

Temperature Profiling Within the Trout Creek Sub-Watershed 2013



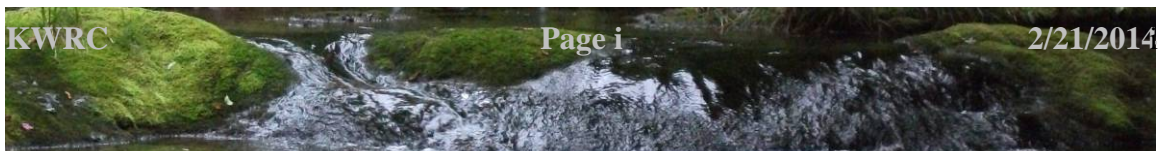
Prepared by the
Kennebecasis Watershed Restoration Committee
January 2014



A partnership project between the KWRC and Agriculture and Agri-Foods Canada

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1.0 Introduction

In 1994 the Kennebecasis Watershed Restoration Committee completed a detailed habitat assessment on over 280km of river. One finding of that report was that elevated water temperatures are limiting the ecological health of the river. In 2013, in partnership with Agriculture and Agri-Food Canada (AAFC), we were able to conduct temperature profiling at six locations within the Trout Creek sub-watershed. This was done by strategically placing temperature data loggers in locations on three separate tributaries of the Trout Creek. These were left in the stream for a total of 166 days, taking temperature readings every half hour. This project was taken on in effort to obtain baseline data to determine fluctuations in water temperatures from the head of a system to a lower location. The data obtained from the data loggers was organized, condensed and analyzed. These were compared to historical data as well as air temperature data.

2.0 Data Collection and Review Process

2.1 Installation and Data Collection

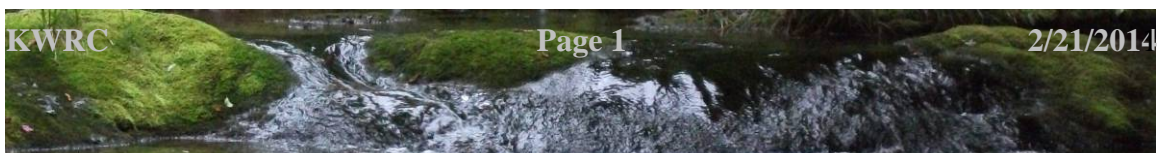
All temperature readings were taken using TidbiT v2 Temp Loggers. A three foot piece of rebar was hammered into the substrate until only 2-4 inches was exposed. Once the rebar was in place, a zip-tie was used to attach the logger to the rebar. It was ensured that they were installed low enough that they would remain submerged at all times, even during low flows. Despite our efforts at placing the loggers, the tidbit at the upper Trout Creek site was dry for a portion of the sampling season.

A sampling period of 166 days was used, from May 9th to October 22nd, 2013. During this period, the loggers recorded the water temperature in the stream at half hour intervals. The data was then filtered to reflect daily mean and daily max temperatures in degrees Celsius.

The loggers were all tested before being installed into the streams and the loggers were checked throughout the summer. The upper Trout Creek site was changed from the 2012 location because the depth of the 2012 site made deployment and retrieval difficult. The 2013 location, unfortunately, experienced a channel movement which resulted in the tidbit being left on a dry gravel bar for a portion of the season and thus the data is not suitable for ongoing monitoring purposes.

2.2 Data Analysis

Once removed from the streams, the data loggers were downloaded to the computer via the Hoboware Software. Through this program we were able to quickly copy data series into corresponding tables, filter the data to attain daily means and daily maximum temperatures, and then export them into an MS Excel spreadsheet so they could be presented more aesthetically.



Each logger had more than 6500 readings thus the need to filter the data to approximately 180 mean and 180 maximum readings. This allowed for better graphing and analysis. Further to the daily mean and max, the KWRC counted the days for each site that registered above 18°C and 20°C and flagged each of these. These temperatures are considered flag levels for various issues such as fish health problems and algal blooms.

Air temperature data was retrieved from the Environment Canada weather office website. By searching the online Climate Data Archives, daily high, low and average air temperatures for each day of water temperature profiling were obtained. These air temperatures were recorded from the Mechanic Settlement station as it was the station in closest proximity to the sampling area. Rain fall information was also collected from this same Environment Canada resource.

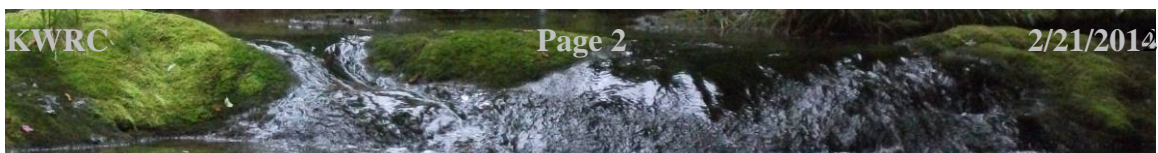
Graphs were generated in order to compare air and water temperatures as well as fluctuations within the streams. These can be found in later sections of the report and the complete data sets can be found in the appendix. Efforts were made to also compare temperature data from past years on each site. Using the annual mean from the same time frames for each site a chart was generated to illustrate these trends. It should be stated that, at this time, there is not enough annual data to draw any conclusions. The charts are included in the appendix however.

3.0 Description of the Study Area

3.1 Environmental Conditions

The Kennebecasis River and its tributaries meander through a collage of geological land types and anthropogenic land-uses including vast agricultural lands, industries, recreational areas and municipalities (i.e. Village of Sussex Corner, Apohaqui, Norton, Bloomfield and the towns of Sussex and Hampton). Approximately seventy-eight percent of the watershed consists of forested lands with seventeen percent consisting of agricultural and occupied lands. The Kennebecasis Watershed is the home to a variety of different activities that directly and indirectly affect water quality. Agricultural, residential and other occupied lands directly influence the water quality of the watershed through cattle grazing, riparian vegetation removal and agricultural and municipal runoff. Residential areas such as Penobsquis, Sussex, Apohaqui, Norton and Hampton as well as rural residences, dot the entire length of the Kennebecasis River and its tributaries. Industries such as a potash mine, saw mills, and fish hatcheries are littered throughout its reaches. Recreational industries including two golf courses are also found on the Kennebecasis tributaries.

The Habitat Assessment report completed by the KWRC in 1995 indicated that elevated stream temperatures were a limiting factor to the health of the Kennebecasis. Since that time the KWRC has engaged in numerous restoration projects and recent temperature profiling will help gauge the success of such efforts.



3.2 Trout Creek Sub-Watershed

The land use in this sub-watershed is broken down as follows:

- 84% Forestry
- 11% Agriculture
- 4% Occupied
- 1% Water/Wetland

The hills around the headwaters of Trout Creek are over 350m (1150'). The valleys are often steep sided and many rock outcrops can easily be seen driving up the watershed. Trout Creek might easily be considered the most dramatic watershed within the Kennebecasis system. In its 29.1km length it drops from approximately 360m to just under 15m. There are 6 key tributaries to the Trout Creek sub-watershed.

Table 1.0: Lengths of major tributaries to the Trout Creek sub-watershed.

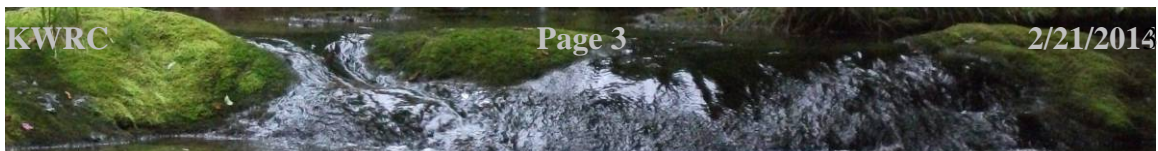
#	Name of Tributary	approx. length (km)
1	Main stem Trout Creek	29.1
2	Cedar Camp Brook	15.5
3	Shannon Brook	5.0
4	Parlee Brook	13.0
5	Mill Brook	7.6
6	Parson's Brook	8.0
7	Ward's Creek	19.1

3.3 Site Selections

The sites selected for the 2013 temperature profile study included an upper and lower site for three stream systems. These sites replicated the sites completed in 2011 and 2012 so that we could build upon the data collected through that effort. As stated earlier, problems with the Upper Trout Creek site will impact the data consistency and make it hard to perform comparisons.

3.3.1 Ward's Creek Tributary

The upper site on this tributary is located just upstream of Route 111 near the junction of Route 111 and Ward's Creek Road. The small tributary recently underwent a restoration project below the upper site and the lower site, located just above the agricultural fording site and approximately 670m below the upper site, will indicate the temperature variation between healthy and restored sites.





MAP 1: Temperature hobo locations on Ward's Creek with WC-Temp 1 being the upper site and WC-Temp 2 being the lower site. Green lines indicate sections of stream with riparian restoration work and the red ovals are fording sites.

3.3.2 Shannon Brook

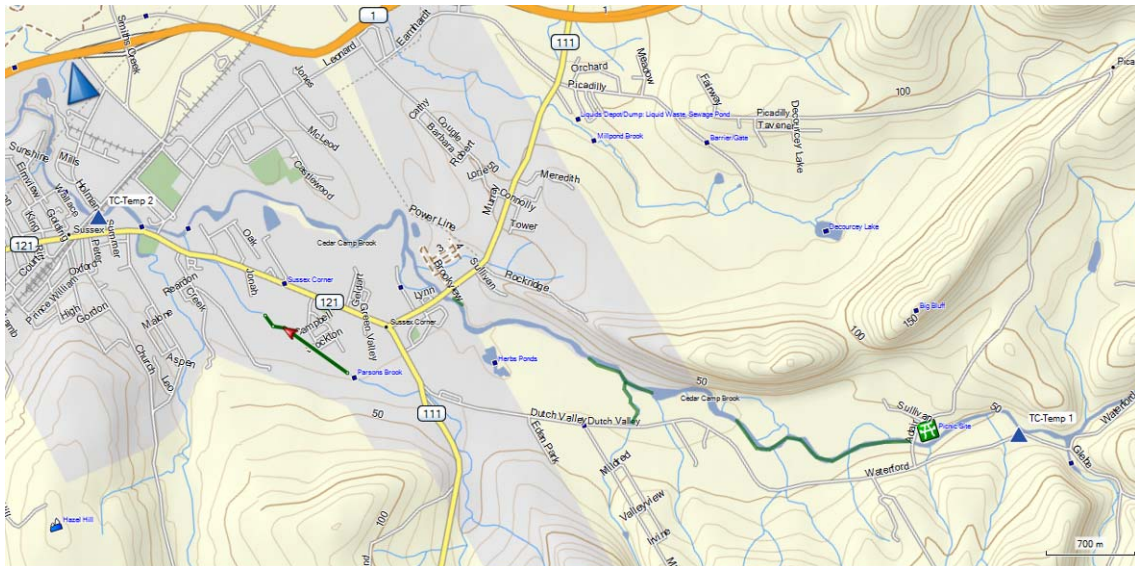
Shannon Brook is a smaller tributary to Trout Creek that has received little attention in the past. In an effort to gain more information on this stream the KWRC placed two hobos, approximately 730m apart, along its lower reaches. It is felt that this small stream is crucial to maintaining colder temperatures in the Trout Creek system as it is spring fed and has a relatively healthy riparian zone.



MAP 2: Temperature hobo placements on Shannon Brook. The green line indicates riparian restoration work sites.

3.3.3 Trout Creek

The upper site on Trout Creek is below both Parlee Brook and Cedar Camp Brook, both of which are large, cold water tributaries. To determine the impacts of the various land use changes the lower site was placed in the center of downtown Sussex. It is expected that the variation between these two sites will be large and it is hoped that over time this variation and mean temperatures will decrease as our restoration sites mature. The sites are approximately 9400m apart but sit in comparable substrate conditions.

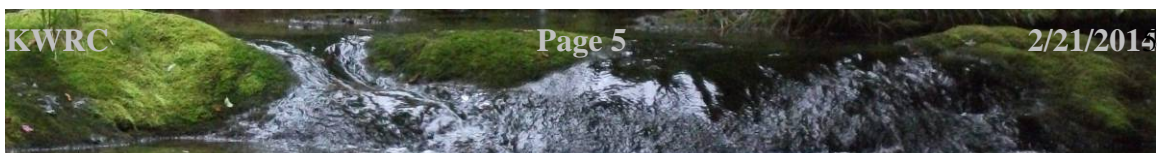


MAP 3: Temperature hobo locations on Trout Creek, TC-Temp 1 is about 500m below the confluence of Parlee Brook, while TC-Temp 2 is just above the CN Rail bridge in downtown Sussex. The green lines indicate past riparian restoration efforts.

4.0 Findings

For each site there were a total of 166 daily mean temperatures calculated. The mean temperatures were derived from the readings taken a half hour apart from May 9th to October 21nd 2012. The daily high was also used to help draw further comparisons for each site.

Annual comparisons and trends are important as well. This is especially true for the Ward's Creek sites. Comparisons of the annual average stream and air temperatures from July to October from 2011 to 2013 were created to look at trends from an annual perspective. The shorter time frame reflects the period in which data was collected in 2011 and thus gives us a true comparison year to year. Over time, this perspective will allow us to determine the effectiveness of our restoration efforts on each system we are studying. Of note, in 2013, the KWRC completed a large riparian restoration project on Shannon Brook above both tidbit stations.



4.1 Ward's Creek –Un-named Tributary

When compared to 2012 data, the results from 2013, at first glance show an improvement. This can be deceiving based on the fact that the overall air temperatures were also cooler for 2013 and this resulted in lower stream temperatures overall. The variation between the two sites in 2013 never exceeded 2°C but there were 22 days where it exceeded 1°C. The total number of days where each site exceeded 20°C was also drastically reduced due to lower air temperatures. Further data is still required before we can determine the effectiveness of the riparian restoration work on this stream.

Table 2: Ward's Creek Temperature Profile overview 2013

Upper Wards Max: Temp, °C	Lower Wards Max Temp, °C	Upper Wards Avg: Temp, °C	Lower Wards Avg. Temp, °C
7dys> 18°C	34dys> 18°C	0dys> 18°C	0dys> 18°C
0dys> 20°C	9dys> 20°C	0dys> 20°C	0dys> 20°C

The complete data tables for Ward's Creek can be found in Appendix.

4.2 Shannon Brook

This small tributary to Trout Creek is an important cold water buffer and thus the KWRC is striving to maintain the ecological and physiological integrity. Temperatures on this system, like that on the other sites, showed a strong relationship to air temperature, as indicated by the similar decrease in the 2013 mean air and water temperatures. Neither of the Shannon Brook sites exceeded 20°C in 2013, while the Upper site only exceeded 18°C once and the lower site, only 6 times. This is a huge difference over 2012 where there were 30 and 45 days respectively for days over 18°C.

Table 3: Shannon Brook Temperature Profile Overview 2013

Upper Shannon Max: Temp, °C	Lower Shannon Max: Temp, °C	Upper Shannon Avg: Temp, °C	Lower Shannon Avg: Temp, °C
1dys> 18°C	6dys> 18°C	0dys> 18°C	0dys> 18°C
0dys> 20°C	0dys> 20°C	0dys> 20°C	0dys> 20°C

The tabular results for the temperature loggers placed on Shannon Brook can be found in the Appendix. With a riparian restoration site completed and future work anticipated in this tributary, it will be interesting to see if this data changes.

4.3 Trout Creek

Unfortunately, due to the upper data logger being dry for most of the season, it was impossible to make a comparison between the upper and lower sites. The only information that can be used in 2013 is the temperature data collected for the lower site. This site was compared to previous years including data collected in 1995 and 2000.

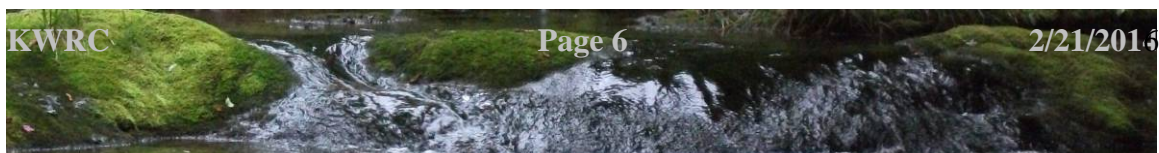


Table 3: Trout Creek Temperature Profile Overview

Max: Upper Trout Temp, °C	Avg: Upper Trout Temp, °C	Max: Lower Trout Temp, °C	Avg: Lower Trout Temp, °C
n/a	n/a	37dys > 18°C	16dys > 18°C
n/a	n/a	24dys > 20°C	0dys > 20°C

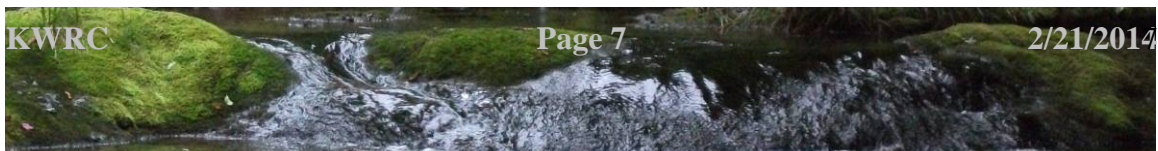
The tabular results for Trout Creek can be found in Appendix.

We now have five years of data on the lower site and the strong indication is that stream temperatures on the lower portion of the stream are likely impacting its ecological function. Through 2013, which was not an overly warm summer, there were 24 days where stream temperatures rose over 20°C and this has a huge implication on fish health and water quality. With high stream temperatures in the main stem of Trout Creek, it indicates that further work is needed to improve riparian zones and suggests as well that storm water handling may also need to be investigated.

5.0 Discussion

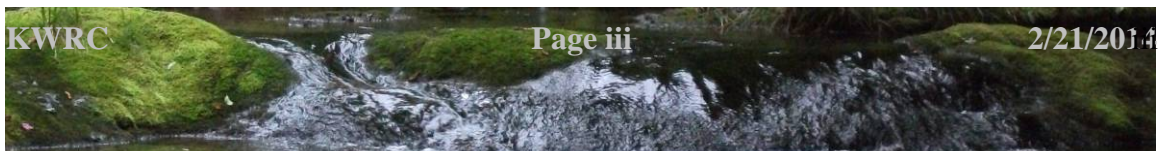
Stream temperatures are crucial in maintaining habitat connectivity and maintaining good water quality. As water temperatures rise the risk of other problems becomes more elevated. The KWRC hopes that as more stream temperature data is collected they can show a direct link between their riparian zone restoration work and water temperature profiles. It is hoped that over time at the Ward’s Creek and Shannon Brook sites that a decrease in the water temperature variation between the upper and lower sites will be realized. This will indicate that riparian restoration works completed are working effectively. It is hoped that as more work is completed on Trout Creek that a similar trend will begin to appear.

Monitoring daily temperatures is also an excellent way to identify drastic short term spikes over background levels. These spikes could indicate potential point source pollution issues as point source discharge is often warmer than natural waters. The daily temperatures also show the impacts of rain and run-off events when looked at more closely. Comparing annual means will help look at the impacts of the changing climate on our rivers and aid in directing where our restoration efforts need to be directed.



APPENDIX A

2013 Raw Stream Temperature Data

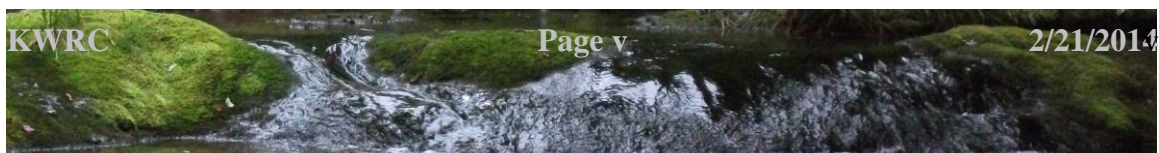


Shannon Brook Data

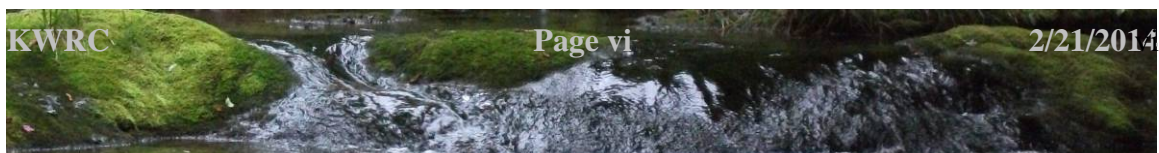
Upper Shannon Max: Temp, °C	Lower Shannon Max: Temp, °C	Upper Shannon Avg: Temp, °C	Lower Shannon Avg: Temp, °C	Max Air Temp °C	Avg Air Temp °C	Rain Amt (cm)	Mean Variation
13.185	14.002	10.567	11.198	18	14.1	0	-0.631
11.953	12.703	10.443	11.07	19.1	14.2	0.04	-0.627
11.248	11.734	10.03	10.575	15.6	11.8	0.91	-0.545
11.516	12.074	10.624	11.118	13.8	11.8	1.09	-0.494
12.316	13.353	9.894	10.475	11.8	6.9	0	-0.581
8.891	9.361	7.574	7.98	9	5.7	0.05	-0.406
11.637	12.34	8.441	8.846	12.5	7.3	0.11	-0.405
10.173	10.345	8.183	8.486	14.2	9	0.81	-0.303
8.17	8.519	7.534	7.82	7.5	4	0.07	-0.286
9.361	9.558	7.073	7.281	5.5	2	0.07	-0.208
11.516	12.05	7.594	7.913	11.9	5.3	0.23	-0.319
8.195	8.444	7.082	7.341	7.7	5.3	0.36	-0.259
9.509	9.78	8.168	8.426	12.5	9.3	0.09	-0.258
9.756	10.051	7.998	8.233	10.4	8.4	0.2	-0.235
10.59	10.883	9.129	9.361	14.7	10.6	0	-0.232
13.305	13.329	11.856	11.981	16.5	12.3	6.4	-0.125
11.613	11.783	9.448	9.677	8.9	6.7	1.62	-0.229
9.361	9.805	8.342	8.645	10.7	7.8	0.29	-0.303
8.891	9.188	7.823	8.089	10.3	7.1	0	-0.266
10.834	11.443	8.162	8.473	16.5	9.4	0	-0.311
11.662	12.364	8.759	9.134	19.8	12.2	0.74	-0.375
10.883	11.37	9.533	9.975	18.9	14.9	0.03	-0.442
14.625	15.414	11.044	11.601	28.1	21.7	0.62	-0.557
15.055	16.01	11.805	12.529	28.6	19.8	0.78	-0.724
14.098	14.912	11.517	12.224	27.2	19.2	0	-0.707
11.492	12.195	10.882	11.51	16.6	13.6	0.37	-0.628
12.485	13.161	10.738	11.335	17.8	12.8	0	-0.597
12.34	13.161	9.603	10.136	16.8	11.3	0	-0.533
11.078	11.662	9.138	9.607	17.7	11.9	0	-0.469
11.929	12.413	9.797	10.317	18.2	13.6	0.07	-0.52
11.394	11.516	10.258	10.56	12.6	9.5	5.77	-0.302
9.78	10.124	9.205	9.545	10.3	8.2	0.03	-0.34
11.88	12.509	9.768	10.21	20.3	14.6	0	-0.442
9.632	10.001	9.012	9.38	16.9	13.7	0.58	-0.368
10.81	10.932	9.685	9.942	10.5	9.5	3.06	-0.257
9.756	10.075	9.074	9.352	14.2	10.8	0	-0.278
9.163	9.46	8.247	8.466	13.4	10.2	0.1	-0.219
11.151	11.613	8.993	9.279	19.4	13.6	0.21	-0.286
11.37	11.953	9.258	9.644	20.8	15.7	0	-0.386
10.712	11.175	9.428	9.85	20.4	15	0	-0.422
12.292	12.92	10.022	10.496	19.4	15.4	0	-0.474
11.807	12.413	9.821	10.322	19.6	15.3	0	-0.501
11.662	12.292	9.551	9.986	21.7	16.5	0	-0.435
12.509	12.968	10.31	10.836	21.9	16.1	0	-0.526
11.856	12.413	10.161	10.657	22.7	18.3	0	-0.496



13.137	13.714	10.752	11.261	24.6	19.1	0.26	-0.509
13.522	14.194	11.314	11.902	24.4	19.2	0	-0.588
15.079	15.772	12.439	13.095	28.3	22.2	0	-0.656
12.219	13.064	11.205	11.842	17.2	12.3	0.55	-0.637
10.345	10.761	9.884	10.351	15	11	0.61	-0.467
12.437	12.606	10.693	11.018	16.4	13.9	5.11	-0.325
13.882	14.194	13.171	13.41	19.6	17.6	3.8	-0.239
14.194	14.888	12.985	13.58	18.3	16.3	0	-0.595
13.088	13.978	11.834	12.607	24.2	19.1	0.31	-0.773
11.2	12.001	10.607	11.3	15.8	13.5		-0.693
12.389	13.088	10.734	11.352	22.7	17.6		-0.618
14.577	15.485	12.014	12.716	27.4	23.2	0	-0.702
15.7	16.701	12.913	13.732	29.1	25.1	0	-0.819
14.433	15.366	12.633	13.485	27.8	24	0	-0.852
15.7	16.677	12.921	13.767	28.9	23.5	0	-0.846
12.582	13.497	11.922	12.751	20.3	16.8	0	-0.829
13.449	14.218	11.388	12.055	22.3	17.3	0	-0.667
13.257	13.834	11.582	12.131	18.7	14.7	0	-0.549
14.625	15.127	13.182	13.745	23.7	19.9	0.81	-0.563
15.27	16.249	13.045	13.786	23.4	18.2	0	-0.741
15.39	16.415	12.682	13.46	26.6	21.9	0	-0.778
16.106	17.082	13.173	13.971	29.1	23.1	0	-0.798
17.011	18.033	13.97	14.85	31.1	26.1	0	-0.88
16.106	17.177	14.093	15.014	24.2	19	0	-0.921
14.697	15.366	13.353	14.127	23.4	18.5	0.26	-0.774
16.892	18.033	14.513	15.389	26.1	21.5	0	-0.876
15.27	15.867	13.681	14.515	21.4	18.1	0.71	-0.834
17.748	18.771	15.154	16.001	28.5	22.6	0.03	-0.847
15.748	16.939	14.032	14.969	19.9	15.8	0	-0.937
15.342	16.487	12.773	13.613	23.7	18.3	0	-0.84
13.906	14.29	13.003	13.634	18.5	15.6	4.76	-0.631
16.892	17.605	14.672	15.267	23.5	19.6	0	-0.595
14.625	15.533	13.742	14.554	19.9	16.1	1	-0.812
18.033	18.176	14.763	15.179	24.4	20.3	4.5	-0.416
17.748	17.962	15.528	15.961	20.2	16.2	0.08	-0.433
15.103	15.676	13.894	14.463	20.8	17.1	0.19	-0.569
13.786	14.361	13.089	13.692	20.9	17.3	0.08	-0.603
14.361	15.103	13.124	13.806	23.2	19	0	-0.682
14.864	15.676	12.798	13.454	21.9	17.9	0	-0.656
15.127	15.891	12.897	13.628	24.6	19.3	0	-0.731
13.185	13.81	12.329	12.963	19.3	16.4	0.03	-0.634
15.031	15.796	13.121	13.778	22.1	17.6	0	-0.657
14.529	15.414	12.534	13.236	23	18	0.03	-0.702
13.401	13.906	12.206	12.821	19.5	15.7	1.24	-0.615
14.697	15.652	12.769	13.386	20.8	15.5	0	-0.617
14.864	15.772	12.472	13.093			0	-0.621
13.281	13.834	12.099	12.653				-0.554
14.601	14.888	13.454	13.873	18.1	16.8	3.36	-0.419
16.773	17.582	14.946	15.43	23.8	18	0.14	-0.484
14.745	15.605	12.858	13.473	21.1	16.1	0	-0.615



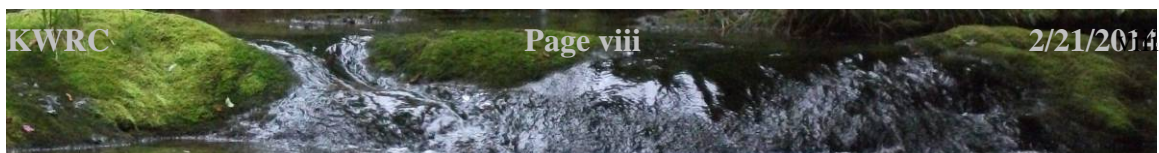
15.151	16.034	12.785	13.433	23.6	18.3	0	-0.648
14.936	15.748	12.803	13.567	23.2	17.2	0	-0.764
15.175	16.034	13.363	14.124	22.1	17	0	-0.761
14.314	15.199	12.667	13.411	20.5	15	0	-0.744
14.481	15.366	12.248	12.948	22.2	16.9	0	-0.7
14.242	15.199	12.133	12.872	21.5	15.6	0	-0.739
14.505	15.485	11.967	12.634	23.5	18.2	0	-0.667
15.294	16.129	12.939	13.636	24.8	19.8	0	-0.697
14.433	15.175	12.848	13.596	23.2	19.4	0	-0.748
16.725	17.653	14.137	14.89	26.4	20.6	0	-0.753
17.368	18.247	15.253	16.056	26.8	20.8	0	-0.803
15.557	16.511	14.434	15.311	20.3	14.6	0.11	-0.877
14.074	15.127	12.1	12.898	19.9	14	0.07	-0.798
14.146	15.103	11.568	12.265	23.3	18.3	0	-0.697
12.896	13.329	11.822	12.356	17.1	13.6	0	-0.534
15.652	16.534	13.469	14.142	24.7	19.1	0	-0.673
14.745	15.461	13.289	13.959	25.8	19.6	0.68	-0.67
13.69	14.17	13.185	13.733	14.1	12.5	0.14	-0.548
13.954	14.721	12.757	13.336	18.6	14.4	0.11	-0.579
14.577	15.39	12.982	13.603	22.7	18.1	0.19	-0.621
14.96	15.342	14.046	14.537	19.7	16.6	1.84	-0.491
13.93	14.361	13.577	14.009	16.4	14.9	1.16	-0.432
15.939	16.249	15.273	15.521	19.6	17.9	3.33	-0.248
16.153	16.892	14.946	15.458	22.1	16.7	0	-0.512
13.858	14.505	12.23	12.76	13.2	9.2	0.18	-0.53
11.734	12.316	9.763	10.172	15.6	9.8		-0.409
13.329	13.882	11.216	11.587	19.1	13.4	0.04	-0.371
12.001	12.461	11.572	11.97	13.2	8.6	1.45	-0.398
11.321	11.88	9.523	9.892	14.9	9	0	-0.369
11.953	12.316	10.891	11.135	14.6	12.1	0.03	-0.244
14.098	14.625	12.685	13.11	18.8	16.2	0.23	-0.425
15.151	15.629	13.786	14.234	22.7	19.6	0	-0.448
14.96	15.366	14.464	14.898	19.8	17.7	0.8	-0.434
14.936	15.557	13.771	14.294	18.8	14.7	0	-0.523
13.522	14.266	12.275	12.811	17.7	12.6	0	-0.536
12.098	12.582	11.271	11.727	13.9	7.4	0.14	-0.456
10.467	11.029	8.866	9.268	13.7	6.8	0	-0.402
11.394	11.904	9.102	9.397	18.6	12.8	0	-0.295
11.759	12.316	9.61	9.93	20.7	14.9	0	-0.32
12.582	12.823	10.84	11.135	16	12.7	0	-0.295
13.81	14.457	12.017	12.361	19.8	15.4	0	-0.344
15.318	15.533	13.456	13.683	22	17.3	2.68	-0.227
14.218	14.433	12.175	12.496	13.1	9.2	0.05	-0.321
10.345	10.614	9.958	10.225	8.1	6.7	0	-0.267
10.687	10.883	9.855	10.076	10.2	7.9	1.17	-0.221
11.224	11.394	10.495	10.666	9.4	8.7	0.65	-0.171
12.074	12.558	10.68	10.949	15.1	11.2	0	-0.269
10.785	11.297	8.802	9.104	20.3	14	0	-0.302
11.467	11.953	9.324	9.546	21.7	15.5	0.06	-0.222
10.663	10.98	8.894	9.13	17.7	13	0	-0.236



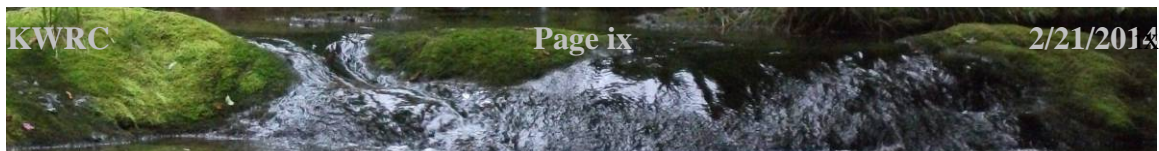
10.687	10.98	9.925	10.165	13.7	11.7	2.3	-0.24
12.025	12.485	10.042	10.416	20.6	15.5	0	-0.374
11.419	11.953	9.984	10.325	16.9	12.9	0	-0.341
10.149	10.663	8.888	9.192	14.3	9.6	0	-0.304
9.238	9.46	7.595	7.816	12.5	8	0	-0.221
8.319	8.717	6.814	7.007	12.2	6.5	0.08	-0.193
11.078	11.029	8.733	8.802	15.7	11	0.46	-0.069
12.968	12.871	11.516	11.663	16.7	10.7	0.76	-0.147
9.064	9.534	7.531	7.78	14.1	9.1	0	-0.249
9.903	10.149	7.759	7.906	19.2	13.1	0	-0.147
10.394	10.687	8.448	8.585	19	12.1	0	-0.137
9.632	9.805	7.902	8.096	10.5	6.4	0	-0.194
7.519	7.92	5.764	5.944	12.5	7.8	0.4	-0.18
8.369	8.618	6.346	6.428	15.4	10.8	0.03	-0.082
10.394	10.761	8.992	9.149	16	10.7	0	-0.157
10.222	10.247	8.77	8.953	12.8	9	1.51	-0.183
12.34	12.703	11.014	11.167	18.8	13.9	0	-0.153
10.638	10.907	9.787	9.971	11.5	9.5	0.19	-0.184
9.952	10.369	9.031	9.251	13.4	9.7	0	-0.22
9.854	10.001	8.667	8.774	11.3	7.4	0.38	-0.107
7.995	8.369	6.752	6.882	8.9	5.2	0	-0.13
13.132	13.684	11.548	11.999	18.125	13.746		
1dys>	6dys>						
18°C	18°C						
0 dys>	0dys>						
20°C	20°C						

WARD'S CREEK DATA

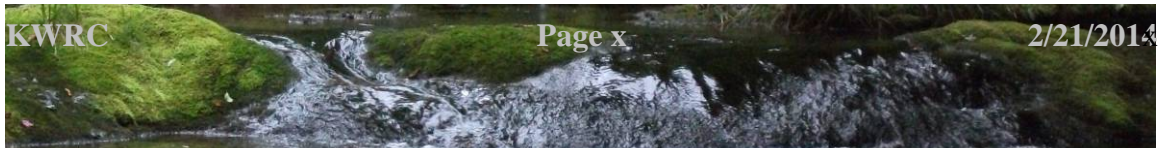
Upper Wards Max: Temp, °C	Lower Wards Max Temp, °C	Upper Wards Avg: Temp, °C	Lower Wards Avg. Temp, °C	Max Air Temp °C	Avg Air Temp °C	Rain Amt (cm)	Variation
15.557	16.939	12.748	13.58	18	14.1	0	-0.832
15.223	16.63	12.997	13.774	19.1	14.2	0.04	-0.777
13.522	14.457	12.261	12.874	15.6	11.8	0.91	-0.613
12.582	13.329	12.012	12.526	13.8	11.8	1.09	-0.514
13.834	15.366	11.378	12.007	11.8	6.9	0	-0.629
10.001	10.956	8.762	9.127	9	5.7	0.05	-0.365
13.401	14.792	9.458	10.174	12.5	7.3	0.11	-0.716
11.734	12.678	9.288	9.729	14.2	9	0.81	-0.441
9.41	9.632	8.451	8.728	7.5	4	0.07	-0.277
9.632	11.175	7.44	7.94	5.5	2	0.07	-0.5
11.904	14.098	8.113	8.976	11.9	5.3	0.23	-0.863
8.817	9.386	7.972	8.227	7.7	5.3	0.36	-0.255
10.173	11.248	8.866	9.323	12.5	9.3	0.09	-0.457
10.467	11.467	8.851	9.313	10.4	8.4	0.2	-0.462
12.799	14.194	10.509	11.116	14.7	10.6	0	-0.607
14.721	13.738	12.327	12.503	16.5	12.3	6.4	-0.176
11.2	11.394	9.011	9.011	8.9	6.7	1.62	0
8.866	9.534	8.048	8.316	10.7	7.8	0.29	-0.268
8.693	9.386	7.819	8.063	10.3	7.1	0	-0.244
11.029	12.147	8.484	8.941	16.5	9.4	0	-0.457
12.171	13.353	9.295	9.838	19.8	12.2	0.74	-0.543
11.54	12.896	10.299	11.015	18.9	14.9	0.03	-0.716
15.055	16.987	11.935	13.007	28.1	21.7	0.62	-1.072
16.058	17.986	13.281	14.258	28.6	19.8	0.78	-0.977
15.557	17.415	13.03	14.032	27.2	19.2	0	-1.002
13.594	14.026	12.413	13.057	16.6	13.6	0.37	-0.644
13.281	15.127	11.978	12.825	17.8	12.8	0	-0.847
12.823	14.721	10.829	11.592	16.8	11.3	0	-0.763
12.171	13.546	10.607	11.281	17.7	11.9	0	-0.674
12.534	14.314	11.201	11.906	18.2	13.6	0.07	-0.705
11.662	12.001	11.097	11.339	12.6	9.5	5.77	-0.242
10.345	10.345	9.613	9.837	10.3	8.2	0.03	-0.224
11.856	13.377	10.168	10.88	20.3	14.6	0	-0.712
10.492	10.81	9.922	10.264	16.9	13.7	0.58	-0.342
10.956	11.053	10.221	10.429	10.5	9.5	3.06	-0.208
9.903	10.32	9.266	9.438	14.2	10.8	0	-0.172
9.435	10.149	8.748	8.995	13.4	10.2	0.1	-0.247
11.2	12.727	9.567	10.213	19.4	13.6	0.21	-0.646
11.37	13.04	10.208	10.891	20.8	15.7	0	-0.683
11.102	12.437	10.373	10.989	20.4	15	0	-0.616
12.364	14.433	11.105	12.017	19.4	15.4	0	-0.912
12.413	14.337	11.166	11.955	19.6	15.3	0	-0.789
12.34	14.649	10.943	11.671	21.7	16.5	0	-0.728



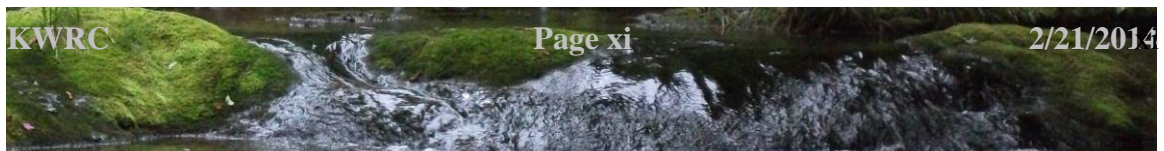
13.209	15.509	11.81	12.765	21.9	16.1	0	-0.955
13.209	14.792	11.907	12.683	22.7	18.3	0	-0.776
14.218	16.749	12.781	13.73	24.6	19.1	0.26	-0.949
14.96	17.463	13.334	14.445	24.4	19.2	0	-1.111
16.796	19.294	14.891	16.154	28.3	22.2	0	-1.263
15.39	15.796	13.744	14.247	17.2	12.3	0.55	-0.503
12.195	12.389	11.537	11.937	15	11	0.61	-0.4
13.209	13.449	11.97	12.407	16.4	13.9	5.11	-0.437
13.906	14.888	13.218	13.808	19.6	17.6	3.8	-0.59
13.666	14.745	13.068	13.746	18.3	16.3	0	-0.678
13.281	14.457	12.657	13.325	24.2	19.1	0.31	-0.668
12.847	13.305	12.087	12.473	15.8	13.5		-0.386
12.871	14.17	11.862	12.533	22.7	17.6		-0.671
14.84	16.701	13.241	14.326	27.4	23.2	0	-1.085
16.082	18.295	14.472	15.736	29.1	25.1	0	-1.264
15.557	17.486	14.639	15.705	27.8	24	0	-1.066
16.272	18.889	14.905	16.097	28.9	23.5	0	-1.192
15.414	15.939	14.347	15.061	20.3	16.8	0	-0.714
14.601	16.582	13.378	14.11	22.3	17.3	0	-0.732
14.242	15.867	13.251	13.972	18.7	14.7	0	-0.721
15.605	17.796	14.738	15.763	23.7	19.9	0.81	-1.025
16.463	18.842	15.075	16.151	23.4	18.2	0	-1.076
16.773	19.08	14.945	15.976	26.6	21.9	0	-1.031
17.677	20.269	15.706	16.892	29.1	23.1	0	-1.186
18.794	21.652	16.765	18.086	31.1	26.1	0	-1.321
18.461	21.032	17.202	18.315	24.2	19	0	-1.113
16.987	19.127	15.985	16.895	23.4	18.5	0.26	-0.91
18.557	21.366	16.948	18.215	26.1	21.5	0	-1.267
17.439	19.175	16.67	17.403	21.4	18.1	0.71	-0.733
19.413	22.513	17.744	19.136	28.5	22.6	0.03	-1.392
18.033	20.007	16.652	17.699	19.9	15.8	0	-1.047
17.13	19.841	15.143	16.323	23.7	18.3	0	-1.18
15.724	15.963	15.169	15.477	18.5	15.6	4.76	-0.308
17.938	20.484	16.224	17.344	23.5	19.6	0	-1.12
16.987	19.032	16.121	16.971	19.9	16.1	1	-0.85
17.534	18.01	16.277	16.585	24.4	20.3	4.5	-0.308
16.892	17.225	15.764	16.188	20.2	16.2	0.08	-0.424
15.318	16.534	14.607	15.234	20.8	17.1	0.19	-0.627
14.649	15.509	14.208	14.752	20.9	17.3	0.08	-0.544
15.318	16.654	14.465	15.166	23.2	19	0	-0.701
15.557	16.915	14.415	15.164	21.9	17.9	0	-0.749
16.177	18.01	14.739	15.541	24.6	19.3	0	-0.802
14.936	15.724	14.366	14.891	19.3	16.4	0.03	-0.525
15.986	17.843	14.925	15.738	22.1	17.6	0	-0.813
15.557	16.963	14.54	15.211	23	18	0.03	-0.671
14.601	16.249	13.962	14.557	19.5	15.7	1.24	-0.595
15.318	17.082	13.975	14.755	20.8	15.5	0	-0.78
15.7	17.201	14.145	14.878			0	-0.733
14.745	15.772	13.871	14.473				-0.602
16.225	16.392	14.992	15.474	18.1	16.8	3.36	-0.482



17.082	18.699	15.827	16.568	23.8	18	0.14	-0.741
15.652	17.32	14.403	15.106	21.1	16.1	0	-0.703
16.272	18.485	14.747	15.555	23.6	18.3	0	-0.808
16.272	18.366	14.952	15.759	23.2	17.2	0	-0.807
16.963	19.413	15.77	16.635	22.1	17	0	-0.865
15.772	17.701	14.787	15.517	20.5	15	0	-0.73
16.129	18.794	14.648	15.497	22.2	16.9	0	-0.849
15.7	17.748	14.46	15.215	21.5	15.6	0	-0.755
15.629	18.2	14.053	14.882	23.5	18.2	0	-0.829
17.011	19.008	15.326	16.102	24.8	19.8	0	-0.776
16.463	18.652	15.475	16.1	23.2	19.4	0	-0.625
18.152	20.984	16.505	17.601	26.4	20.6	0	-1.096
18.675	22.585	17.251	18.432	26.8	20.8	0	-1.181
17.415	19.365	16.686	17.299	20.3	14.6	0.11	-0.613
15.652	18.438	14.115	14.719	19.9	14	0.07	-0.604
15.103	18.247	13.349	14.208	23.3	18.3	0	-0.859
14.409	15.127	13.714	14.082	17.1	13.6	0	-0.368
16.749	19.508	15.295	16.354	24.7	19.1	0	-1.059
16.725	18.485	15.756	16.333	25.8	19.6	0.68	-0.577
15.796	16.129	14.984	15.382	14.1	12.5	0.14	-0.398
14.768	17.058	14.171	14.853	18.6	14.4	0.11	-0.682
16.177	19.08	14.905	15.89	22.7	18.1	0.19	-0.985
16.368	16.749	15.709	16.121	19.7	16.6	1.84	-0.412
15.557	15.986	15.187	15.518	16.4	14.9	1.16	-0.331
16.654	17.32	16.105	16.526	19.6	17.9	3.33	-0.421
16.582	17.701	16.011	16.582	22.1	16.7	0	-0.571
15.414	15.605	13.515	13.909	13.2	9.2	0.18	-0.394
12.34	13.642	10.881	11.438	15.6	9.8		-0.557
13.882	15.151	12.313	12.834	19.1	13.4	0.04	-0.521
13.522	13.69	12.833	13.1	13.2	8.6	1.45	-0.267
11.759	13.088	10.549	11.101	14.9	9	0	-0.552
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16.153	17.558	15.171	15.807	22.7	19.6	0	-0.636
16.058	17.011	15.679	16.215	19.8	17.7	0.8	-0.536
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13.353	14.05	12.578	12.85	13.9	7.4	0.14	-0.272
11.078	12.195	9.595	10.05	13.7	6.8	0	-0.455
11.759	13.497	10.194	10.731	18.6	12.8	0	-0.537
12.364	14.314	10.917	11.425	20.7	14.9	0	-0.508
13.209	15.079	12.111	12.652	16	12.7	0	-0.541
14.122	16.01	12.929	13.519	19.8	15.4	0	-0.59
17.058	17.391	14.474	14.943	22	17.3	2.68	-0.469
15.008	15.342	13.112	13.385	13.1	9.2	0.05	-0.273
11.2	11.492	10.642	10.956	8.1	6.7	0	-0.314
11.029	11.783	10.417	10.774	10.2	7.9	1.17	-0.357
11.492	12.122	10.951	11.287	9.4	8.7	0.65	-0.336
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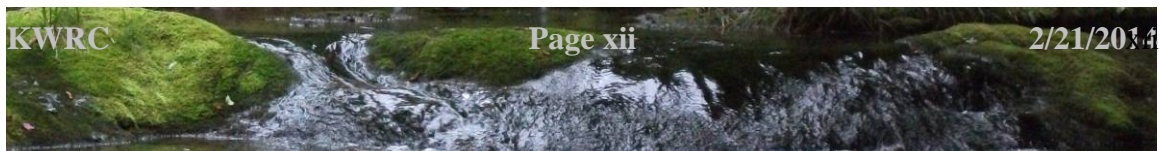


12.05	13.714	10.622	11.117	21.7	15.5	0.06	-0.495
11.419	12.534	10.137	10.491	17.7	13	0	-0.354
11.637	12.147	10.902	11.182	13.7	11.7	2.3	-0.28
12.92	14.697	11.681	12.329	20.6	15.5	0	-0.648
12.122	13.522	11.31	11.703	16.9	12.9	0	-0.393
10.834	12.122	10.127	10.463	14.3	9.6	0	-0.336
9.879	10.687	8.631	8.802	12.5	8	0	-0.171
8.519	9.977	7.562	7.793	12.2	6.5	0.08	-0.231
11.565	11.953	9.295	9.639	15.7	11	0.46	-0.344
13.69	13.762	12.056	12.403	16.7	10.7	0.76	-0.347
9.435	10.907	8.388	8.704	14.1	9.1	0	-0.316
10.638	12.243	8.97	9.305	19.2	13.1	0	-0.335
10.883	12.606	9.494	9.962	19	12.1	0	-0.468
10.394	10.712	8.608	8.887	10.5	6.4	0	-0.279
7.519	9.312	6.31	6.673	12.5	7.8	0.4	-0.363
8.643	10.369	7.021	7.505	15.4	10.8	0.03	-0.484
10.98	12.292	9.659	10.09	16	10.7	0	-0.431
11.248	11.759	9.522	9.761	12.8	9	1.51	-0.239
13.016	14.146	11.699	12.121	18.8	13.9	0	-0.422
11.734	12.05	11.105	11.373	11.5	9.5	0.19	-0.268
10.467	11.54	9.712	10.08	13.4	9.7	0	-0.368
10.345	10.761	9.39	9.526	11.3	7.4	0.38	-0.136
8.444	9.287	7.319	7.635	8.9	5.2	0	-0.316
		12.879	13.428		13.717	73.78	-0.549
	34 dys > 18°C		5dys> 18°C				
	7dys> 18°C						
	9dys> 20°C						

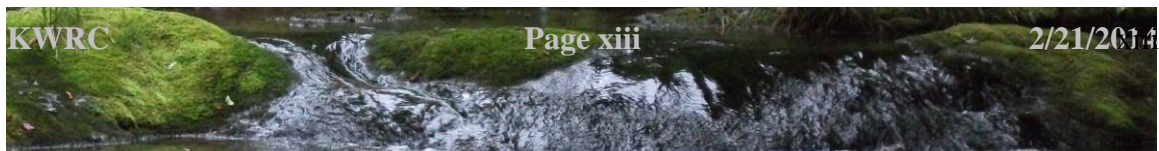


TROUT CREEK DATA

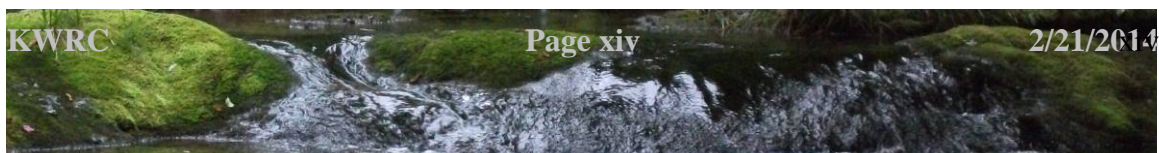
Max: Lower Trout Temp, °C	Avg: Lower Trout Temp, °C	Max Air Temp °C	Avg Air Temp °C	Rainfall Amt (cm)	Max Water Temp Variation
15.7	13.414	18	14.1	0	-1.147
15.055	13.255	19.1	14.2	0.04	-1.63
13.497	12.477	15.6	11.8	0.91	-0.939
13.522	12.558	13.8	11.8	1.09	-1.061
15.724	12.786	11.8	6.9	0	5.904
11.807	10.188	9	5.7	0.05	1.883
14.625	10.938	12.5	7.3	0.11	8.92
12.001	10.378	14.2	9	0.81	4.891
10.614	9.439	7.5	4	0.07	-1.525
11.589	9.144	5.5	2	0.07	1.186
14.481	10.5	11.9	5.3	0.23	7.53
11.54	9.559	7.7	5.3	0.36	-1.048
11.273	9.825	12.5	9.3	0.09	3.663
11.273	9.8	10.4	8.4	0.2	2.993
12.34	10.764	14.7	10.6	0	10.892
15.103	13.016	16.5	12.3	6.4	0.931
12.775	10.389	8.9	6.7	1.62	-0.919
11.102	9.555	10.7	7.8	0.29	-0.831
10.369	9.249	10.3	7.1	0	-0.909
13.425	10.178	16.5	9.4	0	-1.061
14.505	11.104	19.8	12.2	0.74	-1.441
13.69	11.961	18.9	14.9	0.03	-1.495
17.891	13.948	28.1	21.7	0.62	-1.571
18.604	15.516	28.6	19.8	0.78	-1.451
18.343	15.116	27.2	19.2	0	-1.642
15.843	14.254	16.6	13.6	0.37	-2.201
15.963	14.032	17.8	12.8	0	-1.099
16.463	13.368	16.8	11.3	0	-1.288
14.721	12.85	17.7	11.9	0	-0.599
14.912	12.977	18.2	13.6	0.07	5.977
13.546	12.278	12.6	9.5	5.77	-0.024
11.492	10.971	10.3	8.2	0.03	-0.829
16.01	12.608	20.3	14.6	0	-1.673
12.968	11.756	16.9	13.7	0.58	-1.622
11.734	11.259	10.5	9.5	3.06	-1.022
11.929	10.882	14.2	10.8	0	-1.046
11.88	10.423	13.4	10.2	0.1	-1.339
14.721	11.717	19.4	13.6	0.21	-1.32
15.27	12.572	20.8	15.7	0	-1.316
14.026	12.42	20.4	15	0	-1.42
16.439	13.577	19.4	15.4	0	-1.527
17.058	13.879	19.6	15.3	0	-1.907
15.676	13.37	21.7	16.5	0	-1.722
16.534	13.992	21.9	16.1	0	-1.526



15.676	13.923	22.7	18.3	0	0.93
17.034	14.54	24.6	19.1	0.26	4.523
17.582	15.03	24.4	19.2	0	7.265
19.151	16.612	28.3	22.2	0	9.939
17.296	15.289	17.2	12.3	0.55	-0.5
13.666	13.02	15	11	0.61	1.102
13.786	12.9	16.4	13.9	5.11	1.866
15.748	14.34	19.6	17.6	3.8	-1.291
17.011	15.235	18.3	16.3	0	-1.382
17.605	15.264	24.2	19.1	0.31	-2.024
15.27	14.118	15.8	13.5		-1.7
16.654	14.093	22.7	17.6		-1.886
19.984	16.313	27.4	23.2	0	-2.046
21.39	17.912	29.1	25.1	0	-1.954
20.007	17.88	27.8	24	0	-1.997
21.318	18.243	28.9	23.5	0	-1.501
18.794	17.052	20.3	16.8	0	-2.307
18.723	16.1	22.3	17.3	0	7.362
17.391	15.751	18.7	14.7	0	6.106
19.222	17.175	23.7	19.9	0.81	-1.26
21.032	17.878	23.4	18.2	0	8.208
21.509	18.208	26.6	21.9	0	8.91
22.106	18.723	29.1	23.1	0	10.172
23.088	19.7	31.1	26.1	0	10.983
21.987	19.942	24.2	19	0	8.104
19.984	18.538	23.4	18.5	0.26	6.932
22.537	19.487	26.1	21.5	0	8.109
20.198	18.551	21.4	18.1	0.71	5.425
22.729	19.631	28.5	22.6	0.03	8.374
21.604	19.463	19.9	15.8	0	3.897
21.485	18.644	23.7	18.3	0	8.255
19.389	17.351	18.5	15.6	4.76	0.595
21.223	17.92	23.5	19.6	0	8.718
19.77	18.276	19.9	16.1	1	4.618
18.461	17.641	24.4	20.3	4.5	-0.856
17.986	17.459	20.2	16.2	0.08	-0.88
19.199	17.116	20.8	17.1	0.19	-1.641
17.272	16.315	20.9	17.3	0.08	-1.166
18.937	17.048	23.2	19	0	-1.617
19.817	17.277	21.9	17.9	0	0.881
20.746	17.677	24.6	19.3	0	9.22
18.152	16.542	19.3	16.4	0.03	3.285
19.888	17.41	22.1	17.6	0	8.457
20.198	17.564	23	18	0.03	8.295
18.438	16.929	19.5	15.7	1.24	4.698
20.15	17.043	20.8	15.5	0	7.06
20.746	17.565			0	10.585
17.891	16.615				4.096
17.534	16.64	18.1	16.8	3.36	3.402
20.365	17.689	23.8	18	0.14	-1.666



19.27	16.812	21.1	16.1	0	-1.355
19.793	16.952	23.6	18.3	0	0.857
19.698	17.185	23.2	17.2	0	8.152
20.103	17.78	22.1	17	0	7.107
19.555	17.32	20.5	15	0	5.437
19.508	17.101	22.2	16.9	0	8.12
19.508	17.186	21.5	15.6	0	7.997
19.865	17.173	23.5	18.2	0	8.579
19.865	17.556	24.8	19.8	0	7.812
18.961	17.47	23.2	19.4	0	4.487
21.604	18.659	26.4	20.6	0	9.804
21.963	19.488	26.8	20.8	0	9.394
20.222	18.986	20.3	14.6	0.11	6.376
19.817	17.551	19.9	14	0.07	5.49
19.888	17.216	23.3	18.3	0	8.234
17.938	16.263	17.1	13.6	0	1.998
20.103	17.42	24.7	19.1	0	6.715
19.341	18.015	25.8	19.6	0.68	8.287
18.319	16.896	14.1	12.5	0.14	-1.07
18.105	16.431	18.6	14.4	0.11	4.264
19.46	17.401	22.7	18.1	0.19	5.072
18.414	17.612	19.7	16.6	1.84	-0.618
16.963	16.494	16.4	14.9	1.16	2.14
17.891	16.971	19.6	17.9	3.33	-0.19
19.888	17.623	22.1	16.7	0	-1.759
17.415	15.419	13.2	9.2	0.18	-2.431
16.558	13.915	15.6	9.8		3.64
17.486	14.799	19.1	13.4	0.04	6.926
15.652	14.632	13.2	8.6	1.45	-1.003
16.01	13.296	14.9	9	0	2.784
14.84	13.668	14.6	12.1	0.03	4.478
17.415	15.494	18.8	16.2	0.23	6.876
18.129	16.881	22.7	19.6	0	6.042
17.368	16.919	19.8	17.7	0.8	3.116
18.461	16.795	18.8	14.7	0	4.1
17.867	16.102	17.7	12.6	0	3.427
15.533	14.568	13.9	7.4	0.14	0.62
15.199	13.03	13.7	6.8	0	2.716
15.843	13.312	18.6	12.8	0	6.168
16.415	13.881	20.7	14.9	0	7.852
16.272	14.537	16	12.7	0	4.355
17.558	15.177	19.8	15.4	0	7.992
18.033	15.973	22	17.3	2.68	5.56
16.939	14.906	13.1	9.2	0.05	-1.287
13.185	12.65	8.1	6.7	0	-2.058
13.257	12.463	10.2	7.9	1.17	-0.796
13.449	12.641	9.4	8.7	0.65	-0.746
15.175	13.184	15.1	11.2	0	4.856
14.84	12.61	20.3	14	0	8.897
15.342	12.956	21.7	15.5	0.06	10.694



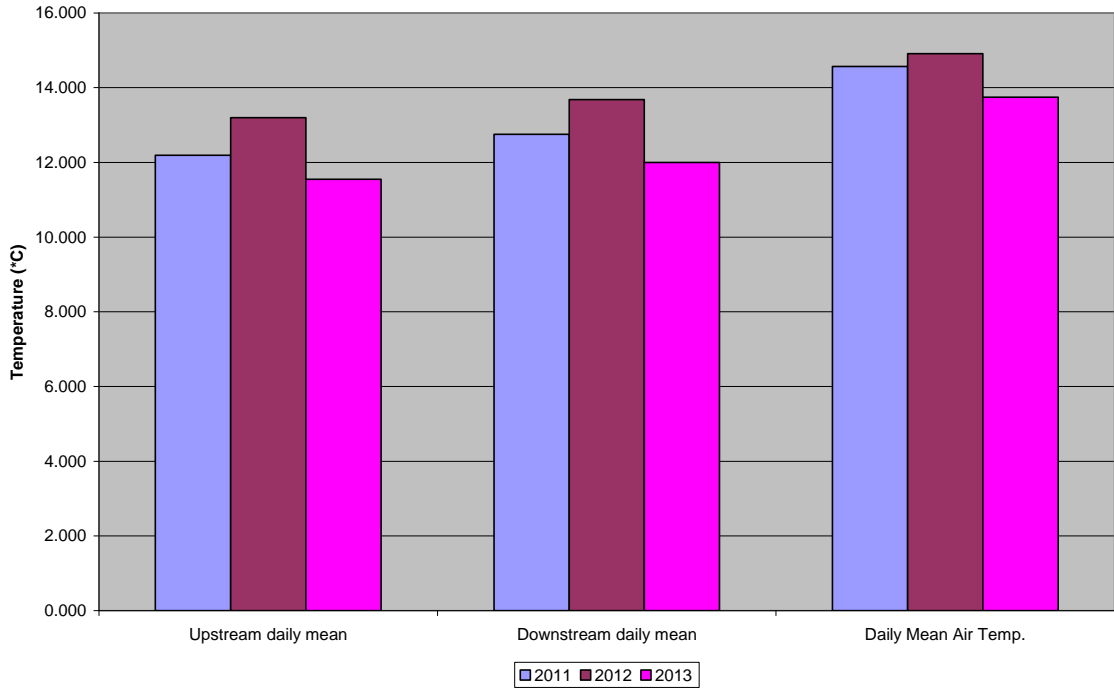
14.266	12.568	17.7	13	0	5.17
13.497	12.738	13.7	11.7	2.3	1.128
15.7	13.442	20.6	15.5	0	7.58
15.008	13.488	16.9	12.9	0	6.883
13.882	12.529	14.3	9.6	0	6.244
12.823	11.353	12.5	8	0	5.52
12.389	10.67	12.2	6.5	0.08	8.452
12.606	10.975	15.7	11	0.46	3.643
15.079	13.758	16.7	10.7	0.76	3.739
12.871	11.104	14.1	9.1	0	9.834
13.064	11.051	19.2	13.1	0	6.896
13.714	11.58	19	12.1	0	6.365
12.654	11.407	10.5	6.4	0	3.189
11.443	9.669	12.5	7.8	0.4	4.615
11.807	9.809	15.4	10.8	0.03	6.678
13.329	11.799	16	10.7	0	4.3
12.509	11.111	12.8	9	1.51	4.549
14.409	12.77	18.8	13.9	0	5.646
13.161	12.058	11.5	9.5	0.19	0.769
12.847	11.437	13.4	9.7	0	2.041
11.467	10.83	11.3	7.4	0.38	2.006
10.81	9.509	8.9	5.2	0	1.844
18.610	16.639	19.576	15.178		
37dys > 18°C	16dys > 18°C				
24dys > 20°C	0dys > 20°C				
14.50%					

APPENDIX B

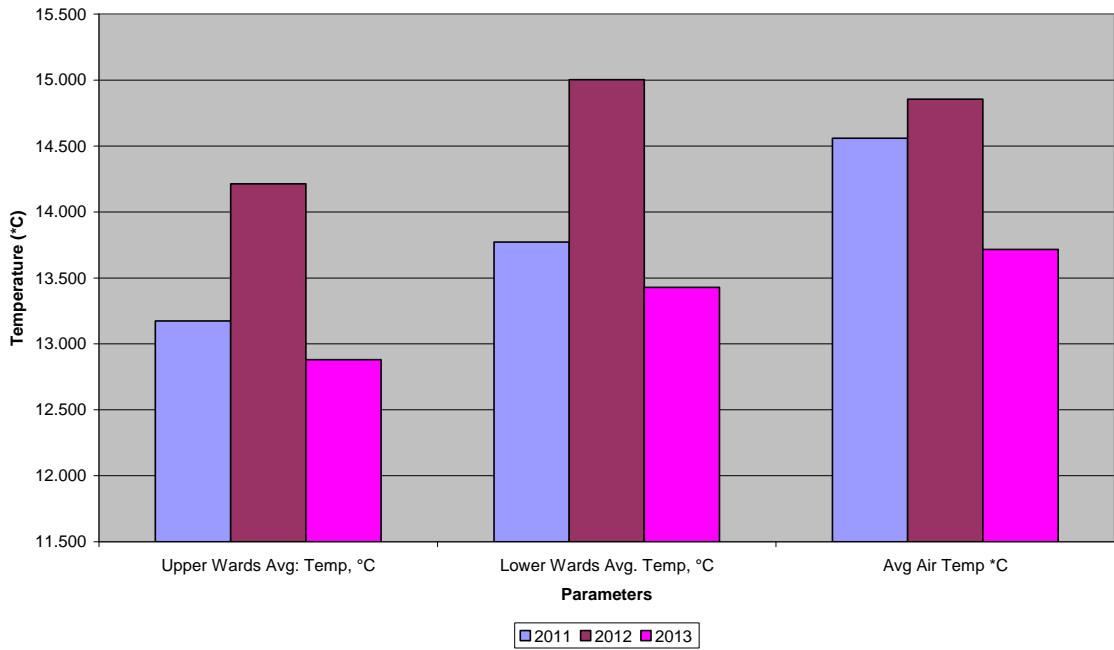
Annual Mean Comparison Charts



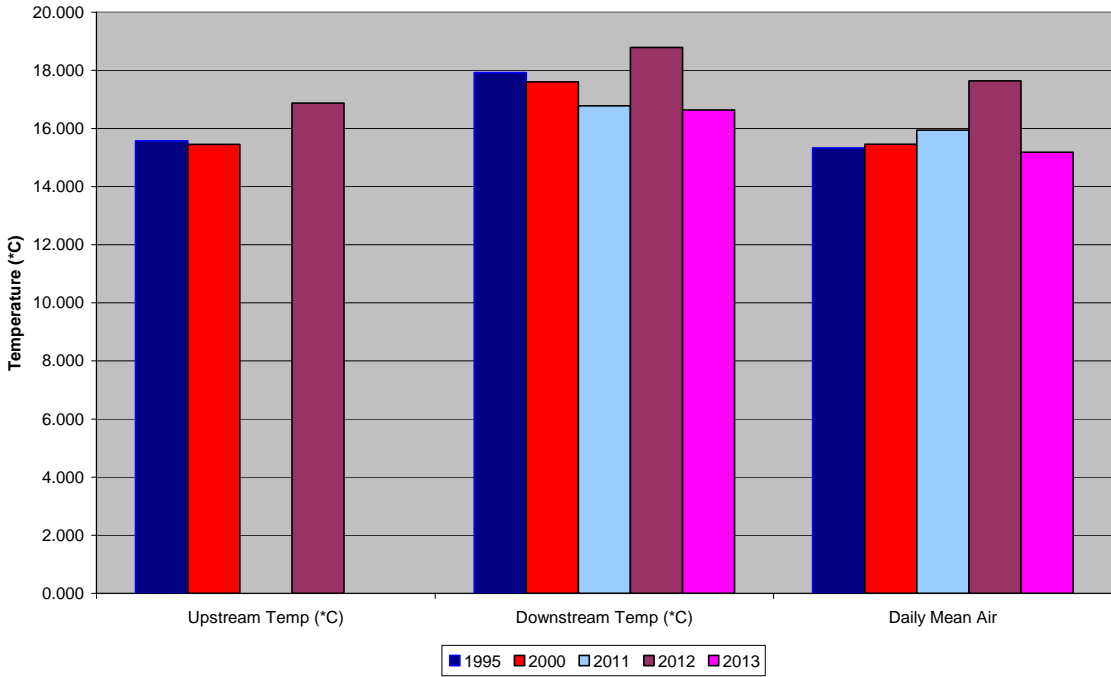
Shannon Brook Temperature Profile: Annual Comparison



**Annual Mean Temperature Comparisons:
Ward's Creek - Unnamed Tributary**

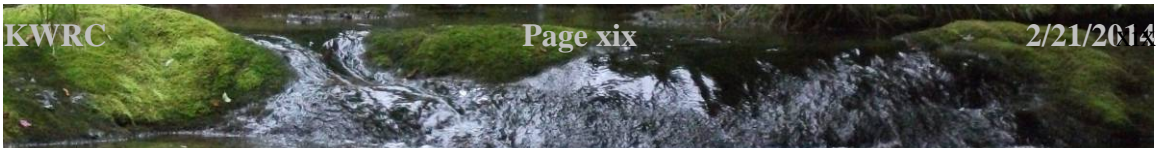


Trout Creek Annual Mean Comparison Chart

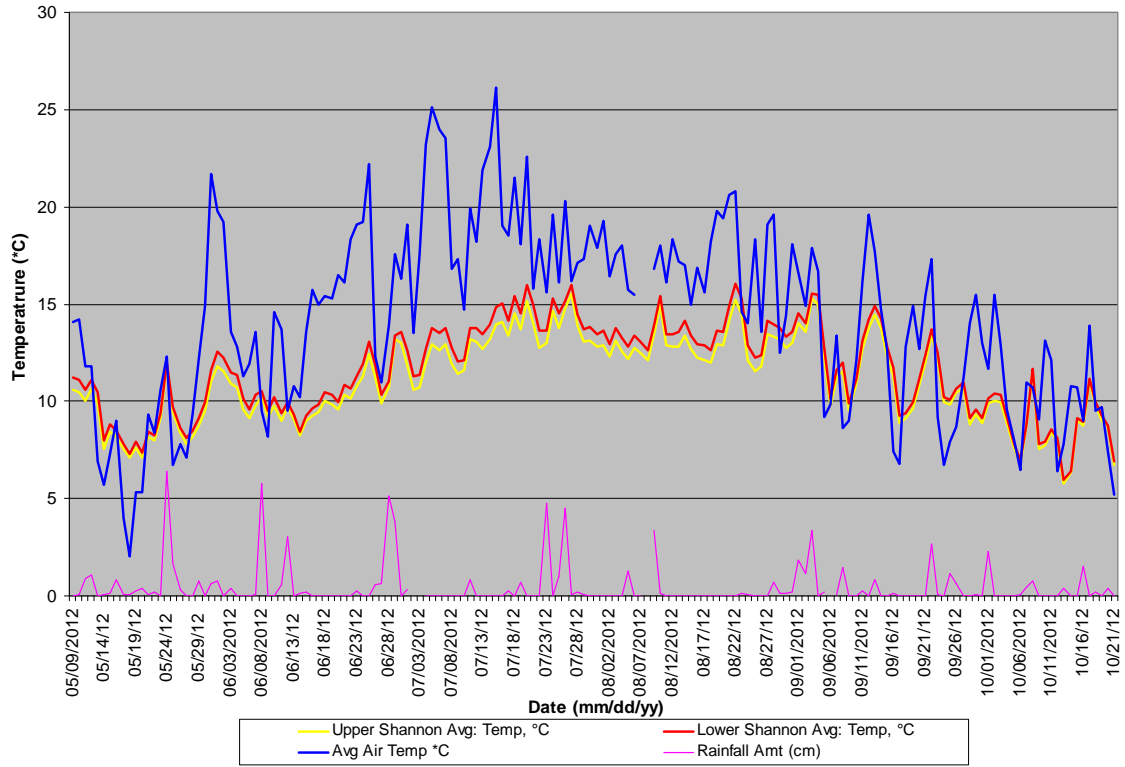


APPENDIX C

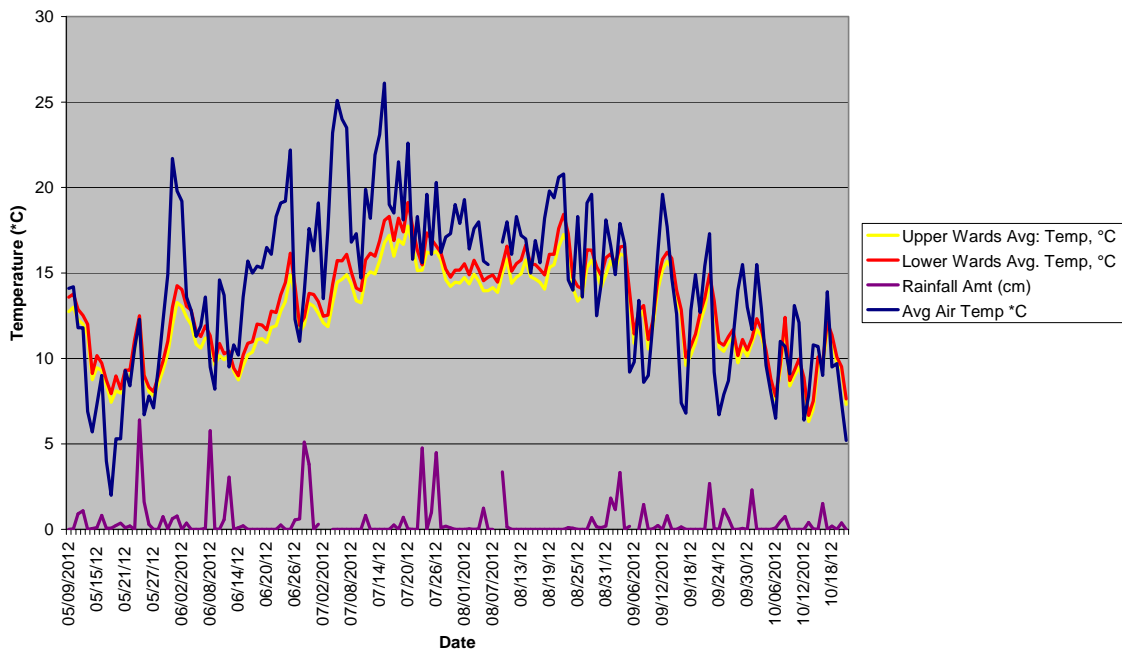
Daily Stream Temperature Profiles: Daily Mean Temperatures 2013



**Shannon Brook Temperature Profiles:
2013 Daily Mean Comparisons**



**2013 Wards Creek Mean Temp
Walkerville Stream**



2013 Trout Creek Temperature Profile: Daily Mean Temp

