

N-STEPS into Stream Nutrient Thresholds:

Refinement of Nutrient Thresholds for New Mexico Wadeable Perennial Streams

Seva Joseph

**Monitoring, Assessment, and Standards Section
Surface Water Quality Bureau
New Mexico Environment Department**





New Mexico Stream Work to Date

In 2004 NMED developed a weight of evidence nutrient assessment protocol for wadeable, perennial streams - using threshold values for both cause (TN & TP) and response (Chlorophyll and DO) variables

“Plant nutrients from other than natural causes shall not be present in concentrations that will produce undesirable aquatic life or result in a dominance of nuisance species in surface waters of the state”

Current TN and TP Level III Ecoregional and Aquatic Live Use Threshold Values in mg/L

	21- Southern Rockies		20/22- AZ/NM Plateau**		23- AZ/NM Mountains		24/79- Chihuahuan Desert**	26- Southwestern Tablelands		
ALU→	CW	T/WW (volcanic)	CW	T/W W	CW	T/W W	T/WW	CW	T	WW
TN	0.25	0.25	0.28	0.48	0.25	0.29	0.53	0.25	0.38	0.45
TP	0.02	0.02 (0.05)	0.04	0.09	0.02	0.05	0.04	0.02	0.03	0.03

Chlorophyll *a* Level III Ecoregional Threshold Values in $\mu\text{g}/\text{cm}^2$

21-Southern Rockies	20/22-AZ/NM Plateau	23-AZ/NM Mountains	24/79-Chihuahuan Desert	25/26-SW Tablelands
3.9 – 5.5	7.4 – 7.8	5.8 – 11.0	16.5 – 17.5	8.2 – 14.0

New Mexico Stream Work to Date Continued:

- **This protocol has been in use since 2004 resulting in listing**
 - **62 assessment units = 1,210 miles**
 - **18% of all impairments**
- **Nutrient TMDLs – 31 completed to date**
- **NPDES Permits with nutrient effluent limits**
- **Ecoregional threshold values used as [TMDL Targets](#) and associated wasteload allocations for permitting**

Nutrient Threshold Refinement Process

- Compile Data
- Identify Reference Sites
- Classify Sites
- Analyze Nutrient Value Distributions
- Conduct Stressor-Response Analysis
- Synthesis of resulting Thresholds



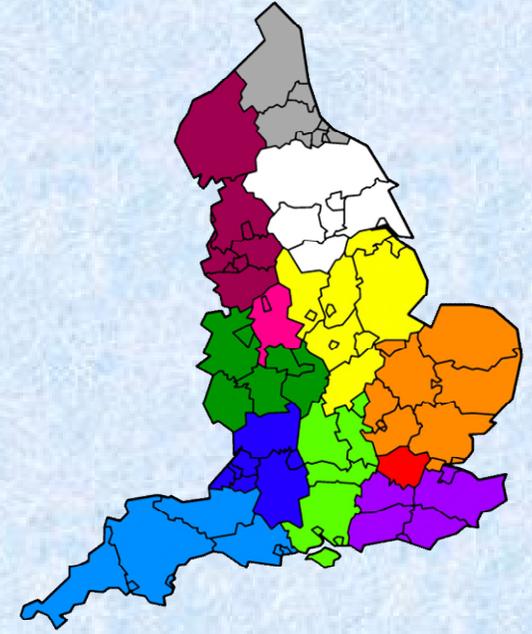
Data Sources and Elements

544 valid sites with nutrient data collected between 1991 and 2012 were compiled from NMED and National Sources -- National Rivers and Streams Assessment (NRSA) and the Wadeable Streams Assessment program (WSA).

- Nutrients – TN and TP
- Benthic macroinvertebrates – BMIs (NMED and NRSA)
- Diatoms (NMED and NRSA)
- Chlorophyll a (NMED and NRSA)
- Dissolved oxygen (diel data in NMED)

GIS Analysis

- Catchment delineations
- Disturbance variables
 - Land use, roads, discharges, activities (dams ,mines, NPDES, and etc.)
- Classification variables
 - Catchment size, ecoregion, geology, precipitation, temperature, average land slope



Reference Site Criteria

Variable	Reference Criteria	Stressed Criteria
Urban Index (%)	<0.02	>1
Agricultural index (%)	<0.5	>4
Road Density (mi/mi ²)	<1.4	>3
Road Crossing Density (#/mi ²)	<1.25	>2
Dam Density (#/mi ²)	<0.005	>0.03
Dam Distance (miles from site)	NA	<1
NPDES Density (#/mi ²)	<0.01	>0.1
NPDES Distance (miles from site)	NA	<1
Superfund Density (#/mi ²)	=0	>0.01
Superfund Distance (miles from site)	NA	<2
Mine Density (#/mi ²)	<0.1	>5
Mine Distance (miles from site)	NA	<0.5

Designations verified with professional judgment to incorporate impacts not captured by GIS analysis

Site Classification

- Account for the natural or systematic variables associated with nutrient
- Classification and Regression Tree (CART) models - resulted in the following classes
 - Both Phosphorus and Nitrogen values were partitioned by average land slope
 - TP also by longitude which was driven by high Phosphorus soils – basins (8 or 12 digit HUCs) with volcanic geology and naturally high soil P were identified

Nutrient Site Classes

TN Flat - TN Flat sites have average catchment land slopes less than 15%

TN Moderate - TN Moderate sites have average catchment land slopes from 15% to 32%

TN Steep - TN Steep sites have average catchment land slopes greater than 32%

TP High-Volcanic –The class includes all sites in the San Antonio and Conejos, the Upper Gila, Upper Gila-Mangas, San Francisco, and Mimbres basins.

TP Flat-Moderate - This class includes all sites less than or equal to 29% average land slope and not in the TP High-Volcanic site class.

TP Steep - The Steep class includes all sites with average land slopes greater than 29% and not in the TP High-Volcanic site class.

Quantiles and 90% confidence intervals of reference sites frequency distribution by site classes

	<u>TP (mg/L)</u>			<u>TN (mg/L)</u>		
Quantile	Lower 90% CI	Value	Upper 90% CI	Lower 90% CI	Value	Upper 90% CI
	<u>TP High-Volcanic (N=55)</u>			<u>TN Flat (N=30)</u>		
50th	0.049	0.058	0.071	0.38	0.47	0.56
75th	0.072	0.084	0.09	0.55	0.61	0.67
80th	0.08	0.088	0.104	0.56	0.62	0.7
85th	0.084	0.092	0.106	0.59	0.65	0.84
90th	0.089	0.105	0.114	0.62	0.69	0.85
	<u>TP Flat-Moderate (N=76)</u>			<u>TN Moderate (N=96)</u>		
50th	0.016	0.025	0.033	0.23	0.25	0.28
75th	0.034	0.041	0.05	0.33	0.35	0.37
80th	0.036	0.048	0.058	0.35	0.37	0.41
85th	0.043	0.054	0.061	0.36	0.40	0.45
90th	0.051	0.061	0.069	0.38	0.42	0.51
	<u>TP Steep (N=48)</u>			<u>TN Steep (N=53)</u>		
50th	0.015	0.015	0.015	0.18	0.20	0.21
75th	0.015	0.015	0.018	0.21	0.23	0.27
80th	0.015	0.016	0.023	0.22	0.25	0.3
85th	0.015	0.018	0.035	0.24	0.28	0.33
90th	0.016	0.030	0.053	0.26	0.30	0.34

Stressor-Response Analysis

- Correlations
- Regression Interpolation
- Change-point Analysis

Correlations

(Spearman rank-order correlation analysis)

Benthic chlorophyll a correlation with TN and TP –**strength of chlorophyll relationships do not support its continued use as a response variable in stream assessments**

Diel Dissolved Oxygen correlations

- DO metrics calculated for each DO record:
 - overall minimum DO (DO_{\min}),
 - maximum daily fluctuation (Delta DO),
 - maximum 4 hour productivity (P_{\max}), and
 - maximum 4 hour respiration (R_{\max})
 - gross primary production (GPP),
 - ecosystem respiration (ER),
- **TN** had significant correlations with DO_{\min} and R_{\max}
- **TP** had significant correlations with DO_{\min} , Delta DO, P_{\max} , R_{\max} , and GPP
- Benthic **chlorophyll a** had significant correlations with Delta DO, P_{\max} , R_{\max} , and ER

Diatoms and Benthic Macroinvertebrates

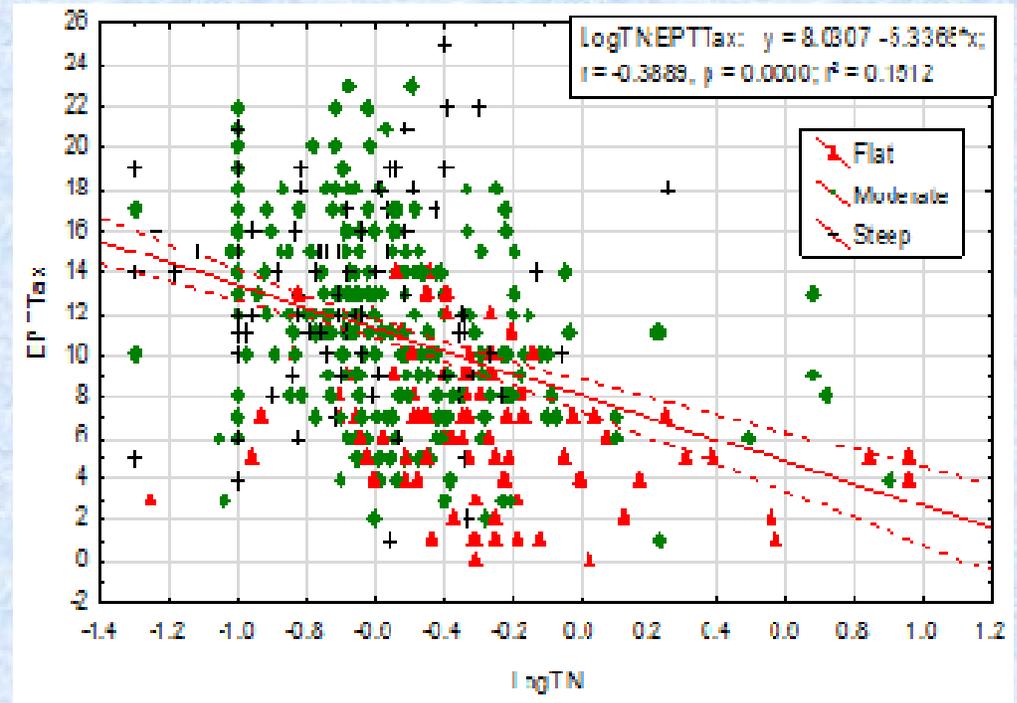
- 68 diatom metrics were analyzed
 - 21 had significant correlations with TN
 - 36 had significant correlations with TP
 - 8 responsive metrics were selected for further analysis
- 63 BMI metrics were analyzed
 - 42 had significant correlations with TN
 - 21 had significant correlations with TP
 - 10 BMI with consistent and strong correlations were identified (including correlations with DO metrics and benthic chlorophyll a concentrations)

Regression Interpolation

When there is a linear relationship between a nutrient concentration and a response variable, a nutrient concentration can be associated with a response threshold through intersection with the linear regression. The 25th or 75th quartile of the response metrics in reference sites was used as the threshold.

The resulting valid candidate thresholds for each metric and site class ranged from:

- 0.13 to 3.26 mg/L for TN
- 0.003 to 1.74 mg/L for TP



Candidate thresholds derived from regression interpolations on BMI and diatom metrics. Values in gray are not valid

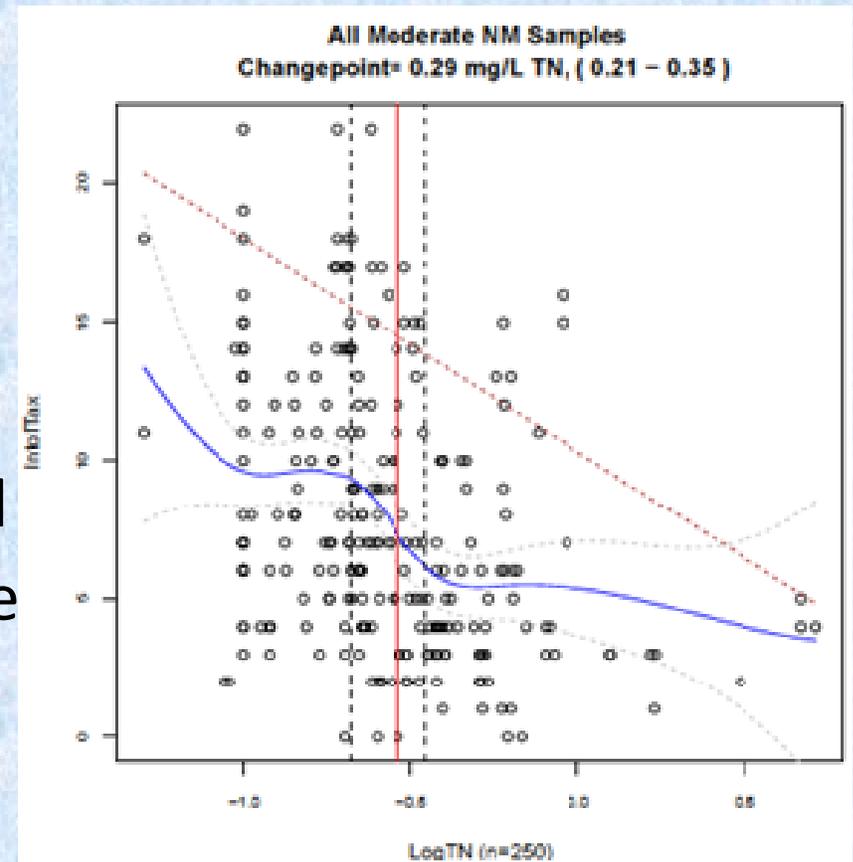
	TN (mg/L)			TP (mg/L)		
	TN Flat	TN Moderate	TN Steep	TP High-Volcanic	TP Flat-Moderate	TP Steep
EPTTax	3.70	0.18	0.43	0.11	3.39	0.11
EphemTax	2.27	0.62	0.62	1.00	211	1.00
PlecoTax	3.26	3.26	3.26	1.61	1.61	0.15
IntolTax	3.48	0.53	0.85	0.88	6.22	0.33
Toler percent	501	0.29	0.33	0.22	3.11	0.017
EPT percent	398	0.13	21.47	59102	31.91	491758
Pleco percent	0.49	0.49	0.49	1.74	1.74	0.80
NonIn percent	28.33	0.21	0.37	1.46	0.281	0.003
ShredTax	2.28	2.28	0.64	56.47	56.47	0.60
Clngr percent	108	0.88	2.44	13.22	5.01	0.50
BMI Medians	2.28	0.49	0.46	0.11	1.61	0.11
wa_OptCat_DisTotMMI	10.35	0.36	0.19	0.042	0.168	0.028
wa_OptCat_L1DisTot	18.26	0.30	0.19	0.024	0.358	0.027
wa_OptCat_L1Ptl	7.45	0.43	0.29	0.068	0.145	0.029
wa_OptCat_LNtl	10.49	0.33	0.18	0.057	0.311	0.054
wa_OptCat_NutMMI	9.26	0.32	0.23	0.047	0.193	0.025
pi_NAWQA_TN_1	1.28	4.36	5.32	0.457	0.129	0.010
pi_Ptpv_TP_all_Hi	7.98	0.25	0.69	0.083	0.152	0.011
x_Shan_e	2.26	16.63	161700	9.272	7.272	0.012
Diatom Medians	1.28	0.33	0.21	0.052	0.168	0.026
Median of all valid interpolated values	2.27	0.33	0.35	0.063	0.237	0.025

Change-point Analysis

The change-point is the point along an environmental gradient (nutrient concentration) at which there is a high degree of change in the response variable (BMI, diatom, or DO metrics)

Change-points were qualified using:

- 1) valuation of 95th quantile regression line,
- 2) the relative size of the confidence interval around the change-point, and
- 3) coincidence of an appropriate slope in the LOWESS regression line



Change-points from selected BMI, diatom and DO metrics. Values in gray are not valid.

Metric	TN (mg/L)			TP (mg/L)		
	TN Flat	TN Moderate	TN Steep	TP High-Volcanic	TP Flat-Moderate	TP Steep
EPTax	0.49	0.25	0.42	0.067	0.044	0.030
EphemTax	0.49	0.22	0.28	0.058	0.044	0.030
PlecoTax	0.56	0.33	0.25	0.063	0.041	0.027
IntolTax	0.48	0.29	0.39	0.061	0.051	0.029
Toler percent	0.66	0.40	0.26	0.083	0.052	0.041
EPT percent	0.97	0.36	0.22	0.047	0.014	0.029
Pleco percent	0.35	0.33	0.14	0.114	0.044	0.027
NonIn percent	0.72	1.26	0.23	0.083	0.014	0.018
ShredTax	0.48	0.25	0.23	0.047	0.151	0.017
CIngr percent	1.09	0.49	0.28	0.122	0.051	0.022
Median CP BMI	0.53	0.31	0.28	0.063	0.044	0.029
wa_OptCat_DisTotMMI	0.48	0.52	0.16	0.068	0.056	0.035
wa_OptCat_L1DisTot	0.50	0.38	0.26	0.068	0.066	0.034
wa_OptCat_L1Ptl	0.48	0.52	0.13	0.066	0.032	0.036
wa_OptCat_LNtl	0.47	0.39	0.19	0.068	0.078	0.035
wa_OptCat_NutMMI	0.47	0.52	0.15	0.066	0.056	0.035
pi_NAWQA_TN_1	0.66	0.67	0.13	0.084	0.028	0.019
pi_Ptpv_TP_all_Hi	0.52	0.71	0.21	0.094	0.032	0.029
x_Shan e	0.70	0.51	0.25	0.071	0.034	0.027
Median CP diatoms	0.49	0.45	0.18	0.068	0.056	0.035
DO_min	0.63	0.34	0.30	0.066	0.039	0.035
Pmax4hr	0.70	0.37	0.36	0.059	0.099	0.035
Median valid CP BMI, diatoms, & DO	0.50	0.36	0.22	0.067	0.044	0.035

Synthesis of Multiple Thresholds

Proposed TN and TP Thresholds

- highest reference quantile between 75 and 90% that was within 15% of the median of the stressor-response derived values
- for the TP in the High-Volcanic site class the 75th quantile is 38% above the stressor-response median.

	TN (mg/L)			TP (mg/L)		
	TN Flat	TN Moderate	TN Steep	TP High-Volcanic	TP Flat-Moderate	TP Steep
Reference quantile	85	80	90	75	90	90
Proposed threshold	0.65	0.37	0.30	0.084	0.061	0.03
90% confidence interval	0.59 - 0.84	0.35-0.41	0.26–0.34	0.072-0.09	0.051–0.069	0.016–0.053
Stressor-response median	0.52	0.33	0.26	0.067	0.066	0.029
Cumulative proportion	57%	61%	63%	86%	48%	53%

Next Steps

Incorporate the proposed thresholds into a revised stream nutrient assessment protocol using diel DO as the primary response variable.

Proposed TN, TP, and DO Thresholds

Nutrient Site Class	TN (mg/L)	TP (mg/L)	Delta DO (mg/L)
TN Flat	0.65	-	-
TN Moderate	0.37	-	-
TN Steep	0.30	-	-
TP High-volcanic	-	0.084	5.02
TP Flat-Moderate	-	0.061	4.08
TP Steep	-	0.030	1.79

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seva.joseph@state.nm.us

<http://www.nmenv.state.nm.us/swqbnutrients/>

