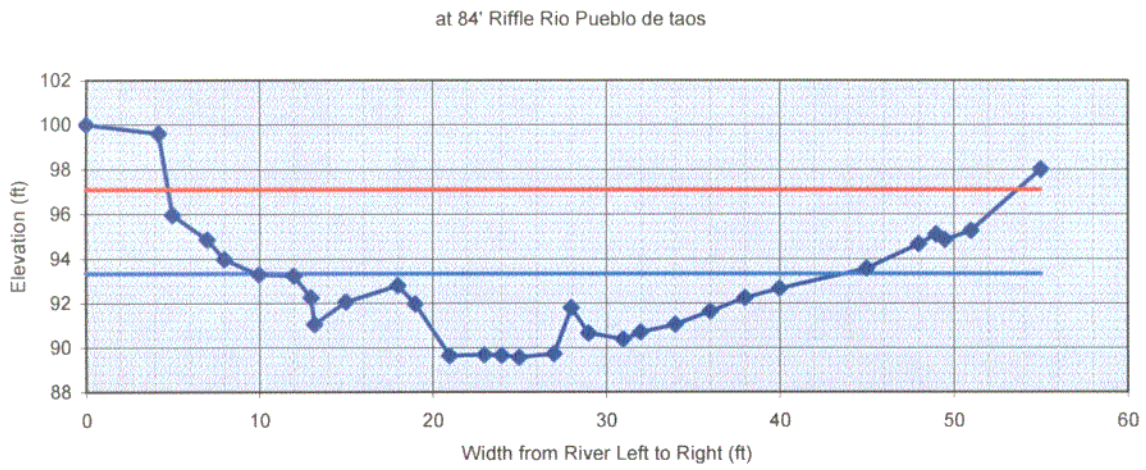
SECTION	A
Low Stage n	0.206
High Stage n	0.062

use this

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	0.16	4.55	4.52	0.03	0.03	0.043	0.206	0.16	0.02
0.20	T	0.74	6.23	6.13	0.12	0.12	0.043	0.202	0.37	0.27
0.30	T	1.36	6.48	6.27	0.21	0.22	0.043	0.198	0.55	0.75
0.40	T	2.00	6.72	6.40	0.30	0.31	0.043	0.194	0.71	1.41
0.50	T	2.64	6.96	6.54	0.38	0.40	0.043	0.190	0.85	2.25
0.60	T	3.30	7.21	6.67	0.46	0.50	0.043	0.187	0.98	3.25
0.70	T	3.98	7.45	6.80	0.53	0.58	0.043	0.183	1.11	4.43
0.80	T	4.66	7.69	6.94	0.61	0.67	0.043	0.179	1.24	5.78
0.90	T	5.41	8.90	8.02	0.61	0.67	0.043	0.175	1.27	6.85
1.00	T	6.27	10.22	9.21	0.61	0.68	0.043	0.171	1.30	8.18
1.10	T	7.25	11.41	10.26	0.63	0.71	0.043	0.167	1.37	9.90
1.20	T	8.31	12.29	10.98	0.68	0.76	0.043	0.163	1.46	12.11
1.30	T	9.44	13.25	11.77	0.71	0.80	0.043	0.159	1.55	14.62
1.40	T	10.66	14.21	12.56	0.75	0.85	0.043	0.155	1.64	17.50
1.50	T	11.96	15.18	13.35	0.79	0.90	0.043	0.152	1.74	20.80
1.60	T	13.33	16.21	14.11	0.82	0.94	0.043	0.148	1.84	24.48
1.70	T	14.78	17.25	14.86	0.86	0.99	0.043	0.144	1.94	28.66
1.80	T	16.30	18.28	15.62	0.89	1.04	0.043	0.140	2.05	33.37
1.90	T	17.90	19.32	16.37	0.93	1.09	0.043	0.136	2.16	38.67
2.00	T	19.58	20.35	17.13	0.96	1.14	0.043	0.132	2.28	44.63
2.10	T	21.33	21.38	17.88	1.00	1.19	0.043	0.128	2.41	51.32
2.20	T	23.15	22.41	18.62	1.03	1.24	0.043	0.124	2.54	58.83
2.30	T	25.05	23.24	19.26	1.08	1.30	0.043	0.120	2.70	67.58
2.40	T	27.00	24.02	19.87	1.12	1.36	0.043	0.116	2.87	77.44
2.50	T	29.02	24.84	20.53	1.17	1.41	0.043	0.113	3.04	88.34
2.60	T	31.12	25.86	21.40	1.20	1.45	0.043	0.109	3.22	100.06
2.70	T	33.30	26.92	22.32	1.24	1.49	0.043	0.105	3.40	113.14
2.80	T	35.59	28.13	23.44	1.27	1.52	0.043	0.101	3.58	127.46
2.90	T	37.99	29.35	24.55	1.29	1.55	0.043	0.097	3.78	143.69
3.00	T	40.50	30.56	25.67	1.33	1.58	0.043	0.093	4.00	162.10
3.10	T	43.12	31.78	26.79	1.36	1.61	0.043	0.089	4.24	182.98
3.20	T	45.86	33.06	27.97	1.39	1.64	0.043	0.085	4.50	206.51
3.30	T	48.70	33.93	28.78	1.44	1.69	0.043	0.081	4.83	235.06
3.40	T	51.61	34.63	29.43	1.49	1.75	0.043	0.078	5.20	268.24
3.50	T	54.59	35.33	30.08	1.54	1.81	0.043	0.074	5.60	305.95
3.60	T	57.63	36.03	30.73	1.60	1.88	0.043	0.070	6.05	348.94
3.70	T	60.76	38.01	32.67	1.60	1.86	0.043	0.066	6.41	389.51
3.80	T	64.12	39.48	34.12	1.62	1.88	0.043	0.062	6.89	441.51

STAGE	ALPHA	FROUDE
0.10	1.00	0.15
0.20	1.00	0.19
0.30	1.00	0.21
0.40	1.00	0.22
0.50	1.00	0.24
0.60	1.00	0.25
0.70	1.00	0.26
0.80	1.00	0.27
0.90	1.00	0.27
1.00	1.00	0.28
1.10	1.00	0.29
1.20	1.00	0.30
1.30	1.00	0.30
1.40	1.00	0.31
1.50	1.00	0.32
1.60	1.00	0.33
1.70	1.00	0.34
1.80	1.00	0.35
1.90	1.00	0.36
2.00	1.00	0.38

Cross Section



section:	at 84'
	Riffle
stream:	Rio Pueblo de taos
location:	above the Rio Grande (Rio Grande to Arroyo del Alamo)
description:	B2a Canopy 28%
height of instrument (ft):	100.20

notes	omit pt.	distance (ft)	FS (ft)	elevation
LBP	☐	0	0-Jan	100
boulder	☐	4.2	0.6	99.6
LFPW	☐	5	4.24	95.96
	☐	7	5.34	94.86
	☐	8	6.23	93.97
LBF	☐	10	6.91	93.29
	☐	12	6.97	93.23
	☐	13	7.95	92.25
LWE	☐	13.2	9.15	91.05
boulder	☐	15	8.14	92.06
	☐	18	7.4	92.8
	☐	19	8.23	91.97
TW	☐	21	10.56	89.64
	☐	23	10.52	89.68
	☐	24	10.55	89.65
	☐	25	10.63	89.57
	☐	27	10.48	89.72
	☐	28	8.41	91.79
	☐	29	9.55	90.65
	☐	31	9.82	90.38
	☐	32	9.5	90.7
REW	☐	34	9.15	91.05
	☐	36	8.56	91.64
	☐	38	7.95	92.25
	☐	40	7.54	92.66
RBF	☐	45	6.63	93.57
	☐	48	5.53	94.67
	☐	49	5.1	95.1
	☐	49.5	5.34	94.86
	☐	51	4.94	95.26
RBP and	☐	55	2.2	98
RFPW	☐			
	☐			

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
6.87	6.87	50.0	4.25	0.062
93.33	93.33			

dimensions			
62.8	x-section area	1.9	d mean
33.8	width	39.1	wet P
3.8	d max	1.6	hyd radi
3.8	bank ht	18.2	w/d ratio
50.0	W flood prone area	1.5	ent ratio

hydraulics	
6.8	velocity (ft/sec)
425.1	discharge rate, Q (cfs)
4.25	shear stress ((lbs/ft sq)
1.48	shear velocity (ft/sec)
33.357	unit stream power (lbs/ft/sec)
0.77	Froude number
4.6	friction factor u/u*
~~1220.1~~	threshold grain size (mm)

check from channel material			
1024	measured D84 (mm)		
0.6	relative roughness	1.4	fric. factor
0.208	Manning's n from channel material		

**********WinXSPRO**********
templet.out
Input File: C:\WXSPRO20\TEMPLET.DAT
Run Date: 11/10/03
Analysis Procedure: Hydraulics
Cross Section Number: 1
Survey Date: 11/04/03

Rio Pueblo de Taos @ Los Cordovas Gage - Above WWTP (@ Arroyo del Alamo To RG del Rancho)

Subsections/Dividing stations
A

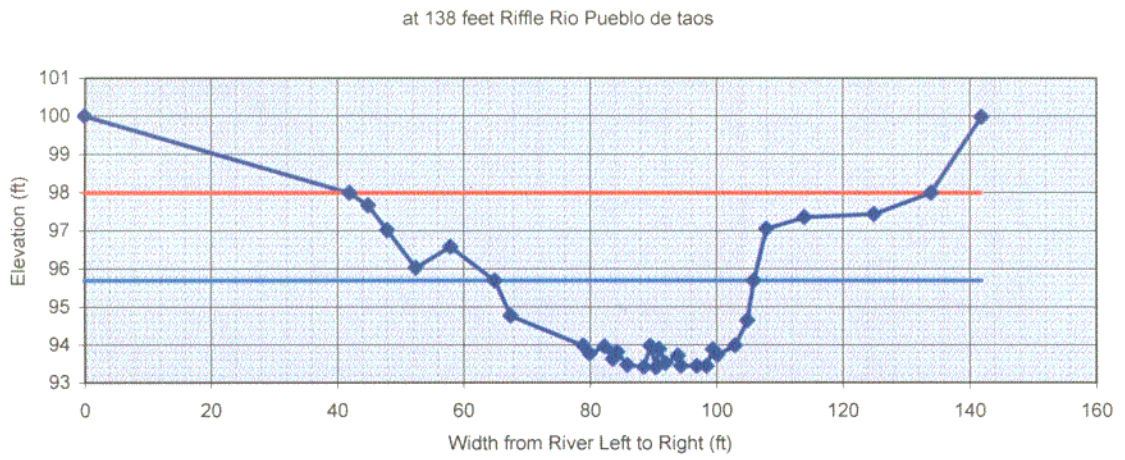
Resistance Method: Manning's n

SECTION	A
Low Stage n	0.018
High Stage n	0.018

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	0.37	7.46	7.34	0.05	0.05	0.004	0.018	0.71	0.26
0.20	T	1.21	9.94	9.65	0.12	0.13	0.004	0.018	1.28	1.55
0.30	T	2.32	13.23	12.74	0.18	0.18	0.004	0.018	1.64	3.81
0.40	T	3.76	17.24	16.56	0.22	0.23	0.004	0.018	1.90	7.13
0.50	T	5.66	22.07	21.20	0.26	0.27	0.004	0.018	2.11	11.95
0.60	T	7.94	25.10	24.17	0.32	0.33	0.004	0.018	2.43	19.31
0.70	T	10.45	26.88	25.93	0.39	0.40	0.004	0.018	2.79	29.14
0.80	T	13.13	28.66	27.69	0.46	0.47	0.004	0.018	3.11	40.85
0.90	T	15.99	30.44	29.45	0.53	0.54	0.004	0.018	3.41	54.48
1.00	T	19.02	32.22	31.20	0.59	0.61	0.004	0.018	3.68	70.07
1.10	T	22.23	33.99	32.96	0.65	0.67	0.004	0.018	3.94	87.67
1.20	T	25.61	35.77	34.72	0.72	0.74	0.004	0.018	4.19	107.31
1.30	T	29.17	37.46	36.38	0.78	0.80	0.004	0.018	4.43	129.25
1.40	T	32.88	38.82	37.69	0.85	0.87	0.004	0.018	4.69	154.11
1.50	T	36.67	39.25	38.06	0.93	0.96	0.004	0.018	5.00	183.47
1.60	T	40.49	39.68	38.42	1.02	1.05	0.004	0.018	5.31	214.89
1.70	T	44.35	40.10	38.79	1.11	1.14	0.004	0.018	5.60	248.33
1.80	T	48.25	40.53	39.16	1.19	1.23	0.004	0.018	5.88	283.74
1.90	T	52.19	40.96	39.52	1.27	1.32	0.004	0.018	6.15	321.08
2.00	T	56.16	41.39	39.89	1.36	1.41	0.004	0.018	6.42	360.32
2.10	T	60.16	41.82	40.26	1.44	1.49	0.004	0.018	6.67	401.43
2.20	T	64.21	42.24	40.62	1.52	1.58	0.004	0.018	6.92	444.38
2.30	T	68.29	42.67	40.99	1.60	1.67	0.004	0.018	7.16	489.15

STAGE	ALPHA	FROUDE
0.10	1.00	0.55
0.20	1.00	0.64
0.30	1.00	0.68
0.40	1.00	0.70
0.50	1.00	0.72
0.60	1.00	0.75
0.70	1.00	0.77
0.80	1.00	0.80
0.90	1.00	0.82
1.00	1.00	0.83
1.10	1.00	0.85
1.20	1.00	0.86
1.30	1.00	0.87
1.40	1.00	0.88
1.50	1.00	0.90
1.60	1.00	0.91
1.70	1.00	0.92
1.80	1.00	0.93
1.90	1.00	0.94
2.00	1.00	0.95
2.10	1.00	0.96
2.20	1.00	0.97
2.30	1.00	0.98

Cross Section



section:	at 138 feet
	Riffle
stream:	Rio Pueblo de taos
location:	at USGS Gage near Los Cordovas (Arroyo del Alamo to Rio Grande del Rancho_
description:	Smolka/Scaeffer/Davis 24-Aug-00 Canopy cover 4.3%
height of instrument (ft):	103.04

notes	omit pt.	distance (ft)	FS (ft)	elevation
LBP	☐	0	3-Jan	100
LFPW	☐	42	5.05	97.99
	☐	45	5.38	97.66
	☐	48	6.02	97.02
	☐	52.5	7.01	96.03
	☐	58	6.46	96.58
LBF	☐	65	7.35	95.69
	☐	67.5	8.27	94.77
LWE	☐	79	9.06	93.98
	☐	80	9.28	93.76
	☐	82.4	9.08	93.96
	☐	83.7	9.42	93.62
	☐	84.4	9.23	93.81
	☐	86	9.58	93.46
	☐	88.6	9.63	93.41
Rock	☐	89.6	9.07	93.97
TW	☐	90.5	9.65	93.39
	☐	91	9.15	93.89
	☐	92	9.53	93.51
	☐	94	9.33	93.71
	☐	94.5	9.6	93.44
	☐	97	9.6	93.44
	☐	98.5	9.6	93.44
	☐	99.5	9.16	93.88
	☐	100.2	9.31	93.73
RWE	☐	103	9.06	93.98
	☐	105	8.4	94.64
RBF	☐	106	7.35	95.69
	☐	108	5.99	97.05
	☐	114	5.69	97.35
Chamisa edc	☐	125	5.6	97.44
RFPW	☐	134	5.05	97.99
RBP	☐	142	3.06	99.98

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
7.35		92.0	0.4	0.018
95.69	---			

dimensions			
68.3	x-section area	1.7	d mean
41.0	width	42.7	wet P
2.3	d max	1.6	hyd radi
0.0	bank ht	24.6	w/d ratio
92.0	W flood prone area	2.2	ent ratio

hydraulics	
7.1	velocity (ft/sec)
487.9	discharge rate, Q (cfs)
0.40	shear stress ((lbs/ft sq)
0.45	shear velocity (ft/sec)
2.971	unit stream power (lbs/ft/sec)
0.95	Froude number
15.7	friction factor u/u*
23.9	threshold grain size (mm)

check from channel material			
1	measured D84 (mm)		
1015.5	relative roughness	20.0	fric. factor
0.014	Manning's n from channel material		

Pebble Count

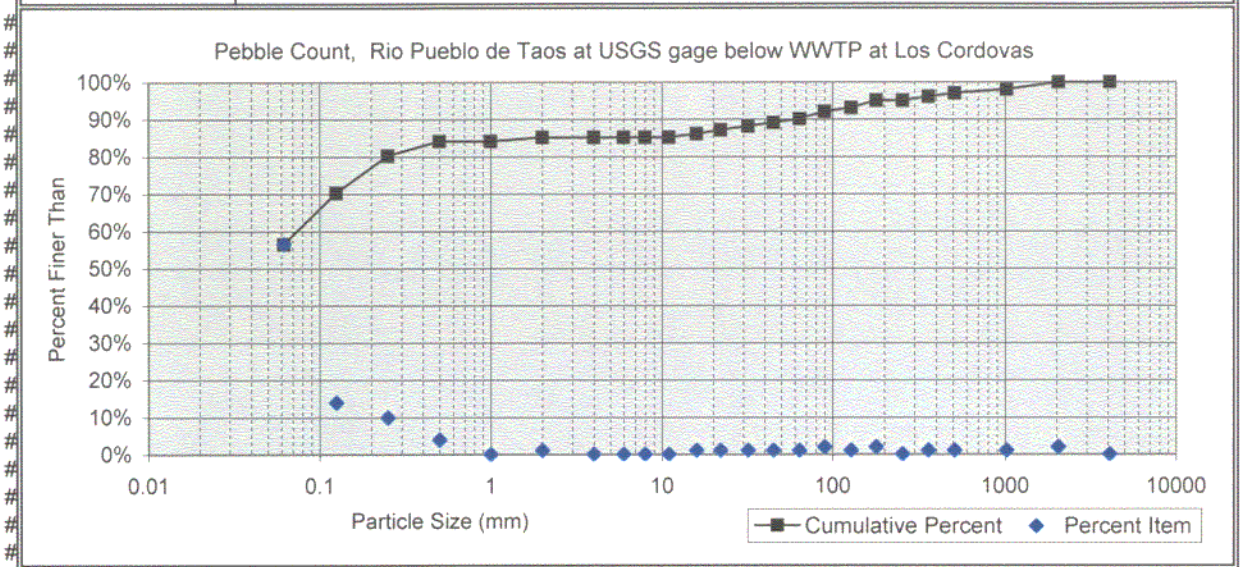
Pebble Count,

Material	Size Range (mm)		Count
silt/clay	0	0.062	**57**
very fine sand	0.062	0.13	**14**
fine sand	0.13	0.25	**10**
medium sand	0.25	0.5	**4**
coarse sand	0.5	1	
very coarse sand	1	2	**1**
very fine gravel	2	4	
fine gravel	4	6	
fine gravel	6	8	
medium gravel	8	11	
medium gravel	11	16	**1**
coarse gravel	16	22	**1**
coarse gravel	22	32	**1**
very coarse gravel	32	45	**1**
very coarse gravel	45	64	**1**
small cobble	64	90	**2**
medium cobble	90	128	**1**
large cobble	128	180	**2**
very large cobble	180	256	
small boulder	256	362	**1**
small boulder	362	512	**1**
medium boulder	512	1024	**1**
large boulder	1024	2048	**2**
very large boulder	2048	4096	
bedrock			
Total Particle Count:			101

stream: **Rio Pueblo de Taos at USGS gage below WWTP at Los Cordovas**

August 24 2000

Note:



Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
#N/A	#N/A	#N/A	0	178	56%	29%	5%	5%	5%	0%

Rio Pueblo de Taos
@ USGS Gage blw WWTP
8-24-00

DRAFT REVISION—July 19, 1999

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

STREAM NAME	LOCATION	
STATION # _____ RIVERMILE _____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE _____ 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	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	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 58	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

T	XS	B
0	0	0
4-0's	4-0's	4 0's
0	0	13

DRAFT REVISION—July 19, 1999

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

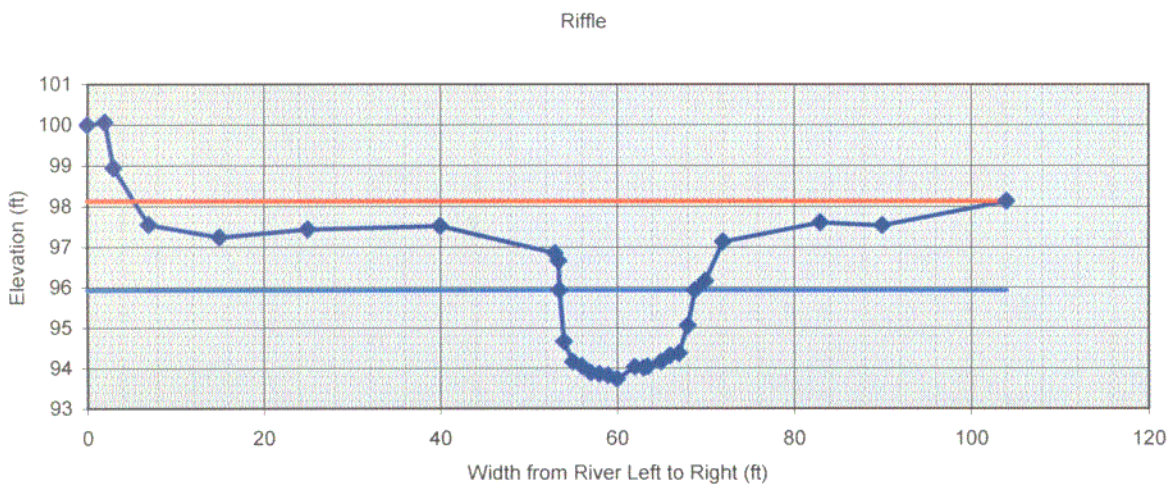
Parameters to be evaluated broader than sampling reach

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	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 107

4.3%

Cross Section



section:	at 474 feet
	Riffle
stream:	Rio Grande del Rancho
location:	At fort Bergwin above Pot Creek
description:	E5 August 23 2000 Smolka/Davis/Schaeaffer
height of instrument (ft):	105.05

notes	omit pt.	distance (ft)	FS (ft)	elevation
LBP	☐	0	5-Jan	100
	☐	2	4.99	100.06
	☐	3	6.11	98.94
	☐	7	7.5	97.55
	☐	15	7.81	97.24
	☐	25	7.61	97.44
	☐	40	7.53	97.52
	☐	53	8.2	96.85
top bnk	☐	53.4	8.39	96.66
LBP	☐	53.5	9.12	95.93
Bnk bottom	☐	54	10.39	94.66
LWE	☐	55	10.89	94.16
	☐	56	10.99	94.06
	☐	57	11.16	93.89
	☐	58	11.19	93.86
	☐	59	11.23	93.82
TW	☐	60	11.32	93.73
	☐	62	11.02	94.03
	☐	63	11.04	94.01
	☐	63.5	11.01	94.04
RWE	☐	65	10.89	94.16
	☐	66	10.73	94.32
	☐	67	10.68	94.37
	☐	68	9.99	95.06
RBF	☐	68.8	9.12	95.93
	☐	70	8.89	96.16
	☐	72	7.92	97.13
	☐	83	7.45	97.6
	☐	90	7.52	97.53
RFPW	☐	104	6.92	98.13

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
9.12	8.39	99.0	0.07	0.035
95.93	96.66			

dimensions			
26.5	x-section area	1.7	d mean
15.3	width	16.9	wet P
2.2	d max	1.6	hyd radi
2.9	bank ht	8.8	w/d ratio
99.0	W flood prone area	6.5	ent ratio

hydraulics	
1.5	velocity (ft/sec)
40.0	discharge rate, Q (cfs)
0.07	shear stress ((lbs/ft sq)
0.19	shear velocity (ft/sec)
0.114	unit stream power (lbs/ft/sec)
0.04	Froude number
8.1	friction factor u/u*
4.7	threshold grain size (mm)

check from channel material			
80	measured D84 (mm)		
6.6	relative roughness	7.5	fric. factor
0.038	Manning's n from channel material		

**********WinXSPRO**********
templet.out
Input File: C:\WXSPRO20\TEMPLET.DAT
Run Date: 11/24/03
Analysis Procedure: Hydraulics
Cross Section Number: 1
Survey Date: 11/04/03

Subsections/Dividing stations
A

Resistance Method: Manning's n

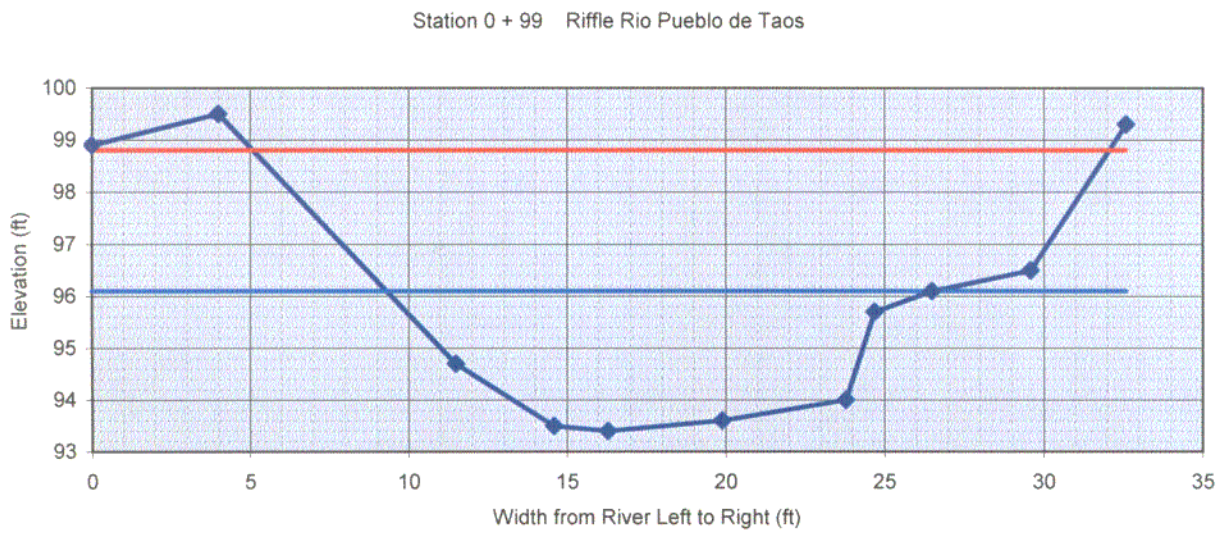
SECTION	A
Low Stage n	0.080
High Stage n	0.078

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	0.17	3.50	3.50	0.05	0.05	0.007	0.080	0.21	0.04
0.20	T	0.63	5.58	5.56	0.11	0.11	0.007	0.080	0.36	0.23
0.30	T	1.24	6.84	6.79	0.18	0.18	0.007	0.080	0.50	0.62
0.40	T	1.99	8.10	8.02	0.25	0.25	0.007	0.080	0.61	1.22
0.50	T	2.85	9.35	9.25	0.30	0.31	0.007	0.080	0.71	2.02
0.60	T	3.84	10.61	10.49	0.36	0.37	0.007	0.080	0.79	3.05
0.70	T	4.90	11.00	10.80	0.45	0.45	0.007	0.080	0.91	4.48
0.80	T	6.00	11.39	11.11	0.53	0.54	0.007	0.079	1.02	6.13
0.90	T	7.12	11.78	11.42	0.60	0.62	0.007	0.079	1.12	8.00
1.00	T	8.28	12.17	11.73	0.68	0.71	0.007	0.079	1.22	10.07
1.10	T	9.47	12.56	12.04	0.75	0.79	0.007	0.079	1.30	12.34
1.20	T	10.69	12.95	12.35	0.83	0.87	0.007	0.079	1.39	14.81
1.30	T	11.94	13.34	12.66	0.90	0.94	0.007	0.079	1.46	17.48
1.40	T	13.22	13.64	12.87	0.97	1.03	0.007	0.079	1.55	20.42
1.50	T	14.51	13.94	13.08	1.04	1.11	0.007	0.079	1.62	23.55
1.60	T	15.83	14.24	13.29	1.11	1.19	0.007	0.079	1.70	26.87
1.70	T	17.17	14.53	13.50	1.18	1.27	0.007	0.079	1.77	30.37
1.80	T	18.53	14.83	13.71	1.25	1.35	0.007	0.079	1.84	34.06
1.90	T	19.91	15.13	13.92	1.32	1.43	0.007	0.079	1.90	37.92
2.00	T	21.32	15.43	14.13	1.38	1.51	0.007	0.079	1.97	41.97
2.10	T	22.74	15.73	14.34	1.45	1.59	0.007	0.078	2.03	46.20
2.20	T	24.18	16.03	14.55	1.51	1.66	0.007	0.078	2.09	50.60
2.30	T	25.65	16.33	14.76	1.57	1.74	0.007	0.078	2.15	55.18
2.40	T	27.15	16.97	15.36	1.60	1.77	0.007	0.078	2.18	59.19
2.50	T	28.72	17.62	15.97	1.63	1.80	0.007	0.078	2.21	63.46
2.60	T	30.35	18.26	16.57	1.66	1.83	0.007	0.078	2.24	67.98
2.70	T	32.04	18.91	17.18	1.69	1.86	0.007	0.078	2.27	72.76

STAGE	ALPHA	FROUDE
0.10	1.00	0.17
0.20	1.00	0.19
0.30	1.00	0.21
0.40	1.00	0.22
0.50	1.00	0.22
0.60	1.00	0.23
0.70	1.00	0.24
0.80	1.00	0.25
0.90	1.00	0.25
1.00	1.00	0.26
1.10	1.00	0.26
1.20	1.00	0.26
1.30	1.00	0.27
1.40	1.00	0.27
1.50	1.00	0.27
1.60	1.00	0.27
1.70	1.00	0.28
1.80	1.00	0.28
1.90	1.00	0.28
2.00	1.00	0.28
2.10	1.00	0.28
2.20	1.00	0.29
2.30	1.00	0.29
2.40	1.00	0.29
2.50	1.00	0.29
2.60	1.00	0.29
2.70	1.00	0.29

Rio Pueblo de Taos @ USGS Gage
at Pueblo (Rio Grande del Rancho To HWY)
≅ 1/2 Way

Cross Section



section:	Station 0 + 99 — 56-57 feet upstream of gage
	Riffle
stream:	Rio Pueblo de Taos — Moody et al August 12, 1998
location:	at USGS gage at Pueblo — 66.6 square mile ws
description:	B4
height of instrument (ft):	103.90

notes	omit pt.	distance (ft)	FS (ft)	elevation
LBP	☐	0	5	98.9
	☐	4	4.4	99.5
	☐	11.5	9.2	94.7
	☐	14.6	10.4	93.5
Thalweg	☐	16.3	10.5	93.4
	☐	19.9	10.3	93.6
	☐	23.8	9.9	94
	☐	24.7	8.2	95.7
RBF	☐	26.5	7.8	96.1
	☐	29.6	7.4	96.5
RBP	☐	32.6	4.6	99.3
	☐			
	☐			
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	☐			
	☐			
	☐			
	☐			
	☐			
	☐			
	☐			
	☐			
	☐			
	☐			

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
7.8	4.6	27.5	0.75	0.078
96.1	99.3			

dimensions			
32.1	x-section area	1.9	d mean
17.2	width	18.9	wet P
2.7	d max	1.7	hyd radi
5.9	bank ht	9.2	w/d ratio
27.5	W flood prone area	1.6	ent ratio

hydraulics	
2.3	velocity (ft/sec)
75.2	discharge rate, Q (cfs)
0.79	shear stress ((lbs/ft sq)
0.64	shear velocity (ft/sec)
2.046	unit stream power (lbs/ft/sec)
0.09	Froude number
3.7	friction factor u/u*
51.2	threshold grain size (mm)

check from channel material			
200	measured D84 (mm)		
2.8	relative roughness	5.4	fric. factor
0.053	Manning's n from channel material		

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

templet.out
Input File: C:\WXSPRO20\TEMPLET.DAT
Run Date: 11/13/03
Analysis Procedure: Hydraulics
Cross Section Number: 1
Survey Date: 11/04/03

Subsections/Dividing stations
A / 34.86/ @

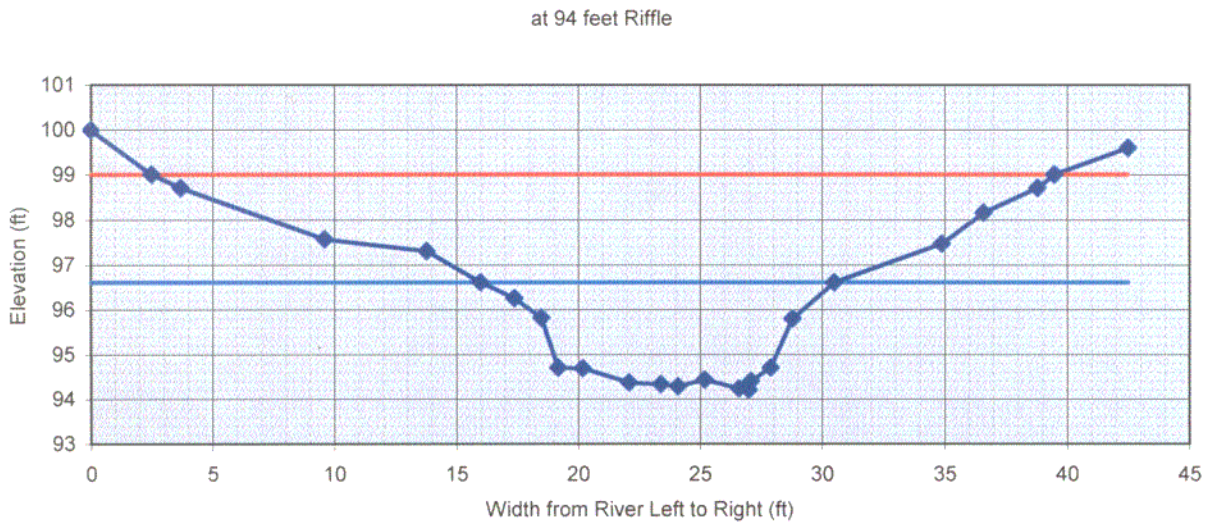
Resistance Method: Thorne and Zevenbergen
D84: 64.000 mm

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	0.06	1.44	1.37	0.04	0.04	0.012	0.166	0.12	0.01
0.20	T	0.38	4.95	4.80	0.08	0.08	0.012	0.097	0.31	0.12
0.30	T	0.94	6.27	6.09	0.15	0.15	0.012	0.068	0.68	0.64
0.40	T	1.59	7.16	6.95	0.22	0.23	0.012	0.060	1.00	1.59
0.50	T	2.34	8.92	8.69	0.26	0.27	0.012	0.055	1.23	2.87
0.60	T	3.22	9.17	8.84	0.35	0.36	0.012	0.049	1.65	5.30
0.70	T	4.11	9.42	8.98	0.44	0.46	0.012	0.046	2.04	8.36
0.80	T	5.01	9.67	9.13	0.52	0.55	0.012	0.044	2.40	12.01
0.90	T	5.93	9.91	9.27	0.60	0.64	0.012	0.042	2.73	16.21
1.00	T	6.87	10.16	9.42	0.68	0.73	0.012	0.041	3.05	20.93
1.10	T	7.81	10.41	9.56	0.75	0.82	0.012	0.040	3.35	26.16
1.20	T	8.78	10.66	9.71	0.82	0.90	0.012	0.039	3.63	31.88
1.30	T	9.76	10.91	9.85	0.89	0.99	0.012	0.039	3.90	38.08
1.40	T	10.75	11.15	10.00	0.96	1.07	0.012	0.038	4.16	44.73
1.50	T	11.76	11.40	10.14	1.03	1.16	0.012	0.038	4.41	51.84
1.60	T	12.78	11.66	10.30	1.10	1.24	0.012	0.037	4.64	59.34
1.70	T	13.83	12.15	10.74	1.14	1.29	0.012	0.037	4.81	66.48
1.80	T	14.93	12.65	11.20	1.18	1.33	0.012	0.037	4.96	74.10
1.90	T	16.07	13.15	11.66	1.22	1.38	0.012	0.036	5.12	82.29
2.00	T	17.26	13.65	12.12	1.26	1.42	0.012	0.036	5.28	91.05
2.10	T	18.50	14.22	12.66	1.30	1.46	0.012	0.036	5.41	100.06
2.20	T	19.79	14.87	13.27	1.33	1.49	0.012	0.036	5.53	109.40
2.30	T	21.15	15.51	13.87	1.36	1.52	0.012	0.036	5.65	119.44
2.40	T	22.57	16.15	14.48	1.40	1.56	0.012	0.035	5.77	130.21

STAGE	ALPHA	FROUDE
0.10	1.00	0.10
0.20	1.00	0.19
0.30	1.00	0.31
0.40	1.00	0.37
0.50	1.00	0.42
0.60	1.00	0.48
0.70	1.00	0.53
0.80	1.00	0.57
0.90	1.00	0.60
1.00	1.00	0.63
1.10	1.00	0.65
1.20	1.00	0.67
1.30	1.00	0.69
1.40	1.00	0.71
1.50	1.00	0.72
1.60	1.00	0.73
1.70	1.00	0.75
1.80	1.00	0.76
1.90	1.00	0.77
2.00	1.00	0.78
2.10	1.00	0.79
2.20	1.00	0.80
2.30	1.00	0.81
2.40	1.00	0.81

Rio Fernando de Taos @
El Nogal CG
Lower –

Cross Section



section:	at 94 feet — 71 square mile WS
	Riffle
stream:	Rio Fernando de Taos
location:	at El Nogel — July 11 200 Smolka/Schaeffer/
description:	E5b — Canopy 100%
height of instrument (ft):	100.50

notes	omit pt.	distance (ft)	FS (ft)	elevation
LBP	☐	0	0.5	100
LFPW	☐	2.5	1.49	99.01
	☐	3.7	1.79	98.71
	☐	9.6	2.93	97.57
	☐	13.8	3.19	97.31
LBF	☐	16	3.89	96.61
	☐	17.4	4.24	96.26
1/2 bank	☐	18.5	4.68	95.82
LWE	☐	19.2	5.79	94.71
	☐	20.2	5.81	94.69
	☐	22.1	6.13	94.37
	☐	23.4	6.16	94.34
	☐	24.1	6.21	94.29
	☐	25.2	6.06	94.44
	☐	26.6	6.26	94.24
TW	☐	27	6.29	94.21
	☐	27.1	6.09	94.41
RWE	☐	27.9	5.79	94.71
	☐	28.8	4.7	95.8
RBF	☐	30.5	3.89	96.61
	☐	34.9	3.03	97.47
	☐	36.6	2.34	98.16
	☐	38.8	1.79	98.71
RFPW	☐	39.5	1.49	99.01
RBP	☐	42.5	0.9	99.6
	☐			
	☐			

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
3.89		37.0	1.2	0.036
96.61	---			

dimensions			
22.6	x-section area	1.6	d mean
14.5	width	16.2	wet P
2.4	d max	1.4	hyd radi
0.0	bank ht	9.3	w/d ratio
37.0	W flood prone area	2.6	ent ratio

hydraulics	
5.7	velocity (ft/sec)
127.7	discharge rate, Q (cfs)
1.05	shear stress ((lbs/ft sq)
0.73	shear velocity (ft/sec)
6.594	unit stream power (lbs/ft/sec)
0.64	Froude number
7.7	friction factor u/u*
79.2	threshold grain size (mm)

check from channel material			
64	measured D84 (mm)		
7.4	relative roughness	7.8	fric. factor
0.036	Manning's n from channel material		

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

templet.out
Input File: C:\WXSPRO20\TEMPLET.DAT
Run Date: 11/13/03
Analysis Procedure: Hydraulics
Cross Section Number: 1
Survey Date: 11/04/03

Subsections/Dividing stations
A / 38.76/ @

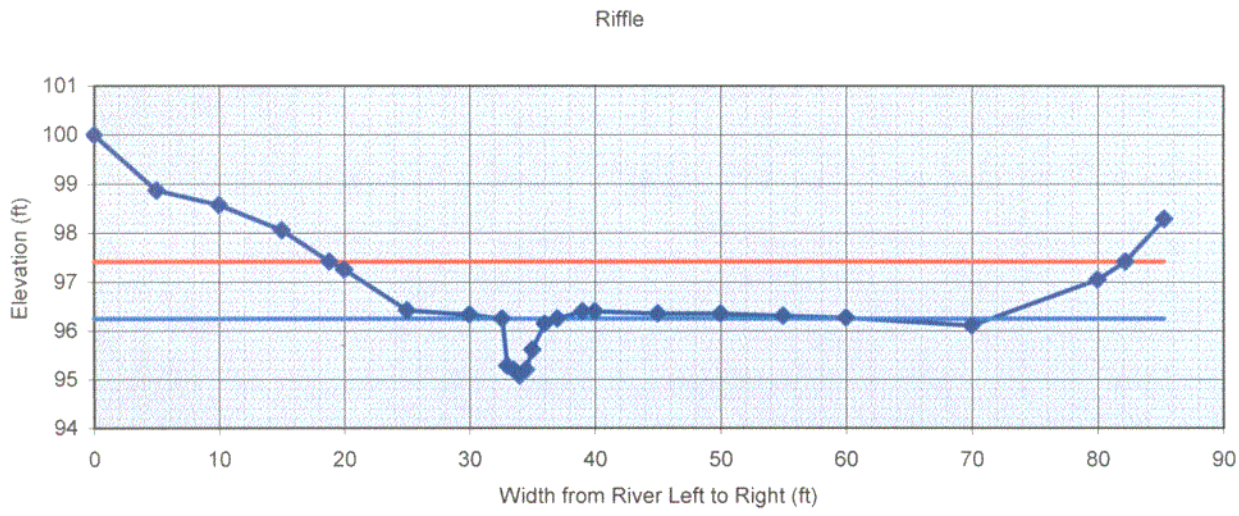
Resistance Method: Thorne and Zevenbergen
D84: 0.500 mm

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	0.04	0.85	0.83	0.05	0.05	0.006	0.014	1.13	0.05
0.20	T	0.16	1.65	1.59	0.10	0.10	0.006	0.013	1.84	0.30
0.30	T	0.33	1.92	1.75	0.17	0.19	0.006	0.013	2.66	0.88
0.40	T	0.51	2.18	1.91	0.24	0.27	0.006	0.013	3.27	1.68
0.50	T	0.71	2.45	2.07	0.29	0.34	0.006	0.013	3.76	2.68
0.60	T	0.93	2.75	2.28	0.34	0.41	0.006	0.013	4.15	3.86
0.70	T	1.17	3.07	2.51	0.38	0.47	0.006	0.013	4.50	5.25
0.80	T	1.43	3.38	2.73	0.42	0.52	0.006	0.014	4.81	6.89
0.90	T	1.71	3.70	2.96	0.46	0.58	0.006	0.014	5.11	8.77
1.00	T	2.02	4.02	3.18	0.50	0.64	0.006	0.014	5.40	10.91
1.10	T	2.35	4.57	3.65	0.51	0.65	0.006	0.013	5.49	12.94
1.20	T	2.79	6.61	5.63	0.42	0.49	0.006	0.013	4.90	13.63

STAGE	ALPHA	FROUDE
0.10	1.00	0.89
0.20	1.00	1.01
0.30	1.00	1.08
0.40	1.00	1.11
0.50	1.00	1.13
0.60	1.00	1.15
0.70	1.00	1.16
0.80	1.00	1.17
0.90	1.00	1.18
1.00	1.00	1.19
1.10	1.00	1.21
1.20	1.00	1.23

Upper Rio Fernando de Taos
@ 64

Cross Section



section:	at 70 feet < 10 square mile ws
	Riffle
stream:	Rio Fernando de Taos
location:	at Hwy 64 at first switchback to Angel fire August 6,2000 Smolka/Davi
description:	E6 canopy 60%
height of instrument (ft):	104.00

notes	omit pt.	distance (ft)	FS (ft)	elevation
LBP	☐	0	4-Jan	100
	☐	5	5.13	98.87
	☐	10	5.42	98.58
	☐	15	5.94	98.06
LFPW	☐	18.8	6.58	97.42
	☐	20	6.74	97.26
	☐	25	7.58	96.42
	☐	30	7.66	96.34
LBF/top bnk	☐	32.6	7.75	96.25
bank base	☐	33	8.72	95.28
LWE	☐	33.5	8.8	95.2
TW	☐	34	8.92	95.08
RWE	☐	34.5	8.8	95.2
1/2 Rt. Bank	☐	35	8.39	95.61
3/4 Rt. Bank	☐	36	7.85	96.15
RBF/top bnk	☐	37	7.75	96.25
	☐	39	7.6	96.4
	☐	40	7.6	96.4
	☐	45	7.64	96.36
	☐	50	7.64	96.36
	☐	55	7.69	96.31
	✓	60	7.73	96.27
	✓	70	7.89	96.11
	☐	80	6.95	97.05
RFPW	☐	82.2	6.58	97.42
RBP	☐	85.3	5.71	98.29
	☐			

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
7.75	7.75	63.4	0.56	0.012
96.25	96.25			

dimensions			
2.7	x-section area	0.6	d mean
4.4	width	5.4	wet P
1.2	d max	0.5	hyd radi
1.2	bank ht	7.3	w/d ratio
63.4	W flood prone area	14.4	ent ratio

hydraulics	
5.8	velocity (ft/sec)
15.4	discharge rate, Q (cfs)
0.17	shear stress ((lbs/ft sq)
0.30	shear velocity (ft/sec)
1.220	unit stream power (lbs/ft/sec)
1.73	Froude number
19.4	friction factor u/u*
10.2	threshold grain size (mm)

check from channel material			
0	measured D84 (mm)		
765.3	relative roughness	19.3	fric. factor
0.012	Manning's n from channel material		

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

templet.out
Input File: C:\WXSPRO20\TEMPLET.DAT
Run Date: 02/09/04
Analysis Procedure: Hydraulics
Cross Section Number: 1
Survey Date: 11/04/03

Subsections/Dividing stations
A

Resistance Method: Manning's n

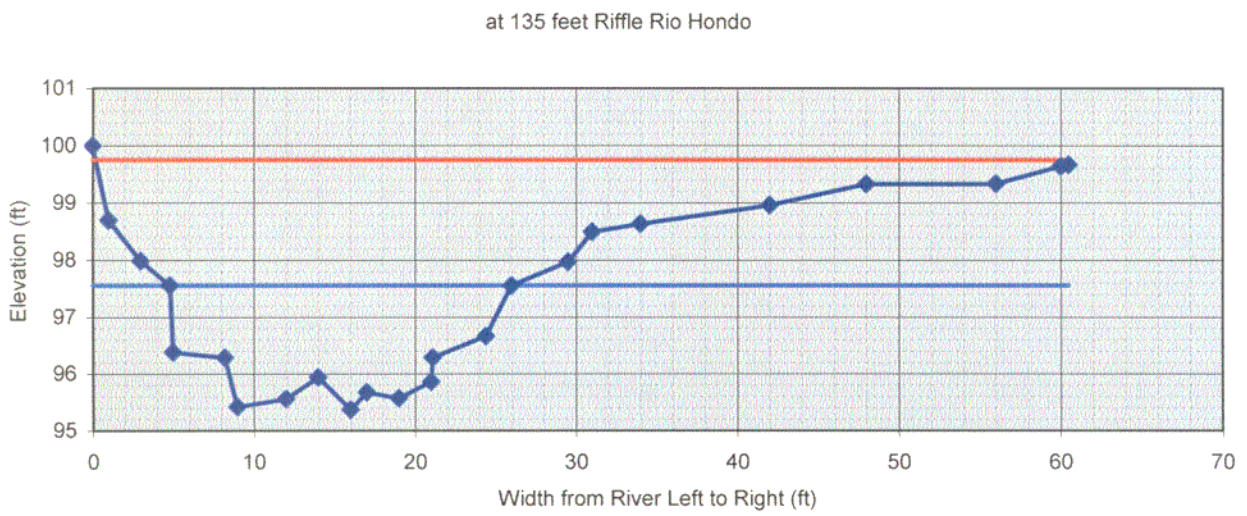
SECTION	A
Low Stage n	0.074
High Stage n	0.036

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	0.06	1.84	1.79	0.03	0.03	0.023	0.074	0.32	0.02
0.20	T	0.39	4.67	4.54	0.08	0.08	0.023	0.072	0.59	0.23
0.30	T	1.03	8.56	8.34	0.12	0.12	0.023	0.070	0.78	0.80
0.40	T	1.97	10.51	10.21	0.19	0.19	0.023	0.069	1.08	2.12
0.50	T	3.07	12.18	11.80	0.25	0.26	0.023	0.067	1.35	4.15
0.60	T	4.29	13.05	12.53	0.33	0.34	0.023	0.065	1.66	7.13
0.70	T	5.55	13.29	12.64	0.42	0.44	0.023	0.063	2.00	11.12
0.80	T	6.82	13.53	12.76	0.50	0.53	0.023	0.061	2.34	15.95
0.90	T	8.11	13.76	12.88	0.59	0.63	0.023	0.059	2.67	21.64
1.00	T	9.54	17.36	16.44	0.55	0.58	0.023	0.058	2.63	25.08
1.10	T	11.26	18.68	17.68	0.60	0.64	0.023	0.056	2.89	32.52
1.20	T	13.07	19.65	18.56	0.67	0.70	0.023	0.054	3.19	41.67
1.30	T	14.97	20.63	19.45	0.73	0.77	0.023	0.052	3.50	52.36
1.40	T	16.93	20.93	19.64	0.81	0.86	0.023	0.050	3.89	65.90
1.50	T	18.90	21.24	19.84	0.89	0.95	0.023	0.049	4.31	81.38
1.60	T	20.89	21.55	20.04	0.97	1.04	0.023	0.047	4.74	98.98
1.70	T	22.91	21.86	20.23	1.05	1.13	0.023	0.045	5.19	118.92
1.80	T	24.94	22.16	20.43	1.13	1.22	0.023	0.043	5.67	141.49
1.90	T	26.99	22.47	20.63	1.20	1.31	0.023	0.041	6.19	167.00
2.00	T	29.06	22.78	20.82	1.28	1.40	0.023	0.039	6.74	195.84
2.10	T	31.16	23.08	21.02	1.35	1.48	0.023	0.038	7.33	228.47
2.19	T	33.06	23.36	21.20	1.42	1.56	0.023	0.036	7.91	261.53

STAGE	ALPHA	FROUDE
0.10	1.00	0.30
0.20	1.00	0.36
0.30	1.00	0.39
0.40	1.00	0.43
0.50	1.00	0.47
0.60	1.00	0.50
0.70	1.00	0.53
0.80	1.00	0.56
0.90	1.00	0.59
1.00	1.00	0.61
1.10	1.00	0.64
1.20	1.00	0.67
1.30	1.00	0.70
1.40	1.00	0.74
1.50	1.00	0.78
1.60	1.00	0.82
1.70	1.00	0.86
1.80	1.00	0.90
1.90	1.00	0.95
2.00	1.00	1.01
2.10	1.00	1.06
2.19	1.00	1.12

Rio Hondo
Above The
Rio Grande

Cross Section



section:	at 135 feet
	Riffle
stream:	Rio Hondo September 7 2000 Smoka/Davis
location:	above the Rio Grande 65 square miles
description:	C4b or B4 Canopy 30%
height of instrument (ft):	102.88

notes	omit pt.	distance (ft)	FS (ft)	elevation
LBP	☐	0	2-Jan	100
LFPW	☐	1	4.18	98.7
	☐	3	4.89	97.99
LBF	☐	4.8	5.32	97.56
	☐	5	6.5	96.38
	☐	8.2	6.59	96.29
LWE	☐	9	7.46	95.42
	☐	12	7.32	95.56
	☐	14	6.94	95.94
TW	☐	16	7.51	95.37
	☐	17	7.2	95.68
	☐	19	7.31	95.57
	☐	21	7.02	95.86
	☐	21.1	6.59	96.29
RWE	☐	24.4	6.21	96.67
RBF	☐	26	5.32	97.56
	☐	29.5	4.91	97.97
	☐	31	4.38	98.5
	☐	34	4.24	98.64
	☐	42	3.92	98.96
	☐	48	3.55	99.33
	☐	56	3.54	99.34
	☐	60	3.24	99.64
RFPW	☐	60.5	3.21	99.67
	☐			

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
5.32	4.89	59.5	2.3	0.036
97.56	97.99			

dimensions			
33.1	x-section area	1.6	d mean
21.2	width	23.4	wet P
2.2	d max	1.4	hyd radi
2.6	bank ht	13.6	w/d ratio
59.5	W flood prone area	2.8	ent ratio

hydraulics	
7.9	velocity (ft/sec)
260.9	discharge rate, Q (cfs)
2.03	shear stress ((lbs/ft sq)
1.02	shear velocity (ft/sec)
17.662	unit stream power (lbs/ft/sec)
1.24	Froude number
7.7	friction factor u/u*
~~288.6~~	threshold grain size (mm)

check from channel material			
325	measured D84 (mm)		
1.5	relative roughness	3.8	fric. factor
0.074	Manning's n from channel material		

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

templet.out
Input File: C:\WXSPRO20\TEMPLET.DAT
Run Date: 11/24/03
Analysis Procedure: Hydraulics
Cross Section Number: 1
Survey Date: 11/04/03

Subsections/Dividing stations
A

Resistance Method: Manning's n

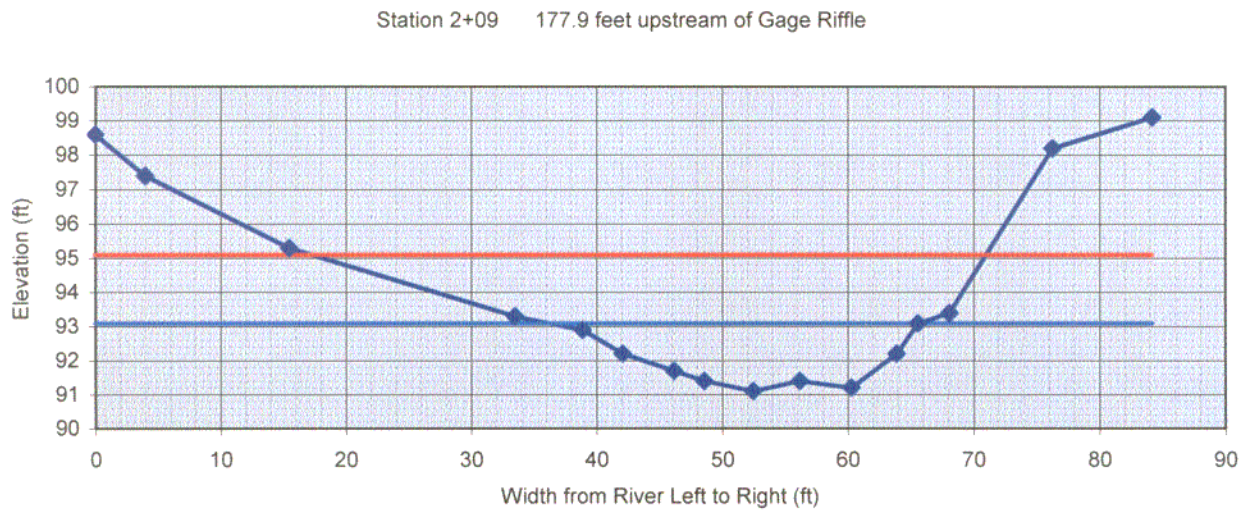
SECTION	A
Low Stage n	0.221
High Stage n	0.060

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	0.13	2.54	2.53	0.05	0.05	0.019	0.221	0.13	0.02
0.20	T	0.63	7.51	7.48	0.08	0.08	0.019	0.213	0.18	0.12
0.30	T	1.62	12.47	12.42	0.13	0.13	0.019	0.204	0.26	0.42
0.40	T	2.92	13.65	13.58	0.21	0.22	0.019	0.196	0.38	1.10
0.50	T	4.34	14.83	14.74	0.29	0.29	0.019	0.187	0.48	2.10
0.60	T	5.87	16.01	15.90	0.37	0.37	0.019	0.179	0.59	3.46
0.70	T	7.52	17.21	17.08	0.44	0.44	0.019	0.170	0.69	5.22
0.80	T	9.29	18.41	18.26	0.50	0.51	0.019	0.162	0.80	7.47
0.90	T	11.17	19.61	19.44	0.57	0.57	0.019	0.153	0.92	10.29
1.00	T	13.17	20.81	20.62	0.63	0.64	0.019	0.145	1.05	13.78
1.10	T	15.29	22.01	21.80	0.69	0.70	0.019	0.136	1.18	18.08
1.20	T	17.51	22.69	22.44	0.77	0.78	0.019	0.128	1.35	23.66
1.30	T	19.78	23.38	23.09	0.85	0.86	0.019	0.119	1.54	30.47
1.40	T	22.12	24.06	23.74	0.92	0.93	0.019	0.111	1.75	38.77
1.50	T	24.53	24.74	24.38	0.99	1.01	0.019	0.102	1.99	48.93
1.60	T	27.00	25.42	25.03	1.06	1.08	0.019	0.094	2.28	61.48
1.70	T	29.54	26.10	25.67	1.13	1.15	0.019	0.085	2.61	77.11
1.80	T	32.13	26.78	26.32	1.20	1.22	0.019	0.077	3.01	96.84
1.90	T	34.84	28.35	27.86	1.23	1.25	0.019	0.068	3.44	119.91
2.00	T	37.71	29.92	29.40	1.26	1.28	0.019	0.060	3.99	150.59

STAGE	ALPHA	FROUDE
0.10	1.00	0.10
0.20	1.00	0.11
0.30	1.00	0.13
0.40	1.00	0.14
0.50	1.00	0.16
0.60	1.00	0.17
0.70	1.00	0.18
0.80	1.00	0.20
0.90	1.00	0.21
1.00	1.00	0.23
1.10	1.00	0.25
1.20	1.00	0.27
1.30	1.00	0.29
1.40	1.00	0.32
1.50	1.00	0.35
1.60	1.00	0.39
1.70	1.00	0.43
1.80	1.00	0.48
1.90	1.00	0.54
2.00	1.00	0.62

Rio Hondo @ Valdez Gage @ USFS Boundary

Cross Section



section:	Station 2+09 177.9 feet upstream of Gage
	Riffle
stream:	Rio Hondo Moody et al 8/13/1998
location:	at USGS gage near Valdez near USFS Boundary Canopy 80%
description:	B4 152 cfs @ bf 36.2 square mile ws
height of instrument (ft):	103.60

notes	omit pt.	distance (ft)	FS (ft)	elevation
LBP	☐	0	5-Jan	98.6
	☐	4	6.2	97.4
LFPW	☐	15.5	8.3	95.3
	☐	33.5	10.3	93.3
	☐	38.9	10.7	92.9
LWE	☐	42.1	11.4	92.2
	☐	46.2	11.9	91.7
	☐	48.6	12.2	91.4
Thalweg	☐	52.5	12.5	91.1
	☐	56.2	12.2	91.4
	☐	60.3	12.4	91.2
RWE	☐	63.9	11.4	92.2
RBF	☐	65.6	10.5	93.1
	☐	68.1	10.2	93.4
	☐	76.3	5.4	98.2
RBP	☐	84.2	4.5	99.1
	☐			
	☐			
	☐			
	☐			
	☐			
	☑			
	☑			
	☐			
	☐			

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
10.5	5.4	53.5	1.94	0.06
93.1	98.2			

dimensions			
37.7	x-section area	1.3	d mean
29.4	width	29.9	wet P
2.0	d max	1.3	hyd radi
7.1	bank ht	22.9	w/d ratio
53.5	W flood prone area	1.8	ent ratio

hydraulics	
4.0	velocity (ft/sec)
151.8	discharge rate, Q (cfs)
1.53	shear stress ((lbs/ft sq)
0.89	shear velocity (ft/sec)
6.251	unit stream power (lbs/ft/sec)
0.39	Froude number
4.5	friction factor u/u*
~~165.2~~	threshold grain size (mm)

check from channel material			
150	measured D84 (mm)		
2.6	relative roughness	5.2	fric. factor
0.052	Manning's n from channel material		

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

templet.out
Input File: C:\WXSPRO20\TEMPLET.DAT
Run Date: 11/05/03
Analysis Procedure: Hydraulics
Cross Section Number: 1
Survey Date: 11/04/03

Upper Costilla

Subsections/Dividing stations
A / 153.91/ @

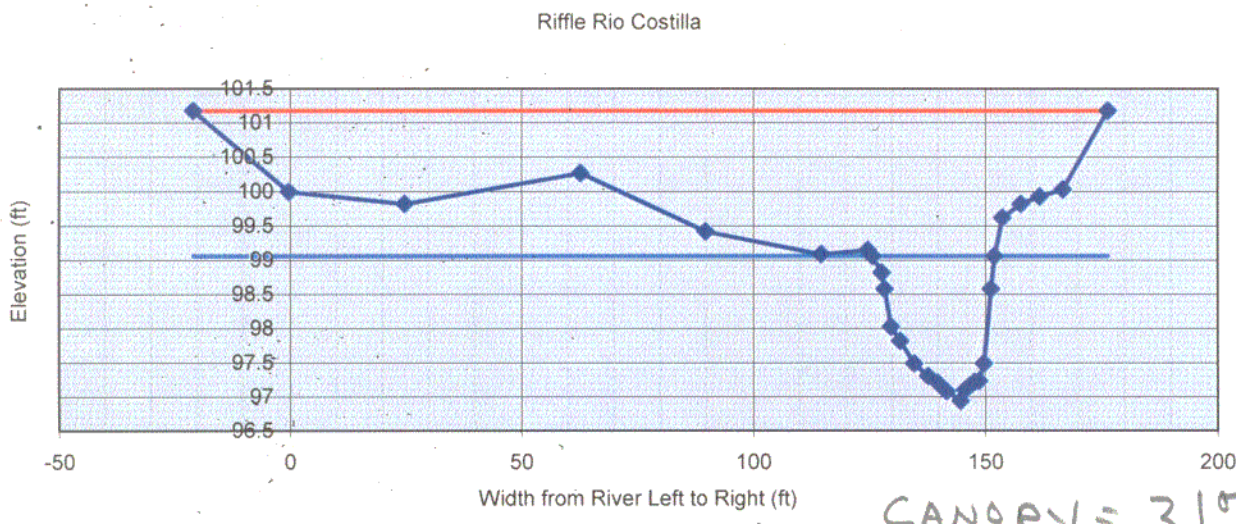
Costilla Cr. below Commanche Cr.

Resistance Method: Thorne and Zevenbergen
D84: 71.000 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	0.14	2.78	2.77	0.05	0.05	0.007	0.129	0.13	0.02
0.20	T	0.55	5.61	5.59	0.10	0.10	0.007	0.093	0.29	0.16
0.30	T	1.28	9.73	9.70	0.13	0.13	0.007	0.082	0.40	0.51
0.40	T	2.38	12.09	12.05	0.20	0.20	0.007	0.068	0.62	1.47
0.50	T	3.68	14.07	14.01	0.26	0.26	0.007	0.058	0.87	3.22
0.60	T	5.17	15.60	15.51	0.33	0.33	0.007	0.053	1.13	5.84
0.70	T	6.77	16.68	16.56	0.41	0.41	0.007	0.049	1.39	9.40
0.80	T	8.48	17.77	17.61	0.48	0.48	0.007	0.047	1.63	13.81
0.90	T	10.29	18.86	18.66	0.55	0.55	0.007	0.045	1.85	19.05
1.00	T	12.22	19.99	19.75	0.61	0.62	0.007	0.044	2.06	25.15
1.10	T	14.24	21.04	20.77	0.68	0.69	0.007	0.042	2.26	32.21
1.20	T	16.34	21.49	21.16	0.76	0.77	0.007	0.041	2.51	40.94
1.30	T	18.48	21.93	21.55	0.84	0.86	0.007	0.041	2.74	50.60
1.40	T	20.65	22.38	21.95	0.92	0.94	0.007	0.040	2.96	61.17
1.50	T	22.87	22.82	22.34	1.00	1.02	0.007	0.039	3.18	72.64
1.60	T	25.12	23.26	22.73	1.08	1.11	0.007	0.039	3.38	85.00
1.70	T	27.41	23.72	23.14	1.16	1.18	0.007	0.038	3.58	98.20
1.80	T	29.75	24.18	23.55	1.23	1.26	0.007	0.038	3.77	112.26
1.90	T	32.12	24.76	24.09	1.30	1.33	0.007	0.038	3.95	126.78
2.00	T	34.58	25.79	25.08	1.34	1.38	0.007	0.037	4.06	140.54
2.10	T	37.14	26.82	26.08	1.38	1.42	0.007	0.037	4.18	155.26

STAGE	ALPHA	FROUDE
0.10	1.00	0.10
0.20	1.00	0.16
0.30	1.00	0.19
0.40	1.00	0.25
0.50	1.00	0.30
0.60	1.00	0.34
0.70	1.00	0.38
0.80	1.00	0.41
0.90	1.00	0.44
1.00	1.00	0.46
1.10	1.00	0.48
1.20	1.00	0.50
1.30	1.00	0.52
1.40	1.00	0.54
1.50	1.00	0.55
1.60	1.00	0.57
1.70	1.00	0.58
1.80	1.00	0.59
1.90	1.00	0.60
2.00	1.00	0.61
2.10	1.00	0.62

Cross Section



CANOPY = 31%

section:	at 68.5'
	Riffle
stream:	Rio Costilla Sept. 19 2000 Smolka/D.Davis
location:	0.5 miles downstream of Commanche Cr ek , 1 mile upstream of USFS/RCLA bndry
description:	C4
height of instrument (ft):	105.33

notes	omit pt.	distance (ft)	FS (ft)	elevation
LFPW	☐	-20.7	4-Jan	101.18
LBP	☐	0	5.33	100
	☐	25	5.51	99.82
big pondoros	☐	63	5.06	100.27
	☐	90	5.91	99.42
	☐	115	6.24	99.09
	☐	125	6.18	99.15
LBF	☐	126	6.27	99.06
LWE	☐	128	6.51	98.82
	☐	128.6	6.75	98.58
	☐	130	7.3	98.03
	☐	132	7.51	97.82
	☐	135	7.84	97.49
	☐	138	8.03	97.3
	☐	140	8.12	97.21
	☐	142	8.25	97.08
TW	☐	145	8.39	96.94
	☐	146	8.23	97.1
	☐	147	8.17	97.16
	☐	148	8.11	97.22
	☐	149	8.1	97.23
	☐	150	7.84	97.49
RWE	☐	151.5	6.75	98.58
RBF	☐	152.3	6.27	99.06
	☐	154	5.71	99.62
	☐	158	5.51	99.82
	☐			

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
6.27	6.27	197.4	0.66	0.037
99.06	99.06			

dimensions			
37.7	x-section area	1.4	d mean
26.3	width	27.0	wet P
2.1	d max	1.4	hyd radi
2.1	bank ht	18.4	w/d ratio
197.4	W flood prone area	7.5	ent ratio

hydraulics	
4.1	velocity (ft/sec)
153.4	discharge rate, Q (cfs)
0.57	shear stress ((lbs/ft sq)
0.54	shear velocity (ft/sec)
2.403	unit stream power (lbs/ft/sec)
0.36	Froude number
7.5	friction factor u/u*
35.7	threshold grain size (mm)

check from channel material			
71	measured D84 (mm)		
6.2	relative roughness	7.3	fric. factor
0.038	Manning's n from channel material		

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

templet.out
Input File: C:\WXSPRO20\TEMPLET.DAT
Run Date: 11/05/03
Analysis Procedure: Hydraulics
Cross Section Number: 1
Survey Date: 11/04/03

Lower Costilla

Costilla @ USGS Gage @ Hwy 196 Above Costilla

Subsections/Dividing stations
A

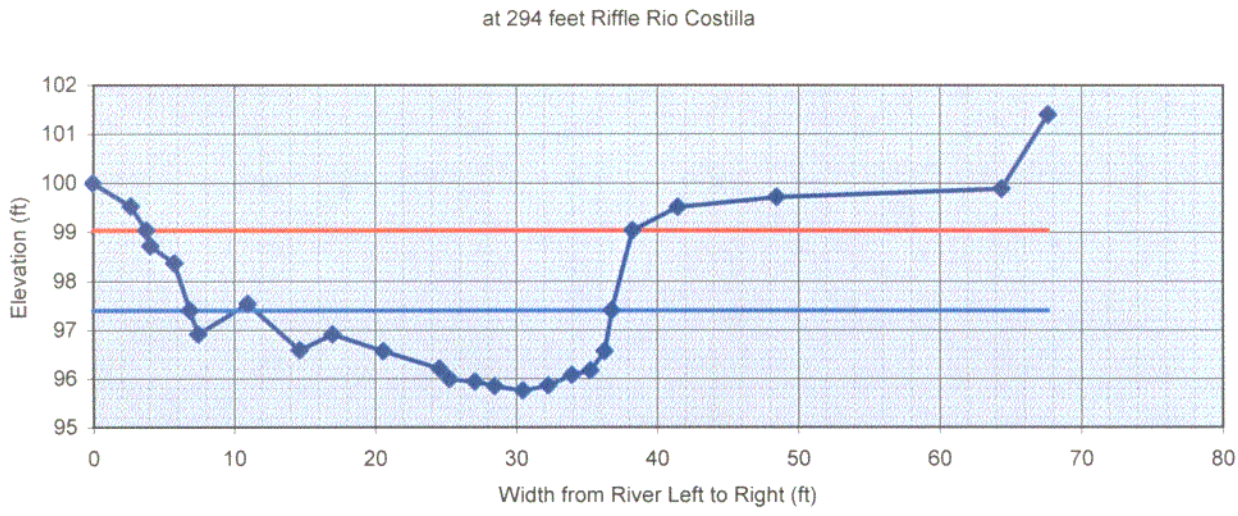
Resistance Method: Manning's n

SECTION	A
Low Stage n	0.147
High Stage n	0.025

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	0.20	3.96	3.95	0.05	0.05	0.011	0.147	0.15	0.03
0.20	T	0.72	6.70	6.69	0.11	0.11	0.011	0.139	0.25	0.18
0.30	T	1.52	8.80	8.76	0.17	0.17	0.011	0.131	0.37	0.57
0.40	T	2.48	10.44	10.39	0.24	0.24	0.011	0.123	0.49	1.21
0.50	T	3.56	11.55	11.48	0.31	0.31	0.011	0.114	0.62	2.22
0.60	T	4.78	12.94	12.84	0.37	0.37	0.011	0.106	0.76	3.62
0.70	T	6.13	14.32	14.20	0.43	0.43	0.011	0.098	0.90	5.54
0.80	T	7.62	15.71	15.56	0.49	0.49	0.011	0.090	1.07	8.16
0.90	T	9.26	17.70	17.47	0.52	0.53	0.011	0.082	1.24	11.47
1.00	T	11.12	20.00	19.70	0.56	0.56	0.011	0.074	1.43	15.92
1.10	T	13.20	22.31	21.93	0.59	0.60	0.011	0.066	1.68	22.14
1.20	T	15.49	24.08	23.60	0.64	0.66	0.011	0.058	2.02	31.35
1.30	T	17.91	25.33	24.73	0.71	0.72	0.011	0.049	2.51	44.96
1.40	T	20.44	26.57	25.86	0.77	0.79	0.011	0.041	3.18	64.98
1.50	T	23.08	27.81	26.99	0.83	0.86	0.011	0.033	4.17	96.14
1.60	T	25.83	29.05	28.11	0.89	0.92	0.011	0.025	5.78	149.35

STAGE	ALPHA	FROUDE
0.10	1.00	0.11
0.20	1.00	0.14
0.30	1.00	0.16
0.40	1.00	0.18
0.50	1.00	0.20
0.60	1.00	0.22
0.70	1.00	0.24
0.80	1.00	0.27
0.90	1.00	0.30
1.00	1.00	0.34
1.10	1.00	0.38
1.20	1.00	0.44
1.30	1.00	0.52
1.40	1.00	0.63
1.50	1.00	0.79
1.60	1.00	1.06

Cross Section



section:	at 294 feet
	Riffle
stream:	Rio Costilla USGS gage above Costilla below HWY 196 bridge
location:	Smolka/Schaeffer BF discharge (RI 1.3 years) from gage =160 cfs
description:	F4 Canopy 44%
height of instrument (ft):	103.15

notes	omit pt.	distance (ft)	FS (ft)	elevation
LBP	☐	0	3-Jan	100
	☐	2.7	3.62	99.53
LFPW	☐	3.8	4.11	99.04
	☐	4.1	4.43	98.72
Top Bank	☐	5.8	4.78	98.37
LBF	☐	6.9	5.75	97.4
Bank bottom	☐	7.5	6.24	96.91
Rock	☐	11	5.61	97.54
	☐	14.7	6.56	96.59
	☐	17	6.24	96.91
LWE	☐	20.6	6.58	96.57
	☐	24.6	6.94	96.21
	☐	25.3	7.16	95.99
	☐	27.1	7.21	95.94
	☐	28.5	7.3	95.85
TW	☐	30.5	7.39	95.76
	☐	32.3	7.29	95.86
	☐	34	7.07	96.08
	☐	35.3	6.98	96.17
RWE	☐	36.3	6.58	96.57
RBF	☐	36.8	5.75	97.4
RFPW and	☐	38.3	4.11	99.04
Top bank	☐	41.5	3.63	99.52
	☐	48.5	3.43	99.72
	☐	64.4	3.26	99.89
	☐	67.7	1.75	101.4
	☐			

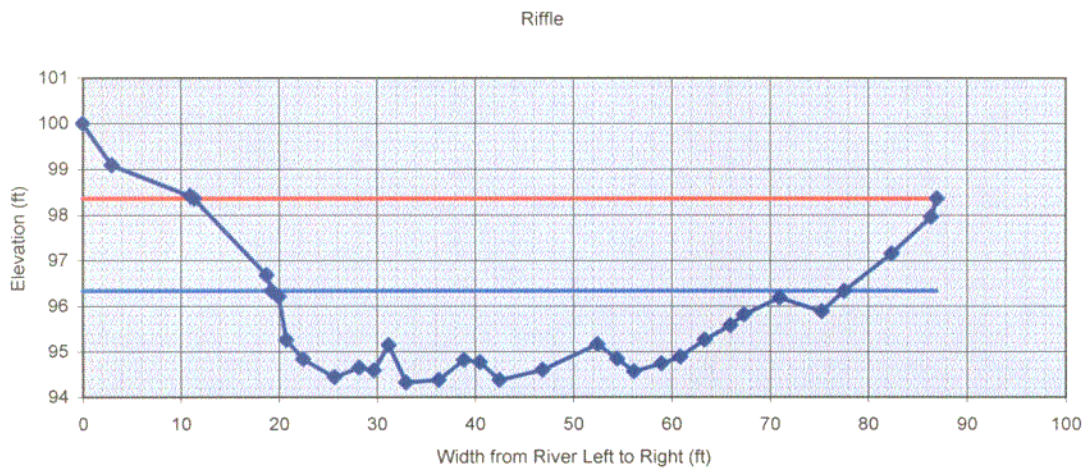
FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
5.75	4.14	34.5	1.1	0.025
97.4	99.01			

dimensions			
27.0	x-section area	0.9	d mean
28.6	width	29.6	wet P
1.6	d max	0.9	hyd radi
3.3	bank ht	30.3	w/d ratio
34.5	W flood prone area	1.2	ent ratio

hydraulics	
5.9	velocity (ft/sec)
158.3	discharge rate, Q (cfs)
0.63	shear stress ((lbs/ft sq)
0.57	shear velocity (ft/sec)
3.803	unit stream power (lbs/ft/sec)
1.13	Froude number
10.3	friction factor u/u*
39.4	threshold grain size (mm)

check from channel material			
120	measured D84 (mm)		
2.4	relative roughness	5.0	fric. factor
0.052	Manning's n from channel material		

Cross Section



section:	at 253'
	Riffle
stream:	Rio Los Pinos at Forest Service Bndry 0.4 miles upstream of 87A Bric
location:	to xs pin
description:	B3c Canopy 27%
height of instrument (ft):	100.69

notes	omit pt.	distance (ft)	FS (ft)	elevation
LBP	☐	0	0.69	100
	☐	3	1.6	99.09
	☐	11	2.27	98.42
	☐	11.4	2.33	98.36
tp bnk	☐	18.8	4	96.69
LBF	☐	19.3	4.35	96.34
Break bnk	☐	20	4.48	96.21
LWE	☐	20.8	5.42	95.27
	☐	22.5	5.85	94.84
	☐	25.7	6.25	94.44
	☐	28.2	6.04	94.65
	☐	29.7	6.1	94.59
	☐	31.2	5.54	95.15
TW	☐	33	6.37	94.32
	☐	36.3	6.31	94.38
	☐	38.9	5.87	94.82
	☐	40.5	5.92	94.77
	☐	42.5	6.31	94.38
	☐	46.9	6.09	94.6
	☐	52.5	5.52	95.17
	☐	54.5	5.84	94.85
	☐	56.2	6.12	94.57
	☐	59	5.95	94.74
	☐	60.9	5.8	94.89
RWE	☐	63.4	5.42	95.27
	☐	66	5.11	95.58
	☐	67.4	4.87	95.82
	☐	71	4.5	96.19
	☐	75.3	4.8	95.89
RBF	☐	77.6	4.35	96.34
	☐	82.4	3.53	97.16
RBP	☐	86.4	2.73	97.96
RFPW	☐	87	2.33	98.36

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
4.35	4	75.6	0.7	0.04
96.34	96.69			

dimensions			
76.2	x-section area	1.3	d mean
58.3	width	59.4	wet P
2.0	d max	1.3	hyd radi
2.4	bank ht	44.6	w/d ratio
75.6	W flood prone area	1.3	ent ratio

hydraulics	
3.7	velocity (ft/sec)
279.4	discharge rate, Q (cfs)
0.56	shear stress ((lbs/ft sq)
0.54	shear velocity (ft/sec)
2.094	unit stream power (lbs/ft/sec)
0.32	Froude number
6.8	friction factor u/u*
34.8	threshold grain size (mm)

check from channel material			
160	measured D84 (mm)		
2.5	relative roughness	5.1	fric. factor
0.054	Manning's n from channel material		

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

templet.out
Input File: C:\WXSPRO20\TEMPLET.DAT
Run Date: 11/12/03
Analysis Procedure: Hydraulics
Cross Section Number: 1
Survey Date: 11/04/03

1

Subsections/Dividing stations
A / 137.99/ @

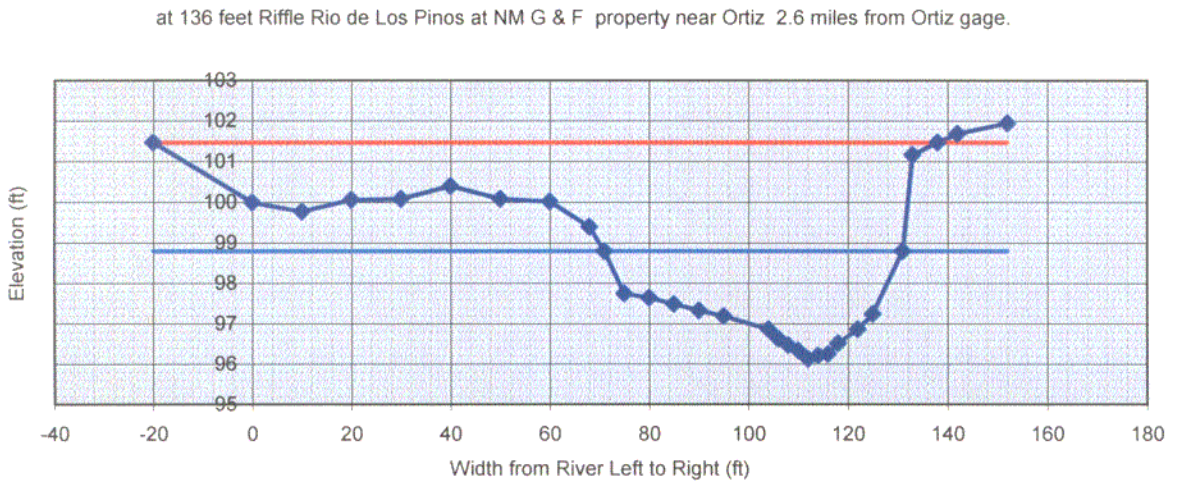
Resistance Method: Thorne and Zevenbergen
D84: 120.000 mm

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	0.18	3.96	3.95	0.04	0.04	0.009	0.141	0.13	0.02
0.20	T	0.73	6.51	6.50	0.11	0.11	0.009	0.121	0.27	0.20
0.30	T	1.49	8.74	8.72	0.17	0.17	0.009	0.101	0.43	0.64
0.40	T	2.47	10.90	10.86	0.23	0.23	0.009	0.087	0.61	1.50
0.50	T	3.68	13.30	13.26	0.28	0.28	0.009	0.078	0.77	2.83
0.60	T	5.10	15.29	15.23	0.33	0.34	0.009	0.070	0.98	4.98
0.70	T	6.72	17.27	17.21	0.39	0.39	0.009	0.063	1.19	8.00
0.80	T	8.57	20.23	20.16	0.42	0.43	0.009	0.065	1.22	10.46
0.90	T	10.77	23.84	23.76	0.45	0.45	0.009	0.063	1.33	14.33
1.00	T	13.33	27.45	27.36	0.49	0.49	0.009	0.060	1.46	19.39
1.10	T	16.25	31.37	31.27	0.52	0.52	0.009	0.058	1.57	25.57
1.20	T	19.58	35.42	35.31	0.55	0.55	0.009	0.056	1.70	33.21
1.30	T	23.29	38.94	38.82	0.60	0.60	0.009	0.054	1.84	42.94
1.40	T	27.34	42.47	42.33	0.64	0.65	0.009	0.053	1.99	54.45
1.50	T	31.75	46.00	45.84	0.69	0.69	0.009	0.052	2.14	67.88
1.60	T	36.57	51.02	50.85	0.72	0.72	0.009	0.051	2.23	81.55
1.70	T	41.78	52.74	52.54	0.79	0.80	0.009	0.049	2.45	102.22
1.80	T	47.07	53.53	53.31	0.88	0.88	0.009	0.048	2.69	126.52
1.90	T	52.44	54.32	54.08	0.97	0.97	0.009	0.047	2.92	153.17
2.00	T	57.89	55.12	54.85	1.05	1.06	0.009	0.046	3.15	182.12
2.10	T	63.41	55.91	55.62	1.13	1.14	0.009	0.046	3.36	213.34
2.20	T	69.01	56.71	56.38	1.22	1.22	0.009	0.045	3.58	246.81
2.30	T	74.69	57.50	57.15	1.30	1.31	0.009	0.044	3.78	282.52
2.40	T	80.44	58.29	57.92	1.38	1.39	0.009	0.044	3.98	320.44
2.50	T	86.27	59.09	58.69	1.46	1.47	0.009	0.044	4.18	360.56
2.60	T	92.18	59.88	59.46	1.54	1.55	0.009	0.043	4.37	402.87
2.70	T	98.16	60.68	60.23	1.62	1.63	0.009	0.043	4.56	447.32

STAGE	ALPHA	FROUDE
0.10	1.00	0.10
0.20	1.00	0.14
0.30	1.00	0.18
0.40	1.00	0.22
0.50	1.00	0.26
0.60	1.00	0.30
0.70	1.00	0.34
0.80	1.00	0.33
0.90	1.00	0.35
1.00	1.00	0.37
1.10	1.00	0.38
1.20	1.00	0.40
1.30	1.00	0.42
1.40	1.00	0.44
1.50	1.00	0.45
1.60	1.00	0.46
1.70	1.00	0.48
1.80	1.00	0.50
1.90	1.00	0.52
2.00	1.00	0.54
2.10	1.00	0.56
2.20	1.00	0.57
2.30	1.00	0.58
2.40	1.00	0.60
2.50	1.00	0.61
2.60	1.00	0.62
2.70	1.00	0.63

Rio Los Pinos near Colorado Border

Cross Section



section:	at 136 feet — 167 square mile ws
	Riffle
stream:	Rio de Los Pinos at NM G & F property near Ortiz 2 upstream of Ortiz gage
location:	
description:	C4 — Canopy 17%
height of instrument (ft):	105.50

notes	omit pt.	distance (ft)	FS (ft)	elevation
LFPW	☐	-20	4-Jan	101.47
LBP	☐	0	5.5	100
	☐	10	5.72	99.78
	☐	20	5.44	100.06
	☐	30	5.42	100.08
	☐	40	5.1	100.4
	☐	50	5.42	100.08
	☐	60	5.48	100.02
top bnk	☐	68	6.1	99.4
LBF	☐	71	6.7	98.8
bot bnk	☐	75	7.75	97.75
	☐	80	7.85	97.65
	☐	85	8.01	97.49
	☐	90	8.17	97.33
	☐	95	8.31	97.19
LWE	☐	104	8.63	96.87
	☐	106	8.87	96.63
	☐	108	9.03	96.47
	☐	110	9.16	96.34
TW	☐	112	9.37	96.13
	☐	114	9.29	96.21
	☐	116	9.25	96.25
	☐	118	8.98	96.52
RWE	☐	122	8.63	96.87
	☐	125	8.25	97.25
RBF	☐	131	6.7	98.8
	☐	133	4.34	101.16
RFPW	☐	138	4.03	101.47
	☐	142	3.82	101.68
RBP	☐	152	3.56	101.94

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
6.7	6.1	158.0	0.95	0.045
98.8	99.4			

dimensions			
96.4	x-section area	1.6	d mean
60.0	width	60.4	wet P
2.7	d max	1.6	hyd radi
3.3	bank ht	37.4	w/d ratio
158.0	W flood prone area	2.6	ent ratio

hydraulics	
4.4	velocity (ft/sec)
423.3	discharge rate, Q (cfs)
0.95	shear stress ((lbs/ft sq)
0.70	shear velocity (ft/sec)
4.183	unit stream power (lbs/ft/sec)
0.37	Froude number
6.3	friction factor u/u*
65.0	threshold grain size (mm)

check from channel material			
120	measured D84 (mm)		
4.1	relative roughness	6.3	fric. factor
0.045	Manning's n from channel material		

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

templet.out
Input File: C:\WXSPRO20\TEMPLET.DAT
Run Date: 11/04/03
Analysis Procedure: Hydraulics
Cross Section Number: 1
Survey Date: 11/04/03

commanche @ upper exclosure

Upper WS

Subsections/Dividing stations
A

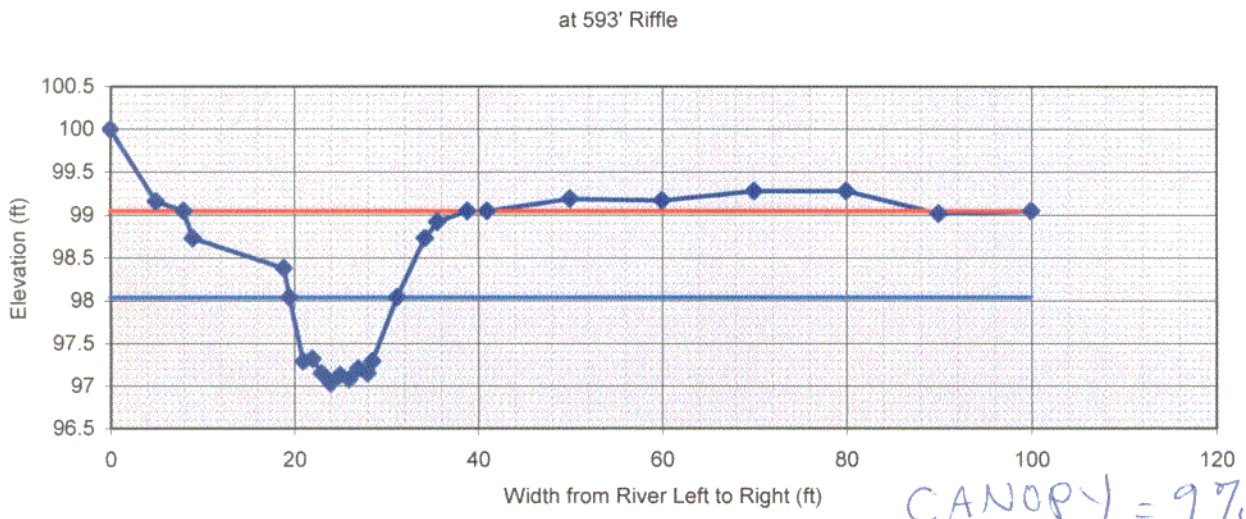
Resistance Method: Manning's n

SECTION	A
Low Stage n	0.114
High Stage n	0.031

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	0.13	3.23	3.21	0.04	0.04	0.006	0.114	0.12	0.01
0.20	T	0.58	5.79	5.74	0.10	0.10	0.006	0.105	0.24	0.14
0.30	T	1.23	7.78	7.71	0.16	0.16	0.006	0.096	0.35	0.43
0.40	T	2.03	8.38	8.27	0.24	0.25	0.006	0.086	0.52	1.05
0.50	T	2.88	8.97	8.83	0.32	0.33	0.006	0.077	0.70	2.02
0.60	T	3.79	9.57	9.38	0.40	0.40	0.006	0.068	0.92	3.48
0.70	T	4.76	10.16	9.94	0.47	0.48	0.006	0.059	1.19	5.64
0.80	T	5.78	10.76	10.50	0.54	0.55	0.006	0.049	1.54	8.91
0.90	T	6.86	11.36	11.06	0.60	0.62	0.006	0.040	2.05	14.06
1.00	T	7.99	11.95	11.62	0.67	0.69	0.006	0.031	2.85	22.75

STAGE	ALPHA	FROUDE
0.10	1.00	0.10
0.20	1.00	0.13
0.30	1.00	0.16
0.40	1.00	0.18
0.50	1.00	0.22
0.60	1.00	0.25
0.70	1.00	0.30
0.80	1.00	0.37
0.90	1.00	0.46
1.00	1.00	0.60

Cross Section



CANOPY = 9%

section:	at 593'
	Riffle
stream:	Commanche Creek at upper exclosure
location:	28-Jun-00
description:	C4 (destabalized E4) Smolka/McGraw/Tsatsaros
height of instrument (ft):	108.13

notes	omit pt.	distance (ft)	FS (ft)	elevation
LBP	☐	0	8-Jan	100
	☐	5	8.97	99.16
LFPW	☐	8	9.08	99.05
	☐	9	9.4	98.73
Top Bank	☐	18.9	9.75	98.38
LBF	☐	19.5	10.09	98.04
	☐	21	10.84	97.29
	☐	22	10.81	97.32
	☐	23	10.98	97.15
Thalweg	☐	24	11.1	97.03
	☐	25	11	97.13
	☐	26	11.05	97.08
	☐	27	10.92	97.21
	☐	28	10.98	97.15
	☐	28.5	10.84	97.29
RBF	☐	31.2	10.09	98.04
Top Bank	☐	34.25	9.4	98.73
	☐	35.6	9.21	98.92
RFPW	☐	38.85	9.08	99.05
	☐	41	9.08	99.05
	☐	50	8.94	99.19
	☐	60	8.96	99.17
Ant hill	☐	70	8.85	99.28
	☐	80	8.85	99.28
	☐	90	9.11	99.02
RBP	☐	100	9.08	99.05
	☐			

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
10.09	9.75	30.9	0.6	0.031
98.04	98.38			

dimensions			
8.1	x-section area	0.7	d mean
11.7	width	12.0	wet P
1.0	d max	0.7	hyd radi
1.4	bank ht	16.8	w/d ratio
30.9	W flood prone area	2.6	ent ratio

hydraulics	
2.9	velocity (ft/sec)
23.2	discharge rate, Q (cfs)
0.25	shear stress ((lbs/ft sq)
0.36	shear velocity (ft/sec)
0.743	unit stream power (lbs/ft/sec)
0.37	Froude number
7.9	friction factor u/u*
14.1	threshold grain size (mm)

check from channel material			
64	measured D84 (mm)		
3.3	relative roughness	5.8	fric. factor
0.042	Manning's n from channel material		

**********WinXSPRO**********
templet.out
Input File: C:\WXSPRO20\TEMPLET.DAT
Run Date: 11/04/03
Analysis Procedure: Hydraulics
Cross Section Number: 1
Survey Date: 11/04/03

Commanche Cr above Costilla

Lowest part of WS

Bankfull To bankfull

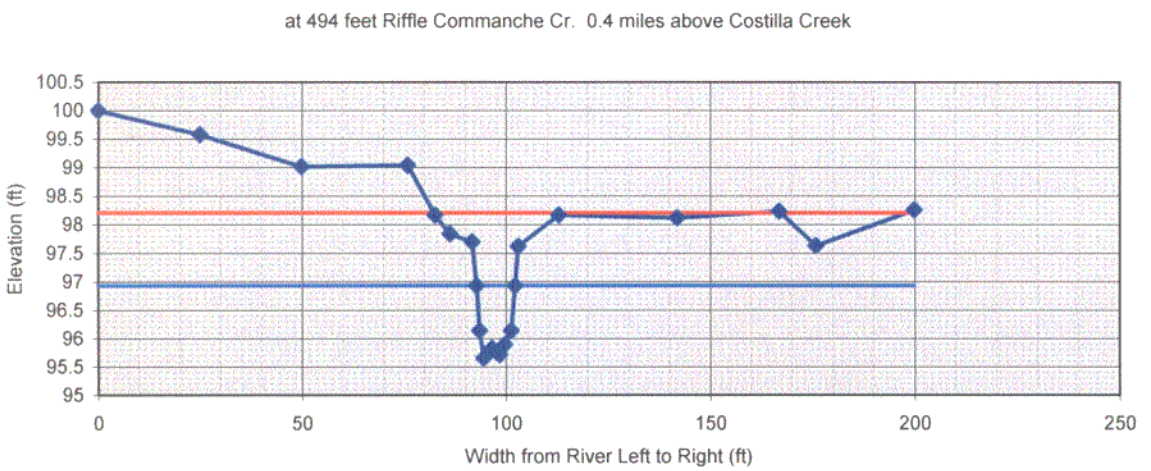
Subsections/Dividing stations
A / 102.70/ @

Resistance Method: Thorne and Zevenbergen
D84: 47.000 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	2.34	2.31	0.04	0.04	0.010	0.109	0.16	0.01
0.20	T	0.49	5.31	5.24	0.09	0.09	0.010	0.074	0.41	0.20
0.30	T	1.05	6.20	6.10	0.17	0.17	0.010	0.056	0.82	0.86
0.40	T	1.71	7.11	6.98	0.24	0.24	0.010	0.048	1.19	2.04
0.50	T	2.45	7.96	7.79	0.31	0.31	0.010	0.044	1.53	3.76
0.60	T	3.24	8.24	7.99	0.39	0.41	0.010	0.041	1.93	6.25
0.70	T	4.05	8.53	8.19	0.47	0.49	0.010	0.040	2.29	9.27
0.80	T	4.88	8.81	8.39	0.55	0.58	0.010	0.038	2.62	12.80
0.90	T	5.73	9.10	8.60	0.63	0.67	0.010	0.037	2.94	16.82
1.00	T	6.60	9.38	8.80	0.70	0.75	0.010	0.036	3.23	21.31
1.10	T	7.49	9.66	9.00	0.77	0.83	0.010	0.036	3.51	26.26
1.20	T	8.40	9.95	9.20	0.84	0.91	0.010	0.035	3.77	31.66
1.30	T	9.33	10.24	9.41	0.91	0.99	0.010	0.035	4.02	37.48

STAGE	ALPHA	FROUDE
0.10	1.00	0.14
0.20	1.00	0.24
0.30	1.00	0.35
0.40	1.00	0.42
0.50	1.00	0.48
0.60	1.00	0.53
0.70	1.00	0.57
0.80	1.00	0.61
0.90	1.00	0.63
1.00	1.00	0.66
1.10	1.00	0.68
1.20	1.00	0.70
1.30	1.00	0.71

Cross Section



section:	at 494 feet
	Riffle
stream:	Commanche Cr. 0.4 miles above Costilla Creek
location:	27-Jun-00 Smolka/McGraw
description:	E4 Canopy cover 0%
height of instrument (ft):	107.22

notes	omit pt.	distance (ft)	FS (ft)	elevation
LBP	☐	0	7-Jan	100
	☐	25	7.64	99.58
	☐	50	8.2	99.02
slope brk	☐	76	8.18	99.04
LFPW	☐	82.7	9.05	98.17
	☐	86.4	9.38	97.84
top bnk	☐	91.8	9.52	97.7
LBF	☐	92.9	10.29	96.93
LWE	☐	93.6	11.08	96.14
TW	☐	94.6	11.57	95.65
	☐	95.6	11.49	95.73
	☐	96.6	11.39	95.83
	☐	97.6	11.45	95.77
	☐	98.6	11.51	95.71
	☐	99.7	11.33	95.89
RWE	☐	101.4	11.08	96.14
RBF	☐	102.3	10.29	96.93
	☐	103.1	9.6	97.62
RFPW	☐	113	9.05	98.17
	☐	142	9.1	98.12
	☐	167	8.98	98.24
	☐	176	9.59	97.63
RBP	☐	200	8.96	98.26
	☐			
	☐			

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
10.29	9.52	30.3	1	0.032
96.93	97.7			

dimensions			
9.2	x-section area	1.0	d mean
9.4	width	10.2	wet P
1.3	d max	0.9	hyd radi
2.1	bank ht	9.6	w/d ratio
30.3	W flood prone area	3.2	ent ratio

hydraulics	
4.3	velocity (ft/sec)
39.7	discharge rate, Q (cfs)
0.56	shear stress ((lbs/ft sq)
0.54	shear velocity (ft/sec)
2.635	unit stream power (lbs/ft/sec)
0.60	Froude number
8.0	friction factor u/u*
34.8	threshold grain size (mm)

check from channel material			
47	measured D84 (mm)		
6.3	relative roughness	7.4	fric. factor
0.035	Manning's n from channel material		

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

templet.out
Input File: C:\WXSPRO20\TEMPLET.DAT
Run Date: 11/12/03
Analysis Procedure: Hydraulics
Cross Section Number: 1
Survey Date: 11/04/03

Subsections/Dividing stations
A / 44.48/ @

Resistance Method: Thorne and Zevenbergen
D84: 72.000 mm

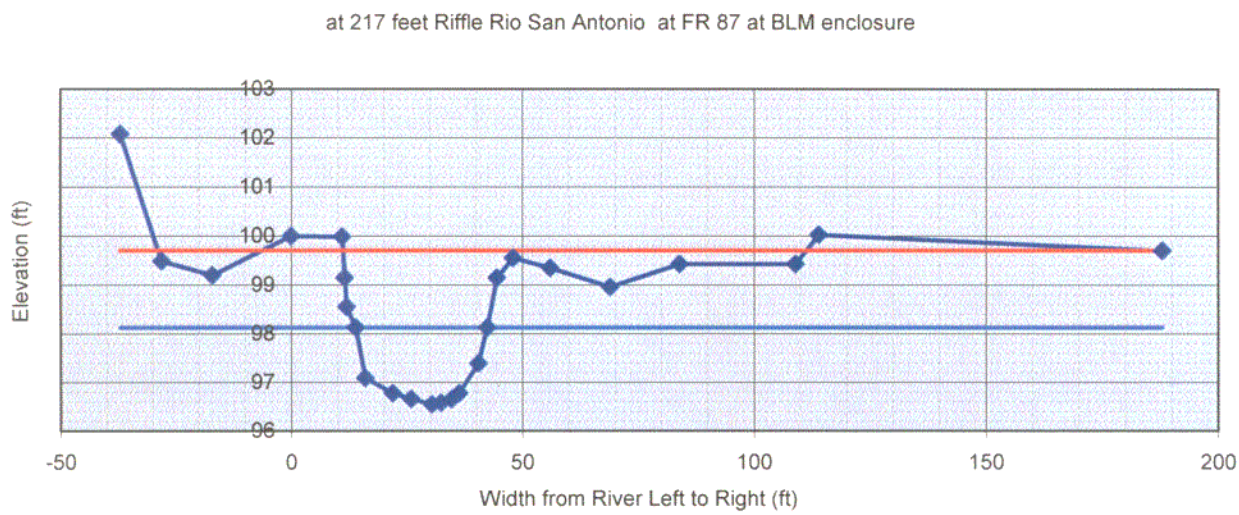
STAGE (ft)	#SEC	AREA (sq ft)	PERIM (ft)	WIDTH (ft)	R (ft)	DHYD (ft)	SLOPE (ft/ft)	n	VAVG (ft/s)	Q (cfs)
0.10	T	0.45	8.30	8.30	0.05	0.05	0.005	0.089	0.17	0.08
0.20	T	1.51	12.93	12.92	0.12	0.12	0.005	0.086	0.29	0.45
0.30	T	2.99	16.15	16.13	0.19	0.19	0.005	0.075	0.45	1.36
0.40	T	4.73	18.78	18.75	0.25	0.25	0.005	0.063	0.67	3.17
0.50	T	6.74	21.41	21.37	0.31	0.32	0.005	0.056	0.87	5.87
0.60	T	8.97	23.01	22.95	0.39	0.39	0.005	0.051	1.09	9.83
0.70	T	11.31	23.92	23.83	0.47	0.47	0.005	0.048	1.33	15.02
0.80	T	13.74	24.84	24.71	0.55	0.56	0.005	0.046	1.54	21.22
0.90	T	16.25	25.50	25.34	0.64	0.64	0.005	0.044	1.76	28.63
1.00	T	18.81	26.00	25.79	0.72	0.73	0.005	0.043	1.98	37.18
1.10	T	21.41	26.50	26.25	0.81	0.82	0.005	0.042	2.18	46.73
1.20	T	24.06	26.99	26.71	0.89	0.90	0.005	0.041	2.38	57.25
1.30	T	26.75	27.49	27.16	0.97	0.98	0.005	0.040	2.57	68.72
1.40	T	29.49	27.99	27.62	1.05	1.07	0.005	0.040	2.75	81.13
1.50	T	32.27	28.49	28.07	1.13	1.15	0.005	0.039	2.93	94.48
1.60	T	35.10	29.03	28.57	1.21	1.23	0.005	0.039	3.09	108.63

STAGE	ALPHA	FROUDE
0.10	1.00	0.13
0.20	1.00	0.15
0.30	1.00	0.19
0.40	1.00	0.24
0.50	1.00	0.27
0.60	1.00	0.31
0.70	1.00	0.34
0.80	1.00	0.36
0.90	1.00	0.39
1.00	1.00	0.41
1.10	1.00	0.43
1.20	1.00	0.44
1.30	1.00	0.46
1.40	1.00	0.47
1.50	1.00	0.48
1.60	1.00	0.49

* Please note - Attached Sheets show 0 Flow @ Border for 3 Consecutive Summers.
∴ To Model This is not applicable

Rio San Antonio 68 sq miles
Midpoint between Headwaters & Colorado Border *

Cross Section



section:	at 217 feet
	Riffle
stream:	Rio San Antonio at FR 87 at BLM enclosure
location:	De-stabilized E channel
description:	C4 Canopy 22%
height of instrument (ft):	103.68

notes	omit pt.	distance (ft)	FS (ft)	elevation
	☐	-37	1-Jan	102.08
	☐	-28	4.19	99.49
	☐	-17	4.48	99.2
LBP	☐	0	3.68	100
LFPW	☐	11	3.69	99.99
	☐	11.6	4.53	99.15
	☐	12	5.13	98.55
LBF	☐	14	5.55	98.13
	☐	16	6.59	97.09
	☐	22	6.9	96.78
	☐	26	7.02	96.66
	☐	30.4	7.13	96.55
	☐	32.4	7.1	96.58
	☐	34.7	7.03	96.65
	☐	36.3	6.9	96.78
	☐	40.5	6.29	97.39
RBF	☐	42.45	5.55	98.13
	☐	44.5	4.53	99.15
	☐	48	4.13	99.55
	☐	56	4.33	99.35
	☐	69	4.72	98.96
	☐	84	4.25	99.43
	☐	109	4.25	99.43
RFPW	☐	114	3.65	100.03
	☐	188	3.98	99.7
	☐			

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
5.55	3.69	103.0	0.5	0.039
98.13	99.99			

dimensions			
34.5	x-section area	1.2	d mean
28.5	width	28.9	wet P
1.6	d max	1.2	hyd radi
3.4	bank ht	23.4	w/d ratio
103.0	W flood prone area	3.6	ent ratio

hydraulics	
3.0	velocity (ft/sec)
104.9	discharge rate, Q (cfs)
0.37	shear stress ((lbs/ft sq)
0.44	shear velocity (ft/sec)
1.150	unit stream power (lbs/ft/sec)
0.24	Froude number
6.9	friction factor u/u*
22.2	threshold grain size (mm)

check from channel material			
72	measured D84 (mm)		
5.1	relative roughness	6.9	fric. factor
0.039	Manning's n from channel material		

APPENDIX D
THERMOGRAPH SUMMARY DATA AND GRAPHICS

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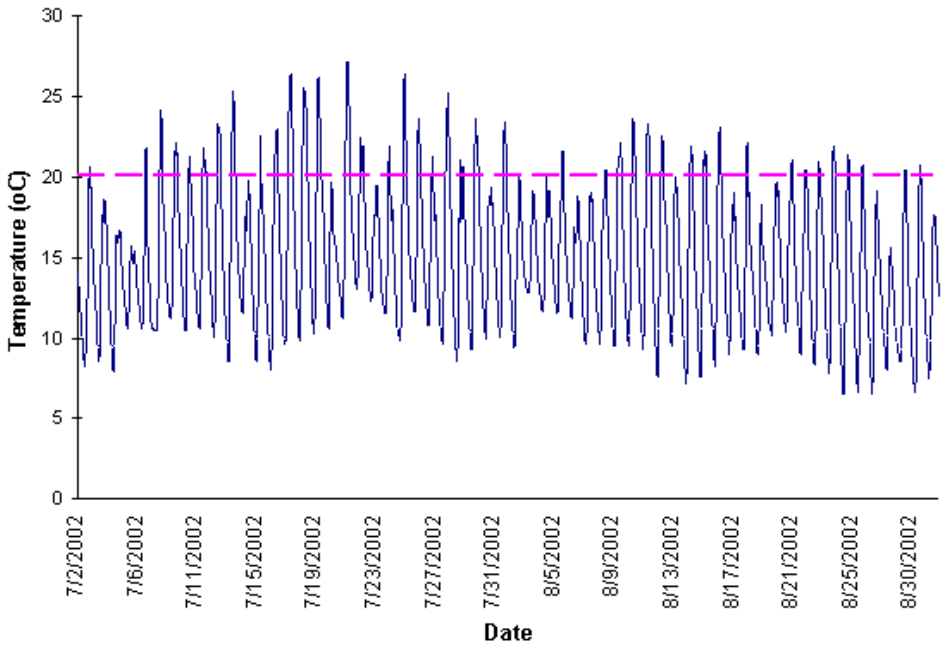
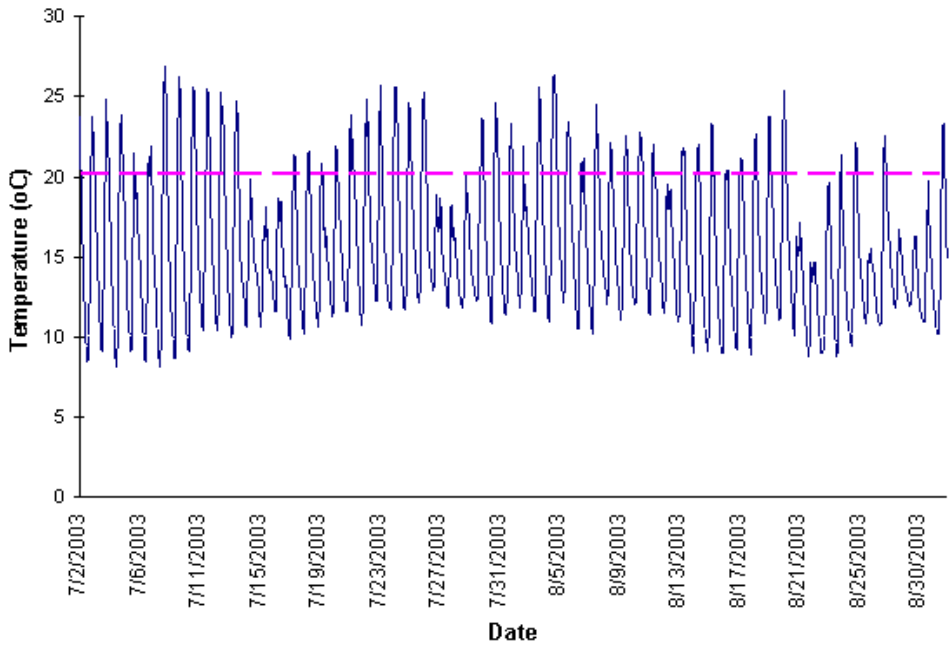
D1.0 Comanche Creek (Costilla Creek to Little Costilla Creek)

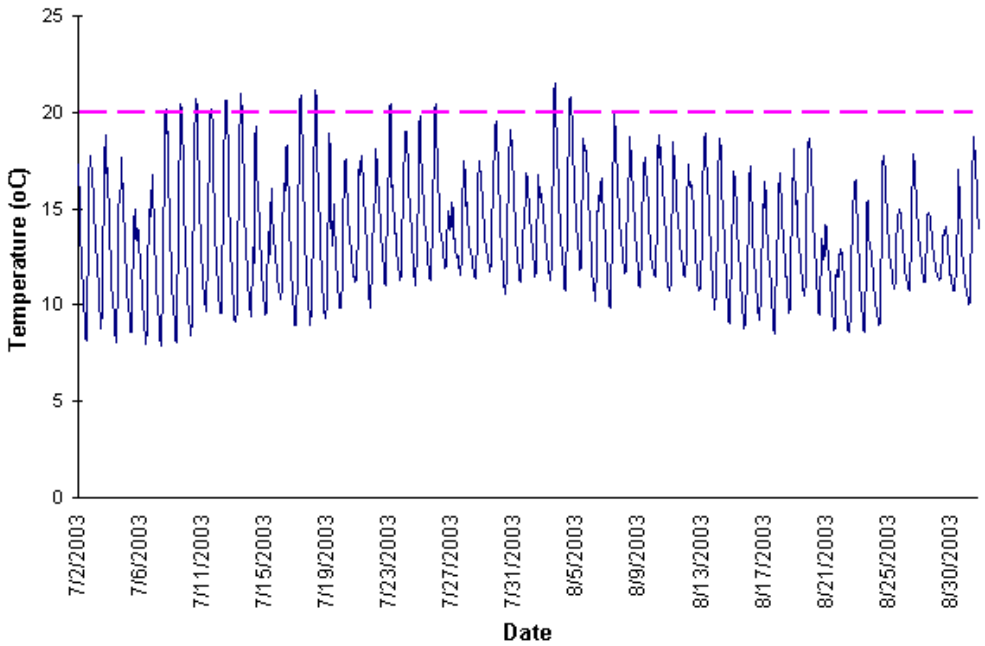
July 2, 2002 (18:46) through August 31, 2002:	
Number of Data Points:	1,446
Number of Measurements >20°C:	202
Percentage Data Points >20°C:	14%
Minimum Temperature (°C):	6.5
Maximum Temperature (°C):	27.1



July 2, 2003 (18:00) through August 31, 2003:	
Number of Data Points:	1,446
Number of Measurements >20°C:	276
Percentage Data Points >20°C:	19%
Minimum Temperature (°C):	8.1
Maximum Temperature (°C):	26.9

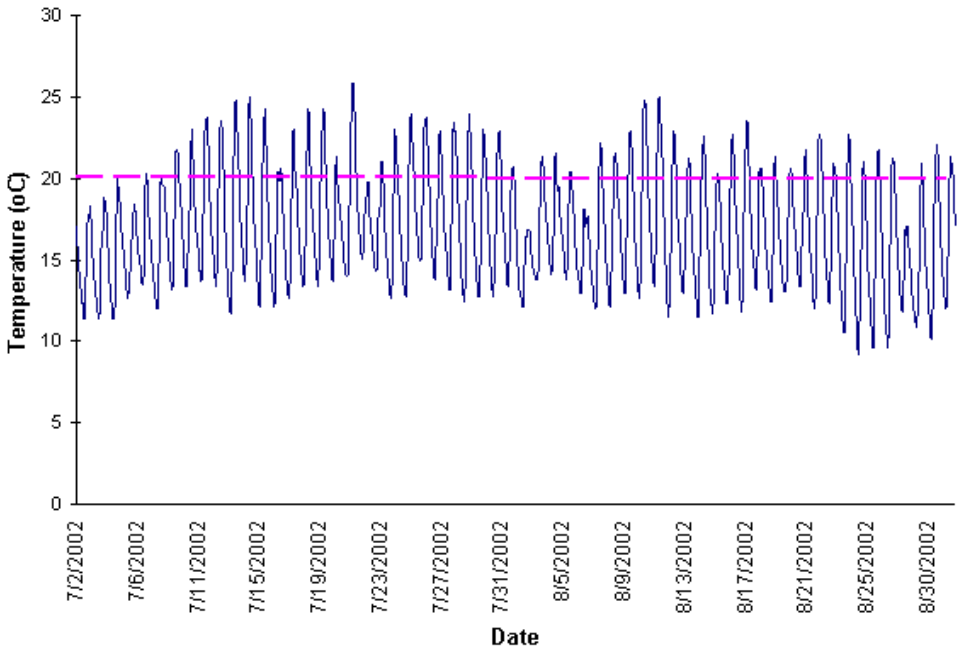


July 2, 2003 (18:00) through August 31, 2003:	
Number of Data Points:	1,446
Number of Measurements >20°C:	32
Percentage Data Points >20°C:	2%
Minimum Temperature (°C):	7.8
Maximum Temperature (°C):	21.5



D2.0 Costilla Creek (Diversion above Costilla to Comanche Creek)

July 2, 2002 (18:38) through August 31, 2002:	
Number of Data Points:	1,446
Number of Measurements >20°C:	330
Percentage Data Points >20°C:	23%
Minimum Temperature (°C):	9.2
Maximum Temperature (°C):	25.8



D3.0 Rio Fernando de Taos (Rio Pueblo de Taos to headwaters)

July 3, 2000 (12:00) through August 31, 2000:	
Number of Data Points:	1,428
Number of Measurements >20°C:	576
Percentage Data Points >20°C:	40%
Minimum Temperature (°C):	15.2
Maximum Temperature (°C):	24.5

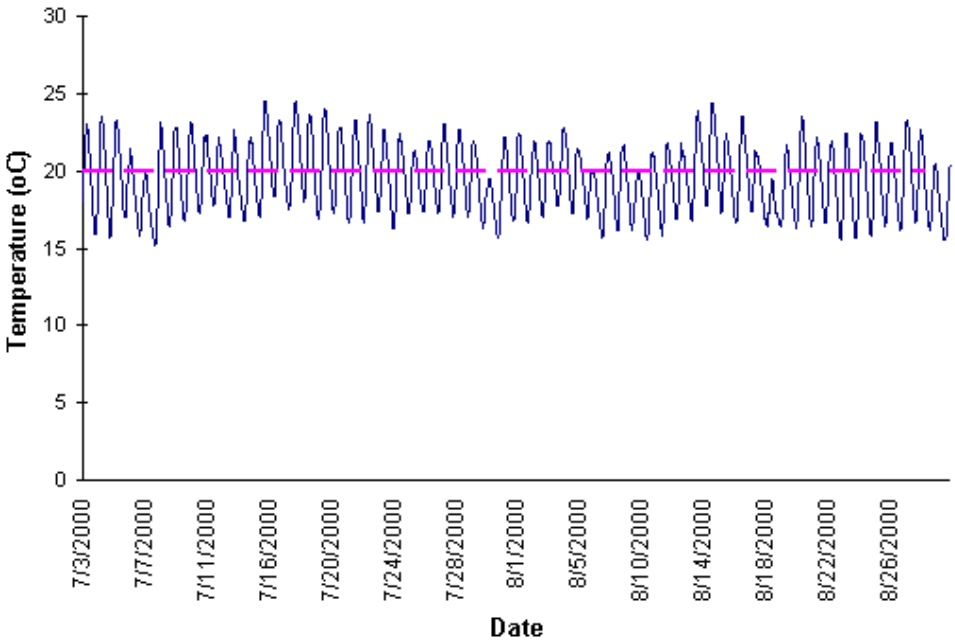
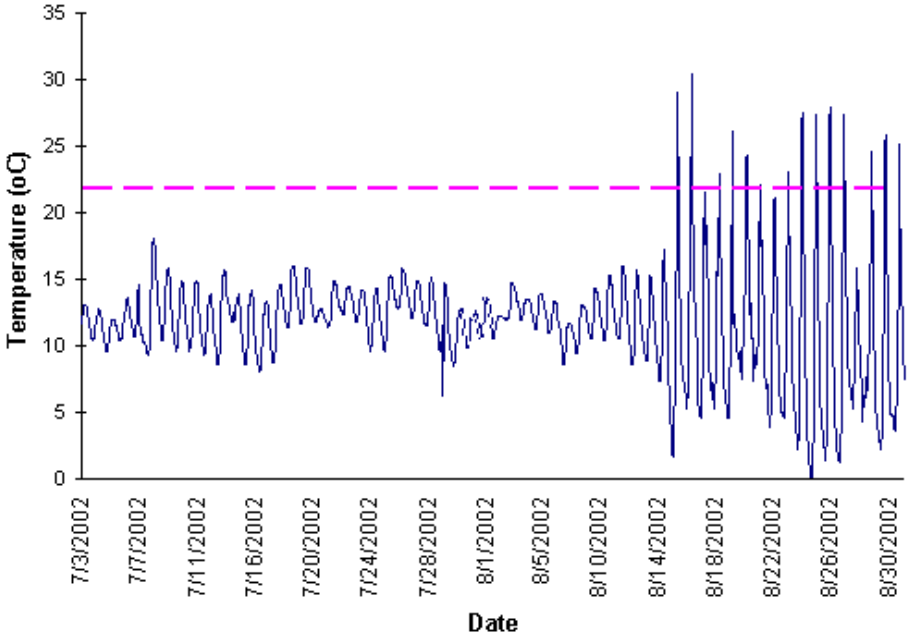
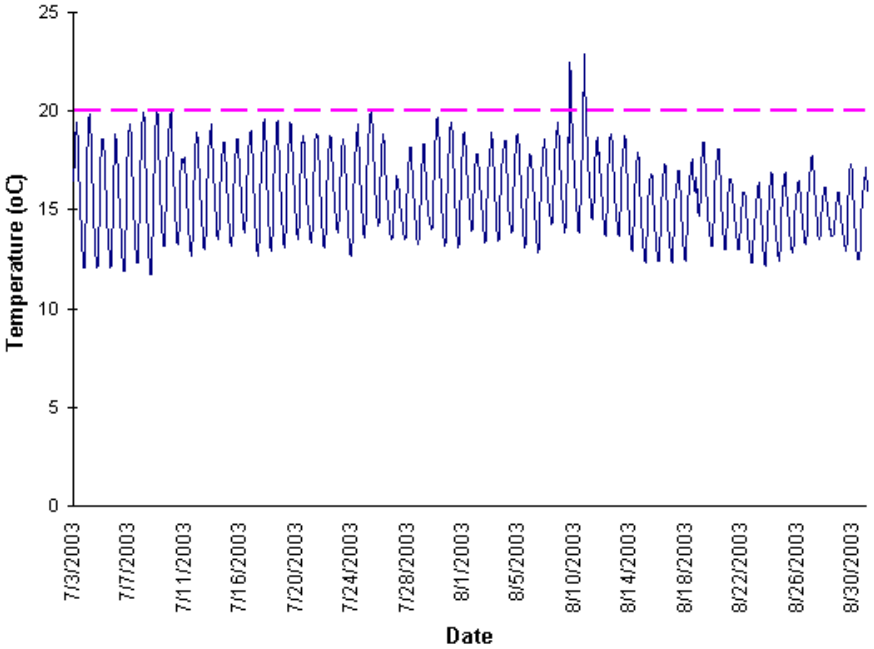


Photo not available for Rio Fernando de Taos near Lower Ranchito

July 3, 2002 (12:24) through August 31, 2002:	
Number of Data Points:	1,428
Number of Measurements >20°C:	43
Percentage Data Points >20°C:	3%
Minimum Temperature (°C):	-0.06
Maximum Temperature (°C):	30.3



July 3, 2003 (12:00) through August 31, 2003:	
Number of Data Points:	1,428
Number of Measurements >20°C:	7
Percentage Data Points >20°C:	0.5%
Minimum Temperature (°C):	11.7
Maximum Temperature (°C):	22.8



D4.0 Rio Grande (Red River to CO border)

July 2, 2003 (18:00) through August 31, 2003:	
Number of Data Points:	1,446
Number of Measurements >20°C:	422
Percentage Data Points >20°C:	29%
Minimum Temperature (°C):	14.0
Maximum Temperature (°C):	26.6

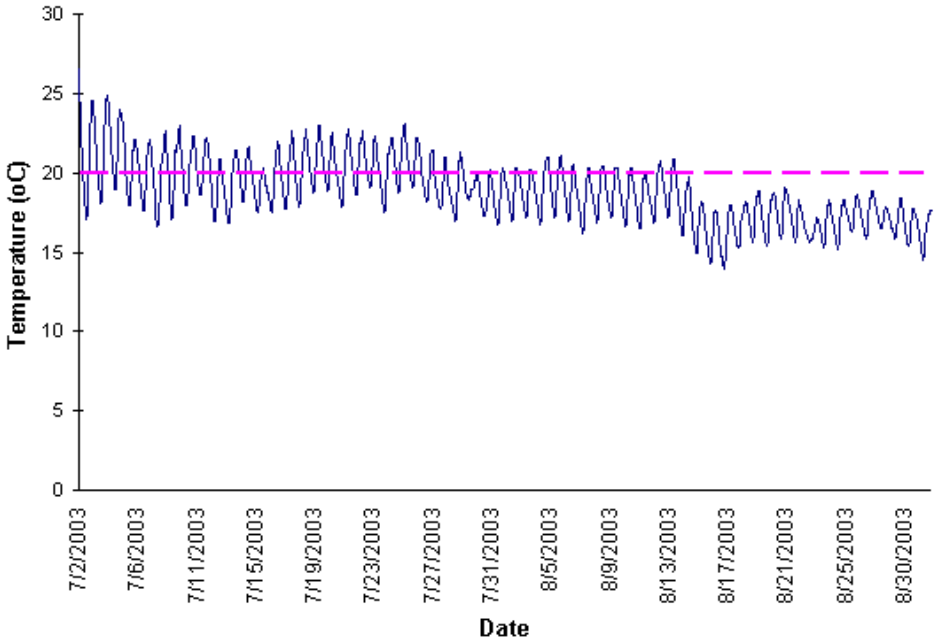
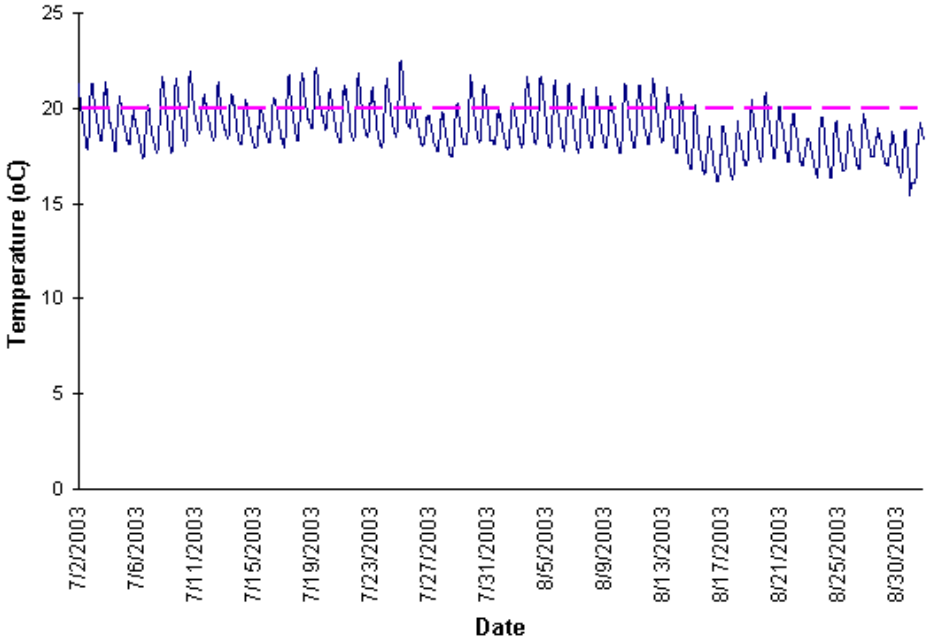


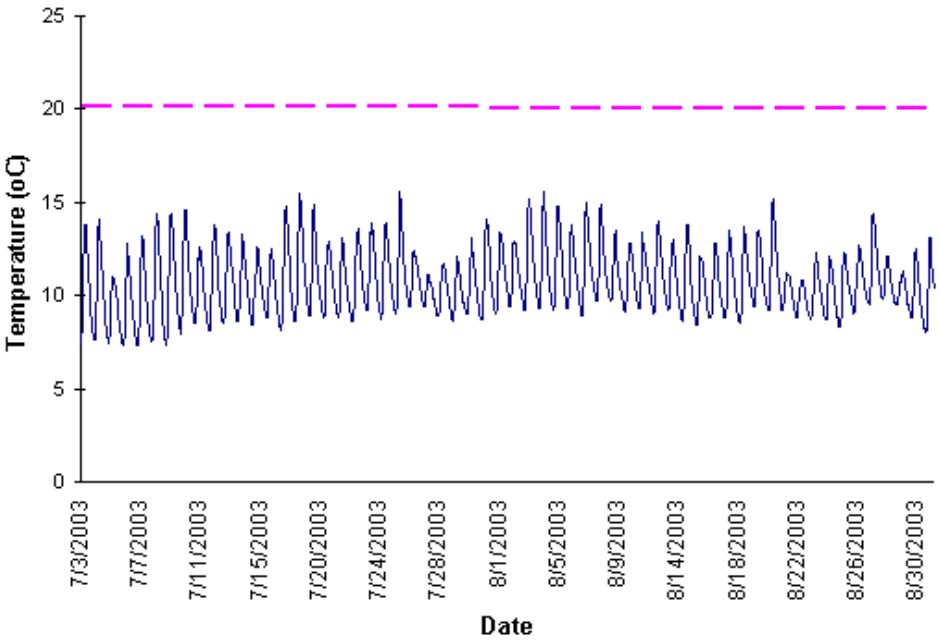
Photo not available for Rio Grande at the NM-CO border

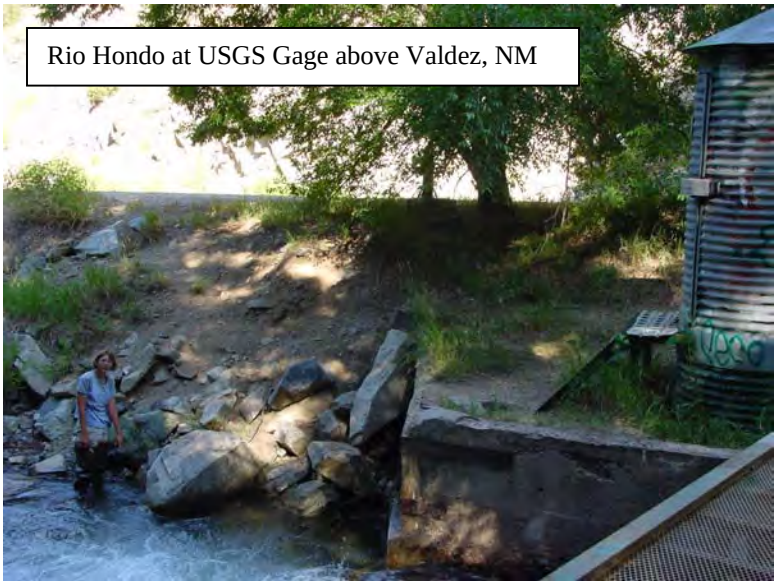
July 2, 2003 (18:00) through August 31, 2003:	
Number of Data Points:	1,446
Number of Measurements >20°C:	314
Percentage Data Points >20°C:	22%
Minimum Temperature (°C):	15.5
Maximum Temperature (°C):	22.5



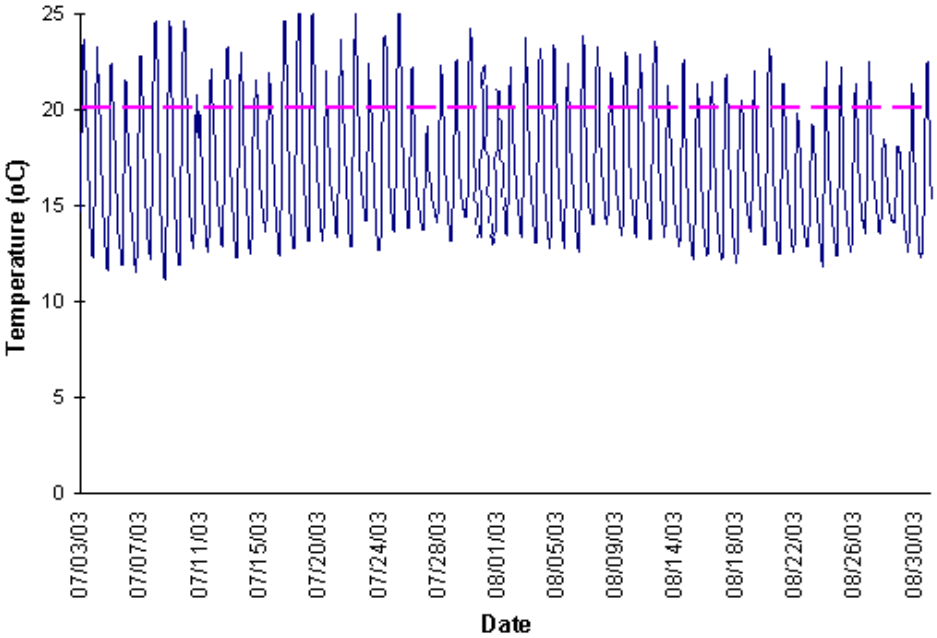
D5.0 Rio Hondo (Rio Grande to USFS boundary)

July 3, 2003 (12:00) through August 31, 2003:	
Number of Data Points:	1,428
Number of Measurements >20°C:	0
Percentage Data Points >20°C:	0%
Minimum Temperature (°C):	7.3
Maximum Temperature (°C):	15.6



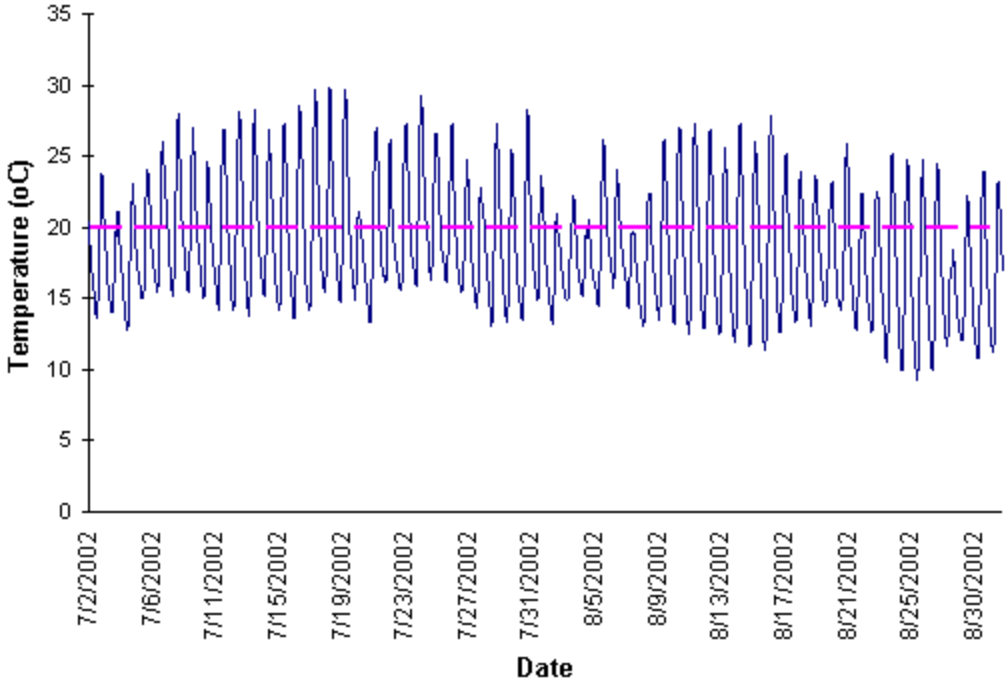

Rio Hondo at USGS Gage above Valdez, NM

July 3, 2003 (12:00) through August 31, 2003:	
Number of Data Points:	1,428
Number of Measurements >20°C:	307
Percentage Data Points >20°C:	21%
Minimum Temperature (°C):	11.1
Maximum Temperature (°C):	25.4

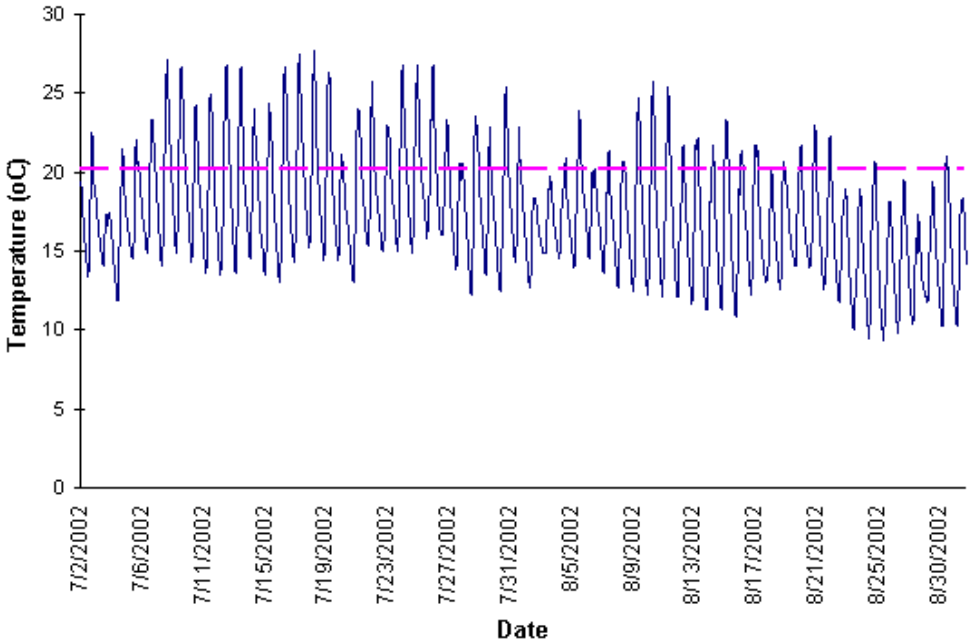


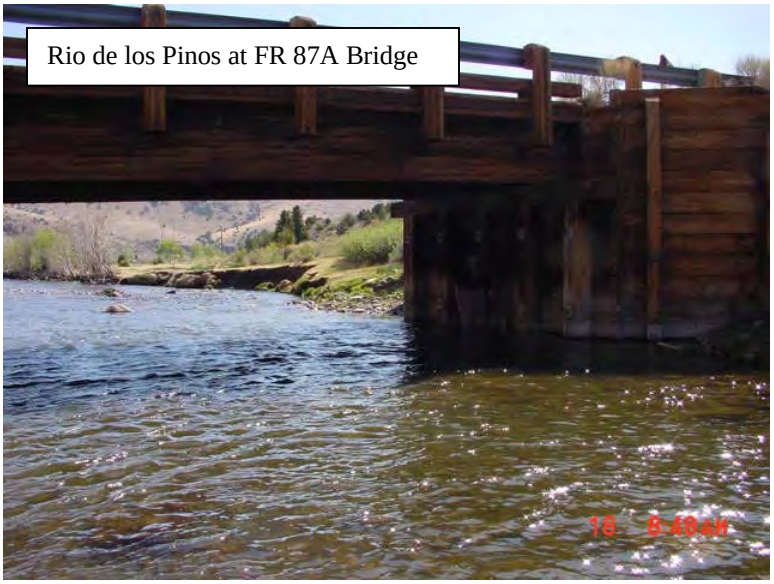
D6.0 Rio de los Pinos (CO border to headwaters)

July 2, 2002 (18:36) through August 31, 2002:	
Number of Data Points:	1,446
Number of Measurements >20°C:	508
Percentage Data Points >20°C:	35%
Minimum Temperature (°C):	9.3
Maximum Temperature (°C):	29.8

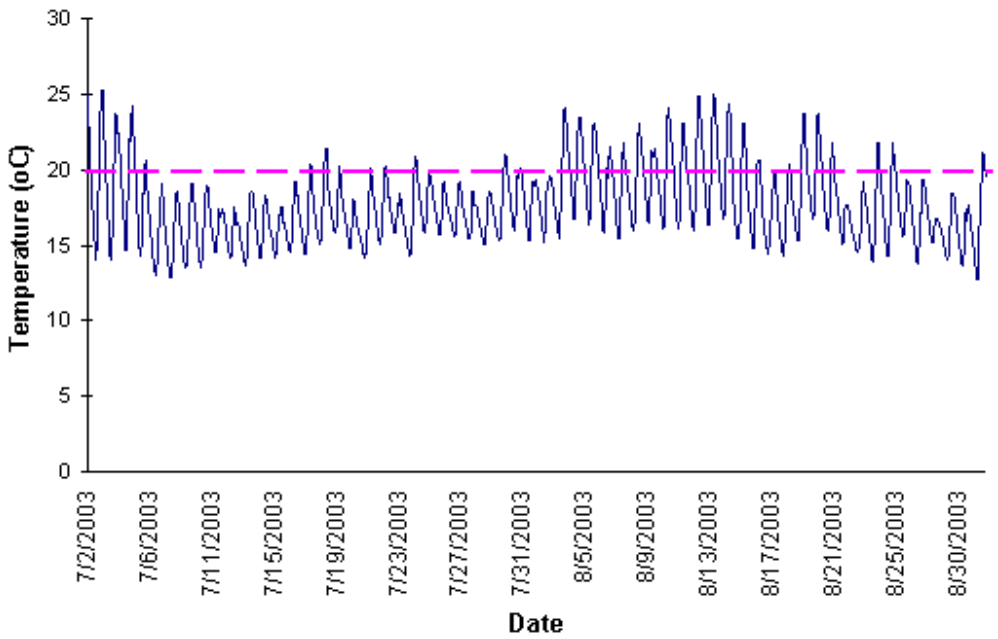


July 2, 2002 (18:31) through August 31, 2002:	
Number of Data Points:	1,446
Number of Measurements >20°C:	344
Percentage Data Points >20°C:	24%
Minimum Temperature (°C):	9.3
Maximum Temperature (°C):	27.7

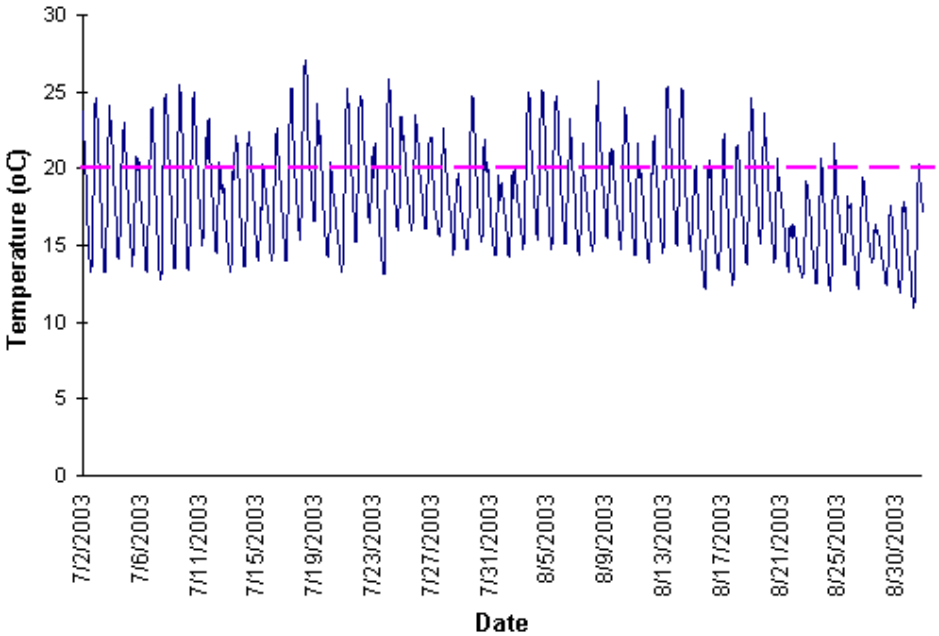




July 2, 2003 (18:00) through August 31, 2003:	
Number of Data Points:	1,446
Number of Measurements >20°C:	246
Percentage Data Points >20°C:	17%
Minimum Temperature (°C):	12.7
Maximum Temperature (°C):	25.3



July 2, 2003 (18:00) through August 31, 2003:	
Number of Data Points:	1,446
Number of Measurements >20°C:	387
Percentage Data Points >20°C:	27%
Minimum Temperature (°C):	11.0
Maximum Temperature (°C):	27.1



D7.0 Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo)

July 3, 2000 (14:00) through August 31, 2000:	
Number of Data Points:	1,426
Number of Measurements >20°C:	682
Percentage Data Points >20°C:	48%
Minimum Temperature (°C):	14.6
Maximum Temperature (°C):	25.1

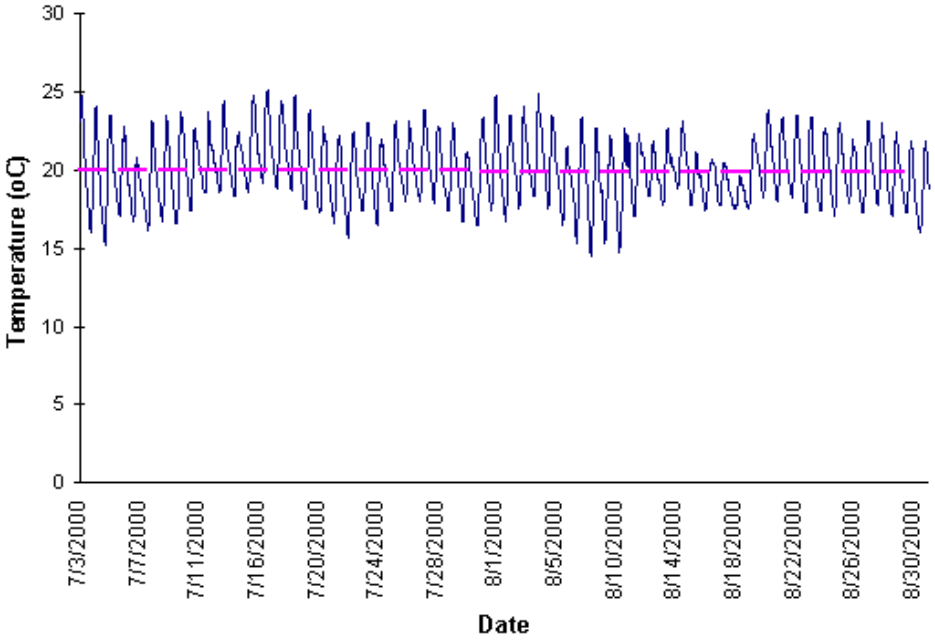


Photo not available for Rio Pueblo de Taos above Rio Grande

July 3, 2003 (14:00) through August 31, 2003:	
Number of Data Points:	1,426
Number of Measurements >20°C:	634
Percentage Data Points >20°C:	44%
Minimum Temperature (°C):	15.7
Maximum Temperature (°C):	25.4

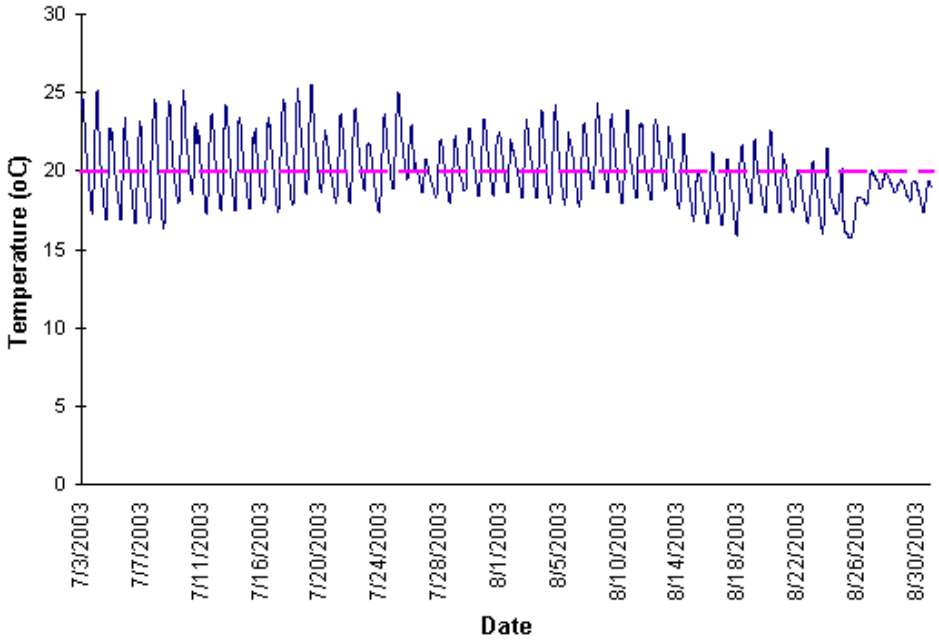


Photo not available for Rio Pueblo de Taos above Rio Grande

D8.0 Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho)

July 3, 2000 (14:00) through August 31, 2000:	
Number of Data Points:	1,426
Number of Measurements >20°C:	745
Percentage Data Points >20°C:	52%
Minimum Temperature (°C):	13.7
Maximum Temperature (°C):	28.3

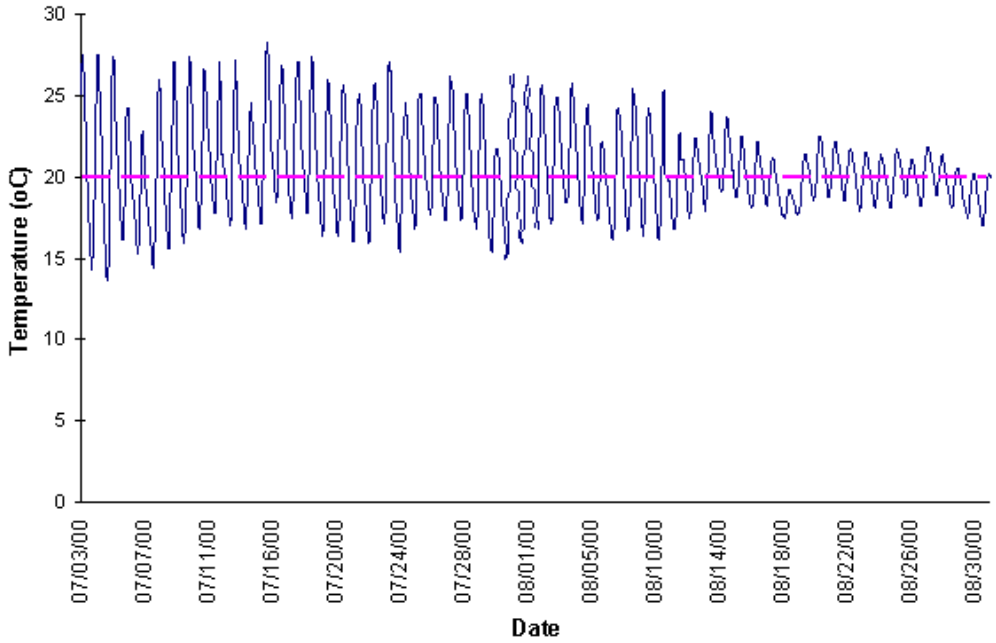


Photo not available for Rio Pueblo de Taos below Taos WWTF

July 3, 2003 (14:00) through August 31, 2003:	
Number of Data Points:	1,426
Number of Measurements >20°C:	693
Percentage Data Points >20°C:	49%
Minimum Temperature (°C):	13.4
Maximum Temperature (°C):	30.8

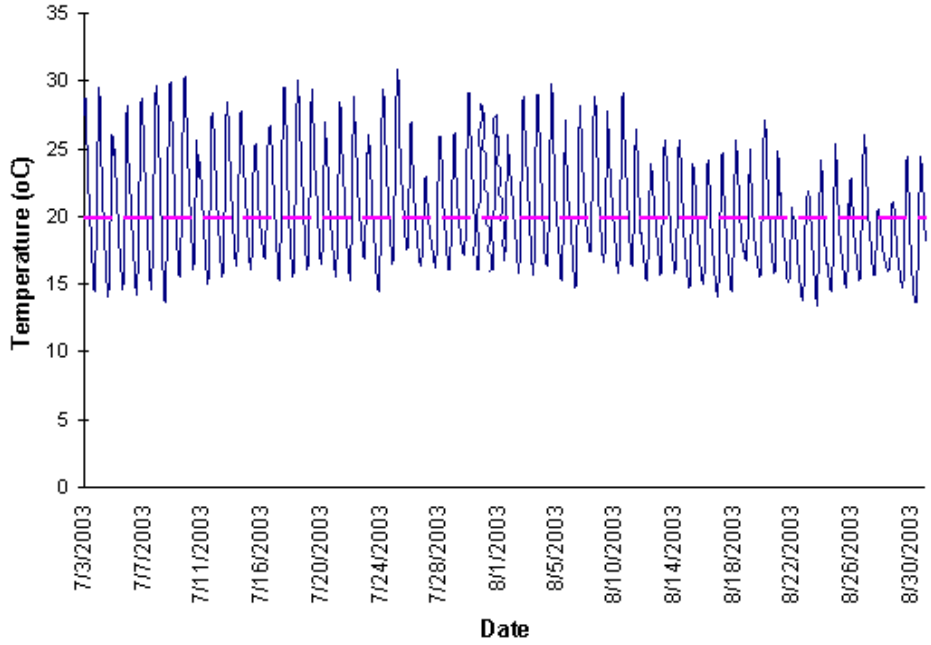


Photo not available for Rio Pueblo de Taos at Highway 240

D9.0 Rio Pueblo de Taos (Rio Grande del Rancho to Taos Pueblo Boundary)

July 3, 2000 (14:00) through August 31, 2000:	
Number of Data Points:	1,426
Number of Measurements >20°C:	410
Percentage Data Points >20°C:	29%
Minimum Temperature (°C):	11.8
Maximum Temperature (°C):	27.2

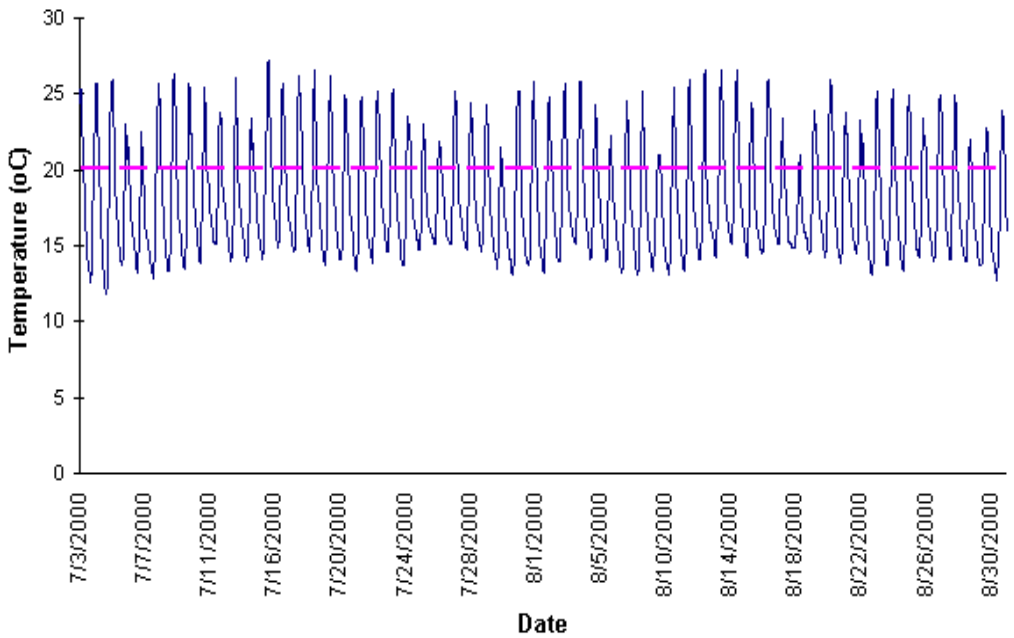
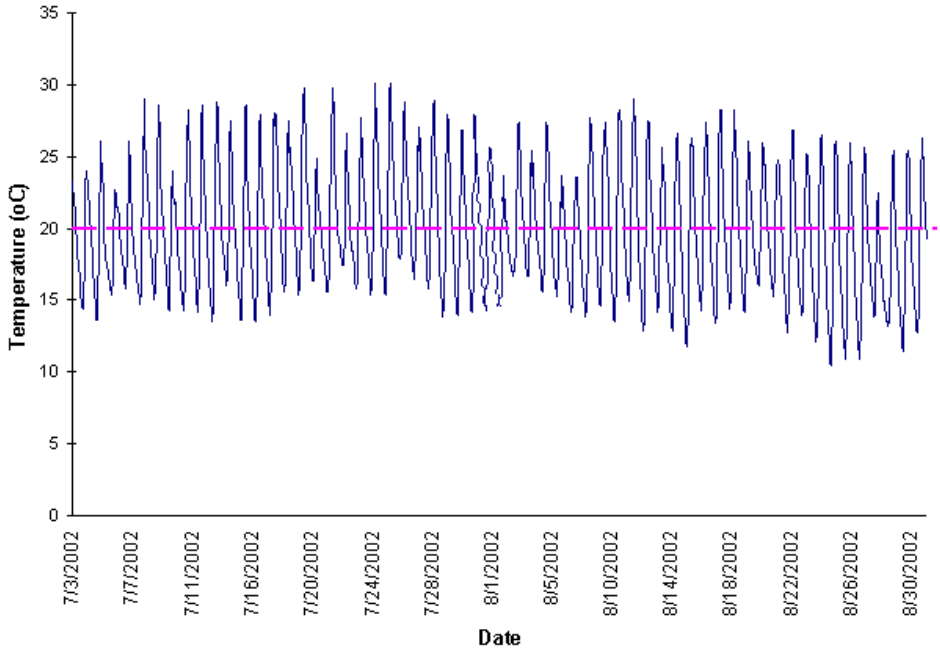


Photo not available for Rio Pueblo de Taos near Lower Ranchito

July 3, 2002 (14:12) through August 31, 2002:	
Number of Data Points:	1,426
Number of Measurements >20°C:	648
Percentage Data Points >20°C:	45%
Minimum Temperature (°C):	10.4
Maximum Temperature (°C):	30.1



July 3, 2003 (14:00) through August 31, 2003:	
Number of Data Points:	1,426
Number of Measurements >20°C:	693
Percentage Data Points >20°C:	49%
Minimum Temperature (°C):	13.4
Maximum Temperature (°C):	30.8

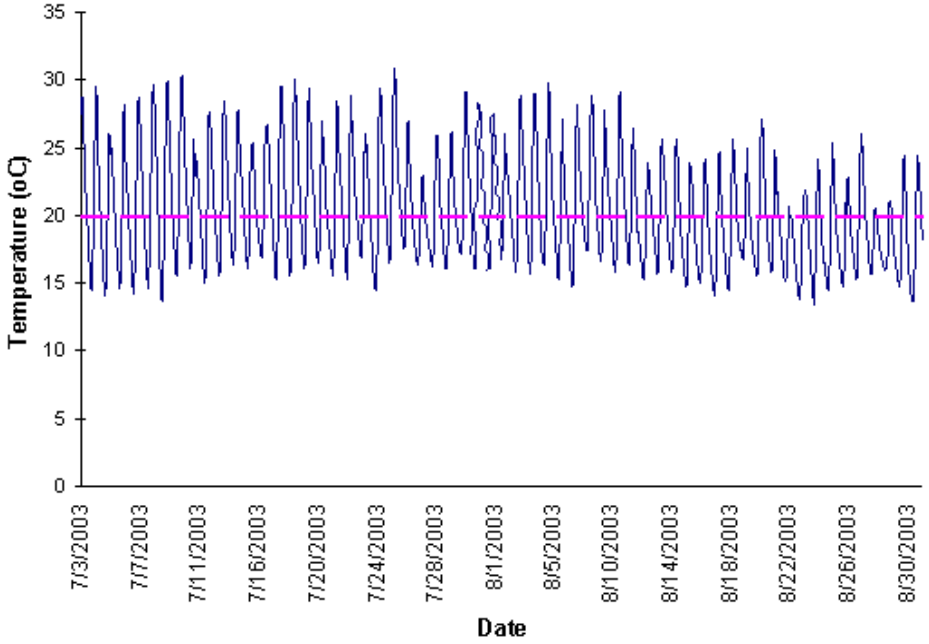
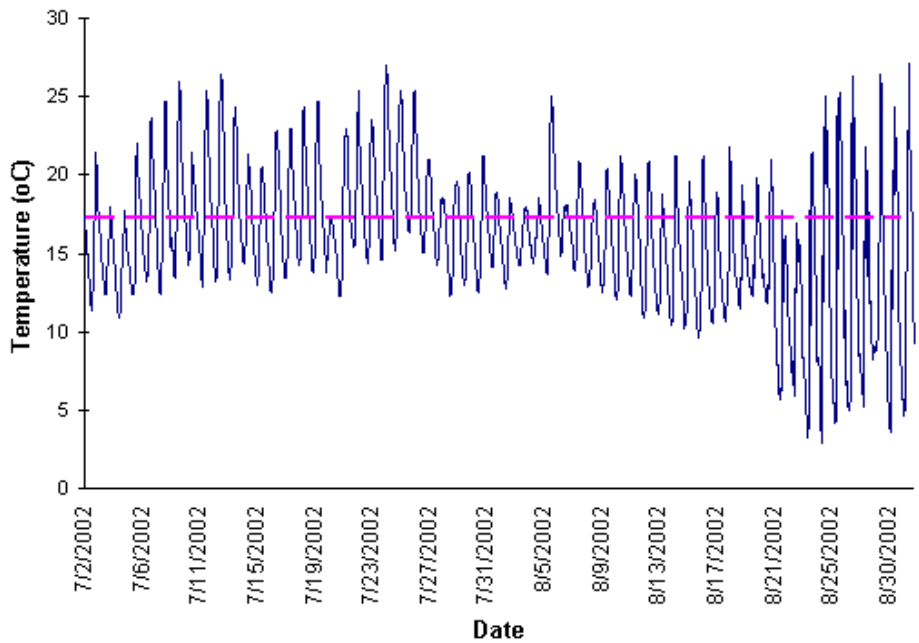
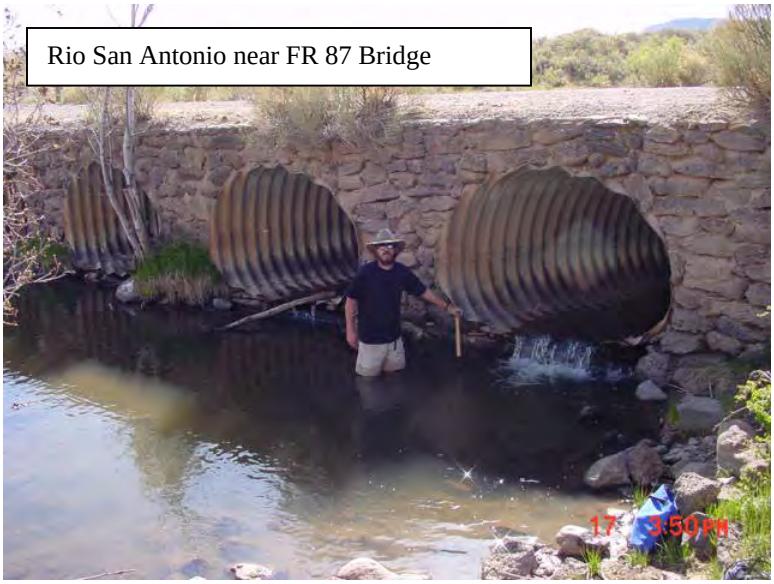


Photo not available for Rio Pueblo de Taos at Highway 240

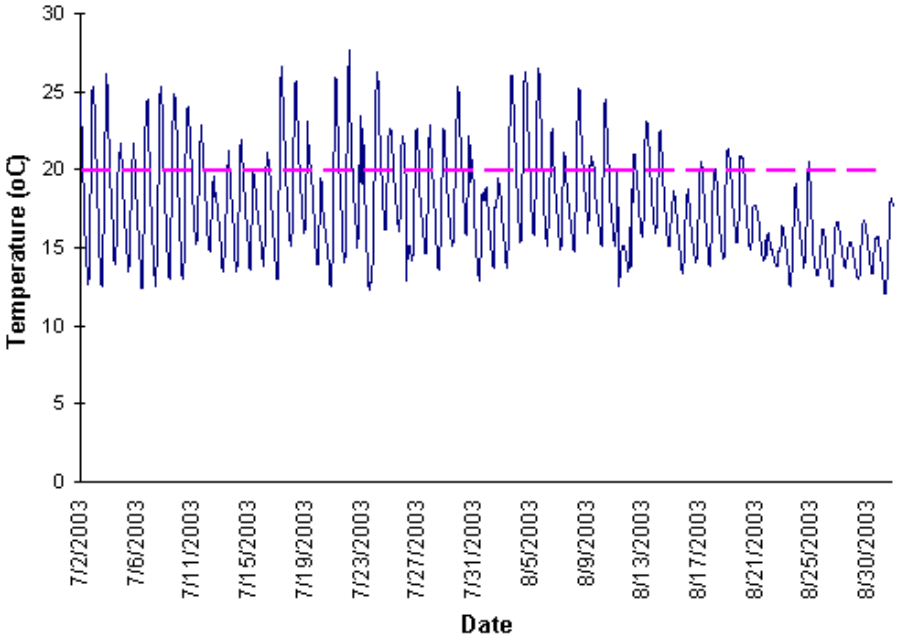
D10.0 Rio San Antonio (Montoya Canyon to headwaters)

July 2, 2002 (18:44) through August 31, 2002:	
Number of Data Points:	1,446
Number of Measurements >20°C:	255
Percentage Data Points >20°C:	18%
Minimum Temperature (°C):	2.9
Maximum Temperature (°C):	27.1




Rio San Antonio near FR 87 Bridge

July 2, 2003 (18:44) through August 31, 2003:	
Number of Data Points:	1,446
Number of Measurements >20°C:	350
Percentage Data Points >20°C:	24%
Minimum Temperature (°C):	12.0
Maximum Temperature (°C):	27.6



Rio San Antonio near FR 87 Bridge

APPENDIX E
HYDROLOGY, GEOMETRY, AND METEROLOGICAL INPUT DATA FOR SSTEMP

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LIST OF ACRONYMS

4Q3	Four-consecutive day discharge that has a recurrence interval of three years
cfs	Cubic Feet per Second
GIS	Geographic Information Systems
GPS	Global Positioning System
IOWDM	Input and Output for Watershed Data Management
mi^2	Square Miles
^oC	Degrees Celcius
SEE	Standard Error of Estimate
SSTEMP	Stream Segment Temperature
SWSTAT	Surface-Water Statistics
TMDL	Total Maximum Daily Load
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WinXSPRO	Windows-Based Stream Channel Cross-Section Analysis

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E1.0 INTRODUCTION

This appendix provides site-specific hydrology, geometry, and meterological data for input into the Stream Segment Temperature (SSTEMP) Model (Bartholow 2002). Hydrology variables include segment inflow, inflow temperature, segment outflow, and accretion temperature. Geometry variables are latitude, segment length, upstream and downstream elevation, Width's A-term, Width's B-term, and Manning's n. Meterological inputs to SSTEMP Model include air temperature, relative humidity, windspeed, ground temperature, thermal gradient, possible sun, dust coefficient, ground reflectivity, and solar radiation. In the following sections, these parameters are discussed in detail for each assessment unit to be modeled using SSTEMP Model. The assessment units and modeled dates are defined as follows:

Table E.1 Assessment Units and Modeled Dates

Assessment Unit ID	Assessment Unit Description	Modeled Date
NM-2120.A_827	= Comanche Creek (Costilla Creek to Little Costilla Creek)	8-4-2003
NM-2120.A_820	= Costilla Creek (Diversion above Costilla to Comanche Creek)	7-31-2002
NM-2120.A_900	= Rio de los Pinos (Colorado border to headwaters)	7-31-2000
NM-2120.A_512	= Rio Fernando de Taos (Rio Pueblo de Taos to headwaters)	7-5-2003
NM-2119_05	= Rio Grande (Red River to New Mexico-Colorado border)	7-8-2003
NM-2120.A_600	= Rio Hondo (Rio Grande to US Forest Service boundary)	7-3-2003
NM-2119_20	= Rio Pueblo de Taos (Rio Grande to Arroyo del Alamo)	7-10-2003
NM-2119_30	= Rio Pueblo de Taos (Arroyo del Alamo to Rio Grande del Rancho)	7-10-2003
NM-2120.A_511	= Rio Pueblo de Taos (Rio Grande del Rancho to Taos Pueblo boundary)	7-31-2000
NM-2120.A_901	= Rio San Antonio (Montoya Canyon to headwaters)	7-3-2003

E2.0 HYDROLOGY

E2.1 Segment Inflow

This parameter is the *mean daily* flow at the top of the stream segment. If the segment begins at an effective headwater, the flow is entered into SSTEMP Model as zero. Flow data from USGS gages were used when available. To be conservative, the lowest four-consecutive-day discharge that has a recurrence interval of three years but that does not necessarily occur every three years (4Q3) was used as the inflow instead of the mean daily flow. These critical low flows were used to decrease assimilative capacity of the stream to adsorb and disperse solar energy. The 4Q3 was determined for gaged sites using a log Pearson Type III distribution through "*Input and Output for Watershed Data Management*" (IOWDM) software, Version 4.1 (USGS 2002a) and "*Surface-Water Statistics*" (SWSTAT) software, Version 4.1 (USGS 2002b).

Discharges for ungaged sites on gaged streams were estimated based on methods published by Thomas and others (1997). If the drainage area of the ungaged site is between 50 and 150 percent of the drainage area of the gaged site, the following equation is used:

$$Q_u = Q_g \left(\frac{A_u}{A_g} \right)^{0.5}$$

where,

Q_u = Area weighted 4Q3 at the ungaged site (cubic feet per second [cfs])
Q_g = 4Q3 at the gaged site (cfs)
A_u = Drainage area at the ungaged site (square miles [mi^2])
A_g = Drainage area at the gaged site (mi^2)

Drainage areas for assessment units to which this method was applied are summarized in the following table:

Table E.2 Drainage Areas for Estimating Flow by Drainage Area Ratios

Assessment Unit	USGS Gage	Drainage Area from Gage (mi^2)	Drainage Area from Top of AU (mi^2)	Drainage Area from Bottom of AU (mi^2)	Ratio of DA of Ungaged (upstream) to Gaged Site	Ratio of DA of Ungaged (downstream) to Gaged Site
NM-2120.A_827	—[a]	—	0.119	42.147	—	—
NM-2120.A_820	08255500	215	115	216	53%	100%
NM-2120.A_512	—[a]	—	—	67.914	—	—
NM-2119_05	08263500	8,440	7,465	8,720	88%	103%
NM-2120.A_600	08267500	36	40	68	111%	***189%***[b]
NM-2120.A_900	08248000	155	—[c]	165	—[c]	106%
NM-2119_20	08246300	384	402	417	106%	109%
NM-2119_30	08276300	384	359	402	94%	105%
NM-2120.A_511	08276300	384	111	201	***289%***[b]	52%
NM-2120.A_901	—[d]	—	—[c]	67.29	—[c]	—[d]

Notes:
[a] Regression method developed by Waltemeyer (2002) was used to estimate flows since USGS this is an ungaged stream.
[b] The method developed by Thomas et al. (1997) is not applicable because the drainage area of the ungaged site is greater than 150 percent of the drainage area of the gaged site. Therefore, the method developed by Waltemeyer (2002) was used to estimate flows for these assessment units.
[c] Assessment unit begins at headwaters.
[d] USGS gage location is downstream of the lower boundary of the assessment unit. The section of the river where the gage is located typically goes dry. The method developed by Thomas et al. (1997) was not used because the only available gage data do not reflect natural flow conditions. Instead, the regression method developed by Waltemeyer (2002) was used.
mi^2 = Square miles
USGS = U.S. Geological Survey
AU = Assessment Unit

4Q3 derivations for ungaged streams were based on analysis methods described by Waltemeyer (2002). In this analysis, two regression equations for estimating 4Q3 were developed based on physiographic regions of New Mexico (i.e., statewide and mountainous regions above 7,500 feet

in elevation). The following statewide regression equation is based on data from 50 gaging stations with non-zero discharge (Waltemeyer 2002):

$$4Q3 \quad = \quad 1.2856 \times 10^{-4} \; DA^{0.42} \; P_w^{\;3.16}$$

where,

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

The average standard error of estimate (SEE) and coefficient of determination are 126 and 48 percent, respectively, for this regression equation (Waltemeyer 2002). The following regression equation for mountainous regions above 7,500 feet in elevation is based on data from 40 gaging stations with non-zero discharge (Waltemeyer 2002):

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

where,

S = Average basin slope (percent)

The average SEE and coefficient of determination are 94 and 66 percent, respectively, for this regression equation (Waltemeyer 2002). The drainage areas, average basin mean winter precipitation, and average basin slope for assessment units where this regression method was used are presented in the following table:

Table E.3 Parameters for Estimating Flow using USGS Regression Model

Assessment Unit	Regression Model[(a)]	Average Elevation for Assessment Unit (feet)	Mean Basin Winter Precipitation (inches)	Average Basin Slope (unitless)
NM-2120.A_827	Mountainous	9,090	12.1	0.248
NM-2120.A_512	Mountainous	7,634	9.3	0.268
NM-2120.A_511	Statewide	6,761	10.9	0.271
NM-2120.A_600	Statewide	7,051	10.4	0.378
NM-2120.A_901	Mountainous	8,775	17.1	0.136

Notes:
mi^2 = Square miles
[(a)] Waltemeyer (2002)

Based on the methods described above, the following values were estimated for inflow:

Table E.4 Inflow

Assessment Unit	Ref.	4Q3[1] (cfs)	DAt (mi^2)	DAg (mi^2)	Pw (in)	S unitless	Inflow (cfs)
NM-2120.A_827	(a)	—	0.119	—	12.1	0.248	0.019
NM-2120.A_820	(b)	4.059	115	215	—	—	2.967
NM-2120.A_512	N/A	—	—	—	9.3	0.268	0.000[2]
NM-2119_05	(b)	66.324	7,465	8,440	—	—	62.376
NM-2120.A_600	(b)	—	40.0	36.2	10.4	0.378	0.990
NM-2120.A_900	N/A	9.283	—	155	—	—	0.000[2]
NM-2119_20	(b)	7.202	402	380	—	—	7.408
NM-2119_30	(b)	7.202	359	380	—	—	7.000
NM-2120.A_511	(a)	7.202	111	384	10.9	0.271	1.762
NM-2120.A_901	N/A	—	—	—	17.1	0.136	0.000[2]

Notes:
N/A = Not applicable, assessment unit begins at headwaters.
Ref. = Reference
(a) Waltemeyer 2002
(b) Thomas et al. 1997
cfs = cubic feet per second
mi^2 = Square miles
in = Inches
Pw = Mean winter precipitation
DAt = Drainage area from top of segment
DAb = Drainage area from bottom of segment
DAg = Drainage area from USGS gage
S = Average basin slope
[1] Based on period of record for USGS gage.
[2] Inflow is zero because assessment unit begins at headwaters.

E2.2 Inflow Temperature

This parameter represents the *mean daily* water temperature at the top of the segment. 2003 data from thermographs positioned at the top of the assessment unit were used when possible. If the segment began at a true headwater, the temperature entered was zero degrees Celcius (^oC) (zero flow has zero heat). The following inflow temperatures for impaired assessment units were modeled in SSTEMP:

Table E.5 Mean Daily Water Temperature

Assessment Unit	Upstream Thermograph Location	Inflow Temp. (^oC)	Inflow Temp. (^oF)
NM-2120.A_827	Comanche below Little Costilla Creek	15.4	59.7
NM-2120.A_820	Costilla Creek below Comanche Creek[a]	16.6[b]	61.9
NM-2120.A_512	None (headwaters)	0	32.0
NM-2119_05	R. Grande at NM-CO Border	21.7	71.0
NM-2120.A_600	R. Hondo at USGS gage above Valdez	10.5	50.8
NM-2120.A_900	None (headwaters)	0	32.0
NM-2119_20	R. Pueblo de Taos at Highway 240[c]	22.5	72.4
NM-2119_30	R. Pueblo de Taos at Highway 240[c]	22.5	72.4
NM-2120.A_511	R. Pueblo de Taos at USGS Gage[d]	20.6[b]	69.1

Assessment Unit	Upstream Thermograph Location	Inflow Temp. (°C)	Inflow Temp. (°F)
NM-2120.A_901	None (headwaters)	0	32.0

Notes:
ºC = Degrees Celcius
ºF = Degrees Farenheit
[(a)] Data from 2002 were used for this assessment unit.
[(b)] Single field measurement – not average daily temperature.
[(c)] The Rio Pueblo de Taos at Arroyo del Alamo was not accessible at the time of thermograph deployment. Therefore, the inflow temperature for the "Arroyo del Alamo to Rio Grande del Rancho" assessment unit is also used as the inflow temperature for the "Rio Grande to Arroyo del Alamo" assessment unit.
[(d)] Data from 2000 were used for this assessment unit.

E2.3 Segment Outflow

Flow data from USGS gages were used when available. To be conservative, the 4Q3 was used as the segment outflow. These critical low flows were used to decrease assimilative capacity of the stream to adsorb and disperse solar energy. Outflow was estimated using the methods described in Section 2.1. The following table summarizes 4Q3s used in the SSTEMP Model:

Table E.6 Segment Outflow

Assessment Unit	Ref.	4Q3[(1)] (cfs)	DAb (mi^2)	DAg (mi^2)	Pw (in)	S unitless	Outflow (cfs)
NM-2120.A_827	(a)	—	42.15	—	12.1	0.248	1.151
NM-2120.A_820	(b)	4.059	216	215	—	—	4.064
NM-2120.A_512	N/A	—	67.91	—	9.3	0.268	0.696
NM-2119_05	(b)	66.324	8,720	8,440	—	—	67.415
NM-2120.A_600	(b)	—	67.59	36.2	10.4	0.378	1.234
NM-2120.A_900	(c)	9.283	165	155	—	—	9.283
NM-2119_20	(b)	7.202	417	380	—	—	7.544
NM-2119_30	(b)	7.202	402	380	—	—	7.408
NM-2120.A_511	(a)	7.202	201	384	10.9	0.271	2.262
NM-2120.A_901	N/A	—	67.29	—	17.1	0.136	2.449

Notes:
N/A = Not applicable, assessment unit begins at headwaters.
Ref. = Reference
(a) Waltemeyer 2002
(b) Thomas et al. 1997
(c) From USGS gage data
cfs = cubic feet per second
mi^2 = Square miles
in = Inches
Pw = Mean winter precipitation
DAt = Drainage area from top of segment
DAb = Drainage area from bottom of segment
DAg = Drainage area from USGS gage
S = Average basin slope
[(1)] Based on period of record for USGS gage.
[(2)] Inflow is zero because assessment unit begins at headwaters.

E2.4 Accretion Temperature

The temperature of the lateral inflow, barring tributaries, generally should be the same as groundwater temperature. In turn, groundwater temperature may be approximated by the mean annual air temperature. Mean annual air temperature for 2003 was used in the absence of measured data. The following table presents the mean annual air temperature for each assessment unit:

Table E.7 Mean Annual Air Temperature as an Estimate for Accretion Temperature

Assessment Unit	Ref.	Mean Annual Air Temperature for 2003 (^oC)	Mean Annual Air Temperature for 2003 (^oF)
NM-2120.A_827	(a)	8.157	46.683
NM-2120.A_820	(a)	7.508[(1)]	45.514[(1)]
NM-2120.A_512	(b)	11.432 [(2)]	52.577 [(2)]
NM-2119_05	(c)	10.543	50.540
NM-2120.A_600	(c)	10.543	50.540
NM-2120.A_900	(d)	5.216	41.389
NM-2119_20	(c)	10.543	50.540
NM-2119_30	(c)	10.543	50.540
NM-2120.A_511	(b)	11.432[(2)]	52.577[(2)]
NM-2120.A_901	(d)	5.216	41.389

Notes:
Ref. = References for Weather Station Data are as follows:

(a) New Mexico State University Climate Network (Costilla Station, Elevation 2,120 meters; Latitude 36°59'N, Longitude 105°33'W)

(b) New Mexico State University Climate Network (Alcalde Station, Elevation 1,745 meters; Latitude 36°05'N, Longitude 106°03'W)

(c) New Mexico State University Climate Network (Taos Station, Elevation 2,161 meters; Latitude 36°27'N, Longitude 105°40'W)

(d) New Mexico State University Climate Network (Chamita Station, Elevation 2,560 meters; Latitude 36°57'N, Longitude 106°39'W)

[(1)] Mean annual temperature for 2002.
[(2)] Mean annual temperature for 2000
^{o}F = Degrees Farenheit
^{o}C = Degrees Celcius

E3.0 GEOMETRY

E3.1 Latitude

Latitude refers to the position of the stream segment on the earth's surface. Latitude is generally determined in the field with a global positioning system (GPS) unit. Latitude for each assessment unit is summarized below:

Table E.8 Assessment Unit Latitude

Assessment Unit	Latitude (decimal degrees)
NM-2120.A_827	36.80
NM-2120.A_820	36.91
NM-2120.A_512	36.40
NM-2119_05	37.00
NM-2120.A_600	36.54
NM-2120.A_900	36.97
NM-2119_20	36.34
NM-2119_30	36.38
NM-2120.A_511	36.39
NM-2120.A_901	36.86

E3.2 Dam at Head of Segment

The following assessment units have a dam at the upstream end of the segment with a constant, or nearly constant diel release temperature:

Table E.9 Presence of Dam at Head of Segment

Assessment Unit	Dam?
NM-2120.A_827	No
NM-2120.A_820	No
NM-2120.A_512	No
NM-2119_05	No
NM-2120.A_600	No
NM-2120.A_900	No
NM-2119_20	No
NM-2119_30	No
NM-2120.A_511	No
NM-2120.A_901	No

E3.3 Segment Length

Segment length was determined with National Hydrographic Dataset Reach Indexing GIS tool. The segment lengths are as follows:

Table E.10 Segment Length

Assessment Unit	Length (miles)
NM-2120.A_827	10.3
NM-2120.A_820	18.0
NM-2120.A_512	21.6
NM-2119_05	27.8
NM-2120.A_600	8.5
NM-2120.A_900	20.9
NM-2119_20	6.4
NM-2119_30	1.2
NM-2120.A_511	2.8
NM-2120.A_901	9.1

E3.4 Upstream Elevation

The following upstream elevations were determined in the field with a GPS unit:

Table E.11 Upstream Elevations

Assessment Unit	Upstream Elevation (feet)
NM-2120.A_827	9,222
NM-2120.A_820	8,963
NM-2120.A_512	8,960
NM-2119_05	7,485
NM-2120.A_600	7,650
NM-2120.A_900	9,624
NM-2119_20	6,670
NM-2119_30	6,730
NM-2120.A_511	6,859
NM-2120.A_901	8,809

E3.5 Downstream Elevation

The following downstream elevations were determined in the field with a GPS unit:

Table E.12 Downstream Elevations

Assessment Unit	Downstream Elevation (feet)
NM-2120.A_827	8,963
NM-2120.A_820	7,953
NM-2120.A_512	5,489
NM-2119_05	6,616
NM-2120.A_600	6,453
NM-2120.A_900	8,120
NM-2119_20	6,099
NM-2119_30	6,670
NM-2120.A_511	6,730
NM-2120.A_901	8,750

E3.6 Width's A and Width's B Term

Width's B Term was calculated as the slope of the regression of the natural log of width and the natural log of flow. Width-versus-flow regression analyses were prepared by entering cross-section field data into a Windows-Based Stream Channel Cross-Section Analysis (WINXSPRO) Program (U.S. Department of Agriculture [USDA] 1998). Theoretically, the Width's A Term is the untransformed Y-intercept. However, because the width versus discharge relationship tends to break down at very low flows, the Width's B-Term was first calculated as the slope and Width's A-Term was estimated by solving for the following equation:

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

where,

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

The following table summarizes Width's A- and B-Terms for assessment units requiring temperature TMDLs:

Table E.13 Width's A and Width's B Terms

Assessment Unit	Width's B-Term	Width's A-Term[(1)]
NM-2120.A_827	0.157[(2)]	6.681[(2)]
NM-2120.A_820	0.230[(2)]	9.474[(2)]
NM-2120.A_512	0.224[(2)]	3.624[(2)]

Assessment Unit	Width's B-Term	Width's A-Term[(1)]
NM-2119_05	0.336[(2)]	16.410[(2)]
NM-2120.A_600	0.222	10.862
NM-2120.A_900	0.275[(2)]	14.463[(2)]
NM-2119_20	0.253	6.482
NM-2119_30	0.241	10.437
NM-2120.A_511	0.185	7.436
NM-2120.A_901	0.158	14.570

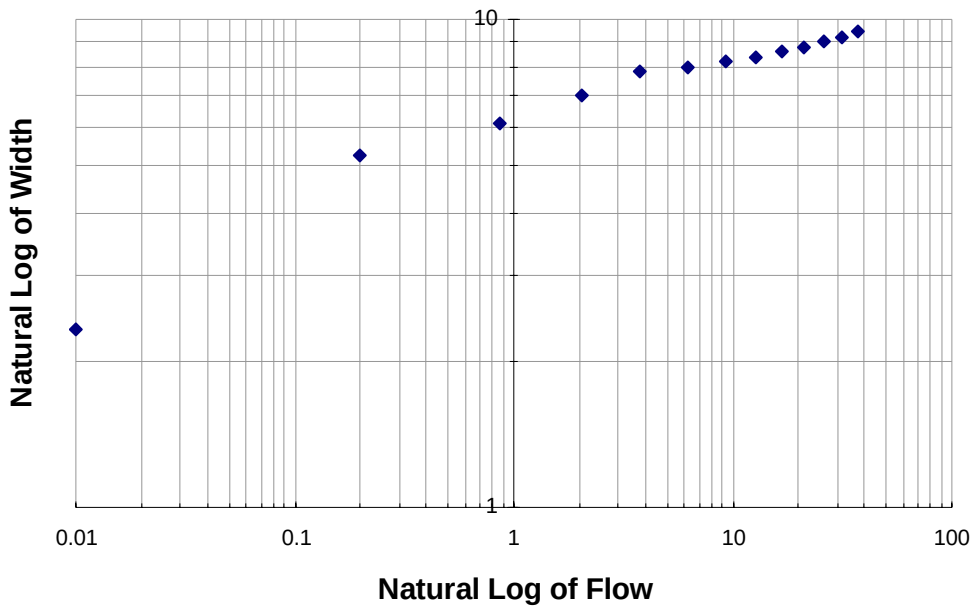
[(1)] A = e^constant from regression.
[(2)] Average of upstream and downstream measurements.

The following subsections present the detailed calculations for the Width's B-Term.

3.6.1 Width's B-Term for Assessment Unit NM-2120.A_827

Measurements were collected from upstream (below upper exclosure) and downstream (above mouth on Rio Costilla) locations within this assessment unit. The regression of natural log of width and natural log of flow for each location is as follows:

Figure E.1 Wetted Width versus Flow for Assessment Unit NM-2120.A_827, Downstream



Comanche Creek above the mouth on Rio Costilla (downstream)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.9690169
R Square	0.9389939
Adjusted R Square	0.9334479
Standard Error	0.0980035
Observations	13

Regression Equation
y = 0.1551x + 1.747
y = LN Width, x = LN Flow

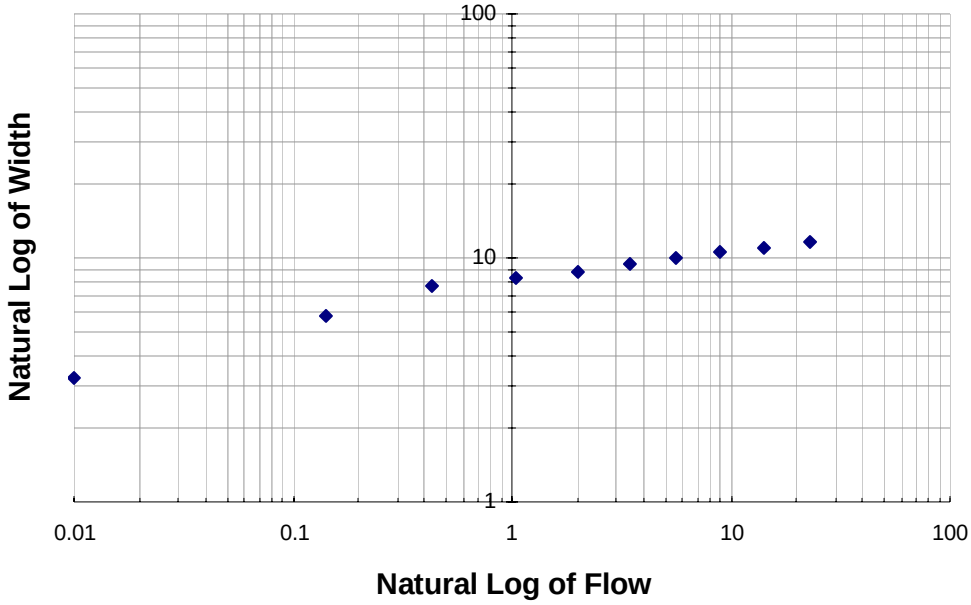
ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1.6261690	1.6261690	169.30988	5.0403E-08
Residual	11	0.1056516	0.0096046		
Total	12	1.7318206			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.7477121	0.0320431	54.542510	9.70113E-15	1.6771856	1.8182386	1.6771856	1.8182386
X Variable 1	**0.1550752**	0.0119179	13.011913	5.04034E-08	0.1288440	0.1813064	0.1288440	0.1813064

Width's B-Term is equal to the slope of the regression line, which is 0.155.

Figure E.2 Wetted Width versus Flow for Assessment Unit NM-2120.A_827, Upstream



Comanche Creek below the Upper Exclosure (upstream)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.97924148
R Square	0.95891387
Adjusted R Square	0.95377811
Standard Error	0.08305505
Observations	10

Regression Equation
y = 0.1596x + 2.0308
y = LN Width, x = LN Flow

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1.28797250	1.28797250	186.712940	7.9232E-07
Residual	8	0.05518514	0.00689814		
Total	9	1.34315764			

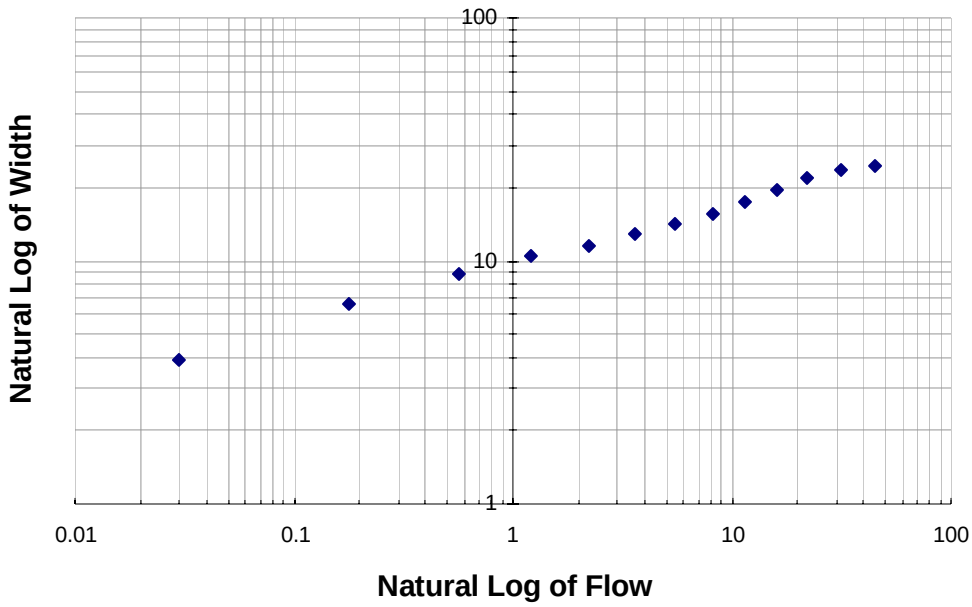
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.0308199	0.0267335	75.965182	1.0049E-12	1.9691721	2.0924676	1.9691721	2.0924676
X Variable 1	**0.1596353**	0.0116826	13.664294	7.9232E-07	0.1326950	0.1865756	0.1326950	0.1865756

Width's B-Term is equal to the slope of the regression line, which is 0.160.

3.6.2 Width's B-Term for Assessment Unit NM-2120.A_820

The regression of natural log of width and natural log of flow for each location is as follows:

Figure E.3 Wetted Width versus Flow for Assessment Unit NM-2120.A_820, Downstream



Costilla Creek above Costilla @ Hwy 196 bridge
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.9953032
R Square	0.9906284
Adjusted R Square	0.9899590
Standard Error	0.0560299
Observations	16

Regression Equation
y = 0.2361x + 2.2731
y = LN Width, x = LN Flow

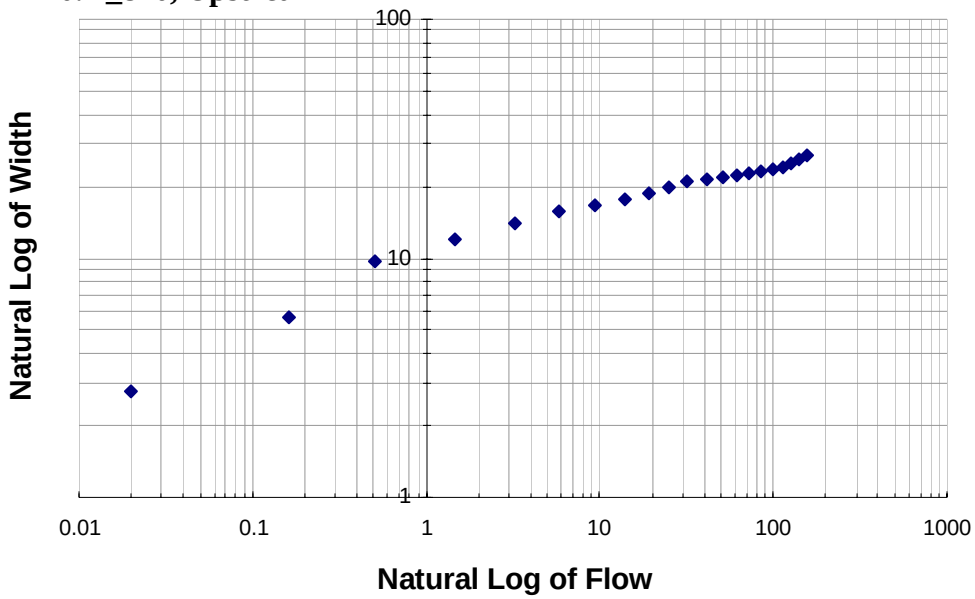
ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	4.6458841	4.6458841	1479.8872	1.3353E-15
Residual	14	0.0439509	0.0031393		
Total	15	4.6898350			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.27306126	0.01803272	126.052010	8.5865E-23	2.23438488	2.3117376	2.23438488	2.3117376
X Variable 1	**0.23611555**	0.00613776	38.4693031	1.3353E-15	0.22295134	0.2492797	0.22295134	0.2492797

Width's B-Term is equal to the slope of the regression line, which is 0.236.

Figure E.4 Wetted Width versus Flow for Assessment Unit NM-2120.A_820, Upstream



Costilla Creek below Comanche Creek

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.97585927
R Square	0.95230131
Adjusted R Square	0.94979085
Standard Error	0.12473998
Observations	21

Regression Equation
y = 0.2235x + 2.2235
y = LN Width, x = LN Flow

ANOVA

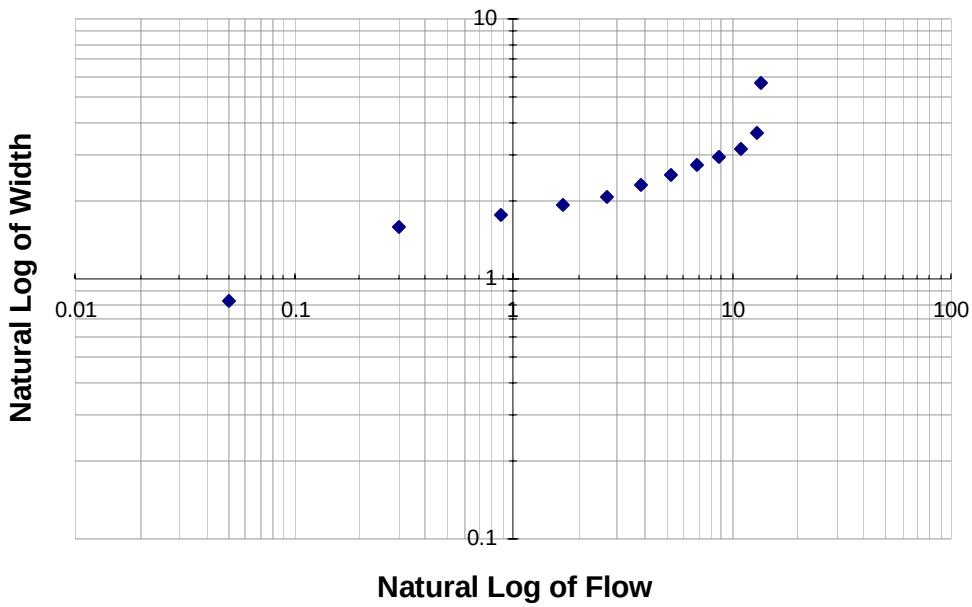
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	5.90245866	5.90245866	379.333826	5.1551E-14
Residual	19	0.29564121	0.01556006		
Total	20	6.19809988			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.22349578	0.04096512	54.2777765	2.6419E-22	2.13775477	2.30923680	2.13775477	2.30923680
X Variable 1	0.22346966	0.01147381	19.4764942	5.1551E-14	0.19945468	0.24748463	0.19945468	0.24748463

3.6.3 Width's B-Term for Assessment Unit NM-2120.A_512

The regression of natural log of width and natural log of flow for each location is as follows:

Figure E.5 Wetted Width versus Flow for Assessment Unit NM-2120.A_512, Upstream



Rio Fernando de Taos at Highway 64 Bridge

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.93710378
R Square	0.87816350
Adjusted R Square	0.86597985
Standard Error	0.17492203
Observations	12

Regression Equation
y = 0.2622x + 0.5932
y = LN Width, x = LN Flow

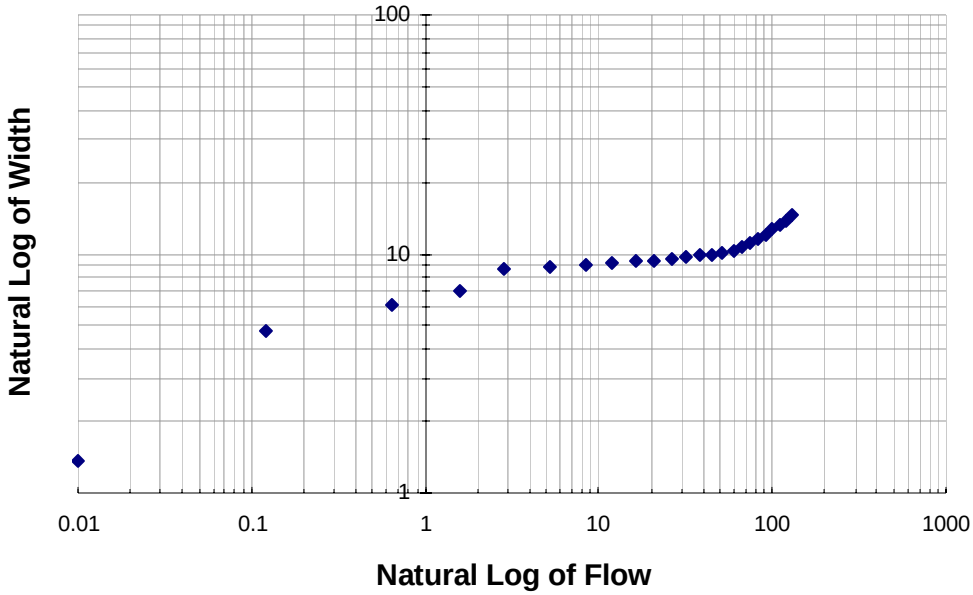
ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2.20539821	2.2053982	72.077210	6.9709E-06
Residual	10	0.30597718	0.0305977		
Total	11	2.51137539			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.59321579	0.05898935	10.0563200	1.5097E-06	0.46177930	0.72465228	0.46177930	0.72465228
X Variable 1	**0.26218065**	0.03088173	8.48982984	6.9709E-06	0.19337185	0.33098945	0.19337185	0.33098945

Width's B-Term is equal to the slope of the regression line, which is 0.262.

Figure E.6 Wetted Width versus Flow for Assessment Unit NM-2120.A_512, Downstream



Rio Fernando de Taos at El Nogal Campground

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.93904521
R Square	0.88180590
Adjusted R Square	0.87643345
Standard Error	0.16615627
Observations	24

Regression Equation
y = 0.1868x + 1.6933
y = LN Width, x = LN Flow

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	4.53141044	4.53141044	164.134517	1.1201E-11
Residual	22	0.60737394	0.02760790		
Total	23	5.13878439			

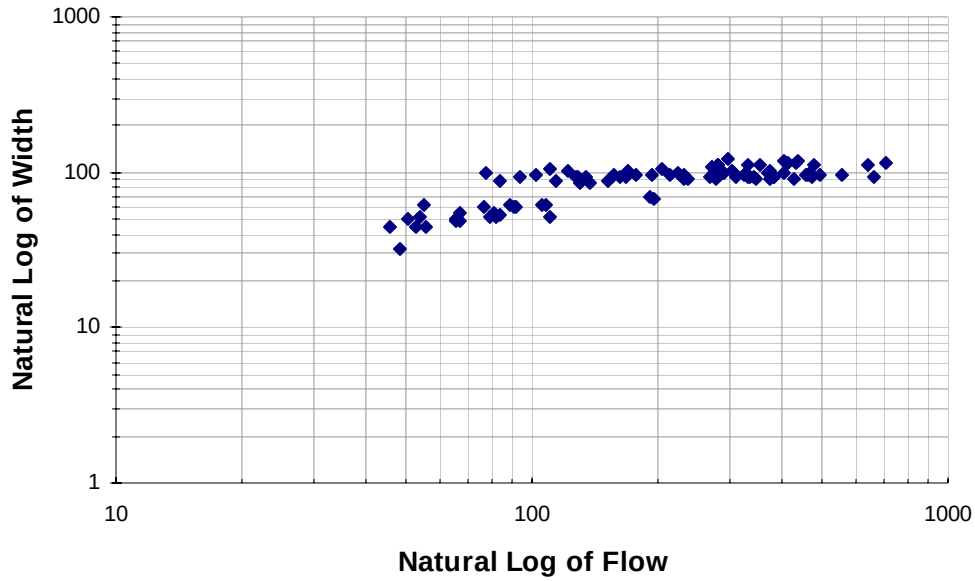
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.69330471	0.05205986	32.5261065	4.2570E-20	1.58533904	1.80127038	1.585339	1.80127
X Variable 1	**0.18675872**	0.01457742	12.8114994	1.1201E-11	0.15652695	0.21699049	0.156527	0.21699

Width's B-Term is equal to the slope of the regression line, which is 0.187.

3.6.4 Width's B-Term for Assessment Unit NM-2119_05

The regression of natural log of width and natural log of flow for each location is as follows:

Figure E.7 Wetted Width versus Flow for Assessment Unit NM-2119_05, Upstream



Rio Grande near Cerro, NM (upstream)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.79541615
R Square	0.63268686
Adjusted R Square	0.62865045
Standard Error	0.17734398
Observations	93

Regression Equation
y = 0.3174x + 2.7597
y = LN Width, x = LN Flow

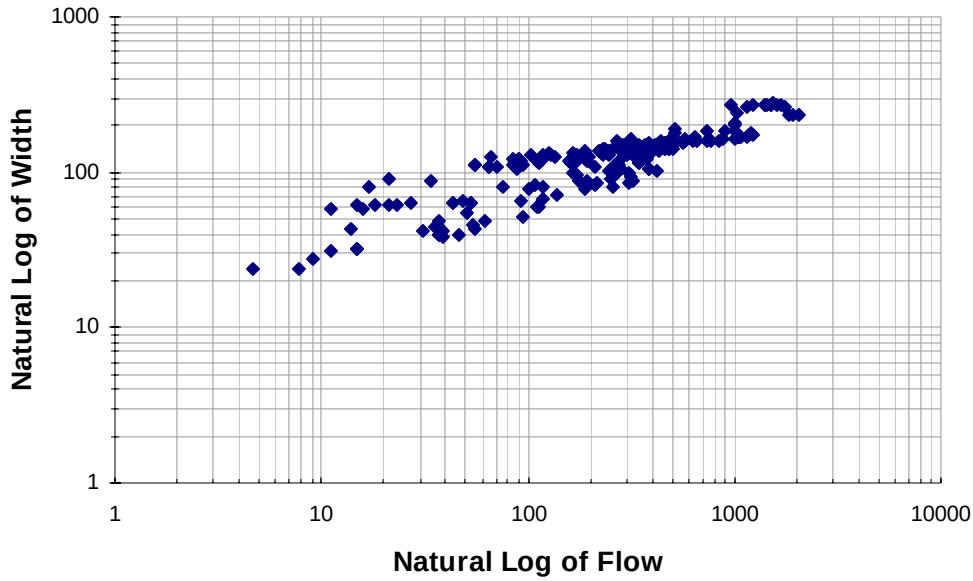
ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	4.92977023	4.92977023	156.745020	1.6870E-21
Residual	91	2.86203090	0.03145088		
Total	92	7.79180114			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.75974246	0.13454647	20.5114443	6.8893E-36	2.49248240	3.02700253	2.492482	3.027003
X Variable 1	**0.31735631**	0.02534838	12.5197851	1.6870E-21	0.26700485	0.36770776	0.267005	0.367708

Width's B-Term is equal to the slope of the regression line, which is 0.317.

Figure E.8 Wetted Width versus Flow for Assessment Unit NM-2119_05, Downstream



Rio Grande at Lobotos (downstream)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.886801046
R Square	0.786416095
Adjusted R Square	0.785422682
Standard Error	0.233241416
Observations	217

Regression Equation
y = 0.355x + 2.8347
y = LN Width, x = LN Flow

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	43.0659139	43.0659139	791.630158	5.1935E-74
Residual	215	11.6963349	0.05440155		
Total	216	54.7622489			

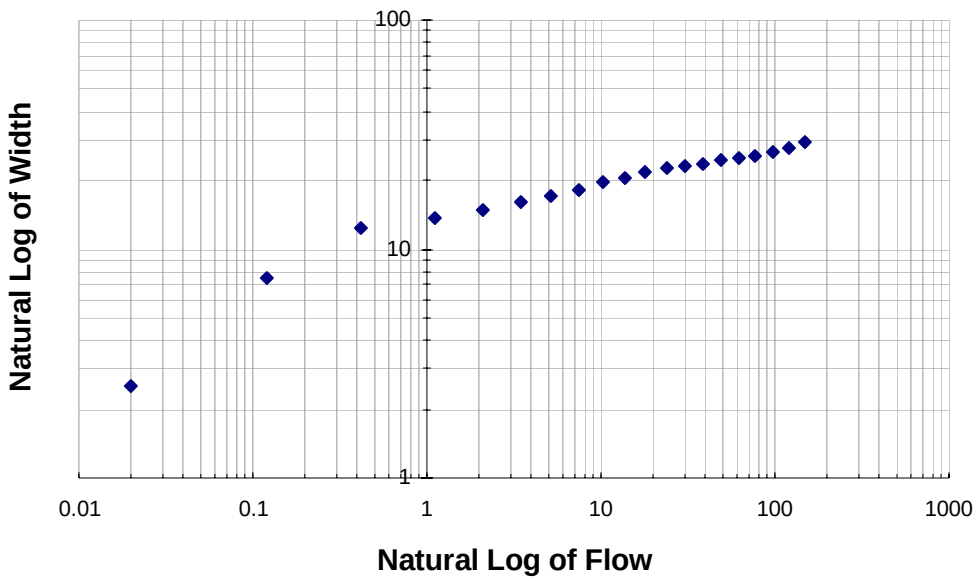
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.8346909	0.06933189	40.8858108	2.299E-103	2.69803378	2.97134801	2.69803	2.971348
X Variable 1	**0.35500156**	0.01261737	28.1359229	5.1935E-74	0.33013199	0.37987113	0.33013	0.379871

Width's B-Term is equal to the slope of the regression line, which is 0.355.

3.6.5 Width's B-Term for Assessment Unit NM-2120.A_600

The regression of natural log of width and natural log of flow for each location is as follows:

Figure E.9 Wetted Width versus Flow for Assessment Unit NM-2120.A_600



Rio Hondo at Valdez Gage

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.946864978
R Square	0.896553286
Adjusted R Square	0.890806246
Standard Error	0.186298077
Observations	20

Regression Equation
y = 0.222x + 2.3853
y = LN Width, x = LN Flow

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	5.41437903	5.41437903	156.002627	2.6421E-10
Residual	18	0.62472552	0.03470697		
Total	19	6.03910455			

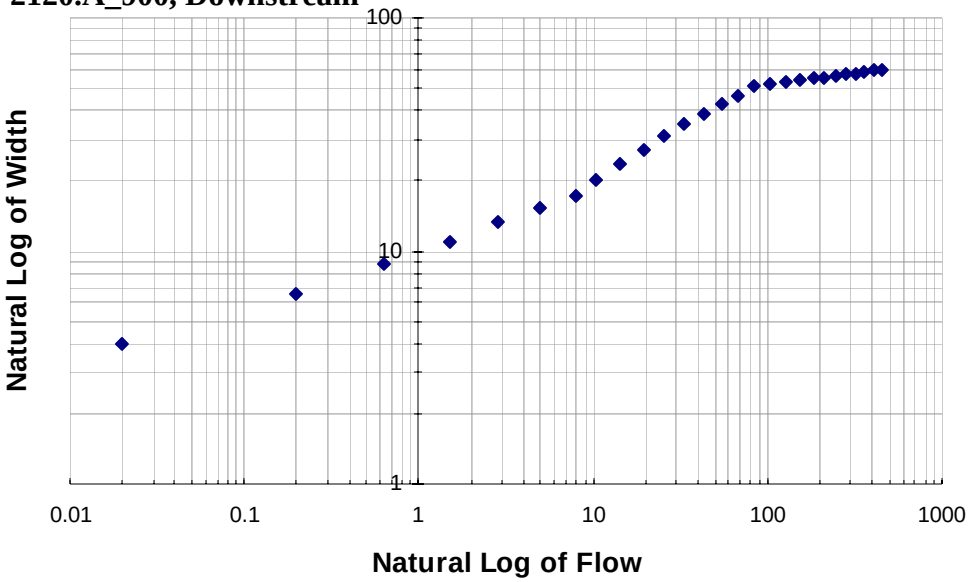
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.38525757	0.05693060	41.8976354	2.1302E-19	2.26565072	2.50486441	2.265651	2.504864
X Variable 1	**0.22202704**	0.01777624	12.4901011	2.6421E-10	0.18468051	0.25937356	0.184681	0.259374

Width's B-Term is equal to the slope of the regression line, which is 0.222.

3.6.6 Width's B Term for Assessment Unit NM-2120.A_900

Measurements were collected from upstream (at USFS boundary) and downstream (at USGS gage) locations within this assessment unit. The regression of natural log of width and natural log of flow for each location is as follows:

Figure E.10 Wetted Width versus Flow at Assessment Unit NM-2120.A_900, Downstream



Rio de los Pinos at USGS Gage

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.988534462
R Square	0.977200382
Adjusted R Square	0.976288398
Standard Error	0.119746332
Observations	27

Regression Equation
y = 0.3047x + 2.3868
y = LN Width, x = LN Flow

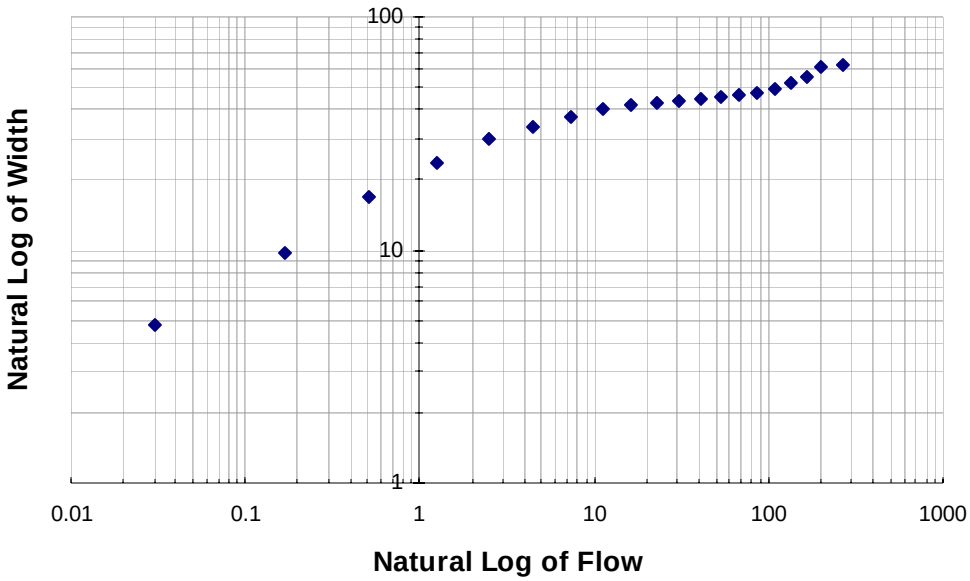
ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	15.3645736	15.3645736	1071.50961	4.7572E-22
Residual	25	0.35847960	0.01433918		
Total	26	15.7230532			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.38679706	0.03871642	61.6481794	7.7731E-29	2.30705915	2.46653497	2.307059	2.466535
X Variable 1	**0.30467286**	0.00930755	32.7339214	4.7572E-22	0.28550359	0.32384212	0.285504	0.323842

Width's B-Term is equal to the slope of the regression line, which is 0.305.

Figure E.11 Wetted Width versus Flow at Assessment Unit NM-2120.A_900, Upstream



Rio de los Pinos above NM Game and Fish Area @ Forest Service bridge

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.954013288
R Square	0.910141354
Adjusted R Square	0.905149207
Standard Error	0.198899686
Observations	20

Regression Equation
y = 0.2456x + 2.893
y = LN Width, x = LN Flow

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	7.21256397	7.21256397	182.314614	7.3899E-11
Residual	18	0.71209953	0.03956108		
Total	19	7.92466350			

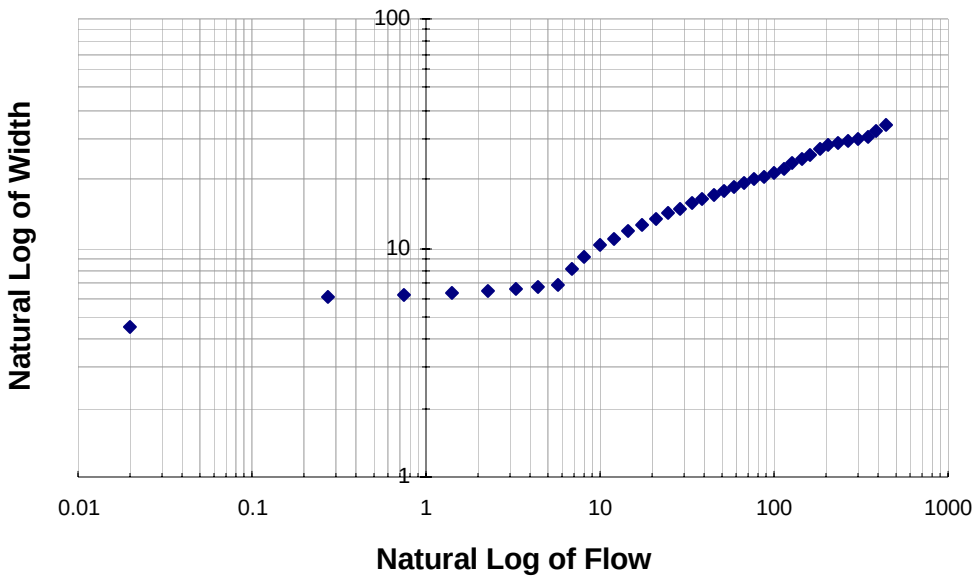
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.89303756	0.06515871	44.3998530	7.5702E-20	2.75614407	3.02993106	2.756144	3.029931
X Variable 1	**0.24558921**	0.01818857	13.5023929	7.3899E-11	0.20737641	0.28380201	0.207376	0.283802

Width's B-Term is equal to the slope of the regression line, which is 0.246.

3.6.7 Width's B-Term for Assessment Unit NM-2119_20

The regression of natural log of width and natural log of flow for each location is as follows:

Figure E.12 Wetted Width versus Flow for Assessment Unit NM-2119_20



Rio Pueblo de Taos at Rio Grande

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.955184036
R Square	0.912376542
Adjusted R Square	0.909942557
Standard Error	0.174517968
Observations	38

Regression Equation
y = 0.2527x + 1.8691
y = LN Width, x = LN Flow

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	11.41659307	11.41659307	374.8488866	1.27868E-20
Residual	36	1.096434764	0.030456521		
Total	37	12.51302783			

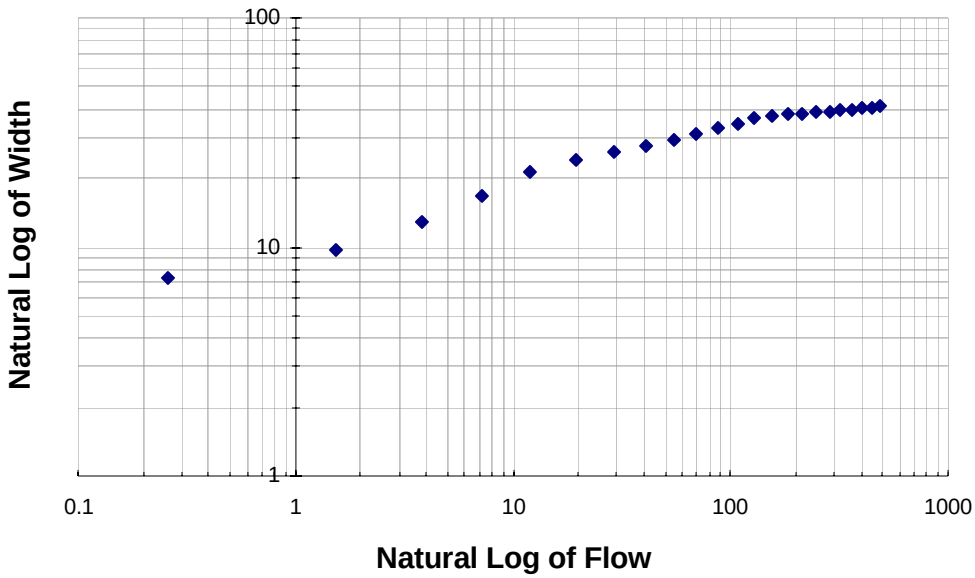
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.86906706	0.05157413	36.2403953	6.2724E-30	1.76447001	1.97366412	1.76447	1.973664
X Variable 1	**0.25273289**	0.01305370	19.3610146	1.2786E-20	0.22625879	0.27920698	0.226259	0.279207

Width's B-Term is equal to the slope of the regression line, which is 0.253.

3.6.8 Width's B-Term for Assessment Unit NM-2119_30

The regression of natural log of width and natural log of flow for each location is as follows:

Figure E.13 Wetted Width versus Flow for Assessment Unit NM-2119_30



Rio Pueblo de Taos at Los Cordovas Gage

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.983093535
R Square	0.966472899
Adjusted R Square	0.964876371
Standard Error	0.091507737
Observations	23

Regression Equation
y = 0.2414x + 2.3454
y = LN Width, x = LN Flow

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	5.06907368	5.06907368	605.358960	5.7421E-17
Residual	21	0.17584698	0.00837366		
Total	22	5.24492067			

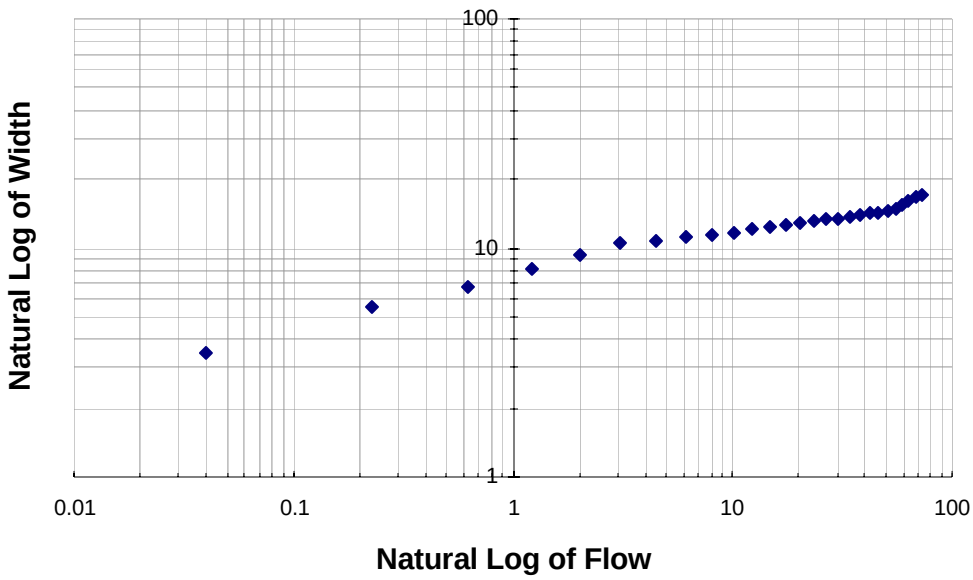
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.34535658	0.0443613	52.8693545	7.9256E-24	2.25310206	2.43761110	2.253102	2.437611
X Variable 1	**0.24135089**	0.0098094	24.6040435	5.7421E-17	0.22095113	0.26175066	0.220951	0.261751

Width's B-Term is equal to the slope of the regression line, which is 0.241.

3.6.9 Width's B-Term for Assessment Unit NM-2120.A_511

The regression of natural log of width and natural log of flow for each location is as follows:

Figure E.14 Wetted Width versus Flow for Assessment Unit NM-2120.A_511



Rio Pueblo de Taos at Gage at Pueblo

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.985936204
R Square	0.972070199
Adjusted R Square	0.970953007
Standard Error	0.060394655
Observations	27

Regression Equation
y = 0.1849x + 2.0063
y = LN Width, x = LN Flow

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	3.17370677	3.17370677	870.101254	6.0279E-21
Residual	25	0.09118785	0.00364751		
Total	26	3.26489463			

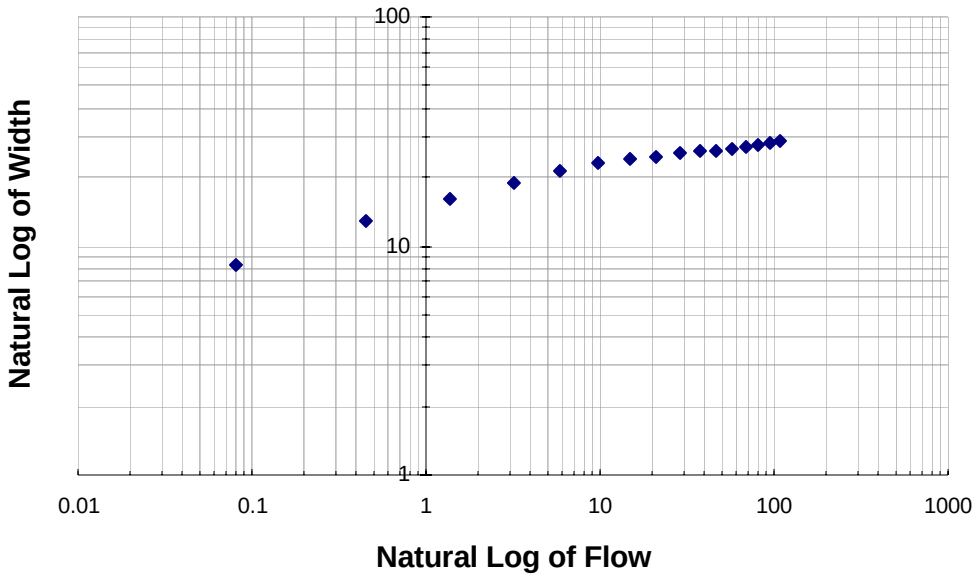
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.00627531	0.01902772	105.439592	1.2191E-34	1.96708701	2.04546361	1.967087	2.045464
X Variable 1	**0.18485494**	0.00626680	29.4974787	6.0279E-21	0.17194822	0.19776165	0.171948	0.197762

Width's B-Term is equal to the slope of the regression line, which is 0.185.

3.6.10 Width's B-Term for Assessment Unit NM-2120.A_901

The regression of natural log of width and natural log of flow for each location is as follows:

Figure E.15 Wetted Width versus Flow for Assessment Unit NM-2120.A_901



Rio San Antonio at Midpoint between Headwaters and Colorado Border

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.97768250
R Square	0.95586307
Adjusted R Square	0.95271044
Standard Error	0.07351574
Observations	16

Regression Equation
y = 0.1583x + 2.679
y = LN Width, x = LN Flow

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1.63863560	1.63863560	303.194744	6.9710E-11
Residual	14	0.07566390	0.00540456		
Total	15	1.71429951			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.67898572	0.02952883	90.7243878	8.5318E-21	2.61565261	2.74231884	2.615653	2.742319
X Variable 1	**0.15828033**	0.00909004	17.4124881	6.9710E-11	0.13878410	0.17777656	0.138784	0.177777

Width's B-Term is equal to the slope of the regression line, which is 0.158.

E3.7 Manning's n or Travel Time

Site-specific values generated from WINXSPRO were used for Manning's n. The following table summarizes the input values:

Table E.14 Manning's n Values

Assessment Unit	Manning's n
NM-2120.A_827	0.031
NM-2120.A_820	0.037
NM-2120.A_512	0.036
NM-2119_05	0.035
NM-2120.A_600	0.060
NM-2120.A_900	0.040
NM-2119_20	0.062
NM-2119_30	0.018
NM-2120.A_511	0.078
NM-2120.A_901	0.039

E4.0 METEOROLOGICAL PARAMETERS

E4.1 Air Temperature

This parameter is the mean daily air temperature for the assessment unit (or average daily temperature at the mean elevation of the assessment unit). Air temperature will usually be the single most important factor in determining mean daily water temperature. Air temperature was measured directly (in the shade) using air thermographs and adjusted to what the temperature would be at the mean elevation of the assessment unit. The following table summarizes mean daily air temperatures for each assessment unit requiring a temperature Total Maximum Daily Load (TMDL):

Table E.15 Mean Daily Air Temperature

Assessment Unit	Elevation at Air Thermograph Location (meters)	Measured Mean Daily Air Temperature (°C)	Mean Elevation for Assessment Unit (meters)	Adjusted Mean Daily Air Temperature (°C)	Adjusted Mean Daily Air Temperature (°F)
NM-2120.A_827	2,811	15.683	2,771	15.942	60.695
NM-2120.A_820	2,120[a]	21.806[a]	2,578	18.802	65.843
NM-2120.A_512	1,745[b]	21.066[b]	1,979	19.532	67.158
NM-2119_05	2,161[c]	23.000	2,149	23.079	73.542
NM-2120.A_600	1,967	23.380	2,123	22.358	72.244
NM-2120.A_900	2,560[d]	17.900[d]	2,590	17.703	63.865
NM-2119_20	1,854	25.954	1,946	25.352	77.634
NM-2119_30	1,854	25.954	2,042	24.721	76.498
NM-2120.A_511	1,745[b]	21.066[b]	2,071	18.927	66.069
NM-2120.A_901	2,560[d]	17.900[d]	2,675	17.148	62.867

Notes:
[a] Mean daily temperature for **July 31, 2002** from New Mexico State University Climate Network (Costilla Station at 2,120 meters elevation).
[b] Mean daily temperature for **July 31, 2000** from New Mexico State University Climate Network (Alcalde Station at 1,745 meters elevation).
[c] Mean daily temperature for **July 5, 2003** from New Mexico State University Climate Network (Taos METAR Station at 2,161 meters elevation
[d] Mean daily temperature for **July 3, 2003** from New Mexico State University Climate Network (Chamita Station at 2,560 meters elevation).
°F = Degrees Farenheit
°C = Degrees Celcius

For the Rio de los Pinos, the adiabatic lapse rate was used to correct for elevational differences from the met station:

$$T_a = T_o + C_t \times (Z - Z_o)$$

where,

T_a = air temperature at elevation E (°C)

T_o = air temperature at elevation E_o (°C)
Z = mean elevation of segment (meters)
Z_o = elevation of station (meters)
C_t = moist-air adiabatic lapse rate (-0.00656 °C/meter)

E4.2 Maximum Air Temperature

Unlike the other variables, the maximum daily air temperature overrides only if the check box is checked. If the box is not checked, the SSTEMP Model estimates the maximum daily air temperature from a set of empirical coefficients (Theurer et al., 1984 as cited in Bartholow 2002) and will print the result in the grayed data entry box. A value cannot be entered unless the box is checked.

E4.3 Relative Humidity

Relative humidity data were obtained from the Western Regional Climate Center web site (www.wrcc.dri.edu) or the New Mexico State University Climate Network (http://weather.nmsu.edu/data/data.htm). The data were corrected for elevation and temperature using the following equation:

$$R_h = R_o \times \left(1.0640^{(To-Ta)}\right) \times \left(\frac{T_a + 273.16}{T_o + 273.16}\right)$$

where,

R_h = relative humidity for temperature T_a (decimal)
R_o = relative humidity at station (decimal)
T_a = air temperature at segment (°C)
T_o = air temperature at station (°C)

The following table presents the adjusted mean daily relative humidity for each assessment unit:

Table E.16 Mean Daily Relative Humidity

Assessment Unit	Ref.	Mean Daily Air Temp. at Weather Station (°C)	Mean Daily Air Temperature at AU (°C)	Mean Daily Relative Humidity at Weather Station (percent)	Mean Daily Relative Humidity for AU (percent)
NM-2120.A_827	(a)	20.889	15.942	43.408	58.007
NM-2120.A_820	(a)	21.806	18.802	58.487	69.752
NM-2120.A_512	(b)	21.066	19.532	59.177	64.744
NM-2119_05	(c)	23.000	23.079	21.998	21.897
NM-2120.A_600	(c)	23.333	22.358	30.604	32.407
NM-2120.A_900	(b)	24.741	17.703	26.823	40.527

Assessment Unit	Ref.	Mean Daily Air Temp. at Weather Station (°C)	Mean Daily Air Temperature at AU (°C)	Mean Daily Relative Humidity at Weather Station (percent)	Mean Daily Relative Humidity for AU (percent)
NM-2119_20	(c)	24.493	25.352	24.002	22.822
NM-2119_30	(c)	24.493	24.721	24.002	23.682
NM-2120.A_511	(b)	21.066	18.927	59.177	67.080
NM-2120.A_901	(b)	24.741	17.148	26.823	41.866

Notes:
Ref. = References for Weather Station Data are as follows:
(a) New Mexico State University Climate Network (Costilla Station, Elevation 2,120 meters; Latitude 36°59'N, Longitude 105°33'W)
(b) New Mexico State University Climate Network (Alcalde Station, Elevation 1,745 meters; Latitude 36°05'N, Longitude 106°03'W)
(c) New Mexico State University Climate Network (Taos Station, Elevation 2,161 meters; Latitude 36°27'N, Longitude 105°40'W)
AU = Assessment Unit
°C = Degrees Celcius

E4.4 Wind Speed

Average daily wind speed data were obtained from the New Mexico State University Climate Network (http://weather.nmsu.edu/data/data.htm). The following table presents the mean daily wind speed for each assessment unit:

Table E.17 Mean Daily Wind Speed

Assessment Unit	Ref.	Mean Daily Wind Speed (miles per hour)
NM-2120.A_827	(a)	5.226
NM-2120.A_820	(b)	3.508
NM-2120.A_512	(b)	1.846
NM-2119_05	(b)	1.831
NM-2120.A_600	(a)	5.514
NM-2120.A_900	(b)	1.734
NM-2119_20	(a)	8.119
NM-2119_30	(a)	8.119
NM-2120.A_511	(b)	1.846
NM-2120.A_901	(b)	1.734

Notes:
Ref. = References for Weather Station Data are as follows:
(a) New Mexico State University Climate Network (Taos Station, Elevation 2,161 meters; Latitude 36°27'N, Longitude 105°40'W)
(b) New Mexico State University Climate Network (Alcalde Station, Elevation 1,745 meters; Latitude 36°05'N, Longitude 106°03'W)

E4.5 Ground Temperature

Mean annual air temperature for 2003 was used in the absence of measured data. The following table presents the mean annual air temperature for each assessment unit:

Table E.18 Mean Annual Air Temperature as an Estimate for Ground Temperature

Assessment Unit	Ref.	Mean Annual Air Temperature for 2003 (^oC)	Mean Annual Air Temperature for 2003 (^oF)
NM-2120.A_827	(a)	8.157	46.683
NM-2120.A_820	(a)	7.508[(1)]	45.514[(1)]
NM-2120.A_512	(b)	11.432 [(2)]	52.577 [(2)]
NM-2119_05	(c)	10.543	50.540
NM-2120.A_600	(c)	10.543	50.540
NM-2120.A_900	(d)	5.216	41.389
NM-2119_20	(c)	10.543	50.540
NM-2119_30	(c)	10.543	50.540
NM-2120.A_511	(b)	11.432[(2)]	52.577[(2)]
NM-2120.A_901	(d)	5.216	41.389

Notes:
Ref. = References for Weather Station Data are as follows:
(a) New Mexico State University Climate Network (Costilla Station, Elevation 2,120 meters; Latitude 36°59'N, Longitude 105°33'W)
(b) New Mexico State University Climate Network (Alcalde Station, Elevation 1,745 meters; Latitude 36°05'N, Longitude 106°03'W)
(c) New Mexico State University Climate Network (Taos Station, Elevation 2,161 meters; Latitude 36°27'N, Longitude 105°40'W)
(d) New Mexico State University Climate Network (Chamita Station, Elevation 2,560 meters; Latitude 36°57'N, Longitude 106°39'W)
[(1)] Mean annual temperature for 2002.
[(2)] Mean annual temperature for 2000
°F = Degrees Farenheit
°C = Degrees Celcius

E4.6 Thermal Gradient

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

E4.7 Possible Sun

Percent possible sun for Albuquerque is found at the Western Regional Climate Center web site http://www.wrcc.dri.edu/cgi-bin/clilcd.pl?nm23050. The percent possible sun is 76 percent for both July and August.

E4.8 Dust Coefficient

If a value is entered for solar radiation, SSTEMP Model will ignore the dust coefficient and ground reflectivity and "override' the internal calculation of solar radiation. Solar radiation data are available from the New Mexico State University Climate Network (see Section 4.10).

E4.9 Ground Reflectivity

If a value is entered for solar radiation, SSTEMP Model will ignore the dust coefficient and ground reflectivity and "override' the internal calculation of solar radiation. Solar radiation data are available from the New Mexico State University Climate Network (see Section 4.10).

E4.10 Solar Radiation

Because solar radiation data were obtained from an external source of ground level radiation, it was assumed that about 90% of the ground-level solar radiation actually enters the water. Thus, the recorded solar measurements were multiplied by 0.90 to get the number to be entered into the SSTEMP Model. The following table presents the measured solar radiation at weather stations representing each assessment unit:

Table E.19 Mean Daily Solar Radiation

Assessment Unit	Ref.	Mean Solar Radiation (L/day)	Mean Solar Radiation x 0.90 (L/day)
NM-2120.A_827	(a)	611.2	550.1
NM-2120.A_820	(b)	600.8	540.7
NM-2120.A_512	(a)	651.9	586.7
NM-2119_05	(c)	736.0	662.4
NM-2120.A_600	(a)	683.6	615.2
NM-2120.A_900	(b)	752.0	676.8
NM-2119_20	(a)	737.0	663.3
NM-2119_30	(a)	737.0	663.3
NM-2120.A_511	(a)	651.9	586.7
NM-2120.A_901	(b)	752.0	676.8

Ref. = References for Weather Station Data are as follows:

(a) New Mexico State University Climate Network (Alcalde Station, Elevation 1,745 meters; Latitude 36°05'N, Longitude 106°03'W)

(b) New Mexico State University Climate Network (Costilla Station, Elevation 2,120 meters; Latitude 36°59'N, Longitude 105°33'W)

(c) New Mexico State University Climate Network (Taos Station, Elevation 2,161 meters; Latitude 36°27'N, Longitude 105°40'W)

E5.0 SHADE

Percent shade was estimated for the assessment unit using densiometer readings taken upstream and downstream. The measurements were averaged along with estimates made at locations between the densiometer readings using aerial photographs downloaded from TerraServer, Version 5.0 (online at http://www.terraserver.microsoft.com/). This parameter refers to how much of the segment is shaded by vegetation, cliffs, etc. The following table summarizes percent shade for each assessment unit:

Table E.20 Percent Shade

Assessment Unit	Percent Shade
NM-2120.A_827	4.5%
NM-2120.A_820	37%
NM-2120.A_512	50%
NM-2119_05	50%
NM-2120.A_600	43%
NM-2120.A_900	20%
NM-2119_20	16%
NM-2119_30	5%
NM-2120.A_511	7%
NM-2120.A_901	16%

E6.0 REFERENCES

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APPENDIX F
SSTEMP MODEL RUN OUTPUT

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CALIBRATION RUN

NM-2120.A_827: COMANCHE CREEK (COSTILLA CREEK TO LITTLE COSTILLA)
"SSTEMP (2.0.8) ","02/09/2004 08:37 am"
"NoName"

"English",	"Segment Inflow (cfs)",	"0.019"
"English",	"Inflow Temperature (°F)",	"59.710"
"English",	"Segment Outflow (cfs)",	"1.151"
"English",	"Accretion Temp. (°F)",	"46.683"
"English",	"Latitude (degrees)",	"36.800"
"English",	"Segment Length (mi)",	"10.300"
"English",	"Upstream Elevation (ft)",	"9222.00"
"English",	"Downstream Elevation (ft)",	"8963.00"
"English",	"Width's A Term (s/ft²)",	"6.681"
"English",	" B Term where W = A*Q**B",	"0.157"
"English",	"Manning's n",	"0.031"
"English",	"Air Temperature (°F)",	"60.695"
"English",	"Relative Humidity (%)",	"58.007"
"English",	"Wind Speed (mph)",	"5.226"
"English",	"Ground Temperature (°F)",	"46.683"
"English",	"Thermal gradient (j/m²/s/C)",	"1.650"
"English",	"Possible Sun (%)",	"76.000"
"English",	"Dust Coefficient",	"5.000"
"English",	"Ground Reflectivity (%)",	"25.000"
"English",	"Solar Radiation (Langleys/d)",	"550.090"
"English",	"Total Shade (%)",	"4.500"

"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Enabled"
"Total Shade","Enabled"
"Month/day","08/04"

"Predicted Mean (°F) = 64.04"
"Estimated Maximum (°F) = 77.47"
"Approximate Minimum (°F) = 50.61"

"Measured Mean (°F) = 64.4" (Error = ± 1%)
"Measured Maximum (°F) = 79.3" (Error = ± 4%)
"Measured Minimum (°F) = 51.8" (Error = ± 6%)

LOAD ALLOCATION: INCREASE SHADE TO 56.8 PERCENT

NM-2120.A_827: COMANCHE CREEK (COSTILLA CREEK TO LITTLE COSTILLA)

```
"SSTEMP (2.0.8)  ","02/09/2004  08:39 am"
"NoName"
"English",          "Segment Inflow (cfs)",            "0.019"
"English",          "Inflow Temperature (°F)",         "59.710"
"English",          "Segment Outflow (cfs)",           "1.151"
"English",          "Accretion Temp. (°F)",            "46.683"
"English",          "Latitude (degrees)",              "36.800"
"English",          "Segment Length (mi)",             "10.300"
"English",          "Upstream Elevation (ft)",         "9222.00"
"English",          "Downstream Elevation (ft)",       "8963.00"
"English",          "Width's A Term (s/ft²)",          "6.681"
"English",          "  B Term where W = A*Q**B",       "0.157"
"English",          "Manning's n",                     "0.031"
"English",          "Air Temperature (°F)",            "60.695"
"English",          "Relative Humidity (%)",           "58.007"
"English",          "Wind Speed (mph)",                "5.226"
"English",          "Ground Temperature (°F)",         "46.683"
"English",          "Thermal gradient (j/m²/s/C)",     "1.650"
"English",          "Possible Sun (%)",                "76.000"
"English",          "Dust Coefficient",                "5.000"
"English",          "Ground Reflectivity (%)",         "25.000"
"English",          "Solar Radiation (Langleys/d)",    "550.090"
"English",          "Total Shade (%)",                 "56.800"

"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Enabled"
"Total Shade","Enabled"
"Month/day","08/04"
         "Predicted Mean (°F) = 57.29"
         "Estimated Maximum (°F) = 65.14"
         "Approximate Minimum (°F) = 49.45"
```

CALIBRATION RUN

NM-2120.A_820: RIO COSTILLA (DIVERSION ABOVE COSTILLA TO COMANCHE CREEK)

```
"SSTEMP (2.0.8)  ","02/02/2004  10:44 am"
"NoName"
"English",         "Segment Inflow (cfs)",            "2.966"
"English",         "Inflow Temperature (°F)",         "61.900"
"English",         "Segment Outflow (cfs)",           "4.064"
"English",         "Accretion Temp. (°F)",            "45.514"
"English",         "Latitude (degrees)",              "36.910"
"English",         "Segment Length (mi)",             "18.000"
"English",         "Upstream Elevation (ft)",         "8963.00"
"English",         "Downstream Elevation (ft)",       "7953.00"
"English",         "Width's A Term (s/ft²)",          "9.474"
"English",         "  B Term where W = A*Q**B",       "0.230"
"English",         "Manning's n",                     "0.037"
"English",         "Air Temperature (°F)",            "65.843"
"English",         "Relative Humidity (%)",           "69.752"
"English",         "Wind Speed (mph)",                "3.508"
"English",         "Ground Temperature (°F)",         "45.514"
"English",         "Thermal gradient (j/m²/s/C)",     "1.650"
"English",         "Possible Sun (%)",                "76.000"
"English",         "Dust Coefficient",                "5.000"
"English",         "Ground Reflectivity (%)",         "25.000"
"English",         "Solar Radiation (Langleys/d)",    "540.720"
"English",         "Total Shade (%)",                 "37.000"

"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Enabled"
"Total Shade","Enabled"
"Month/day","07/31"
         "Predicted Mean (°F) = 67.98"
         "Estimated Maximum (°F) = 76.75"
         "Approximate Minimum (°F) = 59.22"

       "Measured Mean (°F) = 63.8"        (Error = ± 13%)
         "Measured Maximum (°F) = 73.2"   (Error = ±  9%)
         "Measured Minimum (°F) = 55.0"   (Error = ± 19%)
```

LOAD ALLOCATION: INCREASE SHADE TO 73 PERCENT, REDUCE WIDTH'S A TERM BY 20 PERCENT TO 7.579

NM-2120.A_820: RIO COSTILLA (DIVERSION ABOVE COSTILLA TO COMANCHE CREEK)

```
"SSTEMP (2.0.8)  ","02/02/2004  10:54 am"
"NoName"
"English",         "Segment Inflow (cfs)",            "2.966"
"English",         "Inflow Temperature (°F)",         "61.900"
"English",         "Segment Outflow (cfs)",           "4.064"
"English",         "Accretion Temp. (°F)",            "45.514"
"English",         "Latitude (degrees)",              "36.910"
"English",         "Segment Length (mi)",             "18.000"
"English",         "Upstream Elevation (ft)",         "8963.00"
"English",         "Downstream Elevation (ft)",       "7953.00"
"English",         "Width's A Term (s/ft²)",          "7.579"
"English",         "  B Term where W = A*Q**B",       "0.230"
"English",         "Manning's n",                     "0.037"
"English",         "Air Temperature (°F)",            "65.843"
"English",         "Relative Humidity (%)",           "69.752"
"English",         "Wind Speed (mph)",                "3.508"
"English",         "Ground Temperature (°F)",         "45.514"
"English",         "Thermal gradient (j/m²/s/C)",     "1.650"
"English",         "Possible Sun (%)",                "76.000"
"English",         "Dust Coefficient",                "5.000"
"English",         "Ground Reflectivity (%)",         "25.000"
"English",         "Solar Radiation (Langleys/d)",    "540.720"
"English",         "Total Shade (%)",                 "73.000"

"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Enabled"
"Total Shade","Enabled"
"Month/day","07/31"
         "Predicted Mean (°F) = 62.34"
         "Estimated Maximum (°F) = 67.13"
         "Approximate Minimum (°F) = 57.56"
```

CALIBRATION RUN

NM-2120.A_600: RIO HONDO (RIO GRANDE TO USFS BOUNDARY)
"SSTEMP (2.0.8) ","02/02/2004 12:13 pm"
"NoName"

"English",	"Segment Inflow (cfs)",	"0.990"
"English",	"Inflow Temperature (°F)",	"50.830"
"English",	"Segment Outflow (cfs)",	"1.234"
"English",	"Accretion Temp. (°F)",	"50.540"
"English",	"Latitude (degrees)",	"36.540"
"English",	"Segment Length (mi)",	"8.500"
"English",	"Upstream Elevation (ft)",	"7650.00"
"English",	"Downstream Elevation (ft)",	"6453.00"
"English",	"Width's A Term (s/ft²)",	"10.862"
"English",	" B Term where W = A*Q**B",	"0.222"
"English",	"Manning's n",	"0.060"
"English",	"Air Temperature (°F)",	"72.244"
"English",	"Relative Humidity (%)",	"32.407"
"English",	"Wind Speed (mph)",	"5.514"
"English",	"Ground Temperature (°F)",	"50.540"
"English",	"Thermal gradient (j/m²/s/C)",	"1.650"
"English",	"Possible Sun (%)",	"76.000"
"English",	"Dust Coefficient",	"5.000"
"English",	"Ground Reflectivity (%)",	"25.000"
"English",	"Solar Radiation (Langleys/d)",	"615.240"
"English",	"Total Shade (%)",	"43.000"

"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Enabled"
"Total Shade","Enabled"
"Month/day","07/08"
"Predicted Mean (°F) = 65.27"
"Estimated Maximum (°F) = 73.85"
"Approximate Minimum (°F) = 56.68"

"Measured Mean (°F) = 63.6" (Error = ± 5%)
"Measured Maximum (°F) = 76.3" (Error = ± 6%)
"Measured Minimum (°F) = 53.9" (Error = ± 13%)

LOAD ALLOCATION: INCREASE SHADE TO 69.3 PERCENT, DECREASE WIDTH'S A TERM BY 50 PERCENT TO 5.431

NM-2120.A_600: RIO HONDO (RIO GRANDE TO USFS BOUNDARY)

```
"SSTEMP (2.0.8)  ","02/02/2004  12:18 pm"
"NoName"
"English",         "Segment Inflow (cfs)",            "0.990"
"English",         "Inflow Temperature (°F)",         "50.830"
"English",         "Segment Outflow (cfs)",           "1.234"
"English",         "Accretion Temp. (°F)",            "50.540"
"English",         "Latitude (degrees)",              "36.540"
"English",         "Segment Length (mi)",             "8.500"
"English",         "Upstream Elevation (ft)",         "7650.00"
"English",         "Downstream Elevation (ft)",       "6453.00"
"English",         "Width's A Term (s/ft²)",          "5.431"
"English",         "  B Term where W = A*Q**B",       "0.222"
"English",         "Manning's n",                     "0.060"
"English",         "Air Temperature (°F)",            "72.244"
"English",         "Relative Humidity (%)",           "32.407"
"English",         "Wind Speed (mph)",                "5.514"
"English",         "Ground Temperature (°F)",         "50.540"
"English",         "Thermal gradient (j/m²/s/C)",     "1.650"
"English",         "Possible Sun (%)",                "76.000"
"English",         "Dust Coefficient",                "5.000"
"English",         "Ground Reflectivity (%)",         "25.000"
"English",         "Solar Radiation (Langleys/d)",    "615.240"
"English",         "Total Shade (%)",                 "69.300"

"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Enabled"
"Total Shade","Enabled"
"Month/day","07/08"
         "Predicted Mean (°F) = 61.20"
         "Estimated Maximum (°F) = 67.08"
         "Approximate Minimum (°F) = 55.31"
```

CALIBRATION RUN

NM-2120.A_512: RIO FERNANDO DE TAOS (RIO PUEBLO DE TAOS TO HEADWATERS)
"SSTEMP (2.0.8) ","02/02/2004 10:57 am"
"NoName"

"English",	"Segment Inflow (cfs)",	"0.000"
"English",	"Inflow Temperature (°F)",	"32.000"
"English",	"Segment Outflow (cfs)",	"0.696"
"English",	"Accretion Temp. (°F)",	"52.577"
"English",	"Latitude (degrees)",	"36.400"
"English",	"Segment Length (mi)",	"21.600"
"English",	"Upstream Elevation (ft)",	"8960.00"
"English",	"Downstream Elevation (ft)",	"5489.00"
"English",	"Width's A Term (s/ft²)",	"3.624"
"English",	" B Term where W = A*Q**B",	"0.224"
"English",	"Manning's n",	"0.036"
"English",	"Air Temperature (°F)",	"67.158"
"English",	"Relative Humidity (%)",	"64.744"
"English",	"Wind Speed (mph)",	"1.846"
"English",	"Ground Temperature (°F)",	"52.577"
"English",	"Thermal gradient (j/m²/s/C)",	"1.650"
"English",	"Possible Sun (%)",	"76.000"
"English",	"Dust Coefficient",	"5.000"
"English",	"Ground Reflectivity (%)",	"25.000"
"English",	"Solar Radiation (Langleys/d)",	"586.710"
"English",	"Total Shade (%)",	"50.000"

"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Enabled"
"Total Shade","Enabled"
"Month/day","07/31"
"Predicted Mean (°F) = 67.59"
"Estimated Maximum (°F) = 77.24"
"Approximate Minimum (°F) = 57.93"

"Measured Mean (°F) = 65.5" (Error = ± 6%)
"Measured Maximum (°F) = 71.8" (Error = ± 14%)
"Measured Minimum (°F) = 60.2" (Error = ± 8%)

LOAD ALLOCATION: INCREASE SHADE TO 79.2 PERCENT, DECREASE WIDTH'S A TERM BY 25 PERCENT TO 2.448

NM-2120.A_512: RIO FERNANDO DE TAOS (RIO PUEBLO DE TAOS TO HEADWATERS)

```
"SSTEMP (2.0.8)  ","02/02/2004  11:04 am"
"NoName"
"English",         "Segment Inflow (cfs)",            "0.000"
"English",         "Inflow Temperature (°F)",         "32.000"
"English",         "Segment Outflow (cfs)",           "0.696"
"English",         "Accretion Temp. (°F)",            "52.577"
"English",         "Latitude (degrees)",              "36.400"
"English",         "Segment Length (mi)",             "21.600"
"English",         "Upstream Elevation (ft)",         "8960.00"
"English",         "Downstream Elevation (ft)",       "5489.00"
"English",         "Width's A Term (s/ft²)",          "2.448"
"English",         "  B Term where W = A*Q**B",       "0.224"
"English",         "Manning's n",                     "0.036"
"English",         "Air Temperature (°F)",            "67.158"
"English",         "Relative Humidity (%)",           "64.744"
"English",         "Wind Speed (mph)",                "1.846"
"English",         "Ground Temperature (°F)",         "52.577"
"English",         "Thermal gradient (j/m²/s/C)",     "1.650"
"English",         "Possible Sun (%)",                "76.000"
"English",         "Dust Coefficient",                "5.000"
"English",         "Ground Reflectivity (%)",         "25.000"
"English",         "Solar Radiation (Langleys/d)",    "586.710"
"English",         "Total Shade (%)",                 "79.200"

"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Enabled"
"Total Shade","Enabled"
"Month/day","07/31"
         "Predicted Mean (°F) = 61.91"
         "Estimated Maximum (°F) = 67.19"
         "Approximate Minimum (°F) = 56.64"
```

CALIBRATION RUN

NM-2119_05: RIO GRANDE (RED RIVER TO NM-CO BORDER)
"SSTEMP (2.0.8) ","02/02/2004 11:09 am"
"NoName"

"English",	"Segment Inflow (cfs)",	"62.380"
"English",	"Inflow Temperature (°F)",	"71.000"
"English",	"Segment Outflow (cfs)",	"67.415"
"English",	"Accretion Temp. (°F)",	"50.540"
"English",	"Latitude (degrees)",	"37.000"
"English",	"Segment Length (mi)",	"27.800"
"English",	"Upstream Elevation (ft)",	"7485.00"
"English",	"Downstream Elevation (ft)",	"6616.00"
"English",	"Width's A Term (s/ft²)",	"16.410"
"English",	" B Term where W = A*Q**B",	"0.336"
"English",	"Manning's n",	"0.035"
"English",	"Air Temperature (°F)",	"73.542"
"English",	"Relative Humidity (%)",	"21.897"
"English",	"Wind Speed (mph)",	"1.831"
"English",	"Ground Temperature (°F)",	"50.540"
"English",	"Thermal gradient (j/m²/s/C)",	"1.650"
"English",	"Possible Sun (%)",	"76.000"
"English",	"Dust Coefficient",	"5.000"
"English",	"Ground Reflectivity (%)",	"25.000"
"English",	"Solar Radiation (Langleys/d)",	"662.400"
"English",	"Total Shade (%)",	"50.000"

"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Enabled"
"Total Shade","Enabled"
"Month/day","07/05"
"Predicted Mean (°F) = 67.10"
"Estimated Maximum (°F) = 73.62"
"Approximate Minimum (°F) = 60.57"

"Measured Mean (°F) = 66.5" (Error = ± 2%)
"Measured Maximum (°F) = 69.1" (Error = ± 12%)
"Measured Minimum (°F) = 64.0" (Error = ± 11%)

LOAD ALLOCATION: REDUCE WIDTH'S A TERM BY 50 PERCENT TO 8.205,
INCREASE SHADE TO 74.5 PERCENT

NM-2119_05: RIO GRANDE (RED RIVER TO NM-CO BORDER)

"SSTEMP (2.0.8) ","02/02/2004 11:16 am"		
"NoName"		
"English",	"Segment Inflow (cfs)",	"62.380"
"English",	"Inflow Temperature (°F)",	"71.000"
"English",	"Segment Outflow (cfs)",	"67.415"
"English",	"Accretion Temp. (°F)",	"50.540"
"English",	"Latitude (degrees)",	"37.000"
"English",	"Segment Length (mi)",	"27.800"
"English",	"Upstream Elevation (ft)",	"7485.00"
"English",	"Downstream Elevation (ft)",	"6616.00"
"English",	"Width's A Term (s/ft²)",	"8.205"
"English",	" B Term where W = A*Q**B",	"0.336"
"English",	"Manning's n",	"0.035"
"English",	"Air Temperature (°F)",	"73.542"
"English",	"Relative Humidity (%)",	"21.897"
"English",	"Wind Speed (mph)",	"1.831"
"English",	"Ground Temperature (°F)",	"50.540"
"English",	"Thermal gradient (j/m²/s/C)",	"1.650"
"English",	"Possible Sun (%)",	"76.000"
"English",	"Dust Coefficient",	"5.000"
"English",	"Ground Reflectivity (%)",	"25.000"
"English",	"Solar Radiation (Langleys/d)",	"662.400"
"English",	"Total Shade (%)",	"74.500"

"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Enabled"
"Total Shade","Enabled"
"Month/day","07/05"
"Predicted Mean (°F) = 64.38"
"Estimated Maximum (°F) = 67.35"
"Approximate Minimum (°F) = 61.42"

CALIBRATION RUN

NM-2119_20: RIO PUEBLO DE TAOS (RIO GRANDE TO ARROYO DEL ALAMO)
"SSTEMP (2.0.8) ","02/02/2004 01:47 pm"
"NoName"

"English",	"Segment Inflow (cfs)",	"7.408"
"English",	"Inflow Temperature (°F)",	"72.430"
"English",	"Segment Outflow (cfs)",	"7.544"
"English",	"Accretion Temp. (°F)",	"50.540"
"English",	"Latitude (degrees)",	"36.340"
"English",	"Segment Length (mi)",	"6.400"
"English",	"Upstream Elevation (ft)",	"6670.00"
"English",	"Downstream Elevation (ft)",	"6099.00"
"English",	"Width's A Term (s/ft²)",	"6.482"
"English",	" B Term where W = A*Q**B",	"0.253"
"English",	"Manning's n",	"0.062"
"English",	"Air Temperature (°F)",	"77.634"
"English",	"Relative Humidity (%)",	"22.822"
"English",	"Wind Speed (mph)",	"8.119"
"English",	"Ground Temperature (°F)",	"50.540"
"English",	"Thermal gradient (j/m²/s/C)",	"1.650"
"English",	"Possible Sun (%)",	"76.000"
"English",	"Dust Coefficient",	"5.000"
"English",	"Ground Reflectivity (%)",	"25.000"
"English",	"Solar Radiation (Langleys/d)",	"663.300"
"English",	"Total Shade (%)",	"16.000"

"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Enabled"
"Total Shade","Enabled"
"Month/day","07/10"

"Predicted Mean (°F) = 70.03"
"Estimated Maximum (°F) = 78.52"
"Approximate Minimum (°F) = 61.55"

"Measured Mean (°F) = 70.1" (Error = ± 0%)
"Measured Maximum (°F) = 77.3" (Error = ± 3%)
"Measured Minimum (°F) = 64.3" (Error = ± 8%)

LOAD ALLOCATION: INCREASE SHADE TO 92.8 PERCENT, REDUCE WIDTH'S A TERM BY 50 PERCENT TO 3.241

NM-2119_20: RIO PUEBLO DE TAOS (RIO GRANDE TO ARROYO DEL ALAMO)

```
"SSTEMP (2.0.8)  ","02/02/2004  01:56 pm"
"NoName"
"English",         "Segment Inflow (cfs)",            "7.408"
"English",         "Inflow Temperature (°F)",         "72.430"
"English",         "Segment Outflow (cfs)",           "7.544"
"English",         "Accretion Temp. (°F)",            "50.540"
"English",         "Latitude (degrees)",              "36.340"
"English",         "Segment Length (mi)",             "6.400"
"English",         "Upstream Elevation (ft)",         "6670.00"
"English",         "Downstream Elevation (ft)",       "6099.00"
"English",         "Width's A Term (s/ft²)",          "3.241"
"English",         "  B Term where W = A*Q**B",       "0.253"
"English",         "Manning's n",                     "0.062"
"English",         "Air Temperature (°F)",            "77.634"
"English",         "Relative Humidity (%)",           "22.822"
"English",         "Wind Speed (mph)",                "8.119"
"English",         "Ground Temperature (°F)",         "50.540"
"English",         "Thermal gradient (j/m²/s/C)",     "1.650"
"English",         "Possible Sun (%)",                "76.000"
"English",         "Dust Coefficient",                "5.000"
"English",         "Ground Reflectivity (%)",         "25.000"
"English",         "Solar Radiation (Langleys/d)",    "663.300"
"English",         "Total Shade (%)",                 "92.800"

"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Enabled"
"Total Shade","Enabled"
"Month/day","07/10"
         "Predicted Mean (°F) = 66.33"
         "Estimated Maximum (°F) = 67.90"
         "Approximate Minimum (°F) = 64.76"
```

CALIBRATION RUN

NM-2119_30: RIO PUEBLO DE TAOS (ARROYO DEL ALAMO TO RIO GRANDE DEL RANCHO)

```
"SSTEMP (2.0.8)  ","02/02/2004  02:14 pm"
"NoName"
"English",         "Segment Inflow (cfs)",            "7.000"
"English",         "Inflow Temperature (°F)",         "72.430"
"English",         "Segment Outflow (cfs)",           "7.408"
"English",         "Accretion Temp. (°F)",            "50.540"
"English",         "Latitude (degrees)",              "36.380"
"English",         "Segment Length (mi)",             "1.200"
"English",         "Upstream Elevation (ft)",         "6730.00"
"English",         "Downstream Elevation (ft)",       "6670.00"
"English",         "Width's A Term (s/ft²)",          "10.437"
"English",         "  B Term where W = A*Q**B",       "0.241"
"English",         "Manning's n",                     "0.018"
"English",         "Air Temperature (°F)",            "76.498"
"English",         "Relative Humidity (%)",           "23.682"
"English",         "Wind Speed (mph)",                "8.119"
"English",         "Ground Temperature (°F)",         "50.540"
"English",         "Thermal gradient (j/m²/s/C)",     "1.650"
"English",         "Possible Sun (%)",                "76.000"
"English",         "Dust Coefficient",                "5.000"
"English",         "Ground Reflectivity (%)",         "25.000"
"English",         "Solar Radiation (Langleys/d)",    "663.300"
"English",         "Total Shade (%)",                 "5.000"

"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Enabled"
"Total Shade","Enabled"
"Month/day","07/10"
         "Predicted Mean (°F) = 70.61"
         "Estimated Maximum (°F) = 80.77"
         "Approximate Minimum (°F) = 60.45"

         "Measured Mean (°F) = 70.1"      (Error = ±  1%)
         "Measured Maximum (°F) = 77.3"   (Error = ±  8%)
         "Measured Minimum (°F) = 64.3"   (Error = ± 12%)
```

LOAD ALLOCATION: INCREASE SHADE TO 96.7 PERCENT

NM-2119_30: RIO PUEBLO DE TAOS (ARROYO DEL ALAMO TO RIO GRANDE DEL RANCHO)

```
"SSTEMP (2.0.8)  ","02/02/2004  02:28 pm"
"NoName"
"English",         "Segment Inflow (cfs)",            "7.000"
"English",         "Inflow Temperature (°F)",         "72.430"
"English",         "Segment Outflow (cfs)",           "7.408"
"English",         "Accretion Temp. (°F)",            "50.540"
"English",         "Latitude (degrees)",              "36.380"
"English",         "Segment Length (mi)",             "1.200"
"English",         "Upstream Elevation (ft)",         "6730.00"
"English",         "Downstream Elevation (ft)",       "6670.00"
"English",         "Width's A Term (s/ft²)",          "10.437"
"English",         "  B Term where W = A*Q**B",       "0.241"
"English",         "Manning's n",                     "0.018"
"English",         "Air Temperature (°F)",            "76.498"
"English",         "Relative Humidity (%)",           "23.682"
"English",         "Wind Speed (mph)",                "8.119"
"English",         "Ground Temperature (°F)",         "50.540"
"English",         "Thermal gradient (j/m²/s/C)",     "1.650"
"English",         "Possible Sun (%)",                "76.000"
"English",         "Dust Coefficient",                "5.000"
"English",         "Ground Reflectivity (%)",         "25.000"
"English",         "Solar Radiation (Langleys/d)",    "663.300"
"English",         "Total Shade (%)",                 "96.700"

"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Enabled"
"Total Shade","Enabled"
"Month/day","07/10"
         "Predicted Mean (°F) = 66.81"
         "Estimated Maximum (°F) = 67.95"
         "Approximate Minimum (°F) = 65.67"
```

CALIBRATION RUN

NM-2120.A_511: RIO PUEBLO DE TAOS (RIO GRANDE DEL RANCHO TO TAOS PUEBLO BDY)

```
"SSTEMP (2.0.8)  ","02/02/2004  03:00 pm"
"NoName"
"English",         "Segment Inflow (cfs)",            "1.762"
"English",         "Inflow Temperature (°F)",         "69.100"
"English",         "Segment Outflow (cfs)",           "2.262"
"English",         "Accretion Temp. (°F)",            "52.577"
"English",         "Latitude (degrees)",              "36.390"
"English",         "Segment Length (mi)",             "2.800"
"English",         "Upstream Elevation (ft)",         "6859.00"
"English",         "Downstream Elevation (ft)",       "6730.00"
"English",         "Width's A Term (s/ft²)",          "7.436"
"English",         "  B Term where W = A*Q**B",       "0.185"
"English",         "Manning's n",                     "0.078"
"English",         "Air Temperature (°F)",            "66.069"
"English",         "Relative Humidity (%)",           "67.080"
"English",         "Wind Speed (mph)",                "1.846"
"English",         "Ground Temperature (°F)",         "52.577"
"English",         "Thermal gradient (j/m²/s/C)",     "1.650"
"English",         "Possible Sun (%)",                "76.000"
"English",         "Dust Coefficient",                "5.000"
"English",         "Ground Reflectivity (%)",         "25.000"
"English",         "Solar Radiation (Langleys/d)",    "586.700"
"English",         "Total Shade (%)",                 "7.000"

"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Enabled"
"Total Shade","Enabled"
"Month/day","07/31"
         "Predicted Mean (°F) = 71.89"
         "Estimated Maximum (°F) = 84.85"
         "Approximate Minimum (°F) = 58.93"

       "Measured Mean (°F) = 64.1"        (Error = ± 24%)
         "Measured Maximum (°F) = 77.2"   (Error = ± 17%)
         "Measured Minimum (°F) = 55.5"   (Error = ± 15%)
```

LOAD ALLOCATION: INCREASE SHADE TO 77.3 PERCENT, DECREASE WIDTH'S A TERM BY 50 PERCENT TO 3.718

NM-2120.A_511: RIO PUEBLO DE TAOS (RIO GRANDE DEL RANCHO TO TAOS PUEBLO BDY)

```
"SSTEMP (2.0.8)  ","02/02/2004  03:07 pm"
"NoName"
"English",         "Segment Inflow (cfs)",            "1.762"
"English",         "Inflow Temperature (°F)",         "69.100"
"English",         "Segment Outflow (cfs)",           "2.262"
"English",         "Accretion Temp. (°F)",            "52.577"
"English",         "Latitude (degrees)",              "36.390"
"English",         "Segment Length (mi)",             "2.800"
"English",         "Upstream Elevation (ft)",         "6859.00"
"English",         "Downstream Elevation (ft)",       "6730.00"
"English",         "Width's A Term (s/ft²)",          "3.718"
"English",         "  B Term where W = A*Q**B",       "0.185"
"English",         "Manning's n",                     "0.078"
"English",         "Air Temperature (°F)",            "66.069"
"English",         "Relative Humidity (%)",           "67.080"
"English",         "Wind Speed (mph)",                "1.846"
"English",         "Ground Temperature (°F)",         "52.577"
"English",         "Thermal gradient (j/m²/s/C)",     "1.650"
"English",         "Possible Sun (%)",                "76.000"
"English",         "Dust Coefficient",                "5.000"
"English",         "Ground Reflectivity (%)",         "25.000"
"English",         "Solar Radiation (Langleys/d)",    "586.700"
"English",         "Total Shade (%)",                 "77.300"

"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Enabled"
"Total Shade","Enabled"
"Month/day","07/31"
         "Predicted Mean (°F) = 64.24"
         "Estimated Maximum (°F) = 67.51"
         "Approximate Minimum (°F) = 60.96"
```

CALIBRATION RUN

NM-2120.A_900: RIO DE LOS PINOS (COLORADO BORDER TO HEADWATERS)
"SSTEMP (2.0.8) ","02/02/2004 01:25 pm"
"NoName"

"English",	"Segment Inflow (cfs)",	"0.000"
"English",	"Inflow Temperature (°F)",	"32.000"
"English",	"Segment Outflow (cfs)",	"9.283"
"English",	"Accretion Temp. (°F)",	"41.389"
"English",	"Latitude (degrees)",	"36.970"
"English",	"Segment Length (mi)",	"20.900"
"English",	"Upstream Elevation (ft)",	"9624.00"
"English",	"Downstream Elevation (ft)",	"8120.00"
"English",	"Width's A Term (s/ft²)",	"14.463"
"English",	" B Term where W = A*Q**B",	"0.275"
"English",	"Manning's n",	"0.040"
"English",	"Air Temperature (°F)",	"63.865"
"English",	"Relative Humidity (%)",	"40.527"
"English",	"Wind Speed (mph)",	"1.734"
"English",	"Ground Temperature (°F)",	"41.389"
"English",	"Thermal gradient (j/m²/s/C)",	"1.650"
"English",	"Possible Sun (%)",	"76.000"
"English",	"Dust Coefficient",	"5.000"
"English",	"Ground Reflectivity (%)",	"25.000"
"English",	"Solar Radiation (Langleys/d)",	"676.800"
"English",	"Total Shade (%)",	"20.000"

"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Enabled"
"Total Shade","Enabled"
"Month/day","07/03"
"Predicted Mean (°F) = 65.52"
"Estimated Maximum (°F) = 80.02"
"Approximate Minimum (°F) = 51.02"

"Measured Mean (°F) = 66.8" (Error = ± 4%)
"Measured Maximum (°F) = 77.5" (Error = ± 6%)
"Measured Minimum (°F) = 57.2" (Error = ± 24%)

LOAD ALLOCATION: INCREASE TOTAL SHADE TO 58.6 PERCENT, REDUCE WIDTH'S A TERM BY 20 PERCENT TO 11.570

NM-2120.A_900: RIO DE LOS PINOS (COLORADO BORDER TO HEADWATERS)

```
"SSTEMP (2.0.8)  ","02/02/2004  01:42 pm"
"NoName"
"English",         "Segment Inflow (cfs)",            "0.000"
"English",         "Inflow Temperature (°F)",         "32.000"
"English",         "Segment Outflow (cfs)",           "9.283"
"English",         "Accretion Temp. (°F)",            "41.389"
"English",         "Latitude (degrees)",              "36.970"
"English",         "Segment Length (mi)",             "20.900"
"English",         "Upstream Elevation (ft)",         "9624.00"
"English",         "Downstream Elevation (ft)",       "8120.00"
"English",         "Width's A Term (s/ft²)",          "11.570"
"English",         "  B Term where W = A*Q**B",       "0.275"
"English",         "Manning's n",                     "0.040"
"English",         "Air Temperature (°F)",            "63.865"
"English",         "Relative Humidity (%)",           "40.527"
"English",         "Wind Speed (mph)",                "1.734"
"English",         "Ground Temperature (°F)",         "41.389"
"English",         "Thermal gradient (j/m²/s/C)",     "1.650"
"English",         "Possible Sun (%)",                "76.000"
"English",         "Dust Coefficient",                "5.000"
"English",         "Ground Reflectivity (%)",         "25.000"
"English",         "Solar Radiation (Langleys/d)",    "676.800"
"English",         "Total Shade (%)",                 "58.600"

"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Enabled"
"Total Shade","Enabled"
"Month/day","07/03"
         "Predicted Mean (°F) = 57.26"
         "Estimated Maximum (°F) = 66.02"
         "Approximate Minimum (°F) = 48.49"
```

CALIBRATION RUN

NM-2120.A_901: RIO SAN ANTONIO (MONTOYA CANYON TO HEADWATERS)
"SSTEMP (2.0.8) ","03/30/2004 12:57 pm"
"NoName"

"English",	"Segment Inflow (cfs)",	"0.000"
"English",	"Inflow Temperature (°F)",	"32.000"
"English",	"Segment Outflow (cfs)",	"2.449"
"English",	"Accretion Temp. (°F)",	"41.389"
"English",	"Latitude (degrees)",	"36.860"
"English",	"Segment Length (mi)",	"9.100"
"English",	"Upstream Elevation (ft)",	"8809.00"
"English",	"Downstream Elevation (ft)",	"8750.00"
"English",	"Width's A Term (s/ft²)",	"14.570"
"English",	" B Term where W = A*Q**B",	"0.158"
"English",	"Manning's n",	"0.039"
"English",	"Air Temperature (°F)",	"62.867"
"English",	"Relative Humidity (%)",	"41.866"
"English",	"Wind Speed (mph)",	"1.734"
"English",	"Ground Temperature (°F)",	"41.389"
"English",	"Thermal gradient (j/m²/s/C)",	"1.650"
"English",	"Possible Sun (%)",	"76.000"
"English",	"Dust Coefficient",	"5.000"
"English",	"Ground Reflectivity (%)",	"25.000"
"English",	"Solar Radiation (Langleys/d)",	"676.800"
"English",	"Total Shade (%)",	"16.000"

"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Enabled"
"Total Shade","Enabled"
"Month/day","07/03"
"Predicted Mean (°F) = 66.41"
"Estimated Maximum (°F) = 80.57"
"Approximate Minimum (°F) = 52.25"

"Measured Mean (°F) = 65.9" (Error = ± 1%)
"Measured Maximum (°F) = 77.6" (Error = ± 7%)
"Measured Minimum (°F) = 54.8" (Error = ± 11%)

LOAD ALLOCATION: INCREASE SHADE TO 55 PERCENT, DECREASE WIDTH'S A TERM TO 10.75

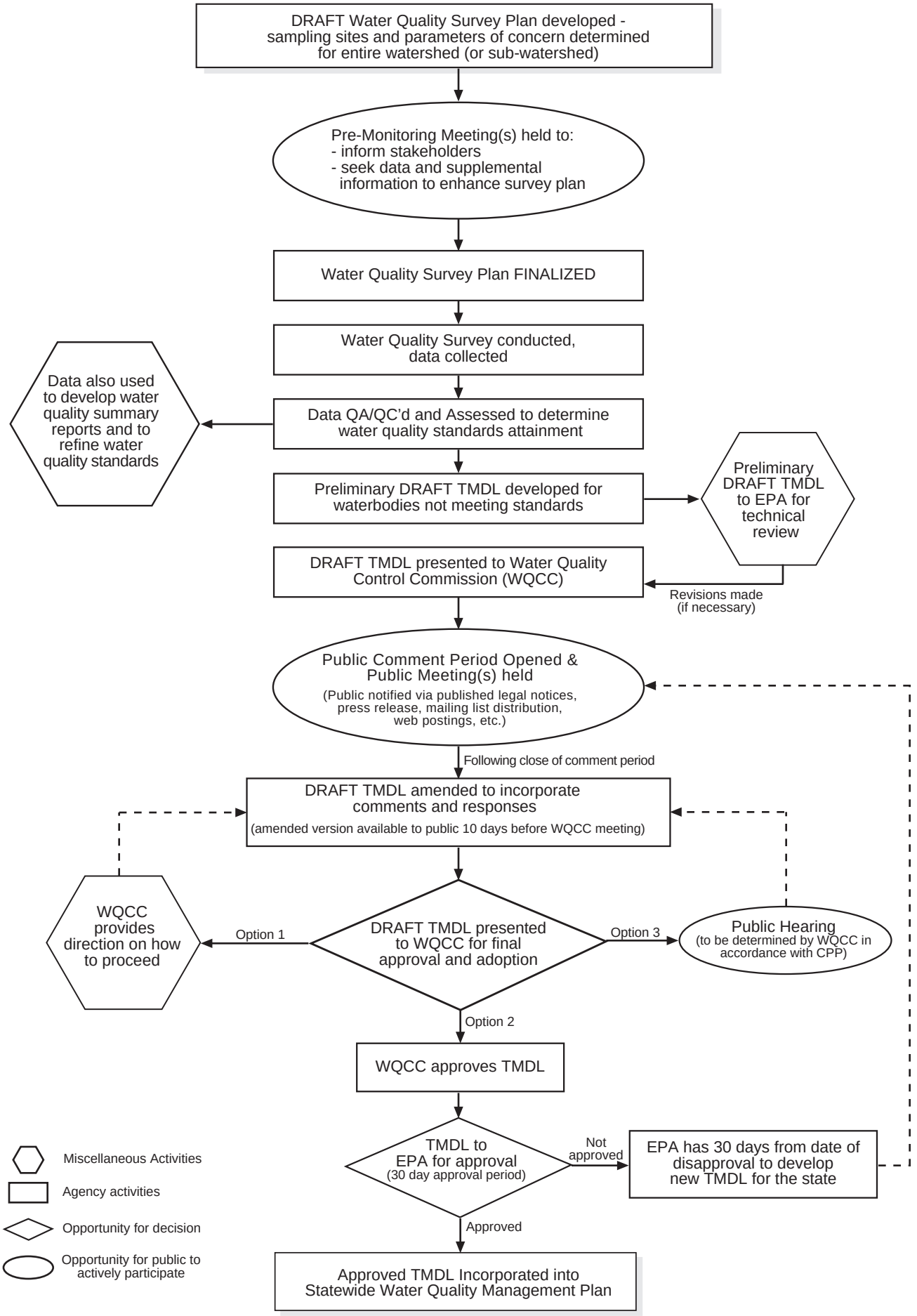
NM-2120.A_901: RIO SAN ANTONIO (MONTOYA CANYON TO HEADWATERS)

```
"SSTEMP (2.0.8)  ","03/30/2004  01:16 pm"
"NoName"
"English",         "Segment Inflow (cfs)",            "0.000"
"English",         "Inflow Temperature (°F)",         "32.000"
"English",         "Segment Outflow (cfs)",           "2.449"
"English",         "Accretion Temp. (°F)",            "41.389"
"English",         "Latitude (degrees)",              "36.860"
"English",         "Segment Length (mi)",             "9.100"
"English",         "Upstream Elevation (ft)",         "8809.00"
"English",         "Downstream Elevation (ft)",       "8750.00"
"English",         "Width's A Term (s/ft²)",          "10.750"
"English",         "  B Term where W = A*Q**B",       "0.158"
"English",         "Manning's n",                     "0.039"
"English",         "Air Temperature (°F)",            "62.867"
"English",         "Relative Humidity (%)",           "41.866"
"English",         "Wind Speed (mph)",                "1.734"
"English",         "Ground Temperature (°F)",         "41.389"
"English",         "Thermal gradient (j/m²/s/C)",     "1.650"
"English",         "Possible Sun (%)",                "76.000"
"English",         "Dust Coefficient",                "5.000"
"English",         "Ground Reflectivity (%)",         "25.000"
"English",         "Solar Radiation (Langleys/d)",    "676.800"
"English",         "Total Shade (%)",                 "55.000"

"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Enabled"
"Total Shade","Enabled"
"Month/day","07/03"
         "Predicted Mean (°F) = 57.75"
         "Estimated Maximum (°F) = 66.27"
         "Approximate Minimum (°F) = 49.23"
```

APPENDIX G
PUBLIC PARTICIPATION PROCESS FLOWCHART

Appendix G: Public Participation Process Flowchart



APPENDIX H
RESPONSES TO COMMENTS

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APPENDIX H
RESPONSES TO COMMENTS

No public comments were submitted.

The last paragraph in Section 4.4.1 was changed from “Therefore, this TMDL does not include a specific WLA for storm water discharges for these two assessment units, nor does it exclude these discharges” to “Individual wasteload allocations for the General Permits were not possible to calculate at this time in this watershed using available tools. Loads that are in compliance with the General Permits from facilities covered are therefore currently calculated as part of the watershed load allocation” per discussions with USEPA Region 6.