Palgrave Fishway Study
2006 Temperature Report

Trout Unlimited Canada Technical Report
No. ON-018

Prepared by:

Silvia D'Amelio
Ontario Provincial Biologist
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Toronto and Region Conservation for The Living City

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Background

The Palgrave Mill Dam is situated in the headwaters area of the main branch of the Humber River in the village of Palgrave within the Town of Caledon. It was built in 1850 and provided a local source of hydro electric power and was in use between 1850 and 1960. Although no longer in operation, the dam and its head pond have remained intact to preserve this structure for its local historical and heritage values.

The section of river which the Palgrave Mill Dam intercepts is designated as a cold water stream and is capable of supporting resident populations of brook and brown trout. In 2001, the Palgrave Fishway was constructed to facilitate movement of resident fish around the dam which increased their access to the upper reaches of the Humber River. The result is a step pool fishway approximately 69m long from the mainstem upstream to the headpond. Limited data exists documenting fish use and it is unknown if use is affected by factors such as temperature and dissolved oxygen. The dam and its head pond pose a number of environmental impacts for both aquatic and terrestrial ecosystems within the Humber River watershed. These impacts relate to physical, chemical and biological processes which must exist for a healthy watershed. The headpond above the dam is known to increase water temperature up to 28ºC and then discharges this warm water downstream (Ontario Streams, 1997). This dramatic increase in water temperature could seriously affect the behaviour and survival of cool and cold water fish species.

Salmonids, especially brook trout, are often considered indicators of good water quality, therefore the data collected from this study will be compared to the thermal preferences of brook trout. Though the upper thermal tolerance of brook trout is commonly known to be approximately 24°C (Power 1980, Grande and Andersen 1991), it has been well documented that their optimal range for physical activity, growth and metabolism is 10-19°C (Power 1980 and references therein), but critical temperatures further limit available brook trout habitat, at particular life history stages. During the summer season, temperatures should not exceed 16°C and spawning maximums should not exceed 12°C with the optimum below 9°C. It is well documented that temperature affects swimming performance and the overall cost of swimming and as a result increases in temperature lead to increases in critical swimming velocity (Heggenes and Traaen 1988, Tang and Boisclair 1995), a significant factor in fishway use.

The purpose of this study is to identify and assess the potential effects of the dam and headpond on temperatures within this reach of the Humber River. These data will be compared with known limits for salmonid species and future directions for monitoring and mitigation will be investigated.

Methods

Temperature data loggers (Hobo Water Temperature Pro®) were launched at multiple locations within the study area to gather data on longitudinal temporal variability impacting the study area. A total of 4 Hobos were launched on May 13, 2006 and were pre-programmed to record temperature every half hour starting at 12am. The first logger (Site 1) was placed approximately 1500m downstream of the Palgrave Mill Dam. The second logger (Site 2) was placed in the mainstem of the river directly below the fishway towards river right (away from fishway entrance). The third logger (Site 3) was placed within the top pool of the fishway. The fourth logger (Site 4) was placed in the mainstem of the river above the impoundment (Figure 1).

The loggers were attached to a piece of substrate using black UV rated cable ties. The piece of substrate utilized was dependent on the average bed load size within the tributary and therefore varied from site to site. The Hobo was placed face down within the main thalweg and where necessary covered by other rocks to eliminate direct warming from sunlight. Location and logger details were recorded on the logger launch form and entered into a logger database to monitor the location and performance of equipment over years. To facilitate long term monitoring these sites have been maintained as standard sites in this monitoring study. The site locations are depicted in Figure 1.

Data were collected continuously at each site from May through November 2006. These data were compiled using Microsoft Excel to create a seamless seasonal temperature plot for each location within the tributary. Erroneous data was removed where justification existed (e.g. where the logger was exposed to air due to low water levels, or following removal and before downloading). Data were summarized. Daily averages, maximums, minimums and temperature ranges were plotted for each sampling location and compared among sampling sites. Trimean average and maximum temperatures were calculated weekly to identify potential sustained temperature trends. These trends account for the degree of temperature variability within the system during the course of a week and may be more indicative of the actual temperature stress felt by aquatic organisms within the system.

Figure 1: Study Site –Sites indicated by circled site number. Site number 4 is located further upstream (not depicted here).

Data and Results

All of the loggers launched were retrieved in November 2006 and data from each were successfully downloaded. A cursory review of the raw data files downloaded from the temperature data loggers indicated that all loggers recorded valid water data throughout the study period.

A coarse analysis of the data indicates an expected warming trend from site 4 to site 3 (Figure 2, 3, 4, 5 and 8). Sites 3 and 2 depict negligible differences in temperature trends which is not surprising given their location (Figure 2, 3, 4, 5 and 8). These data also depict a slight cooling trend from site 2 to site 1 (Figure 2, 5 and 8).

Average summer data indicate that all sites display average, maximum and minimum temperatures above the optimal summer range for brook trout (Figure 2). Specific temporal data evaluating daily trends indicate that all sites exhibit maximum temperatures above brook trout critical maximums during the summer, but do not remain above critical for the duration of the summer months (Figure 3). Sites 3, 2, and 1 exhibit minimum temperatures above critical values for a single day only, while site 4 never reaches critical temperatures (Figure 4). All sites exhibit average temperatures that reach critical levels during the summer months, but for a maximum duration of two days (Figure 5). All sites maintain high temperatures from late June and start cooling early in August (Figures 3, 4 and 5). All sites follow the same patterns of temperature change, with the greatest variance among sites observed from June to August between sites 4 and 3 (Figure 4 and 5).

Trimean average temperatures indicated that site 3, 2 and 1 fall outside of the tolerable limits for brook trout for a short period during the summer season (Figure 9). Trimean maximum temperatures indicate multiple periods for these three sites and one period for site 4 (Figure 10).

Thermal stream classifications of these sites (Stoneman and Jones) indicate that the entire reach studied is fluctuating between warm and cool classification (Figure 11).

Summary Plots

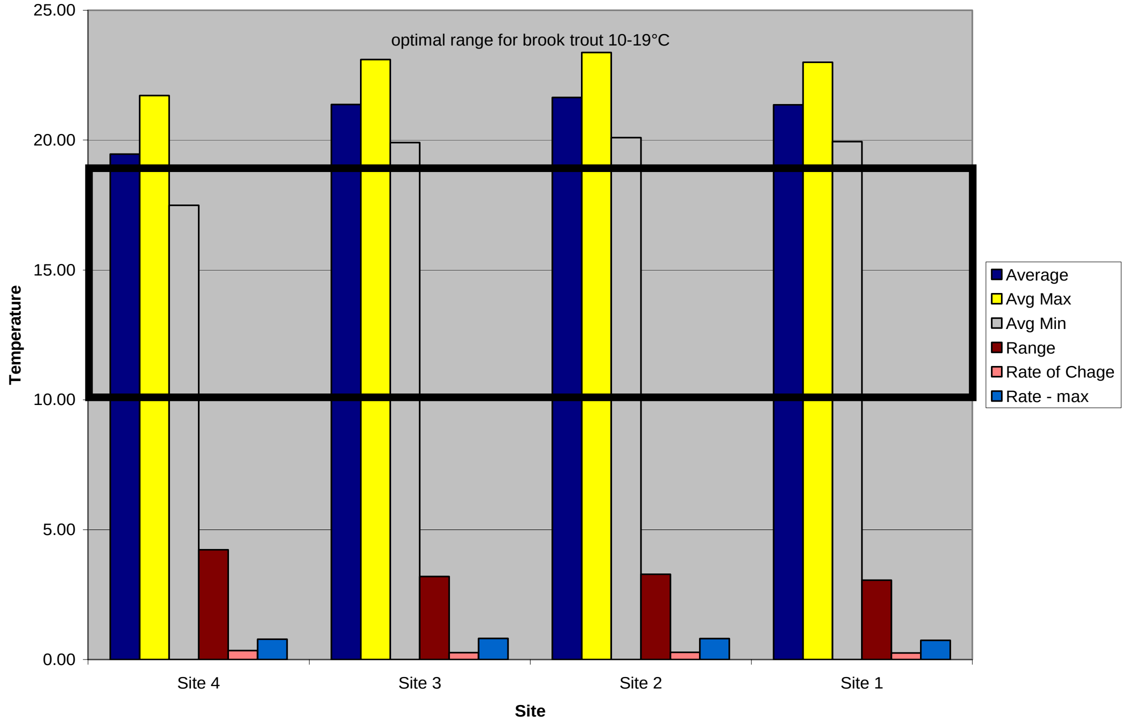


Figure 2: Summary of summer data from all sites. Average daily temperature, average maximum and minimum temperature, average daily range, average daily rate of change and absolute maximum rate of change were calculated for July and August.

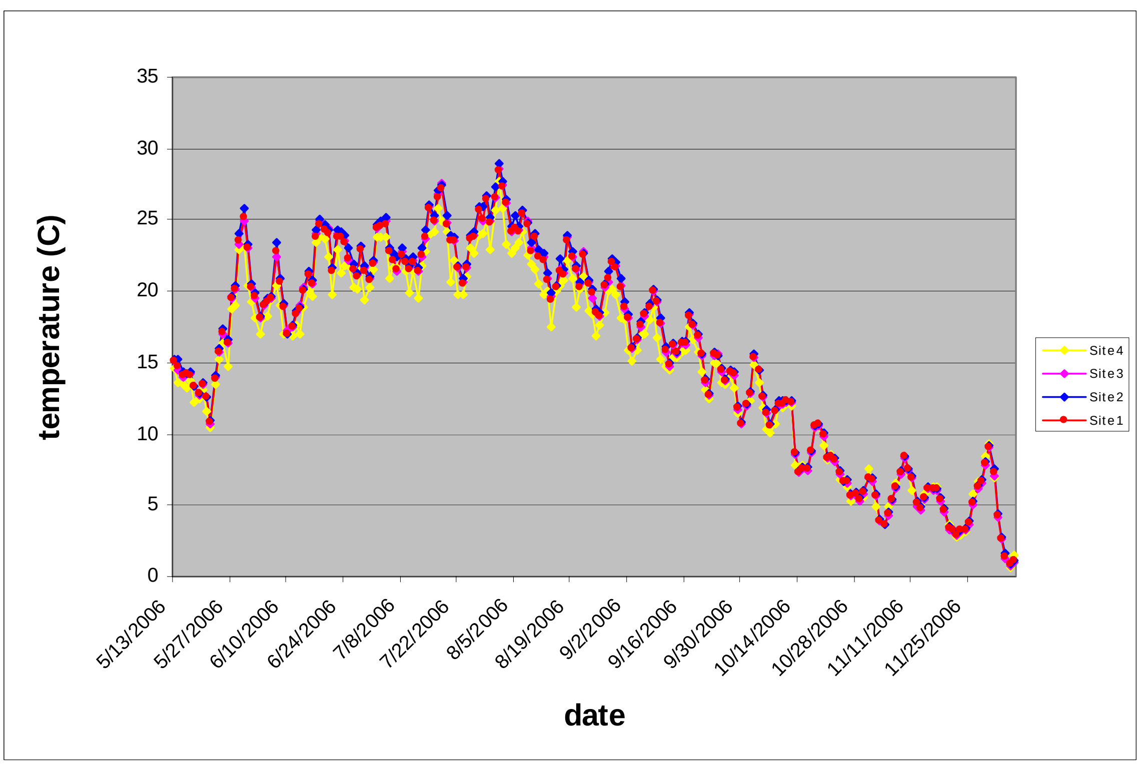


Figure 3: Maximum daily temperature. Sites are listed upstream (site 4) to downstream (site1).

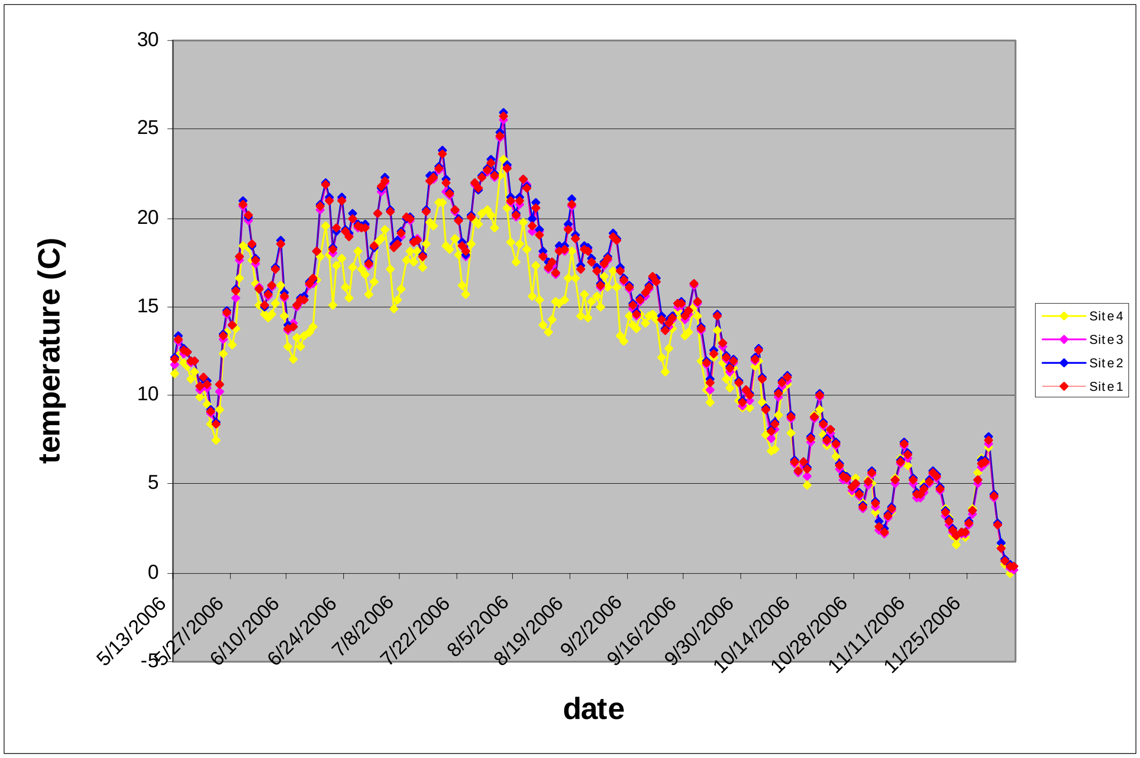


Figure 4: Minimum daily temperature.

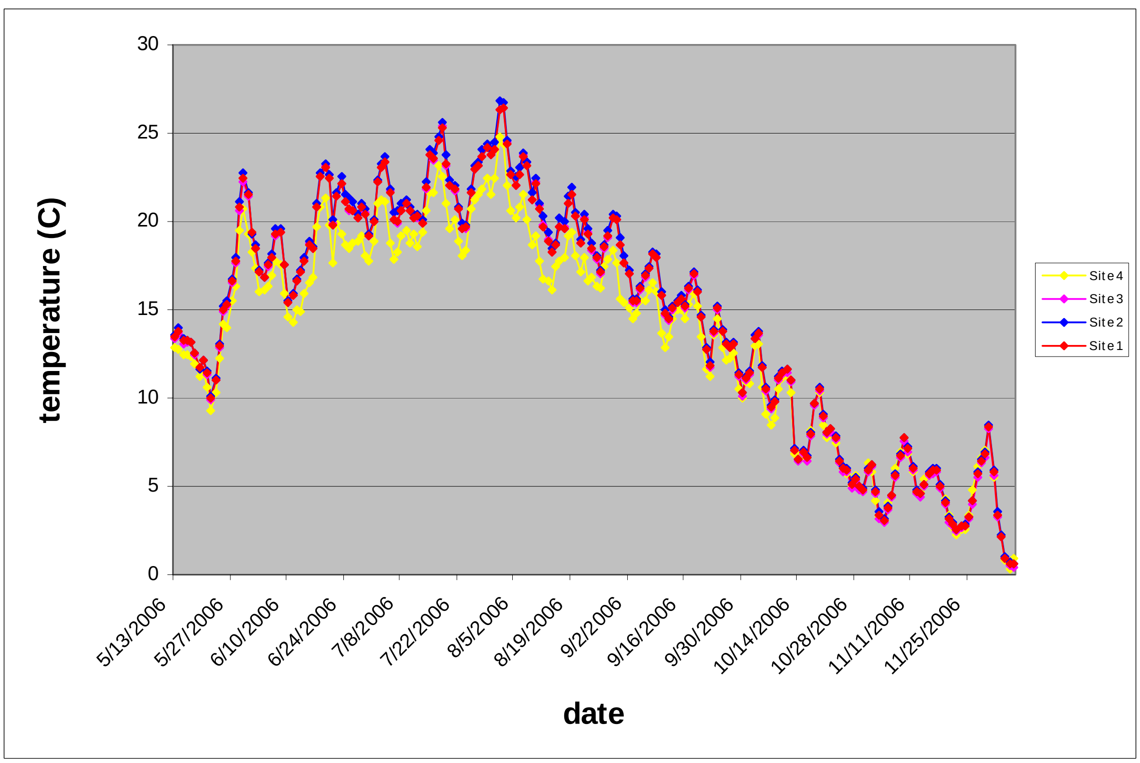


Figure 5: Average daily temperature.

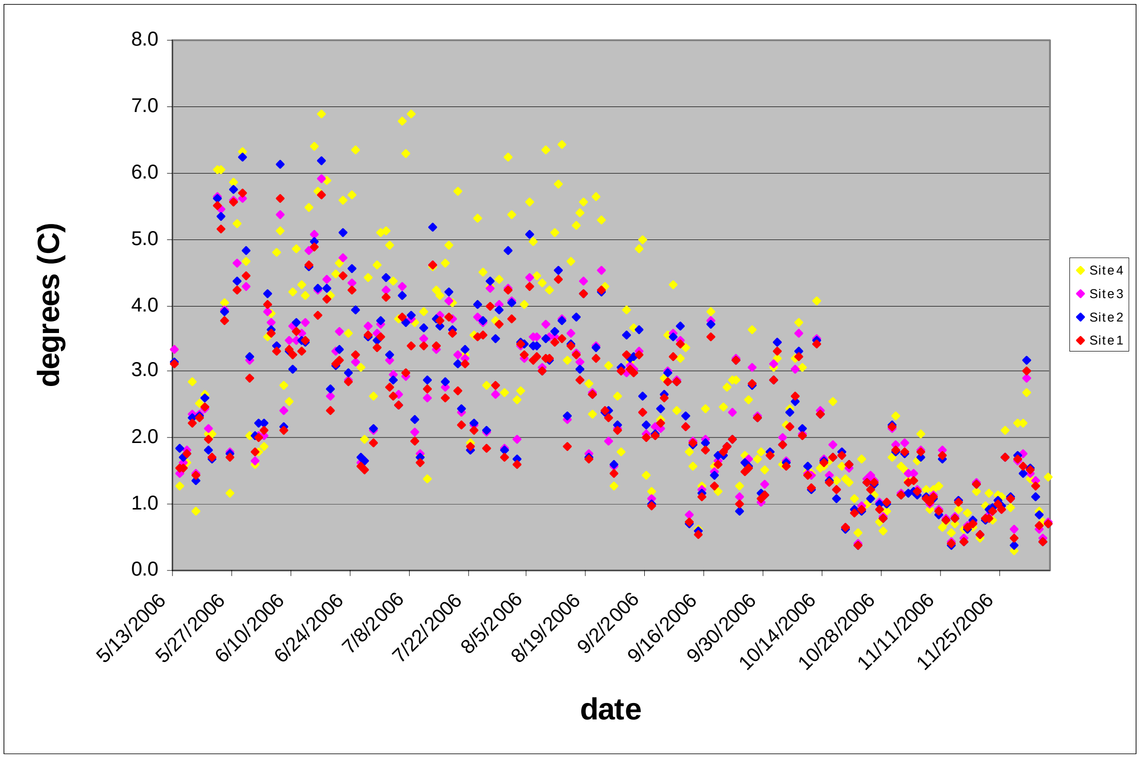


Figure 6: Daily range in temperature.

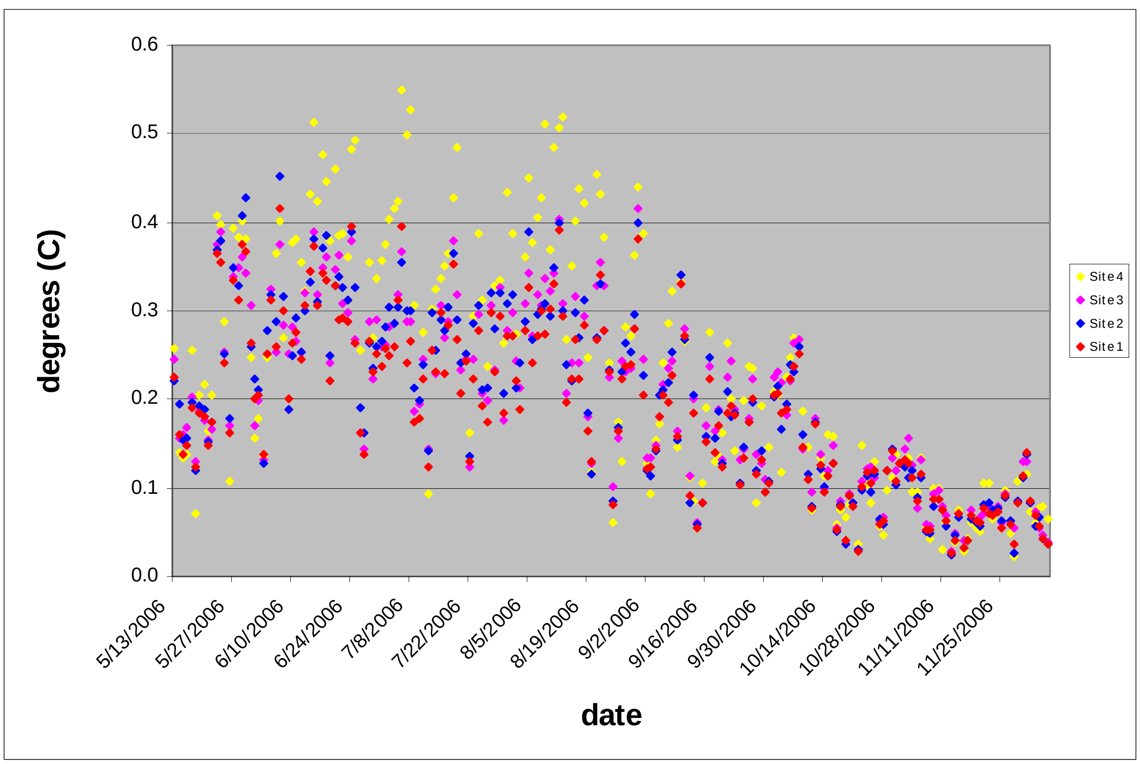


Figure 7: Daily average hourly rate of change in temperature.

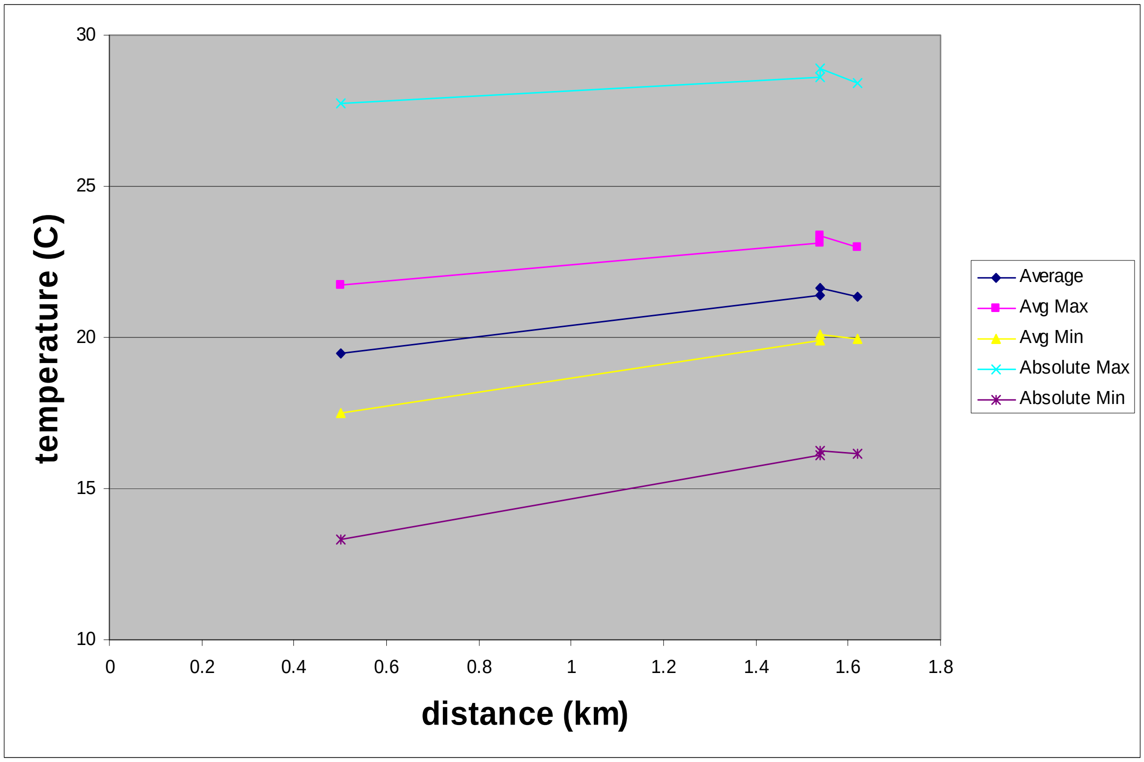


Figure 8: Longitudinal chart showing change in temperature from upstream to downstream during peak summer months (July and August).

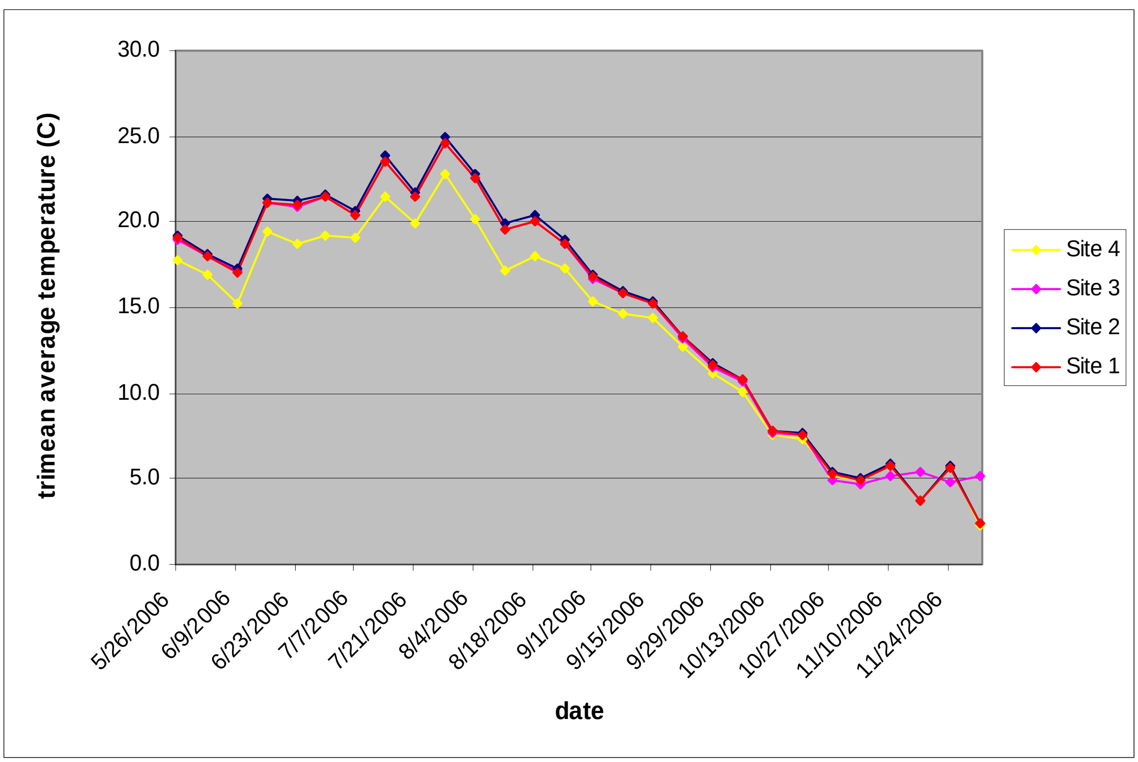


Figure 9: Trimean weekly average temperatures by site.

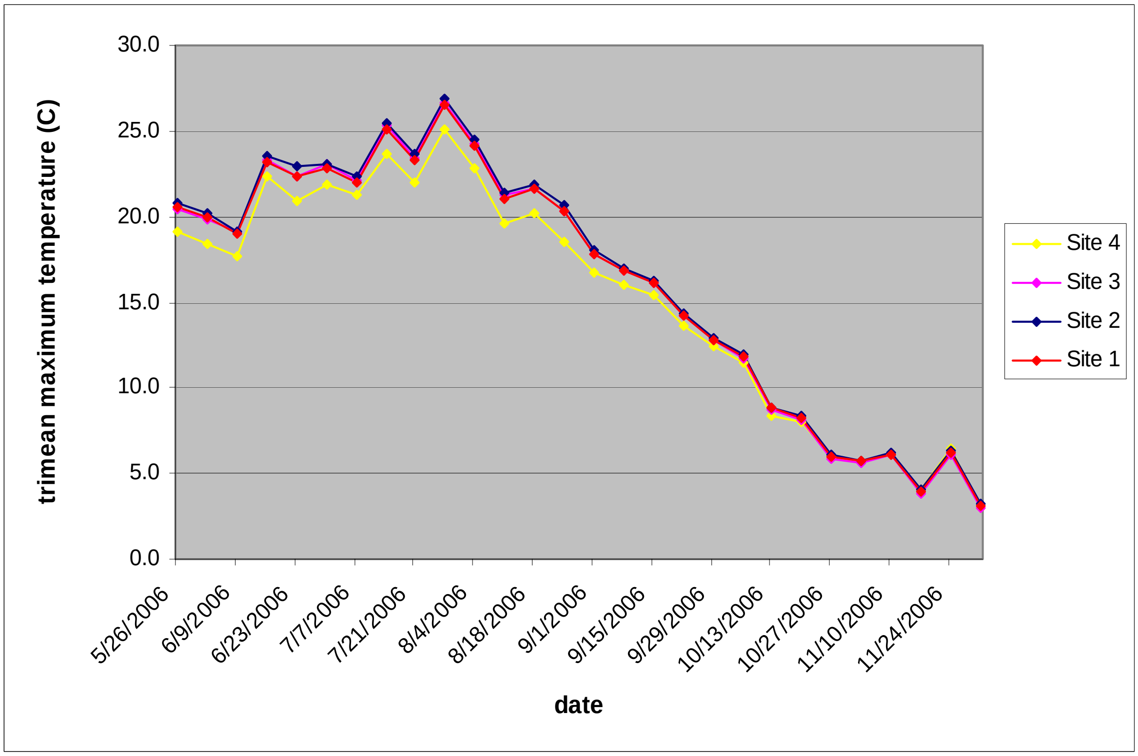


Figure 10: Trimean weekly maximum temperatures by site.

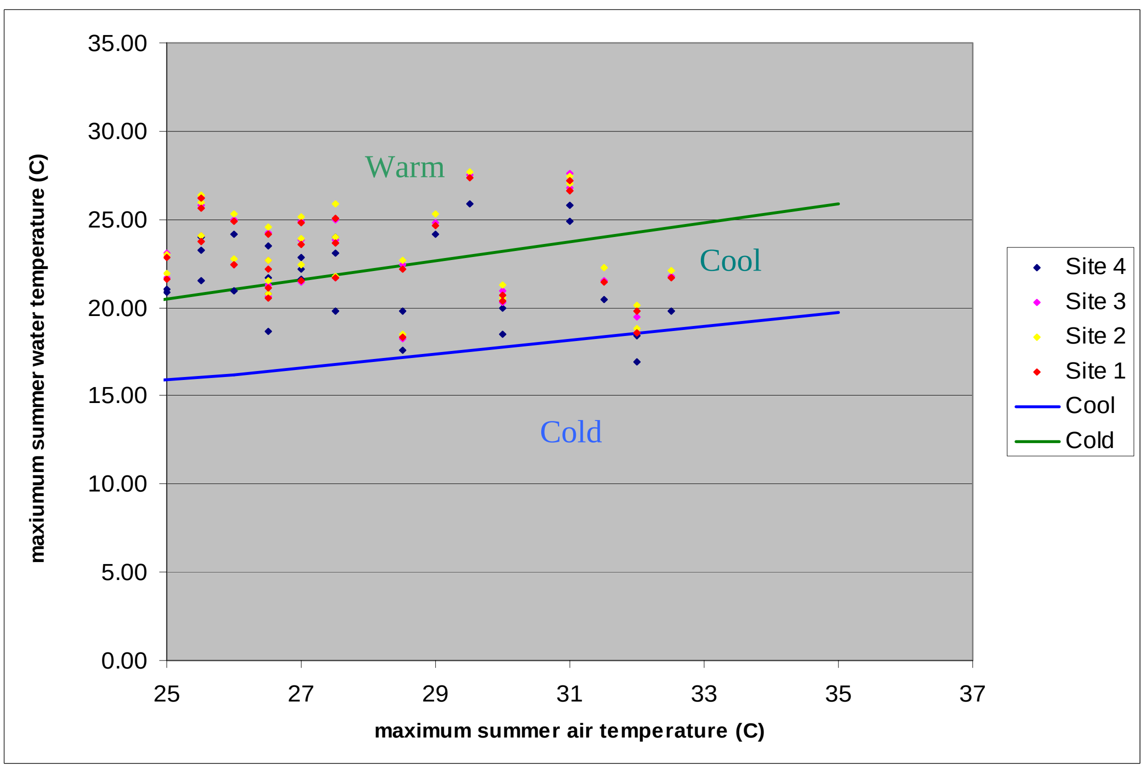


Figure 11: Stream classification of all sites (format from Stoneman and Jones 1996). Sites plotted below blue line classify as cold water, between blue and green classified as cool water and above green classified as warm water sites.

Implications

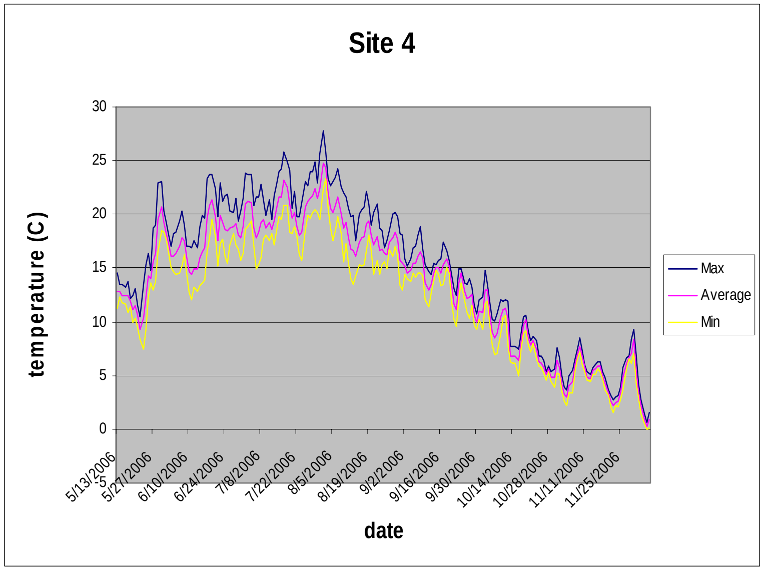
The 2006 temperature data indicate that this system is a cool to warm water system. Longitundinal trends and detailed daily data indicate warming due to Palgrave Mill pond. Interestingly, cooling was observed downstream of the dam and likely indicates groundwater inflows and therefore mitigation of temperatures. Even with this cooling, the warmer tempertures from the pond have implications on the maximal extent of the coolwater system downstream to Bolton. The observed temperatures for surface waters coming over the dam and subsurface water temrperatures from the inflow of the fishway show no discernable difference indicating that the depth of the bottom draw fishway does not provide cooler water resulting from stratification. The water coming out of the headpond and the site downstream of the dam display temperature regimes during the summer that would be considered lethal to brook trout. While the upper most site is tolerable for this species, it does rise above the optimal summer temperatures during the summer months.

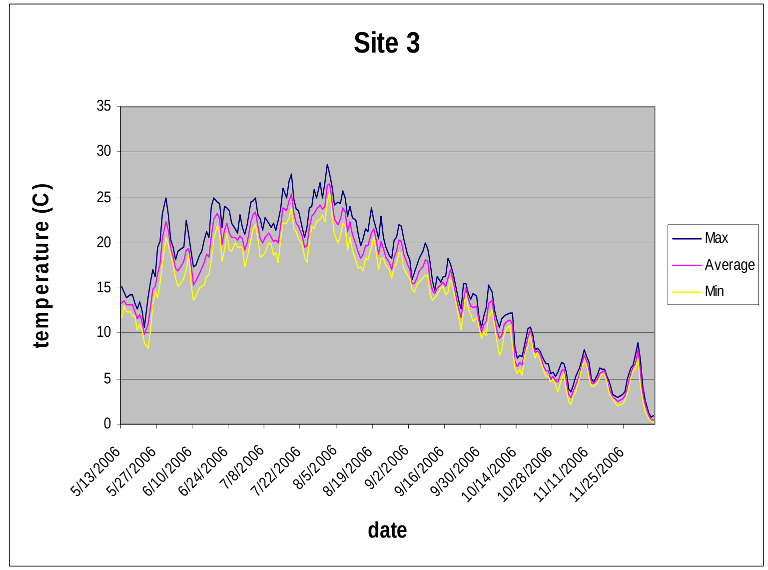
To maintain or improve brook trout populations in this reach, it is necessary to maintain the coolest temperatures possible throughout the reach. Upstream of the impediment, factors effecting temperatures should be identified, assessed and mitigated where possible. Monitoring of the warming effects of the dam and headpond should continue to identify potential temporal trends. Potential mitigation strategies should be investigated.

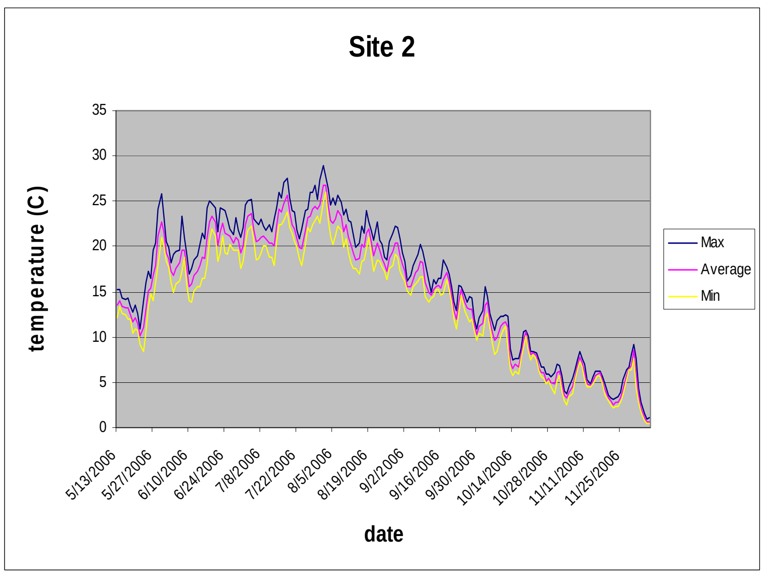
Additional monitoring sites both upstream and downstream of current sites would be beneficial in aiding in our understanding of the longitudinal profile and the potential effects of the headpond. The exclusion of site 2 (immediately below the dam) would be considered acceptable given the lack of variability in temperatures between this site and the site within the fishway. To understand the effects of these temperature trends on the movements of fish through the fishway, it would be necessary to correlate these data to individual species movement data within the fishway.

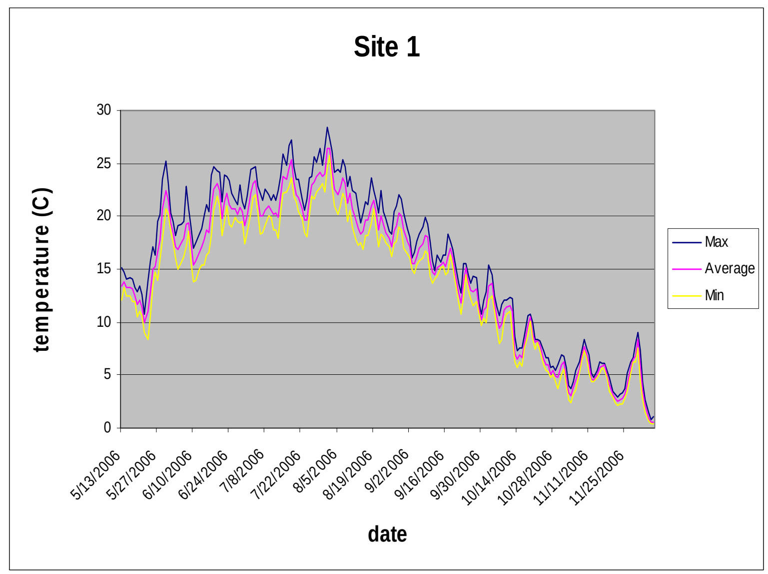
This system displays the potential for the maintenance and enhancement of existing cool-water communities. However, it is important to continue monitoring these sites in order to separate warming due to changes in the watershed from yearly natural fluctuations in temperature. Long term monitoring of this system will aid our understanding of the affects of the impoundment and groundwater contributions.

Appendix A Individual Site Data
Displaying Daily Maximum, Average & Minimum Temperatures









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