Cottonwood Creek Ecological Assessment

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Abstract

This report describes the third year of study conducted on Cottonwood Creek. The water quality, physical habitat and biotic community of Cottonwood Creek were investigated during the summer of 2005. Water temperature loggers were placed within seven different locations extending from the headwaters to near the mouth. Physical measures of channel shape, slope, substrate and large woody debris were conducted at four locations representing different channel conditions. Macroinvertebrates were sampled using the ASCI methods, and relative juvenile fish abundance was determined using baited minnow traps. Water samples were collected four times at eight locations and analyzed for pH, specific conductance, turbidity, dissolved oxygen, nitrate and nitrite-N, ammonia-N, total phosphorus, and total dissolved phosphorus; and four times at three locations and analyzed for total fecal coliform bacteria. Nutrient limitation was tested using nutrient diffusing substrata.

Stream water temperatures were consistently low above Cornelius Lake and within Dry Creek. Water temperatures exceeded State Standards on multiple occasions from the outlet of Nekleson Lake to Surrey Road. Water temperatures were highest at lake outlets and decreased when flowing through well-vegetated channels. Juvenile fish distribution appeared to be affected by water temperatures. Stream water pH values were above neutral, specific conductance was relatively high, near 200 μS/cm. Turbidity was consistently low, below 1 NTU. Low dissolved oxygen concentrations were recorded within the slow-moving macrophyte-filled reach from Wasilla Lake to Edlund Road. Nitrate concentrations were below detection limits, but ammonia nitrogen concentrations were high relative to total or total dissolved phosphorus on most dates. Molar ratios of nitrogen to phosphorus suggested nitrogen limitation during base-flow, but following storm events, ratios decreased supporting nitrogen limitation. Results of the nutrient diffusing experiment supported nitrogen limitation but were not conclusive, likely reflecting the temporal variability in available elements. Water quality was assessed as “good” to “excellent” using samples and metric scores for low-gradient fine-substrate streams, but “poor” to “fair” using metric scores for low-gradient coarse-substrate streams. Macroinvertebrate metric scores decreased slightly from measures in 1998 and 2000.

Introduction

This report describes the third year of data collected on Cottonwood Creek. Cottonwood Creek is a small spring-fed drainage located within South Central Alaska. The drainage contains approximately 16.5 miles of flowing water and an estimated 1,000 acres of lake surface area (Davis and Davis 2005). Cottonwood Creek has been listed on the State's 303(d) list as impaired due to the presence of foam. Previous studies have indicated that foam accumulations likely are the result of natural surfactants rather than human caused. However, concurrent measures of other chemical and physical parameters documented water temperature and total fecal coliform bacteria abundances that exceed State Water Quality Standards. The capture rate of juvenile salmon was considerably lower in 2004 when water temperatures were high. Coho salmon smolt with lesions were documented in 2001, which may be related to water quality.

Other water quality concerns include the potential for low oxygen concentrations due to high organic biomass and temperatures. Therefore, concentrations of macronutrients and measures of nutrient limitation are of importance. Channel physical and riparian characteristics also can influence water temperatures. Stream macroinvertebrates also may be affected by chemical or physical conditions that influence fish abundance.

The objectives of this study were to (1) evaluate the physical factors influencing water temperatures and potential temperature affects to fish, (2) determine abundance of fecal coliform bacteria relative to State Water Quality Standards, (3) obtain measures of water chemical parameters and determine production limiting nutrients, and (4) obtain measures of invertebrate relative abundance at multiple locations as indicators of water quality.

Methods

The sample design, methods, and quality assurance measures are outlined in the Quality Assurance Project Plan (QAPP) in Appendix A. Stream sampling locations are shown in Figure 1. See Davis and Davis 2005 for sampling location details. Temperature loggers were placed at Sites 3, 4, 6, and 7 on July 19, and at Sites 1, 1b, 2 and Dry Creek on August 1, 2005. The Dry Creek site was located just downstream from the Caribou Street crossing. Temperature loggers were removed on August 26. The logger at Site 2 was removed from the stream by kids in the area and lost.

Water samples for nutrient and chemical analyses were collected on June 9, July 20, August 2, August 15 and August 30, 2005 for all 8 Cottonwood Creek sites. Water samples for total fecal coliform bacteria analyses were collected from Sites 3, 4 and 7 on August 2, 15, 23 and 30, 2005. On August 23, four samples were collected from Site 4 between 09:55 and 10:55 for total fecal coliform bacteria analyses.

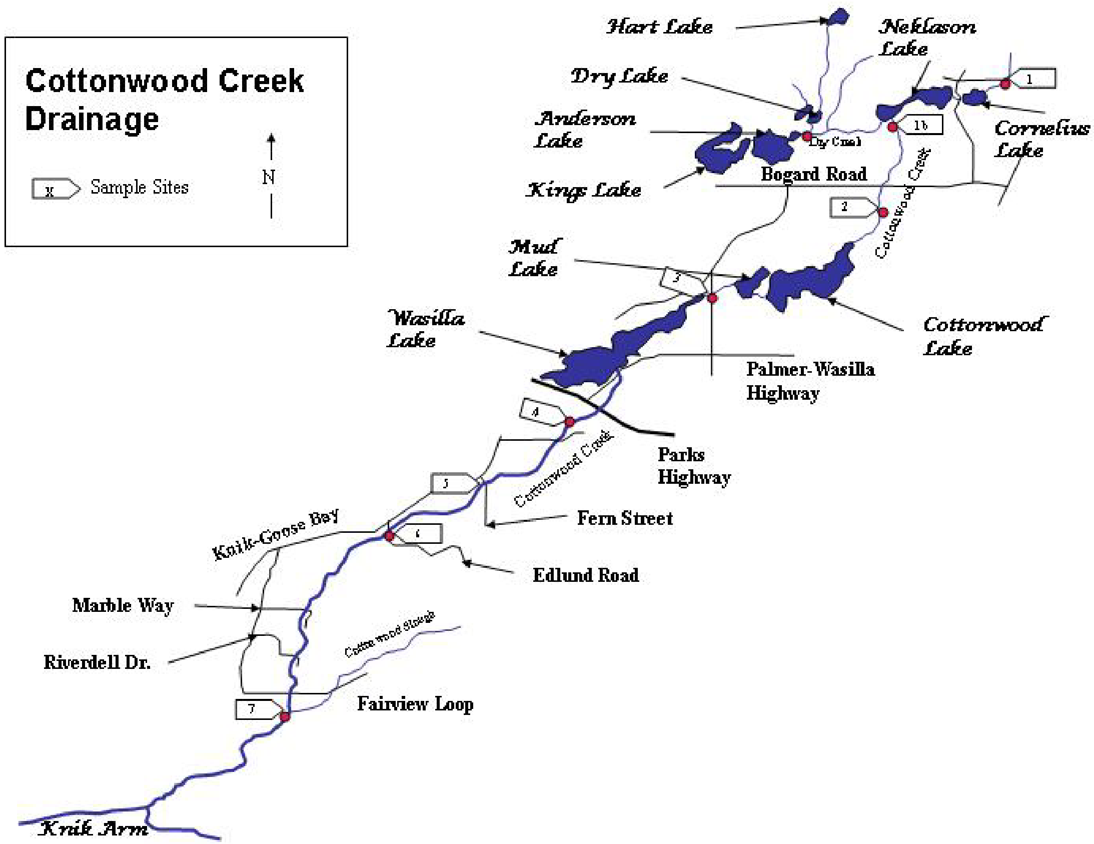

Figure 1. Map of Cottonwood Creek showing sampling sites and locations of temperature data loggers.

Nutrient diffusers were placed at Site 4 (upstream of the foot bridge) and Site 6 on August 6 and removed on September 1, 2005. Baited minnow traps were placed at Sites 1, 1b, 4, and 6 on September 28, near 12:00 and removed on September 29 from 11:40 to 13:40. Channel cross-section measurements, substratum and large woody debris counts, and invertebrate collections were conducted on August 24 and August 26.

Results

Riparian Vegetation and Channel Characteristics

Channel physical characteristics are shown in Table 1. At Site 1b channel cross-sections, substratum and woody debris counts, and invertebrate collections were completed downstream from the Zephyr Road Bridge. Fresh foam accumulations were observed at Site 1b during the August 26 site visit. The stream banks were low at Site 1b with wide floodplains (>100m) on both banks. There was an ATV trail that paralleled the stream on the left bank but the riparian vegetation was otherwise undisturbed. The riparian vegetation consisted of closed tall alder and willow scrub to 3 meters from the channel followed by a closed mixed spruce birch forest up to 100 m. Some cottonwoods (*Populas tricarpa*) were present. All of the alder had been defoliated by the alder wooly sawfly (*Eriocampa ovata*) as observed along the entire length of the stream. The large woody debris index was intermediate with 3 pieces and 5 debris dams. The substratum appeared stable, covered with moss with *Potamagetum natans* common. Two adult sockeye salmon were seen. No fine sediment deposits on the stream margins and 65% of the stones were less than 20% embedded in fine material. Based on the pebble counts, 3 % of the substrate was composed of fines, less than 2 mm (Figure 2).

Table 1. Channel characteristics at four locations on Cottonwood Creek. w/d is width to depth.

	Site 1b	Site 4	Site 6	Site 7
Total Channel Width (m)		16.73	19.87	
Stream Width (m)	8.77	8.90	4.33	7.33
Total Channel Area (m^2)		6.36	4.77	
Area (m^2)	1.90	3.87	1.38	1.37
Total Channel Depth (m)		0.38	0.24	
Average Depth (m)	0.22	0.63	0.33	0.20
w/d ratio (total channel)		44.11	84.27	
w/d Ratio	40.69	14.47	14.43	40.64
L. Bank ht. (m)	0.64	1.04	0.53	1.12
R. Bank ht. (m)	0.21	1.17	0.41	0.85
L. UC (m)	0.17	0.13	0.03	0.12
R. UC (m)	0.19	0.08	0.03	0.14
L. Upper bank slope	45.80	52.75	45.62	71.18
L. Lower bank slope	49.05	41.04	45.54	45.50
R. Upper bank slope	55.41	45.77	23.16	61.23
R. Lower bank slope	34.90	33.27	62.56	45.11
Water Surface Slope	0.0064	0.00385	0.0028	0.023
Large Woody Debris				
Pieces	3	0	0	11
Dams	5	2	0	6
LWDI	301	293	0	639

Site 4 invertebrates and physical measurements were collected upstream from the Old Matanuska Road Bridge, currently a foot bridge. The channel is wide with beds of macrophytes growing on both stream margins. *Calla palustra* and Mare's tail (*Hipparis valgeris*) are dominant. The substratum qualitatively appears to be dominated by sand and gravel with the occasional boulder. Only roughly 1% of the substratum is embedded 20% or less, and fines (particles <2mm) make up 30% of the substrate. Clam shells (*Anodonta sp.*) litter the stream bed. The left bank riparian vegetation consists of a closed birch forest for 20 meters followed by a paved parking lot. On the right bank there was a 2 m zone of tall closed alder followed by closed birch forest from 2 to 20 m, with a building and parking area beyond. All of the alders were defoliated on the August 24 sampling date. Two rather extensive debris dams resulted in a moderate woody debris index. Two adult coho salmon were seen. Relative to the other Cottonwood Creek sites, the stream banks are high, over 1 meter. Upper and lower bank slopes are similar to other sites. The flowing channel width is similar to the steeper sites 1b and 7, but depth is greater and the w/d ratio is low at 14.

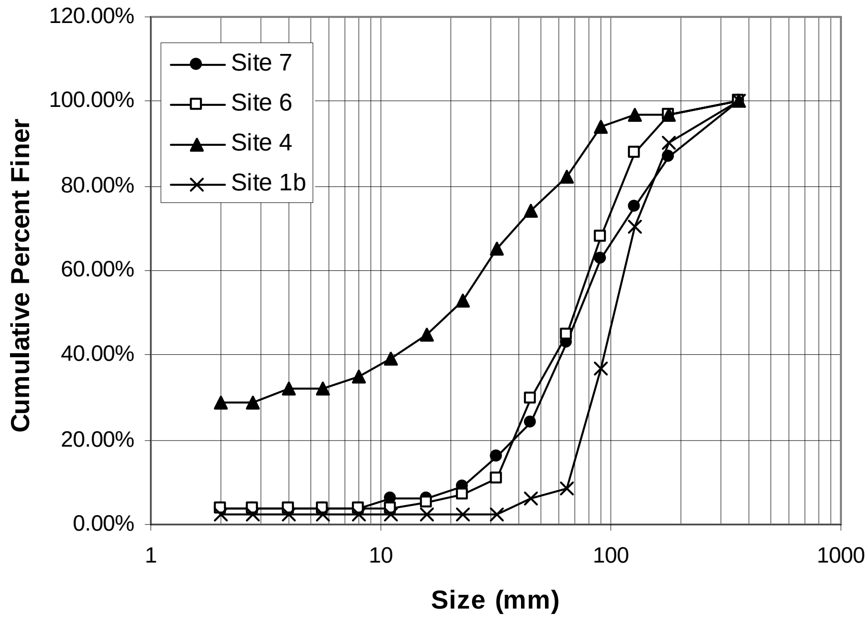

Figure 2. Substratum size distribution from Wolman pebble counts conducted at four sampling reaches.

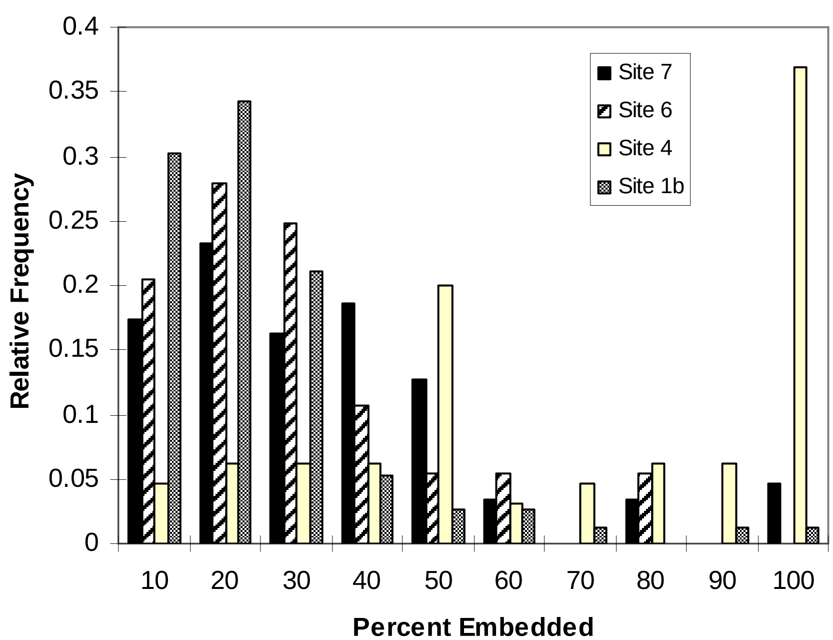

Figure 3. Relative frequency stream particles embedded in fines as percent.

Site 6 channel measurements were taken approximately 500 m below the Edlund Road crossing, just downstream of where Spawning Loop Road comes closest to Cottonwood Creek. Like Site 4, the stream channel is wide, with macrophytes growing on the margins creating a large overall channel with a much smaller flowing water channel. The flowing channel width was much less than at Site 6; however, the w/d ratio was similar and less than those at Sites 1b and 7. Bank heights were near 0.5m on both sides. The riparian vegetation on both banks is largely unmodified. Both banks are vegetated with closed birch forest with some cottonwoods and a 0 to 3 m margin of closed tall alders on the stream banks. Similar to the other sites, the alders were defoliated. There is a large floodplain on the left bank (>100 m). There is a terrace on the right bank approximately 20 m from the stream margin. No large woody debris pieces or debris dams were observed within this reach, although there was a large dam upstream where the channel split around an island and a similar accumulation downstream of the sampling reach. The substratum within the flowing channel was more similar to measures at Sites 1b and 7, although less than 50% of the particles were embedded 20% or less.

Site 7 was located between Fairview Loop and Surrey Road. The single-thread channel was entrenched, with high (approximately 1.0m) and steep (>45°) banks. Stream channel cross-sectional characteristics were otherwise very similar to Site 1b. The riparian vegetation was undisturbed closed birch forest; however, the alder zone occurred only intermittently where the banks were low. There was an ATV trail parallel to the river within the left riparian zone from 2 to 10 m from the channel with one stream crossing below the sampling reach. Large woody debris was common with logs at some locations forming step pools. Eleven pieces and six debris dams were counted within the 100 m reach. The resulting LWDI was highest at this site with a value of 639. Debris dams often formed on submerged alder branches with *Calla palustra* growing on the sediment deposited downstream of the dams. The sediment appeared large with occasional boulders. There was little fine sediment although the substratum was moderately embedded. Only 37% of the substratum was embedded less than 20%. The alders were defoliated as observed at the other sites.

Fecal Coliform Bacteria

Currently the most stringent water quality standard applies to unclassified waters within Alaska. The most stringent standard for fecal coliform bacteria is for water supply for drinking water at 30-day geometric mean of 20 cfu/100ml (18 AAC 70.020 (a)(1)(A)(i)). Second to this is the standard for contact recreation at 100 cfu/100 ml (18 AAC 70.020(a)(1)(B)(i)). The geometric mean for the month of August, 2005 exceeded the Water Supply and Contact Recreation levels at Site 4, immediately downstream from Wasilla Lake and at Site 7, the Surrey Road Crossing, but not at Site 3, upstream of Wasilla Lake (Table 2). The variability among samples collected within Site 4 is shown in Table 3.

Table 2. Total fecal coliform bacteria (cfu/100 ml) collected within a 30-day period from 3 Cottonwood Creek sites. Site 3 is above Wasilla Lake at the Seward-Meridian Highway, Site 4 is below Wasilla Lake, and Site 7 is at the Surrey Road Crossing close to Cook Inlet.

	8/2/2005	8/15/2005	8/23/2005	8/30/2005	Geometric Mean
Site 3	3	5	27	5	10
Site 4	140	72	198	100	127
Site 7	180	120	48	87	109

Table 3. Summary statistics for the 4 replicate total fecal coliform bactera samples collected from Site 4 within one hour.

Mean	197.5
Standard Error	17.5
Median	195
Standard Deviation	35
Range	80
Minimum	160
Maximum	240
Confidence Level (95.0%)	55.69

Water Chemistry and Nutrient Limitation

Biweekly water sampling occurred from mid July through August. Stream discharge was low during on the first sampling date, but increased following storms in late July and early August (Figure 4). Dissolved oxygen concentrations were always at or above saturation at the upstream Site 1 and below saturation at Site 1b after the water had passed through Neklason Lake (Table 4). Dissolved oxygen concentrations also were similarly low, well below saturation at Sites 3 through 6. These sites begin below Mud Lake and include the site below Wasilla Lake, and continue through the relatively slow macrophyte-filled reach of Cottonwood Creek. The lowest dissolved oxygen concentration, (7.17 mg/L) recorded at Site 3 in August, closely approaches the lower limit allowed under State Water Quality Standards for anadromous fish.

Specific conductance, pH, and turbidity were similar to previously recorded values (Davis and Davis 2005). Both pH and specific conductance decreased slightly from July 20 to August 2, concomitant with an increase in discharge.

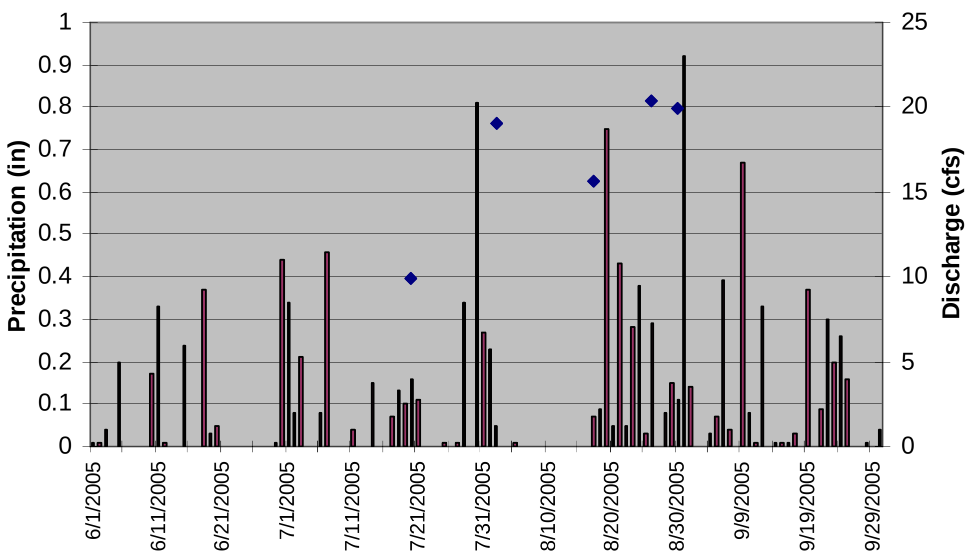

Figure 4. Precipitation data from the Palmer Airport and Cottonwood Creek Discharge (diamonds) from Site 4 gauge measurements.

Table 4. Chemical and physical water sampling results.

Dissolved Oxygen (% Saturation mg L^{-1})				
	7/20/2005	8/2/2005	8/15/2005	8/30/2005
1	103/12.6	105/12.8	99/12.4	101.8/12.66
1b	93/8.8	98/10.0	84.9/8.21	96.6/10.07
2	96/9.2	102/10.5	95.6/9.34	97.8/10.31
3	88/8.3	85/8.6	75.1/7.17	87.8/9.07
4	88/8.1	87/8.6	80.5/7.60	92.6/9.37
5	89/8.4	85/8.6	80.3/7.74	86.5/9.01
6		86/8.7	76.5/7.31	82.4/8.61
7	98/9.7	102/10.7	96.3/9.59	99.9/10.63

pH				
	7/20/2005	8/2/2005	8/15/2005	8/30/2005
1	7.65	7.68	7.79	7.92
1b	7.59	7.73	7.72	7.96
2	7.85	7.89	7.97	8.14
3	7.78	7.69	7.74	7.86
4	7.81	7.41	7.92	8.12
5	7.70	7.58	7.64	7.80
6	7.65	7.56	7.67	7.64
7	7.86	7.87	8.00	8.00

Specific Conductance (µS/cm)				
	7/20/2005	8/2/2005	8/15/2005	8/30/2005
1	207.0	191.5	192.7	191.0
1b	197.0	167.3	177.8	177.0
2	192.6	170.9	182.4	179.1
3	168.6	171.2	172.6	185.1
4	200.0	189.9	186.2	189.9
5	202.0	184.4	190.1	196.6
6	202.0	188.9	188.5	196.9
7	204.0	188.9	192.7	197.2

Turbidity (NTU)				
	7/20/2005	8/2/2005	8/15/2005	8/30/2005
1	0.7	0.7	0.7	0.7
1b	1.0	1.0	1.0	1.1
2	0.8	1.2	1.0	1.2
3	1.6	1.9	1.1	1.4
4	1.2	2.1	2.5	1.7
5	1.3	3.0	3.8	1.2
6	1.0	2.6	2.5	1.1
7	0.9	2.5	0.8	1.2

Table 5. Cottonwood Creek macronutrient data.

Ammonia Nitrogen (mg/L)					
	6/9/2005	7/20/2005	8/2/2005	8/15/2005	8/30/2005
1	<0.005	0.011	0.008	0.012	0.025
1b	<0.005	0.032	0.011	0.012	0.120
2	<0.005	0.042	0.006	0.270	0.240
3	0.01	0.036	0.027	0.045	0.310
4	<0.005	0.042	0.033	0.220	0.140
5	<0.005	0.011	0.016	0.023	0.340
6	<0.005	0.012	0.021	0.039	0.100
7		0.036	0.035	0.027	0.110

Nitrate + Nitrite-N (mg/L)					
	6/9/2005	7/20/2005	8/2/2005	8/15/2005	8/30/2005
1	0.21	0.061	0.018	0.015	<0.01
1b	0.061	<0.01	<0.01	<0.01	<0.01
2	0.033	<0.01	<0.01	<0.01	<0.01
3	0.021	<0.01	<0.01	<0.01	<0.01
4	<0.01	<0.01	<0.01	<0.01	<0.01
5	0.02	<0.01	<0.01	<0.01	<0.01
6	<0.01	<0.01	<0.01	<0.01	<0.01
7	0.076	<0.01	<0.01	<0.01	<0.01

Total Phosphorus (mg/L)					
	6/9/2005	7/20/2005	8/2/2005	8/15/2005	8/30/2005
1	0.028	0.006	<0.005	<0.005	0.01
1b	0.077	<0.005	0.007	0.013	0.008
2	0.027	<0.005	0.014	0.013	0.015
3	0.025	0.005	0.016	0.015	<0.005
4	0.044	<0.005	0.018	0.016	<0.005
5	0.024	<0.005	0.012	0.014	0.007
6	0.03	<0.005	0.008	<0.005	0.006
7	0.028	<0.005	0.008	0.008	<0.005

Total Dissolved Phosphorus (mg/L)					
	6/9/2005	7/20/2005	8/2/2005	8/15/2005	8/30/2005
1	<0.001	<0.001	<0.001	<0.001	0.013
1b	<0.001	<0.001	<0.001	<0.001	0.013
2	<0.001	<0.001	0.009	0.007	0.005
3	<0.001	<0.001	<0.001	<0.001	<0.001
4	<0.001	<0.001	0.006	0.002	0.005
5	<0.001	<0.001	<0.001	0.007	0.003
6	<0.001	<0.001	<0.001	<0.001	0.003
7	<0.001	<0.001	0.003	<0.001	0.004

Nitrate nitrogen and total phosphorus concentrations were highest in early June and then decreased during the growing season at all sites (Table 5). Total phosphorus concentrations increased slightly on August 2 with increases in discharge. Similarly, total dissolved phosphorus was below detection limits on most sampling dates. On August 2 concentrations were above detection limits at 2 sites, and 6 of the 7 sites on August 30. Conversely, Ammonia nitrogen was lowest in early June, increased during the growing season, with highest values at the end of August.

Molar ratios of nitrogen to phosphorus were highly variable. Ratios were calculated as the sum of nitrate plus nitrite and ammonium nitrogen to either total phosphorus or total dissolved phosphorus and then converted from mass to moles (multiplied by 32/14). Since total dissolved phosphorus concentrations were usually below detection limits, ratios consistently suggested phosphorus limitation (N/P ratio >16). Ratios using total phosphorus suggest that both nitrogen and phosphorus limit primary production at different times. On the June 9 sampling date, ratios at all sites were well below 16; however, as the growing season progressed ammonia nitrogen increased while phosphorus decreased and by July 20, ratios suggested phosphorus limitation. With the increase in discharge and total phosphorus on August 2, nitrogen again became limiting based upon ratios. This continued on the August 15 sampling date, but was not consistent among all sites and by August 30, ratios again suggested phosphorus limitation, excluding Site 1, which is chemically different from all other sites (Table 6).

Table 6. Ratios of nitrate, nitrite, and ammonium nitrogen to total phosphorus. P<DL indicates total phosphorus concentrations below detection limits.

	6/9/2005	7/20/2005	8/2/2005	8/15/2005	8/30/2005
1	17.1	27.4	P<DL	P<DL	5.7
1b	1.8	P<DL	3.6	2.1	34.3
2	2.8	P<DL	1.0	47.5	36.6
3	2.8	16.5	3.9	6.9	P<DL
4	0.0	P<DL	4.2	31.4	P<DL
5	1.9	P<DL	3.0	3.8	111.0
6	0.0	P<DL	6.0	P<DL	38.1
7	6.2	P<DL	10.0	7.7	P<DL

Results from the nutrient diffuser experiment support shifting concentrations of rate-limiting nutrients. Based upon ANOVA and Tukey's multiple comparison test (alpha 0.05), there were no significant differences among the four treatments at Site 4. The amount of algal chlorlophyll-*a* on the nitrogen, nitrogen and phosphorus, phosphorus, and control diffusers all averaged between 4 and 5 mg/m^2 (Figure 5). There were no differences between Site 4 (shaded), and Site 6 (open). At Site 6 average chlorophyll-*a* ranged from 3 to 8 mg/m^2. Average chlorophyll-*a* concentrations were highest on the nitrogen diffuser, which was significantly higher that the lowest concentration found on the nitrogen and phosphorus diffuser.

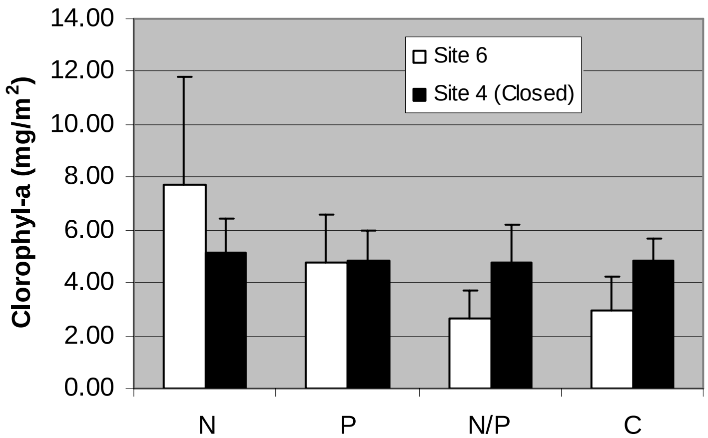

Figure 5. Chlorophyll-*a* concentrations on nutrient diffuser placed within Cottonwood Creek at two locations below Wasilla Lake.

Stream Temperatures

Stream water temperatures were high throughout Cottonwood Creek with the exception of Site 1, upstream of Cornelius Lake. Maximum stream temperatures exceeded State Water Quality Standards at all sites. Maximum stream temperatures were well correlated with maximum air temperatures recorded at the Palmer Airport. Temperatures were highest below lakes and decreased within flowing vegetated stream channels (See Appendix B).

The State Water Quality Standard (18 AAC 70) for fresh water is,

> "May not exceed 20° C at any time. The following maximum temperatures may not be exceeded, where applicable: Migration routes 15° C, Spawning areas 13° C, Rearing areas 15° C, Egg & fry incubation 13° C. For all other waters, the weekly average temperature may not exceed site-specific requirements needed to preserve normal species diversity or to prevent appearance of nuisance organisms."

Site 1 upstream of Cornelius Lake originates from a spring approximately 2 miles upstream from the sampling site (anecdotal from local residents). Stream water temperatures at this location were well below standards set for spawning and incubating salmon eggs or the rearing of fish (Table 7). Maximum stream temperatures did not exceed 10° C. Degree days were calculated by integrating the area under the temperature curve between consecutive lows. Degree days were very similar to average daily water temperatures. Cumulative degree days are the sum of daily values. Plotting cumulative degree days by date provided a rate of degree day accumulation (Appendix B). For Site 1 the degree day accumulation rate was 6.46°C for the month of August (Table 8). Based upon the relationship with maximum air temperature, stream water temperatures at Site 1 are not likely to exceed 13°C (Table 9).

The highest water temperatures were recorded at the sites located below lakes. Site 1b is located just below the outlet of Neklason Lake. Water temperatures at Site 1b were similar to those recorded below Mud Lake (Site 3) and below Wasilla Lake (Site 4). Maximum average water temperatures at Site 1b were 19°C. This is 12.5 degrees higher than Site 1, and 2 degrees higher than Dry Creek. Therefore, average stream water temperature increased at least 12.5 degrees after passing through Cornelius and Neklason Lakes, an exposed surface area of 115.3 acres. The gross temperature increase was likely greater, with lower net values as the water was cooled by Dry Creek flow that enters Neklason Lake close to the Cottonwood Creek outlet. The average daily temperature at Site 1b for August was well above State Standards. Maximum water temperatures exceeded 13°C on all days measured and exceeded 20°C on 11 of the 24 days. Based upon the correlation with maximum air temperature, stream temperatures at Site 1b will exceed 20° C when maximum air temperatures are greater than 70 ° F.

Table 7. Number of days out of 24 (Sites 1, 1b, and Dry Creek) or 22 days (Sites 3 through 7) in August measured stream temperatures exceeded water quality standards for anadromous fish streams.

	Average			Maximum		
	13° C	15° C	20° C	13° C	15° C	20° C
Site 1	0	0	0	0	0	0
Dry Creek	22	17	0	24	20	2
Site 1b	24	23	5	24	24	11
Site 3	22	21	6	22	22	10
Site 4	22	22	6	22	22	14
Site 6	22	21	2	22	22	6
Site 7	22	18	0	22	21	2

Table 8. Slope of correlation with maximum air temperature at Palmer Airport. Daily change is the stream temperature change from minimum to maximum.

	Daily Change	Degree Days	Max Temp
Site 1	0.097	6.46	0.084
Dry Creek	0.165	16.89	0.416
Site 1b	0.227	18.97	0.606
Site 3	0.152	19.75	0.558
Site 4	0.237	19.69	0.529
Site 6	0.191	18.00	0.461
Site 7	0.176	17.06	0.419

Table 9. Maximum air temperatures at Palmer Airport at which stream temperatures exceed given values.

	Air Temperature in Celsius			Air Temperature in Fahrenheit		
	13 C	15 C	20 C	13 C	15 C	20 C
Site 1	83.0	106.9	166.6	181.38	224.40	331.92
Dry Creek	9.9	14.7	26.7	49.78	58.44	80.09
Site 1b	9.4	12.7	20.9	48.85	54.80	69.66
Site 3	7.6	11.2	20.1	45.65	52.11	68.24
Site 4	6.0	9.8	19.3	42.88	49.69	66.72
Site 6	7.8	12.1	23.0	46.04	53.85	73.36
Site 7	8.8	13.6	25.5	47.89	56.49	77.98

Macroinvertebrates and Fish

Macroinvertebrates were collected and analyzed using the Alaska Stream Condition Index (ASCI) methods from sites 1b, 4, 6 and 7 (Major et al. 2001). All sites were considered low gradient under the ASCI methods even though stream slope at Site 7 was at 2%, the cutoff point between low and high gradient. Sites 1b and 7 were analyzed as coarse substrate streams and Site 4 was considered a fine substrate stream. The substrate at site 6 was coarse, within the flowing channel; however, aquatic plants are a dominant habitat component and fine substrates are ubiquitous along the stream margin. Therefore, Site 6 was considered a fine substrate stream under the ASCI methods, although we calculated both suites of metrics and rankings.

Stream conditions was ranked “Good” to “Excellent” using the metrics and scoring for the “Fine Substrate” at Sites 4 and 6 but “Poor” or “Fair” for the coarse-substrate sites 1b and 7 (Tables 10 and 11). These overall average scores are similar to those previously reported; however, they indicate a decrease in water quality at Site 4 (downstream from Wasilla Lake). The average metric score at Site 4 decreased by 13 to 33 points when compared with previous samples collected by the Environment and Natural Resources Institute (ENRI) in 1998 and 2000. This decrease is due to a reduction in Trichoptera taxa and the numbers of non-Baetidae Ephemeroptera. The Hilsenhoff Biotic Index, a measure of the relative abundance of pollution intolerant taxa, also increased resulting in a lower metric score when compared with previous samples.

There was very little change in overall ASCI scores for the coarse-substrate sites relative to previous samples collected in 1998 and 2000. The current data reflect a decrease in non-Baetidae Ephemeroptera; however, changes were slight and metrics that reflect this change are not given as much weight as for fine-substrate streams.

Table 10. ASCI metric scores and ranking from samples collected by the Environment and Natural Resources Institute (Major et al. 2001) and by ARRI staff for this study at low gradient fine-substrate sites. ENRI Cot01 is at the same location as Site 4.

Low Gradient Fine Substrate	ENRI Cot01 May-98	Cot01 Jun-00	ARRI Site 4 Sep-05	Site 6 Sep-05
Trichoptera taxa 100 * X / 7	85.7	100.0	28.6	71.4
% EPT (no Baetidae or Zapada) 100 * X / 15)	100.0	100.0	22.3	100.0
% Diptera 100 * (100 – X) / 70	45.5	64.0	100.0	90.4
O/E (family 75%) 1 100 * X	77.8	88.9	55.6	77.8
% collectors 100 * (100 - X) / 70	41.0	85.7	100.0	82.4
HBI 100 * (6.5 - HBI) / 2	71.0	100.0	33.5	67.7
Average	70.17	89.77	56.66	81.62
Ranking	Excellent	Excellent	Good	Excellent

Table 11. ASCI metric scores and rankings for low-gradient coarse-substrate Cottonwood Creek sites. Cot02 and Site 1b, and Cot03 and Site 7 are at the same locations.

Low Gradient Coarse Substrate	ENRI Cot02 May-98	Cot02 Jun-00	Cot03 May-98	Cot03 Jun-00	ARRI Site 1b Sep-05	Site 6 Sep-05	Site 7 Sep-05
Ephemeroptera taxa 100 * X / 5.5	27.3	18.2	54.5	54.5	14.3	14.3	14.3
% Plecoptera 100 * X / 14	1	0	0	87.2	33.6	6.6	33.9
% Ephemeroptera (no Baetidae) 100 * X / 20	1	0	3.7	3.9	0.0	0.0	0.0
Baetidae / Ephemeroptera 100 * (100 - X) / 100	2.4	0	7.5	7.7	0.0	0.0	0.0
% non-insects 100 * (30 - X) / 30	83	93.7	86.5	84.3	81.5	0.0	88.9
O/E (family 75%) 2 100 * X	50	40	50	70	50.0	60.0	60.0
% scrapers 100 * X / 15	29.8	0	7.4	5.2	22.8	100.0	9.5
HBI 100 * (6.5 - X) / 2	52	36.3	52.1	65.8	56.6	67.7	100.0
Average	30.81	23.53	32.71	47.33	32.35	31.08	38.32
Ranking	Poor	Poor	Poor	Fair	Poor	Poor	Fair

Total fish capture rates were low at all sites in June of 2005 but increased in September. In June, the lower river Sites 4 and 6 fish capture rates were dominated by sticklebacks, with only 5 coho salmon captured at the two sites. The number of coho salmon and other salmonids captured in June of 2005 was considerably less that the previous year (Table 12). Capture rates increased in September relative to previous sampling in September of 2004 and June of 2005. Capture rates were highest at the upper river sites, particularly at Site 1.

Table 12. Number of fish captured in baited minnow traps by species and site for June and September of 2004 and 2005.

	June 2004				June 2005			
	Coho	RB	DV	SB	Coho	RB	DV	SB
Site 1	5	0	4	0	1	0	0	0
Site 1b	Not Sampled				2	0	0	5
Site 4	30	4	0	4	4	0	0	26
Site 6	3	11	0	2	1	0	0	28
	September 2004				September 2005			
	Coho	RB	DV	SB	Coho	RB	DV	SB
Site 1	5	1	21	0	24	1	0	0
Site 1b	11	7	1	2	10	3	0	19
Site 4	0	1	0	0	2	2	0	0
Site 6	1	0	0	0	14	0	0	4

Discussion

There are multiple different physical habitat conditions throughout the Cottonwood Creek drainage. The upper river, above Cornelius Lake, is physically and chemically distinct. The water temperature is lower and does not exceed 10°C. Similarly, Dry Creek is cooler that most downstream sites. From Neklason Lake to Mud Lake, the stream slope is near 1% and flows over large gravel and cobble with few fines. Large woody debris is common, though not abundant. Water temperatures are higher due to warming within upstream lakes. Macrophytes are present along the margins and in depositional areas. The relatively stable spring fed flows (Davis and Davis 2005) appear to provide a more stable habitat for rooted aquatic plants. Stream slopes and water velocities are much lower downstream from Wasilla Lake to below Edlund Road. Within this reach the substrate, particularly along the margins is dominated by fine material. The stream channel is wide; however, macrophytes proliferate during the growing season, restricting the flowing water channel. Water temperatures, which are often very high (20 to 25°C) at the outlet of Wasilla Lake, do not change throughout this reach. Below Edlund Road and continuing down to the Palmer Hay Flats, the channel slope and velocities increase again. Channel width and the abundance of macrophytes decrease while substrate size increases. Stream water temperatures decrease as the stream flows through this reach. Large woody debris is common within this reach forming debris dams and step pools.

Macronutrient concentrations did not vary considerably among sites when Site 1 (upstream of Cornelius Lake) was excluded. Seasonal variation was similar to 2005 observations. Nitrate nitrogen concentrations, which are above detection limits (0.01 mg/L) in the spring rapidly drop below limits during the growing season. Ammonia-N responds in the opposite fashion, increasing during the summer months. Phosphorus within Cottonwood Creek is primarily in the particulate form, with total concentrations generally well above the dissolved concentrations. The amount of both forms of phosphorus and to a lesser extent, ammonia-N, increase following storm events.

Molar ratios of nitrogen to phosphorus have often been used to estimate nutrient limitation, with values above 16 suggesting phosphorus limitation, and below 16 nitrogen limitation. This value is based upon the Redfield ratio from phytoplankton populations (Redfield 1958). However, a ratio of 18:1 may be more appropriate for freshwater algae (Kahlert 1998). Edmundson et al. (2000) predicted phosphorus limitation within Wasilla Lake, due to ratios of total nitrogen (Kjeldahl plus nitrate and nitrite) to total phosphorus over 65. However, it is questionable as to the portion of organic and particulate bound nutrients available to primary producers (Dodds et al. 2002). Therefore, inorganic forms may be more appropriate for assessing nutrient limitation. We documented widely varying molar ratios of nitrogen to phosphorus that were both above and below 18 using inorganic nitrogen to total phosphorus. We were unable to use total dissolved phosphorus concentrations to calculate ratios and concentrations were consistently below detection limits.

Nutrient diffusing substrata are a well used method to detect nutrient limitation (Davis et al. 2001, Tank et al. 2006). The results of the nutrient diffusion experiment within this study were not conclusive. The addition of nutrients clearly did not increase the abundance of algal chlorophyll-a when solar radiation was limiting. However, there was a significant increase in chlorophyll-a on nitrogen diffusers within a more open portion of the stream. However, the differences were only significant when compared to diffusers that contained both nitrogen and phosphorus. It may be that changing concentrations of both phosphorus and nitrogen within Cottonwood Creek acted to reduce the limiting effects of either element to algae on the diffusers. Based upon nutrient concentrations and the result of the nutrient diffusing experiment, we predict that nutrient limitation varies over time. During base-flow conditions phosphorus is likely limiting; however, following inputs of phosphorus during storm events, nitrogen becomes limiting.

The amount of chlorophyll-a on the diffusers was similar to values obtained from within regional streams. Chlorophyll-*a* ranged from 1.5 to 5.56 mg/m^2 on stones at unimpacted sites within Wasilla Creek (Davis and Muhlberg 2002) and up to 11 mg/m^2 at impacted sites. Concentrations within Montana Creek ranged from an average of 5.3 mg/m^2 at an upstream reference site to 43 mg/m^2 at a site with altered riparian vegetation (Davis and Davis 2006). Concentrations within Chester Creek, located within the Municipality of Anchorage ranged from 2.61 mg/m^2 at a reference location to over 160 mg/m^2 at downstream impacted sites (Davis and Muhlberg 2001).

The geometric mean total fecal coliform bacteria from samples collected at the Wasilla Lake inlet was within acceptable values for all classes of water use (18 AAC 70.020). However, below Wasilla Lake and extending to Surry Road, 30-day geometric means exceeded 100 cfu/100 ml. These values are consistent with findings from monthly water sampling in 2004 (Davis and Davis 2005). Total fecal coliform bacteria exceed the standard for water supply used for drinking, culinary, and food processing which is 20 cfu/100 ml and the criteria for contact recreational use (100 cfu/100ml). This is significant in that Wasilla Lake is used for recreational swimming and boating. The public should be made aware of the potential health hazard and intensive sampling should be conducted within Wasilla Lake adjacent to high public use areas.

The water quality assessment of Cottonwood Creek varied when evaluated using the macroinvertebrate community. ASCI scores were "fair" to "poor" when using the criteria for coarse substrate streams and from "good" to "excellent" when using criteria for fine substrate streams. These differences were observed in this study and in previously collected samples. Cottonwood Creek may differ physically from other low-slope coarse-substrate streams that were used to develop the ASCI methodology resulting in a macroinvertebrate community that differs from that expected. The presence of a number of lakes within the drainage and spring source reduces flow variability relative to other coarse substrate streams. The reduced flow variability allows for a more stable substrate and the proliferation of macrophytes. The aquatic insect community is not subject to the large physical disturbance often causes during high flow events that result in bedload movement. Lakes often provide a large source of particulate organic carbon downstream as phytoplankton (Sand-Jensen and Pedersen 2005). The aquatic invertebrate community has been shown to respond to changes in the food base (Minshall et al. 1983). For these reasons, the ASCI scoring for low-gradient and fine substrate may be more applicable for macroinvertebrate water quality assessments of Cottonwood Creek. Using the fine-substrate metric score, we recorded a reduction in water quality below Wasilla Lake when compared to previous sampling conducted in 1998 and 2000 (Major et al. 2001). It is difficult to determine whether this reflects a trend or short-term variability. Regardless, water quality was still assessed as "good" to "excellent".

Cottonwood Creek maximum water temperatures are strongly related to regional air temperatures and in August of 2005 were near or above tolerance levels for cold-water fish. Water temperatures were particularly high below lakes which currently appear to be the dominant factor affecting heat loading. The upper river, above Cornelius Lake, Dry Creek, and the lower river below Edlund Road are cooler and likely serve as cold-water refugia.

The temperature of stream water is a function of energy inputs from solar radiation, conduction from the surrounding air influenced by convection and advection, and convection through tributary and ground water sources. Changes in stream water temperatures can be buffered by hyporheic and ground water exchange (Poole and Berman 2001). Removal of the riparian vegetation can increase solar input and can allow for the convection of warm air across the water surface (Johnson 2004). Increases in channel width also can increase the available surface water for energy exchange through solar radiation and conduction between the air and water surface. Decreases in stream discharge reduce the heat dissipative capacity of the receiving water. Stream water temperatures can be reduced by the inflow or convection of relatively cooler water through tributaries or groundwater inputs. The evaporation of surface water also reduces stream temperatures by releasing water with a high temperature load (Poole and Berman 2001).

Water temperature within the upper river (above Cornelius Lake) was consistently cold, with low daily variability, and poorly correlated with air temperatures. These factors support the conclusion that water temperatures are the result of flow dominated by groundwater sources. The temperature within Dry Creek, although partially derived from a lake, was similar, suggesting a large ground water contribution, with low daily variability, low correlation with air temperature, and maximum water temperatures between 15 and 20°C. The large surface area provided by Cornelius and Nekleson Lakes allowed for rapid increases in water temperature. Average stream water temperatures were near 20°C with maximum temperatures in 2005 often between 20 and 25°C. The daily difference between maximum and minimum temperatures was 4.6°C, the highest among sites measured. High changes in daily temperatures indicate low buffering capacity (Poole and Berman 2001). Although the daily rate of change was high for Cottonwood Creek, Johnson et al. (2004), measured daily temperature differences of over 10°C in a bedrock reach of second order stream in the Oregon Cascades. It is likely that heat exchange with cooler hypolimnetic waters helps to buffer temperature changes.

There was very little variability among maximum stream water temperatures, correlations with air temperatures, and daily temperature changes among sites located below Nekleson Lake, Mud Lake, and Wasilla Lake. Average water temperatures during the period of measurements at these three sites were near 19°C with maximum temperatures commonly over 20°C and daily temperature changes of 4 to 4.5°C. Correlations with air temperature were good and the slope of the regression lines between air and water temperatures was between 0.50 and 0.60. At these sites, maximum water temperature was very close to maximum air temperatures as recorded at the Palmer Airport. Stream water temperature would exceed 20°C when air temperature exceeded 20°C or 67 to 70°F.

Stream water temperatures began to decrease between Wasilla Lake and Edlund Road and continued to decrease between Edlund Road and Surry Road. Average stream water temperatures in August of 2005 decreased from 19.6°C at the outlet of Wasilla Lake to 18°C at Edlund Road and 17°C at Surrey Road. Although there is some clearing for residential development, the riparian vegetation within this section of the river remains largely intact. It appears most likely that the decrease in water temperature is the result of evaporative heat loss and a decrease in heat input through the insolative properties of the riparian vegetation.

The high water temperatures in Cottonwood Creek along with low dissolved oxygen could explain differences in catch rates of juvenile salmon in September of 2004 and June of 2005. Richter and Kolmes (2005) provide a good review of temperature preferences and tolerance limits for cold-water salmon and trout. Optimal rearing temperatures for coho salmon juveniles range between 12 and 17°C. Coho salmon growth optimal temperature is near 15°C. Upper lethal temperatures for coho salmon juveniles have been reported from 25.8°C to 29.2°C. However, behavior, swimming speed, and the occurrence of disease can all be affected at temperatures below the lethal range.

Juvenile coho salmon catch rates were markedly reduced from June of 2004 to September of 2004 (Davis and Davis 2005). This corresponds with average water temperatures below Wasilla Lake that were above 20°C from June through August. Maximum water temperatures exceeded 25°C on a number of dates. These high temperatures could have resulted in the emigration or death of juvenile coho salmon resulting in the absence of fish within this location by September of 2004. Fish remained absent from minnow traps in June of 2005. In 2005, average August water temperatures at Sites 4 and 6 were 19.6 and 18.0°C respectively. Maximum water temperatures exceeded 20°C for 14 days at Site 4 and for only 2 days at Site 6 in August. Only 2 coho salmon juveniles were captured at Site 4 compared to 20 at Site 6 in September of 2005. The catch rates are consistent with the literature and suggest that juvenile coho salmon within Cottonwood Creek avoid locations where water temperatures exceed 20°C. Richter and Kolmes (2005) report that temperature refugia are important for maintaining salmonid populations, which appears to be the case within Cottonwood Creek. The presence of riparian vegetation along the lower and upper river sites allows for cooling of stream water and likely provides refugia for juvenile salmon. The maintenance of riparian vegetation, therefore, is critical for the survival of salmon within Cottonwood Creek.

Cottonwood Creek is a spring-fed stream that provides a multitude of different physical habitats. Habitats vary from upper cold water cobble dominated reaches, a number of lakes, palustrine reaches, moderate-gradient riffle-pool reaches, low-gradient macrophyte filled channels and estuarine waters. The stream supports, coho and sockeye salmon and resident rainbow trout and Dolly Varden. However, Cottonwood Creek flows through the city of Wasilla and is subject to many human impacts associated with residential and commercial development. Currently riparian vegetation removal and wetland fills within the drainage remain minor and are centered around Wasilla Lake and Cottonwood-Mud Lake. The water quality of Cottonwood Creek remains good. Foam deposits are from natural sources of surfactants and are common among similar streams in the region. In spite of high specific conductance, macronutrient concentrations are low, and generally below detection limits for nitrate-nitrogen and total or dissolved phosphorus. Water turbidity is low and does not increase with rising discharge during storm events. The macroinvertebrate community is diverse and consistent with good to excellent water quality for Cook Inlet streams with similar slope and substrate. The increase in development along the lower river has resulted in increases in fecal coliform bacteria that exceed State Water Quality Standards below Wasilla Lake. The large amount of exposed lake surface area makes water temperatures within Cottonwood Creek closely tied to air temperatures. High water temperatures appear to have resulted in the temporary displacement or seasonal death of rearing juvenile salmon within the lower river. Riparian vegetation is critical in allowing for the insulation and cooling of stream water providing for temperature refugia for aquatic organisms. Water withdrawals or diversions that reduce the volume of water can also cause an increase in water temperatures and should be avoided. The high temperatures and high organic matter content are likely the cause of low dissolved oxygen concentrations within the slow moving reach of Cottonwood Creek between Wasilla Lake and Edlund Road. Organic loading could exacerbate this problem. The relatively constant stream flow makes Cottonwood Creek highly susceptible to impacts related to fine sediment deposits as the stream does not have the hydraulic capacity to transport large volumes of sediment.

Water Quality of Cottonwood Creek currently is good, with the exception of high fecal coliform bacteria counts. However, the unique physical and hydraulic characteristics of this stream make it highly susceptible to human induced impacts.

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Appendix A: QAPP

Quality Assurance Project Plan

Cottonwood Creek Water Quality Monitoring

July 2005

(Revision Number 1.1)

AQUATIC RESTORATION AND RESEARCH INSTITUTE
P.O. Box 923, Talkeetna, AK.
(907) 733-5432 (phone/fax), www.arrialaska.org

A1. Cottonwood Creek Water Quality Monitoring

Aquatic Restoration and Research Institute

Project Manager: ______ Date: _

Quality Assurance Officer: ______ Date: _

Alaska Department of Environmental Conservation

Project Manager: ______ Date: _

Quality Assurance Officer: ______ Date: _

Effective Date:____________

A2. Table of Contents

A3. Distribution List

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Juneau, AK
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A4. Project/Task Organization

The ARRI project manager listed below will be responsible for all project components including data collection, entry, analyses, and reports.

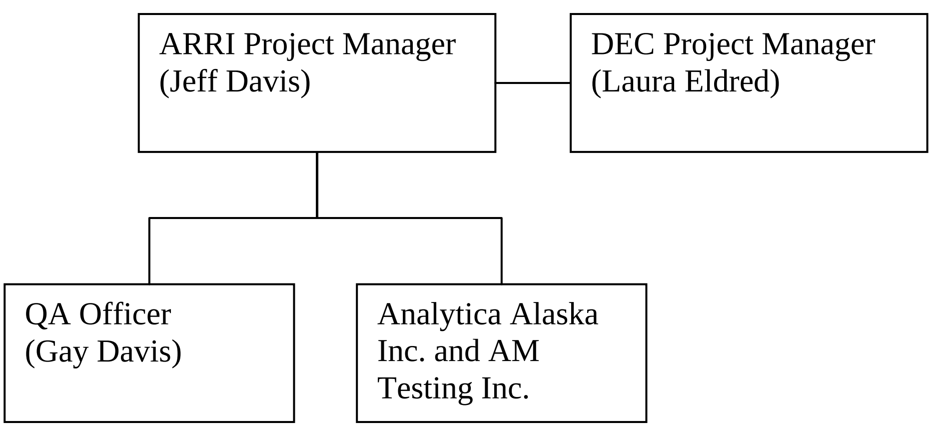
Laura Eldred (DEC). DEC Project Manager. Ms. Eldred will oversee the project for DEC, provide technical support, QAPP review and approval, review of any proposed sampling plan modifications, and the review of all reports.

Jeffrey C. Davis (ARRI): Project Manager. Mr. Davis will make sure that all field data are collected as specified in the QAPP. He will test and maintain all equipment prior to use and perform the review of data entry and analyses. He will be responsible for preparing all reports.

Gay A. Davis (ARRI) will act as Quality Assurance Officer. Ms. Davis will be responsible for making sure that all data are collected, replicate samples taken and analyzed, and all data entered and analyzed correctly.

Analytica Alaska Inc.—5761 International Way, Unit N, Anchorage, Alaska 99518. (907) 258-2155, (907) 258-6634 Fax. The testing laboratory will be responsible for analyzing all collected water samples for fecal coliforms and chlorophyll-a.

AM Testing Inc.—AM Test, Inc. Laboratories,14603 NE 87th Street, Redmond, WA 98052. AM Testing will be responsible for analyzing all collected water samples for the macronutrients nitrogen and phosphorus and providing quality control and quality assurance reports relative to parameters tested.



A5. Problem Definition/Background

Cottonwood Creek has been listed as an impaired waterbody due to the presence of foam. Studies of foam development have uncovered other potential water quality problems. Early detection and evaluation of these potential problems can lead to easier and less expensive recovery plans. Project objectives were developed to build upon previous data and include intensified fecal coliform sampling, increasing water temperature measurement locations and evaluation, investigation of stream nutrient limitation status, and conducting biotic (macroinvertebrates and fish) and habitat assessments. Fecal coliform bacteria concentrations in initial screening exceeded State Water Quality standards for contact recreation (>200 cfu/100ml), particularly below Wasilla Lake in July and August. Sampling locations and frequency will be modified to directly evaluate compliance with State fecal coliform standards. Wasilla Lake is used as a public swimming area so addressing possible fecal coliform contamination is critical. Cottonwood Creek water temperatures exceeded State Water Quality standards for both spawning and incubation (13°C), and migration and rearing (15°C) from mid June through mid-August of 2004 throughout most of the drainage. Juvenile coho salmon populations that were abundant in September of 2003 were absent in 2004 and may be related to water temperature changes. Water temperature and juvenile fish sampling will be repeated and intensified to determine whether 2004 data were an anomaly due to the high summer air temperatures and to identify specific locations of rapid temperature change. Large algal blooms have been observed in recent years. Increasing algal production may be the result of increases in macronutrients associated with human development of the riparian areas. Water sampling will be conducted to evaluate stream nutrient status and experiments will be conducted to determine nutrient limitation.

A6. Project/Task Description

OBJECTIVE 1: Develop a DEC approved sampling plan and revised QAPP

TASK 1: Develop the Cottonwood Creek sampling plan.

Start and end date: July 1, 2005 – July 15, 2005
Description: The project sampling plan will be written by the project manager. A draft plan will be submitted to DEC within 1 week of receiving funding, and a final plan by week 2. The sampling plan will outline sampling locations, frequency, and timing. Sample collection, handling, and processing will be described. The sampling plan will discuss equipment calibration and maintenance. Plan will describe how collected data will be handled as well as reporting requirements.
Product: project sampling plan

TASK 2: Revise the Cottonwood Creek QAPP for DEC approval.

Start and end date: July 1, 2005 – July 15, 2005

Description: The project manager will modify previously approved Cottonwood Creek QAPP to incorporate changes in project workplan and ensure that QAPP contains all of the required elements. Submit draft QAPP within 1 week of receiving workplan approval. Work with the DEC project manager to address any problems in the draft document and submit final QAPP for approval. In lieu of developing or updating a separate project Monitoring Strategy, the QAPP will address two additional elements 1) a timeline, of one to five years, for completion of the monitoring; and 2) a description of monitoring objectives and how they will be determined in consultation with DEC and other state agencies.
Product: approved QAPP

OBJECTIVE 2: Conduct Water Quality Monitoring

TASK 3: Conduct water quality monitoring for fecal coliform.

Start and end date: July 15, 2005 – June 30, 2006
Description: Site selection and sampling frequency for Total Fecal coliform bacteria will be developed through the Sampling Plan and QAPP. Proposed sampling sites will include, upstream and downstream of Wasilla Lake, and Edlund or Surrey Road crossings. Sampling frequency will be weekly so that 4 samples will be collected in a 30-day period. Sampling options will include a more intensive sampling effort to measure variability over an hour. Sampling day and time will be randomized. A follow-up spring sampling option will be examined based upon fall results and the budget. Samples will be analyzed by Analytical Alaska Inc. The laboratory will be contacted in early July and arrangements made to collect sample bottles. Samples will be collected using the "clean hands" methods, sterile procedures as described in the QAPP. Depth integrated samples will be collected in a 60-ml syringe and deposited into the laboratory provided sample bottles. Bottles will be sealed, placed in a cooler, and maintained at 6°C. Chain of custody forms will be filled out and samples will be delivered to the laboratory for analyses.

Product: Tabulated laboratory results with the 2nd quarterly report. Final evaluated results presented and discussed in final report.

TASK 4: Deploy data loggers, collect and analyze data for water temperature

Start and end date: July 15, 2005 – October 30, 2005
Description: Stream water temperature data loggers would be placed within Cottonwood Creek at 8 locations bracketing the major stream reaches. Locations would include: Anderson Lake outlet (farthest upstream portion of Dry Creek), Settlement Avenue (farthest upstream portion of Cottonwood Creek), outlet of Nekleson Lake (Cottonwood and Dry Creeks discharge into Nekleson Lake), Upstream of Cottonwood Lake (1.9 stream miles from Nekleson), upstream of Wasilla Lake (below 300 acre surface area of 2 lakes), below Wasilla Lake (350 acres), below Edlund Road (3 miles of slow moving stream), and Surrey Road (2.8 miles of riffle). Surveys will be conducted between each temperature logger to determine average channel width and depth, flow time, riparian vegetation types (0 to 100 ft) and percent modified (qualitative

estimate). For lakes total surface area and percent riparian vegetation modified will be calculated. The change in temperature between sampling conditions will be compared with characteristics between stations.
Product: temperature data and analyses will be presented in the final report with quarterly updates to DEC

TASK 5: Collect water quality samples for macronutrient monitoring
Start and end date: July 1, 2005 – September 30, 2005
Description: Water samples will be collected at bi-weekly intervals at 8 locations through the growing season (July and August). Depth-integrated water samples will be collected from well mixed areas using clean 60-ml syringes and discharged into laboratory supplied pre-labeled sample containers. Chain of custody forms will be completed and samples placed within a cooler along with frozen gel-paks. The cooler will be sealed and transported directly to the laboratory for analyses. Samples will be analyzed for nitrate and nitrite-N, ammonia-N, total phosphorus and dissolved reactive phosphorus. Stream water samples will also be collected and analyzed for pH, conductivity, dissolved oxygen, and turbidity.
Product: results of nutrient analyses in final report with quarterly updates to DEC

TASK 6: Conduct nutrient limitation experiments
Start and end date: July 1, 2005 – September 30, 2005
Description: Nutrient limitation will be determined experimentally through the use of nutrient diffusing substrata. This standard method involves placement of nutrient enriched agar into plastic vials capped with porous silica crucible covers. Five vials are filled with nitrogen, phosphorus, nitrogen and phosphorus, and un-enriched agar. The vials are secured within a wooden rack and placed securely to the stream bottom. Nutrients diffusing through the porous cap are available for algal uptake. After 3 weeks incubation the vials are removed from the stream and the algae scraped from the lids and analyzed for chlorophyll-a and ash-free dry mass. Algal growth will be greatest on the vials containing the growth limiting nutrient. Light limitation is evaluated by conducting the experiment in open and shaded portions of the stream.
Product: algal growth-limiting nutrients will be presented in final report with draft data in 2nd quarterly report

TASK 7: Conduct biotic and habitat assessments
Start and end date: September 1, 2005 – June 15, 2006
Description: Stream macroinvertebrates would be sampled at 4 locations within Cottonwood Creek in the Fall. Invertebrate collection, identification, and analyses would follow the Alaska Stream Condition Index (ASCI) protocol. Sampling locations used in the development of these methods would be replicated. The ASCI qualitative habitat assessment would be completed at the invertebrate sampling locations as well as quantitative measures of substrate size distribution and embeddedness, large woody debris, channel and bank morphometry, and riparian plant community composition. Baited minnow trap would be used to determine the relative juvenile fish distribution. In addition, all fish would be inspected for any signs of deformity or lesions.

Product: habitat, macroinvertebrate and fish community data and analysis included in final report with quarterly data updates to DEC

OBJECTIVE 3: Analyze data and write Draft and Final Reports

TASK 8: Data analysis and draft final report preparation

Start and end date: September 1, 2005 – March 31, 2006
Description: All field and laboratory data will be entered into excel spreadsheets. Individual fecal coliform colony forming units as well as 30-day geometric means will be calculated and compared with State Water Quality Standards. Sample results will be discussed relative to other streams, and possible sources. Daily temperature data will be converted to daily maximum, minimums, and averages. Daily average temperature differences from successive sites will be evaluated relative to stream and riparian characteristics, and fish distribution and tolerance limits. Water temperatures will be compared to State Standards. Nutrient concentrations will be evaluated relative to previously identified limiting concentrations. Algal biomass produced on the nutrient diffusing substrate will be compared among treatments and discussed relative to other similar studies. The macroinvertebrate community will be compared among sites and with previous values to evaluate any changes in stream condition relative to increased development over space and time. Qualitative stream habitat assessment values will be presented along with stream channel and biotic characteristics. All data will be entered into STORET or supplied to DEC in a STORET compatible format per DEC specifications and requirements.

Product: Draft Final Report Submitted by the end of the 3rd Quarter for DEC review and comment

TASK 9: Develop and submit Final Report

Start and end date: April 1, 2006 – June 30, 2006
Description: Draft report will be updated to include additional June fish collection data. Additional analyses will be conducted and discussions added as directed through review comments. Final document will be edited and printed.

Product: final project report in electronic and hard copy formats

A7. Quality Objectives and Criteria for Measurement of Data

The parameters in the Table 1 will be measured at the indicated performance level. All parameters are critical to meeting project objectives. Criteria for Measurements of Data are the performance criteria: accuracy, precision, comparability, representativeness and completeness of the tests. These criteria must be met to ensure that the data are verifiable and that project quality objectives are met.

Table 13. Accuracy, precision, and completeness objectives for measurement parameters.

Parameter	Method	Resolution/ Limit	Expected Range	Accuracy%	Precision	Completeness
pH	Meter	0.01	6.5 to 8.5	95 to 105 @ 7.0	5%	90%
Turbidity (NTU)	Meter	0.1	1 to 6	75 to 125	20%	90%
Conductivity (µS/cm)	Meter	0.1	100 to 200	95 to 105 @ 100µS/cm	5%	90%
DO (mg/L)	Meter	0.1	8 to 16	95 to 105 @ 10mg/L	5%	90%
Fecal Coliforms (cfu)	SM9222D	1	0 to 300	N/A	25%	90%
Nitrate-N (mg/L)	EPA 353.2	0.010	0.05 to 0.5	75 to 125	20%	90%
Ammonia-N (mg/L)	EPA 350.1	0.005	0.01 to 0.05	75 to 125	20%	90%
Total-P (mg/L)	EPA 365.2	0.005	0.001 to 0.005	75 to 125	20%	90%
Dissolved-P (mg/L)	EPA 365.2	0.001	0.001 to 0.005	75 to 125	20%	90%
Substratum (mm)	Counts	N/A	0.2 to 500	N/A	10%	90%
Macroinvertebrates	ASCI	N/A	N/A	N/A	20%	90%
Temperature (°C)	Stowaway	0.1	0 to 25	97 to 103 @ 15°C	5%	90%
Discharge(cfs)	Measure	1	15 to 40	N/A	10%	90%

Quality Assurance Definitions

Accuracy

Accuracy is a measure of confidence that describes how close a measurement is to its "true" value. Methods to ensure accuracy of field measurements include instrument calibration and maintenance procedures.

$$Accuracy = \frac{MeasuredValue}{TrueValue} \times 100$$

Precision

Precision is the degree of agreement among repeated measurements of the same characteristic, or parameter, and gives information about the consistency of methods. Precision is expressed in terms of the relative percent difference between two measurements (A and B).

$$\Pr ecision = \frac{(A - B)}{((A + B)/2)} \times 100$$

Representativeness

Representativeness is the extent to which measurements actually represent the true condition. Measurements that represent the environmental conditions are related to sample frequency and location relative to spatial and temporal variability of the condition one wishes to describe.

Comparability

Comparability is the degree to which data can be compared directly to similar studies. Standardized sampling and analytical methods and units of reporting with comparable sensitivity will be used to ensure comparability.

Completeness

Completeness is the comparison between the amounts of usable data collected versus the amounts of data called for.

Quality Assurance for Measurement Parameters

Accuracy

The percent accuracy for the acceptance of data is shown for each parameter in Table 1. Accuracy will be determined for those measurements where actual values are known. For pH, conductivity, turbidity, and dissolved oxygen, measurements of commercially purchased standards within the range of expected values will be used. For dissolved oxygen, 100% saturated air will be used as a standard. Measurement accuracy will be determined for each sampling event. Contract laboratories will provide the results of accuracy measures along with chemical analytical reports. Accuracy for Stowaway temperature loggers has been calculated to be 0.40°C by the manufacturer, which at 15°C is 97% to 103%. Accuracy will not be determined where true values are unknown: substratum, macroinvertebrates, and discharge. However for discharge, the velocity meter will be spin tested as per manufacturer's recommendation prior to each use. Accuracy of discharge rating curves will be determined by comparing measured value (as actual) with calculated value.

Precision

Table 1 shows the precision value for the acceptance of data. Precision will be determined for all chemical measure by processing a duplicate for every 8 samples. Discharge measure will be repeated at one site on one occasion to determine measurement precision. Precision of stowaway meters will be determined by placing all meters in one location for 24 hours. Precision for substratum size distribution will be determined by repeating the pebble count at one location and comparing the number of stones within each size class.

Representativeness

The monitoring design site locations, sampling frequency, and timing will ensure that the measurement parameters adequately describe and represent actual stream conditions for the sampling period. Single year data should not be interpreted to be representative of conditions over longer temporal scales. Repeated measures over multiple years are necessary to describe the variability among years. However this is beyond the scope of this project.

Comparability and Completeness

The use of standard collection and analytical methods will allow for data comparisons with previous or future studies and data from other locations. We expect to collect all of the samples, ensure proper handling, and ensure that they arrive at the laboratory and that analyses are conducted. Our objective is to achieve 90% completeness for all measures. Sample collection will be repeated if problems arise such as equipment malfunction or lost samples.

A8. Special Training Requirements/Certification Listed

Jeffrey C. Davis (Project Manager) has a B.S. degree in Biology from University of Alaska Anchorage and a M.S. degree in Aquatic Ecology from Idaho State University. He has 12 years of experience in stream research. Mr. Davis has experience in all of the assessment techniques outlined in this document. He has experience in laboratory chemical analyses, macroinvertebrate collection pursuant to the USGS NAWQA program, the EPA Rapid bioassessment program, modification of these methodologies for Idaho and Alaska. Mr. Davis also has experience in aquatic invertebrate and vertebrate species identification.

Gay Davis (Quality Assurance Officer) has a B.S. degree In Wildlife Biology from the University of Maine. She has 13 years of experience in stream restoration and evaluation. Ms. Davis has over 5 year experience in stream ecological field assessment methods and water quality sampling.

Chemical analyses will be conducted through Analytical International, Inc. laboratory in Anchorage and AM Testing in Redmond Washington.

With the combined experience of these investigators, no additional training will be required to complete this project.

A9. Documentation and Records

Field data including replicates measures for quality assurance will be recorded in Rite-in-the-Rain field books. Upon returning to the laboratory, the field book will be photocopied (daily or weekly). The field data book will be kept and stored by the project manager and the Quality Assurance Officer will store the photocopies. ARRI will maintain records indefinitely. The final data report will include as appendices photocopies of the field data book, Excel data sheets, and results of QC checks. Any sampling problems will be recorded on the data sheets and included in the field sampling report. Laboratory reporting and requested laboratory turn around times of 6 to 10 days are discussed in section B4.

The project reporting requirements are as follows:

<u>Quarterly Reports:</u> Quarterly progress, financial, and MBE/WBE reports will be submitted for the periods ending **September 30, 2005**, **December 31, 2005 and March 31, 2006.** Reports are due 15 days after these dates and are considered late if received more than 20 days after these dates. A final progress, financial, MBE/WBE reports, and all required deliverables are due **July**

31, 2006, and are considered late if received after August 5, 2006. All reports will be submitted in written and electronic formats requested by DEC.

Monitoring Data Entry. In addition to a written project report, any water quality monitoring data collected by the project will be entered into STORET or provided to DEC in accordance with guidance and templates at: http://www.state.ak.us/dec/water/wqsar/storetdocumentation.htm. The guidance and templates show the layout required for STORET compatible files and detail the valid values for various fields used in STORET (e.g. characteristics, analytic procedures, HUCs, etc). The data will be provided to DEC electronically via email, CD, diskette, or via an FTP website (to be determined). Alternate options for data entry are a) the use of the DASLER-X MS Access application or, b) a custom application that will produce STORET compatible text files in accordance with the guidance at the website listed above. The DASLER-X application and training in its use will be provided to the Grantee by ADEC or its representative before December 31, 2005. All data collected by Dec 31, 2005 will be furnished to DEC by March 31, 2006, and all data collected by the project will be furnished to DEC by July 31, 2006.

Project Photographs. At least 3 electronic photograph(s) of the project will be submitted in a format suitable for publishing to the web. These photos will represent all of the following: the problem the project addresses, the project in progress, and the environmental benefit of the project. At least one of these photos must be submitted with the first quarterly report; the remainder will be submitted with the final report or sooner if available. Each photo will be at least 800 x 600 pixels in size and in JPEG format or other format acceptable to the department. Included will be background information on what the photo represents and when and where it was taken. If possible, the information will be in the photo's file name, such as “Fish_Ck_samplesite1_iron_floc_101603". Alternatively, it may be provided with a caption that states the date, location, and describes the subject: for example "MCV-023X.JPG. Taken 10-3-02, Ditch along south side of Alaska Highway that empties into Fish Creek: Note channelization."

Final Report Evaluating Project Accomplishments and Benefits:
A final report will be produced that evaluates and describes the project accomplishments and their environmental benefit. These environmental benefits will be determined by miles of streams monitored to determine water quality status, aquatic habitat, temperature variation, and nutrient limitation and how the results relate to the State Water Quality Standards.

Deliverables: (at least 1 electronic and 3 hard copies of each)
In addition to submitting the information identified in the reporting requirements, the following products will be delivered to the Department. All written products will be submitted to the department in both hard copy and electronic format.

Project Sampling PlanJuly 15, 2005
QAPP July 15, 2005
Total Fecal Coliform Laboratory Data October 31, 2005
Draft Nutrient Limitation Data September 30, 2005

All data collected prior to Dec. 31 entered into STORET March 31, 2006
Draft Final Report March 31, 2006
Final Report July 31, 2006
All Project Data entered into STORET or provided in STORET compatible format July 31, 2006

B1. Sampling Process Design

The sampling locations, frequency, and timing are designed to (1) determine macronutrient concentrations during summer base-flow along the entire stream segment, (2) determine nutrient limitation in the lower river during peak production, (3) measure temperature changes during summer maximum air temperatures and bracketing distinct reaches, (4) obtain measures of fecal coliform counts at locations and time of year when high numbers were previously recorded, and (5) sample invertebrates and fish, and obtain channel measures at multiple different habitats common along the entire creek.

Sampling locations for nutrient sampling are distributed along the entire stream segment from the upper Cornelius Lake inlet stream to the lowest access point near Cook Inlet (Figure 1). Sampling locations will replicate previously used sampling sites allowing ease of comparisons among years. Nutrient limitation experiments will be conducted in open and more heavily shaded portions of the Creek below Wasilla Lake. These locations will provide for the evaluation of light limitation and determine the influence of macronutrients on productivity where excessive algal growths have been observed in the past.

Temperature data loggers will bracket distinct stream reaches. These include Dry Creek, above Cornelius Lake to below Neklason Lake, the stream from Neklason Lake to Cottonwood Lake, Cottonwood and Mud Lakes, Wasilla Lake, Wasilla Lake outlet to Edulund Road, and Edlund Road to Surry Road.

Water sample collection for fecal coliform analyses will occur at four locations; above Wasilla Lake (site 3), below Wasilla Lake (site 4), and the Surrey Road Crossing (site 7). These locations are where high numbers were recorded in August of 2004, and bracket the high public use sites on Wasilla Lake.

Macroinvertebrates, fish, and channel geometry will be sampled and measured at 4 different locations. These locations will be at the outlet of Neklason Lake near Site 1b. This is a stream segement with moderate slope, cobble substrate where the channel is relatively confined. The locations is at the upstream point of most urban development. Below Wasilla Lake upstream of the Old Matanuska Road bridge. The stream slope and water velocity are low at this locations. This is a site where rainbow trout and coho salmon have been observed spawning. The substrate is cobble and gravel with locations of obvious upwelling. Macrophytes are prolific along the stream margins. Macroinvertebrate sampling has been conducted at this location in the past. The third site will be below Edlund Road. This site is comparable to the Old Matanuska Road site in that water velocities are slow and the stream margins are filled with macrophytes; however, the channel is wider and less confined. The forth site will be between Fairview Loop and Surry Roads. This downstream location has comparable physical habitat with the upstream site near Neklason Lake.

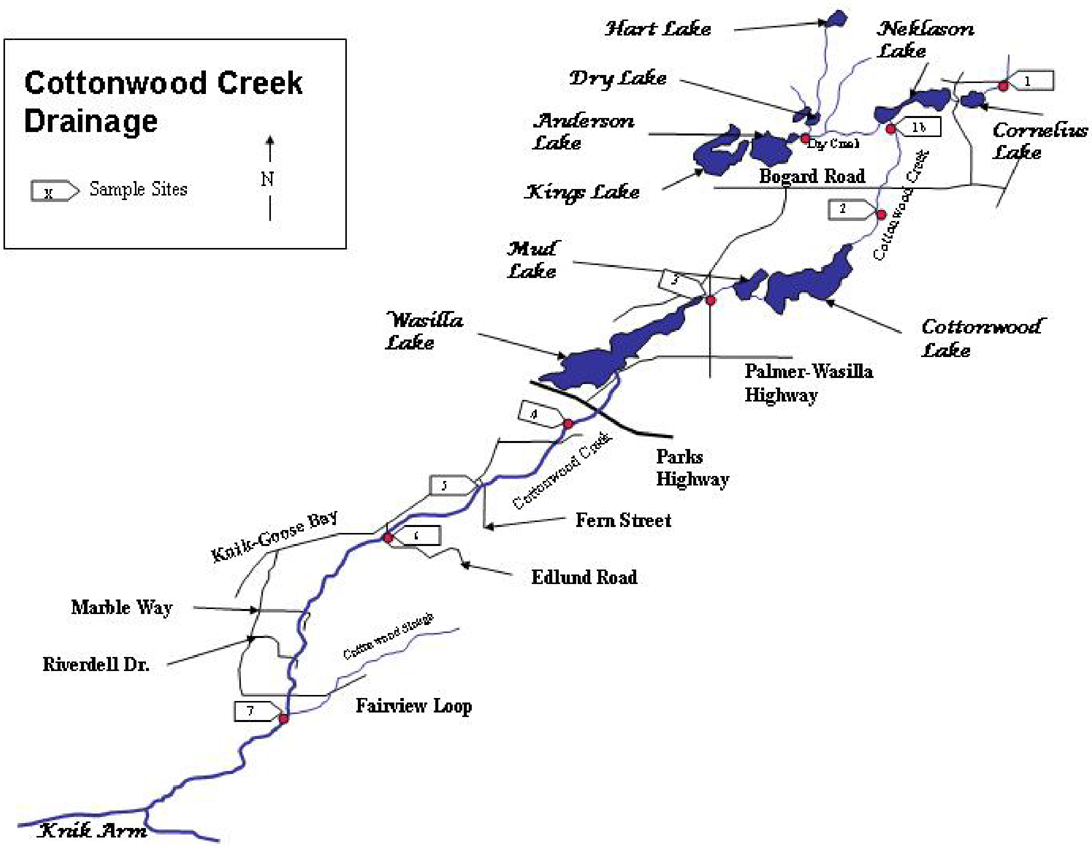


Figure 6. Water sampling locations for macronutrients (numbered) and locations for temperature data loggers (red dots).

<u>Sampling frequency</u> will document the variability of nutrient concentrations during summer base-flow conditions. Bi-weekly sampling will provide a total of 4 sampling dates from July into September. The nutrient limitation experiment will be conducted only once and is timed to occur during August when instream production is high. Water samples for fecal coliform analyses are scheduled to occur during late summer when the highest previous values were recorded. Four samples will be collected over a 30-day period in order to evaluate compliance with State water-quality standards. Sampling days and times will be selected haphazardly. At one sampling site on one occasion, multiple samples will be collected within 1 hour to determine short-term variability. Stream channel and substrate measures will occur only once as intrannual variability should be low. Macroinvertebrates will be sampled in the Fall, consistent with the ASCI methods and during the aquatic phase of most insects life cycle.

Sample Parameters consist of chemical, physical, and biological measures. Recommended parameters as well as proposed methods are as follows (Table 2).

pH. This is a measure of hydrogen ion activity. pH is controlled by the rock weathering, buffering capacity of the water, and influenced by biotic respiration. pH will be measured using a calibrated portable meter in the field (Hanna HI 9023 or equivalent).
Turbidity (NTU). This measures of the reflective properties of the water sample relative to the amount of organic and inorganic particles. Turbidity will be measured using a Turbidimeter (Hach Chemical Co. 16800, or equivalent).
Specific Conductance (µS/cm). Specific conductance is the inverse of electrical resistance and is relative to the concentration of ions in water. Specific conductance is used as a surrogate for Total Dissolved Solids. Specific conductance will be measured in the field using a conductivity probe and meter (Sper Scientific 840039 or equivalent).
Dissolved Oxygen (mg/L). Oxygen concentration and percent saturation will be measured using membrane electrode (YSI 550A).
Fecal Coliform Bacteria (cfu/100 ml). Water samples will be submitted to a commercial laboratory for analyses using SM 9222-D. Analytica International Inc. will be the proposed subcontractor.
Nutrients—Nitrogen (mg/L-N). Water samples will be collected for Nitrate and Nitrite (NO_3 + NO_2) and ammonium (NH_4) analyses. Samples will be submitted to commercial laboratory for analyses using SM 4500-NO_3-E and 4500-NH_3-H. Currently AM testing is the proposed subcontractor.
Nutrients—Phosphorus (mg/L-P). Water samples will be collected and analyzed for total and dissolved phosphorus (SM 4500-P E). Currently AM testing is the proposed subcontractor.
Temperature (°C). Water temperature will be measured at 2 hour intervals using Stowaway data loggers (Onset Corporation). Hand held thermometers will be used to measure water temperature when collecting other samples or measuring conductivity and dissolved oxygen at all sites.
Discharge. Stream discharge will be estimated from a discharge rating curve at the Old Matanuska Road Bridge.
Substratum. The substratum particle size distribution and percent embeddedness will be estimated at 3 mainstem sites and within the two tributaries using pebble counts of 100 stones. Stream surveys to determine cross-section morphometry and energy slope will be conducted at substratum collection points.
Macroinvertebrates/Habitat. Macroinvertebrates will be collected, processed, and analyzed following the Alaska Stream Condition Index (ASCI) methods. Samples will be collected from 4 locations: the upstream end of the reach, the downstream end and within the two major tributaries. Stream habitat conditions will be evaluated using the ASCI qualitative assessment.
Juvenile Fish will be collected in minnow traps baited with salmon eggs and soaked for 24 hours.

External Data
Weather data downloaded or purchased through the National Oceanic and Atmospheric Administration (NOAA) web site (http://www.ncdc.noaa.gov/oa/ncdc.html).

Sample Timing
To minimize diel variability, water sample collection will be standardized to the time between 8:00 to 12:00.

Table 14. Sampling frequency, location, and timing for storm flow and base flow conditions for each measurement parameter.

Parameter	Locations	Frequency/samples	Timing	Total Samples
pH	8	Biweekly/4	AM	24
Alkalinity	8	Biweekly/4	AM	24
Sp. Conductance	8	Biweekly/4	AM	24
Turbidity	8	Biweekly/4	AM	24
Dissolved Oxygen	8	Biweekly/4	AM	24
Nutrients	3	Biweekly/4	AM	24
Fecal Coliforms	3	Weekly/4	Random	12
Substratum/Embeddedness	4	Once	N/A	4
Macroinvertebrates/Habitat	4	Once	N/A	4
Fish	4	Once	N/A	4
Water Temperature	8		N/A	
Discharge	1	Weekly/6	N/A	6

B2. Sampling Methods Requirements

Field Data Collection
Field data collection will be conducted by ARRI staff. The latitude and longitude of sampling locations will be recorded and photographs taken. Sampling will occur on Monday or Tuesday of each week. Measures of dissolved oxygen, will be conducted in the field. Samples for turbidity, pH, and specific conductance will be collected in clean sample bottles and returned to the ARRI Laboratory for analyses. Samples will be collected from a well-mixed area at each sampling site. Water-column integrated samples will be collected by drawing water into a 60 ml sterile syringe while drawing the syringe up from near the stream bottom to near the water surface. The water within the syringes will be discharged into pre-labeled sample bottles. A new sterile syringe and sterile sealed sample bottle will be used for each sample to be analyzed for fecal coliform bacteria. Sample bottles for fecal coliform are received from the laboratory sterile and sealed. Acid washed sample bottles for nutrient analyses are provide by AMtest Inc. Water sample bottles for pH, specific conductance, and turbidity are reused for each specific sampling station.

pH, Specific Conductance, Turbidity, Alkalinity, and Dissolved Oxygen
Depth integrated water samples will be collected in 500 ml sample bottles. The sample bottles will be filled and emptied 3 times before a sample is retained. Water characteristics will be

measured using appropriate meters. Meters, pH, Hanna HI 9023, conductivity, SPER Scientific model 840039, dissolved oxygen, YSI 550A, and turbidity, HACH Chemical Co. Model 16800. Support equipment will include extra batteries and sample bottles. All meters will be tested and calibrated prior to use.

Materials Required: Data book, pencils, sharpie, 500-ml sample bottles (16 minimum), 60-ml syringes, cooler, gel-paks, pH meter with standards, dissolved oxygen meter, thermometer, extra batteries, and camera.

Weather Conditions
Weather conditions for the 24 hours previous to sampling will be obtained through direct observations and from on-line National Weather Service Website for Wasilla.

Nitrogen and Phosphorus
Water samples will be collected in sample containers provided by AM Testing Inc. Sample bottles will contain preservative where required (H_2SO_4 for nitrogen and total phosphorus, 4°C for dissolved phosphorus). Samples will be collected using the "clean hands" method described below. Samples will be sealed within a cooler with frozen gel-paks and shipped by Federal Express to the laboratory for analyses. Maximum holding time for preserved samples is 28 days; however, sample turn-around is 14 to 21 days. Chain of custody forms will be used by ARRI staff and the receiving laboratory to track sample handling.

Materials Required: sample bottles, labels, markers, chain-of-custody forms, cooler, frozen gel-paks (6), 60-cc syringe (9), thermometer, and sterile gloves.

Fecal Coliform Bacteria
Water samples will be collected in containers provided Analytica Alaska Inc. The sample bottles will be sterile. Samples for fecal coliforms will be collected from mid channel-mixed sites. Samples will be depth integrated as described above using only new packaged sterile syringes for each sample. The "clean hands" method will be used to avoid contamination. Sterile or near sterile procedures are used to collect the sample. Sterile gloves are used and contact only the collection bottle and the source water until the sample bottle is sealed. Once the sample is collected, the sample is labeled, and placed in a cooler and gel-packs are used to bring the sample temperature down to and maintained at 4-degrees Celsius. The sample will be labeled with the site ID, sample time and date and any additional information needed by the laboratory. The sample must be returned to the laboratory within 6 hours of collection.

Materials Required: sample bottles, labels, markers, chain-of-custody forms, cooler, frozen gel-paks (6), 60-cc syringe (9), thermometer, and sterile gloves.

Substratum/Embeddedness
Substratum size distribution will be determined through Wolman pebble counts of 100 stones as modified by Bevenger and King (1995). Beginning at the downstream end of the sampling reach, the intermediate axis of rocks is measured at roughly one-meter intervals as the

investigator moves upstream, continually moving at an angle from bank to bank. The rock axis will be determined using an aluminum measuring template. The portion of each rock submerged below the substrate will be estimated from differences in algae or other markings on the rock and recorded as percent embedded (Davis et al. 2001).

Materials Required: Rite-in-the-Rain data book, pencils, aluminum template, meter stick.

Macroinvertebrates/Habitat Assessment
Macroinvertebrates will be collected, processed, and analyzed using the Standard operating procedures for the Alaska Stream Condition Index (ASCI) (Major and Barbour 2001). Composite invertebrate samples will be placed within pre-labeled whir-pak bags. Paper labels will be placed into the bags with the sample and the sample preserved with formalin. Labels will include date, time, location, and investigators. Stream invertebrate collections will be returned to the ARRI laboratory, sorted, and identified to genus (except for Chironomidae, Simuliidae, and Oligochaeta). Stream habitat will be evaluated using the habitat assessment methods of ASCI, or EMAP habitat assessment methods.

Materials Required: ASCI Habitat Assessment Data Sheets, whirl-pak bags, 5-gallon bucket, formalin, D-Nets, gauntlets, labels, pencils, sieve, and sharpies, meter tape, survey level and leveling rod.

Temperature
Stream water temperature data loggers (Stowaway by Onset corp.) will be secured to the bank using plastic coated wire rope. Loggers will be downloaded at least monthly.

Materials Required: 4-m sections of wire rope (3), clamps (6), stowaway temperature data loggers with backup (4), software, base station, coupler, and shuttle.

Juvenile Fish
Fish will be collected in baited minnow traps soaked for 24-hours.

Materials Required: Minnow traps, salmon roe, buckets (2), small net, plastic bags, collection permit, measuring device.

Corrective Actions
The QA officer will ensure that all equipment is prepared and ready for sampling and that all samples are collected as described. The QA officer will inform the project manager of any problems with equipment or any missing data due to collection or laboratory errors. The project manager will be responsible for repairing or replacing equipment, taking additional samples, or replicating measurements as needed.

B3. Sample Handling and Custody Requirements

Water samples will be labeled in the field. Sample labels will record the date, time, location, preservation, and initials of collector. Chain of custody forms will be initiated in the field and completed each time samples are transferred to a laboratory, or other carrier. Carbon copies of chain of custody forms and forms returned with processed samples will be retained on file. Field samples that are to be transferred to either of the contract laboratories will be placed within a cooler and the cooler sealed closed using plastic packing tape. Samples will be transported to the laboratory where they will be placed in a secure location until analyses are completed.

B4. Analytical Methods Requirements

Sample analytical methods are shown in Table 3. Field samples will be collected by ARRI staff and either delivered to the commercial laboratory for subsequent analyses by the identified standard method.

Table 15. List of Analytical methods and detection limits for study parameters.

Measurement	Collection/ Analyses	Method	Limits	Turnaround Time (days)
Fecal Coliforms	ARRI/AI Inc.	SM 9222-D	n/a	6 to 10
Total Phosphorus	ARRI/AM Testing	EPA 365.2	0.005 mg/L	14 to 21
Dissolved Phosphorus	ARRI/AM Testing	EPA 365.2	0.005 mg/L	14 to 21
Ammonia-N	ARRI/AM Testing	EPA 350.1	0.005 mg/L	14 to 21
Nitrate + Nitrite-N	ARRI/AM Testing	EPA 353.2	0.01 mg/L	14 to 21
pH	ARRI/ARRI	Meter (Hanna HI 9023)	0.01 pH units	1
Conductivity	ARRI/ARRI	Meter (SPER 840039)	mhos (0 to 200) 1.0 mhos (>200)	1
Turbidity	ARRI/ARRI	Meter (HACH Model 16800)	NTU (0 to 10) 1.0 NTU (10 to 100)	1
Dissolved Oxygen	ARRI/ARRI	Meter (YSI Model 55)	0.01 mg/L (0 to 20)	1
Temperature	ARRI	HOBO Stowaway	0.1 Degree C	Monthly Download

Corrective Action
ARRI will be responsible for ensuring that all samples are collected and delivered to the laboratory. The QA officer will make sure all samples are labeled and stored correctly and that all equipment has been calibrated and accuracy tests completed as needed. The project manager will be informed of any errors and will be responsible for corrective action including repeating sample collection or analyses (for metered measures). If any samples are lost or are determined to be contaminated by the laboratory or if there are any laboratory problems, the project manager will be responsible for collecting new samples and delivering them to the laboratory.

B5. Quality Control Requirements

The following table (Table 4) lists the percent of field and laboratory replicates to be used for quality control (See section A7 for discussion on calculation of precision and accuracy). If accuracy and precision are not met for analyses ARRI is conducting the meters will be recalibrated and measures will be repeated or meters or probes will be replaced. Data measurements that do not meet the limits described in A7 may or may not be used in the final report depending on degree to which limits are not met. However, the report will clearly state if there are any questions regarding used data.

Table 16. Field and laboratory replicates for quality control.

Parameter	Field Replicates	Laboratory Replicates	Comments
pH, Cond, Turb, DO, alkalinity.	10 Percent	None	Replicate measurements one of every 8 samples.
Fecal Coliform and Total Dissolved Solids, phosphorus, nitrogen,	10 Percent	None	Duplicate sample collected at one of the sites every sampling event.
Substrate	25%	None	Pebble counts will be repeated at one site.
Temperature	1%	None	Water temperature will be measured on each sampling event with meters and compared with stowaway readings. Stowaways will be placed in the same location for 24 hours and reading compared.

B6. Instrument/Equipment Testing, Inspection, and Maintenance Requirements

Instruments and meters will be tested for proper operation as outlined in respective operating manuals. Inspections and calibration will occur prior to use at each site. Equipment that does not calibrate or is not operating correctly will not be used. For most parameters (temperature, conductivity, and pH), duplicate instruments and meters are available. In the case of complete equipment failure, new equipment will be purchased. The Project Manager will be responsible for calibrating and testing and storing equipment and completing log sheets. All calibrating, testing and storage will follow the manufacturer's recommendations. The QA Officer will inspect the log sheets. Spare batteries and repair equipment will be taken during field sampling events.

B7. Instrument Calibration and Frequency

The pH meter, conductivity meter, dissolved oxygen, and turbidity meter will be calibrated in accordance to instructions in the manufacturer's operations manual by the project manager prior to each use and a log will be maintained documenting calibration. Standards are required for pH, and turbidity and will be used for conductivity.

B8. Inspection/Acceptance Requirements for Supplies and Consumables

Sample containers will be obtained from Analytical International Incorporated. Any needed standards for equipment calibration will be purchased directly from the equipment manufacturer if possible or from a well established chemical company. The QA officer will be responsible for ensuring that standards are not outdated and for the purchase of replacements. The date and source of all purchased materials will be recorded within a separate file for each piece of equipment and kept on file by ARRI along with equipment calibration records.

B9. Data Acquisition Requirements for Non-Direct Measurements

Weather data downloaded or purchased through the National Oceanic and Atmospheric Administration (NOAA) web site (http://www.ncdc.noaa.gov/oa/ncdc.html) also will be used and assumed accurate. Some supplemental data such as maps, outfall locations, water quality samples, may be obtained from other currently unknown sources for comparisons.

B10. Data Management

Field data will be entered onto rite-in-the-rain books. The Quality Assurance Officer will copy the field books and review the data to ensure that it is complete and check for any errors. Field and laboratory data sheets will be given to the project manager. The project manager will enter data into Excel spreadsheets. The Quality Assurance Officer will compare approximately 10% of the field and laboratory data sheets with the Excel files. If any errors are found they will be corrected and the Project Manager will check all of the field and laboratory data sheets with the Excel files. The Quality Assurance Officer will then verify correct entry by comparing another 10% of the sheets. This process will be repeated until all errors are eliminated. The Project Manager will then summarize and compare the data. The Quality Assurance officer will review any statistical or other comparisons made. Any errors will be corrected. The Project Manager will write the final report, which will be proofed by the Quality Assurance officer and submitted to the DEC project manager.

Water quality data will be provided to DEC in a modernized STORET compatible format. Data will be formatted into STORET compatible files as described at the following DEC web site (https://www.state.ak.us/dec/water/wqsar/storetdocumentation.htm).

C1. Assessments and Response Actions

Project assessment will primarily be conducted through the preparation of field sampling event reports for DEC by the project manager. Section A6 contains more information on the type and date of each required report. At that time the project manager will review all of the tasks accomplished against the approved workplan to ensure that all tasks are being completed. The project manager will review all data sheets and entered data to make sure that data collection is complete. If necessary, data collection processes or data entry will be modified as necessary. Any modifications of the data collection methods will be reviewed against the processes described within the QAPP to determine whether the document needs to be updated.

The Project Manager will check on contractor's laboratory practices to ensure that samples are handled correctly and consistently. The final report will contain an appendix that will detail all of the QA procedures showing precision and accuracy. Representativeness, completeness, and comparability will be discussed in the body of the report. Any QA problems will be outlined and discussed relative to the validity of the conclusions in the report. Any corrective actions will be discussed as well as any actions that were not correctable, if any.

The QA officer will report to ARRI management any consistent problems in data collection, analyses, or entry identified either internally or through a 3rd party audit. ARRI management will be responsible for developing and implementing a course of action to correct these problems. Where consistent problems may have affected project validity, these will be identified and reported to the DEC project manager directly and included in project reports as directed. Field sampling problems will also be included in the sampling event report submitted to the DEC project manager following each sampling event.

C2. Reports to Management

Reports will be prepared by the ARRI Project Manager and distributed to the Department of Environmental Conservation Project Manager. Reports will update the status of the project relative to the schedule and tasks of the work plan. Reports include Quarterly Reports, Draft Final Report, and Final Report. Any field QA problems will be identified and reported in the sampling event reports. The Project Manager will prepare the draft and final reports. The final report also will be submitted in electronic format. Any potential problems with data due to QA will be identified and reported all submitted reports.

D1. Data Review, Validation, and Verification

The Project Manager and the Quality Assurance Officer will conduct data review and validation. This process for data review is described under section B10 and A7. Data that are obtained using equipment that has been stored and calibrated correctly and that meets the accuracy and precision limits will be used. Data that does not meet the accuracy and precision limits may be used; however, we will clearly identify these data and indicate the limitations.

D2. Validation and Verification Methods

The Project Manager and the Quality Assurance Officer will conduct data validation and verification. The Project Manager will enter all data from laboratory and field data sheets into Excel worksheets. The Project Manager will double-check all entries to ensure that they are correct. The Quality Assurance Officer will compare 10% of the laboratory and field data sheets with the Excel worksheets. The Project Manager will enter all formulas for calculation of parameters and basic statistics. All of these formulas will be checked by the Quality Assurance Officer. If any errors are found, the Project Manager will correct the errors and then check all entries. The Quality Assurance Officer will then repeat a check of 10% of the data entry and all of the formulas and statistics. This process will be repeated until any errors are eliminated. The Project Manager will organize and write the final report. The Quality Assurance Officer will check the results in the report and associated statistical error (i.e. standard deviation and confidence interval) against those calculated with computer programs. Any errors found will be corrected by the Project Manger.

D3. Reconciliation with User Requirements

The project results and associated variability, accuracy, precision, and completeness will be compared with project objectives. If results do not meet criteria established at the beginning of the project, this will be explicitly stated in the final report. Based upon data accuracy some data may be discarded. If so the problems associated with data collection and analysis, or completeness, reasons data were discarded, and potential ways to correct sampling problems will be reported. In some cases accuracy project criteria may be modified. In this case the justification for modification, problems associated with collecting and analyzing data, as well as potential solutions will be reported.

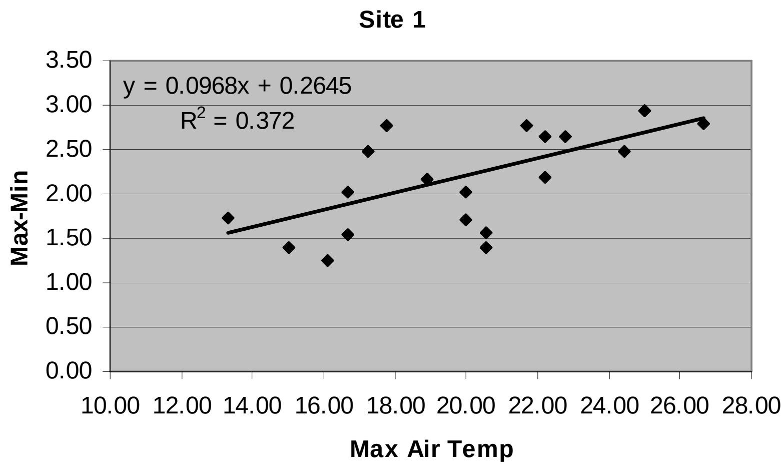
Literature Cited

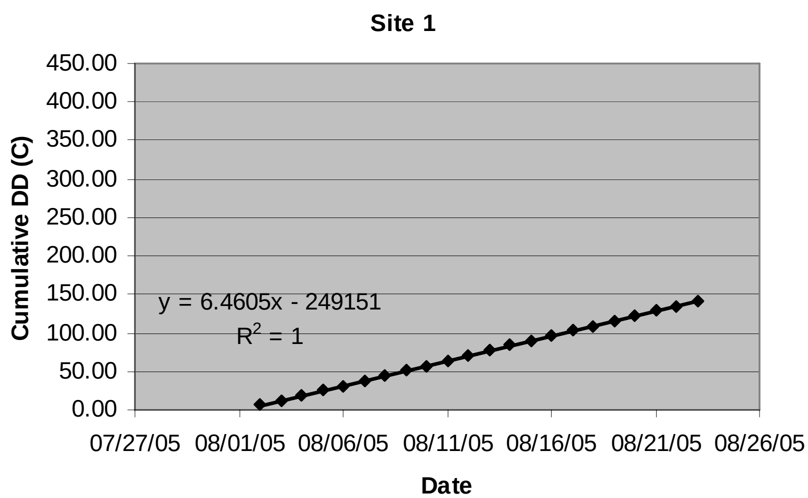
Bevenger, G. S., and R. M. King. 1995. A pebble count procedure for assessing watershed cumulative effects. USDA Forest Service. Rockey Mountain Forest and Range Experiment Station. Fort Collins, CO. Research Paper RM-RP-319.

Davis, J.C., G.W. Minshall, C.T. Robinson, and P. Landres. 2001. Monitoring wilderness stream ecosystems. Gen. Tech. Rep. RMRS-GTR-70. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 137p.

Major, E.B., and M.T. Barbour. 2001. Standard operating procedures for the Alaska Stream Condition Index: A modification of the U.S. EPA rapid bioassessment protocols, 5th edition. Prepared for the Alaska Department of Environmental Conservation, Anchorage, Alaska.

Appendix B: Temperature Charts





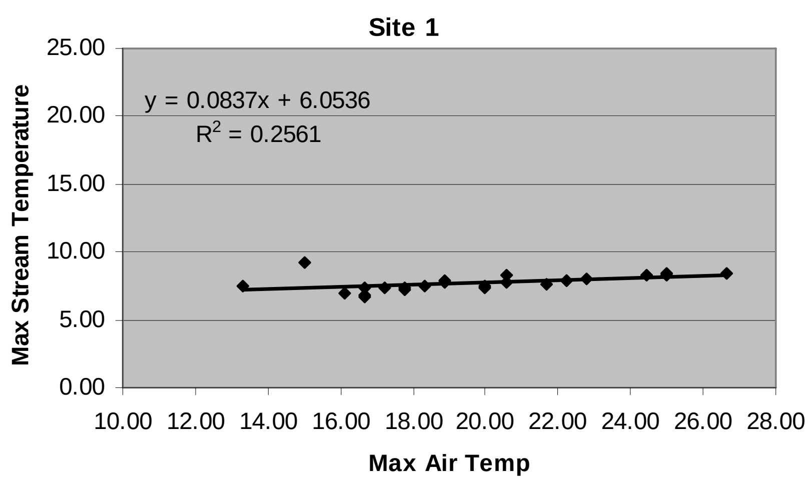
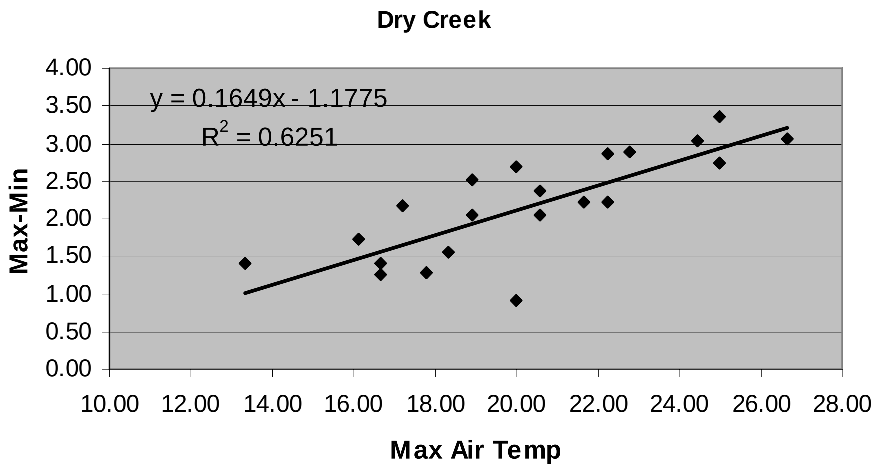
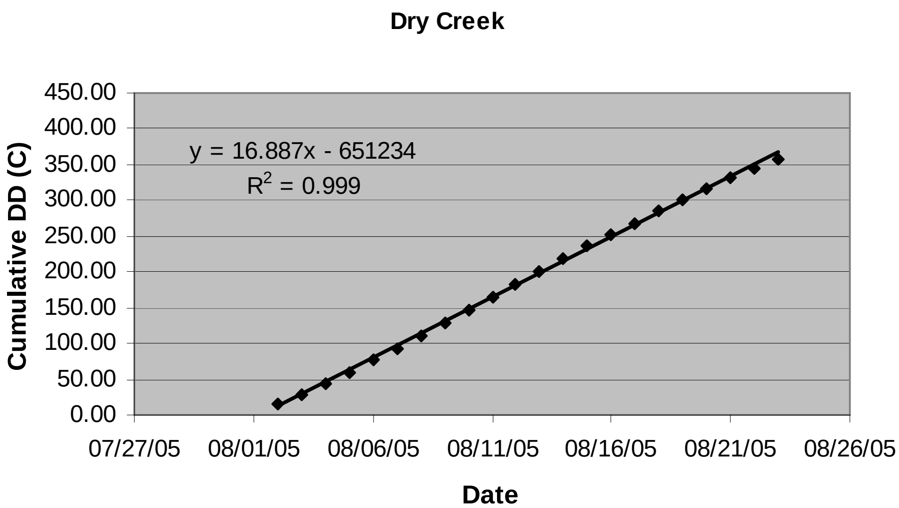
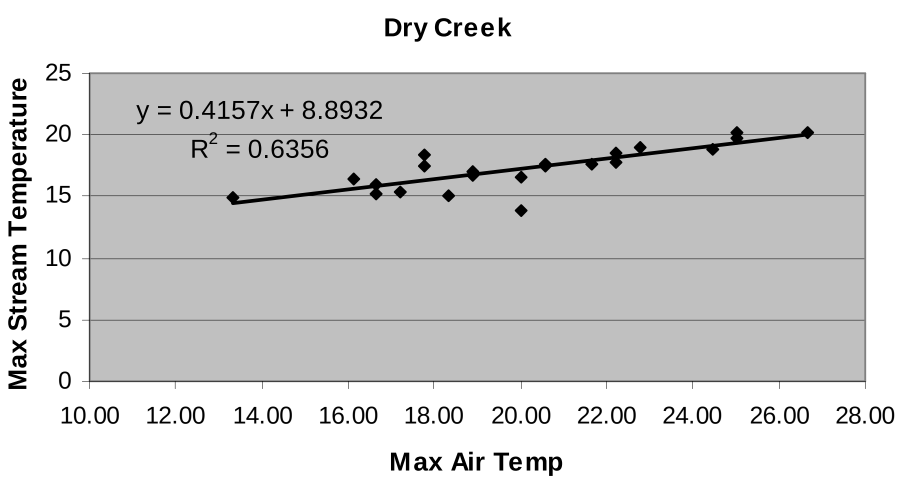
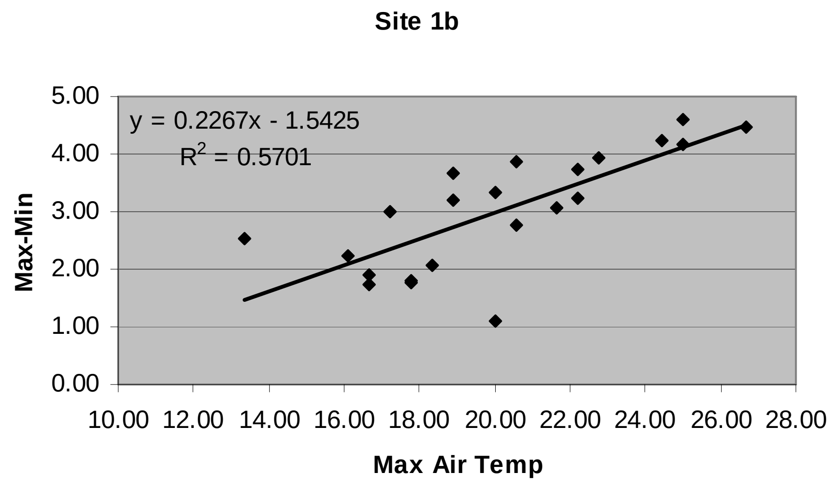


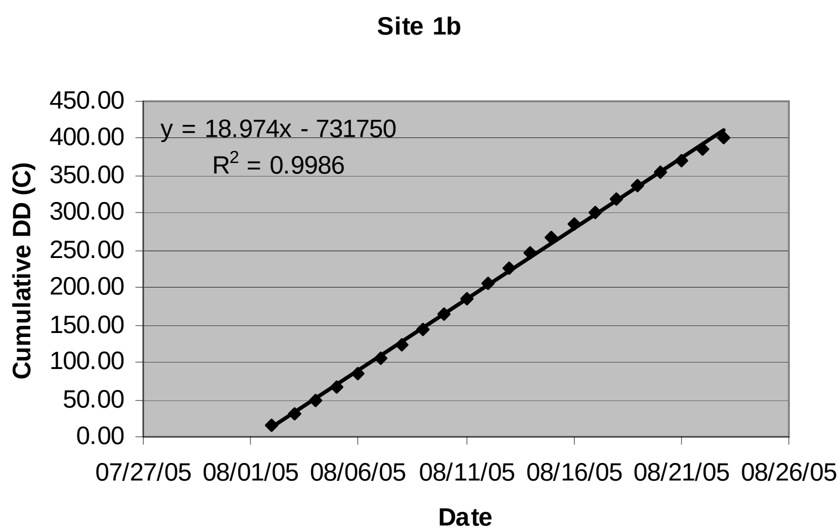
Figure A-7. Regression relationships between maximum air temperatures (°C) recorded at the Palmer Airport and daily change in water temperature (top) and maximum stream temperature (bottom) . Middle chart shows increase in degree days by date.

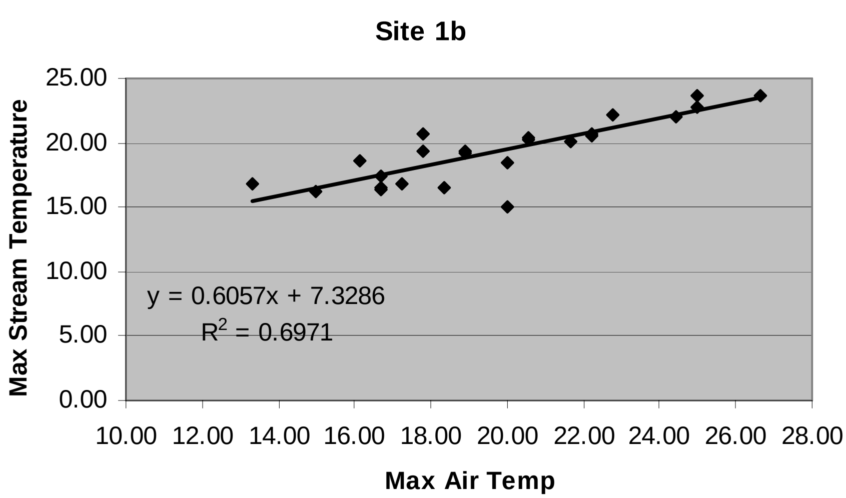

Dry Creek
y = 0.1649x - 1.1775
R2 = 0.6251
Max-Min
Max Air Temp
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
10.00 12.00 14.00 16.00 18.00 20.00 22.00 24.00 26.00 28.00

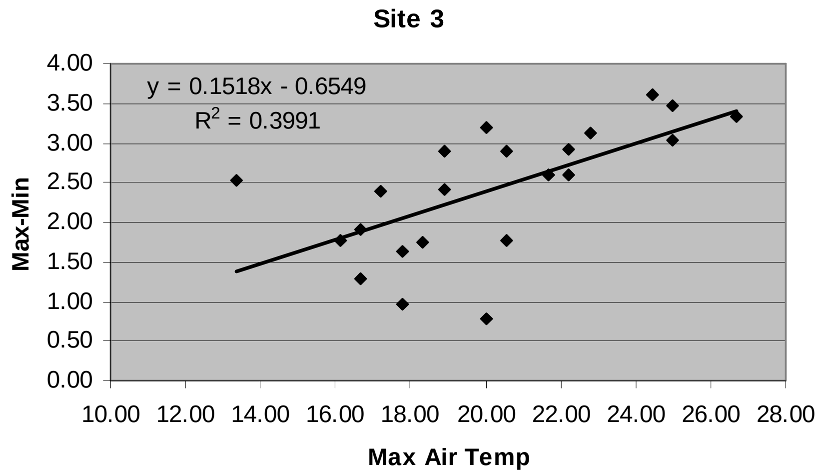

Dry Creek
y = 16.887x - 651234
R2 = 0.999
Cumulative DD (C)
Date
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
07/27/05 08/01/05 08/06/05 08/11/05 08/16/05 08/21/05 08/26/05

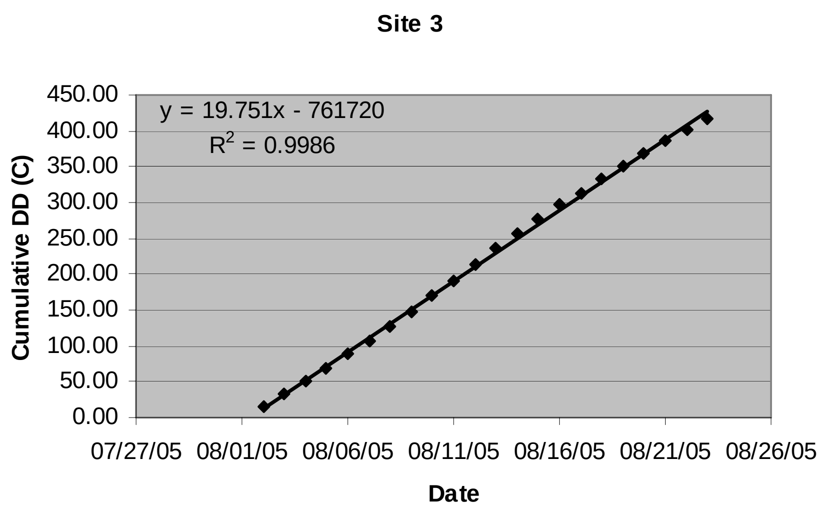

Dry Creek
y = 0.4157x + 8.8932
R2 = 0.6356
Max Stream Temperature
Max Air Temp
25
20
15
10
5
0
10.00 12.00 14.00 16.00 18.00 20.00 22.00 24.00 26.00 28.00

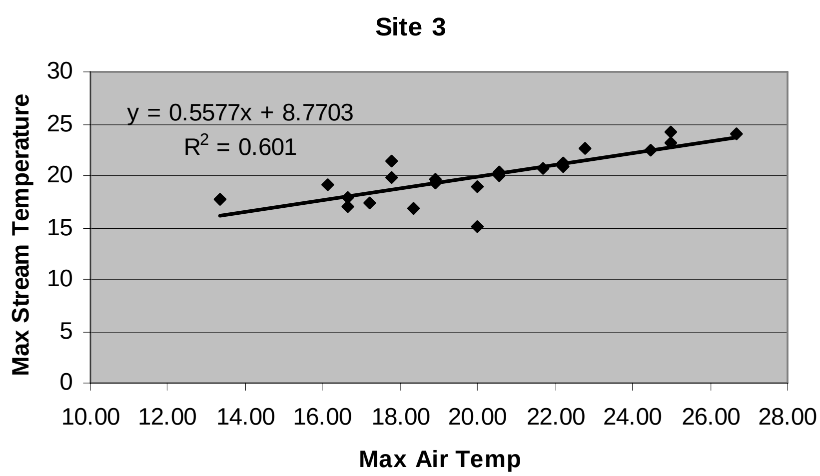

Site 1b
y = 0.2267x - 1.5425
R2 = 0.5701
Max-Min
5.00
4.00
3.00
2.00
1.00
0.00
10.00 12.00 14.00 16.00 18.00 20.00 22.00 24.00 26.00 28.00
Max Air Temp

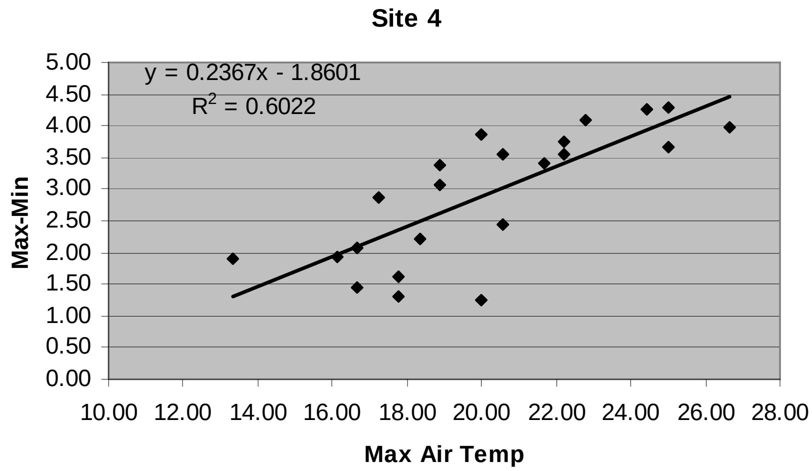

Site 1b
y = 18.974x - 731750
R2 = 0.9986
Cumulative DD (C)
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
07/27/05 08/01/05 08/06/05 08/11/05 08/16/05 08/21/05 08/26/05
Date

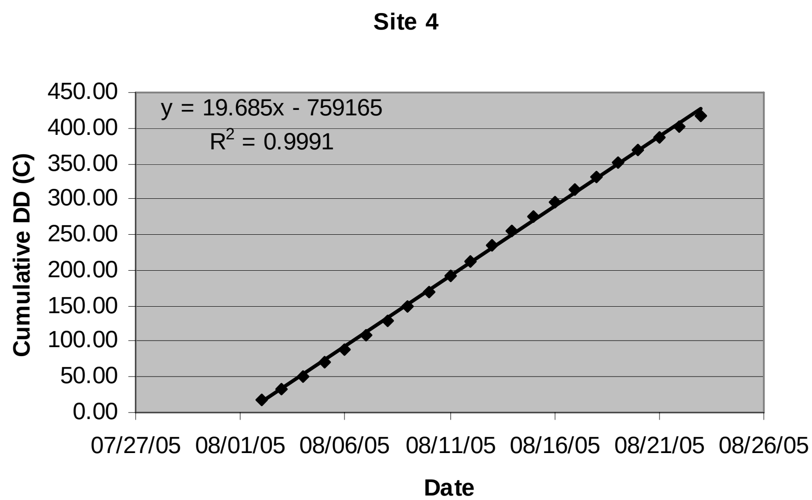

Site 1b
y = 0.6057x + 7.3286
R2 = 0.6971
Max Stream Temperature
25.00
20.00
15.00
10.00
5.00
0.00
10.00 12.00 14.00 16.00 18.00 20.00 22.00 24.00 26.00 28.00
Max Air Temp

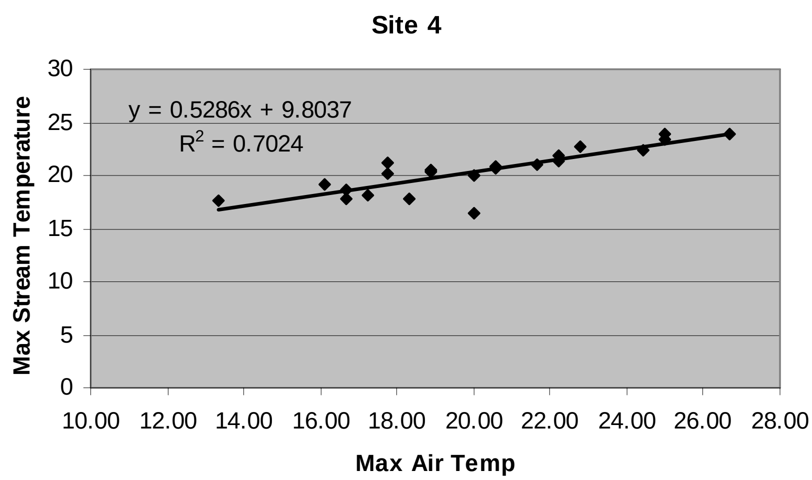

Site 3
y = 0.1518x - 0.6549
R2 = 0.3991
Max-Min
Max Air Temp
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
10.00 12.00 14.00 16.00 18.00 20.00 22.00 24.00 26.00 28.00

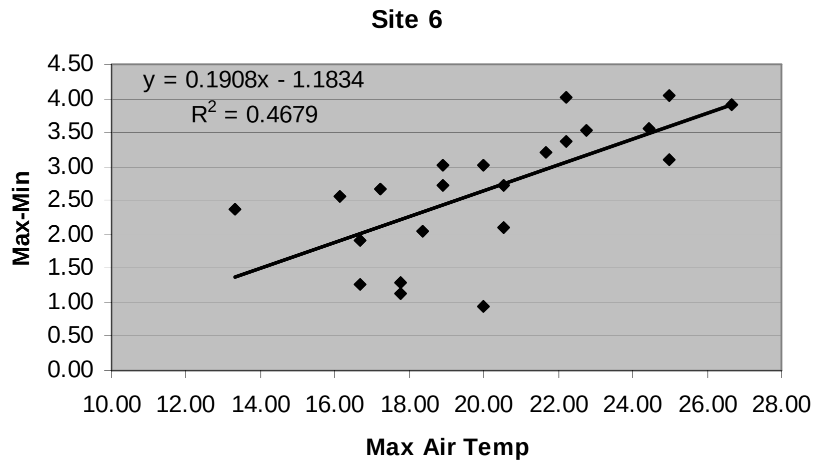

Site 3
y = 19.751x - 761720
R2 = 0.9986
Cumulative DD (C)
Date
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
07/27/05 08/01/05 08/06/05 08/11/05 08/16/05 08/21/05 08/26/05

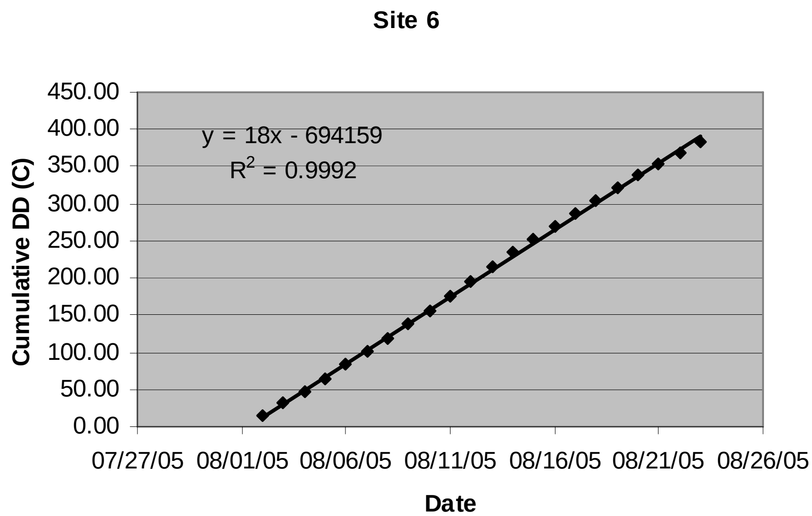

Site 3
y = 0.5577x + 8.7703
R2 = 0.601
Max Stream Temperature
Max Air Temp
30
25
20
15
10
5
0
10.00 12.00 14.00 16.00 18.00 20.00 22.00 24.00 26.00 28.00

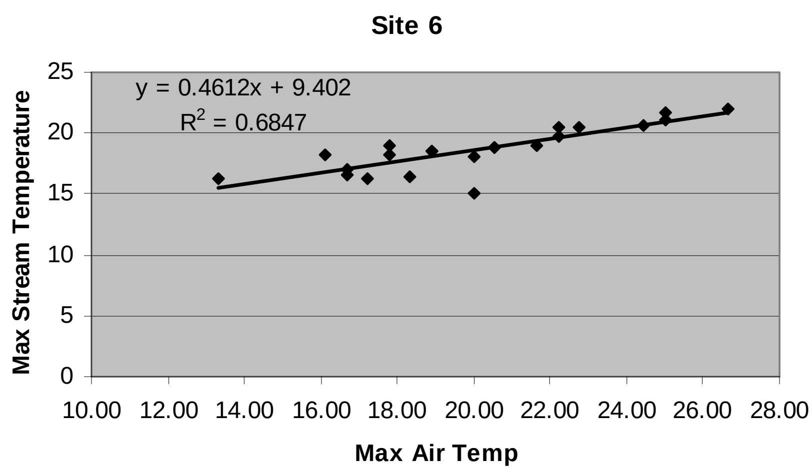

Site 4
y = 0.2367x - 1.8601
R^2 = 0.6022
Max-Min
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
10.00 12.00 14.00 16.00 18.00 20.00 22.00 24.00 26.00 28.00
Max Air Temp

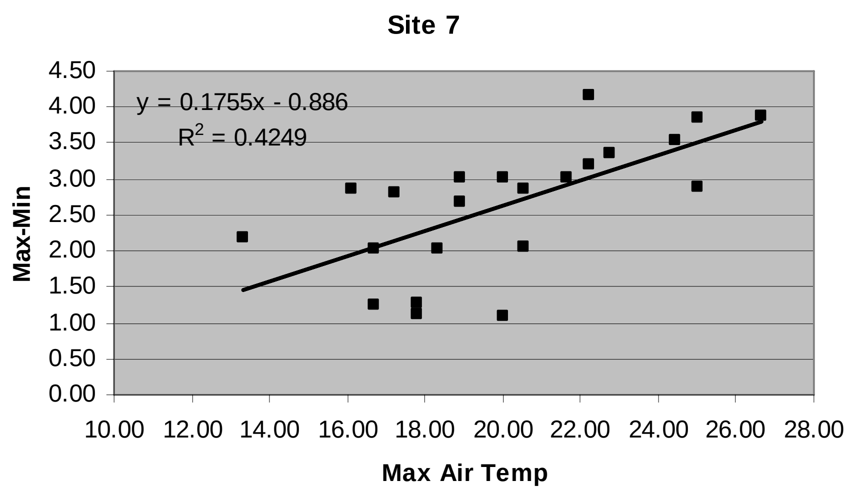

Site 4
y = 19.685x - 759165
R^2 = 0.9991
Cumulative DD (C)
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
07/27/05 08/01/05 08/06/05 08/11/05 08/16/05 08/21/05 08/26/05
Date

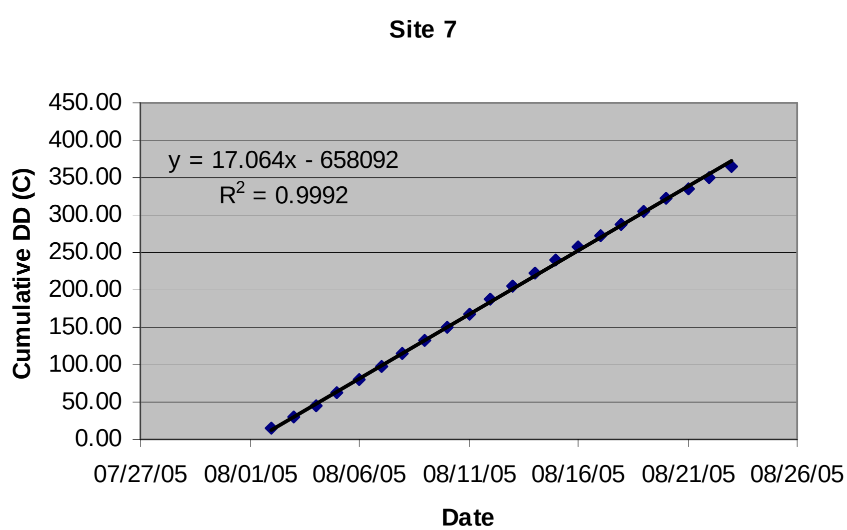

Site 4
y = 0.5286x + 9.8037
R^2 = 0.7024
Max Stream Temperature
30
25
20
15
10
5
0
10.00 12.00 14.00 16.00 18.00 20.00 22.00 24.00 26.00 28.00
Max Air Temp

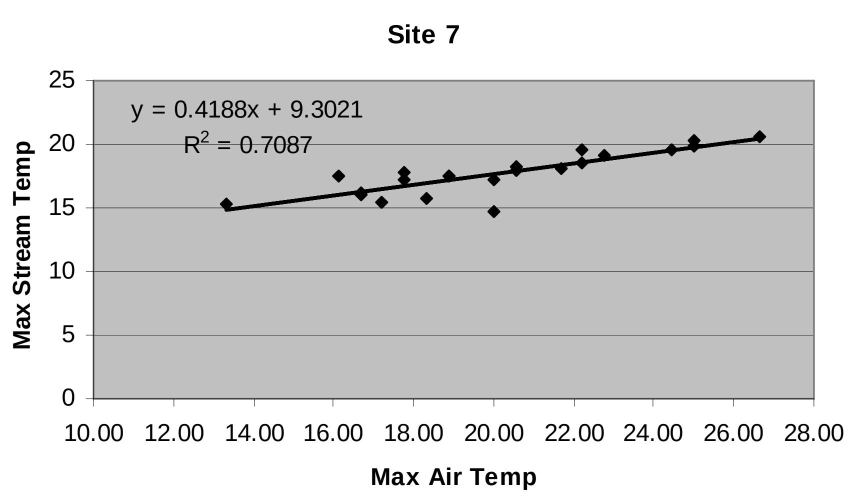

Site 6
y = 0.1908x - 1.1834
R2 = 0.4679
Max-Min
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
10.00 12.00 14.00 16.00 18.00 20.00 22.00 24.00 26.00 28.00
Max Air Temp


Site 6
y = 18x - 694159
R2 = 0.9992
Cumulative DD (C)
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
07/27/05 08/01/05 08/06/05 08/11/05 08/16/05 08/21/05 08/26/05
Date


Site 6
y = 0.4612x + 9.402
R2 = 0.6847
Max Stream Temperature
25
20
15
10
5
0
10.00 12.00 14.00 16.00 18.00 20.00 22.00 24.00 26.00 28.00
Max Air Temp


Site 7
y = 0.1755x - 0.886
R2 = 0.4249
Max-Min
Max Air Temp


Site 7
y = 17.064x - 658092
R2 = 0.9992
Cumulative DD (C)
Date


Site 7
y = 0.4188x + 9.3021
R2 = 0.7087
Max Stream Temp
Max Air Temp

Appendix C: Nutrient Data

Ammonia Nitrogen (mg/L)					
	6/9/2005	**7/20/2005**	**8/2/2005**	**8/15/2005**	**8/30/2005**
1	<0.005	0.011	0.008	0.012	0.025
1b	<0.005	0.032	0.011	0.012	0.120
2	<0.005	0.042	0.006	0.270	0.240
3	0.01	0.036	0.027	0.045	0.310
4	<0.005	0.042	0.033	0.220	0.140
5	<0.005	0.011	0.016	0.023	0.340
6	<0.005	0.012	0.021	0.039	0.100
7		0.036	0.035	0.027	0.110
Nitrate + Nitrite-N (mg/L)					
	6/9/2005	**7/20/2005**	**8/2/2005**	**8/15/2005**	**8/30/2005**
1	0.21	0.061	0.018	0.015	<0.01
1b	0.061	<0.01	<0.01	<0.01	<0.01
2	0.033	<0.01	<0.01	<0.01	<0.01
3	0.021	<0.01	<0.01	<0.01	<0.01
4	<0.01	<0.01	<0.01	<0.01	<0.01
5	0.02	<0.01	<0.01	<0.01	<0.01
6	<0.01	<0.01	<0.01	<0.01	<0.01
7	0.076	<0.01	<0.01	<0.01	<0.01
Total Phosphorus (mg/L)					
	6/9/2005	**7/20/2005**	**8/2/2005**	**8/15/2005**	**8/30/2005**
1	0.028	0.006	<0.005	<0.005	0.01
1b	0.077	<0.005	0.007	0.013	0.008
2	0.027	<0.005	0.014	0.013	0.015
3	0.025	0.005	0.016	0.015	<0.005
4	0.044	<0.005	0.018	0.016	<0.005
5	0.024	<0.005	0.012	0.014	0.007
6	0.03	<0.005	0.008	<0.005	0.006
7	0.028	<0.005	0.008	0.008	<0.005
Total Dissolved Phosphorus (mg/L)					
	6/9/2005	**7/20/2005**	**8/2/2005**	**8/15/2005**	**8/30/2005**
1	<0.001	<0.001	<0.001	<0.001	0.013
1b	<0.001	<0.001	<0.001	<0.001	0.013
2	<0.001	<0.001	0.009	0.007	0.005
3	<0.001	<0.001	<0.001	<0.001	<0.001
4	<0.001	<0.001	0.006	0.002	0.005
5	<0.001	<0.001	<0.001	0.007	0.003
6	<0.001	<0.001	<0.001	<0.001	0.003
7	<0.001	<0.001	0.003	<0.001	0.004

Dissolved Oxygen % Saturation				
	7/20/2005	**8/2/2005**	**8/15/2005**	**8/30/2005**
1	103	105	99	101.8
1b	93	98	84.9	96.6
2	96	102	95.6	97.8
3	88	85	75.1	87.8
4	88	87	80.5	92.6
5	89	85	80.3	86.5
6		86	76.5	82.4
7	98	102	96.3	99.9
Dissolved Oxygen (mg/L)				
	7/20/2005	**8/2/2005**	**8/15/2005**	**8/30/2005**
1	12.6	12.8	12.24	12.66
1b	8.8	10	8.21	10.07
2	9.2	10.5	9.34	10.31
3	8.3	8.6	7.17	9.07
4	8.1	8.6	7.6	9.37
5	8.4	8.6	7.74	9.01
6		8.7	7.31	8.61
7	9.7	10.7	9.59	10.63
pH				
	7/20/2005	**8/2/2005**	**8/15/2005**	**8/30/2005**
1	7.65	7.68	7.79	7.92
1b	7.59	7.73	7.72	7.96
2	7.85	7.89	7.97	8.14
3	7.78	7.69	7.74	7.86
4	7.81	7.41	7.92	8.12
5	7.7	7.58	7.64	7.8
6	7.65	7.56	7.67	7.64
7	7.86	7.87	8.00	8.00
X	7.96	7.93	8.00	8.03
Specific Conductance (μS/cm)				
	7/20/2005	**8/2/2005**	**8/15/2005**	**8/30/2005**
1	207.0	191.5	192.7	191.0
1b	197.0	167.3	177.8	177.0
2	192.6	170.9	182.4	179.1
3	168.6	171.2	172.6	185.1
4	200.0	189.9	186.2	189.9
5	202.0	184.4	190.1	196.6
6	202.0	188.9	188.5	196.9
7	204.0	188.9	192.7	197.2

x	205	189	192.6	196.9
Turbidity (NTU)				
	7/20/2005	**8/2/2005**	**8/15/2005**	**8/30/2005**
1	0.7	0.7	0.7	0.7
1b	1	1	1	1.1
2	0.8	1.2	1	1.2
3	1.6	1.9	1.1	1.4
4	1.2	2.1	2.5	1.7
5	1.3	3	3.8	1.2
6	1	2.6	2.5	1.1
7	0.9	2.5	0.8	1.2
x	0.8	1.6	1.1	1

Precision Calculations							
pH							
Sample 1	Sample 2	Difference	Precision				
7.86	7.96	-0.1	1.26				
7.87	7.93	-0.06	0.76				
8.00	8.00	0	0.00				
8.00	8.03	-0.03	0.37				
Sp. Conductance							
Sample 1	Sample 2	Difference	Precision				
204.0	205	-1	0.49				
188.9	189	-0.1	0.05				
192.7	192.6	0.1	0.05				
197.2	196.9	0.3	0.15				
Turbidity							
Sample 1	Sample 2	Difference	Precision				
0.9	0.8	0.1	11.76				
2.5	1.6	0.9	43.90				
0.8	1.1	-0.3	31.58				
1.2	1	0.2	18.18				
Ammonia-N				**Nitrate +Nitrite**			
Sample 1	Sample 2	Difference	Precision	Sample 1	Sample 2	Difference	Precision
0.005	0.005	0	0.00	5.4	5.5	-0.1	1.83
0.023	0.028	-0.005	19.61	1.6	1.6	0	0.00
0.57	0.58	-0.01	1.74	0.35	0.32	0.03	8.96
0.24	0.26	-0.02	8.00	0.01	0.01	0	0.00
0.005	0.005	0	0.00	0.19	0.18	0.01	5.41
2.3	1.9	0.4	19.05	0.75	0.67	0.08	11.27

0.91	0.96	-0.05	5.35	0.12	0.12	0	0.00
Total Phosphorus				**Total Dissolved Phosphorus**			
Sample 1	Sample 2	Difference	Precision	Sample 1	Sample 2	Difference	Precision
0.018	0.014	0.004	25.00	0.001	0.001	0	0.00
0.005	0.005	0	0.00	0.008	0.007	0.001	13.33
0.033	0.04	-0.007	19.18	0.033	0.03	0.003	9.52
0.032	0.032	0	0.00	0.009	0.008	0.001	11.76
0.035	0.036	-0.001	2.82				
0.01	0.013	-0.003	26.09				

Appendix D: Invertebrate Data

			Cottonwood Creek			**Sep-05**		
Order	**Family**	**Genus**						
Taxa			**Tol Val**	**FFG**	**Site 1b**	**Site 4**	**Site 6**	**Site 7**
Ephemeroptera								
Ephemeroptera	Baetidae							
Ephemeroptera	Baetidae	Baetis	4	Collector	7	1	14	32
Ephemeroptera	Baetidae	Acerpenna	4	Shredder				
Ephemeroptera	Ephemerellidae							
Ephemeroptera	Ephemerellidae	Ephemerella	2	Collector				
Ephemeroptera	Heptageniidae							
Ephemeroptera	Heptageniidae	Drunella	1	Predator		1		
Ephemeroptera	Heptageniidae	Cinygmula	4	Scrapper				
Ephemeroptera	Heptageniidae	Acanthemola						
Plecoptera								
Plecoptera	Chloroperlidae-UNID		1	Predator	5			
Plecoptera	Chloroperlidae-UNID	Katholperla	1	Predator				4
Plecoptera	Chloroperlidae-UNID	Neaviperla	1	Predator				
Plecoptera	Chloroperlidae-UNID	Alloperla	1	Predator				
Plecoptera	Perlodidae							
Plecoptera	Perlodidae	Isoperla	2	Predator	6		2	1
Plecoptera	Nemouridae							
Plecoptera	Nemouridae	Zapada	2	Shredder				
Plecoptera	Pteronarcydae	Pteronarcella	0	Shredder				5
Trichoptera								
Trichoptera	Rhyacophilidae							
Trichoptera	Rhyacophilidae	Rhyacophila	0	Predator				
Trichoptera	Glossosomatidae							
Trichoptera	Glossosomatidae	Glossosoma	0	Scrapper	8	2	7	3
Trichoptera	Brachycentridae							
Trichoptera	Brachycentridae	Brachycentrus	1	Filterer	6		12	39
Trichoptera	Limnephilidae		4	Shredder		6	1	

Trichoptera	Limnephilidae	Ecclisomyia	4	Collector			1	
Trichoptera	Limnephilidae	Onocosmoecus	1	Shredder				
Trichoptera	Limnephilidae	Hesperophylax	5	Shredder				
Trichoptera	Limnephilidae	Psychoglypha	1	Collector				
Trichoptera	Hydropsychidae							
Trichoptera	Hydropsychidae	Hydropsyche	6	Filterer	60		24	25
Trichoptera	Apataniidae							
Trichoptera	Apataniidae	Apatania	4	Scrapper				
Trichoptera								
Diptera								
Diptera	Chironomidae-UNID		6	Collector	29	46	76	46
Diptera	Ceratopogonidae							
Diptera	Ceratopogonidae	Probezzia	6	Predator				
Diptera	Simuliidae-UNID		6	Filterer	99	3	3	40
Diptera	Empididae							
Diptera	Empididae	Chelifera						
Diptera	Empididae	Clinocera						
Diptera	Empididae	Oreogoeton						
Diptera	Dolichopodiidae							
Diptera	Phoridae							
Diptera	Tipulidae		3	Shredder	1			
Diptera	Tipulidae	Dicranota						
Diptera	Tipulidae	Hexatoma						
Diptera	Tipulidae	Tipula						
Diptera	Psychodidae							
Diptera	Psychodidae	Pericoma	4	Collector				8
Coleoptera								
Coleoptera	Hydrophilidae							
Arachnoidea	Hydrachnidia							
Arachnoidea	Hydrachnidia	Hydracarina	6	Predator		1	5	6
Mulusca	Pelycypoda							
Mulusca	Sphaeriidae	Anadonta		Filterer		51	2	
Mulusca	Gastropoda							
Mulusca	Gastropoda	Lymnaeidae	7	Scrapper		51	30	
Mulusca	Gastropoda	Planorbidae	8	Scrapper		15	11	
Mulusca	Gastropoda	Physidae	8	Scrapper			14	
Mulusca	Gastropoda	Valvatiidae						

	Chrysomeliidae-UNID							
Analida	Oligochaeta		8	Collector	1			
Analida	Nematoda							
Hemiptera	Corixidae		5	Predator				1
Amphipoda	Gameroidea	Eogammerus	6	Omnivore	11	90	11	
Arachnoidia	Terrestrial				1		2	
Analid	Hiruindi		9	Predator		2		
Lepidop[tera	Terrestrial							1
Total Organisms					**234**	**269**	**215**	**211**
Ephemeroptera					7	2	14	32
Plecoptera					11	0	2	10
Trichoptera					74	8	45	67
Diptera					129	49	79	94
Richness					12	12	16	13
Ephemeroptera Taxa					1	2	1	1
Trichoptera Taxa					3	2	5	3
% Plectopera					4.701	0.000	0.930	4.739
% Ephemptera (no Baetidae)					0	0.003717472	0	0
% Diptera					55.12820513	18.21561338	36.74418605	44.54976303
Baetidae/Ephemeroptera					1	0.5	1	1
% Non-insects					5.556	78.067	34.884	3.318
HBI					5.37	5.83	5.15	3.90
%Scrapers					3.42	25.28	28.84	1.42
% Collectors					15.81196581	17.47211896	42.3255814	40.75829384
% EPT no Baetids or Zapada					36.32	3.35	21.86	36.49