DEPARTMENT OF ENVIRONMENTAL CONSERVATION
NONPOINT SOURCE POLLUTION PROGRAM
ACWA NPS WATER QUALITY GRANT

FY 2008
FINAL REPORT

Watershed Protection and Recovery for Jordan Creek, Juneau, AK

July 2008

Prepared by:

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PROJECT #: ACWA-08-07
PROJECT TITLE: Watershed Protection and Recovery for Jordan Creek, Juneau, AK

Project Description and Purpose

In 2007-2008, we continued our multi-year efforts directed at monitoring the water quality of Jordan Creek in the Mendenhall Watershed (Figure 1). Our long-term monitoring program aims to characterize the water quality of Jordan Creek, to compare the water quality to Alaska state standards, and to evaluate the effects of urbanization on sediment concentrations in the stream. The stream corridor of Jordan Creek has undergone extensive development, and it has been suffering from low flow levels, including complete drying out at some sites, increased sediment loads, and declines in salmon usage. A suite of water quality parameters was collected at three representative sites on Jordan Creek on four intensive sampling events, one per season.

Jordan Creek flows through the eastern edge of the Mendenhall Valley and drains an area of about 3 mi^2 (Host and Neal, 2004). The upper reaches of Jordan Creek originate along the western edge of Thunder Mountain and are relatively undeveloped, while the lower reaches downstream from Egan Drive are bounded by parking lots apartment complexes and professional malls. Degradation of the riparian zone has occurred where buildings, parking lots, and roads have encroached on the stream channel.

The specific goals of this project included:

- To evaluate the variation in water quality over short time periods (9-10 sampling events over 3 day periods) in order to check for diel- and event- scale variation. Jordan Creek is a very flashy stream that responds and recovers quickly to climatic and hydrologic variations.
- To document existing water quality conditions in Jordan Creek and make comparisons to historic data

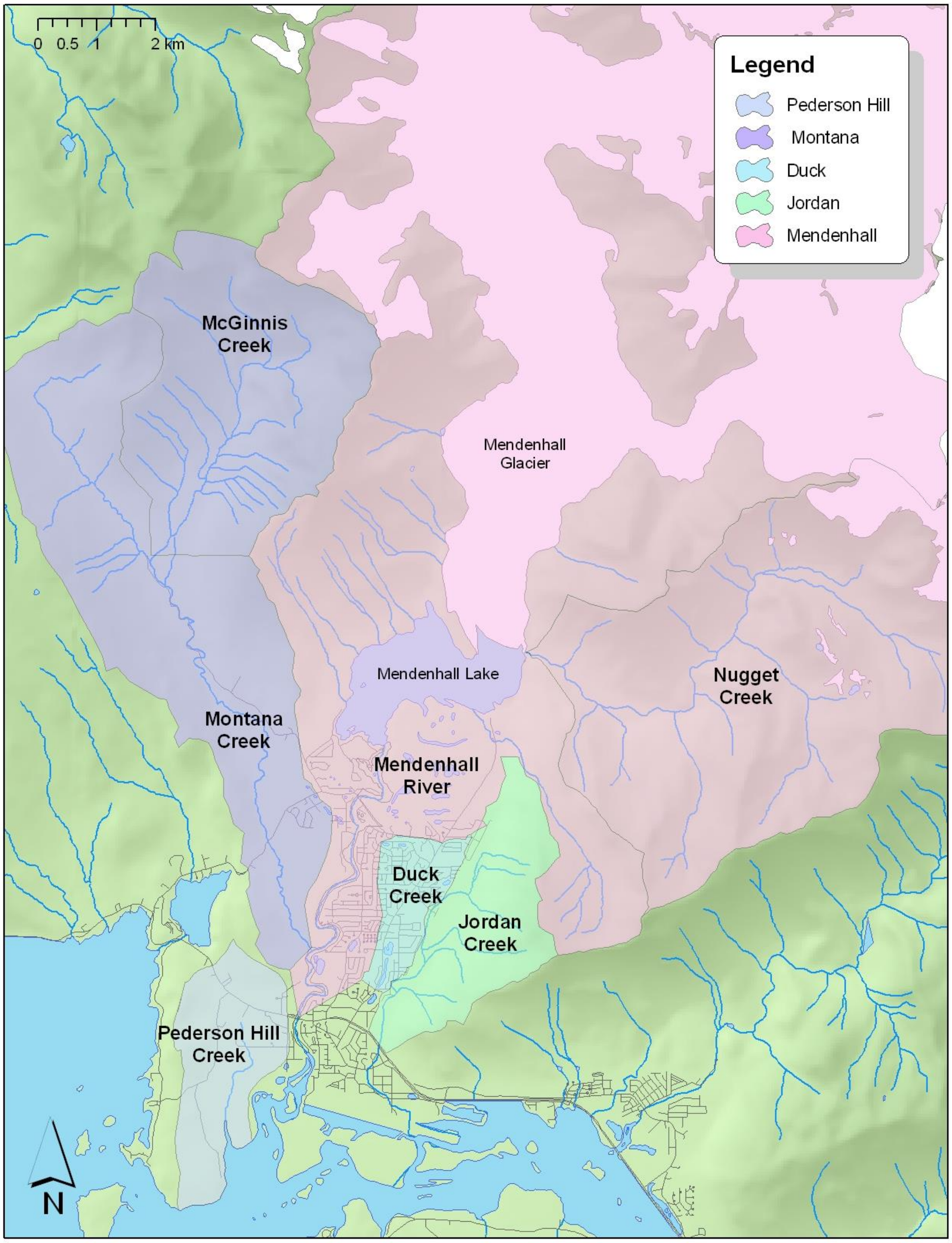


Figure 1: *Location of Jordan Creek watershed and other watersheds in the Mendenhall Valley, Juneau.*

I. Water Quality Monitoring Project

Research Design

The location of the Jordan Creek water quality monitoring sites was kept consistent with previous years' efforts, with three sites along the stream (Table 1, Figure 2). Jordan Creek watershed is 2.6 square miles (above the Jordan C sample site), a large portion of which is suburban development in the Mendenhall Valley.

Table 1. *Stream sample locations along Jordan Creek. Latitude and longitude coordinates were measured using GPS in April, 2006 and are reported in the North American Datum 1983.*

Site Code	Site Description	Latitude	Longitude
JC-A	Jord C @ Amalga Dr	58.38726067004	-134.56351114001
JC-B	Jord C @ Super 8 Motel	58.36616032005	-134.57784830000
JC-C	Jord C @ Yandukin Footbridge	58.35917610005	-134.57835674000

Sample sites on Jordan Creek represent differently impacted areas of the watershed. The JC-A site is upstream, closest to the headwaters of Jordan Creek on the western flank of Thunder Mountain, at the bridge crossing on Amalga Drive. JC-B is located immediately downstream of where Jordan Creek flows under Egan Drive at the site of the US Geological Survey streamgage (near the Super 8 motel). JC-C is located at the edge of the Juneau airport property, just upstream from the fish weir operated by the Alaska Department of Fish and Game.

Stream sampling was conducted from November, 2007 to June 2008. Our approach in FY 2008 differed from previous years by focusing on intensive sampling once per season as opposed to single samples every two weeks. We focused our efforts during 4 specific time periods of FY08 : one fall rainstorm event; one low flow winter period, one high flow spring runoff event, and one warm, dry summer event. Considering that suspended sediments continue to be a large concern for Jordan Creek, it is important to capture high flow events, when sediments are likely carried most efficiently, on a more detailed level (fall rainstorm and spring runoff). Low-flow events in the winter show little to no change, and so we sampled once intensively during this period as well, instead of every 2 weeks. A warm, summer sample served the purpose of focusing on potential violations in water quality for stream temperature. On each of the 4 events, we collected samples 2-3 times per day for 3 days each at the same three sampling sites that UAS/JWP has been monitoring for the past several years. Parameters measured included: pH, dissolved oxygen, specific conductivity, temperature, turbidity, total suspended sediment, dissolved iron, and discharge. Dissolved iron was analyzed on only half of the samples in order to help keep down costs.

No operating stream gauge was available past January, 2006 (before that the USGS operated a stream gage at JC-B); and we manually gaged the discharge at JC-B. Water quality data collected for Jordan Creek during the project is shown in Appendices A and B of this report.

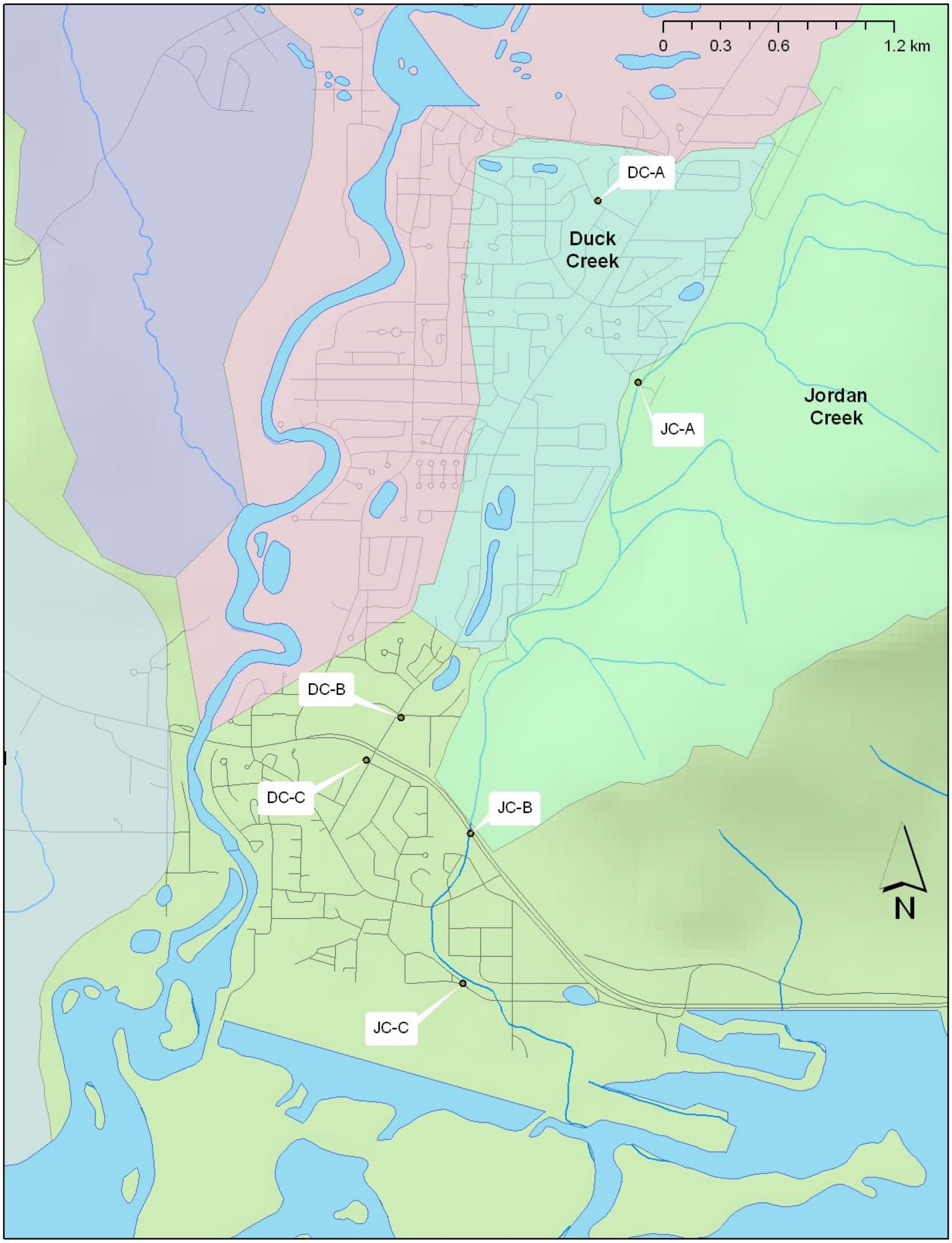


Figure 2. *Map of the Mendenhall Valley and sample sites used in the study on Jordan Creek. Also shown are sample sites from previous study years along neighboring Duck Creek (DC-A, B, C)).*

Water temperature, conductivity, and pH were measured in the field using a YSI multi-probe unit. Dissolved oxygen was measured using a dedicated D.O. meter. Both meters were calibrated in the laboratory at the beginning of each sampling event. All in situ parameters were measured and recorded 3 times; averages of the triplicate values are presented in this report. Grab samples were also collected and returned to the UAS lab for analysis of turbidity, and total suspended sediment (TSS). Turbidity measurements for each event were bracketed by standard checks and were made in the field or within 6 hours of sample collection in the laboratory. TSS samples were obtained by weighing the mass of particulates retained on a glass microfiber filter following a vacuum driven filtration of at least 300 mL of sample. TSS filtrations were made within 48 hours of sample collection. Duplicate analyses were performed on 10% of samples to check for precision. Samples were measured for dissolved iron concentrations on one-half of the Jordan Creek samples (on every-other sampling event).

Fe analyses:

Total dissolved iron was determined spectrophotometrically via the Ferrozine method (Violler et al, 2000). In brief, ferrozine solution was added to an aliquot of the acidified sample. An aqueous solution of hydroxylamine hydrochloride was added next, thus assuring all iron was present as iron(II). The sample was buffered to pH = 9 with ammonia/ammonium acetate buffer and the absorbance of the resulting iron(II)-ferrozine complex measured. Using a modification of Beer's Law, the concentration of dissolved iron was determined by comparison to standard solutions of known concentration. Data quality requirements were verified by running an intermediate standard solution every 10 measurements. Failure of the calculated concentration to fall within +/- 10% of the known value initiated reestablishment of the calibration curve.

Water Quantity and Quality on Jordan Creek

Water Quantity

Although continuous discharge data were unavailable for Jordan Creek in 2007-2008, examination of historic data at the site as well as field observations and occasional measurements, indicates that Jordan Creek is generally a small, flashy stream that responds to and recovers quickly from local precipitation events. The Jordan Creek watershed is comprised largely of suburban development in the Mendenhall Valley, although the creek also receives water from the northwest side of Thunder Mountain. Streamflow in Jordan is derived primarily from rainfall and shallow groundwater, as a result, streamflow is relatively flashy, responding quickly to the large frontal rainstorms typical of fall and winter in the Juneau area. Large winter storms, particularly rain on snow events, can also cause streamflow to rise dramatically. Streamflow in Jordan decreases substantially during the late spring and early summer during periods of low rainfall.

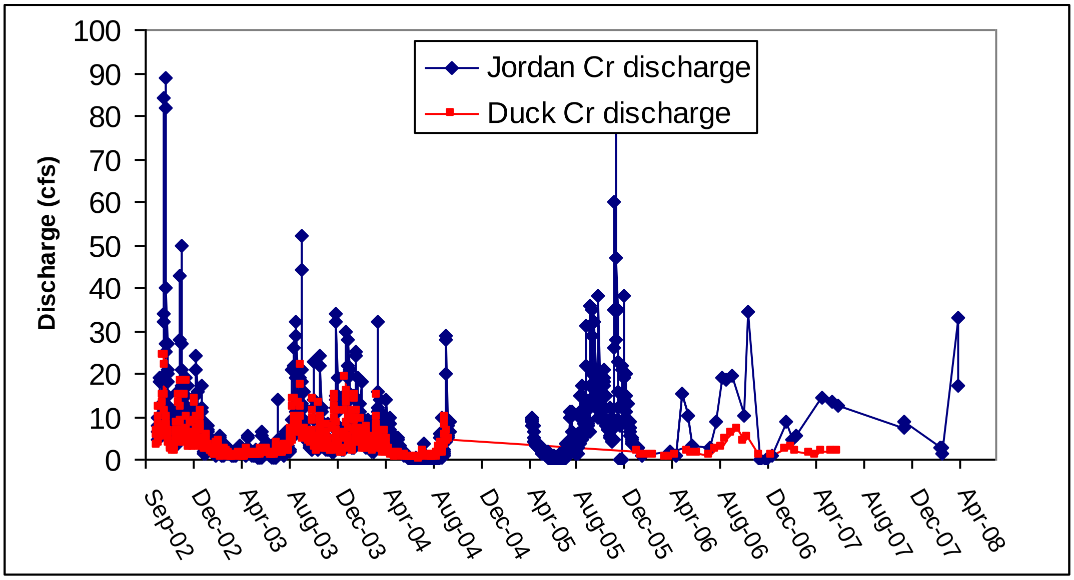


Figure 2. *Discharge on Duck and Jordan Creeks. Data based on USGS stream gage data through December, 2006. Data since January 2006 are based on manually gaging using a pygmy flow meter. Duck Creek discharge was measured at site DC-B, and Jordan Creek discharge was measured at JC-B.*

Discharge patterns at the three sites closely resembled those of previous study years; however, sites were not visited nearly as frequently as in previous years. At the uppermost site (JC-A), water was always present, indicating a steady groundwater input that persisted even during freezing, snowy weather conditions. Both JC-B and JC-C were iced over or dry and filled in with snow for periods in the winter and early spring, although the sites were not visited frequently enough for an accurate assessment of exact dates of water flow or lack thereof. Loss of flow is an obvious major concern for salmonids attempting to utilize Jordan Creek as habitat for rearing, spawning, and egg incubation.

Discharge during the study year was measured at site JC-B during the intensive sampling events. During the fall event (mid-November), which was planned around a forecasted rainstorm that failed to materialize, flow in Jordan Creek was between 7-8 cfs. Winter (Feb. 14-16) flows were between 1-3 cfs; and spring (March 28-30) flows were between 17-35 cfs. The variability in the spring event is an example of the rapid increase in flow that occurred during snowmelt resulting from sudden, warming temperatures.

Figure 3a. *Site JC-A on11/14/07. Flowing water was present at the site on all sampling events, even during the winter.*

Figure 3b. *Site JC-A again, but in the February sampling event. Notice Jordan Creek is open and flowing despite snow and freezing temperatures.*

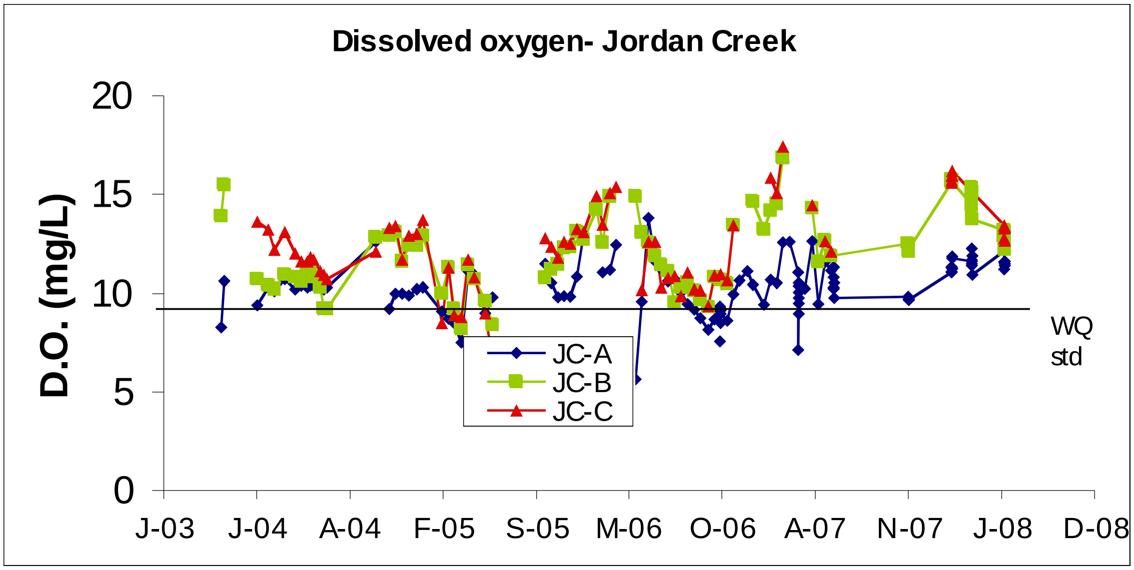
Figure 3c. *Site JC-B on 2/14/08. The streambed was blanketed with snow/ice, while meltwater and rain water provided some surface flow. Also notice the shopping cart discarded in the stream channel. Stream litter continues to be an issue in Jordan Creek.*

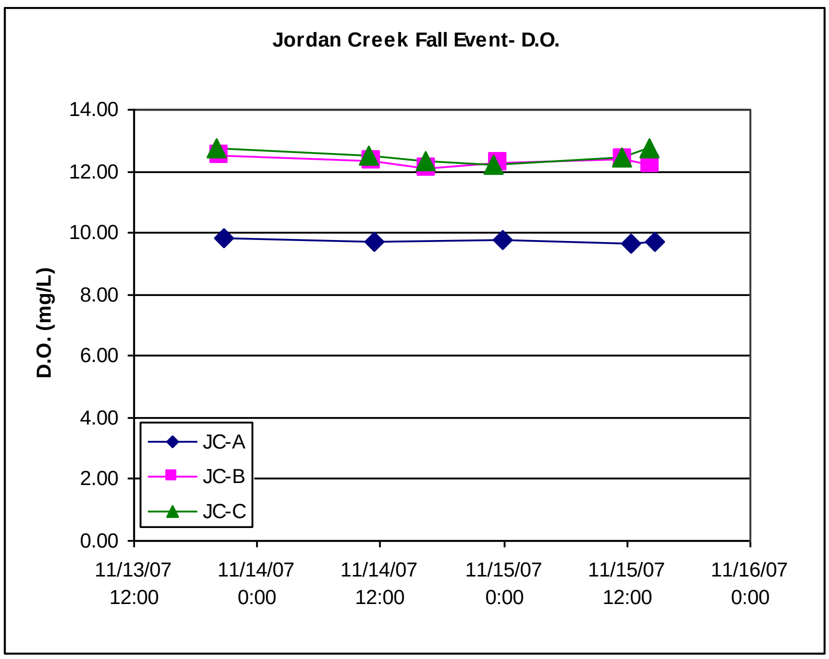
Figure 3d. *Site JC-C on 11/14/08. Streamflow was present at the site on all four sampling events, although it is possible this was not the case inbetween events when the stream was not sampled (previous years' data indicate the site lacked surface flow for weeks or months).*

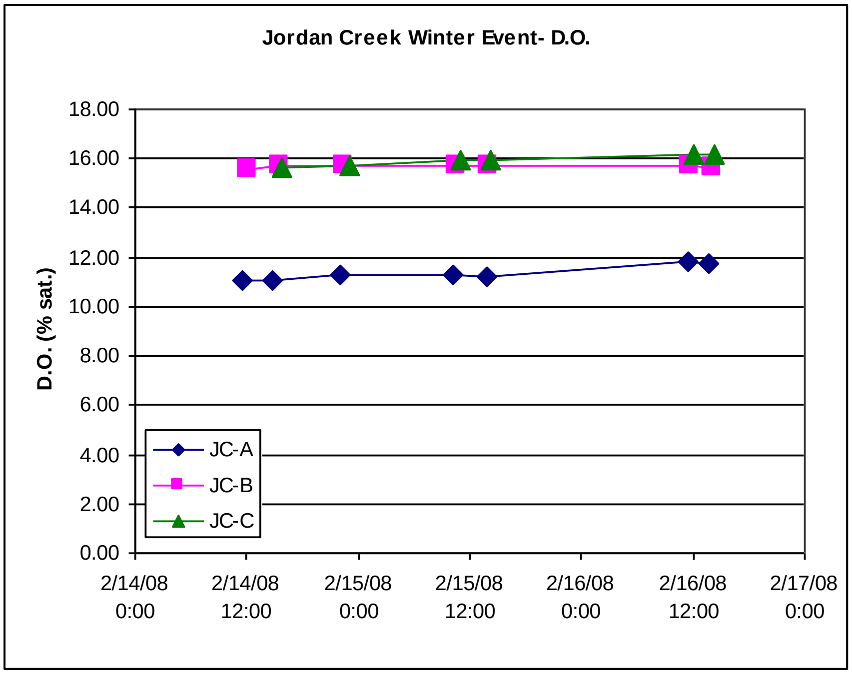
Water Quality

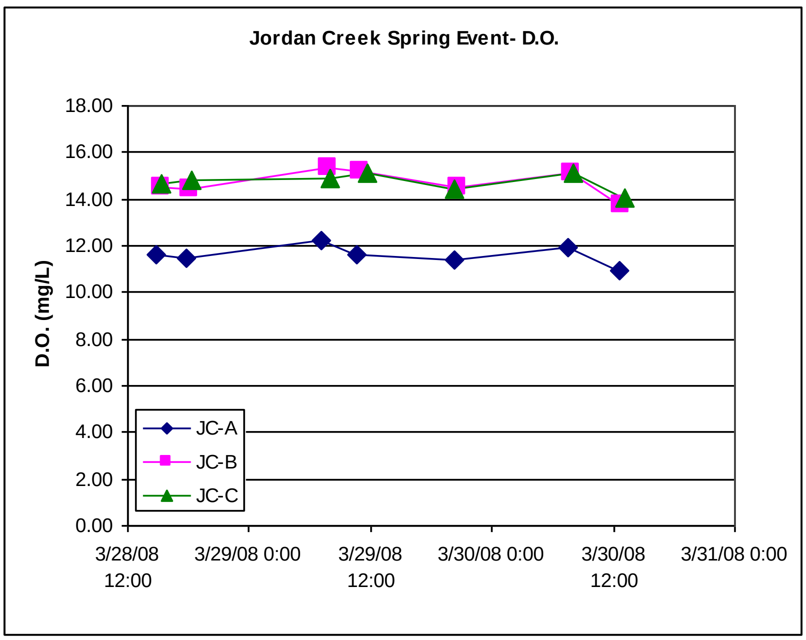
a) Dissolved oxygen, conductivity, and pH

Dissolved oxygen was good at the 3 Jordan Creek sites, and typically ranged between 9 and 15 mg/L, similar to trends of previous study years (Figure 4). During the 4 sampling events, no values fell below the State of Alaska water quality limit of 7.0 mg/L for the growth and propagation of fish, shellfish, and other aquatic life (DEC, 2006). As in previous years, DO levels at JC-B and JC-C were typically higher than at JC-A, which is more strongly influenced by groundwater inputs. No clear diurnal-nocturnal pattern in DO values emerged, and values typically fluctuated within only 1 mg/L during each of the 4 sampling events.


Dissolved oxygen- Jordan Creek
D.O. (mg/L)
20
15
10
5
0
J-03
J-04
A-04
F-05
S-05
M-06
O-06
A-07
N-07
J-08
D-08
WQ std
JC-A
JC-B
JC-C


Jordan Creek Fall Event- D.O.
D.O. (mg/L)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
11/13/07 12:00
11/14/07 0:00
11/14/07 12:00
11/15/07 0:00
11/15/07 12:00
11/16/07 0:00
JC-A
JC-B
JC-C


Jordan Creek Winter Event- D.O.
D.O. (% sat.)
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
2/14/08 0:00
2/14/08 12:00
2/15/08 0:00
2/15/08 12:00
2/16/08 0:00
2/16/08 12:00
2/17/08 0:00
JC-A
JC-B
JC-C


Jordan Creek Spring Event- D.O.
D.O. (mg/L)
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
3/28/08 12:00
3/29/08 0:00
3/29/08 12:00
3/30/08 0:00
3/30/08 12:00
3/31/08 0:00
JC-A
JC-B
JC-C

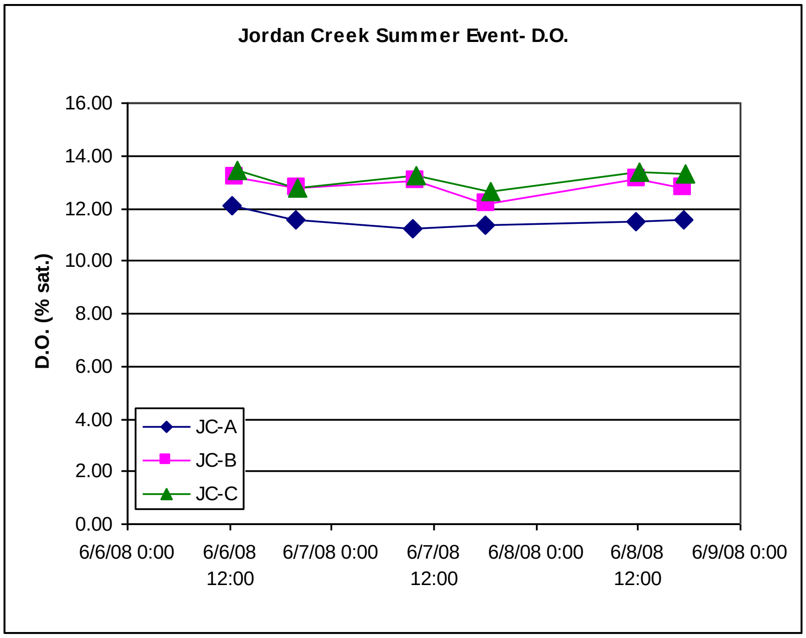
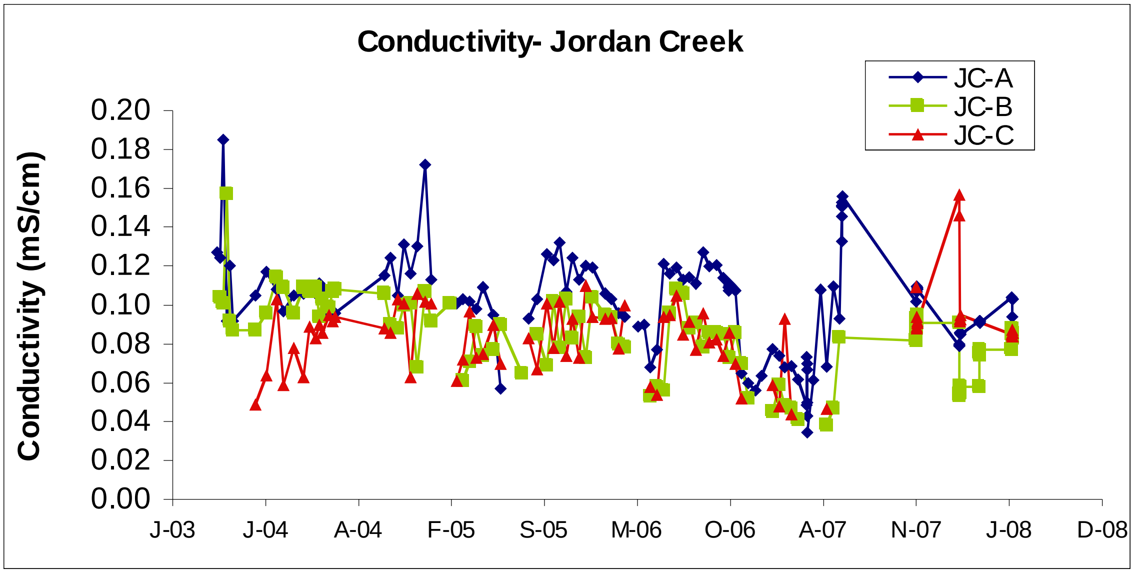
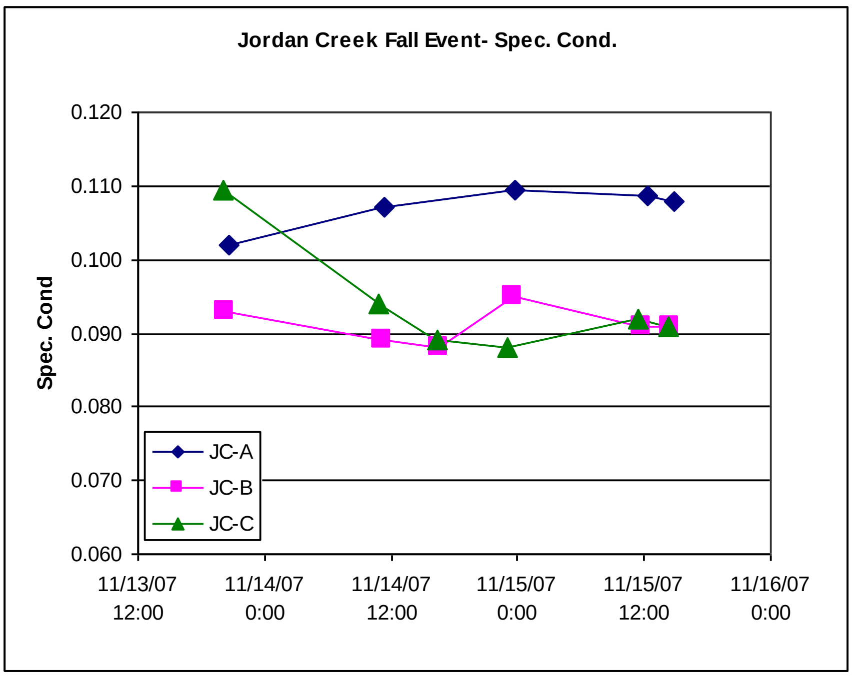
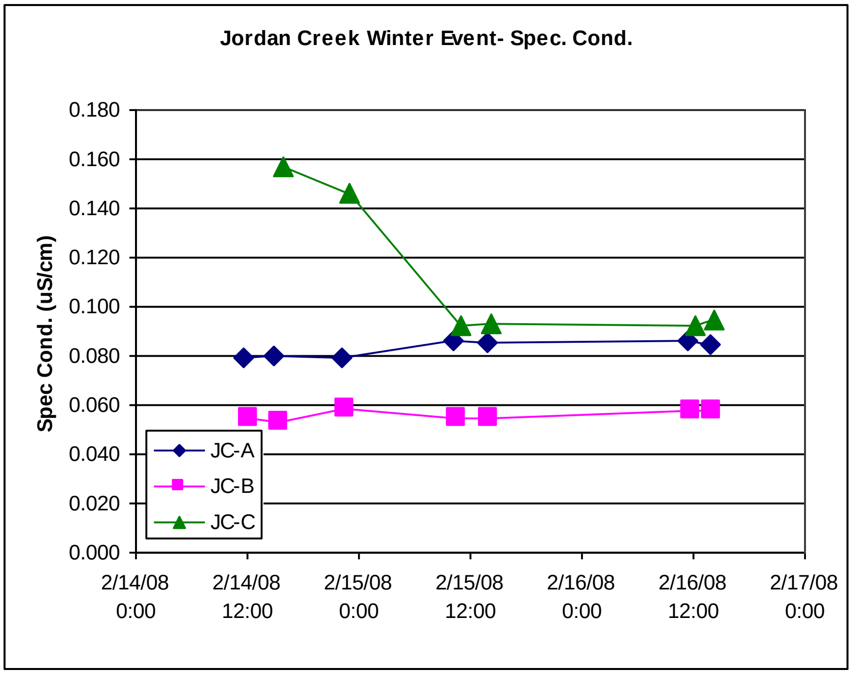


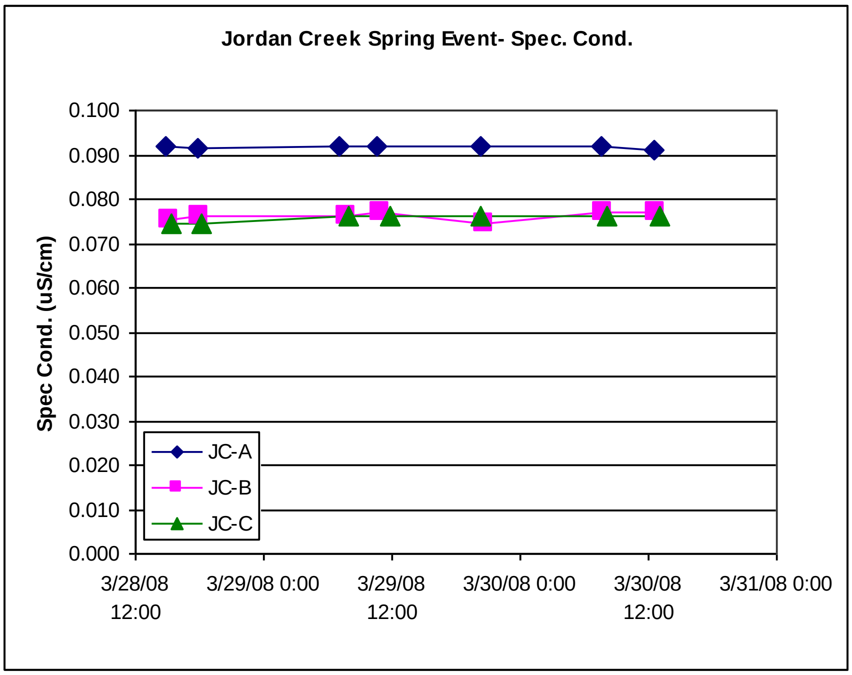
Figure 4. *Dissolved oxygen at the 3 Jordan Creek sites during the 4 seasonal events. The first panel shows DO at Jordan Creek for all the years of study prior to and including 2008-2009.*

Conductivity is a measure of ionic strength and, as such, reflects the load of total dissolved solids in the water column. Conductivity values measured on Jordan Creek were generally about 50% of the values measured in Duck Creek but are substantially higher than conductivity on more pristine local streams like Montana Creek (Hood, unpublished data). Conductivity tended to decrease moving downstream in Jordan Creek, which suggests that either inflows to the Creek below the JC-A site have a lower ionic strength or that that dissolved solids are removed by precipitation or biological uptake. The relatively high conductivity in upper Jordan Creek is a likely a result of inputs of ions such as nitrate and sulfate from anthropogenic sources as well as inputs of iron from groundwater. Conductivity concentrations in FY08 were in the same range as values measured the three years prior. Values were highest in the fall, and similar otherwise. No clear diel trends emerged, and values typically varied within 10% over the course of each 3 day sampling event. Average conductivity was highest at JC-A, reflecting the larger influence of groundwater (typically higher in ionic strength than surface water) compared with the other 2 sites.


Conductivity- Jordan Creek
Conductivity (mS/cm)
JC-A
JC-B
JC-C
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
J-03
J-04
A-04
F-05
S-05
M-06
O-06
A-07
N-07
J-08
D-08


Jordan Creek Fall Event- Spec. Cond.
Spec. Cond
0.120
0.110
0.100
0.090
0.080
0.070
0.060
JC-A
JC-B
JC-C
11/13/07 12:00
11/14/07 0:00
11/14/07 12:00
11/15/07 0:00
11/15/07 12:00
11/16/07 0:00


Jordan Creek Winter Event- Spec. Cond.
Spec Cond. (uS/cm)
0.180
0.160
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
JC-A
JC-B
JC-C
2/14/08 0:00
2/14/08 12:00
2/15/08 0:00
2/15/08 12:00
2/16/08 0:00
2/16/08 12:00
2/17/08 0:00


Jordan Creek Spring Event- Spec. Cond.
Spec Cond. (uS/cm)
0.100
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
JC-A
JC-B
JC-C
3/28/08 12:00
3/29/08 0:00
3/29/08 12:00
3/30/08 0:00
3/30/08 12:00
3/31/08 0:00

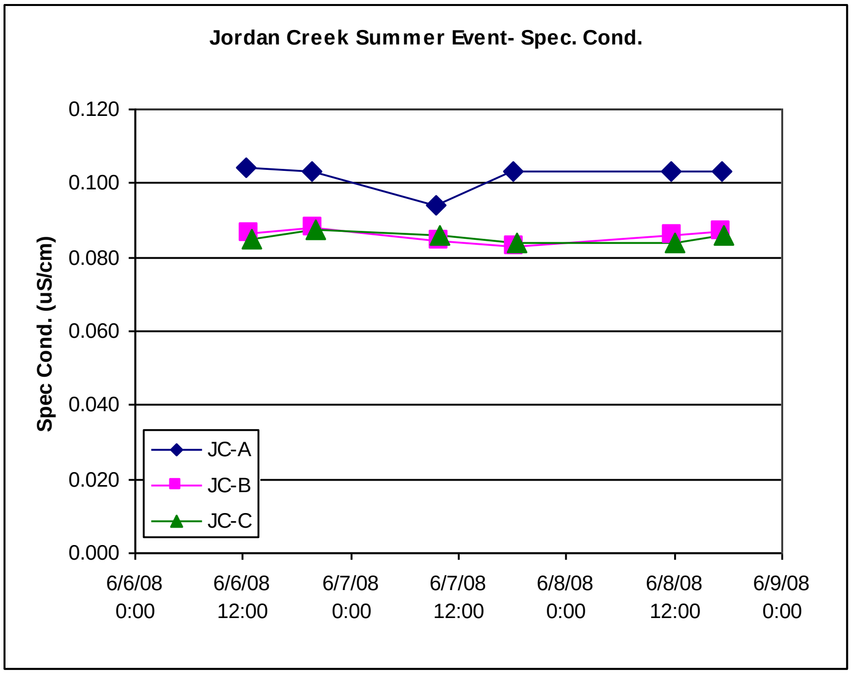
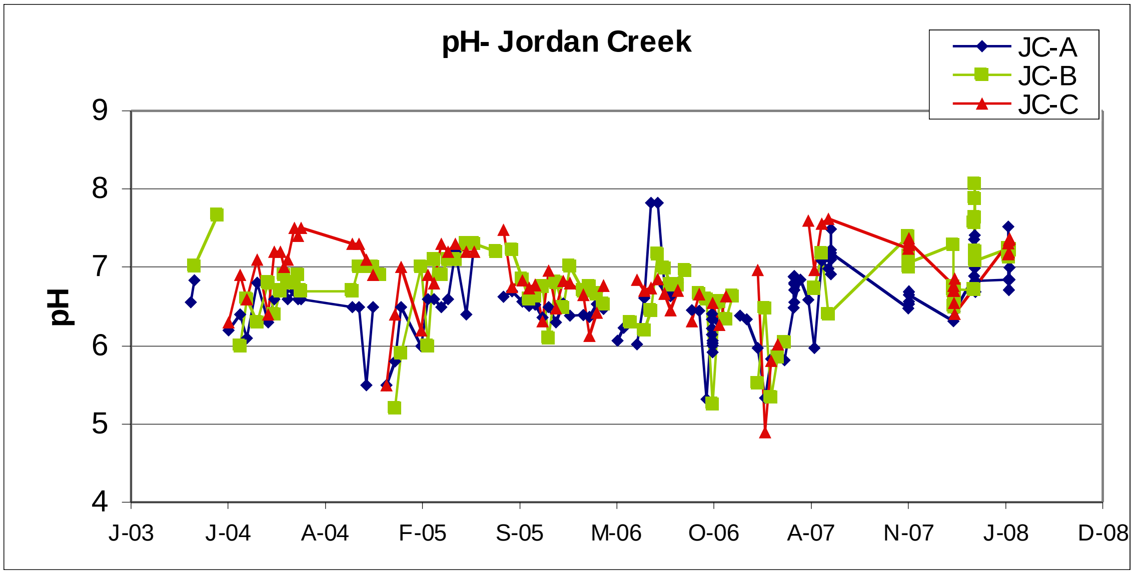
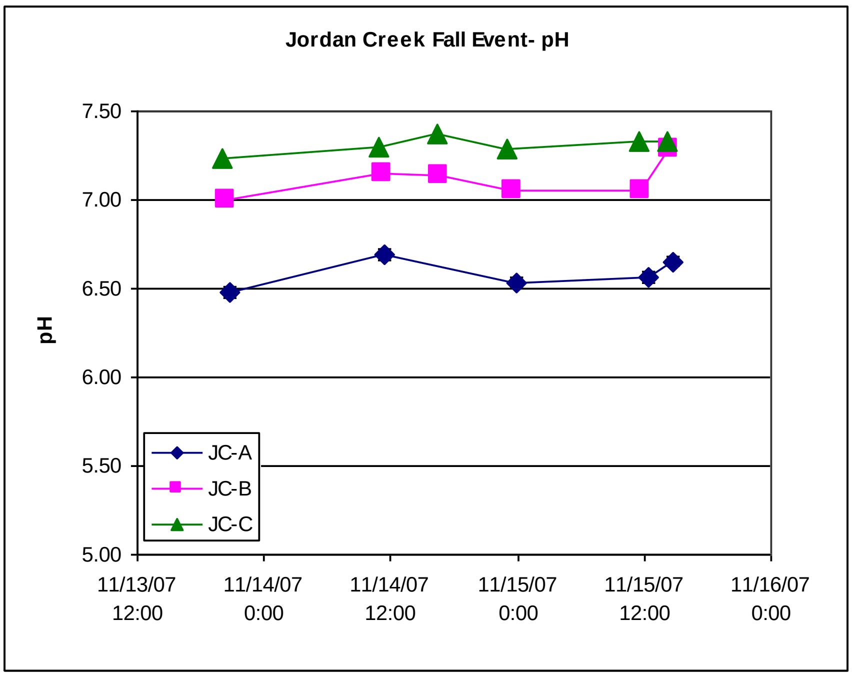
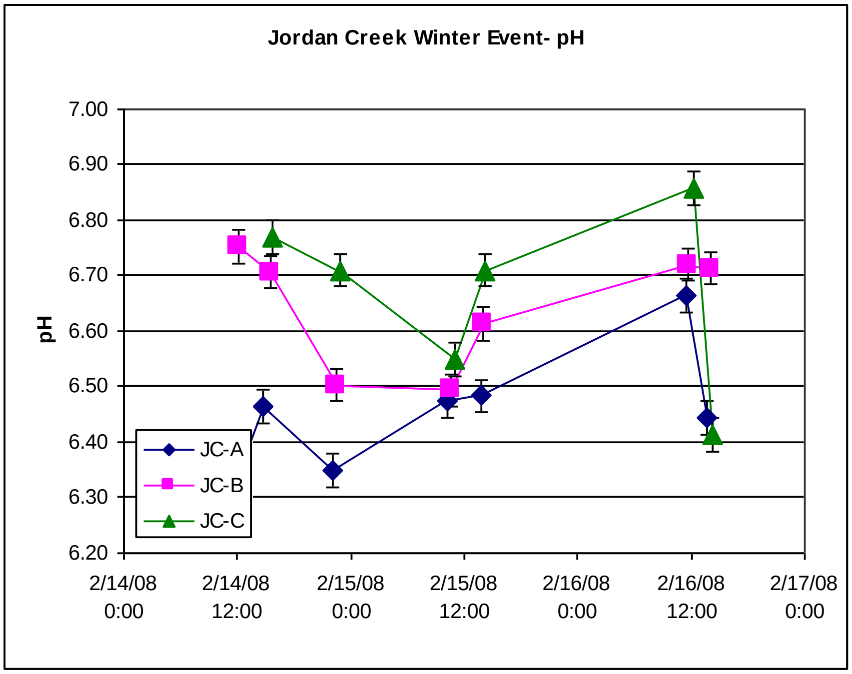


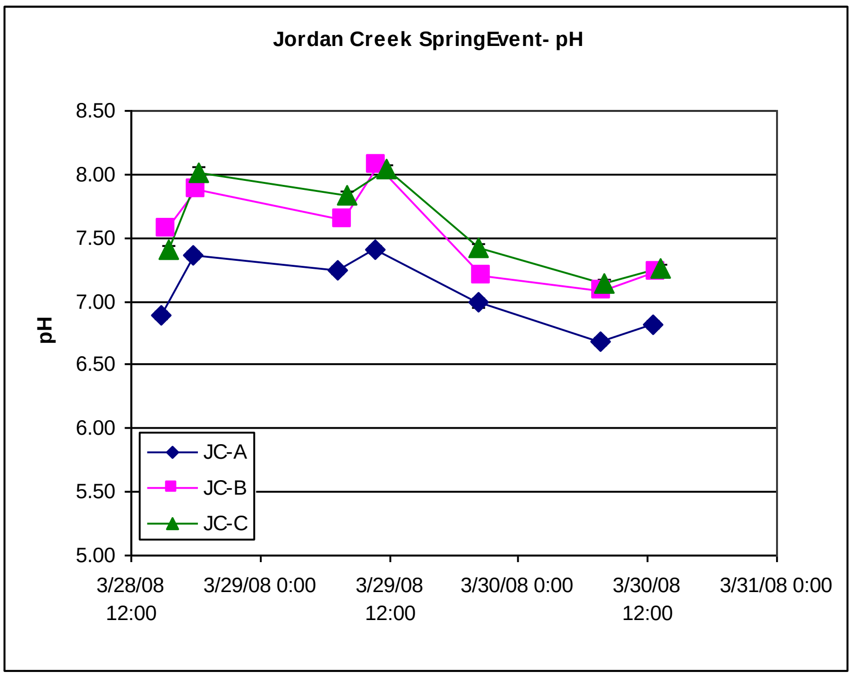
Figure 5. *Conductivity values at the 3 sampling sties on Jordan Creek. The first panel shows conductivity at Jordan Creek for all the years of study prior to and including 2008-2009.*

Values for pH varied mostly between 6.8 and 7.1 during the study period, which is generally consistent with values from the previous years and within Alaska water quality standards (Figure 6). pH values showed no diel signal. pH was consistently lower at JC-A compared with JC-B and JC-C, again showing the strong influence of groundwater on the uppermost site. pH values were lowest in the winter event. Lower pH values are likely caused by iron-rich groundwater intrusion, which becomes the dominant source of water during cold and dry climatic periods. The oxidation of reduced species prevalent in anaerobic groundwater produces significant acidity as a side-product.


pH- Jordan Creek
JC-A
JC-B
JC-C
pH
9
8
7
6
5
4
J-03
J-04
A-04
F-05
S-05
M-06
O-06
A-07
N-07
J-08
D-08


Jordan Creek Fall Event- pH
pH
7.50
7.00
6.50
6.00
5.50
5.00
JC-A
JC-B
JC-C
11/13/07 12:00
11/14/07 0:00
11/14/07 12:00
11/15/07 0:00
11/15/07 12:00
11/16/07 0:00


Jordan Creek Winter Event- pH
pH
7.00
6.90
6.80
6.70
6.60
6.50
6.40
6.30
6.20
2/14/08 0:00
2/14/08 12:00
2/15/08 0:00
2/15/08 12:00
2/16/08 0:00
2/16/08 12:00
2/17/08 0:00
JC-A
JC-B
JC-C


Jordan Creek SpringEvent- pH
pH
8.50
8.00
7.50
7.00
6.50
6.00
5.50
5.00
3/28/08 12:00
3/29/08 0:00
3/29/08 12:00
3/30/08 0:00
3/30/08 12:00
3/31/08 0:00
JC-A
JC-B
JC-C

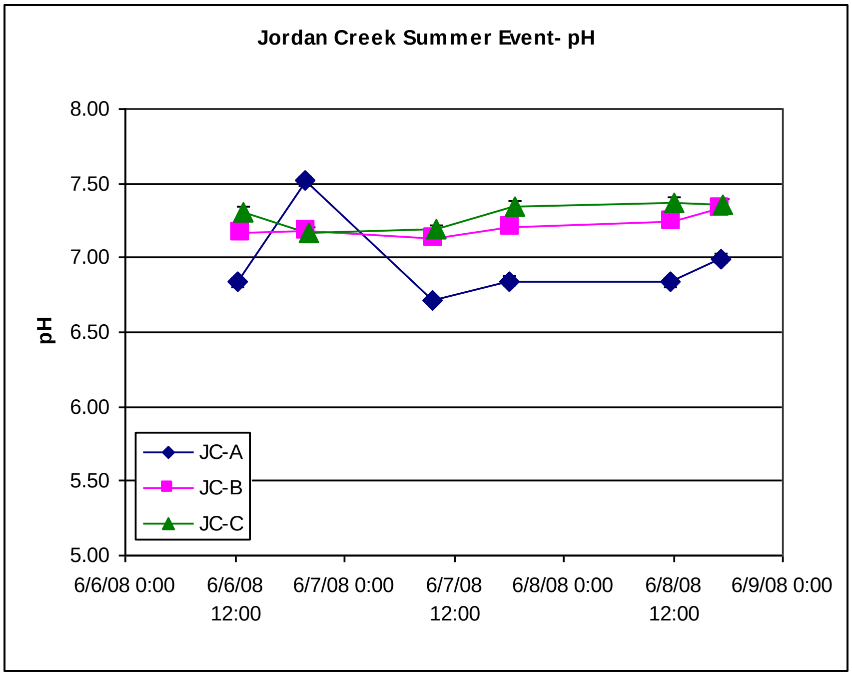


Figure 6. *pH values at the 3 sampling sties on Jordan Creek during the 4 sampling events. The first panel shows pH at Jordan Creek for all the years of study prior to and including 2008-2009.*

Dissolved iron

Levels of dissolved iron found in samples from the three Jordan Creek sites are presented in Figure 8. Fe concentrations in 2007-2008 were usually within the range of concentrations found in 2006 and 2007, indicating no measurable increases in dissolved iron concentrations within Jordan Creek during this time period. Yet there were 2 exceptions-- 2 samples from JC-A, one from the fall event and one from the winter event, which were 2-3 times higher than the normal range of values, indicating the short-term pulses in concentrations that may occur during short-term events, at least at JC-A which is heavily groundwater influenced (Figure 7). Interestingly, the data indicate that in general, levels of dissolved Fe were higher at JCB and JCC relative to those at JCA during most of the year, even though JCA has the stronger groundwater influence based on pH, dissolved oxygen, and specific conductance data. On a within- seasonal event-basis, none of the sites show any particular trends in concentrations. Comparing across seasons, Fe concentrations were generally lowest during the summer (June sampling event). Daily variation may result from short-term changes in groundwater input vs surface runoff during rains, or from slight photosynthetically-driven variations in the reduction-oxidation potential in the water that may transfer particulate iron into dissolved iron and vice versa.

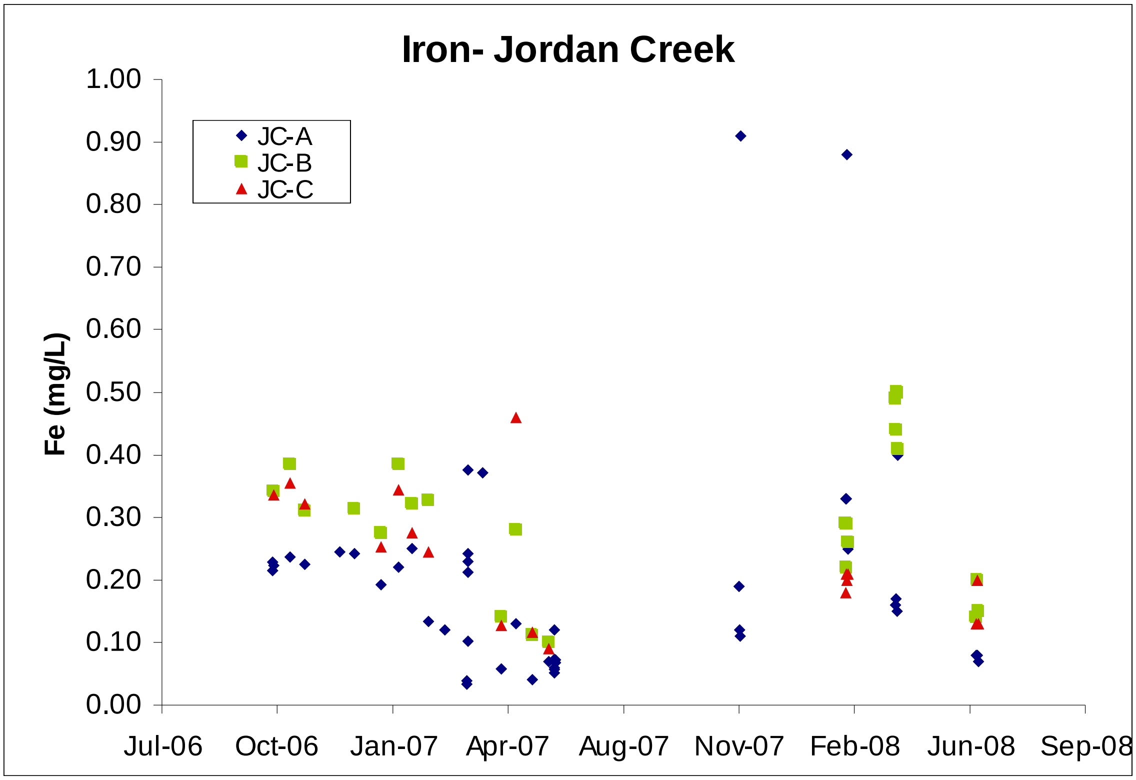
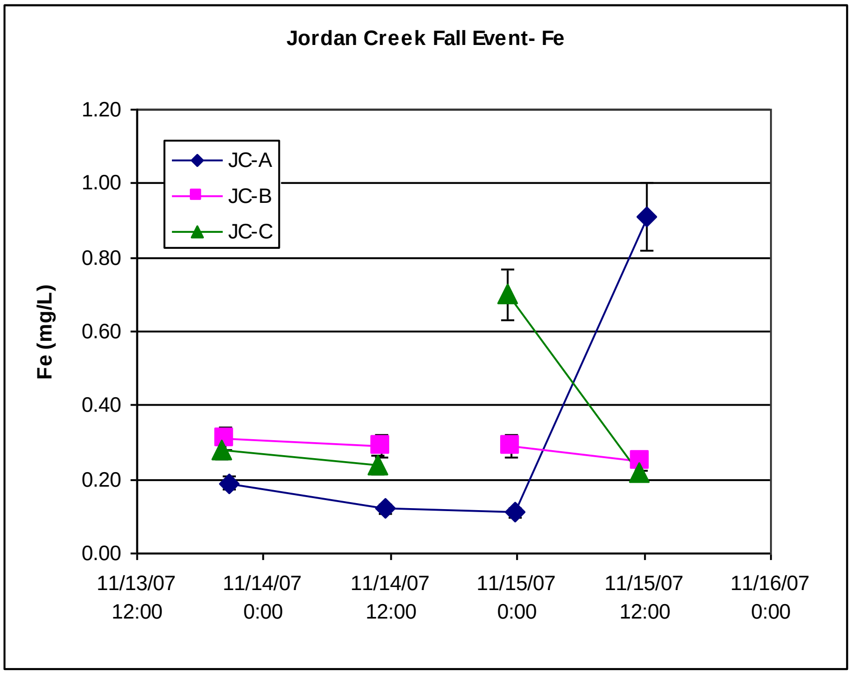
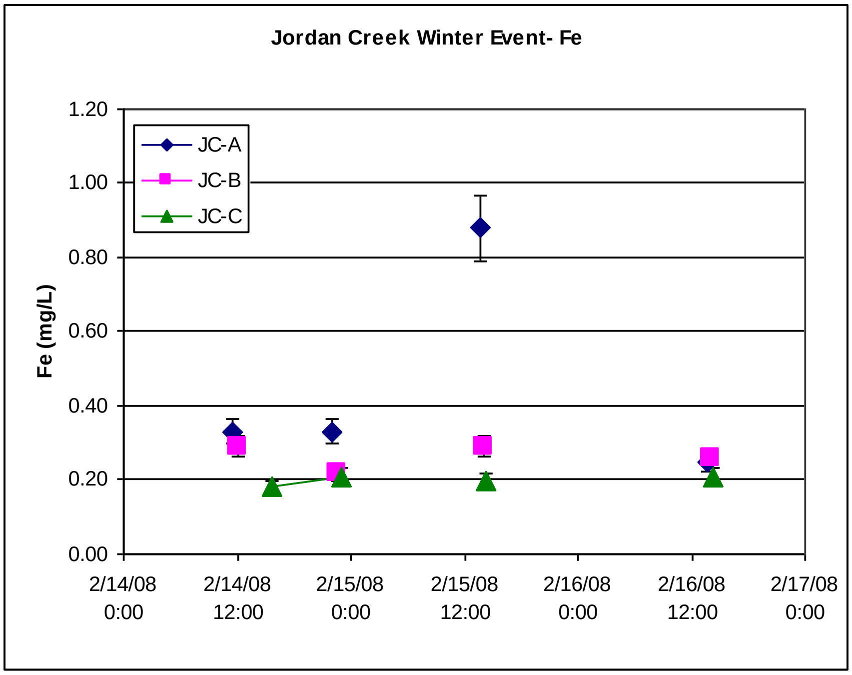
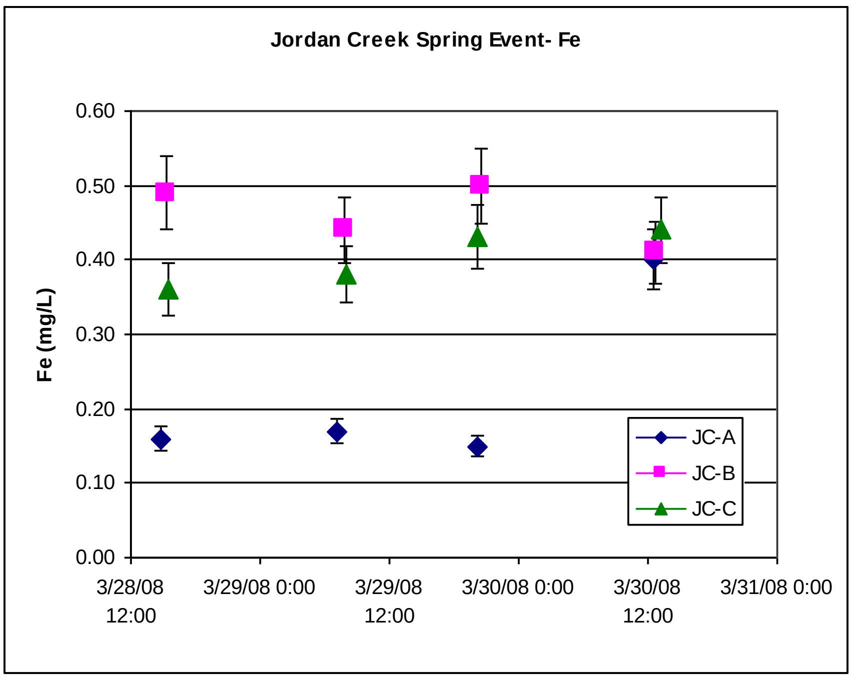


Figure 7. *Dissolved iron in Jordan Creek between October 2006-June 2008*





Jordan Creek Winter Event- Fe
Fe (mg/L)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
JC-A
JC-B
JC-C
2/14/08 0:00
2/14/08 12:00
2/15/08 0:00
2/15/08 12:00
2/16/08 0:00
2/16/08 12:00
2/17/08 0:00



Jordan Creek Spring Event- Fe
Fe (mg/L)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
JC-A
JC-B
JC-C
3/28/08 12:00
3/29/08 0:00
3/29/08 12:00
3/30/08 0:00
3/30/08 12:00
3/31/08 0:00

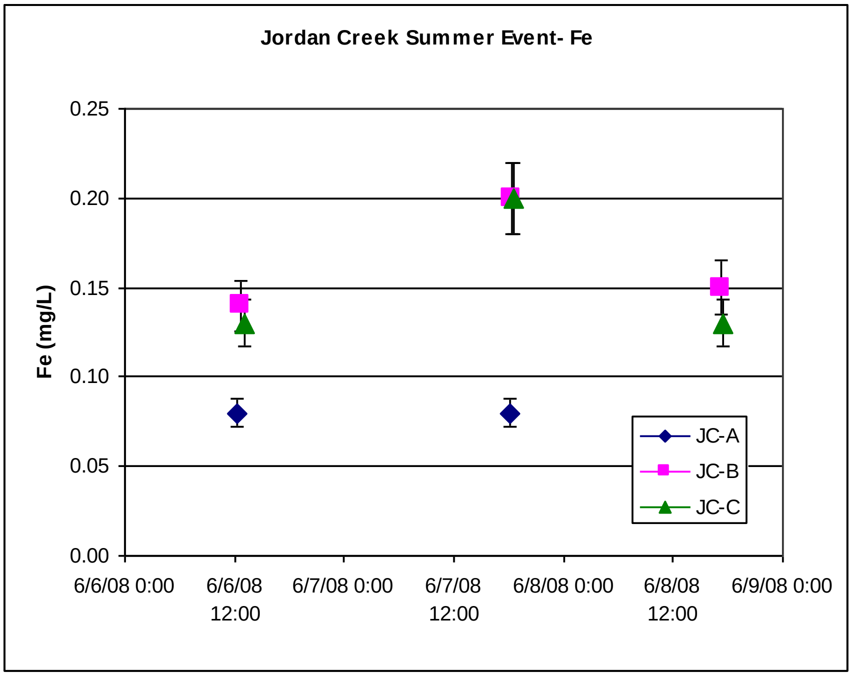
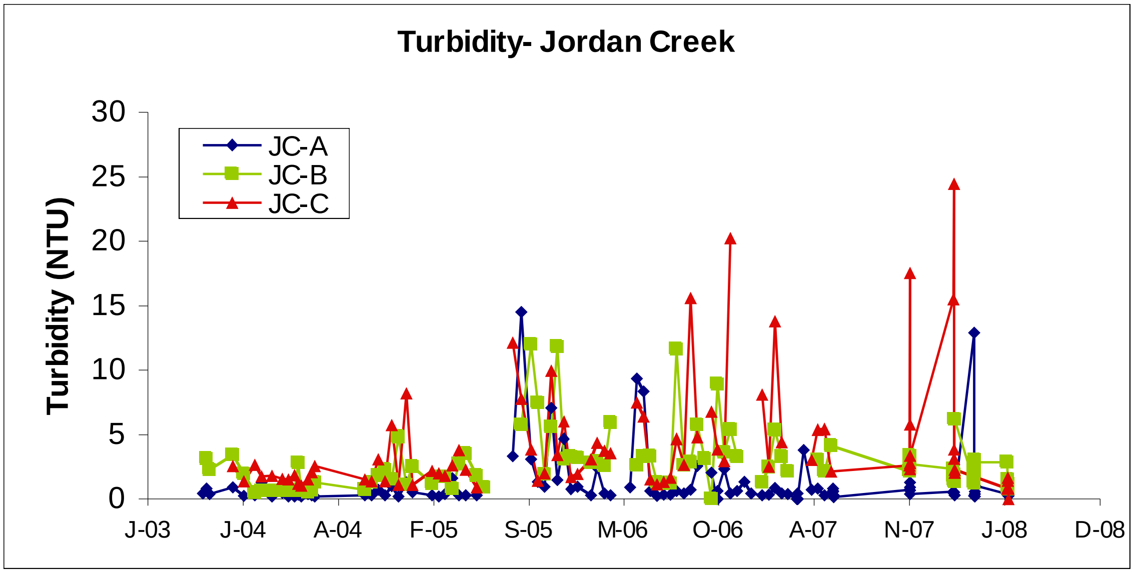


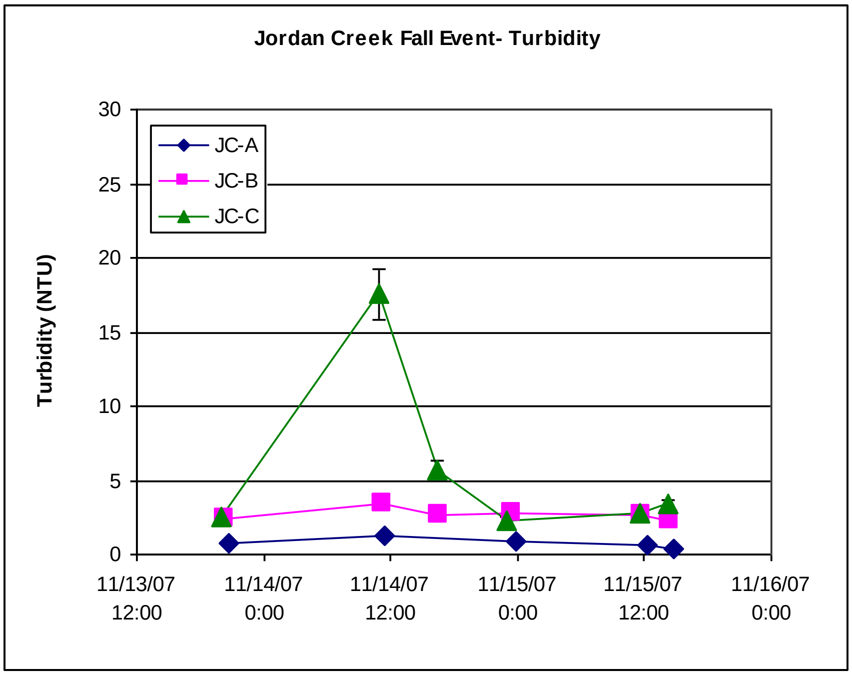
Figure 8. Dissolved iron in Jordan Creek on the 4 seasonal sampling events.

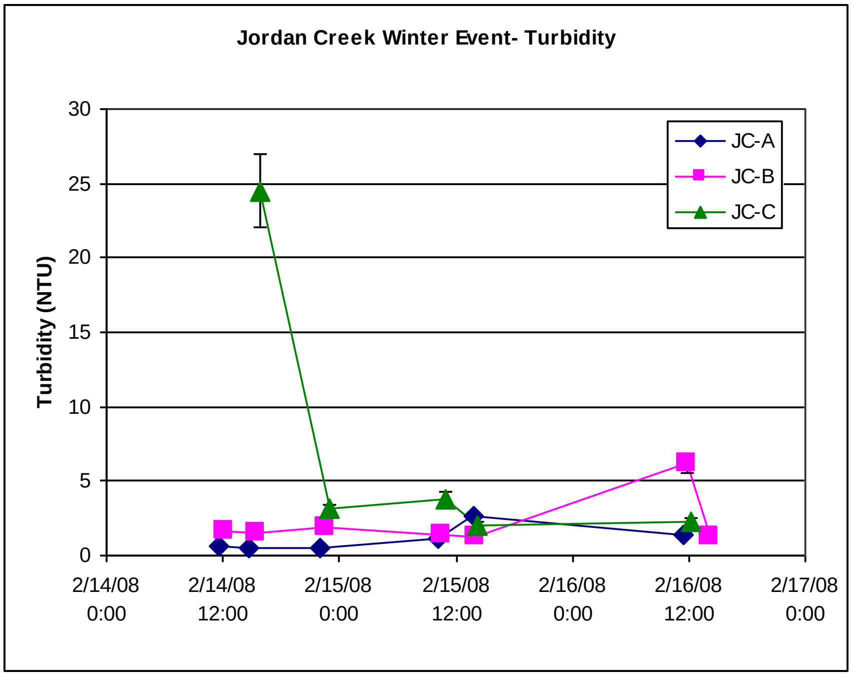
c) Turbidity and Total Suspended Solids (TSS)

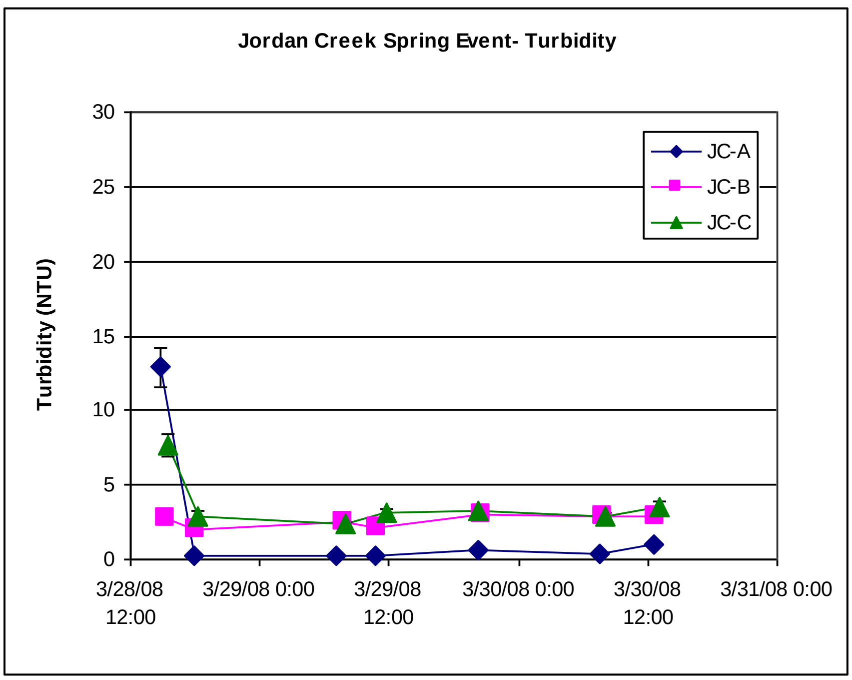
The state of Alaska water quality standards for turbidity dictate that to protect fish and wildlife, turbidity may not exceed 25 nephelometric turbidity units (NTUs) above natural background conditions. Turbidity is not a direct measurement of solids, but is related to the amount of suspended material in the water column because it is a measure of light attenuation due to absorption and reflection by solids. Turbidity can be expected to closely parallel total suspended solids (TSS).

On Jordan Creek, water clarity is generally quite high and well within water quality standards for the state of Alaska. Turbidity at the sample sites was usually <5 NTU, which are well below levels of water quality concern. Turbidity generally increased moving downstream on Jordan Creek. Turbidity also tended to be more flashy at JC-C than at the other 2 sites, possibly due to the influence of the Egan Drive crossing immediately upstream of the sampling site (Figure 9). During the winter event at JC-C, turbidity increased to up to 24 NTU, falling back down to 3 NTU when remeasured 12 hours later. This was the highest turbidity recorded on Jordan Creek since UAS began monitoring in 2003.


Turbidity- Jordan Creek
Turbidity (NTU)
30
25
20
15
10
5
0
JC-A
JC-B
JC-C
J-03
J-04
A-04
F-05
S-05
M-06
O-06
A-07
N-07
J-08
D-08


Jordan Creek Fall Event- Turbidity
Turbidity (NTU)
30
25
20
15
10
5
0
JC-A
JC-B
JC-C
11/13/07 12:00
11/14/07 0:00
11/14/07 12:00
11/15/07 0:00
11/15/07 12:00
11/16/07 0:00


Jordan Creek Winter Event- Turbidity
Turbidity (NTU)
30
25
20
15
10
5
0
JC-A
JC-B
JC-C
2/14/08 0:00
2/14/08 12:00
2/15/08 0:00
2/15/08 12:00
2/16/08 0:00
2/16/08 12:00
2/17/08 0:00


Jordan Creek Spring Event- Turbidity
Turbidity (NTU)
30
25
20
15
10
5
0
JC-A
JC-B
JC-C
3/28/08 12:00
3/29/08 0:00
3/29/08 12:00
3/30/08 0:00
3/30/08 12:00
3/31/08 0:00

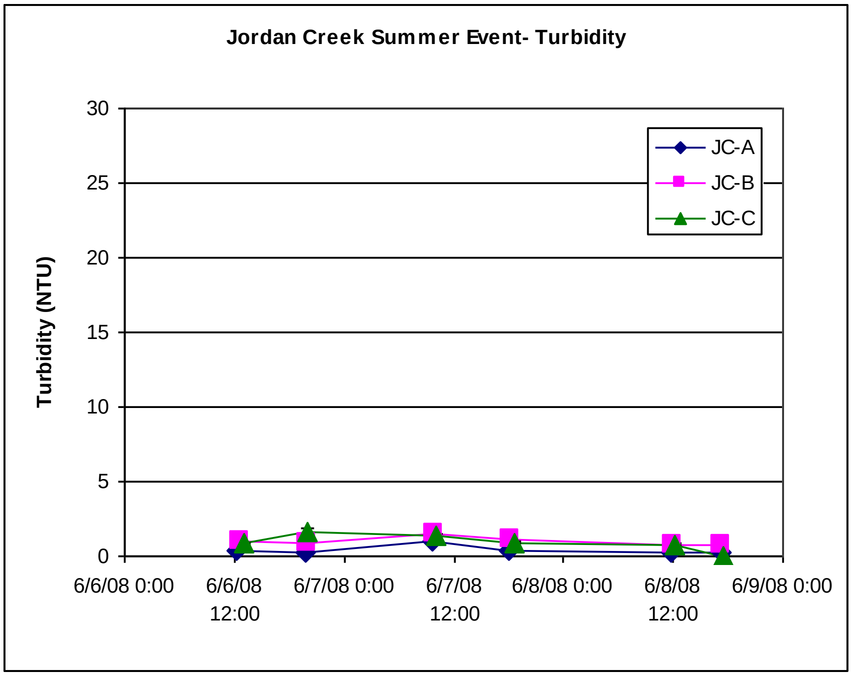
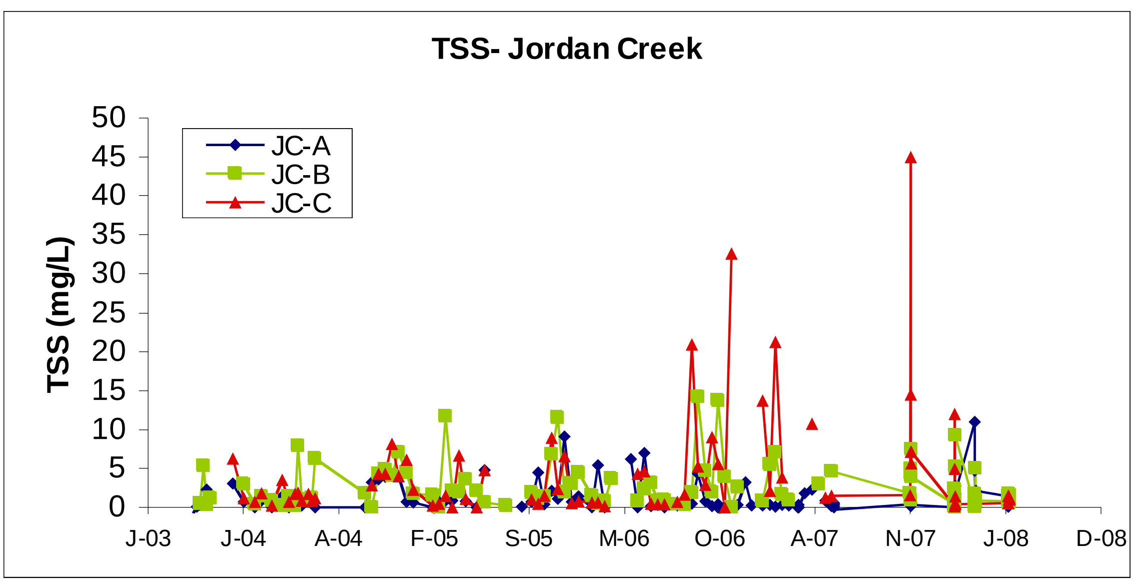
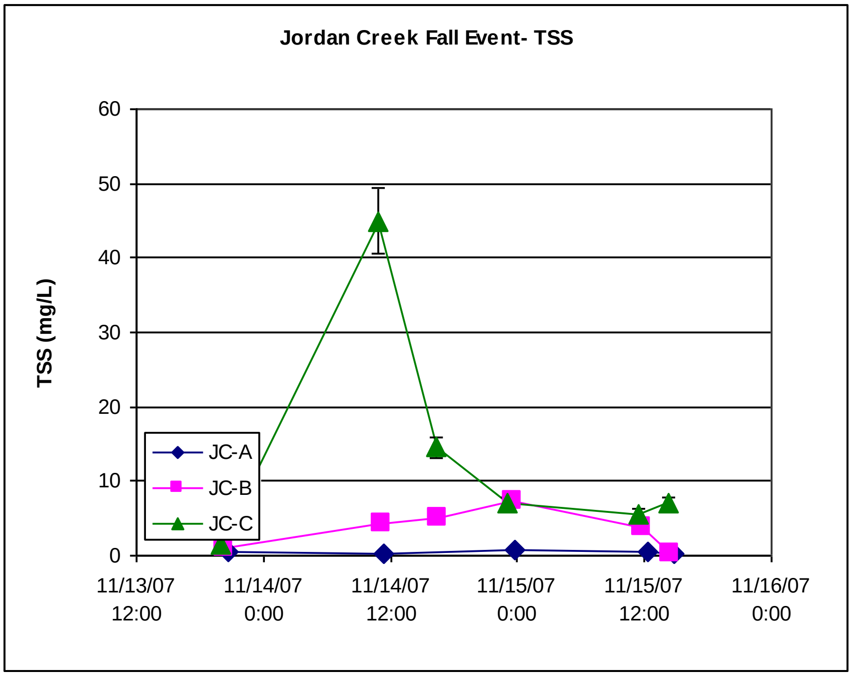
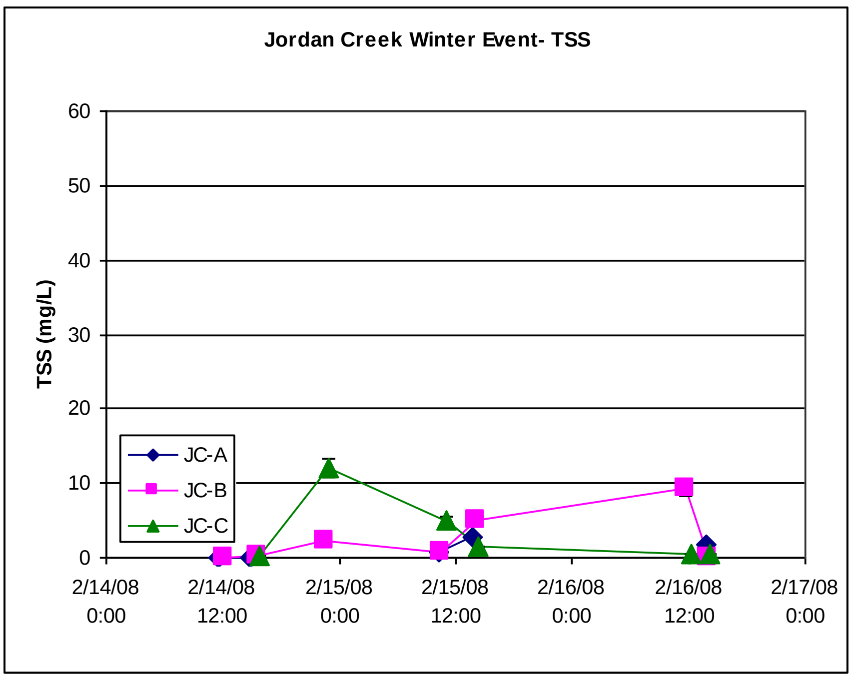


Figure 9. *Turbidity (NTU) at the three Jordan Creek sites. The first panel shows turbidity at Jordan Creek for all the years of study prior to and including 2008-2009.*

Total suspended solids (TSS) refers to solids that are not dissolved in solution and can be removed by filtration. Suspended solids include both organic particles and inorganic, mineral particles, both of which can contribute to turbidity. Similar to the trends in turbidity, values for TSS were relatively low on Jordan Creek. TSS values in Jordan Creek were higher at sites JC-B and JC-C during Both turbidity and TSS were highest during the fall, when large rain events were more common and likely resulted in greater influxes of adjacent sediment and other particles into the stream.




Jordan Creek Fall Event- TSS
TSS (mg/L)
60
50
40
30
20
10
0
JC-A
JC-B
JC-C
11/13/07 12:00
11/14/07 0:00
11/14/07 12:00
11/15/07 0:00
11/15/07 12:00
11/16/07 0:00


Jordan Creek Winter Event- TSS
TSS (mg/L)
60
50
40
30
20
10
0
JC-A
JC-B
JC-C
2/14/08 0:00
2/14/08 12:00
2/15/08 0:00
2/15/08 12:00
2/16/08 0:00
2/16/08 12:00
2/17/08 0:00

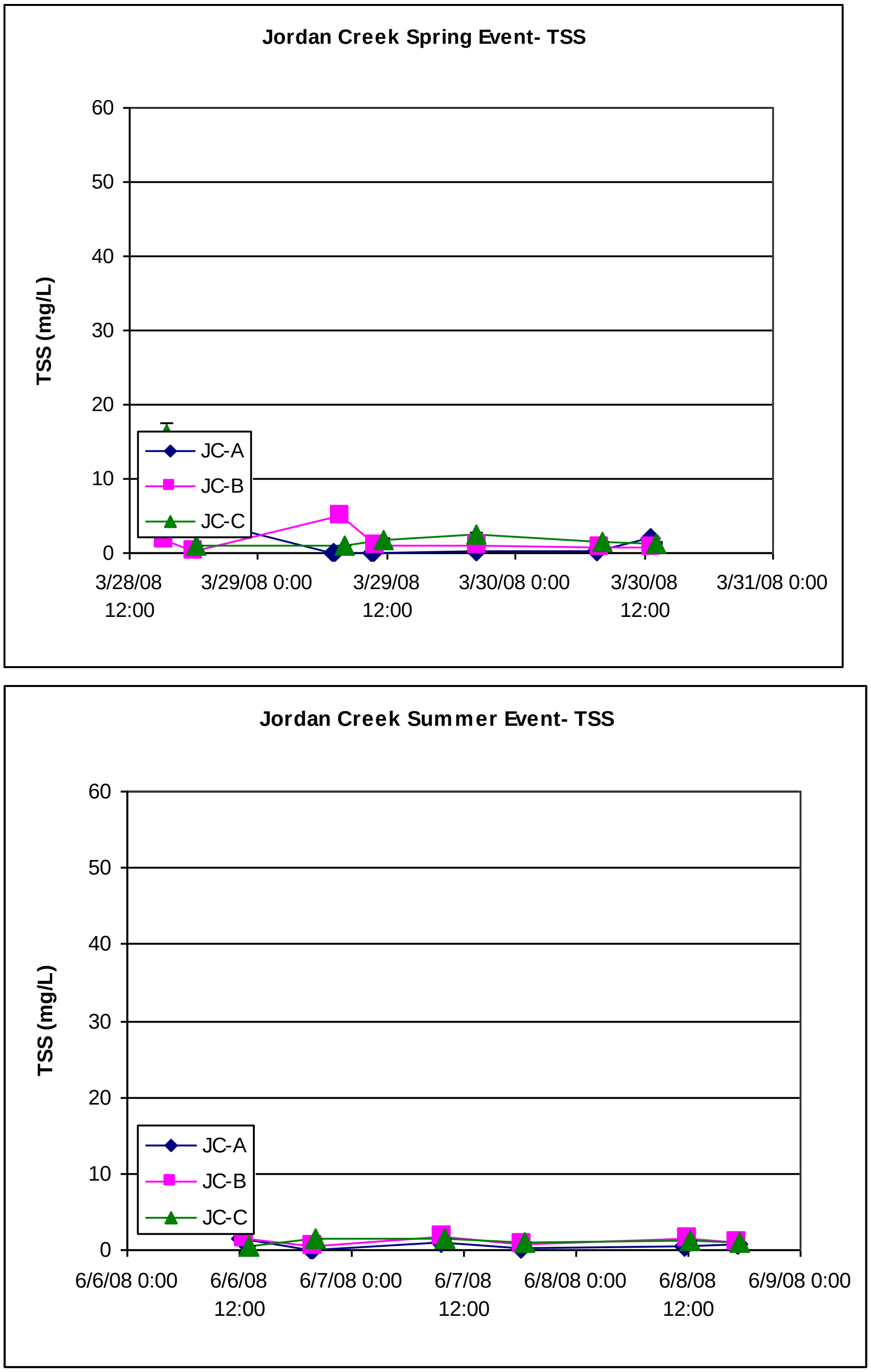
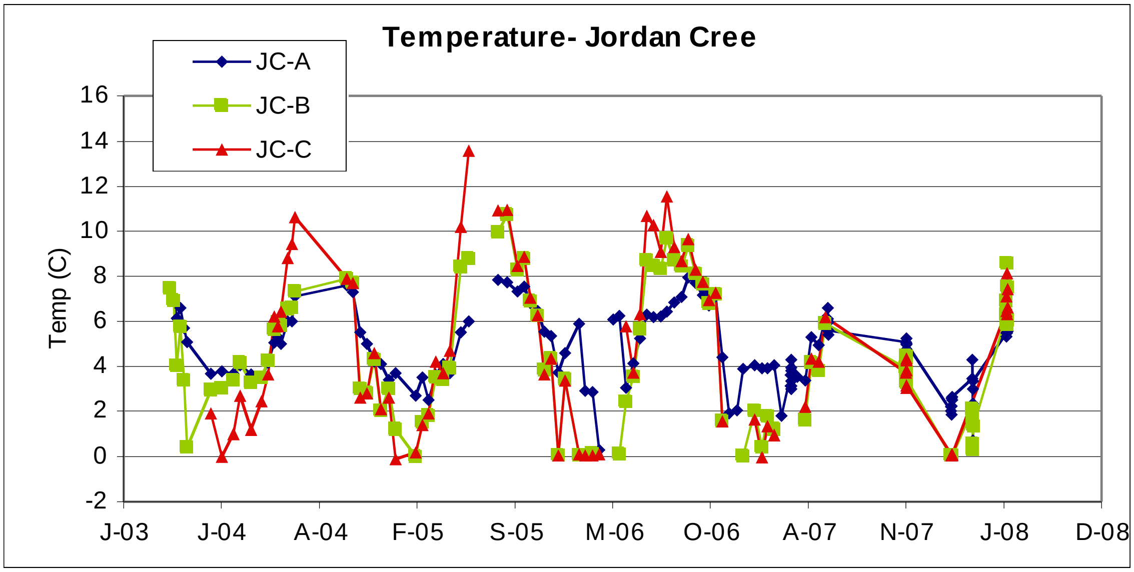
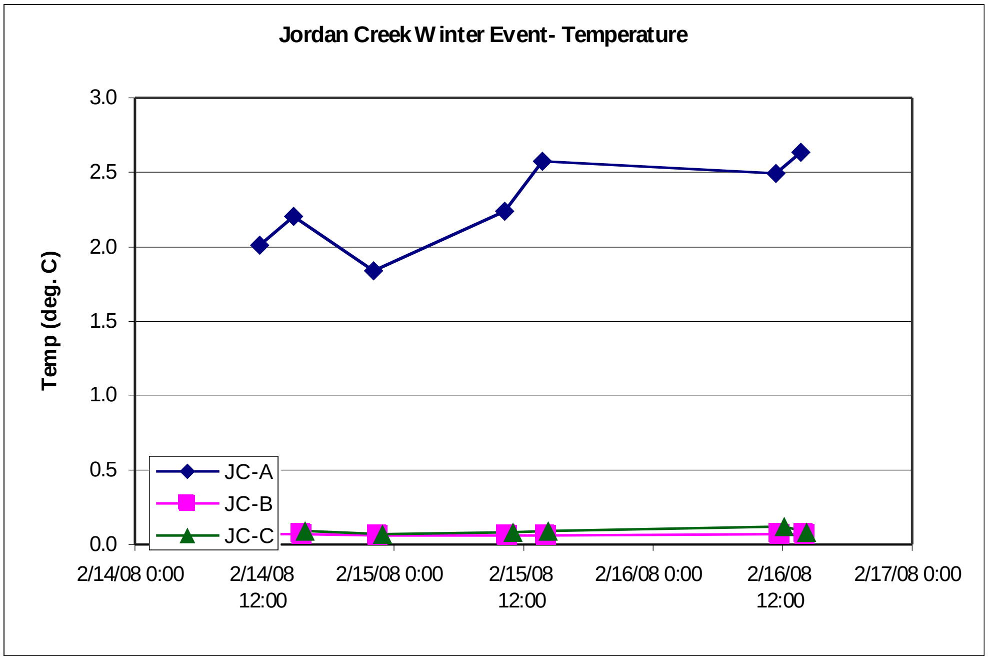


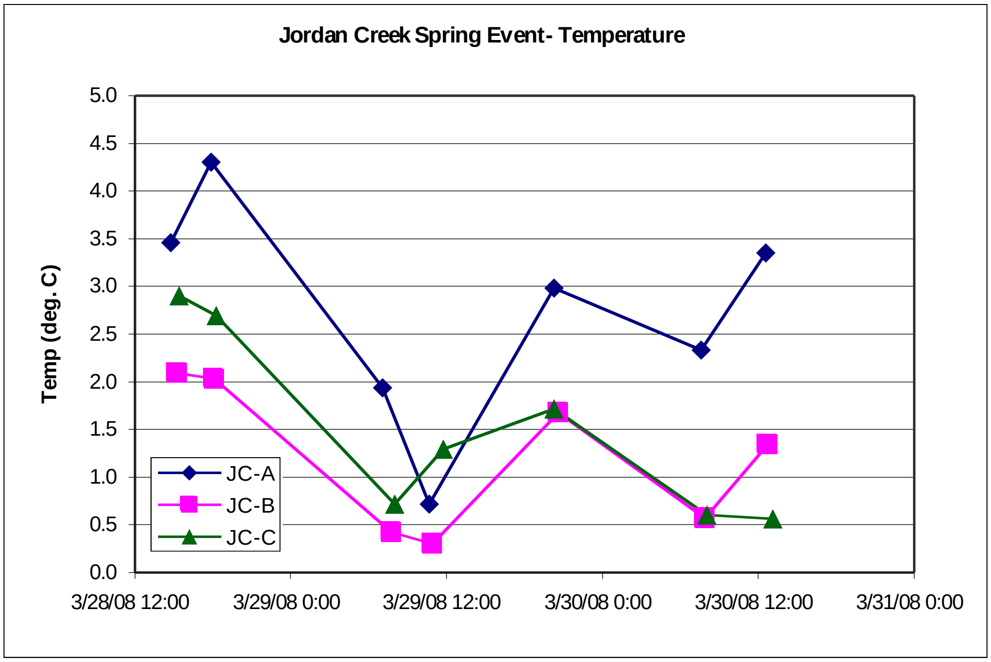
Figure 9. *Total suspended solids (TSS, in mg/L) at the 3 Jordan Creek sites. The first panel shows TSS at Jordan Creek for all the years of study prior to and including 2008-2009.*

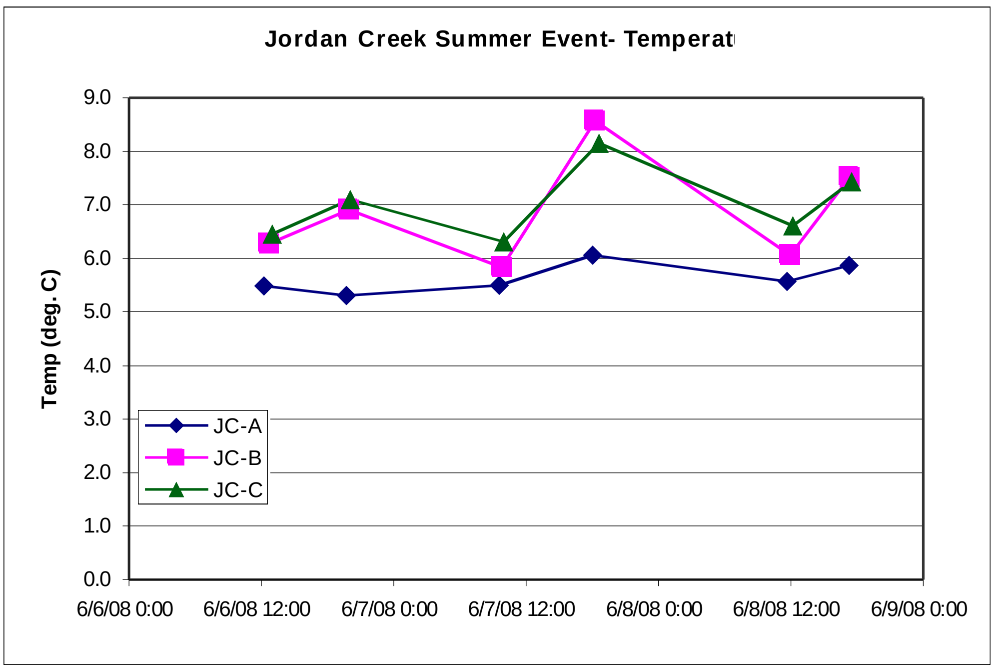
d) Water temperature

Water temperature in Jordan Creek shows strong seasonal variation, despite the flashy (event-controlled) discharge patterns on the stream. Figure 10 shows the temperature at the 3 Jordan Creek sites. Comparison of water temperature at the three locations along Jordan Creek indicates that upstream site JC-A has generally lower summertime and warmer wintertime temperatures than does JC-B (Table 2),which is further indication of the groundwater upwelling at the sites because groundwater maintains a more stable temperature than does surface water. Diel variations were strongest during the spring event, when snow melt was rapid during the warm daytime hours. No exceedences of the Alaska water quality standard for spawning and incubation areas (13 ºC) (DEC, 2006).occurred during this study year, although they have been documented in the past.






Jordan Creek Spring Event- Temperature
Temp (deg. C)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3/28/08 12:00
3/29/08 0:00
3/29/08 12:00
3/30/08 0:00
3/30/08 12:00
3/31/08 0:00
JC-A
JC-B
JC-C


Jordan Creek Summer Event- Temperat
Temp (deg. C)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
6/6/08 0:00
6/6/08 12:00
6/7/08 0:00
6/7/08 12:00
6/8/08 0:00
6/8/08 12:00
6/9/08 0:00
JC-A
JC-B
JC-C

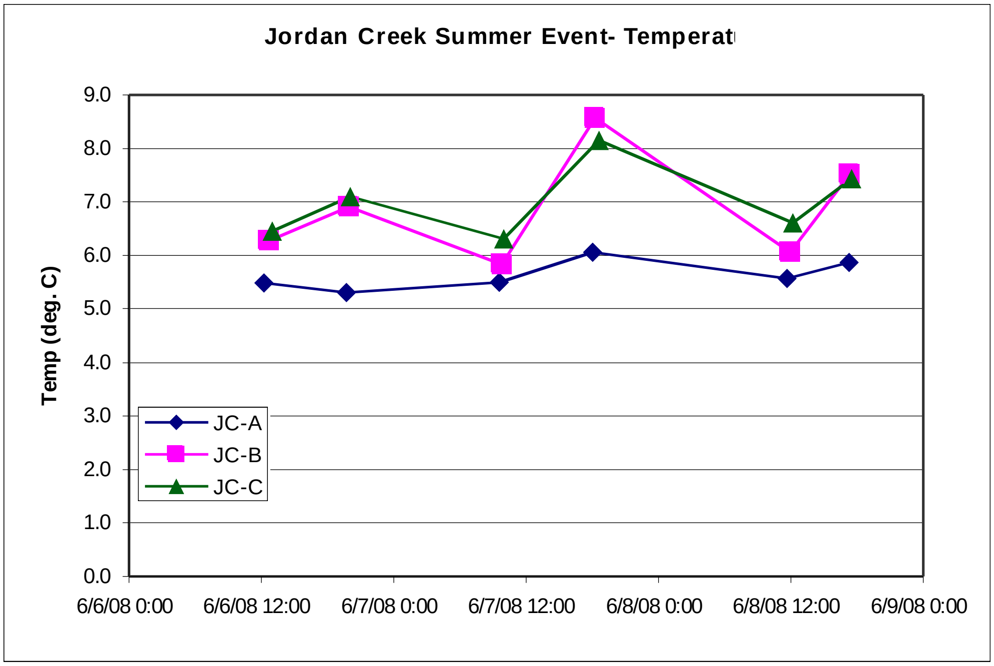


Figure 10*: Water temperature at the three sampling locations on Jordan Creek. The first panel shows temperature at Jordan Creek for all the years of study prior to and including 2008-2009.*

Summary and conclusions

The water quality of Jordan Creek in 2006-2007 was in most respects similar to that of previous years, although this year's dataset was concentrated on 4 seasonal events only. Results show that water quality of Jordan Creek varies little for most parameters on a diel and several-day scale. Exceptions include iron, turbidity, and TSS, which exhibit substantial (several-fold) fluctuations within timescales of several hours. All measured parameters in Jordan Creek surface water conformed to water quality standards on all sampling occasions (not the case in previous years; again this may be due to the sample design occurring on a much coarser annual scale in 2007-2008). Conductivity values and pH were similar to those of previous years. Dissolved iron levels showed no seasonal trend and relatively high variability at JC-A during the diel sampling, indicating complex diurnal-nocturnal fluctuations in dissolved iron levels. Turbidity values in Jordan Creek were well within the water quality standards, although JC-C (the most downstream site) showed the most variation and highest values in general. The total suspended solids values in the creek were typically about half of those in neighboring Duck Creek (comparison to prior year's data, and again, relatively high spikes were found at JC-C. Water temperature was good, with no exceedences of state water quality standards (unlike in previous years). Monitoring in future years should include continuous measurements of turbidity and dissolved oxygen (using optical probes mounted into the streambed) in Jordan Creek.

Acknowledgments
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Appendix A. Water quality data collected on Jordan Creek during the period November 2007 – June, 2008. All reported values are based on averages of triplicate measurements.

Site Name	Date and Time	Q (cfs)	Temp	Spec. Cond. (uS/cm)	DO (%)	DO (mg/L)	pH	Turb (NTU)	TSS (mg/L)	Fe (mg/L
FALL										
average JC-A	11/13/07 20:40		5.08	0.102	77.1	9.82	6.48	0.7	0.40	0.19
average JC-A	11/14/07 11:25		5.25	0.107	76.4	9.69	6.69	1.3	0.17	0.12
average JC-A	11/14/07 23:50		4.75	0.109	75.7	9.74	6.54	0.9	0.65	0.11
average JC-A	11/15/07 12:20		4.97	0.109	75.8	9.68	6.56	0.7	0.55	0.91
average JC-A	11/15/07 14:45		5.03	0.108	75.9	9.69	6.65	0.4	0.28	
average JC-B	11/13/07 20:20	7.2	3.92	0.093	95.3	12.51	7.00	2.4	0.93	0.31
average JC-B	11/14/07 11:10		4.37	0.089	95.1	12.34	7.15	3.4	4.22	0.29
average JC-B	11/14/07 16:35		4.46	0.088	93.4	12.10	7.14	2.7	4.95	
average JC-B	11/14/07 23:30	8.7	3.75	0.095	93.2	12.30	7.05	2.8	7.42	0.29
average JC-B	11/15/07 11:45		3.26	0.091	92.8	12.40	7.06	2.7	3.90	0.25
average JC-B	11/15/07 14:25		3.43	0.091	91.8	12.21	7.29	2.3	0.37	
average JC-C	11/13/07 20:00		3.71	0.109	96.4	12.72	7.24	2.6	1.59	0.28
average JC-C	11/14/07 10:50		4.26	0.094	96.2	12.52	7.29	17.5	45.00	0.24
average JC-C	11/14/07 16:20		4.34	0.089	94.7	12.31	7.37	5.8	14.52	
average JC-C	11/14/07 23:00		3.84	0.088	92.9	12.22	7.29	2.3	7.12	0.70
average JC-C	11/15/07 11:30		3.05	0.092	94.1	12.45	7.33	2.8	5.62	0.22
average JC-C	11/15/07 14:15		3.16	0.091	95.2	12.76	7.33	3.4	7.17	

WINTER										
Site Name	Date and Time	Q (cfs)	Temp	Spec. Cond. (uS/cm)	DO (%)	DO (mg/L)	pH	Turb (NTU)	TSS (mg/L)	Fe (mg/L
average JC-A	2/14/08 11:35		2.01	0.079	79.9	11.04	6.32	0.6	0.0	0.33
average JC-A	2/14/08 14:45		2.20	0.080	80.7	11.08	6.46	0.5	0.0	
average JC-A	2/14/08 22:06		1.84	0.079	81.3	11.28	6.35	0.5		0.33
average JC-A	2/15/08 10:15		2.24	0.086	82.4	11.30	6.47	1.2	0.8	
average JC-A	2/15/08 13:45		2.57	0.086	82.6	11.21	6.48	2.6	2.7	0.88
average JC-A	2/16/08 11:25		2.49	0.086	87.5	11.84	6.66	1.4		
average JC-A	2/16/08 13:44		2.63	0.085	86.5	11.75	6.44	0.3	1.8	0.25
average JC-B	2/14/08 12:10	2.8	0.07	0.054	106.8	15.58	6.75	1.7	0.0	0.29
average JC-B	2/14/08 15:30		0.07	0.053	107.6	15.70	6.71	1.6	0.3	
average JC-B	2/14/08 22:31		0.06	0.058	107.7	15.71	6.50	1.9	2.3	0.22
average JC-B	2/15/08 10:31		0.06	0.055	107.4	15.69	6.49	1.4	0.9	
average JC-B	2/15/08 14:05		0.06	0.055	107.8	15.74	6.61	1.3	5.1	0.29
average JC-B	2/16/08 11:45	1.3	0.07	0.058	107.8	15.74	6.72	6.1	9.2	
average JC-B	2/16/08 14:05		0.07	0.058	106.8	15.61	6.71	1.2	0.1	0.26
average JC-C	2/14/08 15:46		0.09	0.157	107.0	15.60	6.77	15.5	0.1	0.18
average JC-C	2/14/08 22:58		0.07	0.146	107.8	15.72	6.71	24.5	12.0	0.21
average JC-C	2/15/08 11:00		0.08	0.092	109.2	15.92	6.55	3.2	4.9	
average JC-C	2/15/08 14:15		0.09	0.093	109.6	15.97	6.71	3.8	1.4	0.20
average JC-C	2/16/08 12:10		0.12	0.093	111.1	16.18	6.86	2.0	0.5	
average JC-C	2/16/08 14:16		0.08	0.095	111.1	16.20	6.41	2.3	0.4	0.21

SPRING Site Name	Date and Time	Q (cfs)	Temp	Spec. Cond. (uS/cm)	DO (%)	DO (mg/L)	pH	Turb (NTU)	TSS (mg/L)	Fe (mg/L
average JC-A	3/28/08 14:45		3.46	0.092	87.3	11.60	6.89	12.9	10.97	0.16
average JC-A	3/28/08 17:50		4.30	0.091	87.9	11.47	7.36	0.2	4.68	
average JC-A	3/29/08 7:06		1.94	0.092	88.4	12.25	7.25	0.2	0.08	0.17
average JC-A	3/29/08 10:40		0.72	0.092	84.6	11.65	7.41	0.2	0.10	
average JC-A	3/29/08 20:15		2.98	0.092	84.5	11.38	6.99	0.6	0.30	0.15
average JC-A	3/30/08 7:34		2.33	0.092	86.8	11.89	6.69	0.4	0.26	
average JC-A	3/30/08 12:34		3.35	0.091	81.9	10.92	6.82	1.0	2.11	0.40
average JC-B	3/28/08 15:15		2.09	0.075	105.0	14.48	7.56	2.8	1.70	0.49
average JC-B	3/28/08 18:05		2.03	0.076	104.4	14.42	7.88	2.0	0.26	
average JC-B	3/29/08 7:45		0.42	0.076	106.3	15.35	7.64	2.5	5.00	0.44
average JC-B	3/29/08 10:55	32.8	0.30	0.077	104.8	15.18	8.07	2.1	1.00	
average JC-B	3/29/08 20:35		1.68	0.074	104.2	14.54	7.20	3.0	0.98	0.50
average JC-B	3/30/08 7:51		0.57	0.077	105.0	15.12	7.08	2.8	0.84	
average JC-B	3/30/08 12:45	17.4	1.34	0.077	97.6	13.73	7.24	2.9	0.76	0.41
average JC-C	3/28/08 15:25		2.90	0.074	108.4	14.64	7.40	7.7	15.96	0.36
average JC-C	3/28/08 18:15		2.70	0.075	109.2	14.81	8.02	2.9	0.90	
average JC-C	3/29/08 8:00		0.72	0.076	104.1	14.91	7.84	2.3	0.89	0.38
average JC-C	3/29/08 11:45		1.29	0.076	107.3	15.12	8.05	3.1	1.77	
average JC-C	3/29/08 20:15		1.72	0.076	103.7	14.44	7.43	3.2	2.60	0.43
average JC-C	3/30/08 8:02		0.60	0.076	105.0	15.09	7.14	2.8	1.38	
average JC-C	3/30/08 13:08		0.56	0.076	100.1	14.06	7.26	3.5	1.31	0.44

SUMMER Site Name	Date and Time	Q (cfs)	Temp	Spec. Cond. (uS/cm)	DO (%)	DO (mg/L)	pH	Turb (NTU)	TSS (mg/L)	Fe (mg/L
average JC-A	6/6/08 12:15		5.48	0.104	96.3	12.11	6.84	0.4	1.39	0.08
average JC-A	6/6/08 19:42		5.31	0.103	91.2	11.56	7.52	0.3	0.05	
average JC-A	6/7/08 9:35		5.49	0.094	88.9	11.21	6.71	1.1	1.10	
average JC-A	6/7/08 18:03		6.05	0.103	91.7	11.37	6.84	0.4	0.17	0.08
average JC-A	6/8/08 11:40		5.56	0.103	91.3	11.48	6.84	0.2	0.56	
average JC-A	6/8/08 17:15		5.87	0.103	92.8	11.58	6.99	0.2	0.67	0.07
average JC-B	6/6/08 12:40		6.28	0.086	106.7	13.19	7.16	1.0	1.40	0.14
average JC-B	6/6/08 19:56		6.90	0.088	105.2	12.80	7.18	0.8	0.52	
average JC-B	6/7/08 9:49		5.83	0.084	104.1	13.01	7.13	1.5	1.69	
average JC-B	6/7/08 18:15		8.56	0.083	104.4	12.19	7.21	1.2	0.76	0.20
average JC-B	6/8/08 11:55		6.05	0.086	105.5	13.11	7.24	0.8	1.60	
average JC-B	6/8/08 17:20		7.51	0.087	106.8	12.80	7.33	0.8	1.00	0.15
average JC-C	6/6/08 13:00		6.45	0.085	109.2	13.43	7.31	0.8	0.54	0.13
average JC-C	6/6/08 20:04		7.10	0.087	105.7	12.79	7.17	1.7	1.46	
average JC-C	6/7/08 10:00		6.31	0.086	107.4	13.26	7.19	1.4	1.40	
average JC-C	6/7/08 18:35		8.15	0.084	107.1	12.64	7.35	0.9	1.00	0.20
average JC-C	6/8/08 12:10		6.61	0.084	108.5	13.36	7.37	0.8	1.15	
average JC-C	6/8/08 17:30		7.43	0.086	111.1	13.34	7.36	N/A	1.00	0.13