UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

DWQ Response to Letter to WQB from LaVere Merritt

Water Quality Board, May 25, 2016

Erica Gaddis

Utah’s Nutrient Program

Direct Effects of Nutrients

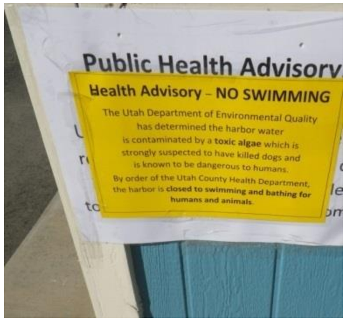
- Nitrates
  - High levels of nitrate cause blue baby syndrome.
  - Drinking water aquifer contamination occurs in Sanpete and Sevier Valleys, Cottonwood Mutual (Morgan County), Millville, and Mendon.
- Ammonia
  - Direct toxic to aquatic life.
  - Utah has 4 streams impaired for ammonia and two new listings for ammonia anticipated in 2016 IR.

Nutrient Pollution Threatens Utah Waters

Aquatic life

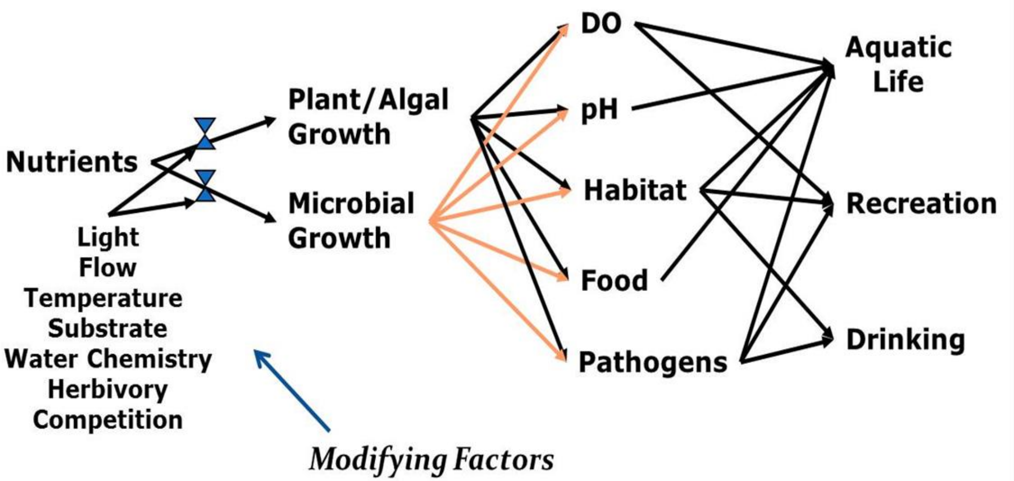
Aesthetics

Livestock



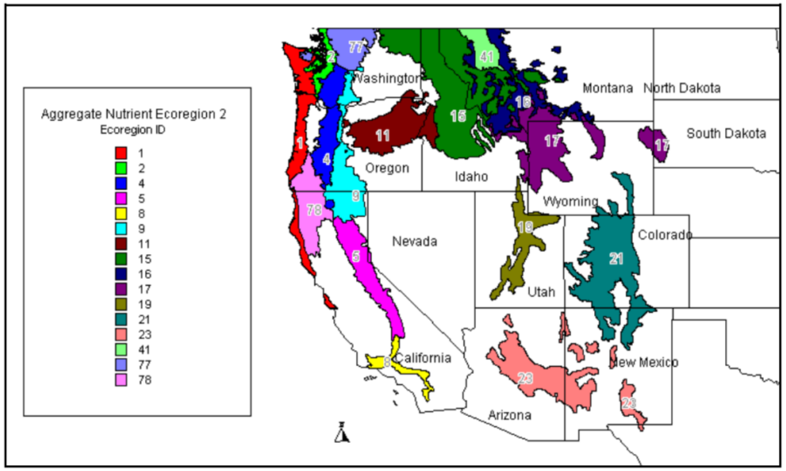
Recreation

Drinking Water

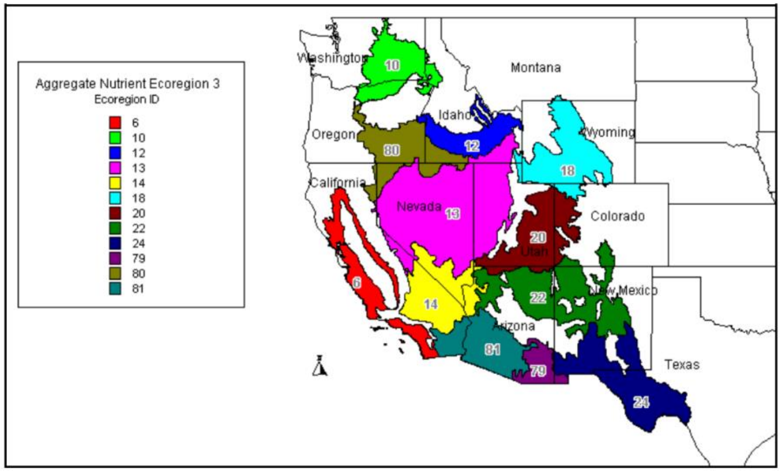


EPA's Ecoregional Criteria: 2002 - 2004

Western Forested Ecoregion (II)



Xeric West Ecoregion (III)



	Rivers and Streams		Lakes and Reservoirs	
	TP (mg/L)	TN (mg/L)	TP (mg/L)	TN (mg/L)
Western Forested Ecoregions (II) *Wasatch and Uintah Mountains (19)*	0.01	0.34	0.005	0.21
Xeric West Ecoregion (II) *Central Basin and Range Subecoregion (13)*	0.028	0.425	0.03	0.51
Xeric West Ecoregion (II) *Colorado Plateaus Subecoregion (20)*	0.02	0.553	0.003	0.15

Nutrient Reduction Tools

Clean Water Act Tool	Approach/ Rationale	Permit Implications	Utah's Nutrient Strategy Application
TMDL	Recover impaired waters	WQBELs	Nutrient Impaired waters (e.g. Bear River, Echo Reservoir)
Numeric Nutrient Criteria	State-wide	WQBELs	EPA's Ecoregional Criteria
	Water body type	WQBELs	Headwater NNC
	Site-specific	WQBELs	Prioritize receiving waters across state
Technology Based Effluent Limits	"Hold the Line"	TBELs	TBPEL for mechanical discharging facilities

Nonpoint Source Implementation

Overall Nutrient Reduction Strategy

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

MAR 1 6 2011

OFFICE OF
WATER

MEMORANDUM

SUBJECT: Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reductions

FROM: Nancy K. Stoner
Acting Assistant Administrator

TO: Regional Administrators, Regions 1-10

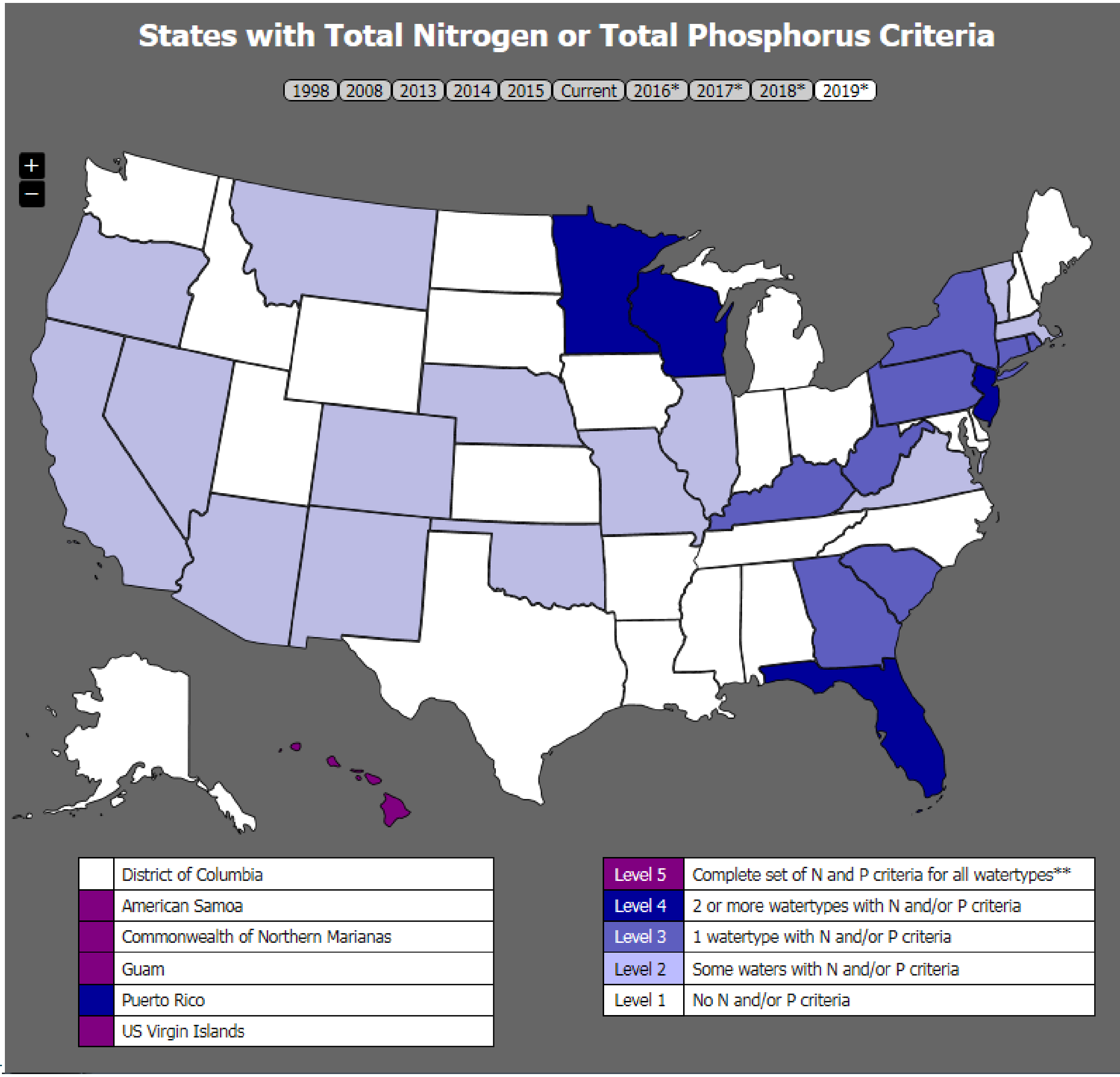
This memorandum reaffirms EPA's commitment to partnering with states and collaborating with stakeholders to make greater progress in accelerating the reduction of nitrogen and phosphorus loadings to our nation's waters. The memorandum synthesizes key principles that are guiding and that have guided Agency technical assistance and collaboration with states and urges the Regions to place new emphasis on working with states to achieve near-term reductions in nutrient loadings.

Over the last 50 years, as you know, the amount of nitrogen and phosphorus pollution entering our waters has escalated dramatically. The degradation of drinking and environmental water quality associated with excess levels of nitrogen and phosphorus in our nation's water has been studied and documented extensively, including in a recent joint report by a Task Group of senior state and EPA water quality and drinking water officials and managers.[1] As the Task Group report outlines, with U.S. population growth, nitrogen and phosphorus pollution from urban stormwater runoff, municipal wastewater discharges, air deposition, and agricultural livestock activities and row crop runoff is expected to grow as well. Nitrogen and phosphorus pollution has the potential to become one of the costliest and the most challenging environmental problems we face. A few examples of this trend include the following:

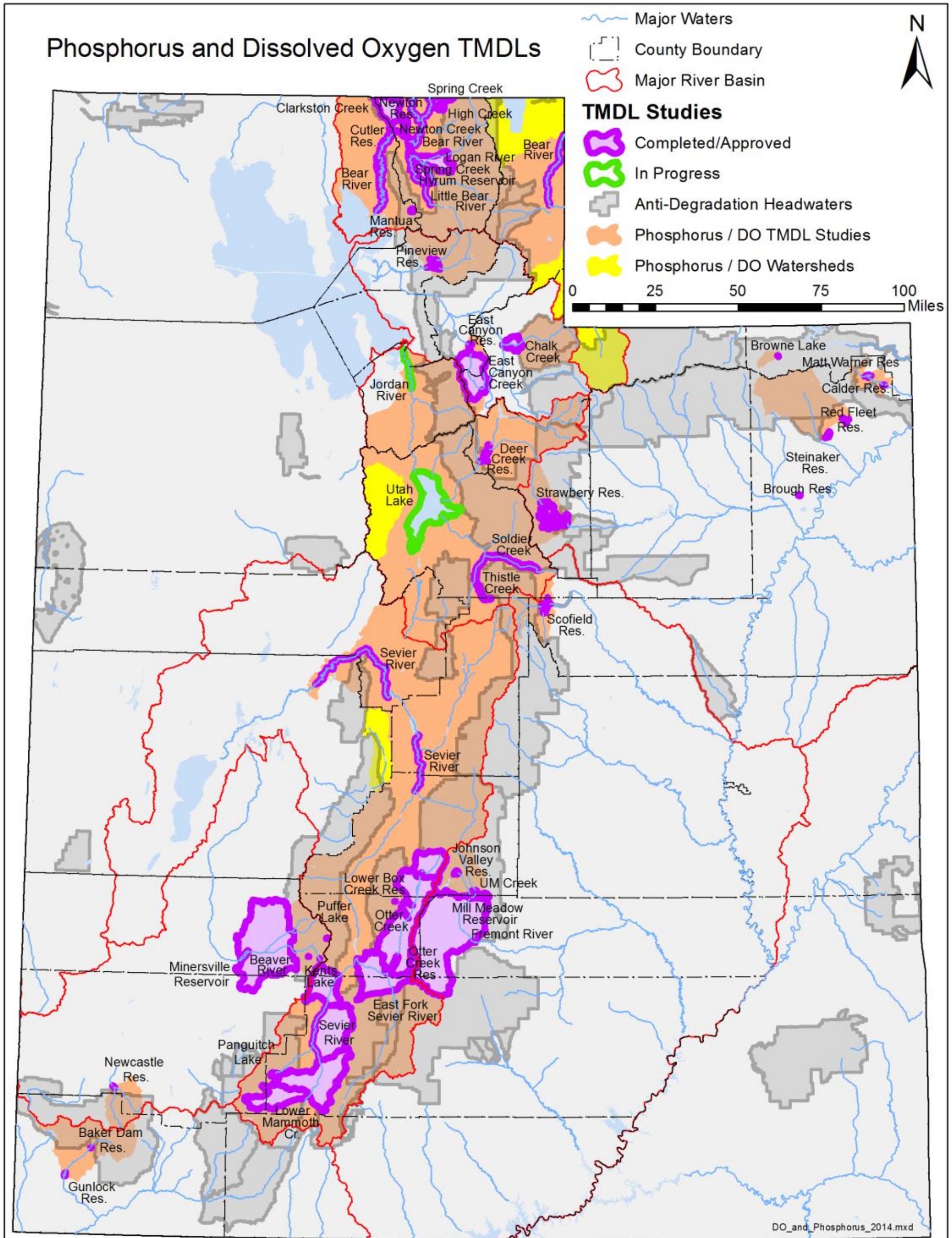
1) 50 percent of U.S. streams have medium to high levels of nitrogen and phosphorus.
2) 78 percent of assessed coastal waters exhibit eutrophication.
3) Nitrate drinking water violations have doubled in eight years.

1. "Hold the Line" on nutrients with the TBPEL.
2. Plan for growth.
3. Develop site-specific nutrient standards.
   Contingent on TBPEL
4. Continue TMDL development in impaired waters.
5. Continue nonpoint source project implementation.
6. "Do nothing" is not an option.

National Progress



State	TBPEL (mg/L)
Chesapeake Bay	0.1
Maryland	0.3
Montana	1
Colorado	1
Iowa	1
Minnesota	1
Pennsylvania	1
Illinois	1
Ohio	1
Michigan	1
Georgia	1
Utah	1


Phosphorus and Dissolved Oxygen TMDLs
Major Waters
County Boundary
Major River Basin
TMDL Studies
Completed/Approved
In Progress
Anti-Degradation Headwaters
Phosphorus / DO TMDL Studies
Phosphorus / DO Watersheds
0
25
50
75
100
Miles
N
Spring Creek
Clarkston Creek
Newton Res.
High Creek
Cutler Res.
Newton Creek
Bear River
Logan River
Bear River
Bear River
Spring Creek
Hyrum Reservoir
Little Bear River
Mantua Res.
Pineview Res.
East Canyon Res.
Chalk Creek
East Canyon Creek
Jordan River
Browne Lake
Matt Warner Res
Calder Res.
Red Fleet Res.
Deer Creek Res.
Steinaker Res.
Utah Lake
Strawbery Res.
Brough Res.
Soldier Creek
Thistle Creek
Scofield Res.
Sevier River
Sevier River
Johnson Valley Res.
Lower Box Creek Res.
UM Creek
Puffer Lake
Mill Meadow Reservoir
Otter Creek
Fremont River
Beaver River
Otter Creek Res.
Minersville Reservoir
Kents Lake
East Fork Sevier River
Sevier River
Panguitch Lake
Newcastle Res.
Lower Mammoth Cr.
Baker Dam Res.
Gunlock Res.
DO_and_Phosphorus_2014.mxd

Response to Primary Scientific Points Raised by Dr. Merritt

Natural Nutrient Concentrations – Western Forested Ecoregion

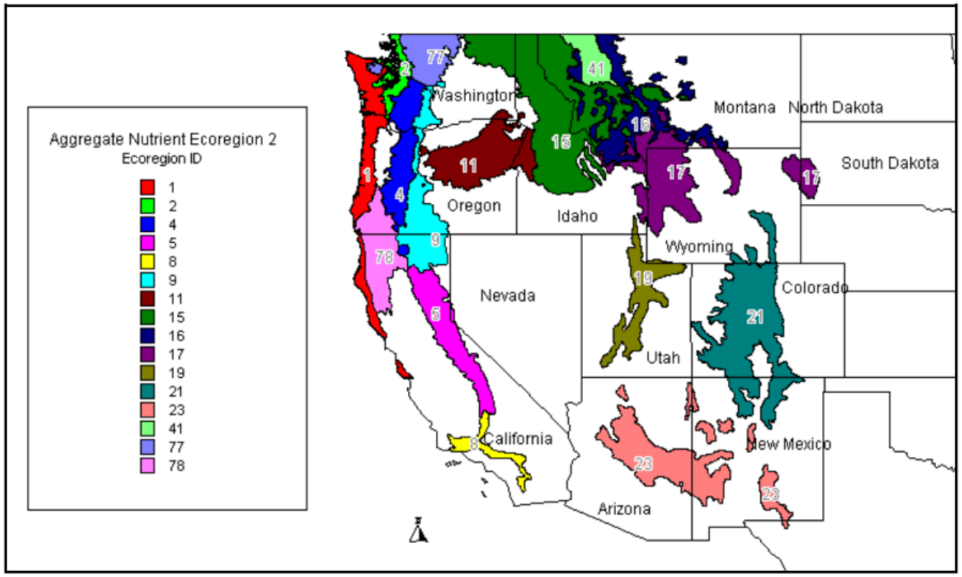
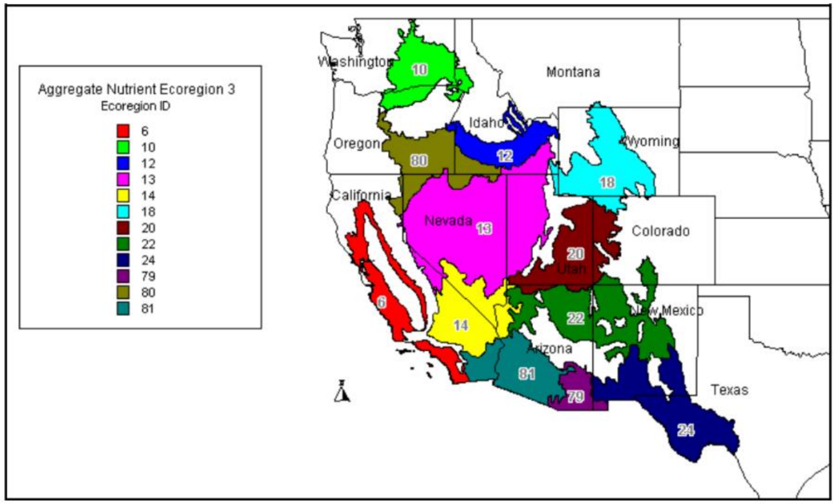


Figure 2. Aggregate Ecoregion II with level III ecoregions shown.

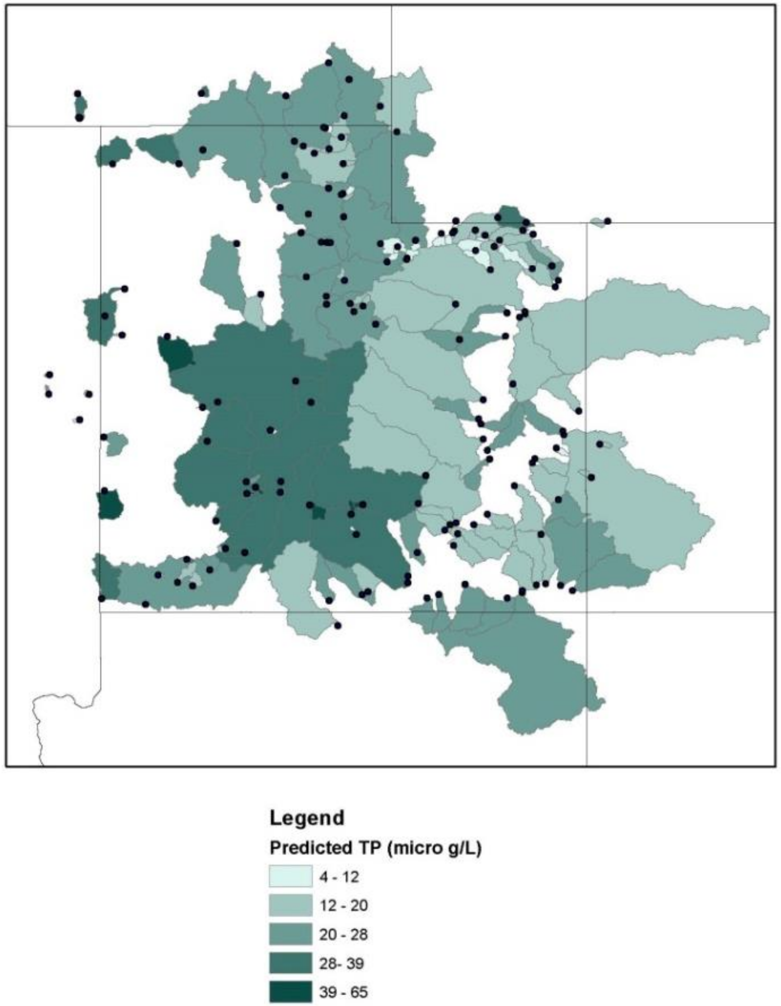
	Rivers and Streams		Lakes and Reservoirs	
	TP (mg/L)	TN (mg/L)	TP (mg/L)	TN (mg/L)
Western Forested Ecoregions (II)	0.003 – 0.0325	ND – 0.53	0.005 – 0.021	0.1 – 0.8
Wasatch and Uintah Mountains (19)	0.01	0.34	0.005	0.21

Natural Nutrient Concentrations – Xeric West Ecoregion



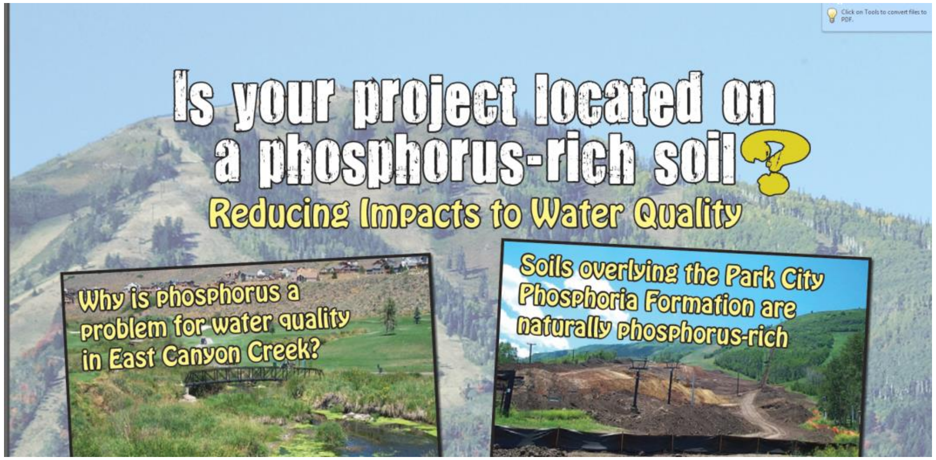
	Rivers and Streams		Lakes and Reservoirs	
	TP (mg/L)	TN (mg/L)	TP (mg/L)	TN (mg/L)
Xeric West Ecoregion (II)	0.01 – 0.055	0.22 – 0.90	0.003 – 0.172	0.15 – 1.44
Central Basin and Range Subecoregion (13)	0.028	0.425	0.03	0.51
Xeric West Ecoregion (II) *Colorado Plateaus Subecoregion (20)*	0.02	0.553	0.003	0.15

Utah's Ambient Total Phosphorus



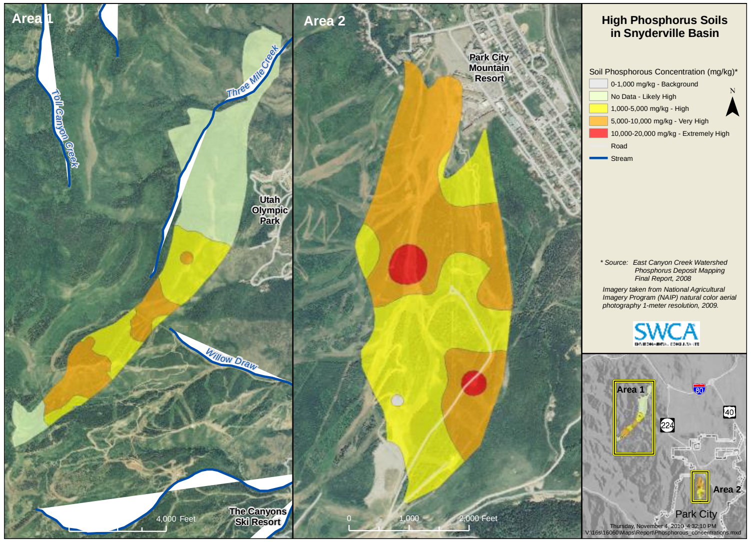
Hawkins et al. 2010

Example of naturally high phosphorus

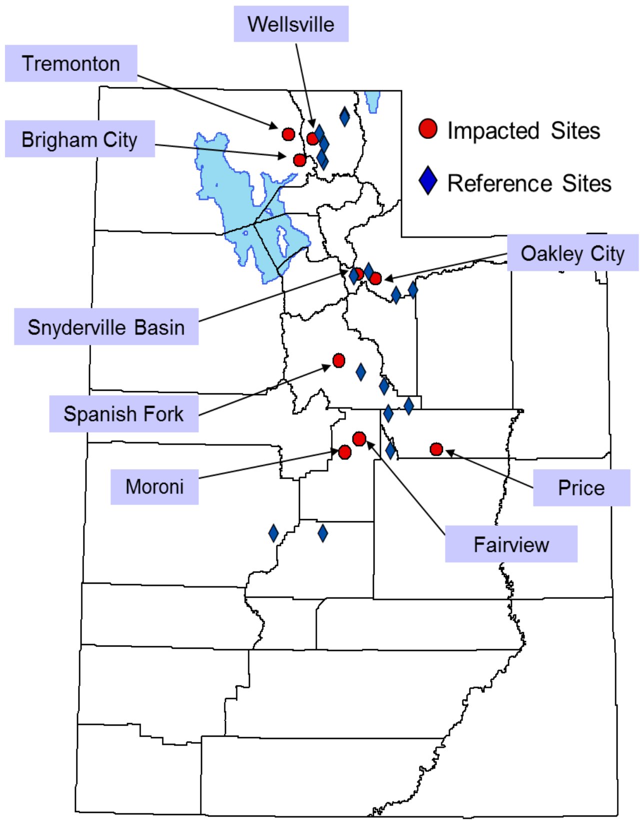


The following advanced Best Management Practices (BMPs) should be used for construction sites that occur on phosphorus-rich soils:

- *Exceptional care to minimize sediment runoff:*
  - *Minimize clearing*
  - *Schedule construction activities to reduce chance of large storm event during project*
  - *Phase construction to minimize soil exposure*
  - *Stabilize all exposed soils using erosion control materials such as silt screen fencing and mulches, mats, or blankets (straw, fiber, wood chips, coconut fiber matting)*
  - *Stabilize temporary stockpiles of soil*
- *Small projects (<10 acres): Build sediment traps or small infiltration basins with the aim to capture 100% of sediment runoff from the project site*
- *Large projects (>10 acres): Use stormwater detention ponds with outlets designed for release only in a 5-year (rather than a 2-year) 24-hour storm event*
- *Monitor runoff from project sites to ensure sediment loss from project site is minimal*
- *Plant native vegetation on all disturbed soils at project completion*
- *Contain sediment runoff until vegetation is reestablished*



Nutrient Concentrations down-gradient of POTWs

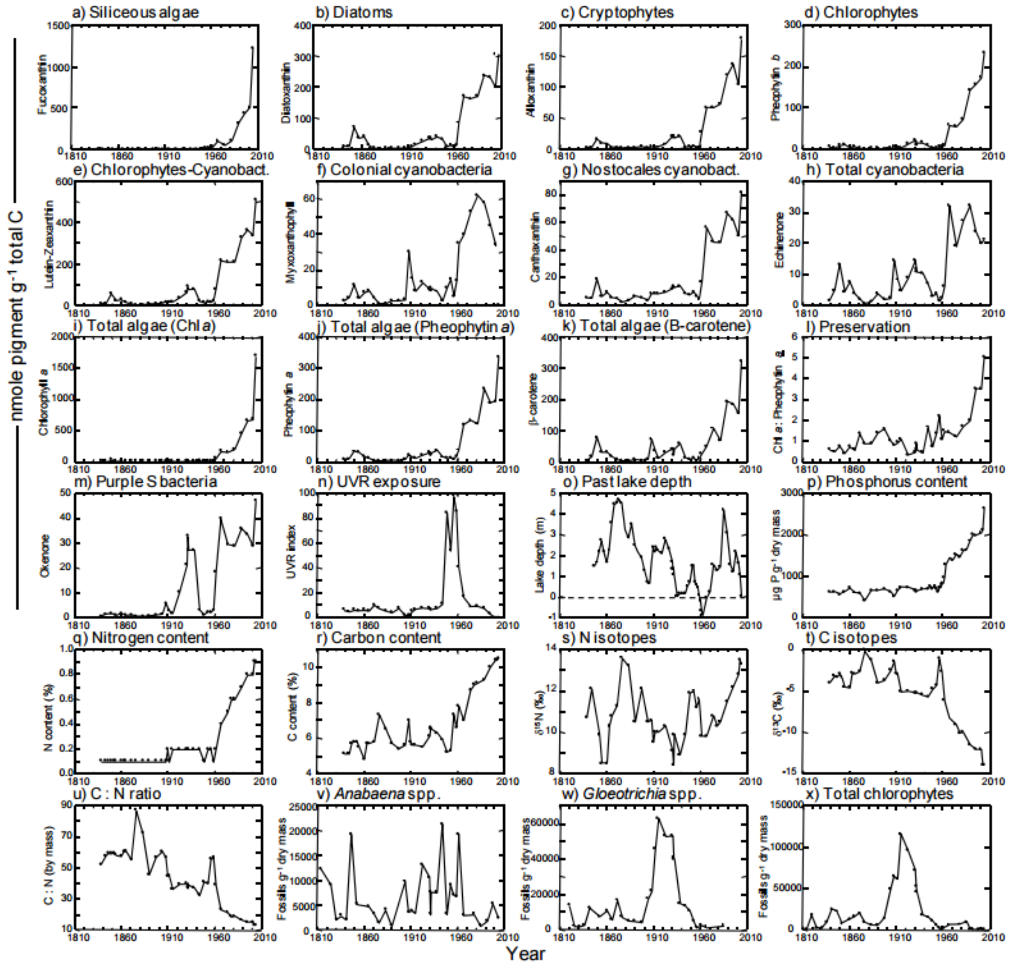


- Sites represent state-wide gradients
- Response variables
  - Nutrient saturation
  - Organic matter standing stocks
  - Whole stream metabolism
  - Macroinvertebrates

	Number of samples	Average TN (mg/L)	Average TP (mg/L)
Reference sites	15	0.25	0.027
Sites above WWTPs	7	1.16	0.098
Sites below WWTPs	7	6.57	1.72

Historical trends in Farmington Bay

Fig. 3. Pigments Farmington Bay, Site 1



Utah Lake

- Claim that Utah Lake is naturally turbid and eutrophic is unsubstantiated and deserves further study.
- Studies of historic Utah Lake condition indicate a transition from clear lake to the current eutrophic turbid lake in the 20th century.
- Shallow lake ecology is different from ecology of deep mountain lakes and reservoirs.
- Relationship between nutrients, turbidity, and algal growth will require site-specific investigation.

Limiting Factors

- Limiting factor: Growth occurs at the rate permitted by the most limiting factor.
  - Nutrients, light, physical space, temperature, salinity
- Not static.
  - Change over a day, season, or year.
- Important to differentiate current limiting factor from *natural* and *potential* limiting factors.

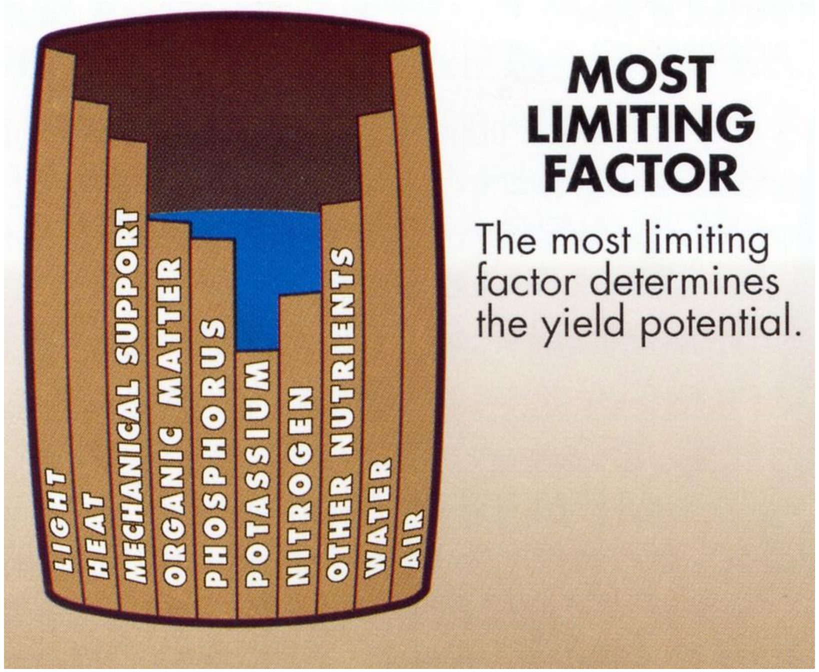


Image source: schoolworkhelper.net

1. What are the actual in-lake conditions?

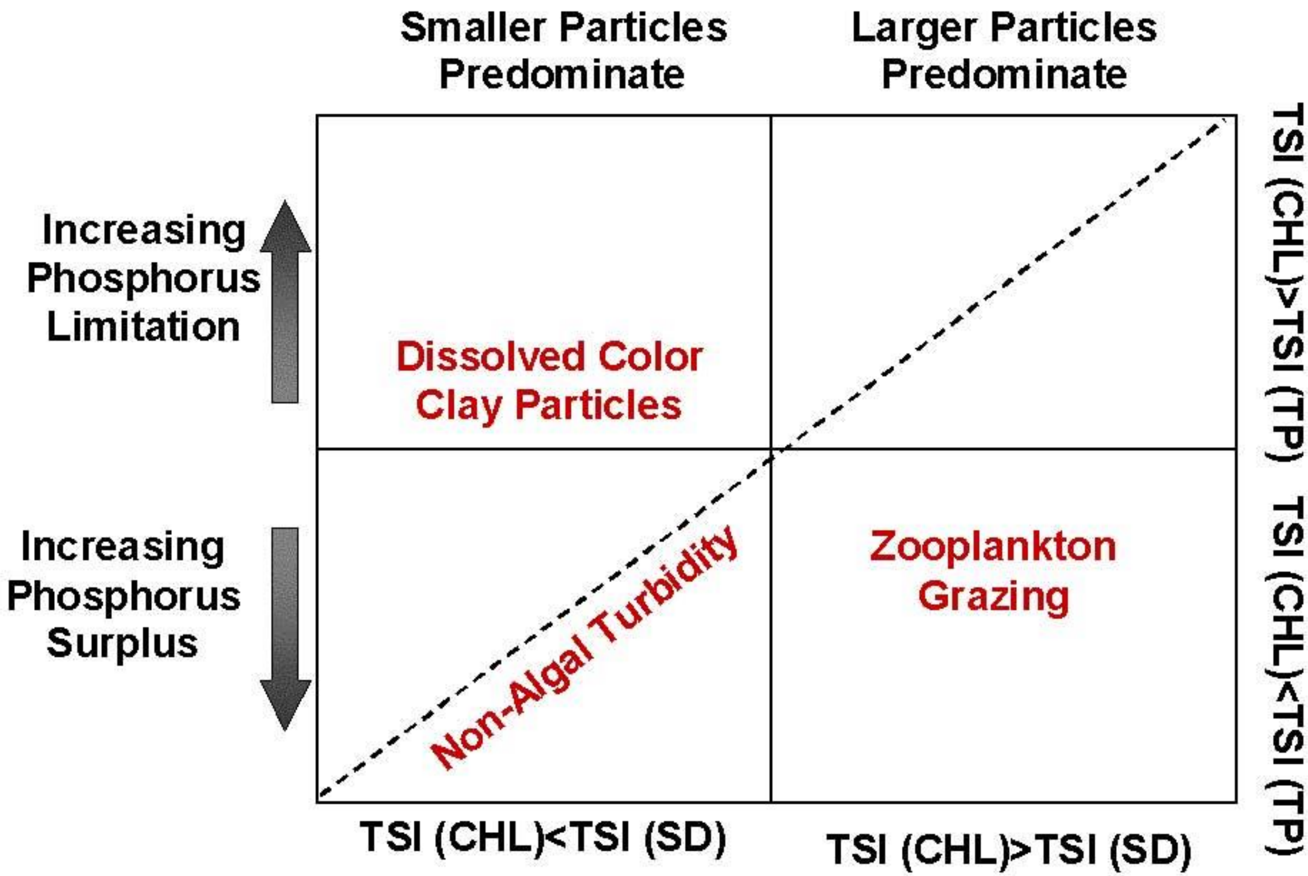
Carlson Trophic State Index

(In-lake conditions—usually use the average of summer conditions)

Utah Lake in red:

Trophic Index	Chl a (ug/l)	P (ug/l)	Secchi Disk (m)	Trophic Class
<30—40	0—2.6	0—12	>8—4	Oligotrophic
40—50	2.6—20	12—24	4—2	Mesotrophic
50—70	**20—56**	**24—96**	2—0.5	**Eutrophic**
70—100+	56—155+	96—384+	**0.5—<0.25**	**Hyper-eutrophic**

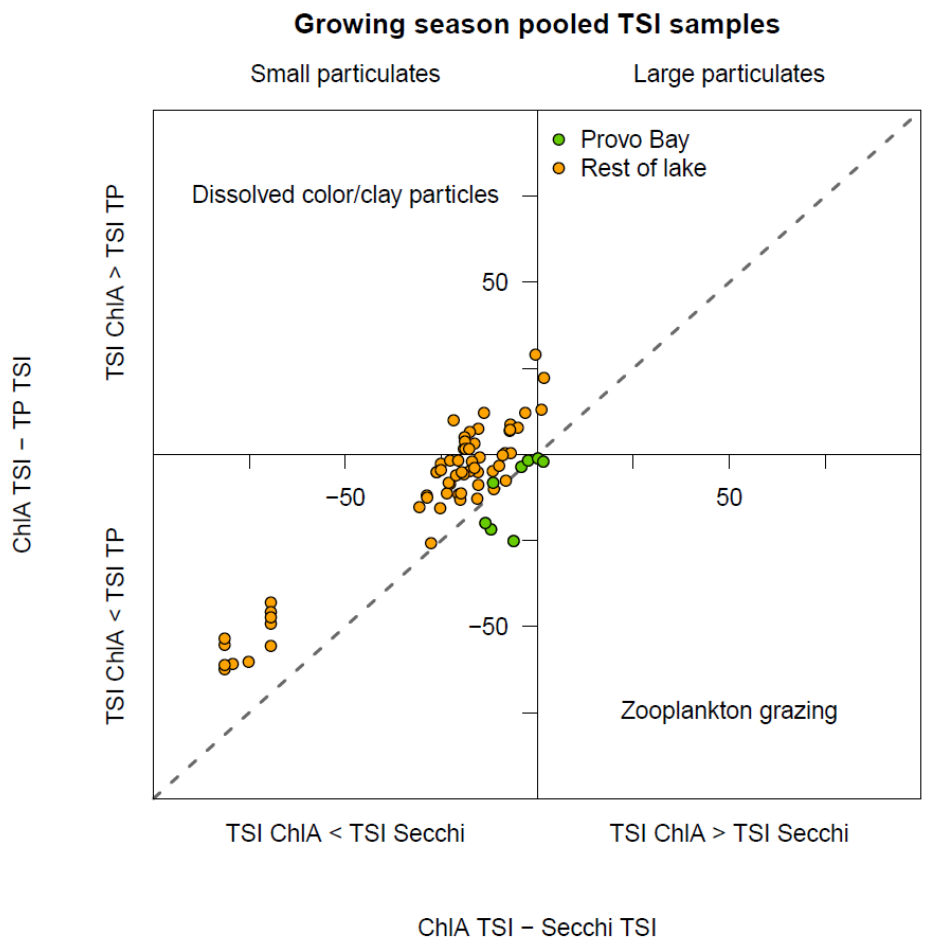
Slide source: LaVere Merritt presentation at WEAU, April 2016

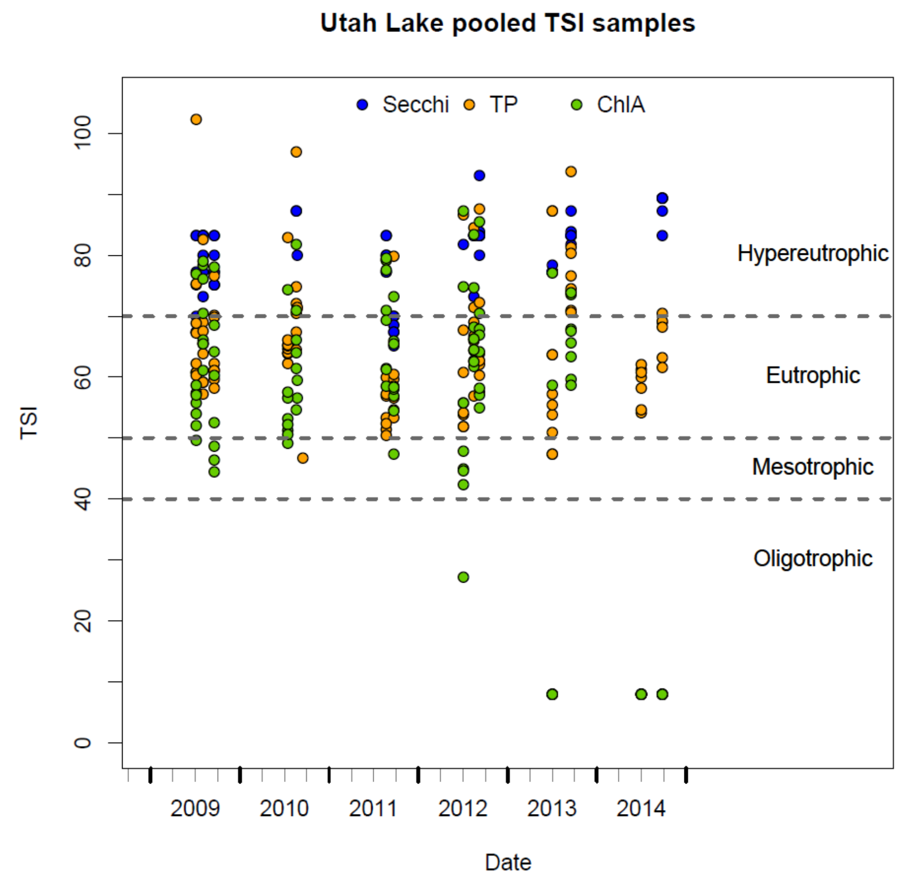


Carlson 1992

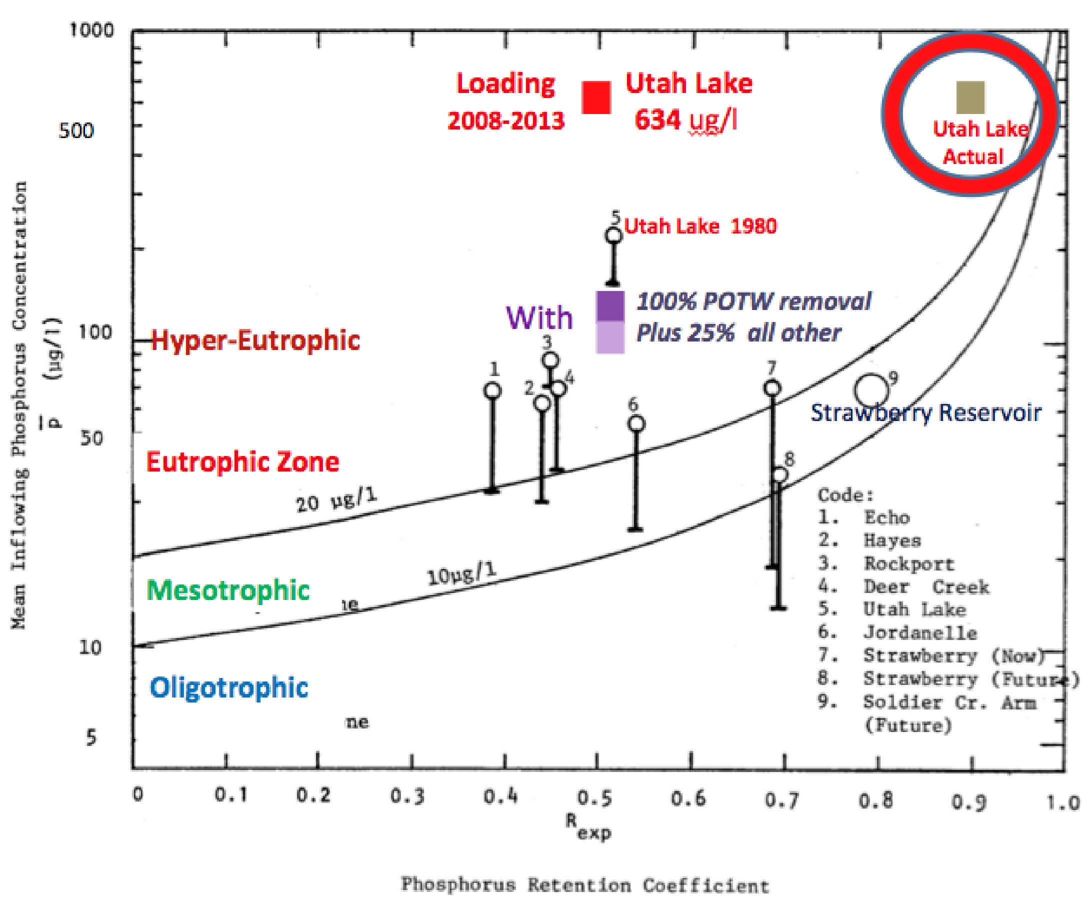
In turbid lakes, it is common to see a close relationship between the total phosphorus TSI and the Secchi depth TSI, while the chlorophyll index falls 10 or 20 units below the others. Clay particles contain phosphorus, and therefore lakes with heavy clay turbidity will have the phosphorus correlated with the clay turbidity, while the algae are neither able to utilize all the phosphorus nor contribute significantly to the light attenuation. This relationship of the variables does not necessarily mean that the algae is limited by light, only that not all the measured phosphorus is being utilized by the algae.

Utah Lake Trophic State





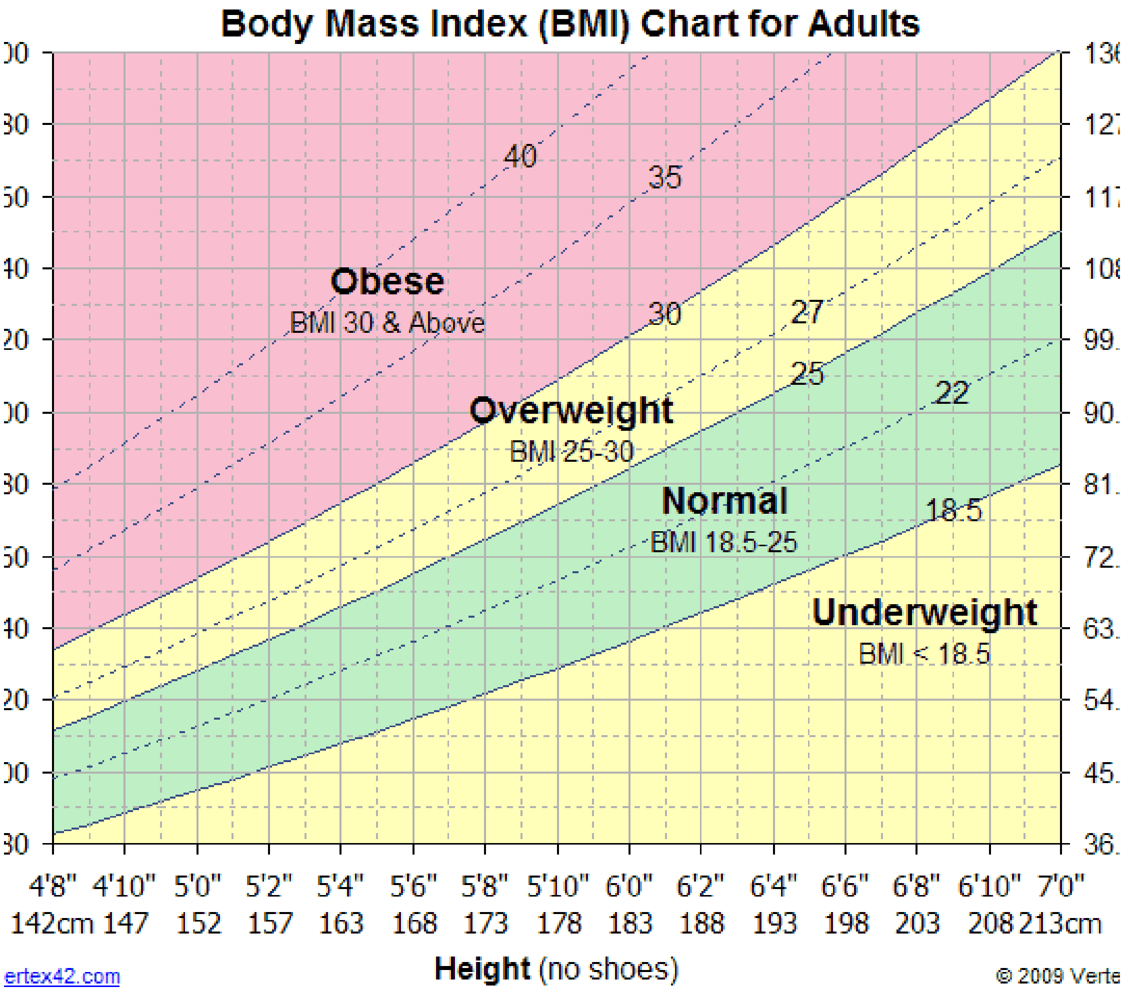
Trophic State Continuum



Predicted Trophic State based on the Larsen-Mercier Model

Figure source: LaVere Merritt presentation at WEAU, April 2016

Health as a Continuum



Complex relationships require empirical study and modeling tools

Chlorophyll-a Models (see discussion)			Applicability Constraints			
Option	**Description / Limiting Factors**	**Equations**	**a**	**(N-150)/P**	**Ninorg/Portho**	**Fs**
0	Do Not Compute	*Predicted = Observed*				
1	P, N, Light, Flushing	$Xpn = [P^{-2} + ((N-150)/12)^{-2}]^{-0.5}$ $Bx = Xpn^{1.33} / 4.31$ $G = Zmix\ (0.14 + 0.0039\ Fs)$ $B = K\ Bx / [(1 + b\ Bx\ G)(1 + Ga)]$				
2	P, Light, Flushing [default]	$Bp = P^{1.37}/4.88$ $G = Zmix\ (0.19 + 0.0042\ Fs)$ $B = K\ Bp / [(1 + b\ Bp\ G)(1 + Ga)]$		>12	>7	
3	P, N, Low Turbidity	$B = K\ 0.2\ Xpn^{1.25}$	<0.9			<25
4	P, Linear	$B = K\ 0.28\ P$	<0.9	>12	>7	<25
5	P, Exponential, Jones & Bachman (1976)	$B = K\ 0.081\ P^{1.46}$	<.4	>12	>7	<25
6	P, Carlson TSI (1977), Lakes	$B = K\ 0.087\ P^{1.45}$	<0.4	>12	>7	<25

Options 1 & 2 require estimates of non-algal turbidity for each model segment. These are entered with observed water quality data on the 'Edit Segments' screen. If non-algal turbidity is not specified, it is estimated from observed Secchi depth and chlorophyll-a. If the latter are not specified, an error message is generated.

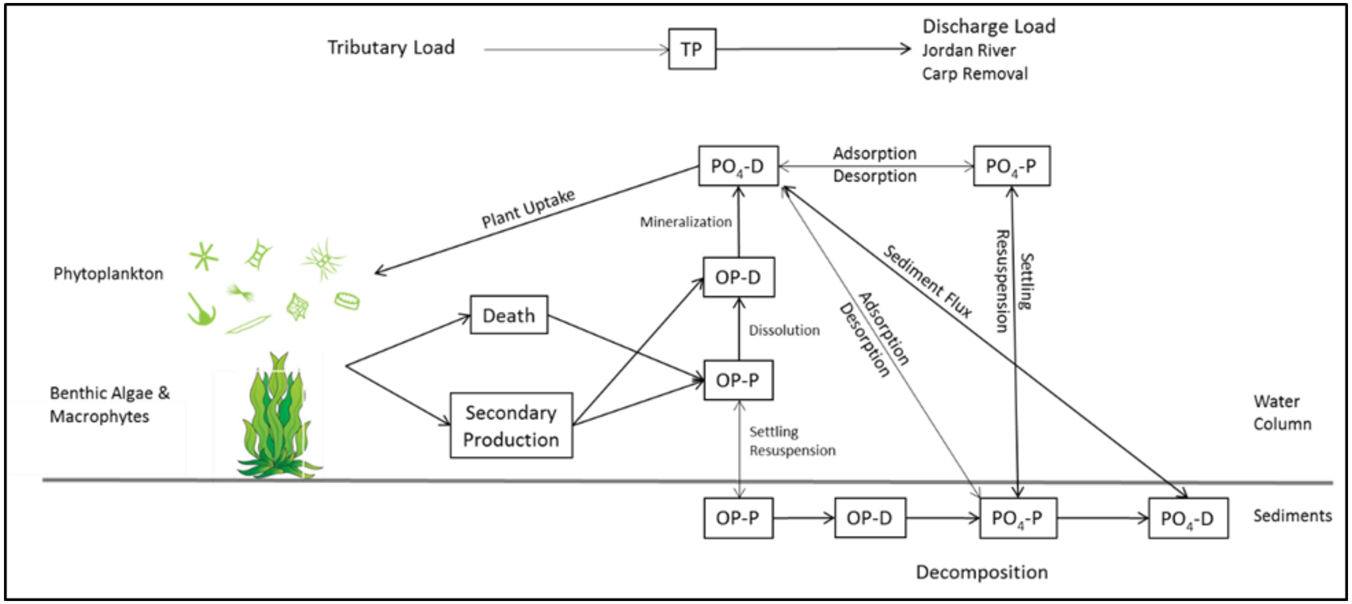
Utah Lake Model Selection

Model Name	WASP	CAEDYM	PCLAKE	CE-QUAL-W2
Spatial Dimension	1D-H	1D-V	0D	2D-V
Stratification	-	+	-	+
Inorganic Sediment Groups	3	2	1	>3
Littoral Zone	-	+	+	-
Phytoplankton Groups	3	7	3	>3
Zooplankton Groups	1	5	1	>3
Benthic Algae Groups	1	4	1	>3
Macrophyte Groups	+	1	1	>3
Macroinvertebrate Groups	0	3	1	0
Fish Groups	0	3	3	0
Bird Groups	0	0	0	0
Hydrodynamics	+	+	±	+
Temperature Dynamics	+	+	+	+
Oxygen Dynamics	+	+	+	+
Inorganic Carbon (CO2/DIC) Dynamics	+	+	-	+
Organic Carbon (DOC/POC) Dynamics	+	+	+	+
Microbial Dynamics	+	+	±	+
Internal Phosphorus Dynamics	+	+	+	+
Phosphorus Sorption to Sediment	±	+	±	±
Internal Nitrogen Dynamics	+	+	+	+
Internal Silica Dynamics	+	+	±	+
Sedimentation/Resuspension	±	+	±	±
Sediment Diagenesis	+	+	±	+
Fisheries Management	-	±	+	-
Dredging	-	-	+	-
Mowing	-	-	+	-
Ice Cover	+	-	-	+
Clear-Turbid State Transition	-	±	+	±

\+ capable
± partially capable
\- not capable

Key Lake Processes: Phosphorus Cycle

- Phosphorus transformations
  - Organic ←→ inorganic
- Internal P loading dynamics
  - Adsorption & desorption to sediments
  - Settling, resuspension and burial of sediment bound P
- Lag time of response to P load reduction



Utah Lake Nutrient Related Research Needs

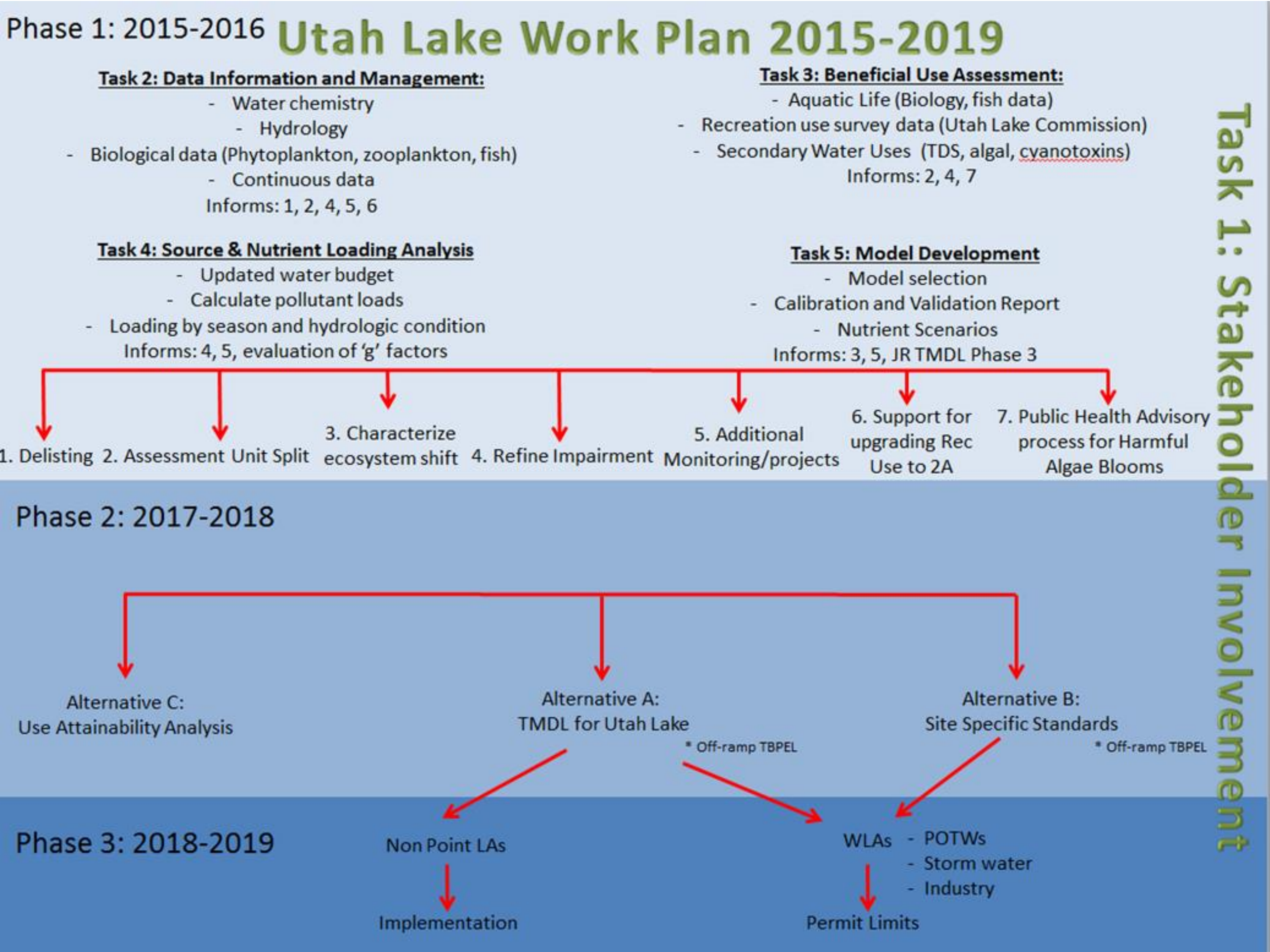
Clear versus turbid lake states

Role of nutrients, carp, and chemistry

Role of internal cycling of nutrients in Utah Lake ecology

What role do phosphorus and nitrogen play in algal blooms?

How prevalent are cyanobacteria blooms?



Phase 1: 2015-2016
Utah Lake Work Plan 2015-2019
Task 2: Data Information and Management:
- Water chemistry
- Hydrology
- Biological data (Phytoplankton, zooplankton, fish)
- Continuous data
Informs: 1, 2, 4, 5, 6
Task 3: Beneficial Use Assessment:
- Aquatic Life (Biology, fish data)
- Recreation use survey data (Utah Lake Commission)
- Secondary Water Uses (TDS, algal, cyanotoxins)
Informs: 2, 4, 7
Task 4: Source & Nutrient Loading Analysis
- Updated water budget
- Calculate pollutant loads
- Loading by season and hydrologic condition
Informs: 4, 5, evaluation of 'g' factors
Task 5: Model Development
- Model selection
- Calibration and Validation Report
- Nutrient Scenarios
Informs: 3, 5, JR TMDL Phase 3
1. Delisting
2. Assessment Unit Split
3. Characterize ecosystem shift
4. Refine Impairment
5. Additional Monitoring/projects
6. Support for upgrading Rec Use to 2A
7. Public Health Advisory process for Harmful Algae Blooms
Task 1: Stakeholder Involvement
Phase 2: 2017-2018
Alternative C: Use Attainability Analysis
Alternative A: TMDL for Utah Lake
* Off-ramp TBPEL
Alternative B: Site Specific Standards
* Off-ramp TBPEL
Phase 3: 2018-2019
Non Point LAs
Implementation
WLAs
- POTWs
- Storm water
- Industry
Permit Limits

Utah Lake – Jordan River – Great Salt Lake

Farmington Bay

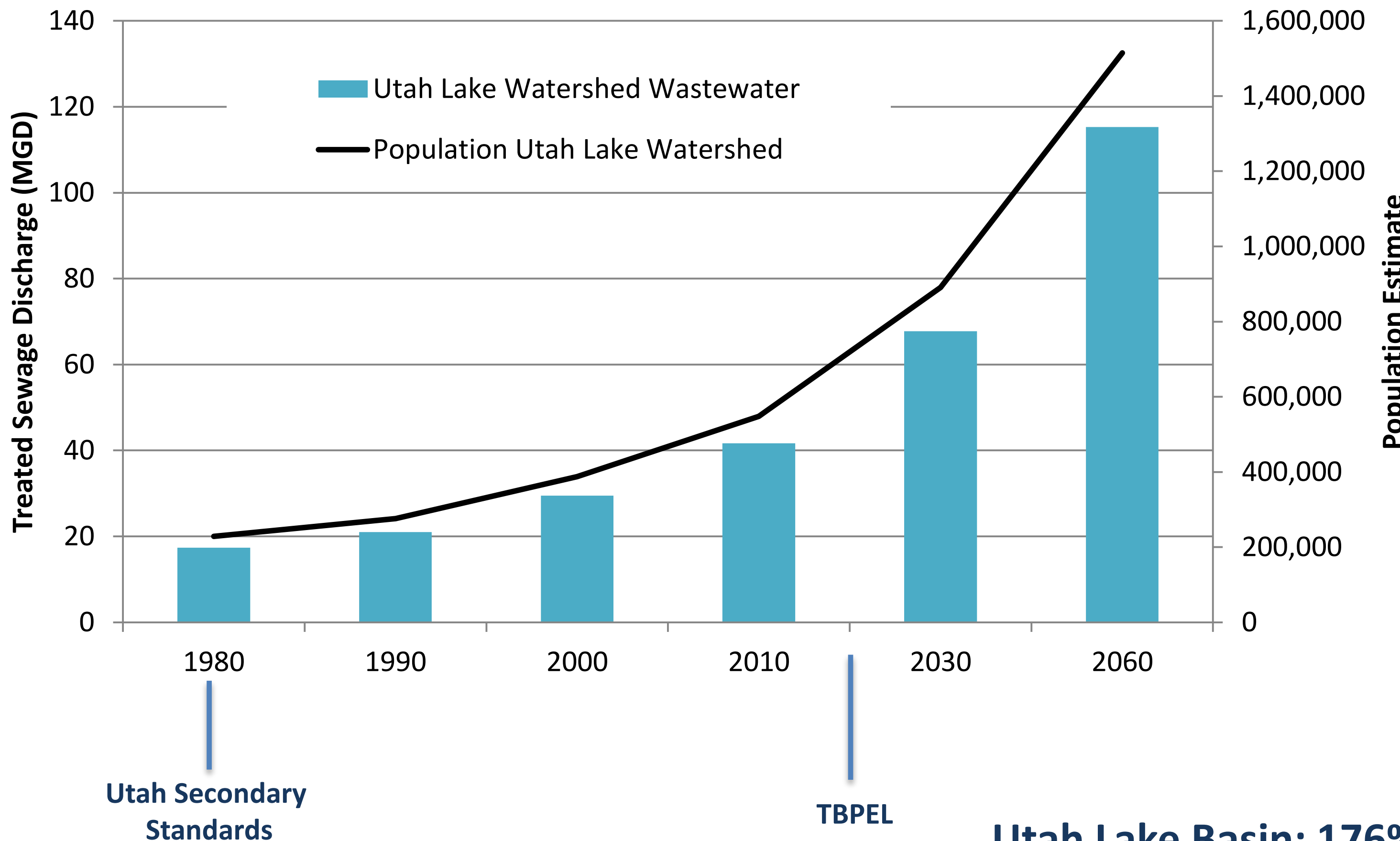
Impounded Wetlands

Wetlands and Ponds

Jordan River

Utah Lake

Population Growth



Utah Lake Basin: 176% Growth

Utah Lake POTWs

	TP Load Reduction (lbs/yr)	TP Load Reduction (tons/year)	Cost per ERU/month	Current TP Concentration
Timpanogos	0 (~58,500 lbs/year reduction already achieved)	0 (~30 reduction already achieved)	$0.13	1.0 mg/L
Provo City Water Reclamation Facility	114,130	57 tons	$1.53	4.23 mg/L
Orem	0 (130,000 lbs/year reduction already achieved)	0 (~65 ton/yr reduction already achieved)	$0.15	1.0 mg/L
Payson	12,110	6	$1.89	4.10 mg/L
Spanish Fork City WWTP	35,905	18	$3.87	4.47 mg/L
Springville WWTP	39,000	20	$1.97	5.23 mg/L

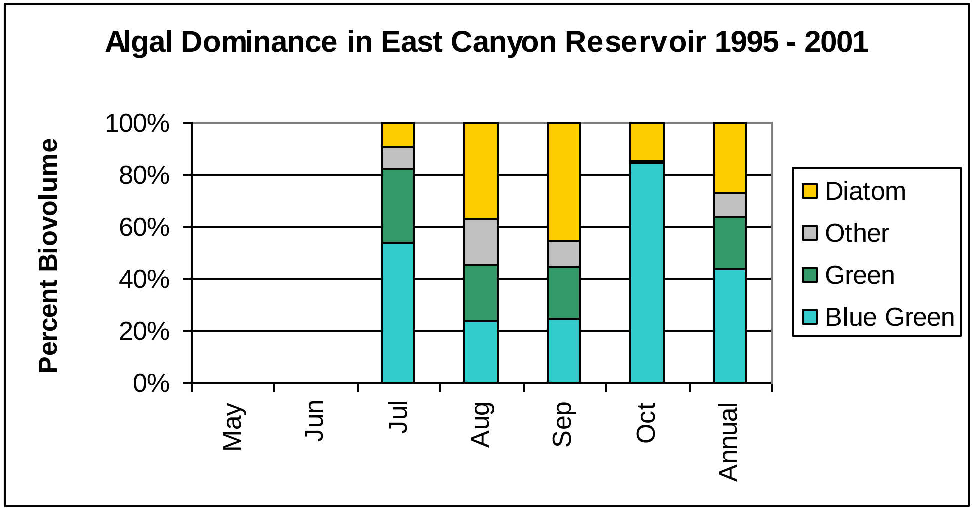
Nutrient Reduction Success: Deer Creek Reservoir

Deer Creek Reservoir Algal Blooms (1970s)

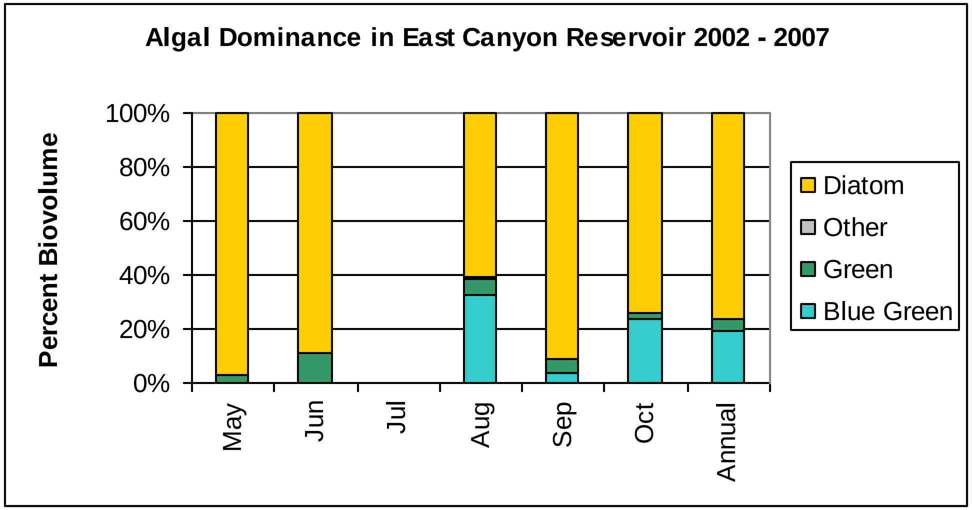
Deer Creek Reservoir Algal Blooms (1990s)

Nutrient Reduction Success: East Canyon Reservoir

Shift from blue green and green algae to diatom dominated system



More data available for 2002 – 2007 period than 1995 – 2001 period



Science	Pseudoscience
Willingness to change with new evidence	Fixed ideas
Ruthless peer review	No peer review
Takes account of all new discoveries	Selects only favourable discoveries
Invites criticism	Sees criticism as conspiracy
Verifiable results	Non-repeatable results
Limits claims of usefulness	Claims of widespread usefulness
Accurate measurement	"Ball-park" measurement

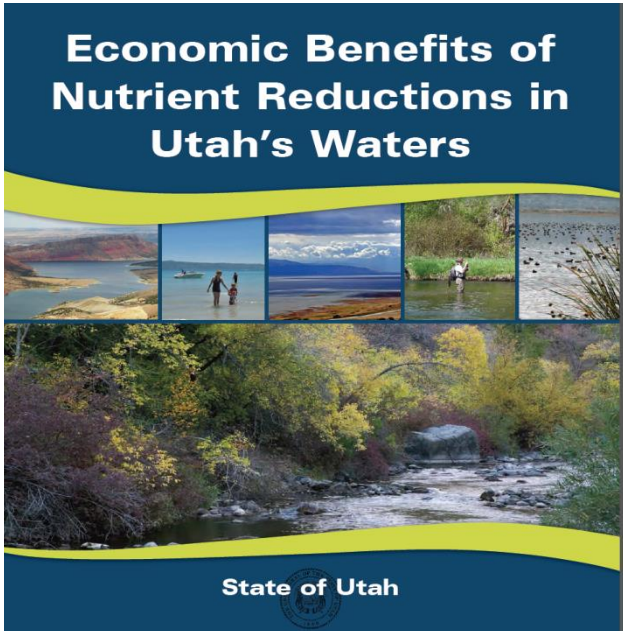
Image source: Leland Myers

Nutrient Related Studies funded by Board and EPA grants

- Nutrient Ecological Study aimed at evaluating the ecological impacts of nutrient additions on the state's rivers and streams.
- Economics Benefits Study that quantifies the economics benefits of implementing nutrient reductions to surface waters in Utah.
- POTW Nutrient Removal Cost Impact Study in which the costs of removing nutrients to varying degrees was calculated for each mechanical Publicly Owned Treatment Works in the state, in collaboration with operators and general managers for each system.
- Technical Basis for Utah's Nutrient Strategy that provides the scientific basis for the development of numeric nutrient criteria for Utah's headwater streams.
- Willard Spur studies to evaluate the effects of nutrient loading on the unique ecosystem of Willard Spur.
- Total Maximum Daily Load studies for Deer Creek Reservoir, Jordanelle Reservoir, Rockport and Echo Reservoirs, Cutler Reservoir, Middle Bear River, Lower Bear River, Newcastle Reservoir, East Canyon Creek and Reservoir, and Pineview Reservoir, among others.
- Preliminary total maximum daily load studies on Utah Lake.

Public Interest in Water Quality

- Utah households
- 97% - important to maintain water quality for future generations
- Report that they are willing to spend $70 million to $271 million per year to protect and improve waters that are threatened by increasing levels of nutrients
- Utahns spend about $1.4 to $2.4 billion a year on trips to the state's waters for water-based recreation activities



Need for Investment to accommodate growth and preserve Utah's Quality of Life