

**STATE OF NEW HAMPSHIRE
INTER-DEPARTMENT COMMUNICATION**

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Offices
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SUBJECT Review of New Hampshire's Water Quality
Criteria for Turbidity (Env-Wq 1703.11)

TO Water Quality Standards Advisory Committee

Situation

Turbidity is a measure of the cloudiness or lack of clarity of water, caused by the scattering or absorption of light by sediment, algae, or other particulates suspended in water. Chronic and high levels of turbidity can impair designated uses such as aquatic life and primary recreation (swimming). Turbidity is measured in Nephelometric Turbidity Units (NTU).

As part of the 2011 Triennial Review, DES received comments that the New Hampshire water quality criteria for turbidity should be reviewed using the latest scientific information and criteria from other states. The comments raised concerns that the criteria for turbidity were not attainable, especially for construction operations and for class A waters.

This memo provides information on the turbidity water quality criteria recommended by the U.S. Environmental Protection Agency (EPA), criteria used by other states, the effects of increased turbidity on designated uses, and background concentrations of turbidity in New Hampshire rivers and lakes.

EPA Guidance for Turbidity Water Quality Criteria

In 1976, EPA published recommended criteria for turbidity and suspended sediments (EPA, 1976), which were:

“Settleable and suspended solids should not reduce the depth of the compensation point for photosynthetic activity by more than 10 percent from the seasonally established norm for aquatic life.”

The EPA derived these criteria for turbidity based on studies performed by the National Academy of Sciences, which recommended that the depth of light penetration not be reduced by more than 10 percent. EPA also cited the European Fisheries Advisory Commission which reported that fish are negatively affected in four ways by high turbidity:

1. Acting directly on the fish by either killing them or reducing their growth rate and disease resistance.
2. Preventing the successful development of fish eggs and larvae.
3. Changing the natural movements and migrations of fish.
4. Reducing the food sources of fish.

The effects of turbidity on recreational activities such as swimming, fishing, and boating were also considered, including:

1. Reduction in the aesthetic quality of the water.
2. Decrease in the safety of the water for swimming due to inability to see obstacles or distressed swimmers in the water.

EPA also mentioned the negative effects of high turbidity on the ability to utilize water as a drinking source (efficient disinfection) and for industrial purposes (fouling of equipment).

More recently EPA is using the term “Suspended and Bedded Sediments” (SABS) to refer to the water quality criterion for turbidity. SABS are defined by EPA as particulate organic and inorganic matter that suspend in or are carried by the water, and/or accumulate in a loose, unconsolidated form on the bottom of natural water bodies. This includes the frequently used terms of clean sediment, suspended sediment, total suspended solids, bedload, turbidity, or in common terms, dirt, soils or eroded materials. In 2006 the EPA released the “Framework for Developing Suspended and Bedded Sediments (SABS) Water Quality Criteria” (EPA, 2006). This document does not contain a new recommended criteria for SABS. Instead, the report is intended to be a framework and recommended process for states to develop SABS water quality criteria.

In December, 2009 EPA proposed a stormwater effluent guideline of 280 NTU for Construction General Permits. This limit was stayed in January 2011. The effluent guideline would have been a maximum, end-of-pipe limit for stormwater discharges. However, the stormwater discharge could not violate state water quality criteria in the receiving water. If a stormwater discharge with turbidity of 280 NTU at the end-of-pipe could cause a violation of the state water quality criteria in the receiving water, then a more stringent effluent limit would be needed. In other words, if the effluent guideline were adopted, the Construction General Permit would have required that 280 NTU be met at the end of pipe, but the discharge would also have to meet the state water quality criteria (<10 NTU for class B waters) in the surface water at the point of discharge or at the boundary of a DES approved mixing zone.

New Hampshire Water Quality Criteria for Turbidity

The earliest record of a New Hampshire water quality criterion for turbidity is from 1971, which pre-dates the federal Clean Water Act. The criteria were 5 NTU for class A waters, 10 NTU for ‘trout waters’ of class B or C, and 25 NTU for other class B or C waters. By 1990, the turbidity criteria in the Surface Water Quality Regulations had changed. For class A waters, no turbidity was permitted unless naturally occurring. This ‘none unless naturally occurring’ language was also used for class A criteria for benthic deposits, oil and grease, color, slicks, odors, and surface floating solids, temperature, nutrients, and pH. For class B and C waters, the 1990 regulations limited turbidity to 10 NTU above naturally occurring conditions. The criteria have remained essentially the same since 1990, with one change. In 2008, details were added specifying that the turbidity upstream of a discharge would be treated as naturally occurring conditions for enforcement monitoring. The changes in New Hampshire’s turbidity criteria over time are listed below.

1971: Water Quality Standards Summary

(a joint publication of USEPA and NH Water Supply and Pollution Control Commission)

Note: These rules pre-date the Clean Water Act and implemented RSA 149.

	Class A	Class B	Class C	Class D
	Potentially acceptable for public water supply after disinfection. No discharge of sewage or other wastes. (Quality uniformly excellent).	Acceptable for bathing and recreation, fish habitat and public water supply after adequate treatment. No disposal of sewage or wastes unless adequately treated. (High aesthetic value).	Acceptable for recreational boating, fishing, and industrial water supply with or without treatment, depending on individual requirements. (Third highest quality).	Aesthetically acceptable. Suitable for certain industrial purposes, power and navigation. (Lowest allowable quality now less than 1/2 mile in entire state).
Turbidity	Not to exceed 5 units.	Not to exceed 10 units in trout water. Not to exceed 25 units in non-trout water.	Not to exceed 10 units in trout water. Not to exceed 25 units in non-trout water.	Not of unreasonable kind, quantity or duration.

1990 Surface Water Quality Regulations (Env-Ws 430 et seq.)

(7) Turbidity. Class A waters shall contain no turbidity unless naturally occurring. Class B and C waters shall not exceed naturally occurring conditions by 10 Nephelometric Turbidity Units (NTU).

1996 Surface Water Quality Regulations (Env-Ws 430 et seq.)

Env-Ws 430.13 Turbidity. Class A waters shall contain no turbidity unless naturally occurring. Class B waters shall not exceed naturally occurring conditions by more than 10 NTUs.

1999 Surface Water Quality Regulations (Env-Ws 1700 et seq.)

Source. #7151, eff 12-10-99

Env-Ws 1703.11 Turbidity.

- (a) Class A waters shall contain no turbidity, unless naturally occurring.
- (b) Class B waters shall not exceed naturally occurring conditions by more than 10 NTUs.
- (c) Waters identified in RSA 485-A:8, III shall contain no turbidity of unreasonable kind or quality.

2008 Surface Water Quality Regulations (Env-Wq 1700 et seq.)

Env-Wq 1703.11 Turbidity.

- (a) Class A waters shall contain no turbidity, unless naturally occurring.
- (b) Class B waters shall not exceed naturally occurring conditions by more than 10 NTUs.
- (c) Waters identified in RSA 485-A:8, III shall contain no turbidity of unreasonable kind or quality.
- (d) For purposes of state enforcement actions, if a discharge causes or contributes to an increase in turbidity of 10 NTUs or more above the turbidity of the receiving water upstream of the discharge or otherwise outside of the visible discharge, a violation of the turbidity standard shall be deemed to have occurred.

Source. (See Revision Note #1 at chapter heading for Env-Wq 1700) #7151, eff 12-10-99; ss by #9034, INTERIM, eff 12-10-07; ss by #9162, eff 5-21-08 (See Revision Note #2 at chapter heading for Env-Wq 1700)

Another relevant regulation is the one for benthic deposits, which addresses issues of bedded sediments.

Env-Wq 1703.08 Benthic Deposits.

- (a) Class A waters shall contain no benthic deposits, unless naturally occurring.
- (b) Class B waters shall contain no benthic deposits that have a detrimental impact on the benthic community, unless naturally occurring.

Source. (See Revision Note #1 at chapter heading for Env-Wq 1700) #7151, eff 12-10-99; ss by #9034, INTERIM, eff 12-10-07; ss by #9162, eff 5-21-08 (See Revision Note #2 at chapter heading for Env-Wq 1700)

Other States' Water Quality Criteria for Turbidity

The criteria for all six New England states plus New York are shown in Table 1. Connecticut, Rhode Island, Vermont, and New York all have numeric turbidity criteria between 5 and 25 NTU depending on the class and the designated use. Vermont's criteria are based on annual average turbidity under dry baseflow conditions. Massachusetts and Maine only have narrative criteria for turbidity. However, Maine regulates runoff from construction sites directly through the Erosion and Sedimentation Control Law (Title 38, M.R.S.A. 420-C). The New Hampshire criteria for class A waters of 'none unless naturally occurring' is the most stringent criteria for the Northeastern states.

In Table 2, the criteria for states outside of the Northeast with *numeric* criteria for turbidity have been summarized. States with only narrative criteria were not included. DES relied on criteria summaries compiled by EPA (2006) and ODEQ (2010) to generate this list. Many states had different numeric criteria for different water bodies or designated uses. To simplify the table, only the ranges of numeric criteria for each state are presented. Criteria were typically expressed in units of NTU or percent change from background or both. Occasionally, the criteria were based on suspended sediment concentrations with units of mg/L.

The majority of states evaluate turbidity in terms of an increase relative to background levels. The allowable increase can either be absolute (e.g., 10 NTU above background) or relative (e.g., 10 percent

above background). The magnitude of the allowable excursion ranges from 1 to 150 NTU and 2 to 20 percent. The higher criteria (>50 NTU) typically correspond to either acute, “not to exceed” thresholds or to coastal or large river environments. A few states define the frequency and duration of allowable excursions. Having different criteria for acute and chronic exposures is the most common approach to regulating based on frequency of exposure.

Effects of Increased Turbidity on Designated Uses

Increased suspended and bedded sediments can cause impairments of aquatic life, recreation, and drinking water designated uses.

Suspended sediments and turbidity affect aquatic life by reducing light penetration into the water. As a result, primary productivity in the water body is lowered and submerged aquatic vegetation cannot survive. These effects have been observed in clear lakes and streams when turbidity values are increased by 5 NTU (ODEQ, 2010). Literature summaries also show that turbidity of 6-10 NTU in streams and less than 5 NTU in lakes also results in reduced prey capture, decreased predatory avoidance, lower reproductive success by fish and other aquatic life (ODEQ, 2010). At high concentrations of suspended sediments (>60 NTU), fish and other aquatic life can experience abrasion or clogging of filtration and respiratory organs (EPA, 2006; Bash et al., 2001).

Aquatic life in streams and lakes are also affected by bedded sediments. Large depositional events of bedded sediments can smother eggs and entrap aquatic organisms. Fine bedded sediments can eliminate spawning and other habitats by filling interstitial spaces between rocks in streams and lakes (EPA, 2006).

Recreational uses of water bodies can also be impaired by turbidity. Turbidity can be safety hazard if swimmers cannot see what is in the water. User perception survey in New Zealand found that the majority of respondents preferred waters with turbidity less than 4.2 NTU for swimming (ODEQ, 2010).

Public water supplies that use surface waters or groundwater under the influence of surface water must filter water if the source water has turbidity levels greater than 5 NTU or if it does not meet other requirements in 40 CFR 141.71. Therefore, increased turbidity in surface waters increases the cost of treatment for waters used for drinking water supplies.

Background Concentrations of Turbidity in New Hampshire Streams and Lakes

DES analyzed all valid results for turbidity in streams and lakes in the DES Environmental Monitoring Database. There were 19,858 results for lakes and 18,591 results for streams. Results were grouped by water body type (e.g., lake vs stream), month when the measurement was taken, whether rain was reported in the preceding days, and whether the measurement was from a ‘reference station’. For this analysis, reference stations were defined as stations with an average specific conductance less than 50 uS/cm based on five or more measurements.

Figures 1 and 2 show the mean and standard error of turbidity for each month for reference and non-reference sites under wet and dry conditions. In rivers, the average turbidity was typically 1 NTU at reference sites and 2 NTU at non-reference sites for dry conditions. The limited dataset of wet weather conditions indicates that the average turbidity in rivers increases to 2-3 NTU after rain events. The average turbidity in lakes was similar to rivers except for spikes in the spring and fall, probably due to algae blooms associated with water column mixing.

Conclusions

- EPA recommended criteria for turbidity was issued in 1976: “Settleable and suspended solids should not reduce the depth of the compensation point for photosynthetic activity by more than 10 percent from the seasonally established norm for aquatic life.” EPA is currently recommending that states establish criteria for both suspended and bedded sediments but has not issued updated guidance.
- New Hampshire has had numeric criteria for turbidity since at least 1971. For the past 20 years, the criteria have been essentially the same: For class A waters, no turbidity is permitted unless naturally occurring; for class B waters, turbidity is limited to 10 NTU above naturally occurring conditions. The class B criterion is consistent with numeric criteria used by other states. The class A criteria of ‘none unless naturally occurring’ is stricter than criteria used by other states.
- Reviews of the scientific literature indicate that increases in turbidity as low as 5 NTU above naturally occurring conditions can have negative effects on designated uses.
- For rivers and lakes in New Hampshire, the typical dry-weather turbidity is between 1 and 2 NTU.

Recommendations

- The New Hampshire turbidity criteria for class A waters is stricter than other states’ criteria. The ‘none unless naturally occurring’ language cannot be practically implemented for any development in the watersheds of class A waters. This part of the criteria should be revised as part of a broader rulemaking proposal to re-define criteria for class A waters in terms of supporting designated uses.
- The New Hampshire turbidity criteria for class B waters (10 NTU) is consistent with other states’ criteria and the scientific literature. Changes to the class B criteria are not recommended.

References

- Bash, J., C. Berman, and S. Bolton. 2001. Effects of Turbidity and Suspended Solids on Salmonids. Center for Streamside Studies, University of Washington, Seattle, WA. Published online: <https://digital.lib.washington.edu/dspace/bitstream/handle/1773/16382/Salmon%20and%20Turbidity.pdf?sequence=1>.
- EPA. 2010. Framework for Developing Suspended and Bedded Sediment (SABS) Water Quality Criteria. U.S. Environmental Protection Agency, Washington, DC, EPA/822-R-06-001. Published online: <http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=164423>.
- EPA. 1976. Quality Criteria for Water. U.S. Environmental Protection Agency, Washington, DC. Published online: http://water.epa.gov/scitech/swguidance/standards/current/upload/2009_01_13_criteria_redbook.pdf.
- ODEQ. 2010. Turbidity Technical Review: Summary of Sources, Effects, and Issues Related to Revising the Statewide Water Quality Standard for Turbidity. Oregon Department of Environmental Quality, Portland, OR. Published online: <http://www.deq.state.or.us/wq/standards/docs/Turbidity/10-WQ-022.pdf>.

Table 1: Turbidity Criteria for New England States and New York

<p>Connecticut (Section 22a-426 of the Connecticut General Statutes) http://www.ct.gov/dep/lib/dep/water/water_quality_standards/wqs_final_adopted_2_25_11.pdf</p>
<p>Class AA, Class A and Class B waters Shall not exceed 5 NTU over ambient levels and none exceeding levels necessary to protect and maintain all designated uses. All reasonable controls or Best Management Practices are to be used to control turbidity.</p> <p>Class SA waters None other than of natural origin except as may result from normal agricultural, road maintenance, or construction activity, dredging activity or discharge of dredged or fill materials provided all reasonable controls and Best Management Practices are used to control turbidity and none exceeding levels necessary to protect and maintain all designated uses.</p> <p>Class SB waters None other than of natural origin except as may result from normal agricultural, road maintenance, or construction activity, or discharge from a waste treatment facility providing appropriate treatment, dredging activity or discharge of dredged or fill materials provided all reasonable controls and Best Management Practices are used to control turbidity and none exceeding levels necessary to protect and maintain all designated uses.</p>
<p>Maine (Title 38 M.R.S.A. Section 464) http://www.mainelegislature.org/legis/statutes/38/title38sec464.html</p> <p>The department may not issue a water discharge license for any of the following discharges: (4) Discharge of pollutants to waters of the State that imparts color, taste, turbidity, toxicity, radioactivity or other properties that cause those waters to be unsuitable for the designated uses and characteristics ascribed to their class.</p>
<p>Massachusetts (314 CMR 4.05) http://water.epa.gov/scitech/swguidance/standards/wqslibrary/upload/mawqs.pdf</p> <p>Narrative Turbidity Criteria Class A, B, C, SA, SB. These waters shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this class.</p>
<p>New Hampshire (Env-Wq 1703.11) http://des.nh.gov/organization/commissioner/legal/rules/documents/env-wq1700.pdf</p> <p>(a) Class A waters shall contain no turbidity, unless naturally occurring. (b) Class B waters shall not exceed naturally occurring conditions by more than 10 NTUs. (c) Waters identified in RSA 485-A:8, III shall contain no turbidity of unreasonable kind or quality. (d) For purposes of state enforcement actions, if a discharge causes or contributes to an increase in turbidity of 10 NTUs or more above the turbidity of the receiving water upstream of the discharge or otherwise outside of the visible discharge, a violation of the turbidity standard shall be deemed to have occurred.</p>
<p>New York (Part 703.2/703.3) http://www.dec.ny.gov/regs/4590.html#16132</p> <p>Turbidity Water body types AA, A, B, C, D, SA, SB, SC, SD, I: No increase except from natural sources that will cause a substantial visible contrast to natural conditions. In water body type GA, Turbidity shall not exceed 5 NTU.</p>
<p>Rhode Island (Water Quality Regulations, Rule 8) http://www.dem.ri.gov/pubs/regs/regs/water/h20q09.pdf</p> <p>Class AA and Class A Waters None in such concentrations that would impair any usages specifically assigned to this class. Turbidity not to exceed 5 NTU over background.</p> <p>Class B, B1, B{a}, B1{a} and Class C Waters None in such concentrations that would impair any usages specifically assigned to this class. Turbidity not to exceed 10 NTU over natural background.</p>
<p>Vermont (Vermont Water Quality Standards Vt. Code R. 12 004 052) http://www.nrb.state.vt.us/wrp/publications/wqs.pdf</p> <p>Class A(1) Waters None in such amounts or concentrations that would prevent the full support of uses, and not to exceed 10 NTU (nephelometric turbidity units) as an annual average under dry weather base-flow conditions.</p> <p>Class A(2) Waters None in such amounts or concentrations that would prevent the full support of uses, and not to exceed 10 NTU (nephelometric turbidity units) as an annual average under dry weather base-flow conditions.</p> <p>Class B Waters a. In Cold Water Fish Habitat waters - None in such amounts or concentrations that would prevent the full support of uses, and not to exceed 10 NTU (nephelometric turbidity units) as an annual average under dry weather base-flow conditions; and b. In Warm Water Fish Habitat waters - None in such amounts or concentrations that would prevent the full support of uses, and not to exceed 25 NTU (nephelometric turbidity units) as an annual average under dry weather base-flow conditions.</p>

Table 2: Numeric Criteria for Turbidity in Non-New England States.

State	Magnitude	Relative to Background (Y/N)	Frequency/Duration Limits	Comments
ALABAMA ¹	50 NTU	Y		Turbidity levels caused by natural runoff included when determining background levels.
ALASKA ^{1,2}	5-15 NTU 10%-20%	Y		
ARIZONA ¹	10-50 NTU	N		
ARKANSAS ¹	10-75 NTU	N		
CALIFORNIA ²	1-10 NTU 10%-20%	Y		Nine Water Resources Control Board Regions with separate criteria. Certain regions allow dilution zones with discharge permits or waivers. Turbidity criteria for the central coast region are expressed in units of Jackson Turbidity Units (JTU).
DELAWARE ¹	10 NTU/FTU	Y		Mixing zone limit of 10 NTU above background.
FLORIDA ¹	29 NTU	Y		
HAWAII ¹	5-25 NTU 2%-10%	N	Frequency/Duration based on wet/dry season.	
IDAHO ^{2,3}	25-50 NTU 10%	Y	For cold water aquatic life turbidity below any mixing zone, background levels cannot be exceeded by 50 NTU instantaneously or more than 25 NTU for more than 10 consecutive days.	
IOWA ¹	25 NTU	Y		
LOUISIANA ¹	25-50 NTU 10%	Y		
MARYLAND ¹	50-150 NTU	N	Turbidity in surface water resulting from any discharge may not exceed 150 NTU any time or 50 NTU as a monthly average.	
MINNESOTA ¹	5-25 NTU	N		
MISSISSIPPI ¹	50 NTU	Y		Outside of 750-foot mixing zone background cannot be exceed by > 50 NTU
MONTANA ¹	5-10 NTU	Y		
NEVADA ¹	5-50 NTU	Y		

State	Magnitude	Relative to Background (Y/N)	Frequency/Duration Limits	Comments
NEW JERSEY ¹	10-50 NTU	Y	Fresh waters not designated as FW1, maximum 30-day average of 15 NTU, a maximum of 50 NTU at any time. Coastal saline waters levels shall not exceed 10 NTU. Saline estuaries maximum 30-day average of 10 NTU, a maximum of 30 NTU anytime.	Separate coastal and marine criteria.
NORTH CAROLINA ¹	10-50 NTU	Y		
OKLAHOMA ¹	10-50 NTU	Y	Numerical criteria apply only to seasonal base flow conditions.	
OREGON ¹	10%	Y	No more than a ten percent cumulative increase in natural stream turbidities shall be allowed, as measured relative to a control point immediately upstream of the turbidity causing activity. However, limited duration activities necessary to address an emergency or to accommodate essential dredging, construction or other legitimate activities and which cause the standard to be exceeded may be authorized provided all practicable turbidity control techniques have been applied and one of the following has been granted...	
PENNSYLVANIA ¹	40-100 NTU	N	The following turbidity criteria are specific to waters in the Neshaminy Creek Basin where indicated, based on special studies: Potable water supply, warm water fishes, migratory fish: Not more than 100 NTU. Potable water supply and Cold Water Fishes (Maintenance or propagation, or both, of fish species including the family Salmonidae and additional flora and fauna which are indigenous to a cold water habitat.): For the period May 15-September 15 of any year, not more than 40 NTU. Warm Water Fish, Migratory fish: for the period September 16-May 14 of any year, not more than 100 NTU.	
SOUTH CAROLINA ¹	10%	Y		

State	Magnitude	Relative to Background (Y/N)	Frequency/Duration Limits	Comments
SOUTH DAKOTA ¹	30-266 mg/l TSS	N	Coldwater permanent fish life propagation waters: Total suspended solids (TSS) less than 30 mg/L as a 30 day average and 53 mg/L as a daily maximum. Coldwater semi-permanent fish life propagation waters: TSS less than 90 mg/L as a 30 day average and 158 mg/L as a daily maximum. Warm water permanent and semi-permanent fish life propagation waters: TSS less than 90 mg/L as a 30 day average and 158 mg/L as a daily maximum. Warm water marginal fish life propagation waters: TSS less than 150 mg/L as a 30 day average and 263 mg/L as a daily maximum.	
UTAH ¹	10-15 NTU	N		
WASHINGTON ¹	5-10 NTU 10%-20%	Y		
WEST VIRGINIA ¹	10 NTU 10%	Y		
WYOMING ¹	10-15 NTU	Y		
DISTRICT OF COLUMBIA ¹	20 NTU	Y		
PUERTO RICO ¹	10-50 NTU	Y		

NTU = Nephelometric Turbidity Units FTU = Formazin Turbidity Unit JTU= Jackson Turbidity Units

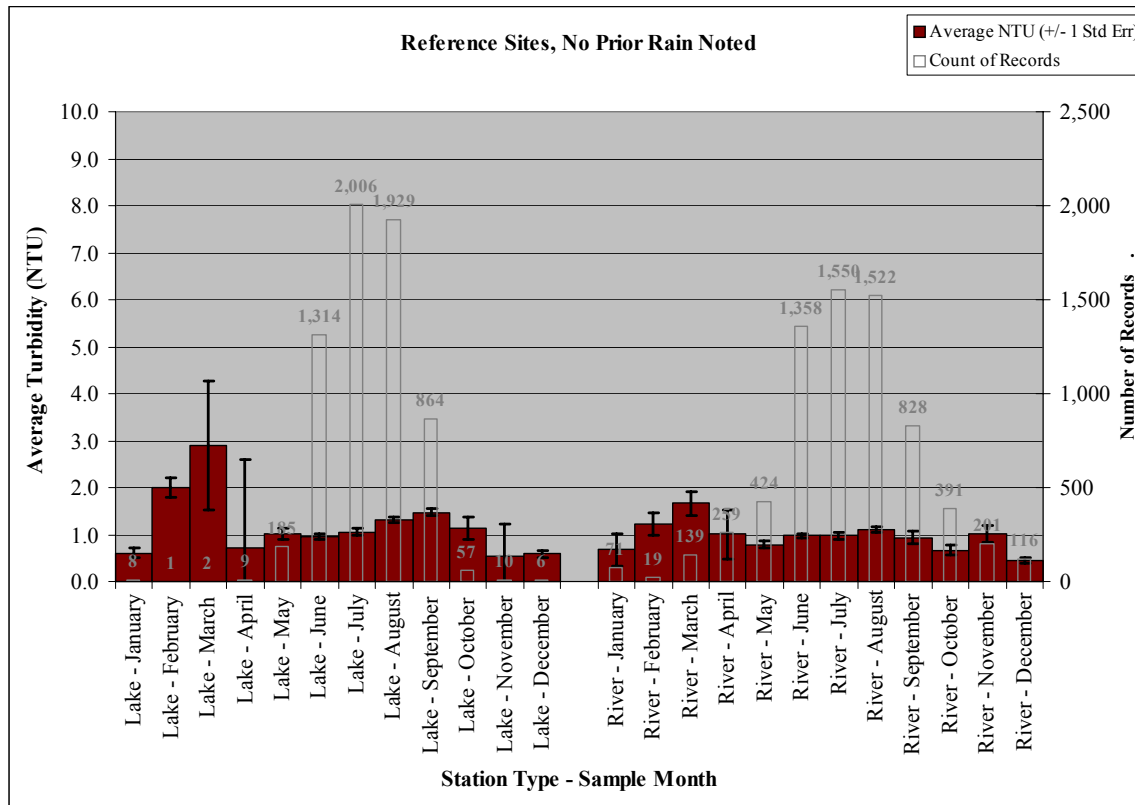
¹ EPA (2006)

² ODEQ (2010)

³U.S. EPA. Web Page. State, Tribal & Territorial Standards. <http://water.epa.gov/scitech/swguidance/standards/wqslibrary/index.cfm>

Figure 1: Average Turbidity in Each Month at Reference Stations in New Hampshire Lakes and Rivers

(a) No Prior Rain Noted



(b) Prior Rain Noted

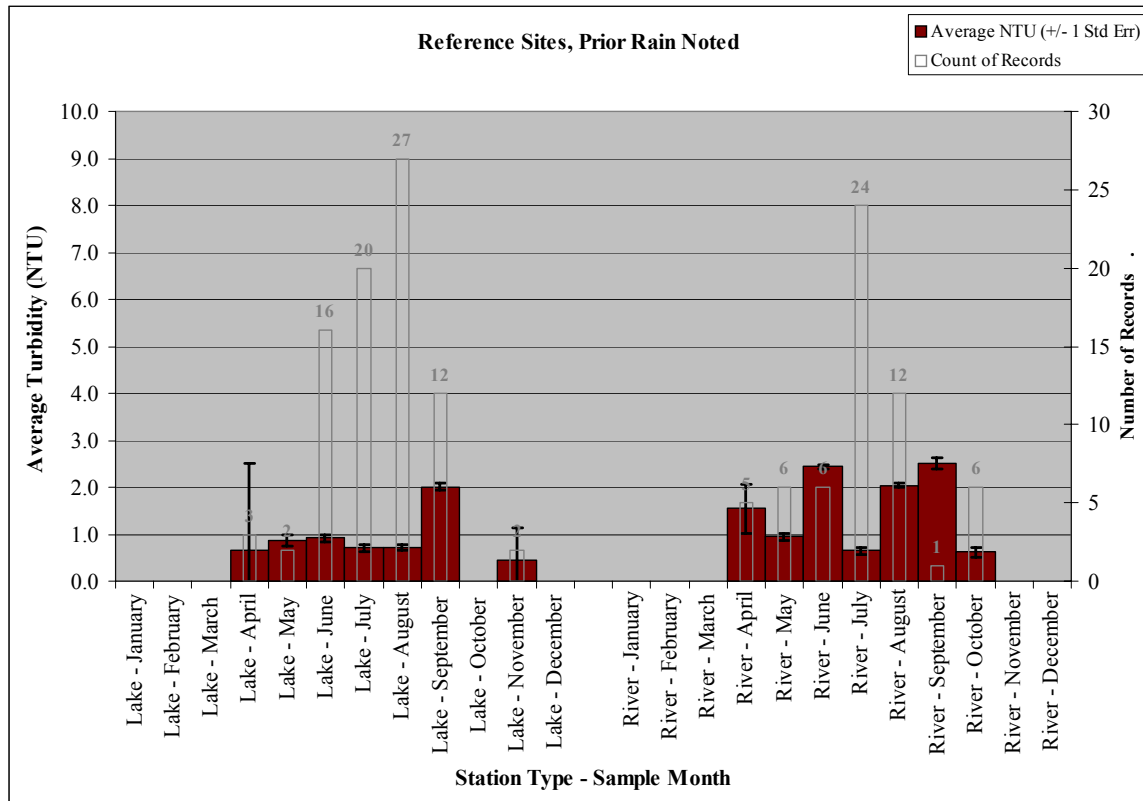
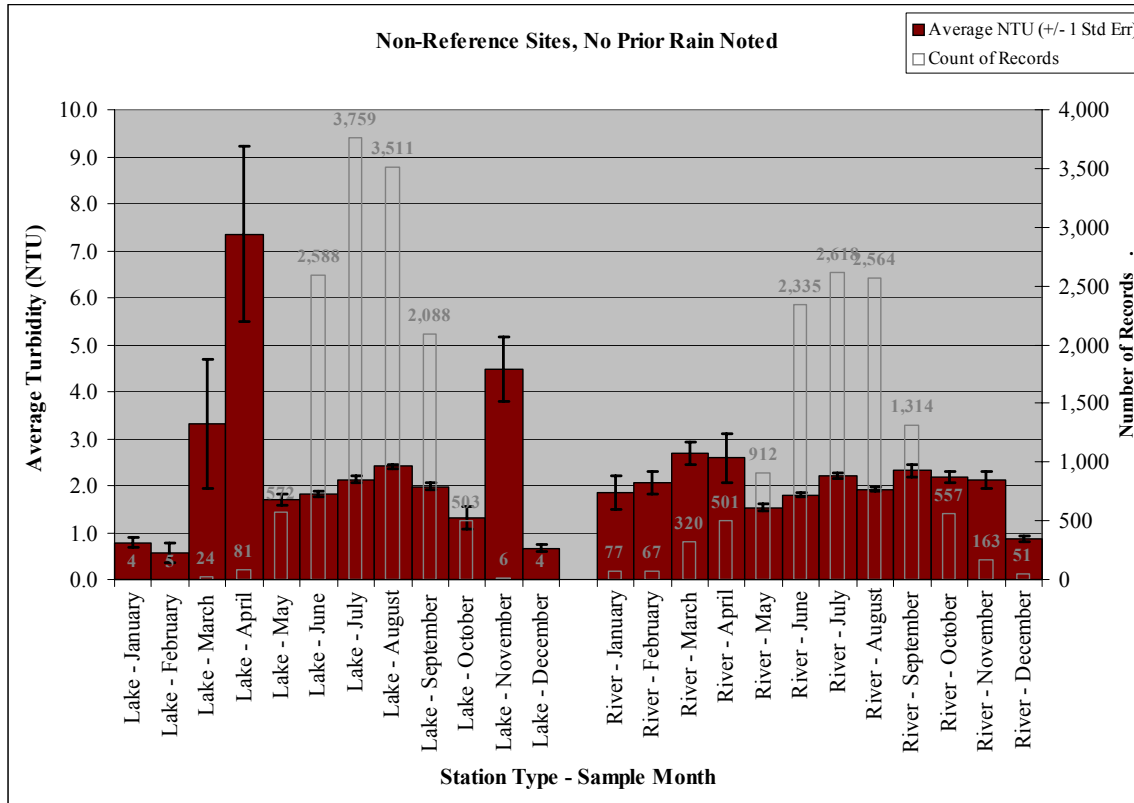


Figure 1: Average Turbidity in Each Month at Non-Reference Stations in New Hampshire Lakes and Rivers

(a) No Prior Rain Noted



(b) Prior Rain Noted

