Connecticut Department of
ENERGY &
ENVIRONMENTAL
PROTECTION

Bantam Lake Nutrient Total Maximum Daily Load (TMDL) Summary

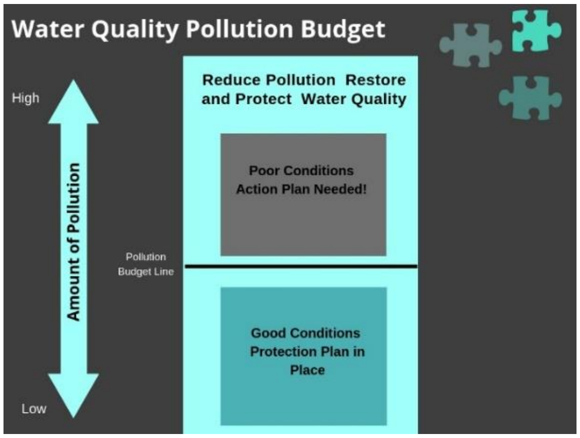
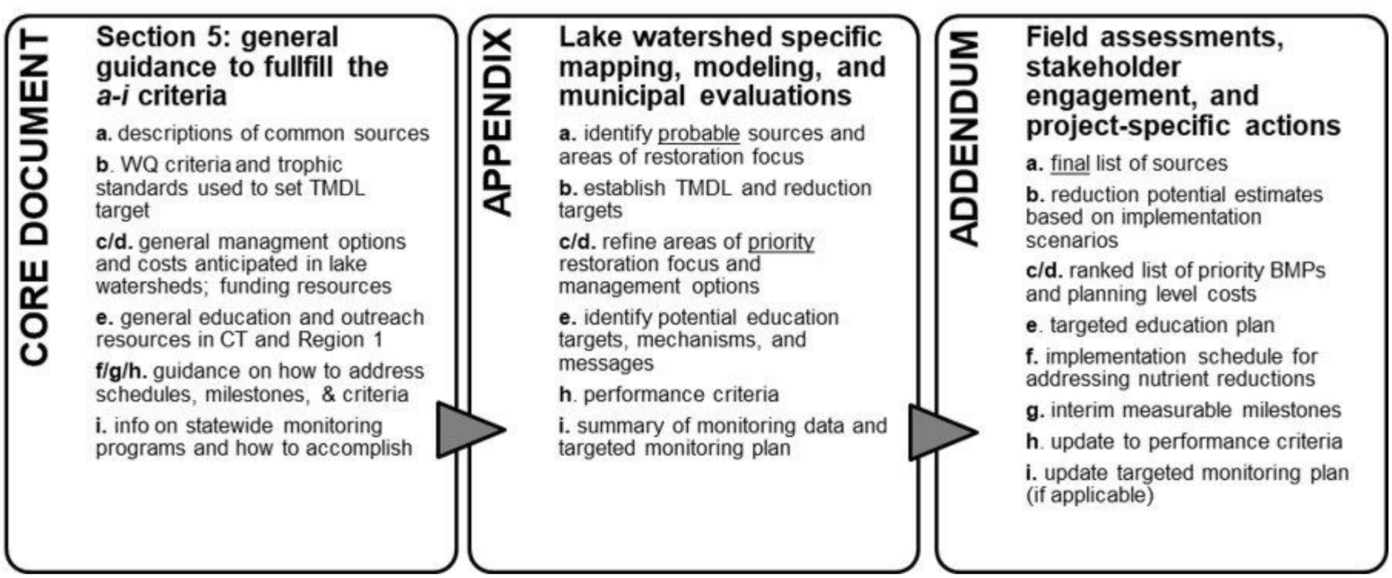


Figure 1: Water Quality Pollution Budget

What is a Total Maximum Daily Load (TMDL)?
A TMDL is an Action Plan used to address pollution, kind of like a budget. A waterbody that is overspending its daily budget for a substance is considered to be polluted or impaired. A waterbody that is spending less than its daily budget for a substance has good water quality which should be protected. TMDLs provide the framework for restoring impaired waters by establishing the maximum amount of a pollutant that a waterbody can receive without adverse impact to fish, wildlife, recreation, or other uses. A TMDL can also be used to set a budget to protect waters with good water quality. TMDLs are action plans that provide water quality targets for the waterbody and identifies sources of water pollution. Information on the health of Connecticut's waters are reported on every two years in the Integrated Water Quality Report to Congress. Water Quality Action Plans are established to achieve restoration or protection goals and to work with partners to protect areas of good water quality and restore areas with poor water quality. The State of Connecticut has competed over 400 TMDLs since 1999.

An Innovative Action Plan Approach
CT DEEP has taken a new, comprehensive approach for establishing plans to address nutrient impacts on lakes and impoundments. CTDEEP has integrated a Core Nutrient TMDL document, the Lake-specific TMDL Appendix and a Watershed Based Plan (WBP) which incorporates the nine-element plan for implementation. Combining these plans will help to streamline environmental protection and restoration efforts, reduce repetitive analysis and presentation, provide more consistency with setting and implementing goals, and allow the WBP to provide more focus on implementation. The Bantam Lake TMDL is the first TMDL developed using this new approach.



Bantam Lake, CT6705-00-3-L3_01, is listed on CT DEEP's IWQR *List of Impaired Waters for Connecticut* for recreational use (CT DEEP, 2020). Causes for the impairment include chlorophyll-*a*, excess algal growth, and nutrient/eutrophication biological indicators. Nutrients such as phosphorus and nitrogen, as well as algae and cyanobacteria, naturally occur in the environment, including lakes and tributaries and their contributing watersheds, and are essential to lake health. Under natural conditions, algae and cyanobacteria concentrations are regulated by limited nutrient inputs and lake mixing processes that keep them from growing too rapidly. However, human-related disturbances, such as erosion, overapplied fertilizers, polluted stormwater runoff, excessive domesticated animal waste, and inadequately treated wastewater, can dramatically increase the amount of nutrients entering lakes and their tributaries.

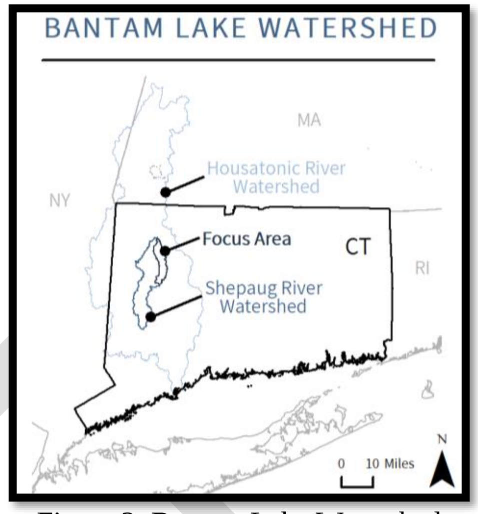


Figure 2: Bantam Lake Watershed

Background

Bantam Lake is located within the towns of Morris and Litchfield in western Connecticut. Bantam Lake is the largest naturally formed freshwater lake in Connecticut and has a total surface area of 946[1] acres, a maximum depth of 26 feet, an average depth of 14.7 feet, and a total volume of over 4.5 billion gallons (Northeast Aquatic Research, 2009). The lake has three primary bays, North Bay, Center Lake, and South Bay. The Bantam River is the largest input to the lake, which flows into the North Bay approximately one-half mile away from the outlet and continues to the Shepaug River and ultimately to Lake Lillinonah, part of the Housatonic River.

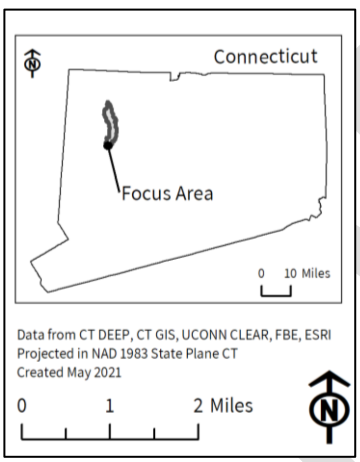


Figure 4: Location of Bantam lake focus area

Bantam Lake (CT6705-00-3-L3_01) is classified as a Class AA Inland Surface Water. Class AA waters have designated uses of existing or potential drinking water supply, fish and wildlife habitat, agricultural and industrial supply, and recreational use (CT DEEP, 2020). Bantam Lake has a unique morphometry which creates varied retention times throughout its bays. The North Bay typically flushes once each month while the entire lake flushes approximately once every 115 days or 3 times per year (Northeast Aquatic Research, 2009). Additionally, the lake outlet is in proximity to the lake inlet, which also affects flushing rates and the flow of nutrients through the lake.

[1] CEI, Inc. (2020) estimates 941-acre surface area.

[1] CEI, Inc. (2020) estimates a 20,959-acre watershed area. Used for percentage calculations.

Trophic State, Eutrophication and The Connecticut Water Quality Standards

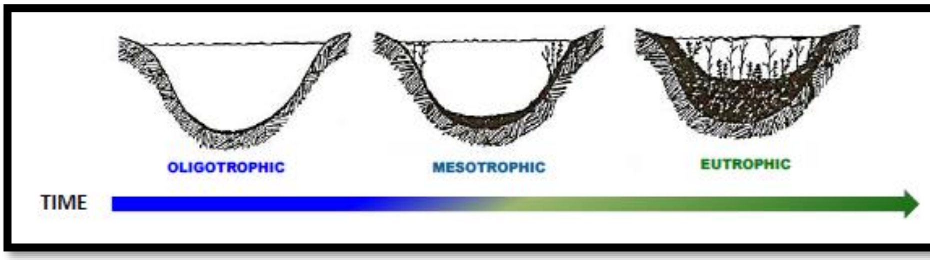


Figure 5: diagram depicting the process of eutrophication in lakes.

Lake trophic state refers to a lake's level of nutrient enrichment and biological productivity (Figure 5) and is based on the measurement of several parameters, total nitrogen, total phosphorus, Secchi disk transparency (or water clarity), and chlorophyll-a (table 1).

In general, oligotrophic lakes have low levels of nutrients which enter the lake from the watershed and have transparent water, little aquatic vegetation, and higher levels of oxygen throughout the water column. Eutrophication is the natural process by which nutrients, organic matter, and sediments gradually accumulate within a waterbody, resulting in decreased depth and increased biological productivity.

The natural trophic status, however, is that which would exist if human-sourced nutrient loading minimally affects the lake. The natural condition corresponds to the trophic state of the lake that supports designated uses and is supported by reasonable measures to minimize the impact of any human-source nutrients within the watershed. The current trophic status of Bantam lake is eutrophic.

Excess nutrient loading to human-disturbed lake systems, in combination with a warming climate, has fueled the increasing prevalence of Harmful Algal Blooms (HABs) or the rapid growth of algae and cyanobacteria in lakes across the United States. Under some circumstances, cyanobacteria blooms can produce one or more toxins that are hazardous to human and pet health. Possible toxins include those which affect the liver such as microcystins, nodularins, and cylindrospermopsin; neurotoxins like anatoxin-a and saxitoxins; and irritants such as lyngbyatoxin-a, aplysiatoxin, and lipopolysaccharides. The main exposure pathways to humans are water ingestion, inhalation, and skin contact from swimming, boating, and similar activities, and possibly fish consumption (CT DPH 2019).

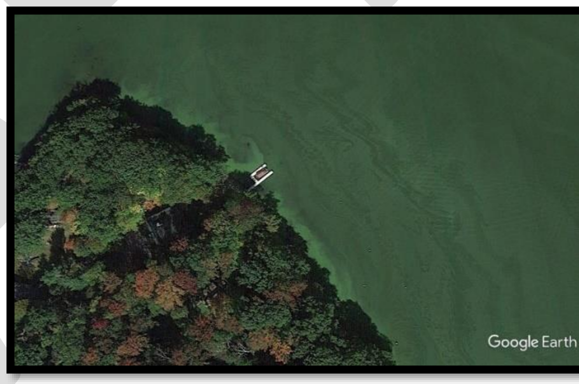


Figure 3: Cyanobacteria bloom in Bantam Lake

Trophic State	Parameter	Range
Oligotrophic	Total Phosphorus	0-10 µg/l
	Total Nitrogen	0-200 µg/l
	Chlorophyll-*a*	0-2 µg/l
	Secchi Disk	6 + meters
Mesotrophic	Total Phosphorus	10-30 µg/l
	Total Nitrogen	200-600 µg/l
	Chlorophyll-*a*	2-15 µg/l
	Secchi Disk	2-6 meters
Eutrophic	Total Phosphorus	30-50 µg/l
	Total Nitrogen	600-1000 µg/l
	Chlorophyll-*a*	15-30- µg/l
	Secchi Disk	1-2 meters
Highly Eutrophic	Total Phosphorus	50 + µg/l
	Total Nitrogen	1000 + µg/l
	Chlorophyll-*a*	30 + µg/l
	Secchi Disk	0-1 meters

Table 1: definition of each trophic state and the parameter ranges that apply to them.

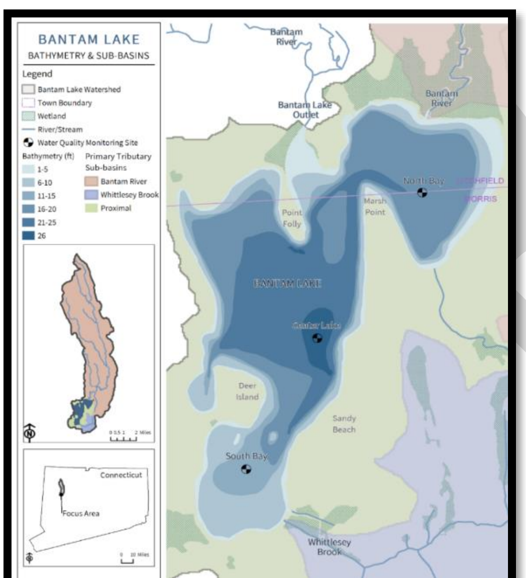


Figure 5: Lake bathymetry, Bantam Lake watershed and in-lake water quality monitoring stations

Section 22a-426-6 of The Connecticut Water Quality Standards says that "the natural trophic state of a lake shall be compared with the current trophic state to determine if the trophic state of the lake has been altered due to excessive anthropogenic inputs. Lakes in advanced trophic states which exceed their natural trophic state due to anthropogenic sources shall be considered to be inconsistent with the Connecticut Water Quality Standards." The natural trophic status determines the best attainable condition of the lake, which forms the basis for the lake management goals and which corresponds to ranges for numeric water quality targets.

Model Analysis

The Bantam Lake TMDL was developed using several water quality models and analysis. The Lake Loading Response Model (LLRM) model was used to model the current average annual nutrient loading to Bantam Lake from the upland watershed. The LLRM calculates the amount of nutrients delivered to the lake from watershed land uses, nearshore septic systems, waterfowl, discharges from treatment facilities and stormwater. The LLRM nutrient loading values were used as inputs to the BATHTUB model, a water-quality based model, to predict in-lake responses to nutrient loading. In addition to inputs from the LLRM, the BATHTUB model also was used to model nutrient loads from atmospheric deposition and internal phosphorus loading. The in-lake responses include total phosphorus concentration, total nitrogen concentration, chlorophyll-*a*, transparency, and hypolimnetic oxygen depletion.

Establishing Bantam Lake Natural Conditions

DEEP staff used a weight of evidence approach to determine the natural trophic status of Bantam Lake. Lines of evidence include the current trophic level, Taylor Landscape Analysis, the Hollister Model, the New England Lake and Pond Model, nutrient loading based on fully forested conditions and lake-specific studies. Using this approach, the natural trophic state for Bantam Lake was set as Mesotrophic. For more information on the weight of evidence approach and the models that were used in the approach please refer to the CT Nutrient TMDL Core Document and Bantam Lake TMDL Appendix.

Bantam Lake TMDL Loading Reductions

The TMDL is comprised of a Waste Load Allocation (WLA; or point sources, PS), Load Allocation (LA; or nonpoint sources, NPS), and Margin of Safety (MOS). In practice, data are usually not sufficiently detailed to allow a precise separation of PS and NPS pollution. Therefore, in this TMDL, the WLA is set as the MS4-regulated watershed load plus any other NPDES regulated discharges. The LA is set as the sum of the non-regulated watershed load[4], excluding background loads, atmospheric deposition, waterfowl, and internal loading.

Background nutrient load is the sum of forested land use load (determined in LLRM), waterfowl (LLRM), and atmospheric loads (BATHTUB). These loads were subtracted from the TMDL prior to setting the WLA, LA, and MOS. There are no municipal MS4-regulated areas in the Bantam Lake watershed but the CTDOT MS4 permit applies to some roads within the watershed. The only point source included in this TMDL is the Woodridge Lake WPCF, and its load is assigned to the WLA. The WLA set for Woodridge Lake WPCF represents a reduction from its current loading based on predicted effluent quality after an upgrade to the treatment system is implemented. The remaining non-background load is set as the LA. The TMDL assigns an explicit MOS of 5% to account for any uncertainty in the analysis (Table 2) for more information please review the Bantam Lake TMDL Appendix.

Table 2: Waste load and load allocations (WLA, LA) for existing conditions, target load (including MOS), and nutrient load reductions for Bantam Lake.

		Current Conditions (kg/year)		**TMDL Load (kg/year)**		**Load Reduction kg/yr (%)**	
		TP	TN	TP	TN	TP	TN
Total Load to Lake	All Sources	1,614.3	26,806	1,211.1	20,325	403.2 (25.0%)	6,481 (24.2%)
Total WLA[1]	Woodridge Lake WPCF[2]	265.9	989.5	22.5	335.7	243.4 (91.5%)	653.80 (66.1%)
Total LA	Sum of internal load, nonpoint pollution sources, and septic systems	733.5	7,458.6	513.2	615.6	218.1 (29.7%)	6,843 (91.7%)
Total Background Load	Sum of forested land use load, waterfowl, and atmospheric loads	614.9	18,358	614.9	18,358.1	0 0.0%	0 0.0%
Margin of Safety (MOS)	5% of total load to lake for TMDL	NA	NA	60.6	1,016.3	NA	NA

What you can do?

Restoring impaired waters is a team effort. The first and most essential management measure is the continued engagement of stakeholders within the Bantam Lake watershed. Existing partners within the watershed are very engaged and have provided substantial information, support and outreach to assist in the development of this TMDL and an associated Watershed-based Plan. Continuing that engagement with an expanded focus on addressing implementation activities within the watershed would be beneficial. Improving a lake's water quality is a major endeavor, requiring a cohesive effort from the whole watershed community.

The steps for implementation to restore the Bantam Lake Watershed are identified in the Watershed Based Plan in detail. The primary goal of the Watershed Based Plan for Bantam Lake is to provide a plan for implementing actions that will result in measurable improvements in water quality and aquatic habitat.

Some of the key components are listed below.

- Reduce nutrient loading from permitted sources in the watershed.
- Amend local ordinances to better protect water resources and reduce future NPS pollution in stormwater runoff through such strategies as low-impact development or green infrastructure.
- Identify areas in the watershed or ways to implement both structural and non-structural BMPs to control existing NPS pollution in stormwater runoff.
- Address groundwater leachate pollutant sources from septic systems.
- Address groundwater leachate pollutant sources from sewer systems.
- Ensure proper use of BMPs on agricultural lands.
- Evaluate local education and outreach programs regarding waterfowl, pet waste, and fertilizer/pesticide use.
- Regulate illegal overboard discharge of sanitary sewage from boats and marinas.
- Consider in-lake treatments to reduce internal phosphorus load.
- Proper disposal of pet waste

For more information on the Bantam Lake planning documents please refer to the project’s dedicated webpage.