5.0 NUTRIENTS

The potential for excessive nutrients in the Rio Ruidoso were noted through visual observation during the 2003 SWQB study and the 2003-2005 Livingston Associates, P.C. study. Assessment of various water quality parameters did not indicate nutrient impairment in the upper Rio Ruidoso (US Highway 70 to the Mescalero Apache Boundary), but did indicate nutrient impairment in the lower Rio Ruidoso (Rio Bonito to US Highway 70). In the lower Rio Ruidoso, total phosphorus values were above the New Mexico State standard of 0.1 milligrams per liter (mg/L) in 66% of the samples; total nitrogen values were above the recommended criteria of 1.0 mg/L in 71% of the samples; and the dissolved oxygen saturation was greater than 120% in 15% of the samples. Since three or more indicators were exceeded along the Rio Ruidoso (Rio Bonito to US Highway 70), nutrients will be added as a cause of non support.

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

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

Rain, overland runoff, groundwater, drainage networks, and industrial and residential waste effluents transport nutrients to receiving waterbodies. Once nutrients have been transported into a waterbody they can be taken up by algae, macrophytes, and microorganisms either in the water column or in the benthos; they can sorb to organic or inorganic particles in the water column and/or sediment; they can accumulate or be recycled in the sediment; or they can be transformed and released as a gas from the waterbody (Figure 5.1).

As noted above, phosphorus and nitrogen are essential for proper functioning of ecosystems. However, excess nutrients cause conditions unfavorable for the proper functioning of aquatic ecosystems. Nuisance levels of algae and other aquatic vegetation (macrophytes) can develop rapidly in response to nutrient enrichment when other factors (e.g., light, temperature, substrate, etc.) are not limiting (Figure 5.1). The relationship between nuisance algal growth and nutrient enrichment in stream systems has been well documented in the literature (Welch 1992; Van Nieuwenhuyse and Jones 1996; Dodds et al. 1997; Chetelat et al. 1999). Unfortunately, the magnitude of nutrient concentration that constitutes an "excess" is difficult to determine and varies by ecoregion.

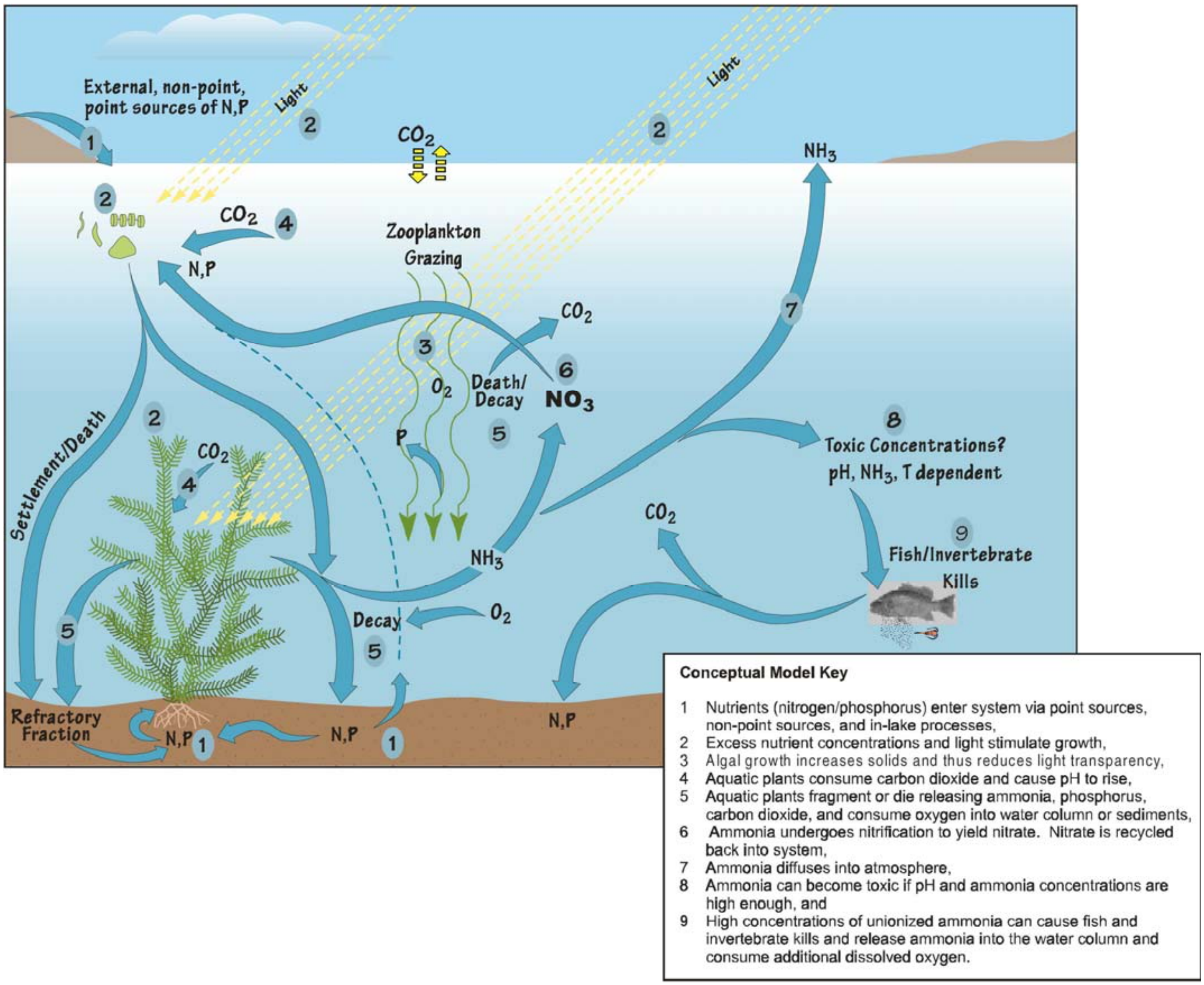

Figure 5.1. Nutrient Conceptual Model (USEPA 1999)

5.1 Target Loading Capacity

The target values for nutrient loads are determined based on 1) the presence of numeric and narrative 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 the target value for plant nutrients is based on both narrative and numeric criteria. This TMDL is consistent with the New Mexico State antidegradation policy.

The New Mexico WQCC has adopted narrative water quality standards for plant nutrients to sustain and protect existing or attainable uses of the surface waters of the state. This general standard applies to surface waters of the state at all times unless a specified standard is provided elsewhere. These water quality standards have been set at a level to protect cold-water aquatic life. The general water quality standards require that a stream have water quality, streambed characteristics, and other attributes of habitat sufficient to protect and maintain coldwater aquatic life. The narrative plant nutrient standard leading to an assessment of use impairment is as follows (NMAC 20.6.4.12.E):

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

In addition to the narrative plant nutrient criteria, the segment-specific criteria leading to an assessment of use impairment for Rio Ruidoso is the numeric criteria stating that, "In any single sample, total phosphorus (as P) shall be less than 0.1 mg/L" (20.6.4 NMAC).

There are two potential contributors to nutrient enrichment in a given stream: excessive nitrogen and/or phosphorus. The reason for controlling plant growth is to preserve aesthetic and ecologic characteristics along the waterway. The intent of numeric standards for phosphorus and nitrogen is to control the excessive growth of attached algae and higher aquatic plants that can result from the introduction of these plant nutrients into streams. Numeric standards also are necessary to establish targets for total maximum daily loads (TMDLs), to develop water quality-based permit limits and source control plans, and to support designated uses within the Rio Ruidoso.

The USEPA (2000) has published recommended nutrient criteria for causal (total nitrogen and total phosphorus) and response (chlorophyll *a* and turbidity) variables associated with the prevention and assessment of eutrophic conditions. The criteria are empirically derived from data in USEPA's STORET to represent conditions of surface waters that are minimally impacted by human activities and protective of aquatic life and recreational uses. Ideally, USEPA wanted to base these criteria on actual reference conditions. The criteria would have been based on the 75^{th} percentile of reference condition data. However, much of USEPA's data could not be considered to be reference conditions. Consequently, USEPA performed a statistical analysis of the entire body of non-reference data. The 25^{th} percentile of each season (winter, spring, summer, fall) was calculated, and then the median of these four values was calculated. This approach assumes that the lower 25^{th} percentile of all data overlaps with the 75^{th} percentile of reference condition data, so therefore the 25th percentile data can be used to represent reference conditions.

The Rio Hondo watershed is located in Level III Ecoregion 23 (the Arizona/New Mexico (AZ/NM) Mountains) contained within Aggregate Ecoregion II (Western Forested Mountains). The USEPA's recommended criteria for total phosphorus and total nitrogen in streams associated with these ecoregions are presented in Table 5.1 below.

Table 5.1. USEPA's Recommended Nutrient Criteria for Ecoregion II (Western Forested Mountains), Level III Ecoregion 23 (AZ/NM Mountains)

Nutrient Parameter	USEPA Recommended Criteria	
	Western Forested Mtns.	AZ/NM Mountains
Total Phosphorus	10.0 µg P/L	11.25 µg P/L
Total Nitrogen	0.12 mg N/L	0.28 mg N/L

The USEPA developed these criteria with the intention that they serve as a starting point for states to develop more refined nutrient criteria, as appropriate. There is a great deal of variability in nutrient levels and nutrient responses throughout the country due to differences in geology, climate and waterbody type. Rather than promulgate the proposed criteria, USEPA has allowed states and tribes to submit nutrient criteria development plans to document how nutrient criteria will be developed. SWQB has submitted a plan to USEPA that uses a weight-of-evidence approach, which includes a number of indicators of nutrient enrichment:

- Total Nitrogen concentration (TN)
- Total Phosphorus concentration (TP)
- Dissolved Oxygen Concentration
- Dissolved Oxygen Saturation
- pH
- Algal Productivity (from algal bioassays)
- Chlorophyll a concentration
- Hilsenhoff Biotic Index
- Benthic Macroinvertebrate IBI Score

The criteria for the other indicators are from USEPA guidance documents, peer reviewed literature, and NMED water quality standards.

A study concerning the effect of phosphorus and nitrogen additions on algal mass was conducted on appropriate river waters in the Rio Ruidoso (Appendix D). The water samples were designated as follows:

Designation	Site Collection
I	Rio Ruidoso @ Mescalero Boundary west of Ruidoso – Upper Canyon Road
II	Rio Ruidoso @ NM mile marker 267.5 (HWY 70), below Wastewater Treatment Plant (WWTP)
III	Rio Ruidoso abv. site on Susan Lattimer's property

In all three water samples, algal growth was increased by the addition of nitrogen indicating that nitrogen is the primary limiting nutrient in the Rio Ruidoso and is driving the productivity of algae and macrophytes in the stream. Phosphorus addition did not increase algal growth by itself but did increase growth when added along with nitrogen addition. Therefore, to ensure that the narrative WQS are met, management procedures should avoid any increase in both nitrogen and phosphorus inputs.

Based on chemical analysis of the Rio Ruidoso's waters, ratios above 10:1 were predictive of phosphorus limitation whereas ratios below 10:1 reflected nitrogen limitation. Table 5.2 reflects the usefulness of the N:P ratio in predicting algal productivity.

While colimitation of phosphorus and nitrogen may occur in waters, this is unusual. But if the limiting nutrient is increased, then a second nutrient becomes limiting. For example, if phosphorus is added to Carrizo Canyon Creek, productivity increases until nitrogen becomes limiting. A further increase of productivity occurs with nitrogen addition.

Table 5.2. N:P ratios for Rio Ruidoso water samples

Sample Sites	Total N / Total P	LIMITING NUTRIENT based on bioassay
Carrizo Canyon Creek below Canton Creek Lodge ½ mile below Mescalero sewage lagoon	19.3	Phosphorus
Rio Ruidoso above the site on Susan Lattimer's property (Algal Assay Site III)	6.2	Nitrogen
Rio Ruidoso @ HWY 70 bridge downstream of racetrack	14.7	Phosphorus
Rio Ruidoso west of Ruidoso @ Mescalero Boundary (Algal Assay Site I)	9.2	Nitrogen (slight)

The current, applicable New Mexico state standard states that TP shall be less than 0.1 mg/L in waters of the Rio Ruidoso (NMAC 20.6.4.208). In recommending a nitrogen standard, the SWQB bases its projection on the ratio of N:P required for algal biomass of 10:1. The chemical analysis of the Rio Ruidoso's waters supports the projection of a nitrogen standard that is 10 times greater than a phosphorus standard (Appendix D; Table 5.2). With a TP standard of 0.1 mg/L, the corresponding nitrogen standard would be 1.0 mg/L (Table 5.3). Total Nitrogen is defined as the sum of Nitrate-N, Nitrite-N, and Total Kjeldahl Nitrogen (TKN). At the present time, there is no USEPA-approved method to test for Total Nitrogen, however a combination of USEPA method 351.2 (TKN) and USEPA method 353.2 (Nitrate + Nitrite) may be appropriate for monitoring Total Nitrogen.

Table 5.3. Numeric Targets

Constituent or Factor	TMDL Target Concentrations
Total Phosphorus	0.1 mg P/L
Total Nitrogen	1.0 mg N/L

5.2 Flow

The presence of plant nutrients in a stream can vary as a function of flow. As flow decreases, the stream cannot effectively dilute its constituents, which causes the concentration of plant nutrients to increase. Thus, a TMDL is calculated for each assessment unit at a specific flow.

The *critical condition* can be thought of as the "worst case" scenario of environmental conditions in the waterbody in which the loading expressed in the TMDL for the pollutant of concern will continue to meet water quality standards. Critical conditions are the combination of environmental factors (e.g., flow, temperature, etc.) that results in attaining and maintaining the water quality criterion and has an acceptably low frequency of occurrence. The critical flow is used in calculation of point source (National Pollutant Discharge Elemination System [NPDES]) permit WLA and in the development of TMDLs.

The critical flow conditions for this TMDL occur when the ratio of effluent to stream flow is the greatest and was obtained using a 4Q3 regression model (Appendix B). The 4Q3 is the minimum average four consecutive day flow that occurs with a frequency of at least once every 3 years. It is assumed that 4Q3 flows will be the critical periods for aquatic life.

It is often necessary to calculate a critical flow for a portion of a watershed where there is no stage gage. This can be accomplished by applying one of two formulas developed by the USGS. One formula (USGS 1993) is recommended when the ratio between the gaged and ungaged watershed areas is between 0.5 and 1.5. The other formula, to be used when the watershed ratio is outside this range, is a regression formula developed by James P. Borland (USGS 1970). These methods of estimating low flows are currently used by the NMED to establish TMDLs for watersheds and to administer water-quality standards through the NPDES program.

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.

5.3 Calculations

This section describes the relationship between the numeric target and the allowable pollutant-level by determining the waterbody's total assimilative capacity, or loading capacity, for the pollutant. The loading capacity is the maximum amount of pollutant loading that a waterbody can receive while meeting its water quality objectives.

As the Rio Ruidoso flows downstream it has a specific carrying capacity for nutrients. This carrying capacity, or TMDL, is defined as the mass of pollutant that can be carried under critical low-flow conditions without violating the target concentration for that constituent. These TMDLs were developed based on simple dilution calculations using 4Q3 flow, the numeric target, and a conversion factor. The specific carrying capacity of a receiving water for a given pollutant, may be estimated using **Equation 3**.

4Q3 (in mgd) x Numeric Target (in mg/L) x 8.34 = TMDL (pounds per day [lbs/day]) **(Eq. 3)**

USGS gage data were used to determine the 4Q3 for this calculation (Appendix B). The 4Q3 was estimated through application of USGS gage data to a log Pearson Type III distribution using IOWDM software, Version 4.1 (USGS 2002a) and SWSTAT software, Version 4.1 (USGS 2002b). A unit-less conversion factor of 8.34 is used to convert units to lbs/day (Appendix E). By applying **Equation 3**, it is determined that the lower Rio Ruidoso can transport approximately 2.72 lbs/day of total phosphorus and 27.2 lbs/day of total nitrogen during critical low-flow conditions and in-stream concentrations will not exceed 0.10 mg/L and 1.0 mg/L, respectively. The annual target loads for TP and TN are summarized in Table 5.4.

Table 5.4. Estimates of Annual Target Loads for TP and TN: Rio Ruidoso (Rio Bonito to US Highway 70)

Parameter	Combined Flow[(a)] (mgd)	Numeric Target (mg/L)	Conversion Factor	Estimate of Target Loading (lbs/day)
Total Phosphorus	3.265	0.10	8.34	2.72[(b)]
Total Nitrogen	3.265	1.0	8.34	27.2[(b)]

Notes:

(a) Combined Flow = 4Q3 low-flow (mgd) + WWTP design capacity (2.50 mgd)

(b) Values rounded to three significant figures.

The measured loads for TP and TN were similarly calculated. In order to achieve comparability between the target and measured loads, the same flow value was used for both calculations. The geometric mean of the collected data that exceeded the standards (Table 5.5; Appendix F) was substituted for the standard in **Equation 3**. The same conversion factor of 8.34 was used. The results are presented in Table 5.6.

Table 5.5 SWQB data that *exceeded* the numeric criteria for TP and TN: Rio Ruidoso (Rio Hondo to US Hwy 70 Bridge)

Location	Sampling Date	TP (mg/L)	TN (mg/L)
Rio Ruidoso 10 ft	3/25/2004	0.24	1.32
above WWTP	2/17/2005	0.19	---
	3/24/2005	---	1.07
Rio Ruidoso	3/18/2003	0.478	2.505
Below WWTP	4/22/2003	0.306	1.277
	5/20/2003	0.681	4.526
	6/24/2003	0.982	4.775
	7/22/2003	1.100	3.385
	8/19/2003	1.260	3.308
	9/2/2003	1.195	4.670
	9/9/2003	1.140	6.120
	9/23/2003	1.000	4.922
	10/22/2003	0.920	6.376
Rio Ruidoso at	3/18/2003	0.183	1.156
Glencoe FR 443	4/22/2003	0.228	1.092
	5/20/2003	---	1.000
	6/24/2003	---	1.215
	7/22/2003	---	1.236
	8/19/2003	---	1.306
	9/23/2003	---	1.464
	10/22/2003	0.104	1.865
	4/24/2003	0.32	1.07
	5/22/2003	0.44	2.51
	6/26/2003	0.67	2.82
	7/24/2003	0.62	1.62
	8/14/2003	0.86	1.9
	8/29/2003	0.52	1.5
	9/25/2003	0.92	3.35
	10/23/2003	0.57	3.04
	11/20/2003	0.56	2.26
	12/18/2003	0.48	3.02
	1/22/2004	0.48	1.52
	2/12/2004	0.39	1.57
	2/26/2004	0.36	1.18
	3/25/2004	0.48	3.07
	4/22/2004	0.29	1.54
	5/19/2004	0.60	2.09
	6/23/2004	1.20	1.92
	7/22/2004	1.02	1.25
	8/25/2004	0.69	2.36
Rio Ruidoso at	9/22/2004	0.70	2.62
Glencoe FR 443	10/20/2004	0.44	1.39
	11/17/2004	0.47	1.66
	12/14/2004	0.33	1.74
	1/19/2005	0.33	1.74
	2/16/2005	0.33	1.74
	3/23/2005	0.33	1.74
R Ruidoso	4/24/2003	0.31	1.25
~1700 feet blw	5/22/2003	0.66	3.66
WWTP outfall	6/26/2003	1.21	4.93
	7/24/2003	1.28	3.27
	8/14/2003	1.41	3.69
	8/29/2003	1.15	3.42
	9/25/2003	1.49	5.42
	10/23/2003	1.08	5.98
	11/20/2003	1.03	4.39
	12/18/2003	0.57	3.01
	1/22/2004	0.38	2.63
	2/12/2004	0.70	2.48
	2/26/2004	0.61	1.96
	3/25/2004	0.47	2.70
	4/22/2004	0.26	1.59
	5/19/2004	0.53	2.25
	6/23/2004	1.19	2.79
	7/22/2004	0.81	1.67
	8/25/2004	0.94	3.62
	9/22/2004	1.23	5.37
	10/20/2004	0.68	2.32
	11/17/2004	0.63	1.86
	12/14/2004	0.46	2.37
	1/19/2005	0.46	2.37
	2/16/2005	0.46	2.37
	3/23/2005	0.46	2.37
R Ruidoso	4/24/2003	0.26	1.08
~3000 feet blw	5/22/2003	0.41	2.37
WWTP outfall	6/26/2003	1.08	4.41
	7/24/2003	1.41	3.34
	8/14/2003	1.98	2.89
	8/29/2003	1.05	3.10
	9/25/2003	1.18	3.49

Location	Sampling Date	TP (mg/L)	TN (mg/L)
R Ruidoso	10/23/2003	0.96	5.33
~3000 feet blw	11/20/2003	0.92	2.12
WWTP outfall	12/18/2003	0.78	4.25
	1/22/2004	0.65	2.05
	2/12/2004	0.48	1.78
	2/26/2004	0.63	1.77
	3/25/2004	0.48	2.69
	4/22/2004	0.28	1.35
	5/19/2004	0.52	2.15
	6/23/2004	1.15	2.64
	7/22/2004	1.23	1.99
	8/25/2004	0.93	3.45
	9/22/2004	1.17	4.77
	10/20/2004	0.71	2.01
	11/17/2004	0.60	1.67
	12/14/2004	0.45	2.08
	1/19/2005	0.45	2.08
	2/16/2005	0.45	2.08
	3/23/2005	0.45	2.08
R Ruidoso	4/24/2003	0.31	0.98
btwn Fox Cave	5/22/2003	0.44	2.55
and San Ysidro	6/26/2003	0.73	3.36
Church	7/24/2003	0.78	2.05
	8/14/2003	0.85	2.01
	8/29/2003	0.71	2.07

Location	Sampling Date	TP (mg/L)	TN (mg/L)
R Ruidoso	9/25/2003	1.07	4.60
btwn Fox Cave	10/23/2003	0.58	3.04
and San Ysidro	11/20/2003	0.45	1.42
Church	12/18/2003	0.37	1.83
	1/22/2004	0.49	1.56
	2/12/2004	0.47	1.97
	2/26/2004	0.47	1.49
	3/25/2004	0.22	1.19
	4/22/2004	0.30	1.55
	5/19/2004	0.41	1.78
	6/23/2004	0.76	1.80
	7/22/2004	1.01	0.67
	8/25/2004	0.52	1.95
	9/22/2004	0.72	2.50
	10/20/2004	0.49	1.54
	11/17/2004	0.47	1.47
	12/14/2004	0.26	1.53
	1/19/2005	0.26	1.53
	2/16/2005	0.26	1.53
	3/23/2005	0.26	1.53
GEOMETRIC MEAN		**0.578**	**2.205**

Table 5.6. Estimates of Annual Measured Loads for TP and TN: Rio Ruidoso (Rio Bonito to US Highway 70)

Parameter	Combined Flow[(a)] (mgd)	Geometric Mean Conc.[(b)] (mg/L)	Conversion Factor	Estimate of Measured Load (lbs/day)
Total Phosphorus	3.265	0.578	8.34	15.7[(c)]
Total Nitrogen	3.265	2.205	8.34	60.0[(c)]

Notes:

(a) Combined Flow = 4Q3 low-flow (mgd) + WWTP design capacity (2.50 mgd)

(b) Geometric mean of TP and TN exceedences (See Table 5.5 or Appendix F for data).

(c) Values rounded to three significant figures.

5.4 Waste Load Allocations and Load Allocations

5.4.1 Waste Load Allocation

The only existing point source along this assessment unit is the NPDES-permitted WWTP owned and operated by the Village of Ruidoso and the City of Ruidoso Downs (NM0029165). There are no individually permitted Municipal Separate Storm Sewer System (MS4) storm water permits in this assessment unit.

Excess nutrient levels 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 BMPs 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 preconstruction 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.

Therefore, this TMDL does not include a specific WLA for storm water discharges for this assessment unit. However, because Ruidoso and Ruidoso Downs own and operate an NPDES-permitted wastewater treatment plant a WLA for the WWTP is included in this TMDL.

A simple mixing model was used to calculate the WLA for NM0029165. Effluent limitations for TP and TN were calculated using the following equation:

$$C_e = \frac{C_s(Q_a + Q_e) - C_a Q_a}{Q_e} - BL$$

where C_e = allowable WWTP effluent concentration (mg/L)
C_s = numeric criterion (mg/L)
C_a = average stream concentration upstream of assessment unit (mg/L)
Q_e = design capacity of WWTP (million gallons per day)
Q_a = critical 4Q3 low-flow of stream (million gallons per day)
BL = Background Load

The equation is based on a simple steady-state mass balance model. The stream standard and ambient upstream concentrations used to calculate the annual effluent limitation are 0.10 and 0.04 mg/L, respectively for TP and 1.0 and 0.46 mg/L, respectively for TN. The data that were used to calculate the average ambient upstream concentration are found in Appendix F. The results of this mixing calculation for TP are presented in Table 5.7 and in Table 5.8 for TN.

Table 5.7 Allowable TP effluent concentration and WLA to meet water quality standards in the Rio Ruidoso (Rio Bonito to US Highway 70)

	Discharge		Total Phosphorus		
Time Scale	Q_a (mgd)	Q_e (mgd)	C_a (mg/L)	C_e (mg/L)	WLA (lbs/day)
Annual	0.765	2.50	0.04	0.10	2.16

NOTES: Q_a = critical 4Q3 low-flow of stream (mgd)
Q_e = design capacity of WWTP (mgd)
C_a = average stream concentration upstream of assessment unit (mg/L)
C_e = allowable WWTP effluent concentration (mg/L)
WLA = Waste Load Allocation (lbs/day)

Table 5.8 Allowable TN effluent concentration and WLA to meet water quality standards in the Rio Ruidoso (Rio Bonito to US Highway 70)

	Discharge		Total Nitrogen		
Time Scale	Q_a (mgd)	Q_e (mgd)	C_a (mg/L)	C_e (mg/L)	WLA (lbs/day)
Annual	0.765	2.50	0.46	0.90	18.9

NOTES: Q_a = critical 4Q3 low-flow of stream (mgd)
Q_e = design capacity of WWTP (mgd)
C_a = average stream concentration upstream of assessment unit (mg/L)
C_e = allowable WWTP effluent concentration (mg/L)
WLA = Waste Load Allocation (lbs/day)

Current loading from the WWTP was estimated from nine grab samples collected by SWQB staff during the 2003 intensive survey. The TP and TN concentrations measured at the WWTP outfall pipe averaged 3.096 and 13.33 mg/L, respectively. Assuming that discharge was at plant capacity (2.50 mgd), the current phosphorus loading from the plant into the Rio Ruidoso is 64.6 lbs/day and the current nitrogen loading from the plant into the Rio Ruidoso is 278 lbs/day. The current phosphorus loading from the WWTP is approximately 30 times the level that it should be to maintain the chemical and biological integrity of the stream. Similarly, the nitrogen loading is approximately 15 times the appropriate level.

5.4.2 Background Load

Rock and soil erosion, leaf litter decay, and wild animal waste supply background phosphorus and nitrogen loads from undeveloped land to the Rio Ruidoso. Background concentrations were determined from USEPA ecoregional reference criteria and SWQB/Livingston Associates nutrient data from the Rio Ruidoso (US Hwy 70 Bridge to Mescalero Apache Boundary), Rio Ruidoso (North Fork), and Carrizo Creek (Rio Ruidoso to headwaters).

Reference sites are relatively undisturbed by human influences. The definition of a reference condition ranges from a pristine, undisturbed state of a stream, to merely the "best available" or "best attainable" conditions. In the case of the New Mexican streams used in this study, the seasonal concentrations from Level III Ecoregion 23 were weighted according to the number of samples collected and were used to help determine background water quality. SWQB and Livingston Associates nutrient data from upstream sampling sites and the USEPA seasonal concentrations from Level III Ecoregion 23 reference sites were averaged to calculate an annual background concentration (Appendix F).

The background load to the Rio Ruidoso is calculated by multiplying the representative 4Q3 flow volume (in mgd) by the background concentration (in mg/L). A unit-less conversion factor of 8.34 is used to convert units to lbs/day (Appendix E). The background loads for the assessment unit are summarized in Table 5.9.

Table 5.9. Calculated Annual TP and TN Background Loads to the Rio Ruidoso

Parameter	Representative 4Q3 Flow[(a)] Volume (mgd)	Background Concentration (mg P/L)	Unit-less Conversion Factor	Estimated Background Load (lbs/day)
Total Phosphorus	0.765	0.014	8.34	0.089[(b)]
Total Nitrogen	0.765	0.26	8.34	1.66[(b)]

Notes:
(a) See Appendix B.
(b) Values rounded to three significant figures.

5.4.3 Load Allocation

In order to calculate the LAs for phosphorus and nitrogen, the WLAs, Background Loads (BL), and MOSs were subtracted from the target capacity (TMDL) using the following equation:

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

The MOS was developed using a combination of conservative assumptions and explicit recognition of potential errors in flow calculations. Results using an explicit MOS of 5% (see Section 5.7 for details) are presented in Table 5.10 and Figures 5.2 and 5.3.

Table 5.10. Calculation of Annual TMDL for TP and TN

Parameter	WLA (lbs/day)	LA (lbs/day)	BL (lbs/day)	MOS (5%) (lbs/day)	TMDL (lbs/day)
Total Phosphorus	2.16	0.34	0.09	0.13	2.72
Total Nitrogen	18.9	5.28	1.66	1.36	27.2

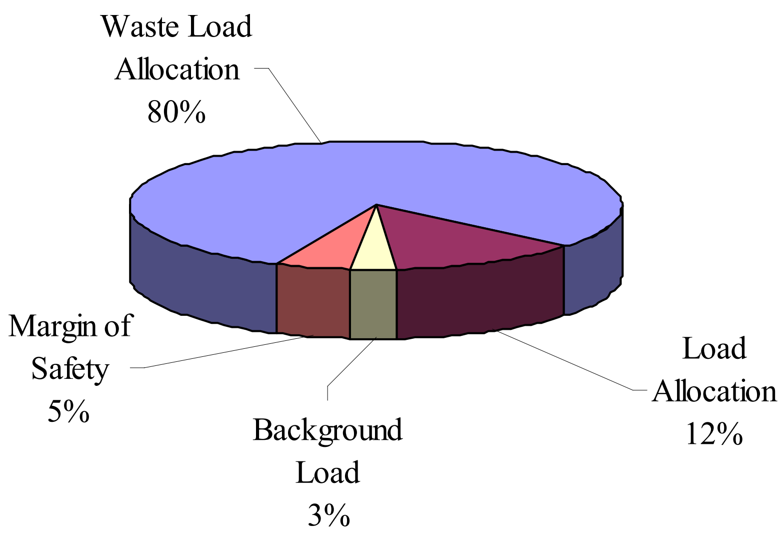

Figure 5.2. Annual TMDL for Total Phosphorus

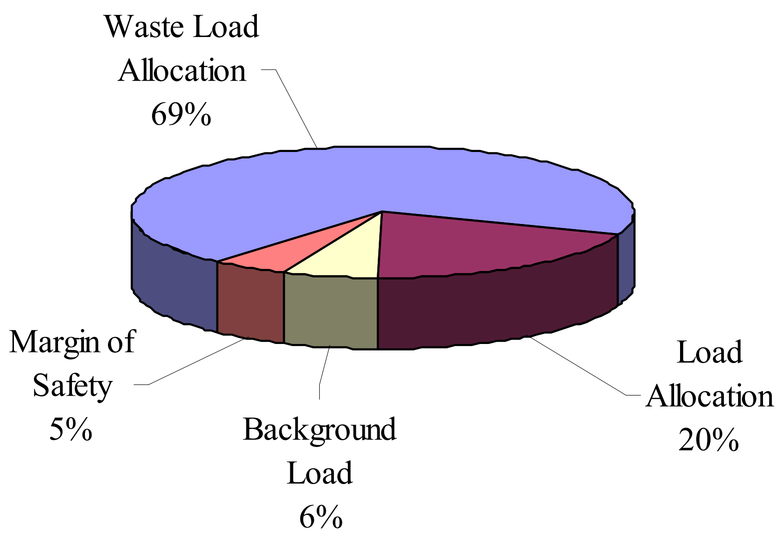

Figure 5.3. Annual TMDL for Total Nitrogen

The load reductions that would be necessary to meet the target loads were calculated to be the difference between the calculated target load allocation (Table 5.4) and the measured load (Table 5.6), and are shown in Table 5.11.

Table 5.11. Calculation of Load Reduction for TP and TN

Parameter	Target Load(a) (lbs/day)	Measured Load (lbs/day)	Load Reduction (lbs/day)	Percent Reduction (b)
Total Phosphorus	2.63	15.7	13.1	83%
Total Nitrogen	25.5	60.0	34.5	57%

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

5.5 Identification and Description of Pollutant Sources

Potential pollutant sources of TP that could contribute to this assessment unit are listed in Table 5.12. Potential sources of TN are listed in Table 5.13.

Table 5.12 Pollutant Source Summary for Total Phosphorus

Pollutant Sources	**Magnitude** (Measured Load [lbs/day])	**Location**	**Potential Sources** (% from each)
Point: NM0029165	12.0[a]	Ruidoso/Ruidoso Downs WWTP	77%
Nonpoint:	3.68[b]	Rio Ruidoso (Rio Hondo to US Hwy 70)	23% Drought-related Impacts Flow Alterations from Water Diversions Municipal (Urbanized High Density Area) On-site Treatment Systems (septic systems and similar decentralized systems) Range Grazing - Riparian or Upland Natural Sources

[a] The measured load for point sources was calculated by multiplying the total measured load calculated in Section 5.3 (Table 5.6) by the percent contribution to streamflow of the effluent discharge (77%).
[b] The measured load for nonpoint sources was calculated by multiplying the total measured load calculated in Section 5.3 (Table 5.6) by the percent contribution to streamflow of the 4Q3 low-flow (23%).

Table 5.13 Pollutant Source Summary for Total Nitrogen

Pollutant Sources	Magnitude (Measured Load [lbs/day])	Location	Potential Sources (% from each)
Point: NM0029165	46.2[a]	Ruidoso/Ruidoso Downs WWTP	77%
Nonpoint:	13.8[b]	Rio Ruidoso (Rio Hondo to US Hwy 70)	23% Drought-related Impacts Flow Alterations from Water Diversions Municipal (Urbanized High Density Area) On-site Treatment Systems (septic systems and similar decentralized systems) Range Grazing - Riparian or Upland Natural Sources

[a] The measured load for point sources was calculated by multiplying the total measured load calculated in Section 5.3 (Table 5.6) by the percent contribution to streamflow of the effluent discharge (77%).

[b] The measured load for nonpoint sources was calculated by multiplying the total measured load calculated in Section 5.3 (Table 5.6) by the percent contribution to streamflow of the 4Q3 low-flow (23%).

5.6 Linkage Between Water Quality and Pollutant Sources

The source assessment phase of TMDL development identifies sources of nutrients that may contribute to both elevated nutrient concentrations and the stimulation of algal growth in a waterbody. Where data gaps exist or the level of uncertainty in the characterization of sources is large, the recommended approach to TMDL assignments requires the development of allocations based on estimates utilizing the best available information.

SWQB fieldwork includes an assessment of the potential sources of impairment (NMED/SWQB 1999). The completed Pollutant Source(s) Documentation Protocol forms in Appendix C provide documentation of a visual analysis of probable sources along an impaired reach. Although this procedure is subjective, SWQB feels that it provides the best available information for the identification of potential sources of impairment in this watershed. Staff completing these forms identify and quantify potential sources of NPS 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. This nutrient TMDL was calculated using the best available methods that were known at the time of calculation and may be revised in the future.

The Rio Ruidoso has six main land uses that were identified as potential sources of phosphorus and nitrogen (Figure 2.1). They include commercial, residential, agriculture, forest, shrubland, and grasslands. As described in Section 5.2, the presence of plant nutrients in a stream can vary as a function of flow. As flow decreases through water diversions and/or drought-related stressors, the stream cannot effectively dilute its constituents, which causes the concentration of plant nutrients to increase. Nutrients generally reach the Rio Ruidoso from land uses that are in close proximity to the stream because the hydrological pathways are shorter and have fewer obstacles than land uses located away from the riparian corridor. However, during the growing season (i.e. in agricultural return flow) and in storm water runoff, distant land uses can become hydrologically connected to the stream, thus transporting nutrients from the hillslopes to the stream during these time periods.

In addition to agriculture, there are several other human-related activities that influence nutrient concentrations in rivers and streams. Residential areas contribute nutrients from septic tank disposal systems, landscape maintenance, as well as backyard livestock (e.g. cattle, horses) and pet wastes. Industrial areas and urban development contribute nutrients by disturbing the land and consequently increasing soil erosion, by increasing the impervious area within the watershed, and by directly applying nutrients to the landscape. Recreational activities such as hiking and biking can also contribute nutrients to the stream by reducing plant cover and increasing soil erosion (e.g. trail network, streambank destabilization), direct application of human waste, campfires and/or wildfires, and dumping trash near the riparian corridor.

Undeveloped, or natural, landscapes also can deliver nutrients to a waterbody through decaying plant material, soil erosion, air deposition, and wild animal waste. Another geographically occurring nutrient source is atmospheric deposition, which adds nutrients directly to the waterbody through dryfall and rainfall. Atmospheric phosphorus and nitrogen can be found in both organic and inorganic particles, such as pollen and dust. The contributions from these natural sources are generally considered to represent background levels. Background loads were estimated using SWQB and Livingston Associates water quality data as well as USEPA data from regional reference streams (Section 5.4.2).

Nutrients from anthropogenic and natural sources reach the Rio Ruidoso primarily by two routes: directly in overland flow (stormwater runoff and irrigation return flow) and indirectly in ground water. Nutrients applied directly to land (e.g. fertilizers, pet wastes) can be carried overland in storm water runoff and agricultural return flow or can dissolve and percolate through the soil to reach ground water. Septic tank disposal systems contribute nutrients primarily into ground water, which may eventually discharge into the stream. According to the public works departments in Ruidoso and Ruidoso Downs, about 20% of the total housing units have on-site wastewater systems (i.e. septic systems). Additionally, there are approximately 450 houses located within 100 meters of the Rio Ruidoso, an area that would be most affected by the use of septic systems because of the hydrologic connectivity between ground water and surface water in this near-stream zone. By multiplying the percent of houses on septic systems by the number of houses near the stream, it can be concluded that roughly 90 houses have on-site wastewater systems **and** are located within 100 m of the stream. Some of the phosphorus and nitrogen loads from these houses will be removed through plant uptake, but site-specific uptake rates are not known, therefore accurate groundwater loads could not be calculated.

This source-specific analysis accounts for the differences in magnitudes between sources and provides a basis for allocating loads. Analyses presented in these TMDLs demonstrate that defined loading capacities will ensure attainment of New Mexico water quality standards.

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. The MOS can be expressed either implicitly or explicitly. An implicit MOS is incorporated by making conservative assumptions in the TMDL analysis, such as allocating a conservative load to background sources. An explicit MOS is applied by reserving a portion of the TMDL and not allocating it to any other sources.

For these nutrient TMDLs, the margin of safety was developed using a combination of conservative assumptions and explicit recognition of potential errors in flow calculations. Therefore, this margin of safety is the sum of the following two elements:

- *Conservative Assumptions*

  Treating phosphorus and nitrogen as conservative pollutants, that is a pollutant that does not readily degrade in the environment, was used as a conservative assumption in developing these loading limits.

  Using the 4Q3 critical low flow to calculate the allowable load.

  Using the treatment plant design capacity for calculating the point source loading when, under most conditions, the treatment plant is not operating at full capacity.

  A more conservative limit of the geometric mean value, rather than the current and proposed standards which allow for higher concentrations in individual grab samples, was used to calculate measured loading values.

- *Errors in calculating flow*

  4Q3 low flow values were determined based on USGS gaging data. There is inherent error in all flow measurements. A conservative MOS for this element is therefore **5 percent**.

5.8 Consideration of Seasonal Variability

Section 303(d)(1) of the CWA requires TMDLs to be "established at a level necessary to implement the applicable WQS with seasonal variation." Data used in the calculation of this TMDL were collected during spring, summer, and fall in order to ensure coverage of any potential seasonal variation in the system. Exceedences were observed from March through November, during all seasons and across multiple years, which captured flow alterations related to snowmelt, agricultural diversions, and summer monsoonal rains. Data that exceeded the target concentration for TP and TN were used in the calculation of the measured loads (Table 5.6) and can be found in Table 5.5 and Appendix F. The critical condition used for calculating the TMDL was low-flow. Calculations made at the critical low-flow (4Q3), in addition to using other conservative assumptions as described in the previous section on MOS, should be protective of the water quality standards designed to preserve aquatic life in the stream. It was assumed that if critical conditions were met during this time, coverage of any potential seasonal variation would also be met.

5.9 Future Growth

Growth estimates by county are available from the New Mexico Bureau of Business and Economic Research. These estimates project growth to the year 2030. Growth estimates for Lincoln County project a 52% growth rate through 2030. Since future projections indicate that nonpoint sources of nutrients will more than likely increase as the region continues to grow and develop, it is imperative that BMPs continue to be utilized and improved upon in this watershed while continuing to improve road conditions and grazing allotments and adhering to SWPPP requirements related to construction and industrial activities covered under the general permit.

The Village of Ruidoso and City of Ruidoso Downs are currently investigating the potential for water quality trading of nutrients in the Rio Ruidoso. If water quality trading is determined to be a viable option for decreasing the amount of nutrient loading to the Rio Ruidoso then this TMDL will be revised to include trading options for the WWTP.