Final Report

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Sediment Accretion, Elevation Change, Water Level, Salinity, and Belowground Production in the Quinnipiac Marshes

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Introduction

Tidal marshes are key components of the coastal landscape, and play several valuable roles: habitat for wading birds, juvenile fish, and invertebrates; sites of high primary production and nutrient processing; buffers for removal of land-derived pollutants; and flood protection. These vital ecosystems have been legally protected from direct anthropogenic impacts (dredge and fill), but several sites, including the Quinnipiac, are experiencing unexplained "submergence," characterized by an increase in wetness, loss of vegetation, and conversion to mudflat.

Healthy marshes can avoid drowning by accreting sediment (organic and inorganic) at rates that allow the marsh to "keep up" with relative sea level rise (SLR). The reasons that submerging marshes are unable to do this are presently unclear.

The Quinnipiac River's extensive tidal marshes (brackish and salt) provide a unique ecological and recreational resource. This area is habitat to numerous birds and aquatic organisms and provides a biogeochemical filter for the waters of the river, as well as being a popular site for birding and boating. Submergence threatens those values.

In this project, we examined the processes determining the stability of the Quinnipiac marshes. In particular, our proposal identified 4 objectives:
1. Monitor 9 long term plots in spring 2014.
2. Monitor 3 of the plots in fall 2014.
3. Establish a water level/salinity monitoring station and obtain data for 6 months.
4. Measure belowground production in 15 plots in summer 2014.

The first three objectives were accomplished, and will be described in detail below. The fourth objective was not accomplished. Our effort to measure belowground production was largely unsuccessful. Methods that we had previously used successfully in salt marshes did not give us good results in the Quinnipiac due to the very wet peat and the very large rhizomes.

Accretion and elevation change (objectives 1 and 2)

Methods

We measured both accretion and elevation change at each of our previously-established Sediment Elevation Table – Marker Horizon (SET-MH) plots (Figure 1) using established methods (Cahoon et al. 2002). Specifically, we sampled triplicate plots in each of 3 vegetation types: *Typha glauca* near the drowning area ("degrading Typha"), *Phragmites australis* near the drowning area ("degrading Phragmites"), and Phragmites away from the drowning area ("healthy Phragmites"). We have previously determined that at the Phragmites sites, sampling more than once per year results in unacceptable damage to vegetation, so we sampled those sites only in April 2014 (before new shoots reached the elevation of our sampling platform). The Typha site is less susceptible to vegetation damage, so we sampled there in both April and October 2014.

Figure 1. Sampling locations in the Quinnipiac marshes (Google Earth image). Red markers indicate SET sites (each with triplicate plots): A = degrading Typha, B = degrading Phragmites, C = healthy Phragmites. Blue markers indicate the locations of water level loggers deployed in summer 2014.

For accretion, sampling involved collection of a small cryo-core using a liquid nitrogen system, followed by measurement of the depth of sediment on top of the feldspar marker horizons (established in 2006). This deposited sediment was also retained and analyzed for organic matter by Loss on Ignition (LOI). For elevation change, sampling involved deploying the sediment elevation table at each plot and collecting readings from 9 pins in each of 4 directions. These measurements were then compared to the initial readings; differences correspond to increases or decreases in sediment elevation.

<u>Results</u>

The two Phragmites sites showed very similar patterns of accretion over time (Figure 2, top), with both sites accreting sediment at just over 3 mm yr^{-1}, roughly the regional rate of SLR. The two sites differed, however, in their elevation change (Figure 2, bottom), with the healthy site showing a considerably higher rate.

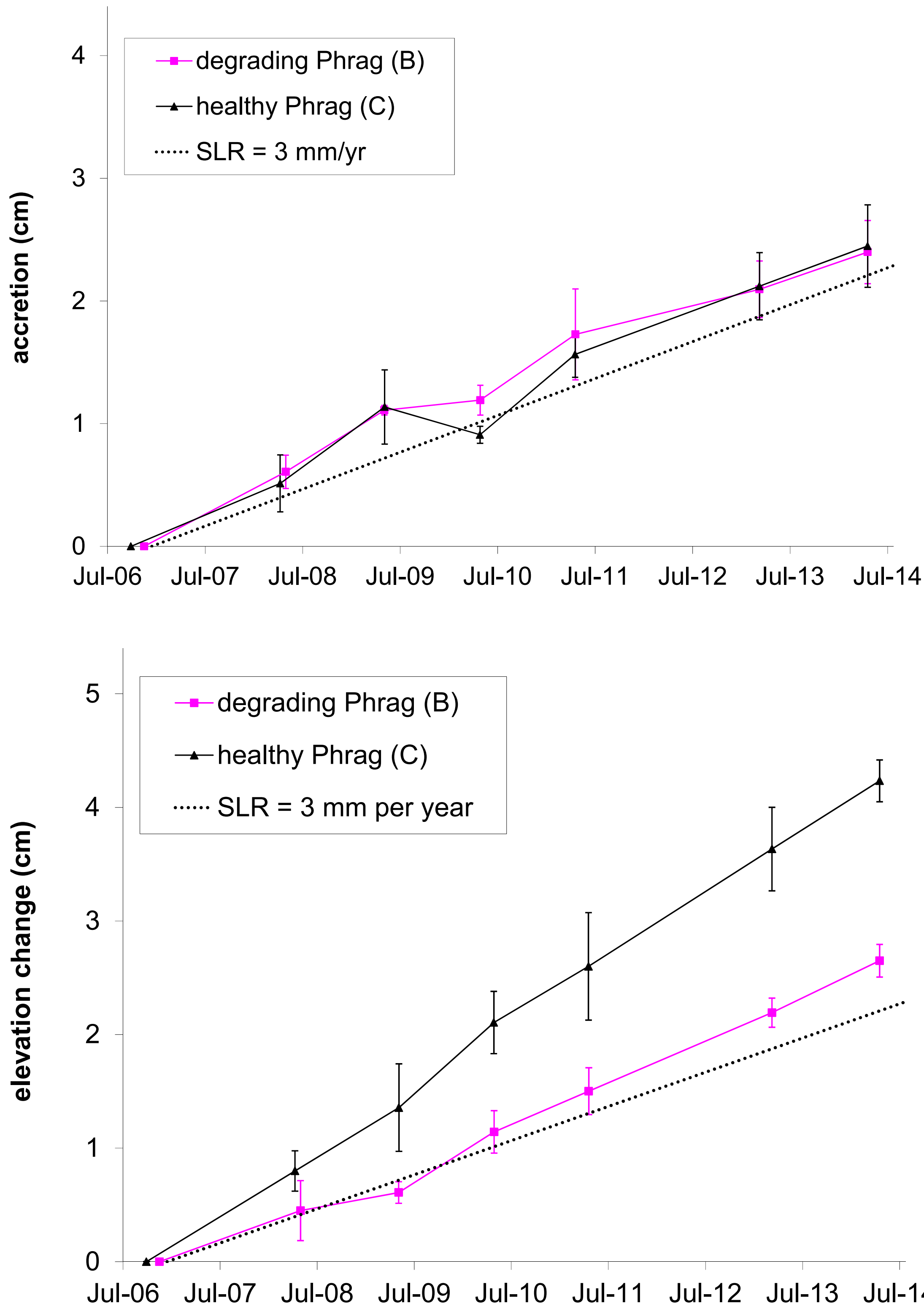

Figure 2. Accretion (top) and elevation change (bottom) at the two SET-MH Phragmites sites (mean and standard error of triplicate plots at each site). Dashed line shows a constant SLR of 3 mm yr^{-1}.

As in previous years, the Typha site continued to show large seasonal variation in accretion and elevation change, with large positive contributions over the summer and small or even negative contributions over the winter. Examining only spring data (Figure 3) revealed that the site is both accreting and gaining elevation at rates well in excess of 3 mm yr^{-1}.

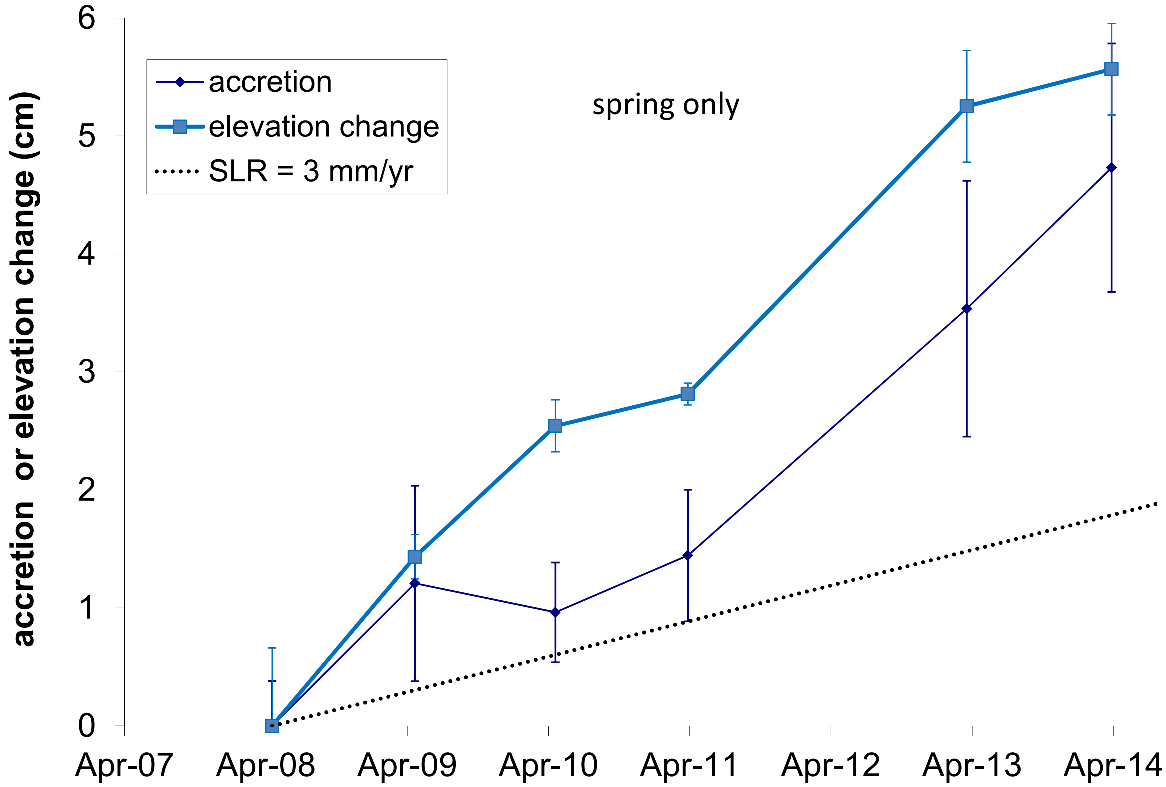

Figure 3. Accretion and elevation change at the SET-MH Typha site (mean and standard error of triplicate plots). Dashed line shows a constant SLR of 3 mm yr^{-1}. Only spring data are shown.

Hydrology and Salinity (objective 3)

Methods

Water level loggers were deployed at three locations in the Quinnipiac marshes (Figure 1) in order to better understand the variation in hydrology within the marsh system:

- "river" site: This site is very close to the mainstem of the river and is expected to experience full river hydrology and salinity. A Solinst LTC Levelogger Junior (S/N 1068049) recorded water level and conductivity every 6 minutes from 4/23/14 to 6/29/14.
- "phrag" site: This site is in a tidal creek in the Phragmites section of the marsh. A Solinst LTC Levelogger Junior (S/N 1062943) recorded water level and conductivity every 6 minutes from 4/23/14 to 6/29/14.

- “typha” site: This site is in a rill in the mudflat in the Typha section of the marsh. A Solinst Levelogger Gold (S/N 1063713) recorded water level every 5 minutes from 5/20/14 to 10/5/14.

Upon retrieval, water level data were downloaded and were then processed as follows:
- Barometric pressure correction was made using barometric pressure data from the NOAA New Haven Harbor site.
- Zero correction was made based on periods when the logger was out of the water.
- High tide times and levels were extracted in R.
- High tide levels from the phrag and typha sites were plotted against high tide levels from the river site; from these plots, we concluded that the phrag logger had shifted in place after 5/29/14, so those data were excluded from the hydrologic analysis.
- Conductivity values were converted to salinity using the “Data Wizard” in the Solinst Levelogger software.

<u>Results</u>

Figure 4 presents high-tide water levels at the typha and phrag loggers, plotted against values for the same high tides at the river logger. The following conclusions can be drawn:
1. The phrag logger site is closely connected hydrologically to the river, as indicated by a slope very close to 1 (0.99), which means that the variability in high-tide heights at the phrag logger site is very similar to that at the river logger site.
2. High-tide variability at the typha site is slightly dampened relative to the river (slope of 0.95), but this difference is surprisingly small given the distance between the two sites.

These conclusions were supported by calculation of the average time lag between high tide at the river and high tide at the typha/phrag sites, which was a mere 5 minutes in both cases.

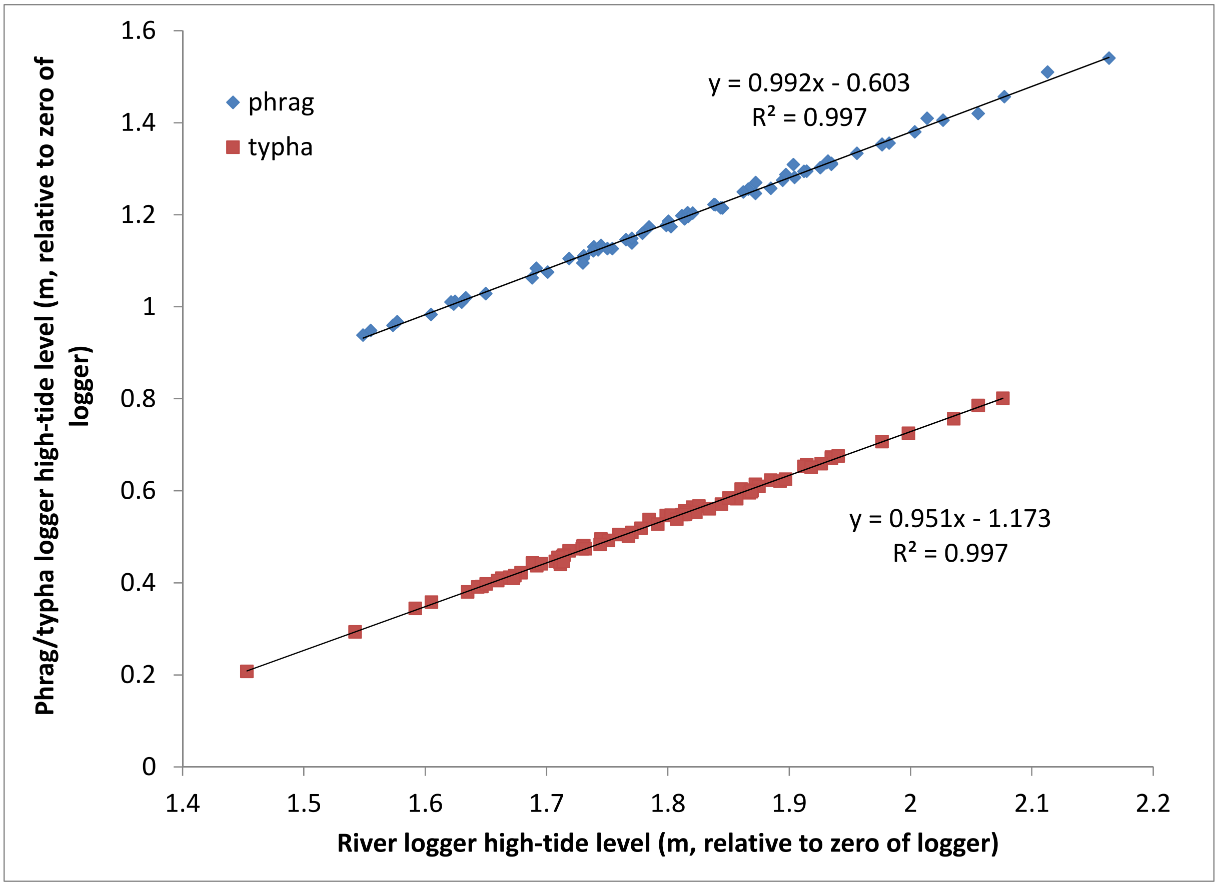

Figure 4. High-tide water levels at the phrag site (top) and typha site (bottom), plotted against the corresponding high-tide water levels at the river site.

Salinity records at both the river and phrag sites (Figure 5) showed a clear tidal pattern, with higher salinities at high tides. A period of high river flows in the first half of May (Figure 6) led to very low salinities at both sites, while the highest salinities observed (around 20psu) were during high tides in June, when river flow was lower (Figure 6).

Conclusions

Our long-term monitoring of accretion and elevation change (objectives 1 and 2) continues to suggest that vegetated areas of the marsh – even areas that are adjacent to the expanding mudflat – are keeping up with sea-level rise. This may indicate that the marsh-destroying processes have not yet reached our plots. Nonetheless, the difference in elevation change between the healthy and degrading Phragmites plots (Figure 2, bottom) is large and growing, and suggests that there is a fundamental difference between the two areas in their resilience to sea-level rise.

Our hydrology monitoring (objective 4) suggests that despite the complicated nature of tidal channels in this marsh system (Figure 1), tidal hydrology is similar throughout the marsh. That is, high tides in the river are experienced throughout the marsh with little time lag and little attenuation of variability. This will simplify future assessments of changes in hydrology over time in this system. In addition, our salinity data demonstrate the dynamic nature of this marsh complex. Depending on river flow and tidal stage, plants must be able to accommodate salinities from nearly 0 to over 20 psu.

Acknowledgments
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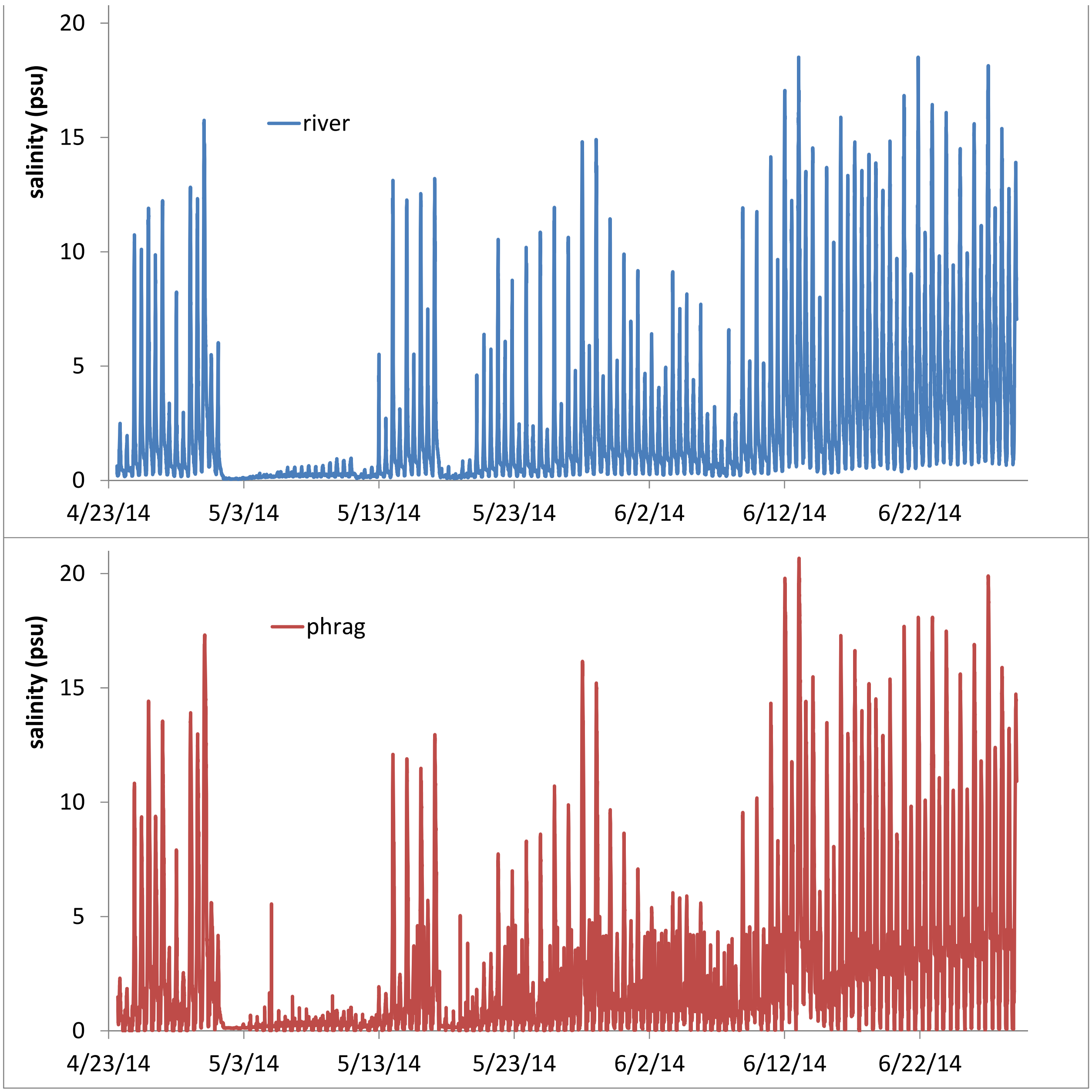

Figure 5. Salinity over time at the river (top) and phrag (bottom) sites.

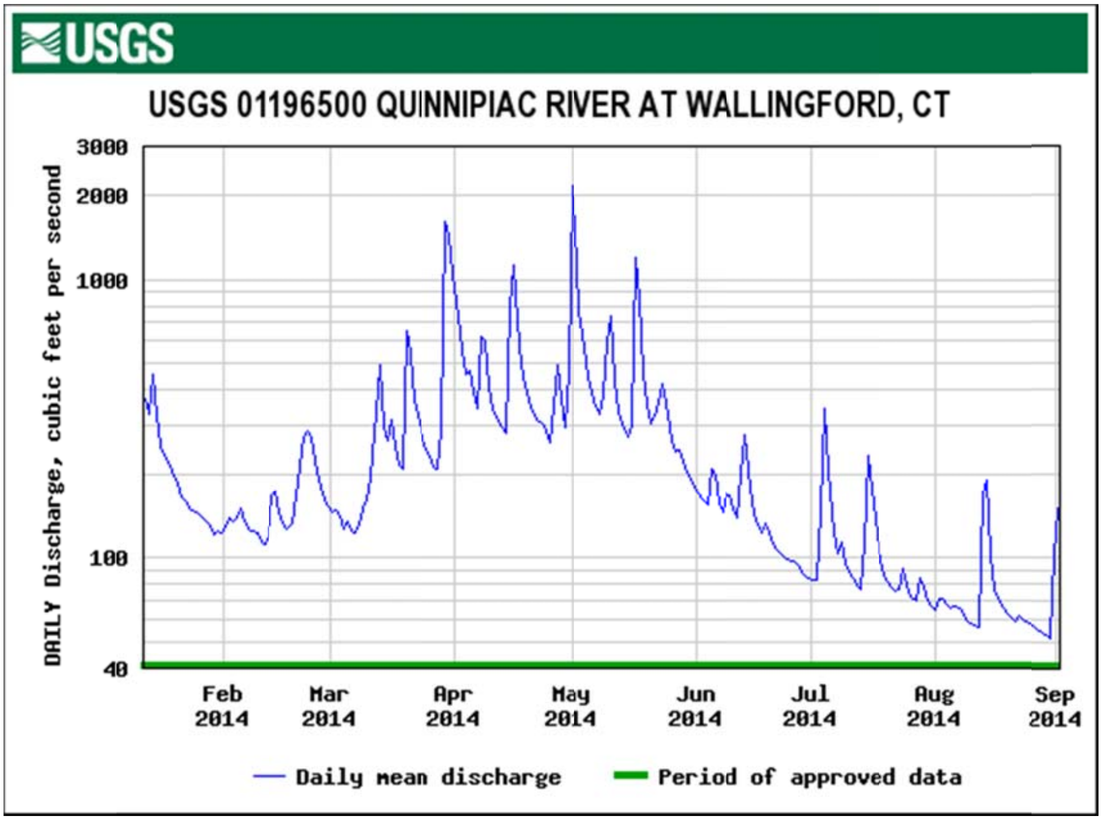

Figure 6. Freshwater flow at the USGS Quinnipiac gauge (Wallingford); *http://waterdata.usgs.gov/nwis/dv/?dd_cd=02_00060_00003&format=img_default&site_no=01196500&begin_date=20140113&end_date=20140901*