Water Quality Evaluation of the Lower Little Susitna River

July 2008 through June 2009

Aquatic Restoration & Research Institute

Jeffrey C. Davis and Gay A. Davis
P.O. Box 923 Talkeetna, Alaska 99676
(907) 733.5432. arri@mtaonline.net

and

Nicholas R Ettema
Grand Valley State University
Allendale, Michigan

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Summary

Water quality sampling was conducted on the Lower Little Susitna River to measure for potential increases in total aromatic hydrocarbon concentration and stream water turbidity during intensive use periods. Water samples were collected weekly from July 27 through September 6, 2008 and from May 17 through June 28, 2009 at seven sites ranging from 1 km upstream to 4 km downstream from the Little Susitna River Public Use Facility (PUF). Water samples were analyzed for benzene, toluene, ethyl benzene and xylene (BTEX). Grab samples collected concurrently were measured *in situ* for turbidity. Turbidity was also measured with Hydrolab meters at a site located 3.5 km downstream from the PUF and 9 km upstream from the PUF (August and September 2008) and near Houston (May and June 2009). Boat use at the PUF launch by motor size and type was recorded during each sampling event by Aquatic Restoration and Research Institute (ARRI) staff and recorded daily by Alaska State Park staff at the entrance booth. Concentrations of total aromatic hydrocarbons (TAH) and turbidity were compared with state water quality standards. Spatial and temporal variability in water quality parameters were evaluated relative to changes in the number of boats and motor types and changes in discharge. The concentration of macroinvertebrates in the water column, and catch rates of juvenile salmonids were used to evaluate potential effects of water quality on the aquatic community.

The concentration of TAH and turbidity exceeded state water quality standards repeatedly throughout the sampling period. Including all dates and sites, 24 samples out of 105 (23%) had TAH concentrations greater than or equal to 10 μg/L. Concentrations exceeded state standards more often during August of 2008 when the number of boats was high and discharge was between 390 and 425 cfs. TAH concentrations exceeded state standards on one date in June of 2009 when boat use was high and discharge was 857 cfs. Significant regression equations were developed between boat numbers by motor type and flow corrected TAH concentrations. Daily TAH concentrations were modeled using boat counts at the entrance booth and discharge. The model predicted concentrations of TAH above state standards on 18 days out of 102 (18%) during 2008.

Stream water turbidity at the PUF was greater than 5 NTU above background measures on most sampling dates. There was more than a 5 NTU difference on 10 of 15 days (67%) based upon weekly grab samples. Average daily turbidity from the hourly measures collected by the Hydrolabs, were more than a 5 NTU above background measures on 26 of 50 days (52%) in 2008, and 21 of 34 days (62%) during spring 2009. Turbidity at the reference sites and the PUF increase during spring runoff and storm events; however, high flows explain only a portion of the changes in turbidity. There is not a direct relationship between daily boat counts and daily average turbidity; however, maximum differences in turbidity coincide with periods of high boat counts.

Increases in turbidity are likely resulting in changes to the biotic community. Measures of primary production, invertebrate drift, and juvenile salmon catch rates all declined significantly between sites upstream and downstream of the PUF. The direct effect of increased turbidity on aquatic biota cannot be confirmed due to the lack of replication and limited data; however, the results are consistent with other published studies.

Introduction

The Little Susitna River is located within southcentral Alaska and flows from the Talkeetna Mountains adjacent to the communities of Wasilla and Houston. The river travels over 100 miles from the Mint Glacier to Cook Inlet. The river flows through the Hatcher Pass State Recreation Area, the Nancy Lake State Recreation Area and the Susitna Flats State Game Refuge. The Little Susitna River is one of the rivers managed under the Susitna Area Recreational Rivers Management Plan (DNR 1991). The river supports a highly popular salmon and trout fishery as well as recreational non-motorized and motorized boating. Most of the residential development is between Edgerton Park Road and Schrock Road, adjacent to the cities of Wasilla and Houston, resulting in bank and riparian modifications (Davis and Davis 2007).

Primary use of the Little Susitna River is related to the salmon sport fishery. Access is limited to undeveloped boat launches near Houston (River Mile 62) and at the Public Use Facility (PUF) (River Mile 25). In 2007, over 11,000 anglers accessed the Little Susitna River at the PUF during the Chinook and coho salmon sport fisheries.

The high amount of boat-accessed fishing, particularly near the PUF, has raised concerns over potential impacts to water quality. Stream water turbidity appears to increase in the lower river during the sport fishery, which was confirmed by sampling conducted in 2006 and 2007 (Davis and Davis 2007). Intensive boat use on the Kenai River and within Big Lake has resulted in concentrations of hydrocarbons within the water column that exceed state water quality standards (18 AAC 70) (Oasis 2006, Oasis 2008).

The evaluation of potential impacts to water quality within Alaska is reviewed and prioritized through the Alaska Clean Water Actions program (ACWA). This program is developed through the coordination of state resources agencies, including the Departments of Environmental Conservation, Fish and Game, and Natural Resources to prioritize waters throughout the state for water quality, quantity and aquatic habitat. Based upon preliminary data, the state developed ACWA priority actions for the Little Susitna River. These actions include intensive monitoring of the lower river (from Houston to Cook Inlet) for water quality parameters related to recreational use. Parameters included turbidity, dissolved oxygen, temperature and petroleum hydrocarbons.

Initial water quality sampling was conducted from July 2007 through June 2008 to determine the location and extent of potential hydrocarbon and turbidity contamination of the Little Susitna River. Sampling was conducted weekly through the fall coho fishery (July through mid September 2007) and the spring Chinook fishery (May and June 2008) above and below the city of Houston and above and below the PUF. Results indicate that total aromatic hydrocarbon concentrations exceeded state water quality standards adjacent to the PUF boat launch during the coho and Chinook fisheries. Stream water turbidities increased above background levels and periodically exceeded state standards (Davis and Davis 2008). These results led to further study in July 2008 – June 2009 in order to more fully understand the scope of the problem.

The objectives of this project are to further identify the extent and duration of hydrocarbon contamination and changes in turbidity adjacent to the developed boat launch at the PUF. Hydrocarbon concentrations were evaluated relative to boat use and motor type (2-cycle or 4-cycle engines), operation time, and stream flows. Secondary objectives included evaluating potential impacts to the macroinvertebrate and fish communities within the affected areas.

Methods

Sampling Locations

Water samples were collected from seven locations near the PUF boat launch. Water sampling locations were distributed from 1.0 km upstream to approximately 4 km downstream (Table 1 and Appendix B QAPP with Addendum 1 for location maps). Reference grab samples for turbidity were collected below Houston upstream of the undeveloped launch at Miller's Reach. In 2008, Hydrolab DS5 Multiprobes were deployed for hourly turbidity monitoring at stations approximately 9 km upstream (PUFUP) from the PUF boat launch and 3.5 km downstream (PUFDN). The PUFUP site was selected in 2008 as a reference turbidity location; however, due to extensive boat activity in the region, the site was relocated upstream of Miller's Reach in 2009 but below the Parks Highway bridge.

Table 1. Water quality sampling locations.

Name	Sample Collection	Distance from PUF Launch km/mi*	Latitude	Longitude
LS-1	Water Sampling Station, Discharge	1.15/0.71	61.44245	150.15931
LS-2	Water Sampling Station	0.44/0.27	61.44236	150.16751
LS-3	Water Sampling Station	0.00	61.43783	150.17386
LS-4	Water Sampling Station	-0.51/-0.32	61.43520	150.17470
LS-5	Water Sampling Station	-1.35/-0.84	61.43345	150.17239
LS-6	Water Sampling Station	-2.01/-1.25	61.43076	150.18345
LS-7	Water Sampling Station	-3.87/-2.40	61.42389	150.18958
Miller's Reach	Reference Turbidity 2008 and 2009, Continuous Turbidity 2009	60.48/37.8	62.62180	149.84939
PUFUP	Continuous Turbidity 2008, Invertebrate Drift, Juvenile Salmon	9.62/5.98	61.46311	150.14569
PUFDN	Continuous Turbidity 2008 and 2009, Invertebrate Drift, Juvenile Salmon	-3.50/-2.17	61.42787	150.18953

* Positive values are upstream and negative values are downstream from the PUF.

Boat Use

Boat use data were obtained from direct counts during water sampling events and from the PUF entrance booth. On each sampling event, an ARRI observer recorded all boat activity at the PUF boat launch. Observations by ARRI began upon arrival, generally between 12:00 and 14:00. The observer recorded the time that a boat entered the water from the launch or approached the launch from the water. The observer recorded the size (horse power), make, and type of motor (2-cycle, 2-cycle direct injection, or 4-cycle). Boat operators were interviewed in order to obtain motor type or size information when this information was not visible on the motor cowling. Time of operation within the launch area was recorded along with route of departure and activity. Observations ended upon completion of water sample collection, generally after 2 or 3 hours.

Boat motor size, boat length, and motor type (2-cycle or 4-cycle) were also recorded by Alaska State Park staff and volunteers at the entrance booth. Data were recorded daily, summarized following the 2008 season and were transmitted to ARRI staff in January 2009. Data collection at the entrance booth continues in 2009; however, results are not available at the time of this report.

Water Sampling

Water samples were collected weekly for 8 weeks in the fall of 2008 and 7 weeks in the spring of 2009 (see Appendix B for detailed Sampling Plan) for BTEX analyses which were used to calculate TAH. Sampling was conducted on Sundays between 12:00 and 16:00. Samples were collected near the thalweg but at a location that did not present a navigational hazard. Water samples were collected below the water surface at approximately 0.5 water depth. Duplicate samples and field blanks were collected on each sampling date. Water samples were preserved with HCL, kept on ice, and shipped to AM Test, Inc. in Kirkland, WA for hydrocarbon analyses (EPA Method 624).

At each sampling station LS-1 though LS-7, on each sampling date, we measured turbidity (mean of 3 samples), pH, specific conductivity, dissolved oxygen, and water temperature *in situ* using hand-held meters. Discharge was measured on each sampling date at LS-1 and downloaded from the U.S.G.S. gauging station (Station No. 15290000) located in Hatcher Pass, approximately 117 km (73 miles) upstream. Hydrolab DS5 Multiprobes were used to obtain hourly measures of dissolved oxygen (2008 only), turbidity, and water temperature. Hourly measures of water temperature were also obtained with Onset ProTemp V2 temperature loggers.

Macroinvertebrate Drift and Juvenile Salmon

Macroinvertebrates were sampled on August 17, 2008 and June 13, 2009 in drift nets (283 μm mesh, 45.7 x 30.5 cm opening) at PUFUP and PUFDN. Drift sampling was conducted following the methods described in Davis et al. 2001. A series of three nets were deployed across the channel 10 to 20 cm below the water surface. Water flow into the nets was measured with a General Oceanics flow meter centered in the net opening. Nets remained in the water until there was a visible decrease in flow. All material within the nets was transferred to 500-ml nalgene bottles and preserved with ethyl-alcohol. Samples were sorted and identified to genus.

Juvenile salmon were sampled concurrent with drift. Ten baited (salmon roe) minnow traps were placed in low velocity areas near or under cover along an outside bend. Traps were allowed to fish for 12 to 24 hours. All fish within the traps were identified to species, and all salmonids measured to fork length. Catches from each trap were recorded individually.

Community Metabolism

Community metabolism is a measure of the amount of energy produced within a stream system and available for insect consumers, the primary food base for rearing salmonids. This measure is the sum of autochthonus primary production from algae and aquatic plants and the respiration of all organic matter. Community metabolism was measured using the open system single station method (Odum 1956, Bott 2007). Dissolved oxygen (DO) and temperature were recorded on 1h or 0.5h intervals using Hach Environmental Minisonde 5 and YSI 600QS sondes deployed for 14-28 days. Turbidity was also monitored (Hach sondes only) and calibrated against a known turbidity sample prior to each deployment. Dissolved oxygen sensors were calibrated in water-saturated air at sea level prior to each deployment. All sondes were monitored for sensor drift prior to deployment and following retrieval. Data collection began on May 19, 2008 and ended September 5, 2008.

Gross primary production and community respiration were determined according to Bott (2007) based on the equation:

$$\Delta DO = P - R + K(t^\circ C)(D)$$

Where ΔDO is the change in dissolved oxygen concentration (g O_2 m^{-3}) and P (g O_2 m^{-3}) and R (g O_2 m^{-3}) correspond to primary production and respiration respectively. The product of the temperature corrected reaeration coefficient ($K(t^\circ C)$) and the oxygen deficit (D in g O_2 m-3) quantifies the net gas exchange with the atmosphere over a time interval (1 h or 0.5 h in this study). During the night, primary production is reduced and changes in DO concentration are due to respiration. Therefore, day-length community respiration (CR24) was determined as the average hourly respiration at night, extrapolated over a 24 -hour period. Gross primary production (GPP) was determined as the sum of daytime respiration and cumulative change in DO during the photoperiod. GPP and CR24 were converted to areal units (g O_2 m^{-2} d^{-1}) by multiplying volumetric rates by site specific average depth.

Results

Boat Use

Boat use observations were conducted at the launch on 15 Sundays during the fall of 2008 and spring of 2009 (Table 2). Observation time ranged from 1.5 to 4 hours. Boat use peaked during the fall coho fishery with a maximum of 43 total boats counted during 2.4 hours on August 10, 2008. From 9 to 18 boats were counted per hour from July 27 to August 17. Total boat counts increased during the spring Chinook fishery with a maximum of 57 boats operating in the launch area over a 2.4 hour period on June 7, 2009. Total boat counts ranged from 8 to 23 per hour through June.

Maximum outboard motor size was 200 HP; however boat motors ranging from 35 to 65 HP were most common. The percent of 2-cycle boat motors (not including 2-cycle direct fuel injection) ranged from 14 to 51%. The percent 2-cycle tended to increase with increasing total boats. The majority of users operated downstream of the boat launch on most dates. However, late in the coho and Chinook fisheries near 60% of the use was upstream of the launch.

Boat use counts obtained by the state for 2008 at the entrance booth are shown in Table 3. Boat counts during sampling events were correlated to boat counts obtained at the entrance booth (r^2 =0.89, n= 7). Maximum booth counts were 49 on June 8 and June 15, 2008, and 48 on August 10, 2008. Boat use was highest on Sundays with an average of 24% of weekly use, followed by Friday and Saturday at near 20%, Monday and Thursday at 16%, and lowest on Tuesdays and Wednesdays at 5% and 9%, respectively. Annual use in 2008 was divided evenly between the Chinook and coho fisheries. Approximately 35% of the annual use occurred from June 1 to June 22, 2008, and 33% from August 3 through August 17, 2008. The percent of 2-cycle motors in 2008 ranged from 0 to 61%. These motor types made up less than 30% of all motors on half of the recorded dates. Using this larger data set, there was no clear relationship between daily boat counts and the percent of boats with 2-cycle motors.

Table 2. Boat use by motor type and size counted at the launch during each sampling event.

	Day	Total Boats	2-Cycle	2-Cycle DI	4-Cycle	Maximum HP	Minimum HP	Average HP	Operated Upstream	Operated Downstream	Observation Time (hrs)	Percent 2-Cycle	Percent Upstream
7/27/2008	Su	39	11	0	28	200	15	61	16	26	4.0	28%	38%
8/2/2008	Sa	33	8	0	25	200	30	69	15	18	1.9	24%	45%
8/10/2008	Su	43	15	0	28	200	20	62	17	26	2.4	35%	40%
8/13/2008	We	29	10	0	19	150	23	61	9	18	3.0	34%	33%
8/17/2008	Su	37	19	0	18	225	2.5	55	18	21	2.0	51%	46%
8/24/2008	Su	20	8	0	12	65	8	47	10	13	2.5	40%	43%
8/30/2008	Sa	9	3	0	6	65	35	53	5	3	1.8	33%	63%
9/6/2008	Sa	5	1	0	4	115	50	67	1	4	1.5	20%	20%
5/17/2009	Su	14	2	2	10	200	6	70	6	5	2.5	14%	55%
5/24/2009	Su	47	20	3	24	140	9.9	60	28	30	3.1	43%	48%
5/31/2009	Su	37	13	1	23	115	15	53	8	30	3.8	35%	21%
6/7/2009	Su	57	21	2	34	200	20	68	44	35	2.4	37%	56%
6/14/2009	Su	36	9	1	26	200	9.9	62	10	16	2.3	25%	38%
6/21/2009	Su	16	8	0	8	140	20	56	5	8	2.0	50%	38%
6/28/2009	Su	31	14	1	16	140	15	63	17	12	3.0	45%	59%

Table 3. Daily booth counts collected at the PUF entrance, showing percent of total count by motor type and percent of seasonal use by week, and weekly use by day.

Date	Day	Boat Totals	2-Cycle	Percent 2-Cycle	Total/Week	Percent of Season Use by Week	Percent of Weekly Use by Day
5/22/2008	Thurs	4	2	50%			9%
5/23/2008	Fri	13	5	38%			28%
5/24/2008	Sat	12	6	50%			26%
5/25/2008	Sun	17	7	41%	46	2.54%	37%
5/26/2008	Mon	42	7	17%			27%
5/27/2008	Tues	6	1	17%			4%
5/28/2008	Wed	2	1	50%			1%
5/29/2008	Thurs	17	8	47%			11%
5/30/2008	Fri	22	7	32%			14%
5/31/2008	Sat	30	7	23%			19%
6/1/2008	Sun	36	10	28%	155	8.56%	23%
6/2/2008	Mon	20	3	15%			11%
6/3/2008	Tues	15	6	40%			8%
6/4/2008	Wed	4	2	50%			2%
6/5/2008	Thurs	25	10	40%			13%
6/6/2008	Fri	37	18	49%			19%
6/7/2008	Sat	40	17	43%			21%
6/8/2008	Sun	49	16	33%	190	10.49%	26%
6/9/2008	Mon	29	6	21%			17%
6/10/2008	Tues	7	1	14%			4%
6/11/2008	Wed	7	2	29%			4%
6/12/2008	Thurs	18	9	50%			10%
6/13/2008	Fri	29	11	38%			17%
6/14/2008	Sat	35	9	26%			20%
6/15/2008	Sun	49	14	29%	174	9.61%	28%
6/16/2008	Mon	22	4	18%			15%
6/17/2008	Tues	12	1	8%			8%
6/18/2008	Wed	5	2	40%			3%
6/19/2008	Thurs	26	14	54%			18%
6/20/2008	Fri	28	17	61%			19%
6/21/2008	Sat	19	1	5%			13%
6/22/2008	Sun	33	10	30%	145	8.01%	23%
6/23/2008	Mon	18	2	11%			17%
6/24/2008	Tues	5	0	0%			5%
6/25/2008	Wed	12	4	33%			12%
6/26/2008	Thurs	17	7	41%			17%
6/27/2008	Fri	21	2	10%			20%
6/28/2008	Sat	11	3	27%			11%
6/29/2008	Sun	19	8	42%	103	5.69%	18%

Date	Day	Boat Totals	2-Cycle	Percent 2-Cycle	Total/Week	Percent of Season Use by Week	Percent of Weekly Use by Day
6/30/2008	Mon	15	4	27%			16%
7/1/2008	Tues	11	3	27%			12%
7/2/2008	Wed	12	5	42%			13%
7/3/2008	Thurs	14	7	50%			15%
7/4/2008	Fri	15	1	7%			16%
7/5/2008	Sat	14	4	29%			15%
7/6/2008	Sun	11	5	45%	92	5.08%	12%
7/7/2008	Mon	3	2	67%			7%
7/8/2008	Tues	2	0	0%			5%
7/9/2008	Wed	8	2	25%			20%
7/10/2008	Thurs	10	4	40%			24%
7/11/2008	Fri	5	2	40%			12%
7/12/2008	Sat	5	1	20%			12%
7/13/2008	Sun	8	0	0%	41	2.26%	20%
7/14/2008	Mon	3	0	0%			8%
7/15/2008	Tues						
7/16/2008	Wed						
7/17/2008	Thurs	5	3	60%			13%
7/18/2008	Fri	7	0	0%			18%
7/19/2008	Sat	6	0	0%			16%
7/20/2008	Sun	17	3	18%	38	2.10%	45%
7/21/2008	Mon	3	1	33%			3%
7/22/2008	Tues	4	0	0%			4%
7/23/2008	Wed	5	1	20%			5%
7/24/2008	Thurs	13	4	31%			12%
7/25/2008	Fri	30	10	33%			28%
7/26/2008	Sat	32	9	28%			30%
7/27/2008	Sun	21	6	29%	108	5.96%	19%
7/28/2008	Mon	17	5	29%			9%
7/29/2008	Tues	3	1	33%			2%
7/30/2008	Wed	12	3	25%			7%
7/31/2008	Thurs	33	20	61%			18%
8/1/2008	Fri	45	12	27%			25%
8/2/2008	Sat	31	10	32%			17%
8/3/2008	Sun	40	9	23%	181	9.99%	22%
8/4/2008	Mon	29	7	24%			12%
8/5/2008	Tues	6	4	67%			3%
8/6/2008	Wed	32	7	22%			14%
8/7/2008	Thurs	40	15	38%			17%
8/8/2008	Fri	43	11	26%			18%
8/9/2008	Sat	37	18	49%			16%
8/10/2008	Sun	48	13	27%	235	12.98%	20%

Date	Day	Boat Totals	2-Cycle	Percent 2-Cycle	Total/Week	Percent of Season Use by Week	Percent of Weekly Use by Day
8/11/2008	Mon	41	13	32%			22%
8/12/2008	Tues	4	1	25%			2%
8/13/2008	Wed	21	5	24%			11%
8/14/2008	Thurs	19	4	21%			10%
8/15/2008	Fri	14	6	43%			8%
8/16/2008	Sat	45	20	44%			24%
8/17/2008	Sun	42	16	38%	186	10.27%	23%
8/18/2008	Mon	14	3	21%			14%
8/19/2008	Tues	8	3	38%			8%
8/20/2008	Wed	11	4	36%			11%
8/21/2008	Thurs	12	5	42%			12%
8/22/2008	Fri	21	10	48%			21%
8/23/2008	Sat	17	3	18%			17%
8/24/2008	Sun	17	6	35%	100	5.52%	17%
8/25/2008	Mon	7	2	29%			41%
8/26/2008	Tues	1	0	0%			6%
8/27/2008	Wed						
8/28/2008	Thurs	4	0	0%			24%
8/29/2008	Fri						
8/30/2008	Sat	1	1	50%			12%
8/31/2008	Sun	3	1	33%	17	0.94%	18%

Concentrations of TAH

TAH concentrations for all sampling dates in 2008 and 2009 are provided in Table 4 and Figure 1. Concentrations of TAH have ranged from below detection limits to 75.2 μg/L. The highest concentrations occurring during the fall of 2008 and spring of 2009 were 30 μg/L, and 10 μg/L, respectively. There were no consistent trends in TAH concentrations from upstream to downstream. On August 13, 2008 concentrations increased from LS-4 to LS-5 and on August 17, concentrations decreased considerably downstream from LS-4. These rapid changes suggest a plume of hydrocarbon contaminated water moving downstream on these sampling dates.

Concentrations exceeded state water quality standards of 10 μg/L ((18 AAC 70.020(b) (5) (A) (iii)) in 31 of 121 samples, or 26%. The highest number of exceedances occurred at sites LS-1 and LS-4 at 26% and 35%, respectively (these were the only sites sampled during the spring of 2008). TAH concentrations exceeded water quality standards on 3 or 4 (depending on the site) of the 15 sampling dates during fall 2008 and spring 2009.

High concentrations of TAH coincided with high boat counts and low flows. High concentrations that resulted in water quality exceedances occurred primarily during the

Chinook and coho fisheries in 2008. These high concentrations were associated with flows ranging from 380 to 600 cfs. Booth boat counts were near 50 for the sampling dates during the Chinook fishery and ranged from 33 to 48 during the coho fishery. In contrast, while high boat counts were obtained during the spring 2009 sampling events, concentrations were generally below the limits of water quality standards. These differences are likely due to the high flows during the spring that ranged from 600 to 900 cfs during the most intensive use.

TAH concentrations are expressed as mass per volume of water. The addition of 10 μg of hydrocarbons to 1 liter of water results in a concentration of 10 μg/L, and the addition of 10 μg to 2 liters of water results in a concentration of 5 μg/L. Similarly, if emissions from a boat result in concentrations of 10 μg/L at a stream flow of 100 cfs, the same emissions at 200 cfs, will result in a concentration of 5 μg/L. To determine the mass of hydrocarbon emission, the concentration is multiplied by the volume of water (i.e. 5 μg/L x 2 L = 10 μg) or, in this case, stream flow. The hydrocarbon emissions, or flow corrected values, can then be related to the number of boats operating by motor type. Therefore, we multiplied concentrations (mg/L) by flows (L/s) to obtain TAH emissions (mg/s), or flow corrected values. Flow corrected values were then compared to boat use by motor type.

Regression relationships were developed between flow corrected values and boat use during sampling events (Figure 2). The best relationships (highest r^2) were for samples collected at LS-3, directly downstream from the boat launch for total boats counted per hour. However, the regression r^2 was only slightly lower when using only 2-cycle motors per hour (0.7 vs. 0.8). The fit of the regression line decreased for sites upstream and downstream from the launch and were lowest upstream. These regression relationships were used to estimate the number of total boats operating within the launch area per hour that could result in water quality exceedances at different flows (Figure 3). Using the relationship with 2-cylcle motors, water quality standards for TAH will be exceeded downstream from the PUF when5 or more boats are operating per hour and discharge is less than 600 cfs.

The discharge measurements from upstream of the PUF were used to investigate the relationship with flows recorded at the U.S.G.S. gauging station. The gauging station is located 73 river miles upstream of the PUF. Using an average water velocity of 1.5 ft/s we estimated approximately 2.9 days for water to travel from the gauging station to the PUF. We found a significant regression relationship between discharge measured at the gauging station and flow at the PUF three days later (Figure 4) and used this equation to estimate discharge at the PUF.

Using the daily boat counts at the booth to estimate 2-cycle motor use per hour, the relationship between 2-cycle motors/hr and flow corrected TAH concentrations, and estimated daily flow at the PUF we could model daily TAH concentrations (Figure 5). Actual TAH values from water sampling were from 0.5 to 1.9 times predicted values; however, estimates from the model predicted water quality exceedances of TAH concentrations on 18 days at the boat launch from May 22 through August 31, 2008 (102 days) or 18% of the days.

Table 4. Total aromatic hydrocarbon concentrations (μg/L) and discharge for all sampling dates and sites in the fall of 2007, 2008, and spring 2009. Exceedance is the number of times concentrations were greater than state water quality standards of 10 μg/L.

	LS-1	LS-2	LS-3 PUF	LS-4	LS-5	LS-6	LS-7	Flow (cfs)
29 Jul 07	2.6			5.1				358*
5 Aug 07	0.0			0.0				400*
12 Aug 07	0.0			0.0				597*
19 Aug 07	6.7			10.17				459*
26 Aug 07	0.0			0.0				363*
2 Sept 07	0.0			0.0				800*
9 Sep 07	0.0			0.0				337*
16 Sept 07	0.0			0.0				321*
10 May 08	0.0			0.0				389
18 May 08	0.0			0.0				312
24 May 08	1.2			5.3				399
1 Jun 08	28.6			27.6				511
8 Jun 08	36.7			75.2				465
15 Jun 08	9.6			22.8				594
21 Jun 08	0.0			9.1				720
29 Jun 08	11.0			13.1				707
27 Jul 08	2.8	3.6	2.5	2.1	2.0	2.4	3.6	830
2 Aug 08	17.2	16.1	18.1	12.4	23.9	18.3	17.6	485
10 Aug 08	13.2	16.1	23.5	30.8	26.1	28.3	27.7	525
13 Aug 08	4.3	4.2	6.2	5.2	11.1	16.5	10.7	479
17 Aug 08	26.2	27.1	27.9	22.3	2.5	0.0	4.8	387
24 Aug 08	6.9	6.8	6.8	10.4	8.4	7.5	9.3	379
30 Aug 08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	386
6 Sept 08	0.0	0.0	0.0	0.0	0.0	2.9	0.0	325
17 May 09	0.0	0.0	0.0	1.0	0.0	0.0	0.0	927
24 May 09	3.1	4.2	8.3	6.8	5.0	9.2	6.9	833
31 May 09	0.0	0.0	3.7	0.0	0.0	1.4	3.6	804
7 June 09	0.0	3.2	10.4	9.1	9.7	9.3	12.7	857
14 June 09	1.9	2.2	5.3	5.4	4.5	5.8	2.9	788
21 June 09	3.1	1.9	1.2	1.8	3.0	3.9	3.1	616
28 June 09	1.8	1.8	2.3	5.4	4.6	4.6	5.2	418
Exceedances	6	3	4	9	3	3	4	
Percent of Total	20%	20%	27%	29%	20%	20%	27%	

* Flows calculated from relationship with values measured at the USGS site in Hatcher Pass.

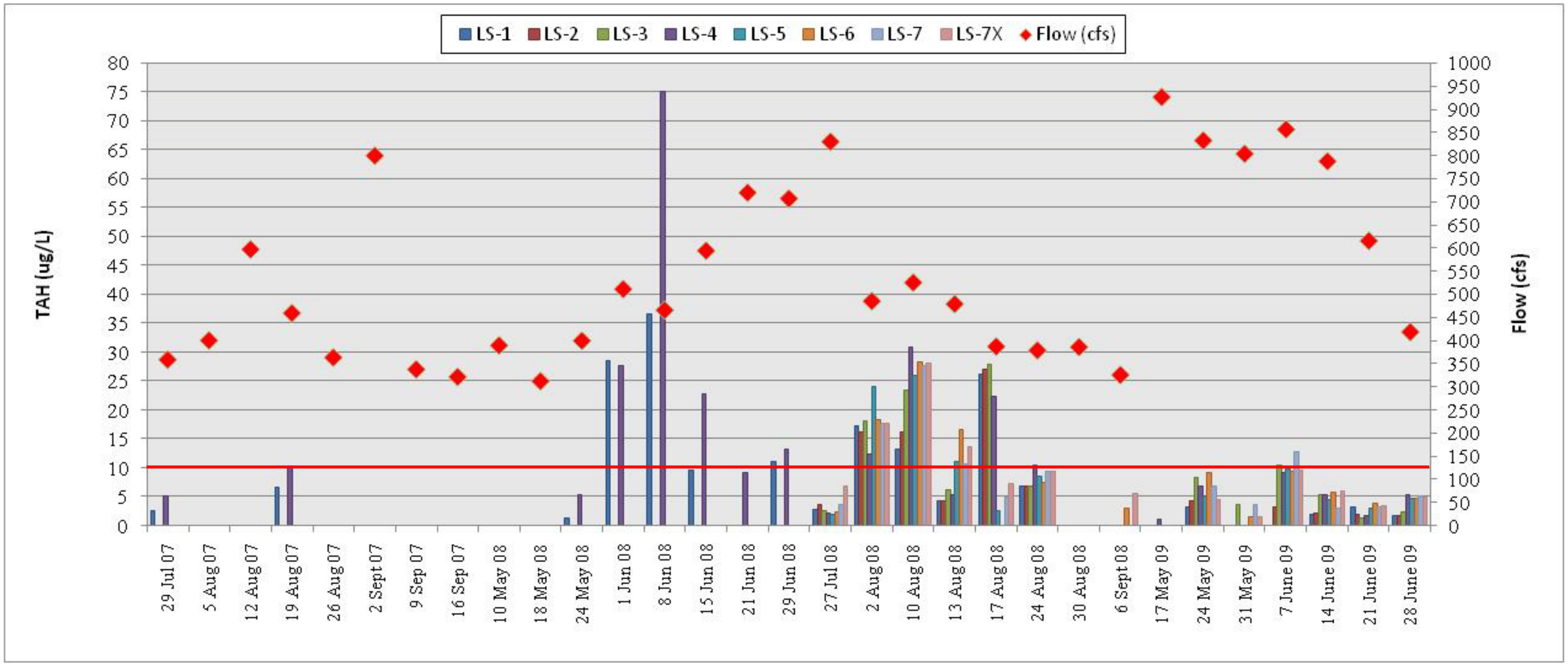

Figure 1. TAH concentrations for all sampling dates and locations, showing discharge (red diamonds). Red line denotes state water quality standard of 10μg/L.

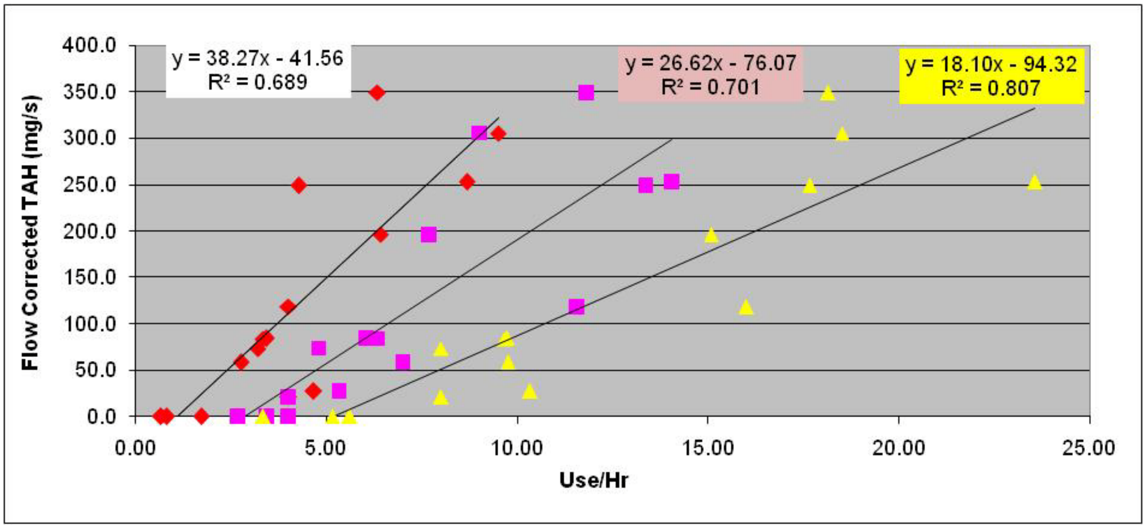

Figure 2. Regression relationships between flow-corrected TAH and the number of boats observed at the launch LS-3 per hour by motor type. Diamonds = 2-Cycle, squares = 4- Cycle, and triangles = total boats.

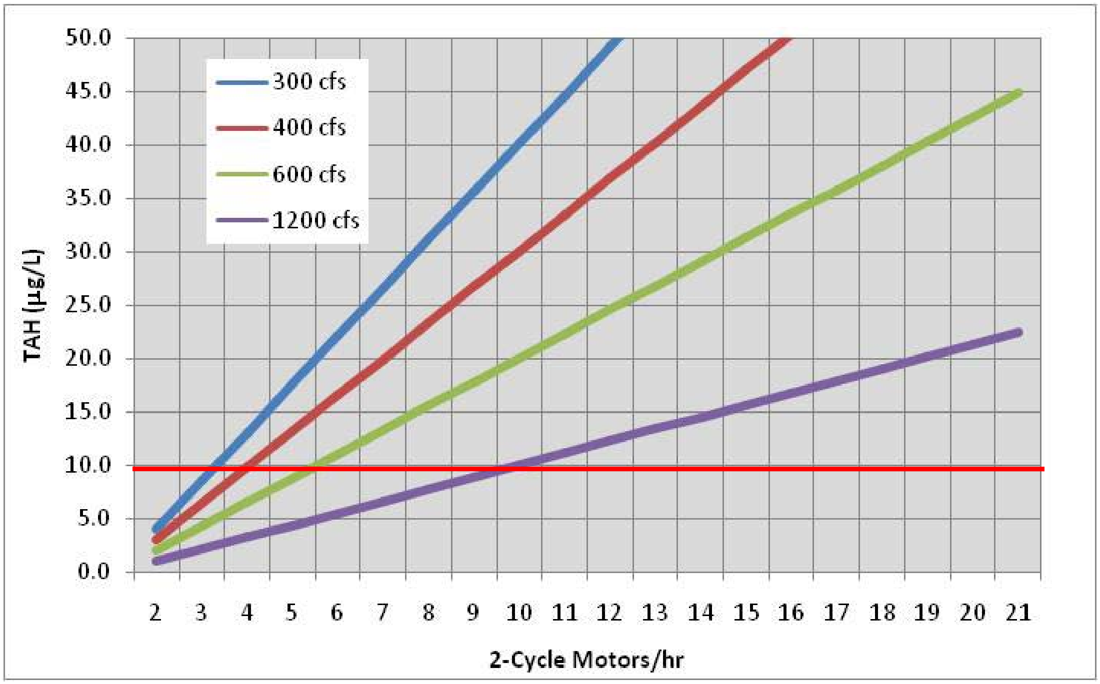

Figure 3. Estimated TAH concentrations at different flows as a function of boat (2-cycle motors) use per hour at the launch. The state water quality standard for TAH is 10 µg/L (red line).

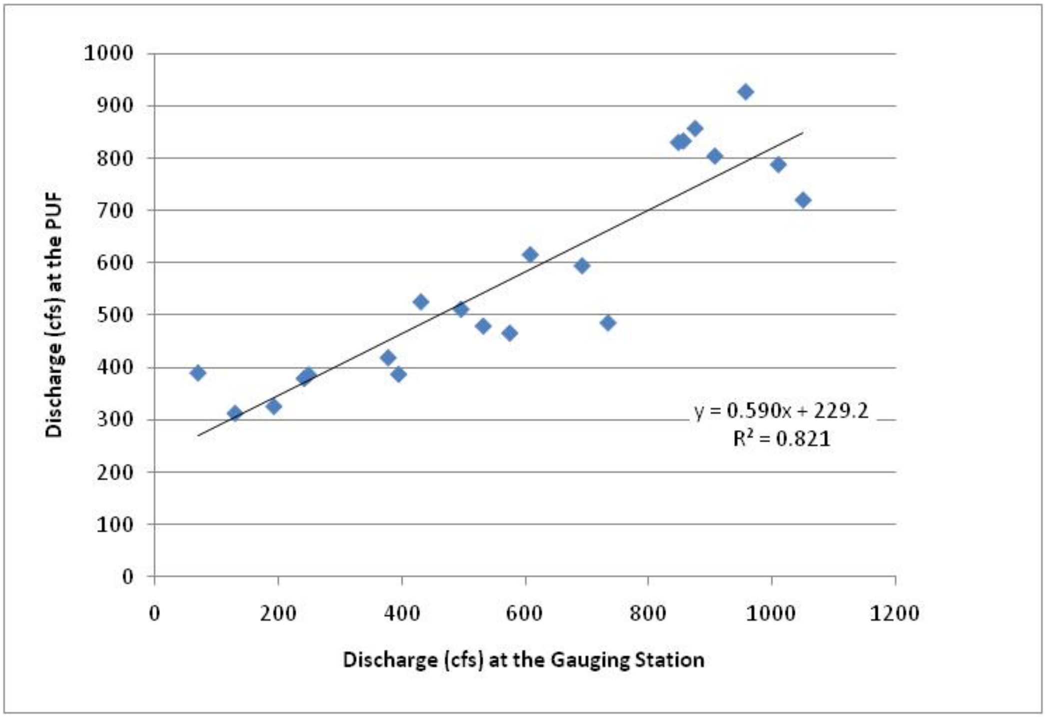

Figure 4. Regression relationship between Little Susitna River discharge measured at LS-1 and discharge 3-days previously measured at the U.S.G.S. gauging station.

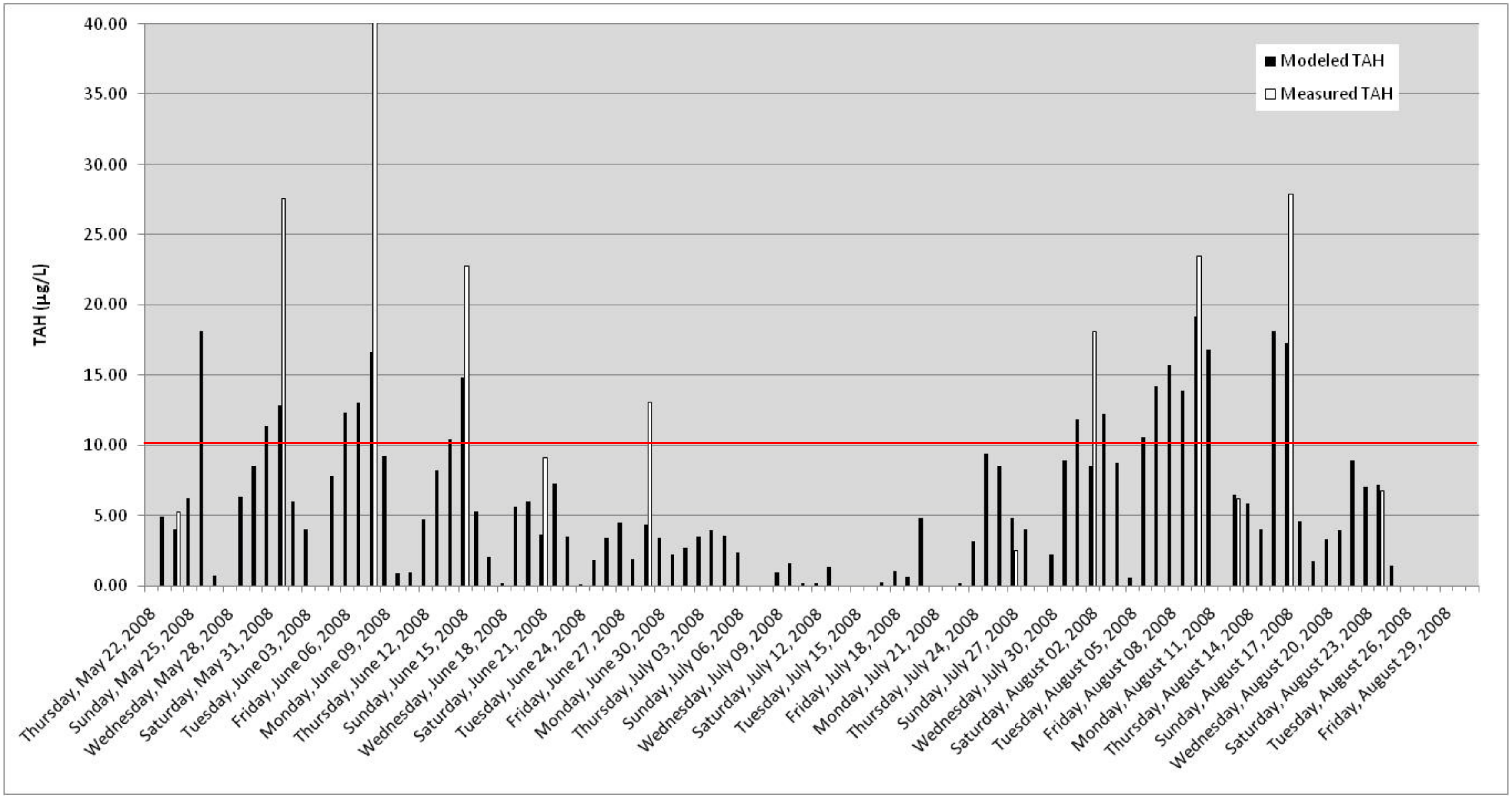

Figure 5. Estimated TAH concentrations at the Little Susitna River PUF (LS-3) based on discharge and 2-cycle boat use per hour modeled from total boat counts at the entrance booth and compared to measured values. Red line marks water quality standard concentration.

Water Temperature and Chemistry

Seasonal stream water temperature statistics for 2008 and 2009 are shown in Table 5. Stream water temperatures increase from Miller's Reach near Houston to the PUF. Water temperatures in 2009 were warmer than in 2008. Water temperatures in this semi-glacial river did not exceed 20°C in 2008 at the PUF but exceeded this temperature on 7 days in 2009.

Table 5. Stream water temperature statistics from measures recorded using temperature data loggers at Miller's Reach near Houston (mile 62.8) and at the PUF (mile 25).

	Season Maximum	Maximum Daily Range	Total Days	Days Max Temp >13	Percent of Total Days > 13	Days Max Temp >15	Percent of Total Days >15	Days Max Temp >20	Jun Cumulative Degree Days	Jul Cumulative Degree Days	Aug Cumulative Degree Days	Sep Cumulative Degree Days
Little Susitna River at Miller's Reach 2008	13.06	3.57	122	1	1	0	0	0	169	292	292	216
Little Susitna River at Miller's Reach 2009	15.20	3.46	100	15	15	1	1	0	183	419	323	228
Little Susitna River at the PUF 2008	16.30	5.50	122	52	43	5	4	0	232	373	373	261
Little Susitna River at the PUF 2009	20.87	5.81	122	85	70	43	35	7	254	501	410	274

Measures of dissolved oxygen, pH and specific conductivity are provided in Appendix A. Dissolved oxygen was near saturation on all sampling dates ranging from 95 to 105%. The pH of water samples ranged from 7.6 to 7.9. Specific conductivity ranged from 70 to 100 μS/cm but was near 80 on most sampling dates.

Turbidity

Stream water turbidity from grab samples from all sampling dates are provided in Table 6 and Figure 6. Average turbidity at the reference site including all sampling dates was 3.4 NTU and ranged from near 0 to 9.2 NTU. Average turbidity (LS-1 through LS-7) adjacent to the PUF ranged from 4 to15.9 NTU. The difference in turbidity between reference and average downstream values ranged from 2.5 to 11.2 NTU. Maximum differences in the fall of 2008 occurred on August 17 and in the spring of 2009 on June 7. Both of these days coincided with high boat counts.

Average daily turbidity values from the Hydrolab probes are shown in Figures 7 (2008) and 8 (Spring 2009). There are three tributaries between the reference site, and the site located below the launch. Theses tributaries, Nancy Lake Creek, Crooked Lake Creek and My Creek, drain wetlands and do not contribute suspended sediment to the Little Susitna River. There was a significant difference in turbidity between upstream and downstream locations (paired t-tests, $p<0.001$). August data during 2008 was lost due to equipment problems. However, differences in 2008 turbidity between the reference site located 9.0 km upstream from the launch, and the site located 3.5 km below the launch ranged from 1 to 14 NTU. Turbidity was very similar during late August and early September 2008. Maximum differences occurred from June 7 through June 14, 2008, (average difference of 10.9) coincidental with increased boat use during the Chinook fishery. The average difference between sites for the remainder of June was 4.3 NTU. Neither average turbidity nor differences in turbidity were correlated with boat counts during sampling events or at the entrance booth.

Turbidity differences also were observed between reference data collected upstream of the Miller's Reach and the site located below the PUF in the spring of 2009. There were only minor differences in turbidity on May 24, but these differences increased to 19 NTU during June. Daily entrance booth counts are not available at this time; therefore more complete comparisons between boat use and turbidity are not possible. Stream water turbidity clearly increased at both locations during spring runoff with average daily values up to 26 NTU at locations above and below the PUF. However, turbidity decreased along with changes in discharge at the reference site, but remained high throughout June downstream from the PUF.

Stream water turbidity was influenced by discharge, particularly during spring runoff; however, relationships are weak. Regression equations were developed between discharge and average daily turbidity. The highest r^2 value (0.58) was obtained for measures below the PUF from June through September 2008. However, this data set did not include 30 days from July 15 to August 15. When 2009 data are added to the regression, the r^2 value decreased to 0.36. There was a poor relationship between discharge and turbidity ($r^2 = 0.31$) at the initial reference site (9 km upstream) when using the 2008 data set. During spring of 2008 (June 6 through June 30), the relationship between discharge and turbidity below the PUF decreases ($r^2 = 0.25$), but increases at the reference site ($r^2 = 0.52$). A similar pattern was not present in 2009, and there was a poor relationship between discharge and turbidity at both the reference site and below the PUF. However, plots of turbidity as a function of discharge below the PUF during spring 2009 showed two distinct patterns with a linear relationship between turbidity and discharge when turbidity was less than 12 NTU (Figure 9). Therefore, in 2009, discharge explained differences in turbidity up to 12 NTU but discharge could not explain differences at higher turbidities.

Table 6. Stream water turbidity for all sampling locations and dates, with average values for sampling stations near the PUF and the difference between measures at Miller's Reach (reference).

	Miller's Reach	LS-1	LS-2	LS-3	LS-4	LS-5	LS-6	LS-7	Ave LS-1 to LS-7	Difference
27 Jul 08		8.4						12.2	10.3	
2 Aug 08	0.2	1.1						6.9	4.0	3.8
10 Aug 08	4.4	5.9	9.7	9.5	7.5	4.3	7.2	7.5	7.4	3.0
13 Aug 08	2.5	5.9	9.7	9.5	7.5	4.3	7.2	7.5	7.4	4.9
17 Aug 08	2.5	7.3	11.6	8.7	7.1	9.3	11.6	9.3	9.3	6.7
24 Aug 08	1.2	6.1	7.6	6.3	6.0	7.2	8.2	7.4	7.0	5.8
30 Aug 08	0.4	6.9	7.0	5.7	7.0	7.5	6.9	7.0	6.9	6.5
6 Sept 08	1.6	2.9	3.2	3.2	3.0	3.7	5.8	6.7	4.1	2.5
17-May-09	9.2	8.5	16.8	13.0	13.0	12.5	11.5	12.2	12.5	3.3
24-May-09	5.7	10.0	11.0	11.0	13.6	11.6	14.9	12.4	12.1	6.4
31-May-09	4.2	10.0	8.3	9.2	9.3	9.4	9.9	10.5	9.5	5.3
7-Jun-09	4.7	13.6	14.7	16.9	16.1	15.5	16.4	18.0	15.9	11.2
14-Jun-09	3.7	8.5	9.1	9.2	10.5	10.1	11.3	11.1	10.0	6.3
21-Jun-09	2.5	6.6	7.9	9.2	9.5	8.7	10.1	12.0	9.1	6.6
28-Jun-09	4.3	9.9	10.4	10.5	11.3	9.8	11.4	14.4	11.1	6.8

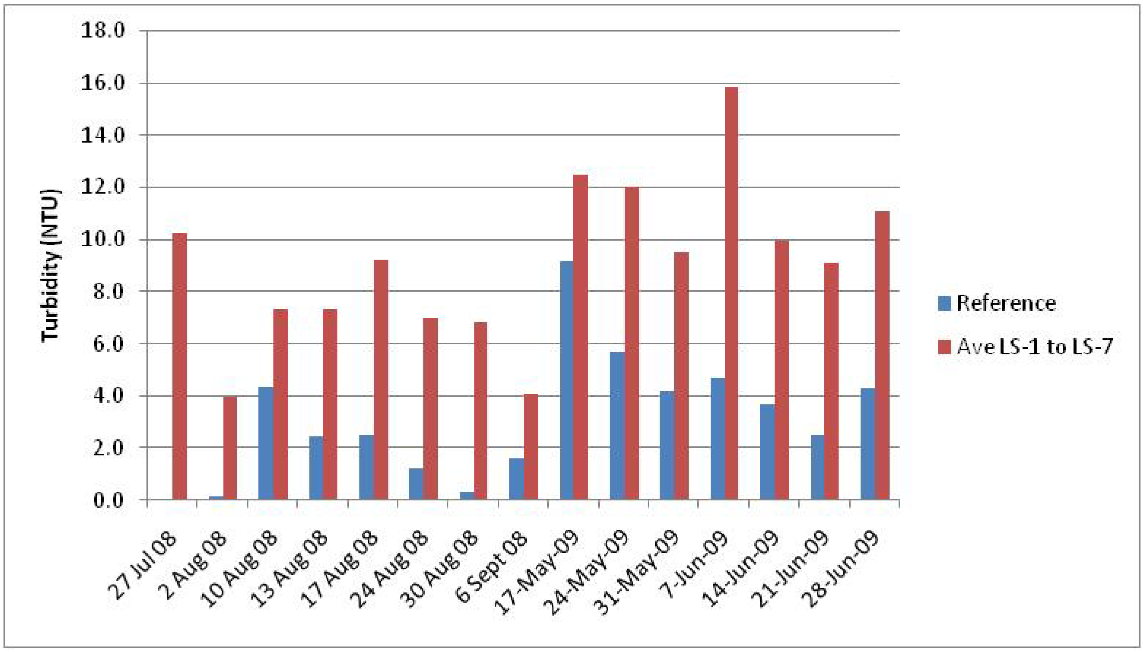

Figure 6. Graphical presentation of turbidity data from weekly grab samples.

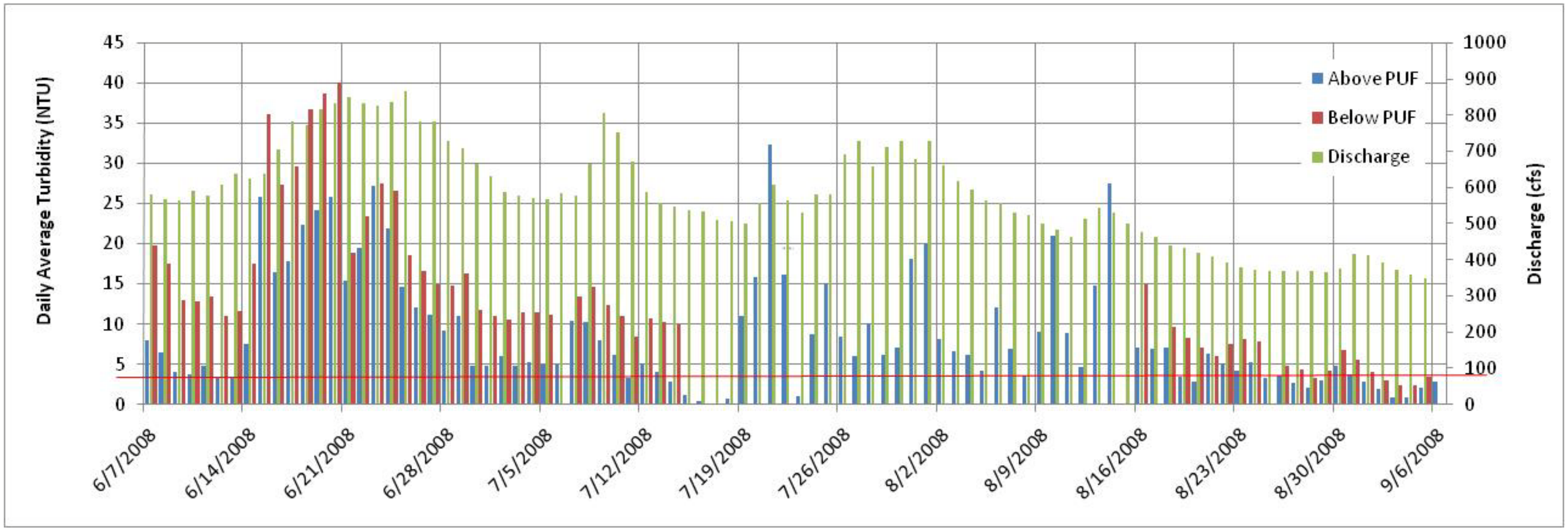

Figure 7. Average daily turbidity from hourly Hydrolab measures collected at PUFUP (9 km upstream from the boat launch) and PUFDN (3.5 km downstream from the boat launch), and discharge. Red line is average reference turbidity from grab samples collected between 2007 and 2009.

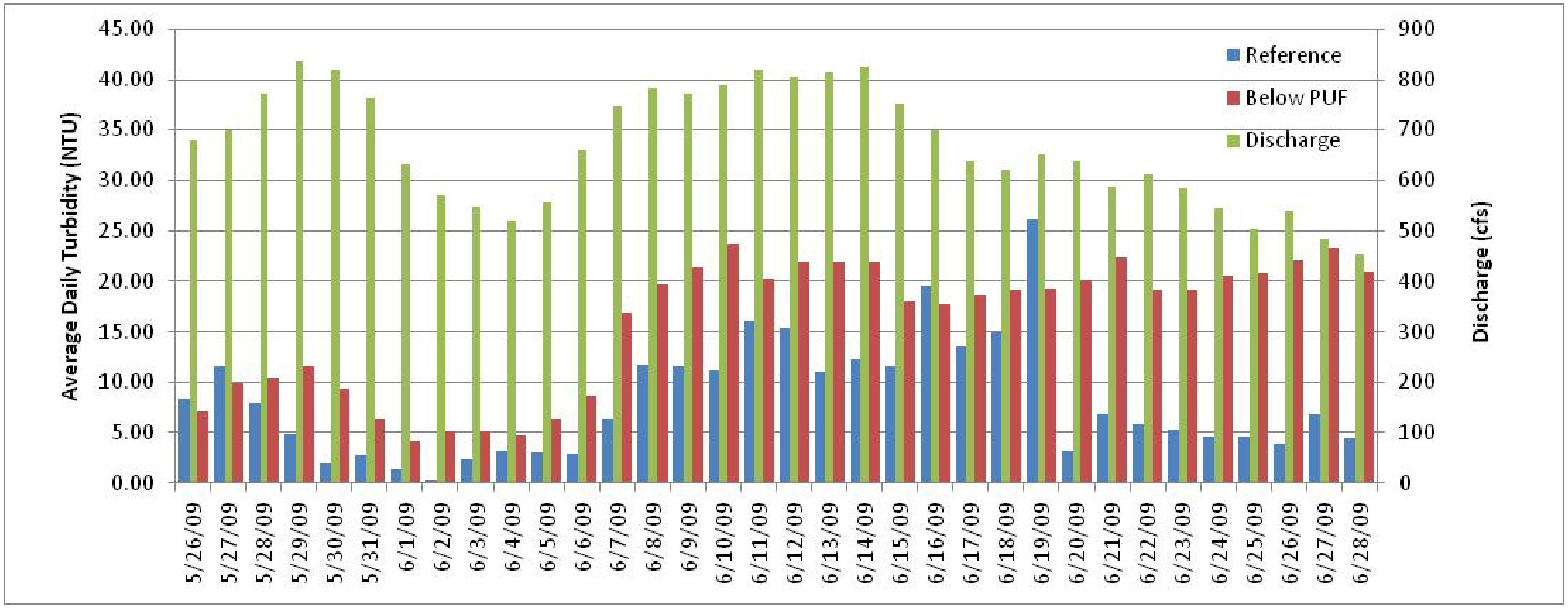

Figure 8. Average daily turbidity from hourly Hydrolab data collected at Miller's Reach and PUFDN, and discharge for the spring of 2009. Turbidity decreases at the reference site following spring runoff but remains high downstream from the PUF.

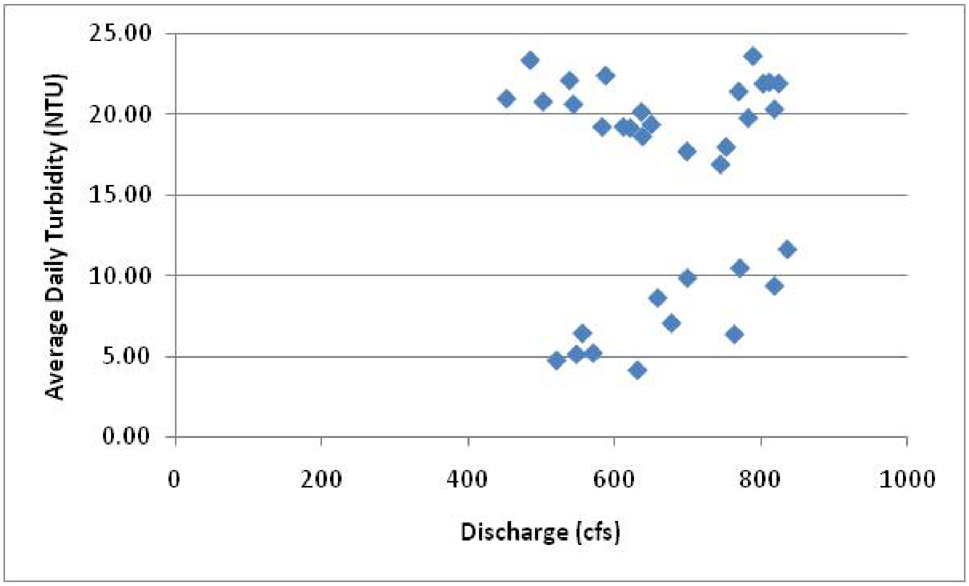

Figure 9. Relationship between discharge and average daily turbidity at PUFDN showing two distinct groupings. Turbidity changes from 5 to 12 NTU appear to be related to changes in discharge.

State water quality standards vary for designated uses, and the state regulates for the most stringent designated use. The most stringing standard is 5 NTU above natural background ((18 AAC 70.020(b)(12)(A)(i)). In the fall of 2008, based upon weekly grab samples, turbidity was 5 or more NTU higher than samples at the reference site on 10 of the 15 dates (67%) measured. Using average daily turbidity data from the Hydrolabs, there was a greater than 5 NTU increase in turbidity from PUFUP to PUFDN on 26 out of 50 (52%) days in 2008. In the fall of 2008, mean daily boat use was 11/day when turbidity differed by less than 5 NTU, however, mean daily boat use was over 20/day when turbidity differed by 5 or more NTU. When average daily turbidity differed from 5 to 10 NTU, average daily boat use increased to 13/day and when 10 NTU or greater difference, average boat use was 30/day. In the spring of 2009, turbidity below the PUF was 5 NTU or greater than average daily values at the reference site on 21 of 34 days (62%). Turbidity differences were generally less than 5 NTU in late May and early June (approximately June 6), and 5 NTU or greater throughout the rest of June concurrent with increased boat use.

Juvenile Salmon, Macroinvertebrate Drift, and Community Metabolism

We measured significant differences in all biotic measures among samples collected above and below the PUF. Juvenile salmon and macroinvertebrates were sampled on August 17, 2008 and June 14, 2009. Coho and Chinook salmon were captured on all sampling dates and locations. Total salmonid catch rates were significantly (t-test, $p < 0.05$) different in August, with average catch rates near 40 fish/trap 9 km upstream of the PUF, and 12 fish per trap downstream (Figure 10). Differences also were significant for catches of coho and Chinook salmon with significantly more fish per trap upstream.

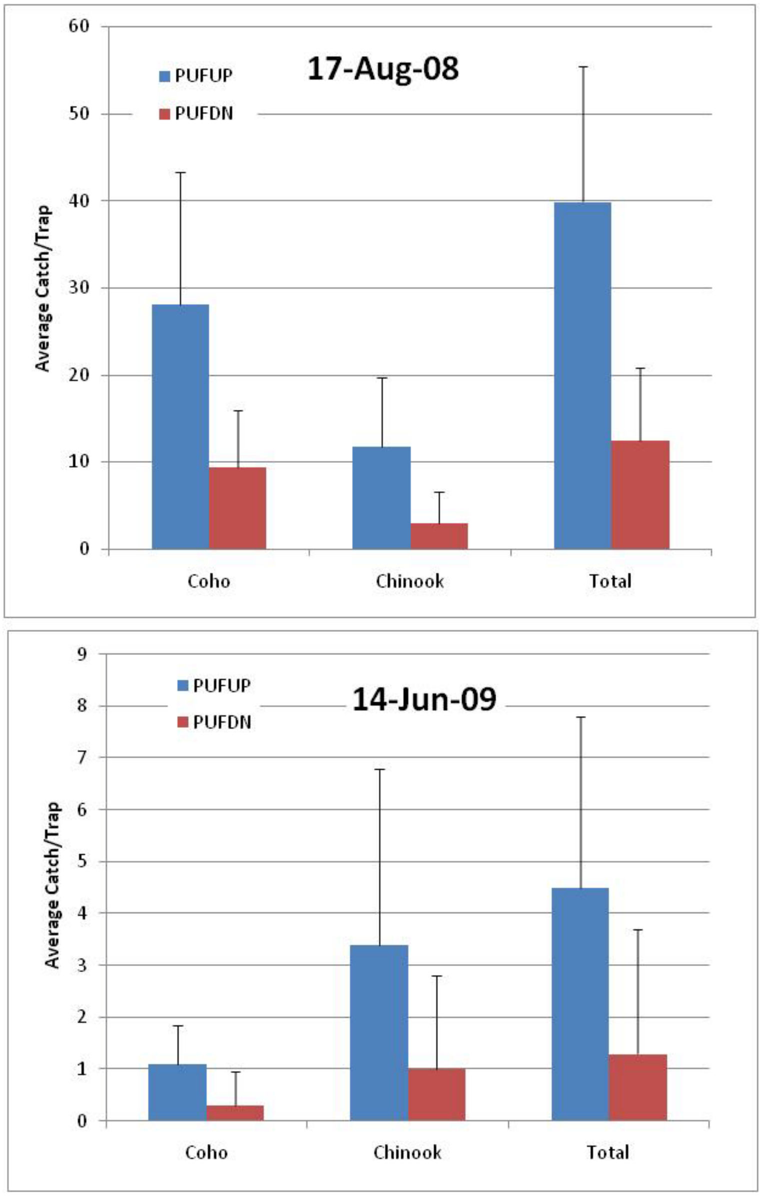

Figure 10. Average salmonid catch rates/trap (n=10) for sites located above and below the PUF in August 2008 and June 2009 showing the higher relative upstream catch rates. Differences were significant for all comparisons except for June Chinook salmon (p=0.08).

Overall, total catches were lower in June; however, total catch per trap, coho salmon catch per trap and Chinook salmon catch per trap were all significantly higher upstream. Coho salmon dominated the catch at both up and downstream locations during August but were less common than Chinook salmon in the spring.

The average concentration of organisms within the drift also was greater upstream. Differences were only significant however, in the spring. The number of food organisms increased by approximately 1.5 per m^3 at the upstream reference location (Figure 11).

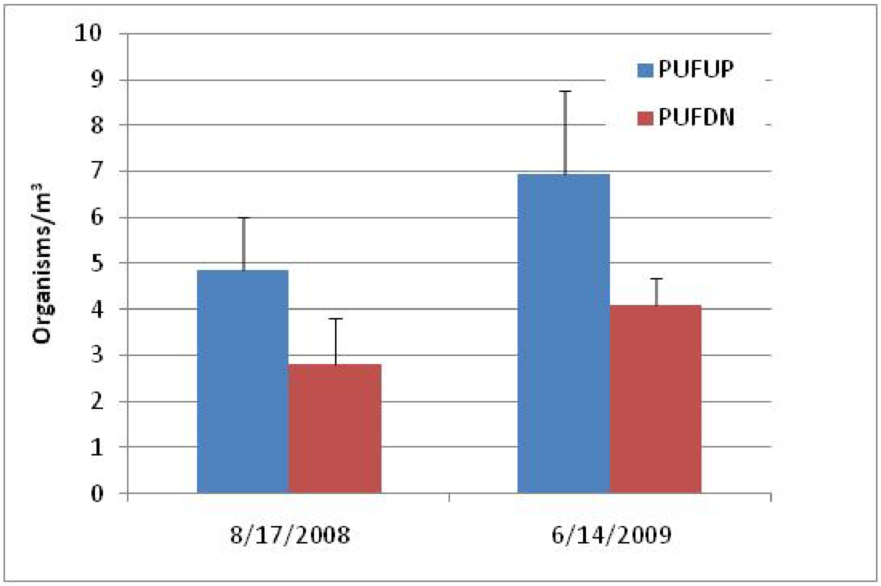

Figure 11. Average (n=3) concentrations of aquatic invertebrates captured in drift samples above and below the PUF. Differences were significant in June 2009.

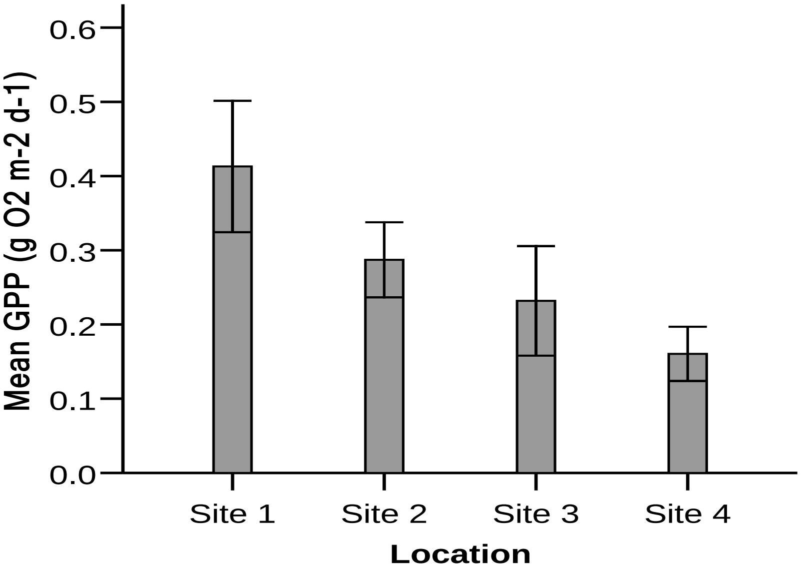

Figure 12. Average GPP for locations upstream and downstream of the PUF. Site 1 was at PUFUP (9 km upstream); Site 2 was approximately 1 km downstream from Site 1. Sites 3 and 4 were located at 2.5 and 3.5 km downstream from the PUF boat launch, respectively.

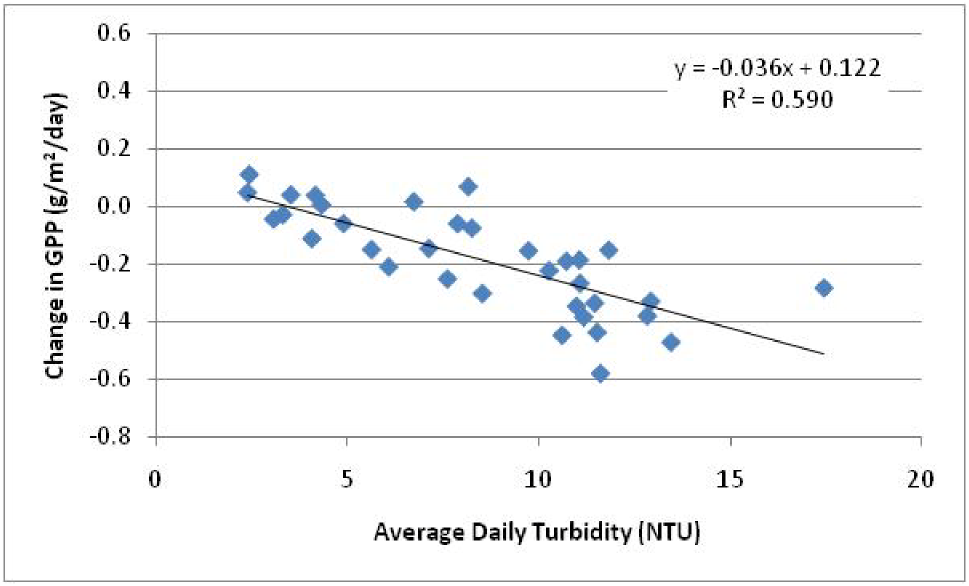

Figure 13. Relationship between the upstream to downstream change in GPP and average daily turbidity measured at PUFDN when turbidity is below 14 NTU.

The drift was dominated by Trichoptera larva (brachcentridae) at both locations in August 2009, and by Diptera (chironomidae and simulidae) during spring sampling.

Mean daily gross primary production decreased from upstream to downstream with significant differences between organic matter production at the upstream reference site and downstream of the PUF. Average GPP decreased consistently downstream to 0.5 times upstream values (Figure 12). The difference in GPP was negatively correlated to stream water turbidity when turbidity was between 1 and 14 NTU (Figure 13). There was no relationship between turbidity and average daily NTU at higher values.

Discussion

Concentrations of TAH

The intensive use of the Lower Little Susitna River is causing changes to the physical and chemical environment, is resulting in concentrations of hydrocarbons and turbidity that exceed state water quality standards, and appears to be affecting the aquatic community. Motor boats on the Lower Little Susitna River are used for recreation, and to access fishing and hunting locations. The highest use periods in 2008 were during the first three weeks in June and the first three weeks in August, which accounted for approximately 60% of the seasonal use (May 22 through Sept 4), which coincides with the peak Chinook and coho fisheries. Concentrations of TAH increased concurrently with increased boat use resulting in concentrations that exceeded state standards. However, high boat use did not result in concentrations above state water quality standards under conditions of high flow.

Regression analyses did not reveal a relationship between boat use and hydrocarbon concentrations. However, there were significant regression relationships between boat use and hydrocarbons when we corrected for changes in discharge. Fuel loss from 2-cycle motors is considered to be the primary cause of hydrocarbon contamination, and we expected the number of 2-cycle motors to explain most of the variability in hydrocarbon concentrations. The slightly weeker relationship with 2-cycle motors compared to total boat counts may be due to high variability in hydrocarbon discharge among 2-cycle motors. That is, considering only 2-cycle motors, hydrocarbon discharge from one boat may have a disproportional effect on resulting TAH concentrations and regression relationships, particularly when counts are low.

State water quality standards for TAH were exceeded on 3 or 4 dates out of 15 or 20% of the time. Sampling was conducted on Sundays, which, on average, were the busiest day of the week and during the middle of the day. These data, therefore, may overestimate the portion of days that the water quality standards were exceeded. However, the percent of days when concentrations were estimated to exceed 10 μg/L decreased only slightly, to 18%, when based on models for 2008 using boat counts for all days. While Sunday sampling did not account for low use days, it also did not include other high use days (Friday and Saturday). Maximum boat use per week was, on average, higher on Sundays, but for many weeks use was as high or higher on Fridays or Saturdays.

We did not observe any consistent decrease in hydrocarbon concentrations from the launch to 4.0 km downstream. We expected concentrations to decline with distance as molecules moved to, and evaporated from the water surface. However, either rates of downstream transportation must exceed rates of vertical migration and evaporation, or hydrocarbons discharged into the water as boats traveled downstream equaled loss rates. TAH concentrations were lower at sites upstream from the boat launch (LS-1 and LS-2) on 6 of the 12 sampling dates when hydrocarbons were present. Concentrations should be lower upstream since only a portion of the total boats travel in that direction.

Since TAH concentrations are related to total boat counts/hr and discharge, and boat counts/hr are related to daily boat counts at the entrance booth, we can use this relationship to predict exceedances from daily booth counts (Figure 14). Water quality exceedances can be predicted from discharge at the PUF and daily booth counts. Since discharge at the PUF is related to discharge 3 days previous in Hatcher Pass, the total number of boats that can enter the launch and still maintain water quality standards can be determined in advance by monitoring flows at the U.S.G.S gauging station. The current model can be improved over time with additional data and continuous monitoring downstream of the launch can ensure that water quality standards are maintained and allow for model adjustments over time.

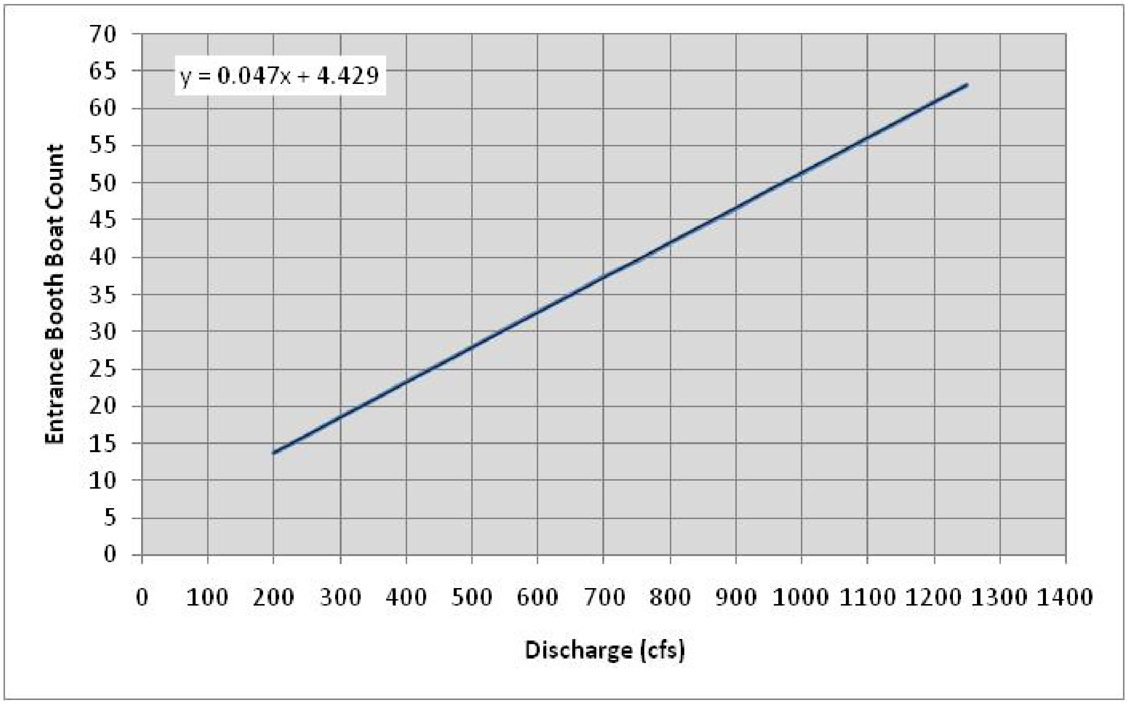

Figure 14. Estimate of the total number of boats counted at the entrance booth as a function of discharge that will result in TAH concentrations that exceed state standards.

Turbidity

The relationship between turbidity in the Lower Little Susitna River, boat use, and discharge is not clear. Stream water turbidity at reference sites located upstream of the PUF either 9 km upstream or at Miller's Reach are below 5 NTU on most sampling dates. Average turbidity at Miller's Reach based upon 35 grab samples collected from August 2006 to June 2009 is 3.7 NTU (Davis and Davis 2007, 2008). This average is consistent with turbidity data from samples collected at multiple locations in Hatcher Pass (Goldmint Trailhead to Edgerton Park Bridge) where average turbidity from 60 grab samples collected from 2006 through 2008 is 3.2 NTU (Davis and Davis 2008b, 2009b). Average turbidity from 35 grab samples collected below the PUF, on the same dates as those at Miller's reach, was 8.0 NTU. Based upon the average of grab samples, there is a 0.5 NTU difference in average turbidity between Hatcher Pass and Houston, and a 4.3 NTU difference between Houston and the PUF. Maximum differences between grab samples at Miller's Reach and the PUF occur during periods of high boat use in the Lower River.

Hourly Hydrolab turbidity monitoring showed greater differences between reference sites and sites below the PUF than the grab samples did. Average daily turbidity commonly differed by 10 to 20 NTU during heavy use periods based upon Hydrolab data compared to differences of 5 to 10 NTU based on grab samples. The Hydrolabs measured intermittent high turbidity values, up to 100 NTU, that likely occurred when turbidity recorded short-term increases following the passage of a boat, resulting in higher daily averages. We delayed collecting grab samples until approximately 10 minutes after reaching a sampling location or if there was an obvious increase after a boat passed. Therefore, average daily turbidity is probably a more accurate measure of turbidity differences between sites.

Turbidity at all sites increased with rising flows during spring runoff or storm events. However, this only explained a portion of the variability in turbidity. There was not a good relationship between daily boat use and turbidity or differences in turbidity with reference sites. However, large differences in turbidity that extended over weeks did coincide with higher average daily boat use. Increases in suspended sediment are visible as waves from boats entrain particles into the water column from shallow nearshore areas, wash in sediments from the bank, or suspend sediments from the stream bottom in shallow water as the jet intake draws water and sediment from the stream bed. Changes in nearshore turbidity following boat-induced waves have been documented previously (Hill et al. 2002). The influence of an individual boat however, will depend upon wave size that varies with hull shape, boat size, speed, and weight, bank types and water depths (Maynord 2001). The size of suspended particles also will influence sedimentation rates and the length of time particles are in the water column. Suspended sediments are more likely to remain in the water column if the water column is intermittently mixed due to jet intake or boat waves.

Increases in turbidity is likely resulting in changes to the biotic community. Considerable work has been conducted evaluating the impact of turbidity on primary production, macroinvertebrates and fish. Loyd et al. (1987) and Lloyd (1987) summarized these affects for Alaska streams and evaluated the effectiveness of Alaska Water Quality Standards. Lloyd et al. (1987) predicted a decrease in GPP of approximately 50% in streams with an average depth of 0.5 m with turbidity increases of near 25 NTU. Results of productivity measures on the Lower Little Susitna River are consistent with these findings. We measured an average decrease of 50% of reference GPP with tubidity differences of 10 to 20 NTU. Similarly, regression equations showed a change of -0.5 in GPP with a 14 NTU increase in turbidity. We measured an approximately 60% decline in macroinvertebrates in the drift between reference sites and sites located below the PUF. Lloyd et al. (1987) found that turbidity explained the greatest difference in macroinvertebrate density between mined and unmined streams. Increases in turbidity negatively affect fish metabolism, feeding ability, and behavior (Newcombe and Jensen 1996). We found a significant decrease in juvenile coho and Chinook salmon catch rates with increasing turbidity.

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Appendix A. Water Sample Results and Quality Objectives

Quality Objectives and Criteria for Measurement of Data

Water sampling results are provided in the following table. Water samples were collected on 15 dates which meets the completeness objective. One additional mid-week sampling event was scheduled during peak the Chinook fishery; however, this sampling date was eliminated due to the relatively low number of returning fish and a rapid decline in use. All field meters were calibrated as proposed and met accuracy criteria. Analyses of grab samples for turbidity did not meet precision measurements during initial sampling in the Fall of 2008 with precision from replicates greater than 20%. Due to the variability in replicate samples collected at the same location, sampling was modified so that three measures of turbidity were collected at each site on each sampling date and the average of these measures reported. Hydrocarbons were not detected in any of the field or trip blanks. Laboratory accuracy measures were within acceptable limits on all sampling dates. Differences between replicate samples TAH measures averaged 1.7 μg/L. The maximum TAH difference was 5.6 μg/L, with site LS-7 value below detection and the replicate value at 5.6 μg/L. A result below detection limits was used for this sampling date. Differences of 2 to 3 μg/L between replicates were found on 7 dates. At a 3 μg/L difference, precision criteria are not met when the lowest value is below 13 μg/L. This occurred on 5 sampling dates and on one date affected whether or not water quality standards were met. On this date, June 7, 2009, samples from LS-1 to LS-7 ranged from 9.1 to 12.7 μg/L, with concentrations at two sites above water quality standards.

Date	**Site**	**Measurement**	**Value**	**Units**
7/27/2008	LS-1	Temperature	10.6	Celsius
7/27/2008	LS-1	Discharge	830.2	csf
7/27/2008	LS-1	Latitude	61.44252	decimal degrees
7/27/2008	LS-1	Longitude	150.15929	decimal degrees
7/27/2008	LS-1	Benzene	<0.5	μg/L
7/27/2008	LS-1	D.O. mg/L	11.12	μg/L
7/27/2008	LS-1	Ethyl Benzene	0.63	μg/L
7/27/2008	LS-1	Toluene	1.01	μg/L
7/27/2008	LS-1	Total Xylene	1.18	μg/L
7/27/2008	LS-1	TAH	2.82	μg/L
7/27/2008	LS-1	Specific Conductivity	70.2	microS/cm
7/27/2008	LS-1	Turbidity	8.35	NTU
7/27/2008	LS-1	D.O. %	100.1	Percent Saturation
7/27/2008	LS-1	pH	7.64	
7/27/2008	LS-2	Latitude	61.44239	decimal degrees
7/27/2008	LS-2	Longitude	150.16745	decimal degrees
7/27/2008	LS-2	Benzene	<0.5	μg/L
7/27/2008	LS-2	Ethyl Benzene	0.59	μg/L
7/27/2008	LS-2	Toluene	1.19	μg/L
7/27/2008	LS-2	Total Xylene	1.78	μg/L
7/27/2008	LS-2	TAH	3.56	μg/L
7/27/2008	LS-3	Latitude	61.43782	decimal degrees
7/27/2008	LS-3	Longitude	150.17391	decimal degrees
7/27/2008	LS-3	Benzene	<0.5	μg/L
7/27/2008	LS-3	Ethyl Benzene	<0.5	μg/L
7/27/2008	LS-3	Toluene	0.98	μg/L
7/27/2008	LS-3	Total Xylene	1.5	μg/L
7/27/2008	LS-3	TAH	2.48	μg/L
7/27/2008	LS-4	Latitude	61.43518	decimal degrees
7/27/2008	LS-4	Longitude	150.17468	decimal degrees
7/27/2008	LS-4	Benzene	<0.5	μg/L
7/27/2008	LS-4	Ethyl Benzene	<0.5	μg/L
7/27/2008	LS-4	Toluene	0.86	μg/L
7/27/2008	LS-4	Total Xylene	1.23	μg/L
7/27/2008	LS-4	TAH	2.09	μg/L
7/27/2008	LS-5	Latitude	61.43345	decimal degrees
7/27/2008	LS-5	Longitude	150.17239	decimal degrees
7/27/2008	LS-5	Benzene	<0.5	μg/L
7/27/2008	LS-5	Ethyl Benzene	<0.5	μg/L
7/27/2008	LS-5	Toluene	0.84	μg/L
7/27/2008	LS-5	Total Xylene	1.16	μg/L
7/27/2008	LS-5	TAH	2.00	μg/L
7/27/2008	LS-6	Latitude	61.43077	decimal degrees
7/27/2008	LS-6	Longitude	150.18342	decimal degrees
7/27/2008	LS-6	Benzene	<0.5	μg/L
7/27/2008	LS-6	Ethyl Benzene	<0.5	μg/L
7/27/2008	LS-6	Toluene	0.99	μg/L
7/27/2008	LS-6	Total Xylene	1.39	μg/L

Date	Site	Measurement	Value	Units
7/27/2008	LS-6	TAH	2.38	µg/L
7/27/2008	LS-7	Temperature	11.6	Celsius
7/27/2008	LS-7	Latitude	61.42389	decimal degrees
7/27/2008	LS-7	Longitude	150.18958	decimal degrees
7/27/2008	LS-7	Benzene	<0.5	µg/L
7/27/2008	LS-7	D.O. mg/L	11.01	mg/L
7/27/2008	LS-7	Ethyl Benzene	0.7	µg/L
7/27/2008	LS-7	Toluene	1.65	µg/L
7/27/2008	LS-7	Total Xylene	1.22	µg/L
7/27/2008	LS-7	TAH	3.57	µg/L
7/27/2008	LS-7	Specific Conductivity	70.5	microS/cm
7/27/2008	LS-7	Turbidity	12.20	NTU
7/27/2008	LS-7	D.O. %	101.3	Percent Saturation
7/27/2008	LS-7	pH	7.36	
7/27/2008	LS-7X	Benzene	<0.5	µg/L
7/27/2008	LS-7X	Ethyl Benzene	1.04	µg/L
7/27/2008	LS-7X	Toluene	2.43	µg/L
7/27/2008	LS-7X	Total Xylene	3.37	µg/L
7/27/2008	LS-7X	TAH	6.84	µg/L
7/27/2008	My Creek	Temperature	13.7	Celsius
7/27/2008	My Creek	D.O. mg/L	9.8	mg/L
7/27/2008	My Creek	Specific Conductivity	173.1	microS/cm
7/27/2008	My Creek	Turbidity	0.15	NTU
7/27/2008	My Creek	D.O. %	94.2	Percent Saturation
8/2/2008	LS-1	Temperature	12.3	Celsius
8/2/2008	LS-1	Discharge	485.02	cfs
8/2/2008	LS-1	Benzene	8.91	µg/L
8/2/2008	LS-1	D.O. mg/L	10.38	mg/L
8/2/2008	LS-1	Ethyl Benzene	1.46	µg/L
8/2/2008	LS-1	Toluene	2.81	µg/L
8/2/2008	LS-1	Total Xylene	3.99	µg/L
8/2/2008	LS-1	TAH	17.17	µg/L
8/2/2008	LS-1	Turbidity	1.06	NTU
8/2/2008	LS-1	D.O. %	96.9	Percent Saturation
8/2/2008	LS-1	pH	7.64	
8/2/2008	LS-2	Benzene	8.83	µg/L
8/2/2008	LS-2	Ethyl Benzene	1.13	µg/L
8/2/2008	LS-2	Toluene	2.62	µg/L
8/2/2008	LS-2	Total Xylene	3.54	µg/L
8/2/2008	LS-2	TAH	16.12	µg/L
8/2/2008	LS-3	Benzene	9.88	µg/L
8/2/2008	LS-3	Ethyl Benzene	1.28	µg/L
8/2/2008	LS-3	Toluene	2.93	µg/L
8/2/2008	LS-3	Total Xylene	4	µg/L
8/2/2008	LS-3	TAH	18.09	µg/L
8/2/2008	LS-4	Benzene	6.84	µg/L
8/2/2008	LS-4	Ethyl Benzene	0.87	µg/L
8/2/2008	LS-4	Toluene	2.01	µg/L
8/2/2008	LS-4	Total Xylene	2.72	µg/L
8/2/2008	LS-4	TAH	12.44	µg/L

Date	Site	Measurement	Value	Units
8/2/2008	LS-5	Benzene	13.2	µg/L
8/2/2008	LS-5	Ethyl Benzene	1.67	µg/L
8/2/2008	LS-5	Toluene	3.9	µg/L
8/2/2008	LS-5	Total Xylene	5.17	µg/L
8/2/2008	LS-5	TAH	23.94	µg/L
8/2/2008	LS-6	Benzene	10.3	µg/L
8/2/2008	LS-6	Ethyl Benzene	1.24	µg/L
8/2/2008	LS-6	Toluene	2.95	µg/L
8/2/2008	LS-6	Total Xylene	3.83	µg/L
8/2/2008	LS-6	TAH	18.32	µg/L
8/2/2008	LS-7	Temperature	12.4	Celsius
8/2/2008	LS-7	Benzene	9.68	µg/L
8/2/2008	LS-7	D.O. mg/L	10.33	mg/L
8/2/2008	LS-7	Ethyl Benzene	1.2	µg/L
8/2/2008	LS-7	Toluene	2.92	µg/L
8/2/2008	LS-7	Total Xylene	3.77	µg/L
8/2/2008	LS-7	TAH	17.57	µg/L
8/2/2008	LS-7	Turbidity	4.86	NTU
8/2/2008	LS-7	D.O. %	96.6	Percent Saturation
8/2/2008	LS-7	pH	7.67	
8/2/2008	LS-7X	Benzene	10.1	µg/L
8/2/2008	LS-7X	Ethyl Benzene	1.59	µg/L
8/2/2008	LS-7X	Toluene	2	µg/L
8/2/2008	LS-7X	Total Xylene	4.02	µg/L
8/2/2008	LS-7X	TAH	17.71	µg/L
8/2/2008	LS-7X	Turbidity	8.92	NTU
8/2/2008	LS-Houston	Turbidity	0.16	NTU
8/10/2008	LS-1	Temperature	11.0	Celsius
8/10/2008	LS-1	Discharge	525.24	cfs
8/10/2008	LS-1	Benzene	6.68	µg/L
8/10/2008	LS-1	D.O. mg/L	11.76	mg/L
8/10/2008	LS-1	Ethyl Benzene	1	µg/L
8/10/2008	LS-1	Toluene	2.2	µg/L
8/10/2008	LS-1	Total Xylene	3.34	µg/L
8/10/2008	LS-1	TAH	13.22	µg/L
8/10/2008	LS-1	Turbidity	4.57	NTU
8/10/2008	LS-1	D.O. %	106.4	Percent Saturation
8/10/2008	LS-1	pH	7.66	
8/10/2008	LS-2	Benzene	8.16	µg/L
8/10/2008	LS-2	Ethyl Benzene	1.21	µg/L
8/10/2008	LS-2	Toluene	2.85	µg/L
8/10/2008	LS-2	Total Xylene	3.89	µg/L
8/10/2008	LS-2	TAH	16.11	µg/L
8/10/2008	LS-3	Benzene	12	µg/L
8/10/2008	LS-3	Ethyl Benzene	1.82	µg/L
8/10/2008	LS-3	Toluene	4.06	µg/L
8/10/2008	LS-3	Total Xylene	5.58	µg/L
8/10/2008	LS-3	TAH	23.46	µg/L
8/10/2008	LS-4	Benzene	15.7	µg/L
8/10/2008	LS-4	Ethyl Benzene	2.34	µg/L

Date	**Site**	**Measurement**	**Value**	**Units**
8/10/2008	LS-4	Toluene	5.3	µg/L
8/10/2008	LS-4	Total Xylene	7.48	µg/L
8/10/2008	LS-4	TAH	30.82	µg/L
8/10/2008	LS-5	Benzene	13.2	µg/L
8/10/2008	LS-5	Ethyl Benzene	2.01	µg/L
8/10/2008	LS-5	Toluene	4.4	µg/L
8/10/2008	LS-5	Total Xylene	6.45	µg/L
8/10/2008	LS-5	TAH	26.06	µg/L
8/10/2008	LS-6	Benzene	14.3	µg/L
8/10/2008	LS-6	Ethyl Benzene	2.14	µg/L
8/10/2008	LS-6	Toluene	4.89	µg/L
8/10/2008	LS-6	Total Xylene	6.96	µg/L
8/10/2008	LS-6	TAH	28.29	µg/L
8/10/2008	LS-7	Temperature	12.0	Celsius
8/10/2008	LS-7	Benzene	14	µg/L
8/10/2008	LS-7	D.O. mg/L	11.53	mg/L
8/10/2008	LS-7	Ethyl Benzene	2.11	µg/L
8/10/2008	LS-7	Toluene	4.88	µg/L
8/10/2008	LS-7	Total Xylene	6.75	µg/L
8/10/2008	LS-7	TAH	27.74	µg/L
8/10/2008	LS-7	Turbidity	10.97	NTU
8/10/2008	LS-7	D.O. %	107.4	Percent Saturation
8/10/2008	LS-7	pH	7.77	
8/10/2008	LS-7X	Benzene	14	µg/L
8/10/2008	LS-7X	Ethyl Benzene	2.12	µg/L
8/10/2008	LS-7X	Toluene	4.86	µg/L
8/10/2008	LS-7X	Total Xylene	7.09	µg/L
8/10/2008	LS-7X	TAH	28.07	µg/L
8/10/2008	LS-7X	Turbidity	11.80	NTU
8/10/2008	LS-Houston	Turbidity	4.40	NTU
8/13/2008	LS-1	Temperature	11.8	Celsius
8/13/2008	LS-1	Discharge	478.8	cfs
8/13/2008	LS-1	Benzene	2.32	µg/L
8/13/2008	LS-1	D.O. mg/L	10.94	mg/L
8/13/2008	LS-1	Ethyl Benzene	<0.5	µg/L
8/13/2008	LS-1	Toluene	0.79	µg/L
8/13/2008	LS-1	Total Xylene	1.2	µg/L
8/13/2008	LS-1	TAH	4.31	µg/L
8/13/2008	LS-1	Specific Conductivity	65.6	microS/cm
8/13/2008	LS-1	Turbidity	5.91	NTU
8/13/2008	LS-1	D.O. %	101.1	Percent Saturation
8/13/2008	LS-1	pH	7.64	
8/13/2008	LS-2	Benzene	2.31	µg/L
8/13/2008	LS-2	Ethyl Benzene	<0.5	µg/L
8/13/2008	LS-2	Toluene	0.78	µg/L
8/13/2008	LS-2	Total Xylene	1.12	µg/L
8/13/2008	LS-2	TAH	4.21	µg/L
8/13/2008	LS-2	Turbidity	9.65	NTU
8/13/2008	LS-3	Benzene	3.64	µg/L
8/13/2008	LS-3	Ethyl Benzene	<0.5	µg/L

Date	Site	Measurement	Value	Units
8/13/2008	LS-3	Toluene	1.05	µg/L
8/13/2008	LS-3	Total Xylene	1.49	µg/L
8/13/2008	LS-3	TAH	6.18	µg/L
8/13/2008	LS-3	Turbidity	9.48	NTU
8/13/2008	LS-4	Benzene	2.9	µg/L
8/13/2008	LS-4	Ethyl Benzene	<0.5	µg/L
8/13/2008	LS-4	Toluene	0.97	µg/L
8/13/2008	LS-4	Total Xylene	1.35	µg/L
8/13/2008	LS-4	TAH	5.22	µg/L
8/13/2008	LS-4	Turbidity	7.50	NTU
8/13/2008	LS-5	Benzene	5.58	µg/L
8/13/2008	LS-5	Ethyl Benzene	0.81	µg/L
8/13/2008	LS-5	Toluene	1.97	µg/L
8/13/2008	LS-5	Total Xylene	2.69	µg/L
8/13/2008	LS-5	TAH	11.05	µg/L
8/13/2008	LS-5	Turbidity	4.25	NTU
8/13/2008	LS-6	Benzene	8.28	µg/L
8/13/2008	LS-6	Ethyl Benzene	1.36	µg/L
8/13/2008	LS-6	Toluene	2.78	µg/L
8/13/2008	LS-6	Total Xylene	4.08	µg/L
8/13/2008	LS-6	TAH	16.50	µg/L
8/13/2008	LS-6	Turbidity	7.19	NTU
8/13/2008	LS-7	Benzene	5.03	µg/L
8/13/2008	LS-7	Ethyl Benzene	0.92	µg/L
8/13/2008	LS-7	Toluene	1.74	µg/L
8/13/2008	LS-7	Total Xylene	3.03	µg/L
8/13/2008	LS-7	TAH	10.72	µg/L
8/13/2008	LS-7	Turbidity	7.48	NTU
8/13/2008	LS-7X	Benzene	6.12	µg/L
8/13/2008	LS-7X	Ethyl Benzene	1.19	µg/L
8/13/2008	LS-7X	Toluene	2.28	µg/L
8/13/2008	LS-7X	Total Xylene	4.12	µg/L
8/13/2008	LS-7X	TAH	13.71	µg/L
8/13/2008	LS-Houston	Turbidity	2.48	NTU
8/14/2008	LS-7	Temperature	12.6	Celsius
8/14/2008	LS-7	D.O. mg/L	10.73	mg/L
8/14/2008	LS-7	Specific Conductivity	65.7	microS/cm
8/14/2008	LS-7	D.O. %	100.7	Percent Saturation
8/14/2008	LS-7	pH	7.59	
8/17/2008	LS-1	Temperature	11.8	Celsius
8/17/2008	LS-1	Benzene	12.1	µg/L
8/17/2008	LS-1	D.O. mg/L	10.85	mg/L
8/17/2008	LS-1	Ethyl Benzene	2.22	µg/L
8/17/2008	LS-1	Toluene	4.5	µg/L
8/17/2008	LS-1	Total Xylene	7.37	µg/L
8/17/2008	LS-1	TAH	26.19	µg/L
8/17/2008	LS-1	Specific Conductivity	72.2	microS/cm
8/17/2008	LS-1	Turbidity	7.27	NTU
8/17/2008	LS-1	D.O. %	100.4	Percent Saturation
8/17/2008	LS-1	pH	7.7	

Date	**Site**	**Measurement**	**Value**	**Units**
8/17/2008	LS-2	Temperature	12.1	Celsius
8/17/2008	LS-2	Benzene	11.9	µg/L
8/17/2008	LS-2	D.O. mg/L	10.77	mg/L
8/17/2008	LS-2	Ethyl Benzene	2.37	µg/L
8/17/2008	LS-2	Toluene	4.8	µg/L
8/17/2008	LS-2	Total Xylene	8.02	µg/L
8/17/2008	LS-2	TAH	27.09	µg/L
8/17/2008	LS-2	Specific Conductivity	72.7	microS/cm
8/17/2008	LS-2	Turbidity	11.60	NTU
8/17/2008	LS-2	D.O. %	100.1	Percent Saturation
8/17/2008	LS-2	pH	7.74	
8/17/2008	LS-3	Benzene	12.4	µg/L
8/17/2008	LS-3	Ethyl Benzene	2.42	µg/L
8/17/2008	LS-3	Toluene	4.93	µg/L
8/17/2008	LS-3	Total Xylene	8.12	µg/L
8/17/2008	LS-3	TAH	27.87	µg/L
8/17/2008	LS-3	Turbidity	8.40	NTU
8/17/2008	LS-3	Turbidity	9.06	NTU
8/17/2008	LS-4	Benzene	10.1	µg/L
8/17/2008	LS-4	Ethyl Benzene	2	µg/L
8/17/2008	LS-4	Toluene	3.77	µg/L
8/17/2008	LS-4	Total Xylene	6.46	µg/L
8/17/2008	LS-4	TAH	22.33	µg/L
8/17/2008	LS-4	Turbidity	7.05	NTU
8/17/2008	LS-5	Benzene	<0.5	µg/L
8/17/2008	LS-5	Ethyl Benzene	1.12	µg/L
8/17/2008	LS-5	Toluene	<0.5	µg/L
8/17/2008	LS-5	Total Xylene	1.33	µg/L
8/17/2008	LS-5	TAH	2.45	µg/L
8/17/2008	LS-5	Turbidity	9.26	NTU
8/17/2008	LS-6	Benzene	<0.5	µg/L
8/17/2008	LS-6	Ethyl Benzene	<0.5	µg/L
8/17/2008	LS-6	Toluene	<0.5	µg/L
8/17/2008	LS-6	Total Xylene	<1	µg/L
8/17/2008	LS-6	TAH	0.00	µg/L
8/17/2008	LS-6	Turbidity	11.60	NTU
8/17/2008	LS-7	Temperature	12.4	Celsius
8/17/2008	LS-7	Benzene	0.91	µg/L
8/17/2008	LS-7	D.O. mg/L	10.66	mg/L
8/17/2008	LS-7	Ethyl Benzene	<0.5	µg/L
8/17/2008	LS-7	Toluene	2.36	µg/L
8/17/2008	LS-7	Total Xylene	1.56	µg/L
8/17/2008	LS-7	TAH	4.83	µg/L
8/17/2008	LS-7	Specific Conductivity	74.1	microS/cm
8/17/2008	LS-7	Turbidity	8.93	NTU
8/17/2008	LS-7	D.O. %	99.7	Percent Saturation
8/17/2008	LS-7	pH	7.72	
8/17/2008	LS-7X	Benzene	1.28	µg/L
8/17/2008	LS-7X	Ethyl Benzene	<0.5	µg/L
8/17/2008	LS-7X	Toluene	3.09	µg/L

Date	Site	Measurement	Value	Units
8/17/2008	LS-7X	Total Xylene	2.96	µg/L
8/17/2008	LS-7X	TAH	7.33	µg/L
8/17/2008	LS-7X	Turbidity	9.58	NTU
8/18/2008	LS-1	Discharge	386.61	cfs
8/18/2008	LS-Houston	Turbidity	3.06	NTU
8/18/2008	LS-Houston	Turbidity	1.97	NTU
8/18/2008	LS-Houston	Turbidity	2.58	NTU
8/24/2008	LS-1	Temperature	11.3	Celsius
8/24/2008	LS-1	Discharge	378.5	cfs
8/24/2008	LS-1	Benzene	2.6	µg/L
8/24/2008	LS-1	D.O. mg/L	11.24	mg/L
8/24/2008	LS-1	Ethyl Benzene	1.58	µg/L
8/24/2008	LS-1	Toluene	1.03	µg/L
8/24/2008	LS-1	Total Xylene	1.67	µg/L
8/24/2008	LS-1	TAH	6.88	µg/L
8/24/2008	LS-1	Specific Conductivity	72.9	microS/cm
8/24/2008	LS-1	Turbidity	5.86	NTU
8/24/2008	LS-1	Turbidity	4.86	NTU
8/24/2008	LS-1	Turbidity	7.70	NTU
8/24/2008	LS-1	D.O. %	102.8	Percent Saturation
8/24/2008	LS-1	pH	7.69	
8/24/2008	LS-2	Benzene	2.64	µg/L
8/24/2008	LS-2	Ethyl Benzene	1.52	µg/L
8/24/2008	LS-2	Toluene	0.98	µg/L
8/24/2008	LS-2	Total Xylene	1.67	µg/L
8/24/2008	LS-2	TAH	6.81	µg/L
8/24/2008	LS-2	Turbidity	8.17	NTU
8/24/2008	LS-2	Turbidity	7.05	NTU
8/24/2008	LS-2	Turbidity	7.05	NTU
8/24/2008	LS-3	Benzene	2.96	µg/L
8/24/2008	LS-3	Ethyl Benzene	0.6	µg/L
8/24/2008	LS-3	Toluene	1.22	µg/L
8/24/2008	LS-3	Total Xylene	2.04	µg/L
8/24/2008	LS-3	TAH	6.82	µg/L
8/24/2008	LS-3	Turbidity	6.39	NTU
8/24/2008	LS-3	Turbidity	6.52	NTU
8/24/2008	LS-3	Turbidity	5.96	NTU
8/24/2008	LS-4	Benzene	4.84	µg/L
8/24/2008	LS-4	Ethyl Benzene	0.84	µg/L
8/24/2008	LS-4	Toluene	1.76	µg/L
8/24/2008	LS-4	Total Xylene	2.91	µg/L
8/24/2008	LS-4	TAH	10.35	µg/L
8/24/2008	LS-4	Turbidity	6.08	NTU
8/24/2008	LS-4	Turbidity	5.88	NTU
8/24/2008	LS-4	Turbidity	6.05	NTU
8/24/2008	LS-5	Benzene	3.86	µg/L
8/24/2008	LS-5	Ethyl Benzene	0.73	µg/L
8/24/2008	LS-5	Toluene	1.39	µg/L
8/24/2008	LS-5	Total Xylene	2.46	µg/L
8/24/2008	LS-5	TAH	8.44	µg/L
8/24/2008	LS-5	Turbidity	7.55	NTU

Date	**Site**	**Measurement**	**Value**	**Units**
8/24/2008	LS-5	Turbidity	6.32	NTU
8/24/2008	LS-5	Turbidity	7.75	NTU
8/24/2008	LS-6	Benzene	3.27	µg/L
8/24/2008	LS-6	Ethyl Benzene	0.64	µg/L
8/24/2008	LS-6	Toluene	1.3	µg/L
8/24/2008	LS-6	Total Xylene	2.3	µg/L
8/24/2008	LS-6	TAH	7.51	µg/L
8/24/2008	LS-6	Turbidity	7.26	NTU
8/24/2008	LS-6	Turbidity	8.36	NTU
8/24/2008	LS-6	Turbidity	8.95	NTU
8/24/2008	LS-7	Temperature	12.0	Celsius
8/24/2008	LS-7	Benzene	4.15	µg/L
8/24/2008	LS-7	D.O. mg/L	11.03	mg/L
8/24/2008	LS-7	Ethyl Benzene	0.79	µg/L
8/24/2008	LS-7	Toluene	1.66	µg/L
8/24/2008	LS-7	Total Xylene	2.74	µg/L
8/24/2008	LS-7	TAH	9.34	µg/L
8/24/2008	LS-7	Specific Conductivity	75.7	microS/cm
8/24/2008	LS-7	Turbidity	10.63	NTU
8/24/2008	LS-7	Turbidity	7.98	NTU
8/24/2008	LS-7	Turbidity	6.51	NTU
8/24/2008	LS-7	Turbidity	7.83	NTU
8/24/2008	LS-7	D.O. %	102.3	Percent Saturation
8/24/2008	LS-7	pH	7.62	
8/24/2008	LS-7X	Benzene	4.14	µg/L
8/24/2008	LS-7X	Ethyl Benzene	0.8	µg/L
8/24/2008	LS-7X	Toluene	1.63	µg/L
8/24/2008	LS-7X	Total Xylene	2.76	µg/L
8/24/2008	LS-7X	TAH	9.33	µg/L
8/24/2008	LS-Houston	Turbidity	1.12	NTU
8/24/2008	LS-Houston	Turbidity	1.26	NTU
8/24/2008	LS-Houston	Turbidity	1.26	NTU
8/30/2008	LS-1	Temperature	13.0	Celsius
8/30/2008	LS-1	Discharge	385.54	cfs
8/30/2008	LS-1	Benzene	<0.5	µg/L
8/30/2008	LS-1	Ethyl Benzene	<0.5	µg/L
8/30/2008	LS-1	Toluene	<0.5	µg/L
8/30/2008	LS-1	Total Xylene	<1	µg/L
8/30/2008	LS-1	TAH	0.00	µg/L
8/30/2008	LS-1	Specific Conductivity	70.6	microS/cm
8/30/2008	LS-1	Turbidity	5.92	NTU
8/30/2008	LS-1	Turbidity	7.38	NTU
8/30/2008	LS-1	Turbidity	7.43	NTU
8/30/2008	LS-1	pH	7.73	
8/30/2008	LS-2	Benzene	<0.5	µg/L
8/30/2008	LS-2	Ethyl Benzene	<0.5	µg/L
8/30/2008	LS-2	Toluene	<0.5	µg/L
8/30/2008	LS-2	Total Xylene	<1	µg/L
8/30/2008	LS-2	TAH	0.00	µg/L
8/30/2008	LS-2	Turbidity	6.53	NTU
8/30/2008	LS-2	Turbidity	7.11	NTU

Date	Site	Measurement	Value	Units
8/30/2008	LS-2	Turbidity	7.49	NTU
8/30/2008	LS-3	Benzene	<0.5	µg/L
8/30/2008	LS-3	Ethyl Benzene	<0.5	µg/L
8/30/2008	LS-3	Toluene	<0.5	µg/L
8/30/2008	LS-3	Total Xylene	<1	µg/L
8/30/2008	LS-3	TAH	0.00	µg/L
8/30/2008	LS-3	Turbidity	5.57	NTU
8/30/2008	LS-3	Turbidity	6.20	NTU
8/30/2008	LS-3	Turbidity	5.40	NTU
8/30/2008	LS-4	Benzene	<0.5	µg/L
8/30/2008	LS-4	Ethyl Benzene	<0.5	µg/L
8/30/2008	LS-4	Toluene	<0.5	µg/L
8/30/2008	LS-4	Total Xylene	<1	µg/L
8/30/2008	LS-4	TAH	0.00	µg/L
8/30/2008	LS-4	Turbidity	6.45	NTU
8/30/2008	LS-4	Turbidity	7.58	NTU
8/30/2008	LS-4	Turbidity	6.91	NTU
8/30/2008	LS-5	Benzene	<0.5	µg/L
8/30/2008	LS-5	Ethyl Benzene	<0.5	µg/L
8/30/2008	LS-5	Toluene	<0.5	µg/L
8/30/2008	LS-5	Total Xylene	<1	µg/L
8/30/2008	LS-5	TAH	0.00	µg/L
8/30/2008	LS-5	Turbidity	7.26	NTU
8/30/2008	LS-5	Turbidity	9.17	NTU
8/30/2008	LS-5	Turbidity	6.11	NTU
8/30/2008	LS-6	Benzene	<0.5	µg/L
8/30/2008	LS-6	Ethyl Benzene	<0.5	µg/L
8/30/2008	LS-6	Toluene	<0.5	µg/L
8/30/2008	LS-6	Total Xylene	<1	µg/L
8/30/2008	LS-6	TAH	0.00	µg/L
8/30/2008	LS-6	Turbidity	5.51	NTU
8/30/2008	LS-6	Turbidity	6.79	NTU
8/30/2008	LS-6	Turbidity	8.30	NTU
8/30/2008	LS-7	Temperature	13.3	Celsius
8/30/2008	LS-7	Benzene	<0.5	µg/L
8/30/2008	LS-7	Ethyl Benzene	<0.5	µg/L
8/30/2008	LS-7	Toluene	<0.5	µg/L
8/30/2008	LS-7	Total Xylene	<1	µg/L
8/30/2008	LS-7	TAH	0.00	µg/L
8/30/2008	LS-7	Specific Conductivity	72.7	micrS/cm
8/30/2008	LS-7	Turbidity	6.62	NTU
8/30/2008	LS-7	Turbidity	7.30	NTU
8/30/2008	LS-7	Turbidity	7.09	NTU
8/30/2008	LS-7	pH	7.7	
8/30/2008	LS-7X	Benzene	<0.5	µg/L
8/30/2008	LS-7X	Ethyl Benzene	<0.5	µg/L
8/30/2008	LS-7X	Toluene	<0.5	µg/L
8/30/2008	LS-7X	Total Xylene	<1	µg/L
8/30/2008	LS-7X	TAH	0.00	µg/L
8/30/2008	LS-Houston	Turbidity	0.41	NTU

Date	Site	Measurement	Value	Units
8/30/2008	LS-Houston	Turbidity	0.61	NTU
8/30/2008	LS-Houston	Turbidity	0.04	NTU
9/6/2008	LS-1	Temperature	10.9	Celsius
9/6/2008	LS-1	Discharge	325.02	cfs
9/6/2008	LS-1	Benzene	<0.5	µg/L
9/6/2008	LS-1	D.O. mg/L	11.39	mg/L
9/6/2008	LS-1	Ethyl Benzene	<0.5	µg/L
9/6/2008	LS-1	Toluene	<0.5	µg/L
9/6/2008	LS-1	Total Xylene	<1	µg/L
9/6/2008	LS-1	TAH	0.00	µg/L
9/6/2008	LS-1	Specific Conductivity	100.8	microS/cm
9/6/2008	LS-1	Turbidity	3.16	NTU
9/6/2008	LS-1	Turbidity	2.04	NTU
9/6/2008	LS-1	Turbidity	3.56	NTU
9/6/2008	LS-1	D.O. %	102.5	Percent Saturation
9/6/2008	LS-1	pH	7.92	
9/6/2008	LS-2	Benzene	<0.5	µg/L
9/6/2008	LS-2	Ethyl Benzene	<0.5	µg/L
9/6/2008	LS-2	Toluene	<0.5	µg/L
9/6/2008	LS-2	Total Xylene	<1	µg/L
9/6/2008	LS-2	TAH	0.00	µg/L
9/6/2008	LS-2	Turbidity	2.28	NTU
9/6/2008	LS-2	Turbidity	3.00	NTU
9/6/2008	LS-2	Turbidity	4.39	NTU
9/6/2008	LS-3	Benzene	<0.5	µg/L
9/6/2008	LS-3	Ethyl Benzene	<0.5	µg/L
9/6/2008	LS-3	Toluene	<0.5	µg/L
9/6/2008	LS-3	Total Xylene	<1	µg/L
9/6/2008	LS-3	TAH	0.00	µg/L
9/6/2008	LS-3	Turbidity	3.44	NTU
9/6/2008	LS-3	Turbidity	3.70	NTU
9/6/2008	LS-3	Turbidity	2.51	NTU
9/6/2008	LS-4	Benzene	<0.5	µg/L
9/6/2008	LS-4	Ethyl Benzene	<0.5	µg/L
9/6/2008	LS-4	Toluene	<0.5	µg/L
9/6/2008	LS-4	Total Xylene	<1	µg/L
9/6/2008	LS-4	TAH	0.00	µg/L
9/6/2008	LS-4	Turbidity	2.64	NTU
9/6/2008	LS-4	Turbidity	3.05	NTU
9/6/2008	LS-4	Turbidity	3.27	NTU
9/6/2008	LS-5	Benzene	<0.5	µg/L
9/6/2008	LS-5	Ethyl Benzene	<0.5	µg/L
9/6/2008	LS-5	Toluene	<0.5	µg/L
9/6/2008	LS-5	Total Xylene	<1	µg/L
9/6/2008	LS-5	TAH	0.00	µg/L
9/6/2008	LS-5	Turbidity	3.67	NTU
9/6/2008	LS-5	Turbidity	3.89	NTU
9/6/2008	LS-5	Turbidity	3.57	NTU
9/6/2008	LS-6	Benzene	<0.5	µg/L

Date	**Site**	**Measurement**	**Value**	**Units**
9/6/2008	LS-6	Ethyl Benzene	0.52	µg/L
9/6/2008	LS-6	Toluene	0.86	µg/L
9/6/2008	LS-6	Total Xylene	1.53	µg/L
9/6/2008	LS-6	TAH	2.91	µg/L
9/6/2008	LS-6	Turbidity	5.36	NTU
9/6/2008	LS-6	Turbidity	4.98	NTU
9/6/2008	LS-6	Turbidity	7.09	NTU
9/6/2008	LS-7	Temperature	11.2	Celsius
9/6/2008	LS-7	Benzene	<0.5	µg/L
9/6/2008	LS-7	D.O. mg/L	11.23	mg/L
9/6/2008	LS-7	Ethyl Benzene	<0.5	µg/L
9/6/2008	LS-7	Toluene	<0.5	µg/L
9/6/2008	LS-7	Total Xylene	<1	µg/L
9/6/2008	LS-7	Specific Conductivity	101.7	microS/cm
9/6/2008	LS-7	Turbidity	6.11	NTU
9/6/2008	LS-7	Turbidity	6.64	NTU
9/6/2008	LS-7	Turbidity	7.48	NTU
9/6/2008	LS-7	D.O. %	101	Percent Saturation
9/6/2008	LS-7	pH	7.69	
9/6/2008	LS-7X	Benzene	2.34	µg/L
9/6/2008	LS-7X	Ethyl Benzene	0.54	µg/L
9/6/2008	LS-7X	Toluene	0.87	µg/L
9/6/2008	LS-7X	Total Xylene	1.88	µg/L
9/6/2008	LS-7X	TAH	5.63	µg/L
9/6/2008	LS-Houston	Turbidity	1.36	NTU
9/6/2008	LS-Houston	Turbidity	0.81	NTU
9/6/2008	LS-Houston	Turbidity	2.63	NTU
5/17/2009	Houston	turbidity	10.52	NTU
5/17/2009	Houston	Turbidity	8.86	NTU
5/17/2009	Houston	Turbidity	8.27	NTU
5/17/2009	Houston	Temp Logger	2004066	
5/17/2009	LS-1	D.O. %	98.9	%
5/17/2009	LS-1	Temperature	7.6	Celsius
5/17/2009	LS-1	Temperature	7.6	Celsius
5/17/2009	LS-1	Discharge	927.1	cfs
5/17/2009	LS-1	Benzene	<1	µg/L
5/17/2009	LS-1	D.O. mg/L	11.8	mg/L
5/17/2009	LS-1	Ethyl Benzene	<1	µg/L
5/17/2009	LS-1	m,p Xylene	<1	µg/L
5/17/2009	LS-1	o-Xylene	<1	µg/L
5/17/2009	LS-1	TAH	0.00	µg/L
5/17/2009	LS-1	Toluene	<1	µg/L
5/17/2009	LS-1	Total Xylenes	<1	µg/L
5/17/2009	LS-1	Specific Conductivity	79.9	microS/cm
5/17/2009	LS-1	Turbidity	8.53	NTU
5/17/2009	LS-1	Turbidity	12.70	NTU
5/17/2009	LS-1	Turbidity	10.86	NTU
5/17/2009	LS-1	pH	7.52	
5/17/2009	LS-2	D.O. %	93.8	%
5/17/2009	LS-2	Temperature	8.1	Celsius

Date	**Site**	**Measurement**	**Value**	**Units**
5/17/2009	LS-2	Temperature	8.1	Celsius
5/17/2009	LS-2	Benzene	<1	µg/L
5/17/2009	LS-2	D.O. mg/L	11.06	mg/L
5/17/2009	LS-2	Ethyl Benzene	<1	µg/L
5/17/2009	LS-2	m,p Xylene	<1	µg/L
5/17/2009	LS-2	o-Xylene	<1	µg/L
5/17/2009	LS-2	TAH	0.00	µg/L
5/17/2009	LS-2	Toluene	<1	µg/L
5/17/2009	LS-2	Total Xylenes	<1	µg/L
5/17/2009	LS-2	Specific Conductivity	80.4	microS/cm
5/17/2009	LS-2	Turbidity	17.60	NTU
5/17/2009	LS-2	Turbidity	15.10	NTU
5/17/2009	LS-2	Turbidity	17.80	NTU
5/17/2009	LS-2	pH	7.57	
5/17/2009	LS-3	D.O. %	95.6	%
5/17/2009	LS-3	Temperature	8.1	Celsius
5/17/2009	LS-3	Temperature	8.2	Celsius
5/17/2009	LS-3	Benzene	<1	µg/L
5/17/2009	LS-3	D.O. mg/L	11.28	mg/L
5/17/2009	LS-3	Ethyl Benzene	<1	µg/L
5/17/2009	LS-3	m,p Xylene	<1	µg/L
5/17/2009	LS-3	o-Xylene	<1	µg/L
5/17/2009	LS-3	TAH	0.00	µg/L
5/17/2009	LS-3	Toluene	<1	µg/L
5/17/2009	LS-3	Total Xylenes	<1	µg/L
5/17/2009	LS-3	Specific Conductivity	81.5	microS/cm
5/17/2009	LS-3	Turbidity	12.80	NTU
5/17/2009	LS-3	Turbidity	15.20	NTU
5/17/2009	LS-3	Turbidity	10.95	NTU
5/17/2009	LS-3	pH	7.54	
5/17/2009	LS-4	D.O. %	95.6	%
5/17/2009	LS-4	Temperature	8.3	Celsius
5/17/2009	LS-4	Temperature	8.3	Celsius
5/17/2009	LS-4	Benzene	<1	µg/L
5/17/2009	LS-4	D.O. mg/L	11.24	mg/L
5/17/2009	LS-4	Ethyl Benzene	<1	µg/L
5/17/2009	LS-4	m,p Xylene	<1	µg/L
5/17/2009	LS-4	o-Xylene	<1	µg/L
5/17/2009	LS-4	TAH	1.00	µg/L
5/17/2009	LS-4	Toluene	<1	µg/L
5/17/2009	LS-4	Total Xylenes	1	µg/L
5/17/2009	LS-4	Specific Conductivity	81.1	microS/cm
5/17/2009	LS-4	Turbidity	10.12	NTU
5/17/2009	LS-4	Turbidity	15.80	NTU
5/17/2009	LS-4	Turbidity	13.20	NTU
5/17/2009	LS-4	pH	7.56	
5/17/2009	LS-5	D.O. %	95.4	%
5/17/2009	LS-5	Temperature	8.5	Celsius
5/17/2009	LS-5	Temperature	8.5	Celsius
5/17/2009	LS-5	Benzene	<1	µg/L
5/17/2009	LS-5	D.O. mg/L	11.18	mg/L

Date	Site	Measurement	Value	Units
5/17/2009	LS-5	Ethyl Benzene	<1	μg/L
5/17/2009	LS-5	m,p Xylene	<1	μg/L
5/17/2009	LS-5	o-Xylene	<1	μg/L
5/17/2009	LS-5	TAH	0.00	μg/L
5/17/2009	LS-5	Toluene	<1	μg/L
5/17/2009	LS-5	Total Xylenes	<1	μg/L
5/17/2009	LS-5	Specific Conductivity	81.1	microS/cm
5/17/2009	LS-5	Turbidity	11.70	NTU
5/17/2009	LS-5	Turbidity	11.80	NTU
5/17/2009	LS-5	Turbidity	13.90	NTU
5/17/2009	LS-5	pH	7.54	
5/17/2009	LS-6	D.O. %	95.5	%
5/17/2009	LS-6	Temperature	8.6	Celsius
5/17/2009	LS-6	Temperature	8.6	Celsius
5/17/2009	LS-6	Benzene	<1	μg/L
5/17/2009	LS-6	D.O. mg/L	11.13	mg/L
5/17/2009	LS-6	Ethyl Benzene	<1	μg/L
5/17/2009	LS-6	m,p Xylene	<1	μg/L
5/17/2009	LS-6	o-Xylene	<1	μg/L
5/17/2009	LS-6	TAH	0.00	μg/L
5/17/2009	LS-6	Toluene	<1	μg/L
5/17/2009	LS-6	Total Xylenes	<1	μg/L
5/17/2009	LS-6	Specific Conductivity	81.1	microS/cm
5/17/2009	LS-6	Turbidity	12.10	NTU
5/17/2009	LS-6	Turbidity	11.00	NTU
5/17/2009	LS-6	Turbidity		NTU
5/17/2009	LS-6	pH	7.55	
5/17/2009	LS-7	D.O. %	95.1	%
5/17/2009	LS-7	Temperature	8.7	Celsius
5/17/2009	LS-7	Temperature	8.7	Celsius
5/17/2009	LS-7	Benzene	<1	μg/L
5/17/2009	LS-7	D.O. mg/L	11.08	mg/L
5/17/2009	LS-7	Ethyl Benzene	<1	μg/L
5/17/2009	LS-7	m,p Xylene	<1	μg/L
5/17/2009	LS-7	o-Xylene	<1	μg/L
5/17/2009	LS-7	TAH	0.00	μg/L
5/17/2009	LS-7	Toluene	<1	μg/L
5/17/2009	LS-7	Total Xylenes	<1	μg/L
5/17/2009	LS-7	Specific Conductivity	81.1	microS/cm
5/17/2009	LS-7	Turbidity	11.50	NTU
5/17/2009	LS-7	Turbidity	11.60	NTU
5/17/2009	LS-7	Turbidity	13.40	NTU
5/17/2009	LS-7	pH	7.54	
5/17/2009	LS-7x	Benzene	<1	μg/L
5/17/2009	LS-7x	Ethyl Benzene	<1	μg/L
5/17/2009	LS-7x	m,p Xylene	<1	μg/L
5/17/2009	LS-7x	o-Xylene	<1	μg/L
5/17/2009	LS-7x	TAH	0.00	μg/L
5/17/2009	LS-7x	Toluene	<1	μg/L
5/17/2009	LS-7x	Total Xylenes	<1	μg/L
5/24/2009	Houston	Hach Latitude	61.62196	decimal degrees

Date	Site	Measurement	Value	Units
5/24/2009	Houston	Hach Longitude	149.89702	decimal degrees
5/24/2009	Houston	Turbidity	4.88	NTU
5/24/2009	Houston	Turbidity	6.34	NTU
5/24/2009	Houston	Turbidity	5.90	NTU
5/24/2009	LS-1	D.O. %	102.7	%
5/24/2009	LS-1	Temperature	9.4	Celsius
5/24/2009	LS-1	Temperature	9.6	Celsius
5/24/2009	LS-1	Discharge	832.97	cfs
5/24/2009	LS-1	Benzene	1.1	μg/L
5/24/2009	LS-1	D.O. mg/L	11.71	mg/L
5/24/2009	LS-1	Ethyl Benzene	<1	μg/L
5/24/2009	LS-1	m,p Xylene	<1	μg/L
5/24/2009	LS-1	o-Xylene	<1	μg/L
5/24/2009	LS-1	TAH	3.10	μg/L
5/24/2009	LS-1	Toluene	2	μg/L
5/24/2009	LS-1	Total Xylenes	<1	μg/L
5/24/2009	LS-1	Specific Conductivity	79.5	microS/cm
5/24/2009	LS-1	Turbidity	9.02	NTU
5/24/2009	LS-1	Turbidity	10.49	NTU
5/24/2009	LS-1	Turbidity	10.49	NTU
5/24/2009	LS-1	pH	7.95	
5/24/2009	LS-2	D.O. %	101.5	%
5/24/2009	LS-2	Temperature	9.6	Celsius
5/24/2009	LS-2	Temperature	9.8	Celsius
5/24/2009	LS-2	Benzene	1.9	μg/L
5/24/2009	LS-2	D.O. mg/L	11.51	mg/L
5/24/2009	LS-2	Ethyl Benzene	<1	μg/L
5/24/2009	LS-2	m,p Xylene	<1	μg/L
5/24/2009	LS-2	o-Xylene	<1	μg/L
5/24/2009	LS-2	TAH	4.20	μg/L
5/24/2009	LS-2	Toluene	2.3	μg/L
5/24/2009	LS-2	Total Xylenes	<1	μg/L
5/24/2009	LS-2	Specific Conductivity	70.6	microS/cm
5/24/2009	LS-2	Turbidity	9.96	NTU
5/24/2009	LS-2	Turbidity	12.10	NTU
5/24/2009	LS-2	Turbidity		NTU
5/24/2009	LS-2	pH	7.59	
5/24/2009	LS-3	D.O. %	101.8	%
5/24/2009	LS-3	Temperature	9.8	Celsius
5/24/2009	LS-3	Temperature	10.0	Celsius
5/24/2009	LS-3	Benzene	3.8	μg/L
5/24/2009	LS-3	D.O. mg/L	11.47	mg/L
5/24/2009	LS-3	Ethyl Benzene	<1	μg/L
5/24/2009	LS-3	m,p Xylene	<1	μg/L
5/24/2009	LS-3	o-Xylene	<1	μg/L
5/24/2009	LS-3	TAH	8.30	μg/L
5/24/2009	LS-3	Toluene	4.5	μg/L
5/24/2009	LS-3	Total Xylenes	<1	μg/L
5/24/2009	LS-3	Specific Conductivity	80.8	microS/cm
5/24/2009	LS-3	Turbidity	12.50	NTU
5/24/2009	LS-3	Turbidity	10.91	NTU

Date	Site	Measurement	Value	Units
5/24/2009	LS-3	Turbidity	9.47	NTU
5/24/2009	LS-3	pH	7.6	
5/24/2009	LS-4	D.O. %	102.3	%
5/24/2009	LS-4	Temperature	10.0	Celsius
5/24/2009	LS-4	Temperature	10.2	Celsius
5/24/2009	LS-4	Benzene	2.2	µg/L
5/24/2009	LS-4	D.O. mg/L	11.48	mg/L
5/24/2009	LS-4	Ethyl Benzene	<1	µg/L
5/24/2009	LS-4	m,p Xylene	<1	µg/L
5/24/2009	LS-4	o-Xylene	<1	µg/L
5/24/2009	LS-4	TAH	6.80	µg/L
5/24/2009	LS-4	Toluene	3.5	µg/L
5/24/2009	LS-4	Total Xylenes	1.1	µg/L
5/24/2009	LS-4	Specific Conductivity	80.6	microS/cm
5/24/2009	LS-4	Turbidity	13.30	NTU
5/24/2009	LS-4	Turbidity	14.70	NTU
5/24/2009	LS-4	Turbidity	12.90	NTU
5/24/2009	LS-4	pH	7.57	
5/24/2009	LS-5	D.O. %	102.5	%
5/24/2009	LS-5	Temperature	10.4	Celsius
5/24/2009	LS-5	Temperature	10.2	Celsius
5/24/2009	LS-5	Benzene	2.2	µg/L
5/24/2009	LS-5	D.O. mg/L	11.47	mg/L
5/24/2009	LS-5	Ethyl Benzene	<1	µg/L
5/24/2009	LS-5	m,p Xylene	<1	µg/L
5/24/2009	LS-5	o-Xylene	<1	µg/L
5/24/2009	LS-5	TAH	5.00	µg/L
5/24/2009	LS-5	Toluene	2.8	µg/L
5/24/2009	LS-5	Total Xylenes	<1	µg/L
5/24/2009	LS-5	Specific Conductivity	80.6	microS/cm
5/24/2009	LS-5	Turbidity	12.20	NTU
5/24/2009	LS-5	Turbidity	10.38	NTU
5/24/2009	LS-5	Turbidity	12.30	NTU
5/24/2009	LS-5	pH	7.56	
5/24/2009	LS-6	D.O. %	102.6	%
5/24/2009	LS-6	Temperature	10.5	Celsius
5/24/2009	LS-6	Temperature	10.3	Celsius
5/24/2009	LS-6	Benzene	3.2	µg/L
5/24/2009	LS-6	D.O. mg/L	11.44	mg/L
5/24/2009	LS-6	Ethyl Benzene	<1	µg/L
5/24/2009	LS-6	m,p Xylene	<1	µg/L
5/24/2009	LS-6	o-Xylene	<1	µg/L
5/24/2009	LS-6	TAH	9.20	µg/L
5/24/2009	LS-6	Toluene	6	µg/L
5/24/2009	LS-6	Total Xylenes	<1	µg/L
5/24/2009	LS-6	Specific Conductivity	80.7	microS/cm
5/24/2009	LS-6	Turbidity	16.00	NTU
5/24/2009	LS-6	Turbidity	14.00	NTU
5/24/2009	LS-6	Turbidity	14.70	NTU
5/24/2009	LS-6	pH	7.54	
5/24/2009	LS-7	D.O. %	102.5	%

Date	Site	Measurement	Value	Units
5/24/2009	LS-7	Temperature	10.7	Celsius
5/24/2009	LS-7	Temperature	10.4	Celsius
5/24/2009	LS-7	Benzene	2.2	μg/L
5/24/2009	LS-7	D.O. mg/L	11.4	mg/L
5/24/2009	LS-7	Ethyl Benzene	<1	μg/L
5/24/2009	LS-7	m,p Xylene	<1	μg/L
5/24/2009	LS-7	o-Xylene	<1	μg/L
5/24/2009	LS-7	TAH	6.90	μg/L
5/24/2009	LS-7	Toluene	4.7	μg/L
5/24/2009	LS-7	Total Xylenes	<1	μg/L
5/24/2009	LS-7	Specific Conductivity	80.8	microS/cm
5/24/2009	LS-7	Turbidity	12.60	NTU
5/24/2009	LS-7	Turbidity	11.90	NTU
5/24/2009	LS-7	Turbidity	12.60	NTU
5/24/2009	LS-7	pH	7.52	
5/24/2009	LS-7x	Benzene	2	μg/L
5/24/2009	LS-7x	Ethyl Benzene	<1	μg/L
5/24/2009	LS-7x	m,p Xylene	<1	μg/L
5/24/2009	LS-7x	o-Xylene	<1	μg/L
5/24/2009	LS-7x	TAH	4.50	μg/L
5/24/2009	LS-7x	Toluene	2.5	μg/L
5/24/2009	LS-7x	Total Xylenes	<1	μg/L
5/31/2009	Houston	Turbidity	2.92	NTU
5/31/2009	Houston	Turbidity	5.75	NTU
5/31/2009	Houston	Turbidity	4.04	NTU
5/31/2009	LS-1	D.O. %	101.5	%
5/31/2009	LS-1	Temperature	8.6	Celsius
5/31/2009	LS-1	Temperature	8.0	Celsius
5/31/2009	LS-1	Discharge	804.08	cfs
5/31/2009	LS-1	Benzene	<1	μg/L
5/31/2009	LS-1	D.O. mg/L	12.02	mg/L
5/31/2009	LS-1	Ethyl Benzene	<1	μg/L
5/31/2009	LS-1	m,p Xylene	<1	μg/L
5/31/2009	LS-1	o-Xylene	<1	μg/L
5/31/2009	LS-1	TAH	0.00	μg/L
5/31/2009	LS-1	Toluene	<1	μg/L
5/31/2009	LS-1	Total Xylenes	<1	μg/L
5/31/2009	LS-1	Specific Conductivity	81.5	microS/cm
5/31/2009	LS-1	Turbidity	11.90	NTU
5/31/2009	LS-1	Turbidity	9.48	NTU
5/31/2009	LS-1	Turbidity	8.47	NTU
5/31/2009	LS-1	pH	7.65	
5/31/2009	LS-2	D.O. %	101.5	%
5/31/2009	LS-2	Temperature	8.8	Celsius
5/31/2009	LS-2	Temperature	8.3	Celsius
5/31/2009	LS-2	Benzene	<1	μg/L
5/31/2009	LS-2	D.O. mg/L	11.94	mg/L
5/31/2009	LS-2	Ethyl Benzene	<1	μg/L
5/31/2009	LS-2	m,p Xylene	<1	μg/L
5/31/2009	LS-2	o-Xylene	<1	μg/L
5/31/2009	LS-2	TAH	0.00	μg/L

Date	Site	Measurement	Value	Units
5/31/2009	LS-2	Toluene	<1	µg/L
5/31/2009	LS-2	Total Xylenes	<1	µg/L
5/31/2009	LS-2	Specific Conductivity	58.1	microS/cm
5/31/2009	LS-2	Turbidity	7.47	NTU
5/31/2009	LS-2	Turbidity	7.70	NTU
5/31/2009	LS-2	Turbidity	9.76	NTU
5/31/2009	LS-2	pH	7.7	
5/31/2009	LS-3	D.O. %	101.6	%
5/31/2009	LS-3	Temperature	8.9	Celsius
5/31/2009	LS-3	Temperature	8.4	Celsius
5/31/2009	LS-3	Benzene	1.3	µg/L
5/31/2009	LS-3	D.O. mg/L	11.92	mg/L
5/31/2009	LS-3	Ethyl Benzene	<1	µg/L
5/31/2009	LS-3	m,p Xylene	<1	µg/L
5/31/2009	LS-3	o-Xylene	<1	µg/L
5/31/2009	LS-3	TAH	3.70	µg/L
5/31/2009	LS-3	Toluene	2.4	µg/L
5/31/2009	LS-3	Total Xylenes	<1	µg/L
5/31/2009	LS-3	Specific Conductivity	83.8	microS/cm
5/31/2009	LS-3	Turbidity	7.76	NTU
5/31/2009	LS-3	Turbidity	8.56	NTU
5/31/2009	LS-3	Turbidity	11.40	NTU
5/31/2009	LS-3	pH	7.67	
5/31/2009	LS-4	D.O. %	101.7	%
5/31/2009	LS-4	Temperature	9.0	Celsius
5/31/2009	LS-4	Temperature	8.4	Celsius
5/31/2009	LS-4	Benzene	<1	µg/L
5/31/2009	LS-4	D.O. mg/L	11.93	mg/L
5/31/2009	LS-4	Ethyl Benzene	<1	µg/L
5/31/2009	LS-4	m,p Xylene	<1	µg/L
5/31/2009	LS-4	o-Xylene	<1	µg/L
5/31/2009	LS-4	TAH	0.00	µg/L
5/31/2009	LS-4	Toluene	<1	µg/L
5/31/2009	LS-4	Total Xylenes	<1	µg/L
5/31/2009	LS-4	Specific Conductivity	83.4	microS/cm
5/31/2009	LS-4	Turbidity	9.60	NTU
5/31/2009	LS-4	Turbidity	7.61	NTU
5/31/2009	LS-4	Turbidity	10.68	NTU
5/31/2009	LS-4	pH	7.67	
5/31/2009	LS-5	D.O. %	101.6	%
5/31/2009	LS-5	Temperature	9.1	Celsius
5/31/2009	LS-5	Temperature	8.5	Celsius
5/31/2009	LS-5	Benzene	<1	µg/L
5/31/2009	LS-5	D.O. mg/L	11.87	mg/L
5/31/2009	LS-5	Ethyl Benzene	<1	µg/L
5/31/2009	LS-5	m,p Xylene	<1	µg/L
5/31/2009	LS-5	o-Xylene	<1	µg/L
5/31/2009	LS-5	TAH	0.00	µg/L
5/31/2009	LS-5	Toluene	<1	µg/L
5/31/2009	LS-5	Total Xylenes	<1	µg/L
5/31/2009	LS-5	Specific Conductivity	83.5	microS/cm

Date	Site	Measurement	Value	Units
5/31/2009	LS-5	Turbidity	9.39	NTU
5/31/2009	LS-5	Turbidity	8.96	NTU
5/31/2009	LS-5	Turbidity	9.95	NTU
5/31/2009	LS-5	pH	7.66	
5/31/2009	LS-6	D.O. %	101.3	%
5/31/2009	LS-6	Temperature	9.1	Celsius
5/31/2009	LS-6	Temperature	8.6	Celsius
5/31/2009	LS-6	Benzene	<1	µg/L
5/31/2009	LS-6	D.O. mg/L	11.84	mg/L
5/31/2009	LS-6	Ethyl Benzene	<1	µg/L
5/31/2009	LS-6	m,p Xylene	<1	µg/L
5/31/2009	LS-6	o-Xylene	<1	µg/L
5/31/2009	LS-6	TAH	1.40	µg/L
5/31/2009	LS-6	Toluene	1.4	µg/L
5/31/2009	LS-6	Total Xylenes	<1	µg/L
5/31/2009	LS-6	Specific Conductivity	8.36	microS/cm
5/31/2009	LS-6	Turbidity	10.58	NTU
5/31/2009	LS-6	Turbidity	8.74	NTU
5/31/2009	LS-6	Turbidity	10.41	NTU
5/31/2009	LS-6	pH	7.65	
5/31/2009	LS-7	D.O. %	101.2	%
5/31/2009	LS-7	Temperature	9.3	Celsius
5/31/2009	LS-7	Temperature	8.7	Celsius
5/31/2009	LS-7	Benzene	1.5	µg/L
5/31/2009	LS-7	D.O. mg/L	11.79	mg/L
5/31/2009	LS-7	Ethyl Benzene	<1	µg/L
5/31/2009	LS-7	m,p Xylene	<1	µg/L
5/31/2009	LS-7	o-Xylene	<1	µg/L
5/31/2009	LS-7	TAH	3.60	µg/L
5/31/2009	LS-7	Toluene	2.1	µg/L
5/31/2009	LS-7	Total Xylenes	<1	µg/L
5/31/2009	LS-7	Specific Conductivity	83.4	microS/cm
5/31/2009	LS-7	Turbidity	10.37	NTU
5/31/2009	LS-7	Turbidity	9.73	NTU
5/31/2009	LS-7	Turbidity	11.30	NTU
5/31/2009	LS-7	pH	7.65	
5/31/2009	LS-7x	Benzene	1.2	µg/L
5/31/2009	LS-7x	Ethyl Benzene	<1	µg/L
5/31/2009	LS-7x	m,p Xylene	<1	µg/L
5/31/2009	LS-7x	o-Xylene	<1	µg/L
5/31/2009	LS-7x	TAH	1.40	µg/L
5/31/2009	LS-7x	Toluene	2	µg/L
5/31/2009	LS-7x	Total Xylenes	<1	µg/L
6/7/2009	LS-1	D.O. %	104.1	%
6/7/2009	LS-1	Temperature	10.9	Celsius
6/7/2009	LS-1	Temperature	10.4	Celsius
6/7/2009	LS-1	Discharge	857	cfs
6/7/2009	LS-1	Benzene	<1	µg/L
6/7/2009	LS-1	D.O. mg/L	11.66	µg/L
6/7/2009	LS-1	Ethyl Benzene	<1	µg/L
6/7/2009	LS-1	m,p Xylene	<1	µg/L

Date	**Site**	**Measurement**	**Value**	**Units**
6/7/2009	LS-1	o-Xylene	<1	µg/L
6/7/2009	LS-1	TAH	0.00	µg/L
6/7/2009	LS-1	Toluene	<1	µg/L
6/7/2009	LS-1	Total Xylenes	<1	µg/L
6/7/2009	LS-1	Specific Conductivity	76.9	microS/cm
6/7/2009	LS-1	Turbidity	11.30	NTU
6/7/2009	LS-1	Turbidity	16.30	NTU
6/7/2009	LS-1	Turbidity	13.30	NTU
6/7/2009	LS-1	pH	7.66	
6/7/2009	LS-2	D.O. %	104.1	%
6/7/2009	LS-2	Temperature	11.3	Celsius
6/7/2009	LS-2	Temperature	10.7	Celsius
6/7/2009	LS-2	Benzene	<1	µg/L
6/7/2009	LS-2	D.O. mg/L	11.58	mg/L
6/7/2009	LS-2	Ethyl Benzene	<1	µg/L
6/7/2009	LS-2	m,p Xylene	<1	µg/L
6/7/2009	LS-2	o-Xylene	<1	µg/L
6/7/2009	LS-2	TAH	3.20	µg/L
6/7/2009	LS-2	Toluene	3.2	µg/L
6/7/2009	LS-2	Total Xylenes	<1	µg/L
6/7/2009	LS-2	Specific Conductivity	79.2	microS/cm
6/7/2009	LS-2	Turbidity	11.80	NTU
6/7/2009	LS-2	Turbidity	15.50	NTU
6/7/2009	LS-2	Turbidity	16.70	NTU
6/7/2009	LS-2	pH	7.67	
6/7/2009	LS-3	D.O. %	104.1	%
6/7/2009	LS-3	Temperature	11.5	Celsius
6/7/2009	LS-3	Temperature	10.9	Celsius
6/7/2009	LS-3	Benzene	3.9	µg/L
6/7/2009	LS-3	D.O. mg/L	11.52	mg/L
6/7/2009	LS-3	Ethyl Benzene	<1	µg/L
6/7/2009	LS-3	m,p Xylene	<1	µg/L
6/7/2009	LS-3	o-Xylene	<1	µg/L
6/7/2009	LS-3	TAH	10.40	µg/L
6/7/2009	LS-3	Toluene	6.5	µg/L
6/7/2009	LS-3	Total Xylenes	<1	µg/L
6/7/2009	LS-3	Specific Conductivity	78.1	microS/cm
6/7/2009	LS-3	Turbidity	18.90	NTU
6/7/2009	LS-3	Turbidity	13.90	NTU
6/7/2009	LS-3	Turbidity	17.80	NTU
6/7/2009	LS-3	pH	7.6	
6/7/2009	LS-4	D.O. %	104.1	%
6/7/2009	LS-4	Temperature	11.6	Celsius
6/7/2009	LS-4	Temperature	11.0	Celsius
6/7/2009	LS-4	Benzene	3.1	µg/L
6/7/2009	LS-4	D.O. mg/L	11.48	mg/L
6/7/2009	LS-4	Ethyl Benzene	<1	µg/L
6/7/2009	LS-4	m,p Xylene	<1	µg/L
6/7/2009	LS-4	o-Xylene	<1	µg/L
6/7/2009	LS-4	TAH	9.10	µg/L
6/7/2009	LS-4	Toluene	6	µg/L

Date	Site	Measurement	Value	Units
6/7/2009	LS-4	Total Xylenes	<1	µg/L
6/7/2009	LS-4	Specific Conductivity	78.1	microS/cm
6/7/2009	LS-4	Turbidity	15.80	NTU
6/7/2009	LS-4	Turbidity	16.90	NTU
6/7/2009	LS-4	Turbidity	15.50	NTU
6/7/2009	LS-4	pH	7.57	
6/7/2009	LS-5	D.O. %	104.1	%
6/7/2009	LS-5	Temperature	11.7	Celsius
6/7/2009	LS-5	Temperature	11.1	Celsius
6/7/2009	LS-5	Benzene	3.2	µg/L
6/7/2009	LS-5	D.O. mg/L	11.46	mg/L
6/7/2009	LS-5	Ethyl Benzene	<1	µg/L
6/7/2009	LS-5	m,p Xylene	<1	µg/L
6/7/2009	LS-5	o-Xylene	<1	µg/L
6/7/2009	LS-5	TAH	9.70	µg/L
6/7/2009	LS-5	Toluene	6.5	µg/L
6/7/2009	LS-5	Total Xylenes	<1	µg/L
6/7/2009	LS-5	Specific Conductivity	78.2	microS/cm
6/7/2009	LS-5	Turbidity	15.60	NTU
6/7/2009	LS-5	Turbidity	16.70	NTU
6/7/2009	LS-5	Turbidity	14.30	NTU
6/7/2009	LS-5	pH	7.59	
6/7/2009	LS-6	D.O. %	104.1	%
6/7/2009	LS-6	Temperature	11.9	Celsius
6/7/2009	LS-6	Temperature	11.3	Celsius
6/7/2009	LS-6	Benzene	3.2	µg/L
6/7/2009	LS-6	D.O. mg/L	11.42	mg/L
6/7/2009	LS-6	Ethyl Benzene	<1	µg/L
6/7/2009	LS-6	m,p Xylene	<1	µg/L
6/7/2009	LS-6	o-Xylene	<1	µg/L
6/7/2009	LS-6	TAH	9.30	µg/L
6/7/2009	LS-6	Toluene	6.1	µg/L
6/7/2009	LS-6	Total Xylenes	<1	µg/L
6/7/2009	LS-6	Specific Conductivity	78.1	microS/cm
6/7/2009	LS-6	Turbidity	14.40	NTU
6/7/2009	LS-6	Turbidity	16.90	NTU
6/7/2009	LS-6	Turbidity	17.90	NTU
6/7/2009	LS-6	Hach Logger	47921	
6/7/2009	LS-6	pH	7.58	
6/7/2009	LS-7	D.O. %	104.3	%
6/7/2009	LS-7	Temperature	12.0	Celsius
6/7/2009	LS-7	Temperature	11.4	Celsius
6/7/2009	LS-7	Benzene	3.3	µg/L
6/7/2009	LS-7	D.O. mg/L	11.37	mg/L
6/7/2009	LS-7	Ethyl Benzene	<1	µg/L
6/7/2009	LS-7	m,p Xylene	<1	µg/L
6/7/2009	LS-7	o-Xylene	<1	µg/L
6/7/2009	LS-7	TAH	12.70	µg/L
6/7/2009	LS-7	Toluene	9.4	µg/L
6/7/2009	LS-7	Total Xylenes	<1	µg/L
6/7/2009	LS-7	Specific Conductivity	78.2	microS/cm

Date	**Site**	**Measurement**	**Value**	**Units**
6/7/2009	LS-7	Turbidity	17.00	NTU
6/7/2009	LS-7	Turbidity	18.60	NTU
6/7/2009	LS-7	Turbidity	18.40	NTU
6/7/2009	LS-7	pH	7.64	
6/7/2009	LS-7x	Benzene	3.1	μg/L
6/7/2009	LS-7x	Ethyl Benzene	<1	μg/L
6/7/2009	LS-7x	m,p Xylene	<1	μg/L
6/7/2009	LS-7x	o-Xylene	<1	μg/L
6/7/2009	LS-7x	TAH	9.60	μg/L
6/7/2009	LS-7x	Toluene	6.5	μg/L
6/7/2009	LS-7x	Total Xylenes	<1	μg/L
6/7/2009	Miller's Reach	Turbidity	3.59	NTU
6/7/2009	Miller's Reach	Turbidity	5.58	NTU
6/7/2009	Miller's Reach	Turbidity	4.80	NTU
6/7/2009	Miller's Reach	Hach Logger	47920	
6/13/2009	DN Drift	Lt bank time	2.52	min
6/13/2009	DN Drift	Rt bank time	3	min
6/13/2009	DN Drift	Lt bank Start	98938	
6/13/2009	DN Drift	Lt bank Stop	102577	
6/13/2009	DN Drift	Rt bank Start	94339	
6/13/2009	DN Drift	Rt bank Stop	96536	
6/13/2009	Little Su	Mid time	3	min
6/13/2009	Little Su	Mid time	2.24	min
6/13/2009	Little Su	Mid Start	96536	
6/13/2009	Little Su	Mid Start	109564	
6/13/2009	Little Su	Mid Stop	98934	
6/13/2009	Little Su	Mid Stop	113206	
6/13/2009	UP Drift	Lt bank time	2.35	min
6/13/2009	UP Drift	Rt bank time	2.46	min
6/13/2009	UP Drift	Lt bank Start	105472	
6/13/2009	UP Drift	Lt bank Stop	109569	
6/13/2009	UP Drift	Rt bank Start	102591	
6/13/2009	UP Drift	Rt bank Stop	105469	
6/14/2009	Houston	Turbidity	3.50	NTU
6/14/2009	Houston	Turbidity	3.43	NTU
6/14/2009	Houston	Turbidity	4.30	NTU
6/14/2009	LS-1	D.O. %	100.8	%
6/14/2009	LS-1	Temperature	12.0	Celsius
6/14/2009	LS-1	Temperature	12.3	Celsius
6/14/2009	LS-1	Discharge	787.87	cfs
6/14/2009	LS-1	Benzene	<1	μg/L
6/14/2009	LS-1	D.O. mg/L	10.78	mg/L
6/14/2009	LS-1	Ethyl Benzene	<1	μg/L
6/14/2009	LS-1	m,p Xylene	<1	μg/L
6/14/2009	LS-1	o-Xylene	<1	μg/L
6/14/2009	LS-1	TAH	1.90	μg/L
6/14/2009	LS-1	Toluene	1.9	μg/L
6/14/2009	LS-1	Total Xylenes	<1	μg/L
6/14/2009	LS-1	Specific Conductivity	81.1	microS/cm
6/14/2009	LS-1	Turbidity	7.59	NTU
6/14/2009	LS-1	Turbidity	8.39	NTU
6/14/2009	LS-1	Turbidity	9.45	NTU

Date	Site	Measurement	Value	Units
6/14/2009	LS-1	pH	7.77	
6/14/2009	LS-2	D.O. %	98.9	%
6/14/2009	LS-2	Temperature	11.9	Celsius
6/14/2009	LS-2	Temperature	12.2	Celsius
6/14/2009	LS-2	Benzene	<1	µg/L
6/14/2009	LS-2	D.O. mg/L	10.63	mg/L
6/14/2009	LS-2	Ethyl Benzene	<1	µg/L
6/14/2009	LS-2	m,p Xylene	<1	µg/L
6/14/2009	LS-2	o-Xylene	<1	µg/L
6/14/2009	LS-2	TAH	2.20	µg/L
6/14/2009	LS-2	Toluene	2.2	µg/L
6/14/2009	LS-2	Total Xylenes	<1	µg/L
6/14/2009	LS-2	Specific Conductivity	83.4	microS/cm
6/14/2009	LS-2	Turbidity	9.64	NTU
6/14/2009	LS-2	Turbidity	7.73	NTU
6/14/2009	LS-2	Turbidity	9.95	NTU
6/14/2009	LS-2	pH	7.77	
6/14/2009	LS-3	D.O. %	98.7	%
6/14/2009	LS-3	Temperature	12.0	Celsius
6/14/2009	LS-3	Temperature	12.2	Celsius
6/14/2009	LS-3	Benzene	1.6	µg/L
6/14/2009	LS-3	D.O. mg/L	10.56	mg/L
6/14/2009	LS-3	Ethyl Benzene	<1	µg/L
6/14/2009	LS-3	m,p Xylene	<1	µg/L
6/14/2009	LS-3	o-Xylene	<1	µg/L
6/14/2009	LS-3	TAH	5.30	µg/L
6/14/2009	LS-3	Toluene	3.7	µg/L
6/14/2009	LS-3	Total Xylenes	<1	µg/L
6/14/2009	LS-3	Specific Conductivity	82.8	microS/cm
6/14/2009	LS-3	Turbidity	10.27	NTU
6/14/2009	LS-3	Turbidity	8.14	NTU
6/14/2009	LS-3	Turbidity	9.27	NTU
6/14/2009	LS-3	pH	7.75	
6/14/2009	LS-4	D.O. %	98.5	%
6/14/2009	LS-4	Temperature	12.1	Celsius
6/14/2009	LS-4	Temperature	12.3	Celsius
6/14/2009	LS-4	Benzene	1.6	µg/L
6/14/2009	LS-4	D.O. mg/L	10.54	mg/L
6/14/2009	LS-4	Ethyl Benzene	<1	µg/L
6/14/2009	LS-4	m,p Xylene	<1	µg/L
6/14/2009	LS-4	o-Xylene	<1	µg/L
6/14/2009	LS-4	TAH	5.40	µg/L
6/14/2009	LS-4	Toluene	3.8	µg/L
6/14/2009	LS-4	Total Xylenes	<1	µg/L
6/14/2009	LS-4	Specific Conductivity	82.4	microS/cm
6/14/2009	LS-4	Turbidity	10.61	NTU
6/14/2009	LS-4	Turbidity	12.60	NTU
6/14/2009	LS-4	Turbidity	8.14	NTU
6/14/2009	LS-4	pH	7.74	
6/14/2009	LS-5	D.O. %	98.6	%
6/14/2009	LS-5	Temperature	12.2	Celsius

Date	Site	Measurement	Value	Units
6/14/2009	LS-5	Temperature	12.5	Celsius
6/14/2009	LS-5	Benzene	1.4	µg/L
6/14/2009	LS-5	D.O. mg/L	10.5	mg/L
6/14/2009	LS-5	Ethyl Benzene	<1	µg/L
6/14/2009	LS-5	m,p Xylene	<1	µg/L
6/14/2009	LS-5	o-Xylene	<1	µg/L
6/14/2009	LS-5	TAH	4.50	µg/L
6/14/2009	LS-5	Toluene	3.1	µg/L
6/14/2009	LS-5	Total Xylenes	<1	µg/L
6/14/2009	LS-5	Specific Conductivity	82.6	microS/cm
6/14/2009	LS-5	Turbidity	11.40	NTU
6/14/2009	LS-5	Turbidity	9.96	NTU
6/14/2009	LS-5	Turbidity	9.08	NTU
6/14/2009	LS-5	pH	7.75	
6/14/2009	LS-6	D.O. %	98.7	%
6/14/2009	LS-6	Temperature	12.4	Celsius
6/14/2009	LS-6	Temperature	12.6	Celsius
6/14/2009	LS-6	Benzene	1.3	µg/L
6/14/2009	LS-6	D.O. mg/L	10.48	mg/L
6/14/2009	LS-6	Ethyl Benzene	<1	µg/L
6/14/2009	LS-6	m,p Xylene	<1	µg/L
6/14/2009	LS-6	o-Xylene	<1	µg/L
6/14/2009	LS-6	TAH	5.80	µg/L
6/14/2009	LS-6	Toluene	4.5	µg/L
6/14/2009	LS-6	Total Xylenes	<1	µg/L
6/14/2009	LS-6	Specific Conductivity	82.5	microS/cm
6/14/2009	LS-6	Turbidity	12.20	NTU
6/14/2009	LS-6	Turbidity	10.96	NTU
6/14/2009	LS-6	Turbidity	10.81	NTU
6/14/2009	LS-6	pH	7.73	
6/14/2009	LS-7	D.O. %	98.1	%
6/14/2009	LS-7	Temperature	12.7	Celsius
6/14/2009	LS-7	Temperature	12.9	Celsius
6/14/2009	LS-7	Benzene	<1	µg/L
6/14/2009	LS-7	D.O. mg/L	10.34	mg/L
6/14/2009	LS-7	Ethyl Benzene	<1	µg/L
6/14/2009	LS-7	m,p Xylene	<1	µg/L
6/14/2009	LS-7	o-Xylene	<1	µg/L
6/14/2009	LS-7	TAH	2.90	µg/L
6/14/2009	LS-7	Toluene	2.9	µg/L
6/14/2009	LS-7	Total Xylenes	<1	µg/L
6/14/2009	LS-7	Specific Conductivity	82.7	microS/cm
6/14/2009	LS-7	Turbidity	12.70	NTU
6/14/2009	LS-7	Turbidity	9.68	NTU
6/14/2009	LS-7	Turbidity	10.82	NTU
6/14/2009	LS-7	pH	7.75	
6/14/2009	LS-7x	Benzene	1.9	µg/L
6/14/2009	LS-7x	Ethyl Benzene	<1	µg/L
6/14/2009	LS-7x	m,p Xylene	<1	µg/L
6/14/2009	LS-7x	o-Xylene	<1	µg/L
6/14/2009	LS-7x	TAH	6.00	µg/L

Date	Site	Measurement	Value	Units
6/14/2009	LS-7x	Toluene	4.1	µg/L
6/14/2009	LS-7x	Total Xylenes	<1	µg/L
6/21/2009	Houston	Turbidity	1.51	NTU
6/21/2009	Houston	Turbidity	4.77	NTU
6/21/2009	Houston	Turbidity	1.19	NTU
6/21/2009	Houston	Turbidity	2.52	NTU
6/21/2009	LS-1	D.O. %	96.8	%
6/21/2009	LS-1	Temperature	10.7	Celsius
6/21/2009	LS-1	Temperature	11.0	Celsius
6/21/2009	LS-1	Discharge	615.53	cfs
6/21/2009	LS-1	Benzene	1.2	µg/L
6/21/2009	LS-1	D.O. mg/L	10.67	mg/L
6/21/2009	LS-1	Ethyl Benzene	<1	µg/L
6/21/2009	LS-1	m,p Xylene	<1	µg/L
6/21/2009	LS-1	o-Xylene	<1	µg/L
6/21/2009	LS-1	TAH	3.10	µg/L
6/21/2009	LS-1	Toluene	2.1	µg/L
6/21/2009	LS-1	Total Xylenes	<1	µg/L
6/21/2009	LS-1	Specific Conductivity	86.3	microS/cm
6/21/2009	LS-1	Turbidity	6.71	NTU
6/21/2009	LS-1	Turbidity	6.16	NTU
6/21/2009	LS-1	Turbidity	6.87	NTU
6/21/2009	LS-1	pH	7.83	
6/21/2009	LS-2	D.O. %	95.8	%
6/21/2009	LS-2	Temperature	10.8	Celsius
6/21/2009	LS-2	Temperature	11.1	Celsius
6/21/2009	LS-2	Benzene	<1	µg/L
6/21/2009	LS-2	D.O. mg/L	10.55	mg/L
6/21/2009	LS-2	Ethyl Benzene	<1	µg/L
6/21/2009	LS-2	m,p Xylene	<1	µg/L
6/21/2009	LS-2	o-Xylene	<1	µg/L
6/21/2009	LS-2	TAH	1.90	µg/L
6/21/2009	LS-2	Toluene	1.9	µg/L
6/21/2009	LS-2	Total Xylenes	<1	µg/L
6/21/2009	LS-2	Specific Conductivity	88.9	microS/cm
6/21/2009	LS-2	Turbidity	8.52	NTU
6/21/2009	LS-2	Turbidity	7.35	NTU
6/21/2009	LS-2	Turbidity	7.92	NTU
6/21/2009	LS-2	pH	7.85	
6/21/2009	LS-3	D.O. %	95.7	%
6/21/2009	LS-3	Temperature	10.9	Celsius
6/21/2009	LS-3	Temperature	11.1	Celsius
6/21/2009	LS-3	Benzene	<1	µg/L
6/21/2009	LS-3	D.O. mg/L	10.52	mg/L
6/21/2009	LS-3	Ethyl Benzene	<1	µg/L
6/21/2009	LS-3	m,p Xylene	<1	µg/L
6/21/2009	LS-3	o-Xylene	<1	µg/L
6/21/2009	LS-3	TAH	1.20	µg/L
6/21/2009	LS-3	Toluene	1.2	µg/L
6/21/2009	LS-3	Total Xylenes	<1	µg/L
6/21/2009	LS-3	Specific Conductivity	87.3	microS/cm

Date	Site	Measurement	Value	Units
6/21/2009	LS-3	Turbidity	8.18	NTU
6/21/2009	LS-3	Turbidity	9.30	NTU
6/21/2009	LS-3	Turbidity	10.03	NTU
6/21/2009	LS-3	pH	7.79	
6/21/2009	LS-4	D.O. %	95.6	%
6/21/2009	LS-4	Temperature	10.9	Celsius
6/21/2009	LS-4	Temperature	11.2	Celsius
6/21/2009	LS-4	Benzene	<1	μg/L
6/21/2009	LS-4	D.O. mg/L	10.51	mg/L
6/21/2009	LS-4	Ethyl Benzene	<1	μg/L
6/21/2009	LS-4	m,p Xylene	<1	μg/L
6/21/2009	LS-4	o-Xylene	<1	μg/L
6/21/2009	LS-4	TAH	1.80	μg/L
6/21/2009	LS-4	Toluene	1.8	μg/L
6/21/2009	LS-4	Total Xylenes	<1	μg/L
6/21/2009	LS-4	Specific Conductivity	85.2	microS/cm
6/21/2009	LS-4	Turbidity	9.69	NTU
6/21/2009	LS-4	Turbidity	8.67	NTU
6/21/2009	LS-4	Turbidity	10.10	NTU
6/21/2009	LS-4	pH	7.81	
6/21/2009	LS-5	D.O. %	95	%
6/21/2009	LS-5	Temperature	11.0	Celsius
6/21/2009	LS-5	Temperature	11.2	Celsius
6/21/2009	LS-5	Benzene	<1	μg/L
6/21/2009	LS-5	D.O. mg/L	10.41	mg/L
6/21/2009	LS-5	Ethyl Benzene	<1	μg/L
6/21/2009	LS-5	m,p Xylene	<1	μg/L
6/21/2009	LS-5	o-Xylene	<1	μg/L
6/21/2009	LS-5	TAH	3.00	μg/L
6/21/2009	LS-5	Toluene	3	μg/L
6/21/2009	LS-5	Total Xylenes	<1	μg/L
6/21/2009	LS-5	Specific Conductivity	87.6	microS/cm
6/21/2009	LS-5	Turbidity	8.19	NTU
6/21/2009	LS-5	Turbidity	9.88	NTU
6/21/2009	LS-5	Turbidity	8.03	NTU
6/21/2009	LS-5	pH	7.8	
6/21/2009	LS-6	D.O. %	94.7	%
6/21/2009	LS-6	Temperature	11.0	Celsius
6/21/2009	LS-6	Temperature	11.3	Celsius
6/21/2009	LS-6	Benzene	<1	μg/L
6/21/2009	LS-6	D.O. mg/L	10.38	mg/L
6/21/2009	LS-6	Ethyl Benzene	<1	μg/L
6/21/2009	LS-6	m,p Xylene	<1	μg/L
6/21/2009	LS-6	o-Xylene	<1	μg/L
6/21/2009	LS-6	TAH	3.90	μg/L
6/21/2009	LS-6	Toluene	3.9	μg/L
6/21/2009	LS-6	Total Xylenes	<1	μg/L
6/21/2009	LS-6	Specific Conductivity	87.7	microS/cm
6/21/2009	LS-6	Turbidity	11.70	NTU
6/21/2009	LS-6	Turbidity	9.09	NTU
6/21/2009	LS-6	Turbidity	9.49	NTU

Date	**Site**	**Measurement**	**Value**	**Units**
6/21/2009	LS-6	pH	7.77	
6/21/2009	LS-7	D.O. %	94.4	%
6/21/2009	LS-7	Temperature	11.1	Celsius
6/21/2009	LS-7	Temperature	11.4	Celsius
6/21/2009	LS-7	Benzene	<1	μg/L
6/21/2009	LS-7	D.O. mg/L	10.31	mg/L
6/21/2009	LS-7	Ethyl Benzene	<1	μg/L
6/21/2009	LS-7	m,p Xylene	<1	μg/L
6/21/2009	LS-7	o-Xylene	<1	μg/L
6/21/2009	LS-7	TAH	3.10	μg/L
6/21/2009	LS-7	Toluene	3.1	μg/L
6/21/2009	LS-7	Total Xylenes	<1	μg/L
6/21/2009	LS-7	Specific Conductivity	81.6	microS/cm
6/21/2009	LS-7	Turbidity	14.50	NTU
6/21/2009	LS-7	Turbidity	11.00	NTU
6/21/2009	LS-7	Turbidity	10.53	NTU
6/21/2009	LS-7	pH	7.75	
6/21/2009	LS-7x	Benzene	<1	μg/L
6/21/2009	LS-7x	Ethyl Benzene	<1	μg/L
6/21/2009	LS-7x	m,p Xylene	<1	μg/L
6/21/2009	LS-7x	o-Xylene	<1	μg/L
6/21/2009	LS-7x	TAH	3.40	μg/L
6/21/2009	LS-7x	Toluene	3.4	μg/L
6/21/2009	LS-7x	Total Xylenes	<1	μg/L
6/28/2009	LS-1	Discharge	418.32	cfs
6/28/2009	LS-1	Benzene	<1	mg/L
6/28/2009	LS-1	Ethyl Benzene	<1	μg/L
6/28/2009	LS-1	m,p Xylene	<1	μg/L
6/28/2009	LS-1	o-Xylene	<1	μg/L
6/28/2009	LS-1	TAH	1.80	μg/L
6/28/2009	LS-1	Toluene	1.8	μg/L
6/28/2009	LS-1	Total Xylenes	<1	μg/L
6/28/2009	LS-1	Turbidity	7.86	NTU
6/28/2009	LS-1	Turbidity	9.08	NTU
6/28/2009	LS-1	Turbidity	12.60	NTU
6/28/2009	LS-1	Turbidity	9.85	NTU
6/28/2009	LS-2	Benzene	<1	μg/L
6/28/2009	LS-2	Ethyl Benzene	<1	μg/L
6/28/2009	LS-2	m,p Xylene	<1	μg/L
6/28/2009	LS-2	o-Xylene	<1	μg/L
6/28/2009	LS-2	TAH	1.80	μg/L
6/28/2009	LS-2	Toluene	1.8	μg/L
6/28/2009	LS-2	Total Xylenes	<1	μg/L
6/28/2009	LS-2	Turbidity	8.07	NTU
6/28/2009	LS-2	Turbidity	8.49	NTU
6/28/2009	LS-2	Turbidity	13.20	NTU
6/28/2009	LS-2	Turbidity	11.80	NTU
6/28/2009	LS-2	Turbidity	10.40	NTU
6/28/2009	LS-3	Benzene	<1	μg/L
6/28/2009	LS-3	Ethyl Benzene	<1	μg/L
6/28/2009	LS-3	m,p Xylene	<1	μg/L

Date	**Site**	**Measurement**	**Value**	**Units**
6/28/2009	LS-3	o-Xylene	<1	µg/L
6/28/2009	LS-3	TAH	2.30	µg/L
6/28/2009	LS-3	Toluene	2.3	µg/L
6/28/2009	LS-3	Total Xylenes	<1	µg/L
6/28/2009	LS-3	Turbidity	13.80	NTU
6/28/2009	LS-3	Turbidity	10.67	NTU
6/28/2009	LS-3	Turbidity	7.03	NTU
6/28/2009	LS-3	Turbidity	10.50	NTU
6/28/2009	LS-4	Benzene	2.3	µg/L
6/28/2009	LS-4	Ethyl Benzene	<1	µg/L
6/28/2009	LS-4	m,p Xylene	<1	µg/L
6/28/2009	LS-4	o-Xylene	<1	µg/L
6/28/2009	LS-4	TAH	5.40	µg/L
6/28/2009	LS-4	Toluene	3.1	µg/L
6/28/2009	LS-4	Total Xylenes	<1	µg/L
6/28/2009	LS-4	Turbidity	12.70	NTU
6/28/2009	LS-4	Turbidity	9.17	NTU
6/28/2009	LS-4	Turbidity	11.90	NTU
6/28/2009	LS-4	Turbidity	11.30	NTU
6/28/2009	LS-5	Benzene	2	µg/L
6/28/2009	LS-5	Ethyl Benzene	<1	µg/L
6/28/2009	LS-5	m,p Xylene	<1	µg/L
6/28/2009	LS-5	o-Xylene	<1	µg/L
6/28/2009	LS-5	TAH	4.60	µg/L
6/28/2009	LS-5	Toluene	2.6	µg/L
6/28/2009	LS-5	Total Xylenes	<1	µg/L
6/28/2009	LS-5	Turbidity	9.63	NTU
6/28/2009	LS-5	Turbidity	10.73	NTU
6/28/2009	LS-5	Turbidity	9.14	NTU
6/28/2009	LS-5	Turbidity	9.80	NTU
6/28/2009	LS-6	Benzene	2	µg/L
6/28/2009	LS-6	Ethyl Benzene	<1	µg/L
6/28/2009	LS-6	m,p Xylene	<1	µg/L
6/28/2009	LS-6	o-Xylene	<1	µg/L
6/28/2009	LS-6	TAH	4.60	µg/L
6/28/2009	LS-6	Toluene	2.6	µg/L
6/28/2009	LS-6	Total Xylenes	<1	µg/L
6/28/2009	LS-6	Turbidity	11.50	NTU
6/28/2009	LS-6	Turbidity	13.60	NTU
6/28/2009	LS-6	Turbidity	9.13	NTU
6/28/2009	LS-6	Turbidity	11.40	NTU
6/28/2009	LS-7	Benzene	2.2	µg/L
6/28/2009	LS-7	Ethyl Benzene	<1	µg/L
6/28/2009	LS-7	m,p Xylene	<1	µg/L
6/28/2009	LS-7	o-Xylene	<1	µg/L
6/28/2009	LS-7	TAH	5.20	µg/L
6/28/2009	LS-7	Toluene	3	µg/L
6/28/2009	LS-7	Total Xylenes	<1	µg/L
6/28/2009	LS-7	Turbidity	13.60	NTU
6/28/2009	LS-7	Turbidity	15.50	NTU

Date	**Site**	**Measurement**	**Value**	**Units**
6/28/2009	LS-7	Turbidity	14.00	NTU
6/28/2009	LS-7	Turbidity	14.40	NTU
6/28/2009	LS-7x	Benzene	2	µg/L
6/28/2009	LS-7x	Ethyl Benzene	<1	µg/L
6/28/2009	LS-7x	m,p Xylene	<1	µg/L
6/28/2009	LS-7x	o-Xylene	<1	µg/L
6/28/2009	LS-7x	TAH	4.80	µg/L
6/28/2009	LS-7x	Toluene	2.8	µg/L
6/28/2009	LS-7x	Total Xylenes	<1	µg/L
6/28/2009	Miller's Reach	Turbidity	2.92	NTU
6/28/2009	Miller's Reach	Turbidity	5.81	NTU
6/28/2009	Miller's Reach	Turbidity	4.17	NTU
6/28/2009	Miller's Reach	Turbidity	4.30	NTU

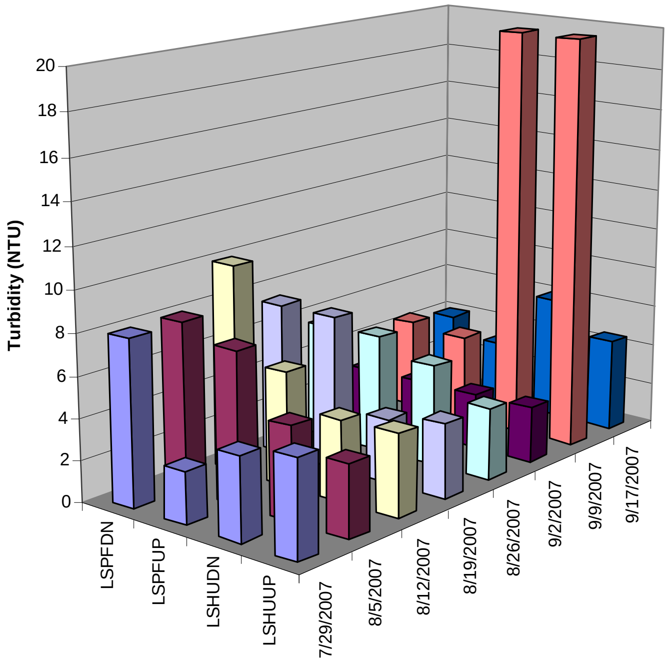
Appendix B. Sampling Plan and QAPP

Quality Assurance Project and Sampling Plan

Water Quality Evaluation of the Lower Little Susitna River

July 2008

(Revision Number 2.0)



ALASKA
Department of
Environmental
Conservation

ARRI
Aquatic Restoration & Research Institute

Jeffrey C. Davis and Gay A. Davis
P.O. Box 923 Talkeetna, Alaska
(907) 733.5432. www.arrialaska.org

A1. Water Quality Evaluation of the Lower Little Susitna River

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

Ms. Laura Eldred
Alaska Department of Environmental Conservation
1700 E. Bogard Rd., Bldg B, Ste 103
Wasilla, Alaska 99654
Ph: 907-376-1855
laura.eldred@alaska.gov

Mr. Jim Gendron
DEC Quality Assurance Officer
410 Willoughby Ave., Ste 303
PO Box 111800
Juneau, AK 99811-1800
Ph: 907-465-5305
jim.gendron@alaska.gov

A4. Project/Task Organization

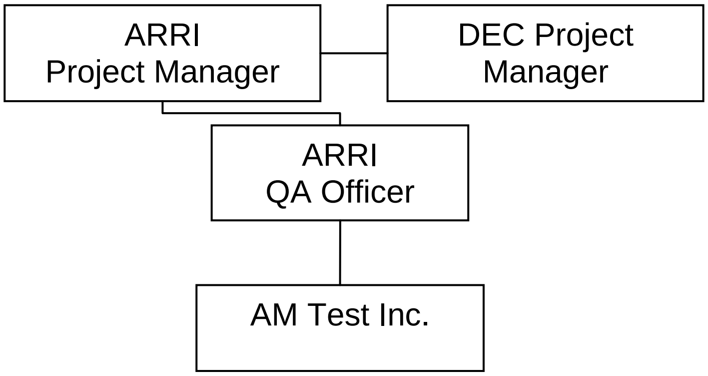
The Project Manager listed below will be responsible for all project components including data collection, entry, analyses, and reports.

Laura Eldred (DEC) DEC Project Manager. Ms. Eldred will oversee the project for DEC, provide technical support, QAPP review and approval, and the review of all quarterly reports and the final report.

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.

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.

AM Test Inc.—Redmond, WA. The testing laboratory will be responsible for analyzing all collected water chemistry samples.



A5. Problem Definition/Background

The Little Susitna River flows from the Talkeetna Mountains to Cook Inlet. The river flows through the Hatcher Pass State Recreation Area, the residential communities of Wasilla and Houston, the Nancy Lake State Recreation Area and the Susitna Flats State Game Refuge. The Little Susitna River is one of the rivers managed under the Susitna Area Recreational Rivers Management Plan. The river supports a highly popular salmon and trout fishery as well as recreational non-motorized and motorized boating. There is a relatively high degree of residential development between Edgerton Park Road and Schrock Road, adjacent to the city of Wasilla, and the city of Houston. The lower river, from Houston to the Public Use Facility (PUF), is a popular recreational area for motorized and non-motorized boating, camping and sport fishing. Potential impacts to the lower river segment are from the residential development adjacent to the city of Houston, and recreation, primarily boat-accessed sport fishing, with over 11,000 angler days in 2007 at the Public Use Facility. There are two areas of concentrated motor boat use, from Houston to Lake Creek and from 3 miles upstream of the public use site downstream to near Cook Inlet.

Recreation use also can cause an increase in sediment delivery rates and toxic hydrocarbons. Fine sediment delivery rates can increase with increasing bank failures due to the removal of bank vegetation with foot traffic. Boat waves also can increase bank failure rates and sediment delivery by eroding bank materials. Motor boats can deliver toxic hydrocarbons through fuel and oil leaks, spills or the inefficient combustion of engines, fuel spills, and bilge pumping.

Water quality sampling was conducted from July 2007 through June 2008 to determine the location and extent of potential hydrocarbon and turbidity contamination of the Little Susitna River. Sampling was conducted week through the fall coho fishery (July and August of 2007) and spring Chinook fishery (May and June of 2008) above and below the city of Houston and the Miller’s Reach undeveloped boat launch and above and below the Public Use Facility. Preliminary results indicate total aromatic hydrocarbon concentrations exceeded state water quality standards adjacent to the Public Use Facility boat launch during the coho and Chinook fisheries. Stream water turbidities increased above background levels and periodically exceeded state standards.

The objectives of this project are to further identify the extent and duration of hydrocarbon contamination and changes in turbidity adjacent to the developed boat launch at the Public Use Facility. Hydrocarbon concentrations will be evaluated relative to boat use and motor type (2-cycle or 4-cycle engines), operation time, and stream flows. Secondary objectives include evaluating potential impacts to the macroinvertebrate and fish communities within affected areas.

A6. Project/Task Description Total Aromatic Hydrocarbons

This project has been designed to evaluate potential hydrocarbon contamination of the Little Susitna River and increases in turbidity near the public use facility. This will be accomplished by collecting water samples and analyzing them for Total Aromatic Hydrocarbons (TAH) and comparing to the State Water Quality Standard in 18 AAC 70. Water samples will be collected during times of heavy boat use during the recreational sport fisheries and during times of low boat use. Samples will be collected above and below high boat concentration use areas. Observations of boat motor type and duration within the sampling reach, and measures of discharge will be used to evaluate hydrocarbon inputs from boat use. Turbidity within heavy use areas will be compared to upstream reference locations.

OBJECTIVE 1: Quantify the spatial and temporal distribution of TAH concentrations adjacent to the public use facility and determine the relationship between 2-stroke motor use, stream flow, and TAH concentrations.

TASK 1: QAPP and Sampling Plan Approval

Start and end date: July 1, 2008 – July 31, 2008

Description: The ARRI project manager will modify the existing approved Quality Assurance Project Plan and Sampling Plan for DEC review and approval. Previously approved QAPP and Sampling Plan will be modified for the specific project tasks. These documents will describe in detail the frequency, duration, and location of all proposed sampling, including those listed under separate objectives. They will identify the equipment that will be used and how the equipment will be calibrated and maintained. It will describe the analytical methods that will be used and who will be handling and analyzing the water samples. The methods that will be used to determine data accuracy, precision, and completeness will be outlined. Data handling, management and reporting will be described. It will detail the responsibilities of all staff members and contractors and who will be responsible for each phase of the project. A draft QAPP and Sampling Plan will be completed within 3 days of receiving DEC authorization to work. The project manager will coordinate with the DEC project manager to address any inadequacies in the documents. ARRI will focus on completing this task as soon as possible.

Product: DEC approved QAPP and Sampling Plan.

TASK 2: TAH Sampling and Analyses

Start and end date: July 1, 2008 – June 30, 2009

Description: Water samples for TAH analyses will be collected at locations above and below the PUF during peak use times, and at a non-peak use time for comparison, that coincide with the fall coho salmon, and spring Chinook salmon fisheries. Fall sampling will begin in late July and extend through August. Spring sampling will begin in mid May and extend through June. Samples will be collected weekly on weekends, for seven weeks with more frequent sampling to coincide with peak use. Sampling locations will be at 1.0 km upstream of the PUF, 0.5 km upstream, at the PUF, 0.5 km downstream, 1.0 km downstream, 2.0 km downstream, and 4.0 km downstream. Water samples will be collected in sample containers provided by a commercial laboratory. Sampling will use the sampler and methods developed by the U.S.G.S. Samples will be preserved and shipped immediately to the laboratory for analyses. One duplicate sample will be collected and submitted on each sampling date. A portion of the sample also is held by the laboratory for repeat analyses if necessary. The laboratory will use EPA method 624 or as directed by DEC. The exact methodology will be described in detail within the QAPP and approved by DEC prior to beginning sample collection.

Product: Concentration of TAH and BETX during heavy use times at multiple locations surrounding the PUF. Data will be presented within the draft and final reports or as requested by the DEC project manager.

TASK 3: Determining 2-cycle (not fuel injected) Motor Use and Discharge

Start and end date: July 1, 2008 – June 30, 2009

Description: The most likely source of hydrocarbon input to the Little Susitna River will be quantified along with stream flow dilution. These parameters will be used to model expected concentrations to compare with analytical values. Model parameters include the size and running time 2-cycle engines are operating within the sampling reach. On water sampling dates, we will observe the boats at the launch, either leaving or returning, and report for each boat with a 2-cycle motor, motor size, and time (minutes) engine is running at launch. We will estimate the time within the reach based upon average time to travel 4 km. We also will obtain data from the entry station on the number of boats entering the launch on each sampling date, and if possible, the size and type of motor. Comparisons between our counts and the station counts will provide a check on the accuracy of observations. Discharge will be measured at 1.0 km upstream from the public use facility. We will obtain direct measures of discharge by wading when flows allow or by wading and boat when necessary.

Product: The relative number and use of 2-cycle motors in comparison to total number of boats and measures of discharge. A model of hydrocarbon inputs and a comparison with analytical measures. Data will be presented in the draft and final reports or as directed by the DEC project manager.

OBJECTIVE 2: Quantify changes in turbidity and determine if there are differences in the abundance of prey items or the catch rate of juvenile salmonids during the coho fishery above and below areas of peak use.

TASK 4: Quantify Changes in Turbidity

Start and end date: July 1, 2008 – June 30, 2009

Description: Turbidity within the Little Susitna River will be measured above and below the PUF during heavy use times. Turbidity would be measured from grab samples collected at times and location concurrent with TAH sampling. Turbidity also will be determined from continuous data loggers (HACH Mini-Sondes) placed upstream of the area of heavy use and at 1.0 km downstream from the PUF. Loggers will be deployed during and following concentrated use during the coho and Chinook fishery.

Product: Stream water turbidity comparing reference and potentially impacted stream reaches.

TASK 5: Evaluate the Abundance of Prey and Juvenile Salmonids

Start and end date: July 1, 2008 – June 30, 2009

Description: Sampling will be conducted to evaluate the relative catch rate of juvenile salmon and prey items in drift. Sampling will be conducted during peak boat use during the coho (fall 2008) and Chinook (spring 2009) sport fisheries at sampling locations above and within peak use areas. Juvenile salmon will be captured in baited minnow traps. Traps will be placed on outside bends within areas of similar depth, velocity, and cover. Traps will be removed after 12 to 24-hours soak time. All captured fish will be counted, identified, and measured. Fish will be observed for DELT (Deformities, Eroded fins, Lesions, or Tumors) anomalies per U.S.G.S. methodology.

Macroinvertebrate drift is a measure of the relative food available for juvenile fish. Stream macroinvertebrates will be collected from drift nets placed above and within peak use areas. Drift nets will be placed just below the water surface. Nets will be left in place until debris within the mesh begins to diminish flows. Water velocity will be measured at the net opening at placement and prior to removal in order to calculate the total volume of filtered water. Samples will be combined for a composite for each site. All invertebrates within the sample will be identified to the lowest possible taxonomic level.

Product: The resulting data will be provided within the final report. Results will determine differences in biotic parameters between sites that have heavy boat use and adjacent reference sites.

OBJECTIVE 3: Obtain baseline measures of water chemistry and temperature.

TASK 6: Measure Basic Water Chemistry and Temperature

Start and end date: July 1, 2008 – June 30, 2009

Description: Water samples will be analyzed for pH, specific conductivity, and dissolved oxygen. Stream water temperature will be measured continuously using HOBO Water Temp pro data loggers. Water samples will be collected concurrently with samples collected for TAH and turbidity. Dissolved oxygen concentration, percent saturation, pH, and temperature will be measured in the field; specific conductivity and turbidity will be analyzed in the laboratory. Temperature data loggers will be placed upstream and at 1 km downstream from the PUF. Loggers will be placed in an area that is well mixed and will record temperature at 15 minute intervals. More details on sampling methods, sample locations, sample frequency and sample analyses will be provided within the QAPP and adjusted as directed by the DEC project manager.

Product: Basic water chemistry and temperature data at a reference location and at a recreational use area. Data will be presented in draft and final reports.

TASK 7: Data Formatting for STORET, Draft and Final Reports

Start and end date: June 1, 2009 – June 30, 2009

Description: Sampling locations, dates, methods, and resulting measurement values will be formatted for uploading into the STORET database. Data will either be transferred to DEC or uploaded by ARRI staff.

Draft and final written reports will be prepared. The final report will provide background information and describe the project need, objectives, and the approach that was taken to meet the objectives. Field methods will be described and the project QAPP and sampling plan will be attached. All of the data results will be presented and described relative to the project objectives. We will make recommendations on further data collection, if necessary, and the potential causes and sources of increases in TAH if they occur. Data will be discussed relative to water quality standards and potential impact to aquatic biota. Project success will be determined based upon the completeness of data collection and on whether project objectives were accomplished.

Product: The draft report will be submitted to the DEC project manager by the end of the 3rd Quarter. Comments on the draft document as well as spring data results will be incorporated and a final document submitted prior to the end of July 2009, or as requested by the DEC project manager.

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 1. 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%
Specific Conductance (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%
TAH (mg/L)	EPA 624	0.001	0.001 to 0.01	75 to 125	20%	90%
Total Fecal Coliforms (cfu)	SM9222D	1	0 to 300	N/A	25%	90%
Juvenile Fish	Baited minnow traps	1	0 to 50	N/A	N/A	90%
Macroinvertebrates	Drift Nets	1	300	N/A	N/A	90%
Temperature (°C)	HOBO	0.1	0 to 15	97 to 103 @ 15°C	5%	90%
Discharge (cfs)	Sum of Component Flow	1.0	200 to 600	N/A	20%	90%
Boat Counts	Observations	1.0	0 to 20	N/A	5%	90%

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 discussed in Section B of this QAPP.

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

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 and Precision

The percent accuracy and precision for the acceptance of data is shown for each parameter in Table 1.

Water Chemistry. 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. The accuracy of sonde turbidity measures will be determined using known standards before and after deployment. Precision will be determined through comparisons with grab samples. Measurement accuracy will be determined for each sampling event. Contract laboratories will provide the results of accuracy measures along with chemical analytical reports. Sample analytical precision will be determined by obtaining a sample replicate at one site on all sampling dates. For aromatic hydrocarbons, duplicate samples will be collected at all sampling sites on all dates which can be used for additional precision measures if necessary. Trip blanks will be carried on all sampling events to test for contamination from external sources.

Temperature. 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 be checked at two known temperatures, 0°C and 20°C, prior to deployment and upon retrieval.

Fish. Fish identification and counts will be assumed accurate. ARRI staff are well trained in the identification of juvenile salmon and other common fish species often captured within minnow traps. Similarly, it is assumed that a repeat count of fish collected within a trap will result in the same value.

Macroinvertebrates. There is no known standard that can be used to check the accuracy of the macroinvertebrate drift samples. Measurement duplicates likely will produce different results. At least three replicates will be collected above and within the heavy use area. Differences in the abundance and community composition of macroinvertebrates will be based on statistical tests and data will be presented as means with standard deviations to demonstrate site variability in macroinvertebrate data.

Discharge. Accuracy cannot be checked against a known value. Precision of measures will be calculated from replicate discharge measures conducted twice each season.

Boat Use. The precision of boat use observations will be calculated by having two independent observers count boat use, motor type and size on the same date and compare results.

Representativeness

The site location, 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.

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. Due to the size of the Little Susitna River the completeness of some measures may be reduced due to high flows.

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 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 16 years of experience in stream restoration and evaluation.

Chemical analyses will be conducted through AM Test Inc., in Redmond Washington. AM Test Inc., has been accredited by Washington State Department of Ecology for drinking water, waste water and solid matrix chemical analyses.

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 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. Laboratory reports will be received as paper and electronic files. Copies of the laboratory reports will be included within the final report.

The project reporting requirements are as follows:

- Quarterly Reports: Quarterly progress, financial, and MBE/WBE reports will be submitted for the periods ending **September 30, 2008**, **December 31, 2008 and March 31, 2009.** Reports are due 15 days after the final date of the quarter and are considered late if received more than 15 days after these dates. A final progress, financial, MBE/WBE reports, and all required deliverables are due **July 31, 2009, and are considered late if received after that date**. 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 provided to the DEC in accordance with the guidance and templates provided 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). All data collected by Dec 31, 2008 will be furnished to DEC by March 31, 2009, and all data collected by the project will be furnished to DEC by July 31, 2009.

- Project Photographs. At least 3 electronic photograph(s) of the project will be submitted in a format suitable for publishing. Additional project photos are appreciated. 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_101608". Alternatively, it may be provided with a caption that states the date, location, and describes the subject: for example "MCV-023X.JPG. Taken 10-16-08, 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 the description of the spatial and temporal extent of total aromatic hydrocarbon concentrations within the Little Susitna River adjacent to the Public Use Facility. The environmental benefits will be determined by the description of the spatial and temporal extent of turbidity changes relative to activity surrounding sport fisheries in the lower Little Susitna River.

- 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.

QAPP and Sampling Plan	July 31, 2008
Draft Final Report	April 15, 2009
Final Report	July 31, 2009

B1. Sampling Process Design

The sampling design consists of obtaining water samples for TAH analyses at river locations and times with heavy boat use and at locations and times with little or no boat use. Background water chemistry and water temperature will be obtained at the same time. Sampling is designed to occur before, during and after the coho salmon fishery in 2008 and before and during the Chinook fishery in 2009. Sampling locations are upstream of and within areas heavily used for boat-accessed fishing. Sampling sites will be located above and below the Public Use Facility. The timing and intensity and type of boat use on the Little Susitna River will be obtained through survey data collected by State Park staff at the Public Use fee station and by observations during water sampling. Turbidity within the heavy use areas will be determined using data loggers and grab samples. One data logger will be placed well upstream of most boat use and provide reference measurements. The second logger will be placed within the heavy use area approximately 2 km below the boat launch. Loggers will be placed on the edge of the thalweg on outside stream bends in water depths of at least 0.5 m.

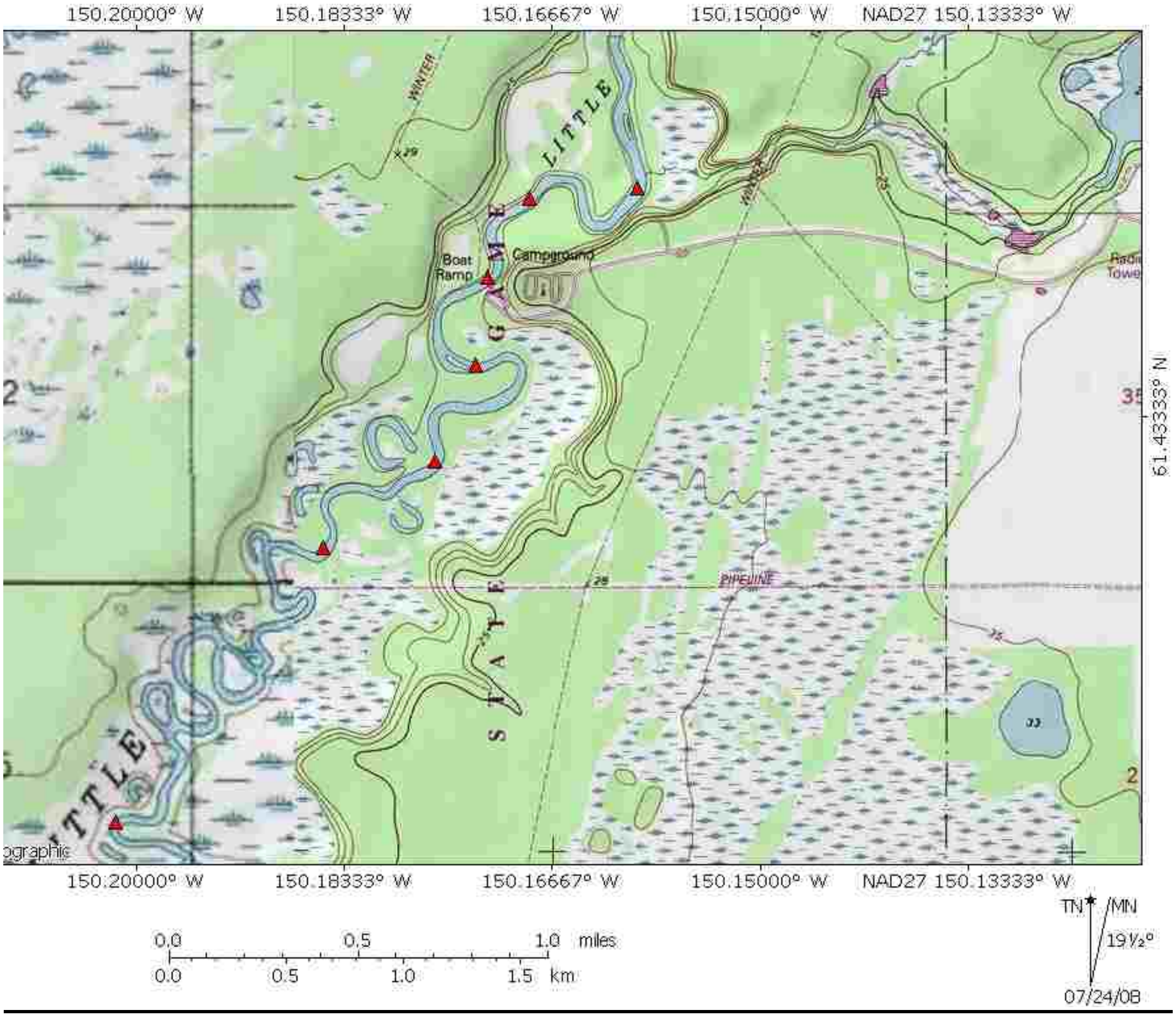


Figure 1. Map of the Little Susitna River in the vicinity of the Public Use Facility and boat launch showing sampling locations (red triangles).

Grab samples will be collected concurrent with TAH sampling (at the furthest upstream and downstream locations). Turbidity will be measured at turbidity logger locations upon deployment, battery checks, and removal. The potential influence of elevated TAH concentrations and turbidity on the biotic community will be determined through measures of macroinvertebrates and fish. Macroinvertebrates will be collected from the drift at reference and heavy use areas. Juvenile salmon will be captured in baited minnow traps from reference and heavy use areas.

Sampling Locations

The sampling locations for TAH will be distributed from 1.0 km above the public use site to 4.0 km downstream. Samples will be collected from 1.0 km and 0.5 km above the boat launch, at the boat launch, and 0.5 km, 1.0 km, 2.0 km and 4.0 km below the boat launch (Figure 1). Basic water chemistry will be conducted at two locations (furthest upstream and furthest downstream sampling locations).

Continuous measures of turbidity, macroinvertebrate, and fish sampling will be conducted above and below the public use site. Reference samples will collected approximately 5.0 km upstream of the boat launch, which is above most boat-accessed fishing. Samples within the heavy use area will be collected approximately 2.0 km below the public use site.

Discharge will be measured 1.0 km upstream of the boat launch. Observations of boat use by motor type will be conducted at the boat launch.

Sample Parameters

Water samples collected weekly from the seven sampling sites will be analyzed for the following parameters.

- 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 in the field using a calibrated portable meter (Hanna HI 9023 or equivalent).
- Turbidity (NTU). This measures the reflective properties of the water sample relative to the amount of organic and inorganic particles. Turbidity will be measured in the laboratory from grab samples using a Turbidimeter (LaMotte TC-3000e) and *in situ* using Hach Minisonde MS5.
- 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 laboratory 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) in the field.
- Total Aromatic Hydrocarbons (Gasoline)—Water samples will be collected by ARRI and submitted to AM Test Inc. for analyses using EPA 624 methodology. Samples will be collected using the sampler and methodology developed through the U.S. Geological Survey NAWQA program (Shelton 1997). See Appendix A. Duplicate samples will be collected from each sampling site on each sampling date. Field blanks will be collected and trip blanks will be carried and submitted with samples for analyses.
- Temperature (°C). Water temperature will be measured at 15 minute intervals using Water Temp Pro 2 data loggers (Onset Corporation). Temperature loggers will be placed at Millers Reach, and downstream of the public use site.
- Boat use. Boat use at the Public Use Facility is monitored by Alaska State Park staff at the launch fee area. They record the number of boats by date and the approximate boat length. Park staff also will record the type (2-cycle or 4-cycle) of motor. During the hydrocarbon sampling period, we will keep a log of all boats observed, note motor type based on upon cowling wording and size, and duration of time in the reach. If we are unsure of boat motor type, we will attempt to ask the boat owner or place a question mark by the notation.

- Macroinvertebrates. Macroinvertebrates will be collected using drift nets. Three replicate drift samples will be collected from reference and potentially impacted locations. Samples will be preserved and returned to the laboratory for identification. Measures of invertebrate abundance and community composition will be compared between locations.
- Juvenile Salmon. Juvenile salmon and other fish will be captured in baited minnow traps. A minimum of 10 baited minnow traps will be fished for 12 to 24 hours. All of the fish will be identified, observed for abnormalities, and measured for fork length.

Sampling Frequency

Water Chemistry. Sampling frequency is designed to provide data before and after heavy use periods. Heavy use occurs during the Chinook and coho salmon fisheries. The Chinook fishery begins the first or second week in June in the lower river near the Public Use Facility and extends into the first week of July. The coho salmon fishery begins near the end of July and extends through August. Sampling will occur weekly for 7 weeks before, during and following the coho fishery and before and during the Chinook fishery.

Table 2. Sampling frequency, location, and timing for each measurement parameter.

Parameter	Locations	Frequency/samples	Timing	Total Samples *
TAH	8*	Weekly for 7 Weeks in August and September 2008, with biweekly (twice per week) sampling during peak use. Weekly for 7 Weeks in May and June 2009, with biweekly samples during peak use/16	Mid-Day	128
pH, Specific Conductance, Turbidity, Dissolved Oxygen	2	Concurrent with TAH Sampling/16	Mid-Day	32
Water Temperature	2	Continuous	15 minute intervals	N/A
Discharge	1	Concurrent with water sampling	Mid-Day	14
Macroinvertebrates	2	During peak coho and Chinook fisheries	Mid-Day	4
Fish	2	During peak coho and Chinook fisheries	12 to 24 hours	4

* includes replicate samples for precision calculations.

Turbidity

The Sonde will be placed within the stream channel to record turbidity at reference and potentially impacted locations for 3 weeks during the fall coho fishery and for 3 weeks during the spring Chinook fishery. The Sonde will be programmed to record turbidity at hourly intervals.

Macroinvertebrates and Fish

Macroinvertebrates and juvenile salmon will be sampled on one day during the peak of the coho fishery and during the peak of the Chinook fishery.

Sample Timing

Water samples will be collected weekly on Saturday or Sunday between 12:00 and 16:00 hours.

External Data

Discharge data will be obtained from the USGS web site (http://nwis.waterdata.usgs.gov/ak/nwis/dv/?site_no=15290000&agency_cd=USGS) and weather data will be downloaded from the National Climate Data Center (http://www.ncdc.noaa.gov/oa/ncdc.html).

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 upstream, downstream and across the channel at each site. Photographs also will be used to document boating activity and concentration. Sampling will occur on Saturday or Sunday of each week. Measures of dissolved oxygen and pH will be conducted in the field. Samples for turbidity 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. TAH sampling will be conducted using the sampler and methods described below, and samples preserved and shipped for laboratory analyses.

pH, Specific Conductance, Turbidity, 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 from well mixed samples will be measured using appropriate meters. Meters, pH, Hanna HI 9023, conductivity, SPER Scientific model 840039, and turbidity, LaMotte TC-3000e. Support equipment will include extra batteries and sample bottles. Clean sample bottles will be used. All meters will be tested and calibrated prior to use. Dissolved oxygen and pH will be measured in situ. Water samples will be returned to the ARRI laboratory for turbidity and specific conductance measures.

Continuous (hourly) measures of turbidity will be collected using a Hach mini-sonde MS5. The sonde will be suspended in the water column from a cable attached to overhanging vegetation.

The sonde will be positioned near the thalweg on the outside of a meander bend. The sonde will be calibrated using turbidity standards prior to deployment.

Materials Required: Data book, pencils, sharpie, 500-ml sample bottles (16 minimum), 60-ml syringe, cooler, gel-paks, pH meter with standards, Hach Sondes, turbidity calibration standard, cable, extra batteries, turbidimeter, dissolved oxygen meter, thermometer, extra batteries, and camera.

Macroinvertebrates

Macroinvertebrates will be captured as they drift within the water column. Drift nets (363 µm mesh) (3) will be secured below the water surface. A velocity meter (General Oceanics) will be placed within the opening of the net. The drift net will remain in place until velocity at the inlet decreases indicating that the net mesh is filling with debris. The total sample will be transferred to a sample container (500 ml nalgene bottle) labeled (site name, location, date, replicate) and preserved with ethanol. The sample will be returned to the laboratory. All invertebrates will be removed from the sample and identified to the lowest taxonomic level, generally genus.

Materials Required: Drift nets, rebar or metal fence posts, flagging, bucket, 250 µm sieve, sample bottles, labels, ethanol, and hammer.

Juvenile Salmon

Fish will be collected in 10 baited minnow traps soaked for 12 to 24 hours. Captured fish will be identified, measured to fork length, and observed for deformities, eroded fins, lesions or tumors (DELT anomalies) using the USGS NAWQA methodology (Moulton II et al. 2002).

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

Total Aromatic Hydrocarbons (TAH)

Samples will be collected in accordance with the USGS report "Field guide for collecting samples for analysis of volatile organic compounds in stream water for the national Water Quality Assessment Program (USGS Open File Report 97-401)." This report contains detailed instructions on sample collection procedures (Appendix A) using the USGS-designed VOC sampler distributed by Wildco. Prior to sample collection, the VOC sampler will be decontaminated in Alconox (or similar detergent) and rinsed thoroughly in the river for a few minutes.

Samples will be collected in sample bottles obtained from the contract laboratory. One sample to be analyzed for TAH will be collected (2 vials) from each lowering of the sampler. Samples will be collected at least 12 cm below the water surface and away from any observable sheen. Sampling locations will be accessed by boat or foot. When sampling from the boat, the boat will be anchored, the motor turned off for 5 minutes prior to a sample being collected upstream off of the bow. The samples will be collected adjacent to the thalweg. A rope will be attached to the sampler cables and the sampler lowered into the flowing water until the sampler opening is at 0.5 stream depth. The attached rope and weighted sampler will be used to keep the sampler upright.

HCl acid, provided by the contract laboratory, will be added to each vial after sample collection for preservation and capped (~1 drop). Clean vinyl gloves will be worn at all times when handling sampling bottles. The samples will be checked to ensure that there are no air bubbles after capping. The sample bottles will be dried, labeled using adhesive labels, placed within a cooler on frozen gel-paks and shipped to the contract laboratory. Sample temperatures will be recorded by the contract laboratory upon receipt using a laser thermometer. Trip blanks provided by the contract laboratory will accompany the sample bottles during collection, shipping, and analyses. Field blanks will be collected at the end of each sampling event by submerging the sampler in a stainless steel pot filled with municipal well water.

<u>Materials Required</u>: Sample bottles, labels, hydrochloric acid, dropper, Alconox, VOC sampler, rope and carabineer, gel-paks, cooler, thermometer, 100 ml water bottle, laboratory chain-of-custody forms, and gloves.

Temperature
Stream water temperature data loggers will be placed within the stream at two locations. Loggers will be secured to the bank using plastic coated wire rope. Loggers will be downloaded at least monthly.

<u>Materials Required</u>: 4-m sections of wire rope, clamps, temperature data loggers with backup, software, base station, coupler, and shuttle.

Discharge
Discharge will be measured using the sum of individual components method of Rantz et al. (1982). Velocity will be measured using a Swoffer 3000 velocity meter and wading rod. Lateral distance will be measured using a meter tape or distance finder.

<u>Materials Required</u>: Velocity meter and wading rod, and distance finder or 50-meter tape.

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. Field samples that are to be transferred to the contract laboratories will be placed within a cooler and the cooler sealed closed using plastic packing tape. Samples will be transported or shipped 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 delivered to the commercial laboratory for subsequent analyses by the identified standard method. Dissolved oxygen and pH will be measured in the field. Turbidity and specific conductance will be analyzed at the ARRI laboratory.

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.

Table 3. List of Analytical methods and detection limits for study parameters.

Measurement	**Collection/ Analyses**	**Method**	**Limits**	**Turnaround Time (days)**
Total Aromatic Hydrocarbons	ARRI/ AM Test Inc	EPA 624	0.001 mg/L	14-21
Temperature	ARRI	Temperature logger	0.1 Degree C	Weekly Download
pH	ARRI/ARRI	Meter (Hanna HI 9023)	0.01 pH units	15 minutes
Conductivity	ARRI/ARRI	Meter (SPER 840039)	0.1 mhos (0 to 200) 1.0 mhos (>200)	1
Turbidity	ARRI/ARRI	Meter (HACH Model 16800)	0.1 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)	15 minutes
Discharge	ARRI	Swoffer 3000 Velocity Meter	0.1 cfs	1
Macroinvertebrates	ARRI	Invertebrate Drift (Hauer and Resh 2007)	1	6 Months
Fish	ARRI	Minnow Trap	1	1

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 the 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.

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, discharge, and pH), duplicate instruments and meters are available. In the case of complete equipment failure, new equipment will be purchased. The VOC sampler is on loan from the State of Alaska. The sampler is of simple and sturdy construction. If damaged we will first, attempt to repair the sampler, second, attempt to borrow a second sampler from the State, and if none are available, we will work with DEC to develop an alternative sampling method The Project Manager will be responsible for calibrating, 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.

Table 4. Field and laboratory replicates for quality control.

Parameter	**Field Replicates**	**Laboratory Replicates**	**Comments**
pH, Specific Conductivity, Turbidity, Dissolved Oxygen	14 %	14%	Replicate measurements one of every 7 samples.
TAH	14 %	10%	Duplicate sample collected at one of the sites and a trip blank for every sampling event.
Temperature	1%	None	Water temperature will be measured on each sampling event with meters and compared with temperature logger readings. Loggers will be placed in the same location for 24 hours and reading compared.
Discharge	10%	N/A	Duplicate discharge measure will be collected on every 10th sampling date (twice each field season).
Macroinvertebrates	N/A	N/A	Replicate samples will be collected to determine variability.
Fish	N/A	N/A	10 replicates will be collected to determine variability in catch rate.

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. The velocity meter will be calibrated and checked for accuracy following the manufacturer's recommendation. Calibration will be checked monthly. Standards are required for pH, and turbidity and conductivity.

B8. Inspection/Acceptance Requirements for Supplies and Consumables

Sample containers will be obtained from AM Test Inc. 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

Discharge data will be obtained from the USGS web site (http://nwis.waterdata.usgs.gov/ak/nwis/dv/?site_no=15290000&agency_cd=USGS) and weather data will be downloaded from the National Climate Data Center (http://www.ncdc.noaa.gov/oa/ncdc.html) for the Anchorage Airport. Data from both of these sources will be assumed accurate for the locations where collected. Flow data from the USGS site located near Hatcher Pass will be compared with direct measures to determine whether it is representative of sampling locations.

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.

Along with presenting project data in easy to understand tables and graphs in the final project report, the 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.dec.state.ak.us/water/wqsar/storetdocumentation.htm).

C1. Assessments and Response Actions

Project assessment will primarily be conducted through the preparation of 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 Quality Assurance Officer 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.

C2. Reports to Management

Quarterly 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. 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 in 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

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Appendix A. USGS Open File Report 97- 401

FIELD GUIDE FOR COLLECTING SAMPLES FOR ANALYSIS OF VOLATILE ORGANIC COMPOUNDS IN STREAM WATER FOR THE NATIONAL WATER-QUALITY ASSESSMENT PROGRAM

By Larry R. Shelton

U.S. GEOLOGICAL SURVEY
Open-File Report 97-401

Sacramento, California
1997

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Gorden P. Eaton, Director

For printed copies of the published report contact:

U.S. Geological Survey
Field Technical Support, NAWQA
Placer Hall, 6000 J St.
Sacramento, Ca. 95819

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CONVERSION FACTORS, ABBREVIATIONS, AND ACRONYMS

Conversion Factors

Multiply	By	To obtain
foot (ft)	0.3048	meter
gallon (gal)	3.785	liter
inch (in.)	25.4	millimeter

Temperature is given in degrees Celsius (C), which can be converted to degrees Fahrenheit (F) by the following equation: F=1.8(C)+32

Abbreviations

L, liter
mg/L, microgram per liter
mL, milliliter
lb, pound

ASR, analytical services request
DIW, deionized water
FS, field spike
FSR, field-spike replicate
HCL, hydrochloric acid
ID, identification

QA, quality assurance
QC, quality control
VBW, pesticide/volatile blank water
VG, VOC grade blank
VOC, volatile organic compound

Acronyms

NAWQA, National Water-Quality Assessment
NWQL, National Water Quality Laboratory
USGS, U.S. Geological Survey
WRD, Water Resources Division

GLOSSARY

Environmental Setting -- Land areas characterized by a unique, homogeneous combination of natural and human-related factors, such as row-crop cultivation on glacial-till soils.

Gaging station -- A fixed site on a stream or river where hydrologic and environmental data are collected.

Indicator Sites -- Stream sampling sites located at outlets of drainage basins with relatively homogeneous land use and physiographic conditions. Basins are as large and representative as possible, but still encompassing primarily one Environmental Setting (typically 50 to 500\x11km2).

Integrator Site -- Stream sampling sites located downstream from drainage basins that are large and complex and commonly contain multiple Environmental Settings. Most Integrator Sites are on major streams with drainage basins that include a substantial portion of the Study Unit area (typically, 10 to 100 percent).

Point sample -- A sample collected at a single point in the stream cross section and at a single point in the stream vertical.

Study Unit -- A major hydrologic system of the United States in which NAWQA studies are focused. NAWQA Study Units are geographically defined by a combination of ground- and surface-water features and usually encompass more than 10,000 km2 of land area. The NAWQA design is based on assessment of these Study Units, which collectively cover a large part of the Nation, encompass the majority of population and water use, and include diverse hydrologic systems that differ widely in natural and human factors that affect water quality.

Water-Column Studies -- Assessment of physical and chemical characteristics of stream water, including suspended sediment, dissolved solids, major ions and metals, nutrients, organic carbon, and dissolved pesticides, in relation to hydrologic conditions, sources, and transport.

Field Guide For Collecting Samples For Analysis of Volatile Organic Compounds In Stream Water For The National Water-quality Assessment Program

By Larry R. Shelton

Abstract

For many years, stream samples for analysis of volatile organic compounds have been collected without specific guidelines or a sampler designed to avoid analyte loss. In 1996, the U.S. Geological Survey's National Water-Quality Assessment Program began aggressively monitoring urban stream-water for volatile organic compounds. To assure representative samples and consistency in collection procedures, a specific sampler was designed to collect samples for analysis of volatile organic compounds in stream water. This sampler, and the collection procedures, were tested in the laboratory and in the field for compound loss, contamination, sample reproducibility, and functional capabilities. This report describes that sampler and its use, and outlines field procedures specifically designed to provide contaminant-free, reproducible volatile organic compound data from stream-water samples.

These guidelines and the equipment described represent a significant change in U.S. Geological Survey instructions for collecting and processing stream-water samples for analysis of volatile organic compounds. They are intended to produce data that are both defensible and interpretable, particularly for concentrations below the microgram-per-liter level. The guidelines also contain detailed recommendations for quality-control samples.

INTRODUCTION

One of the goals of the National Water-Quality Assessment (NAWQA) Program of the U.S. Geological Survey (USGS) (Hirsch and others, 1988) is to establish a network of comprehensive and integrated urban water-quality studies to develop an understanding of the occurrence, significance, sources, movement, and fate of environmental chemicals in urbanized hydrologic systems (Lopes and Price, 1997; Squillace and Price, 1996). The occurrence of many contaminants, including volatile compounds, are being assessed in urban areas. For the information to be comparable among studies in different parts of the Nation, consistent procedures and equipment specifically designed to produce contaminant-free, reproducible volatile organic compound (VOC) data from stream-water samples are critical.

The assessment of VOCs in stream water is part of the Water-Column Studies (Gilliom and others, 1995), which focus on assessing the occurrence, concentrations and seasonal distribution of VOCs (Lopes and Price, 1997). The purpose of this report is to describe the equipment used to sample VOCs in streams and the procedures for using the VOC sampler. Companion reports by Koterba and others (1996) outline the procedures used for collecting VOC samples in ground-water, and Majewski and Capel (1995) discuss sampling of pesticides in the atmosphere.

The glossary at the front of this report includes brief definitions of some terms used in this report. Key terms used to describe the NAWQA Program are capitalized. Trade names used in connection with equipment or supplies do not constitute an endorsement of the product.

OVERVIEW

The sampling designs for stream-water studies rely on coordinated sampling of varying intensity and scope at two general types of sites, Integrator Sites and Indicator Sites. Integrator Sites are chosen to represent water-quality conditions of streams and rivers in the large basins affected by complex combinations of land-use settings, point sources, and natural influences. Indicator Sites, in contrast, are chosen to represent water-quality conditions of streams with relatively homogeneous land use and, usually, are associated with smaller basins in specific Environmental Settings. Most, but not all VOC samples will be collected at urban Indicator Sites located in residential and commercial areas. Site selection and sampling strategies for urban Indicator Sites are described in Lopes and Price (1997).

Two primary sampling strategies are used at the selected Integrator and Indicator Sites: (1) fixed interval sampling (usually monthly) characterizes the spatial and temporal distribution of contaminants in relation to hydrologic conditions and contaminant sources, and (2) intensive sampling characterizes seasonal and short-term temporal variability of contaminant transport during high flows and at more frequent fixed intervals.

Most VOCs are man-made compounds that are components of gasoline, by-products of chlorinating drinking water, or solvents. Laboratory analysis is done by the purge-and-trap technique to separate the VOCs from the water matrix, and the quantitation is done by capillary-column gas chromatography/mass spectrometry. Results are reported in micrograms per liter. The USGS National Water Quality Laboratory (NWQL) VOC analysis schedule 2020 will be used. The analytes are summarized in table 1.

PREPARATION FOR SAMPLE COLLECTION

Site Selection

All VOC sampling sites should be at or near streamflow gaging stations because stream discharges associated with contaminant concentrations are needed to evaluate relations between streamflow and water-quality characteristics (Gilliom and others, 1995; Lopes and Price, 1997). The sample collection site should not be more than a few hundred feet from the station.

Collection sites should be located in relatively straight channel reaches where the flow is uniform. Collecting samples directly in a ripple, or from ponded or sluggish water, should be avoided. Sites directly upstream or downstream of confluences or direct sources of contamination also should be avoided to minimize problems caused by backwater effects or poorly mixed flows. In addition, samples collected downstream from a bridge can be contaminated by runoff from the road surface. Proper field judgement is crucial to achieve a sample representative of the typical environmental conditions.

Samples should be collected at the centroid of the stream in the same cross section throughout the project. This will eliminate many of the potential problems that might arise during the interpretation of the data. This does not mean that the same section used during the low-water wading stage must be used during higher stages that require the use of a bridge or cableway.

However, the flow characteristics at different cross sections can result in incomparable data if the cross sections are not located near each other or in the same flow regime. Rapidly changing stage, discharge, and constituent concentrations dictate that sampling schemes and techniques be planned carefully in advance to ensure that representative samples are obtained.

Table 1. List of volatile organic compound analytes for the National Water-Quality Assessment Program.

[CAS, Chemical Abstract Service number; PCODE, USGS Parameter Code]

Laboratory analyses: Schedule Number 2020

CAS number	PCODE	Compound
Halogenated Alkanes		
630-20-6	77562	1,1,1,2-Tetrachloroethane
71-55-6	34506	1,1,1-Trichloroethane
79-34-5	34516	1,1,2,2-Tetrachloroethane
76-13-1	77652	1,1,2-Trichloro-1,2,2-trifluoroethane
79-00-5	34511	1,1,2-Trichloroethane
75-34-3	34496	1,1-Dichloroethane
96-18-4	77443	1,2,3-Trichloropropane
96-12-8	82625	1,2-Dibromo-3-chloropropane
106-93-4	77651	1,2-Dibromoethane
107-06-2	32103	1,2-Dichloroethane
78-87-5	34541	1,2-Dichloropropane
142-28-9	77173	1,3-Dichloropropane
594-20-7	77170	2,2-Dichloropropane
74-97-5	77297	Bromochloromethane
75-27-4	32101	Bromodichloromethane
74-83-9	34413	Bromomethane
124-48-1	32105	Chlorodibromomethane
75-00-3	34311	Chloroethane
74-87-3	34418	Chloromethane
74-95-3	30217	Dibromomethane
75-71-8	34668	Dichlorodifluoromethane
75-09-2	34423	Dichloromethane
67-72-1	34396	Hexachloroethane
74-88-4	77424	Iodomethane
56-23-5	32102	Tetrachloromethane
75-25-2	32104	Tribromomethane
75-69-4	34488	Trichlorofluoromethane
67-66-3	32106	Trichloromethane
Halogenated Alkenes		
75-35-4	34501	1,1-Dichloroethene
563-58-6	77168	1,1-Dichloropropene
107-05-1	78109	3-Chloro-1-propene
593-60-2	50002	Bromoethene

75-01-4	39175	Chloroethene
87-68-3	39702	Hexachlorobutadiene
127-18-4	34475	Tetrachloroethene
79-01-6	39180	Trichloroethene
156-59-2	77093	cis-1,2-Dichloroethene
10061-01-5	34704	cis-1,3-Dichloropropene
156-60-5	34546	trans-1,2-Dichloroethene
10061-02-6	34699	trans-1,3-Dichloropropene
110-57-6	73547	trans-1,4-Dichloro-2-butene

Aromatic Hydrocarbons

71-43-2	34030	Benzene
91-20-3	34696	Naphthalene
100-42-5	77128	Styrene

Alkyl Benzenes

488-23-3	49999	1,2,3,4-Tetramethylbenzene
527-53-7	50000	1,2,3,5-Tetramethylbenzene
526-73-8	77221	1,2,3-Trimethylbenzene
95-63-6	77222	1,2,4-Trimethylbenzene
95-47-6	77135	1,2-Dimethylbenzene
108-67-8	77226	1,3,5-Trimethylbenzene
108-38-3	85795	1,3-Dimethylbenzene
106-42-3	---	1,4-Dimethylbenzene
611-14-3	77220	2-Ethyltoluene
100-41-4	34371	Ethylbenzene
98-82-8	77223	Isopropylbenzene
108-88-3	34010	Methylbenzene
104-51-8	77342	n-Butylbenzene
103-65-1	77224	n-Propylbenzene
99-87-6	77356	p-Isopropyltoluene
135-98-8	77350	sec-Butylbenzene
98-06-6	77353	tert-Butylbenzene

Halogenated Aromatics

87-61-6	77613	1,2,3-Trichlorobenzene
120-82-1	34551	1,2,4-Trichlorobenzene
95-50-1	34536	1,2-Dichlorobenzene
541-73-1	34566	1,3-Dichlorobenzene
106-46-7	34571	1,4-Dichlorobenzene
95-49-8	77275	2-Chlorotoluene
106-43-4	77277	4-Chlorotoluene
108-86-1	81555	Bromobenzene
108-90-7	34301	Chlorobenzene

Ethers and other Oxygenated Compounds

78-93-3	81595	2-Butanone
591-78-6	77103	2-Hexanone
108-10-1	78133	4-Methyl-2-pentanone
67-64-1	81552	Acetone

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   60-29-7     81576     Diethyl ether
  108-20-3     81577     Diisopropyl ether
  637-92-3     50004     Ethyl tert-butyl ether
 1634-04-4     78032     Methyl tert-butyl ether
  109-99-9     81607     Tetrahydrofuran
  994-05-8     50005     tert-Amyl methyl ether

Others

  107-02-8     34210     2-Propenal
  107-13-1     34215     2-Propenenitrile
   75-15-0     77041     Carbon disulfide
   97-63-2     73570     Ethyl methacrylate
   96-33-3     49991     Methyl acrylate
  126-98-7     81593     Methyl acrylonitrile
   80-62-6     81597     Methyl methacrylate
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Sampling Equipment

Sampler

Obtaining representative VOC samples in flowing streams is a difficult task. Of critical importance is the design and operation of the equipment and the sampling procedure (Brown and others, 1970). Samplers must be designed to collect an unbiased sample of environmental conditions. One important process is to flush atmospheric gases from the sampler before collecting a stream sample (Kilpatrick and others, 1989).

A newly developed VOC sampler designed by the USGS and built by Wildco (fig. 1) will be used to collect stream-water samples for VOC analysis. This sampler has been tested for analyte loss, reproducibility, and carryover contamination in the laboratory and in field settings. The sampler, which is made of noncontaminating materials (stainless steel and refrigeration-grade copper) that will not sorb the analytes of interest, can collect a sample representative of environment conditions in most streams. An important function of the sampler design is to evacuate air and other gases from the sampler before collecting a sample. The VOC sampler weighs 11 lb and can be suspended, by hand, from a short rope or chain while wading a stream. However, when sampling during periods of high flow, 10-lb weights can be added to keep the sampler vertical when it is suspended from a bridge or cableway.

The sampler is designed to collect a sample at a single point in the stream. The stainless-steel sampler holds four 40-mL vials. Copper tubes extend to the bottom of each vial from the inlet ports on top of the sampler. The vials fill and overflow into the sampler body, displacing the air in the vials and in the sampler through the exhaust tube. The total volume of the sampler is eight times larger then the vials; therefore, the vials are flushed seven times (removing the air) before the final volume is retained in the vial. The small (1/16-in. inside diameter) copper inlet ports results in a slow (3 to 4 minutes) filling time. This important design feature helps to produce a representative sample and allows sufficient time to place the sampler at the desired depth. The sampler begins to fill as soon as it enters the stream; however, the final sample is retained in the vial during the last 15 to 20 seconds of the filling process. A cover over the inlet ports prevents contamination from surface oil and debris when the sampler is removed from the stream.

Figure 1. Schematic of volatile organic compound (VOC) sampler. The sampler body is made of stainless steel, weighs 11 pounds and is 6 inches high. It has an air exhaust tube extending above the sampler, and four copper inlet tubes that extend into four 40-milliliter sample vials.

Support Equipment

Field vehicles are commonly used for more than one purpose (such as streamflow measurements, gaging station maintenance, construction, stream sampling, and sample processing). Sample contamination is more likely to occur when these multiuse vehicles are used to collect and process water samples. Glues and adhesives used in vehicles, and the cabinet construction, can contaminate samples for VOCs. Therefore, it is important that the processing area be free of contaminants, plastics, dirt, fumes, and oil residue. Samples should be removed from the sampler, processed, and capped streamside to avoid possible contaminants in the vehicles. Each vehicle should have a separate storage area for the VOC sampling equipment and supplies. A complete equipment list is given in table 2.

Table 2. List of equipment and supplies for collecting and processing stream-water volatile organic compound (VOC) samples.

[Sources for some items are listed to maintain quality standards. OCALA, USGS Water-Quality Service Unit at Ocala, Florida; NWQL, National Water Quality Laboratory; VG, VOC grade blank; VBW, pesticide/volatile blank water]

Sampling equipment and supplies

Volatile organic compound (VOC) sampler (Wildco 990-J98)
Vial, glass, amber septum, 40 milliliter (NWQL and OCALA 333FLD)
Rope, nylon, 1/4-inch diameter (OCALA 84FLD)

Cleaning and storing equipment and supplies

Gloves, vinyl, powderless (OCALA 155HWS)
Detergent, phosphate free, 0.2 percent by volume (OCALA 62FLD)
Methanol, pesticide grade
Deionized water
VOC grade blank water (VG or VBW) (NWQL)
Bottles, wash, plastic, for detergent (OCALA 357FLD)
Bottles, wash, Teflon, for VG water (OCALA 377FLD)
Bottles, wash, Teflon, for methanol (OCALA 377FLD)
Basins, wash, plastic (2)
Brush, scrub, soft metallic
Bag, plastic, sealable, medium (OCALA 23FLD)
Storage container, sealable, 8 inches x 8 inches x 12 inches
Foil, aluminum, heavy duty
Container, waste, solvent, 5 gallons

Processing equipment and supplies

Cannister, stainless steel, 8 quarts with cover (for field blanks)
Flask tongs
Gloves, vinyl, powderless (OCALA 155HWS)
Hydrochloric acid 1:1 acid, in Teflon vials (NWQL)
Kit, matrix spike (NWQL)
pH paper (alkacid test ribbon)
Bottle labels (OCALA 84FLD)
Sleeves, foam (OCALA 358FLD)
Coolers, shipping, 1 gallon
Coolers, shipping, 5 gallon s
Bags, plastic, 5 gallons
Ice

Miscellaneous equipment and supplies

Boots, hip
Waders, chest
Tools
First aid kit
Highway emergency kit
Forms, field documentation (OCALA)
Forms, analytical request (NWQL)
Tissues, laboratory
Pens, marking, permanent, (OCALA 77FLD)
Field meters, conductance, pH, dissolved oxygen
Supplies for field measurements

EQUIPMENT CLEANING

All equipment that will come in contact with the sample should be soaked in a dilute phosphate-free detergent solution; rinsed with tap water, VOC grade blank (VG) water, and methanol; and then air dried prior to each field trip and between sites (Shelton, 1994). Detergents and methanol should be used with care to avoid the possibility of the residue contaminating the sample. A thorough native-water rinse is required at each field site before sampling to remove any remaining cleaning agents and to equilibrate the equipment to the sampling conditions. A list of the supplies needed for equipment cleaning is given in table 2, and detailed procedures for cleaning the VOC sampler are outlined below.

1. Open sampler.
2. Submerge top and base in a 0.2-percent solution of phosphate-free detergent. Scrub the sampler thoroughly with a nylon brush. Use a small squeeze bottle, filled with the detergent, to flush the copper tubing.
3. Rinse the sampler thoroughly with warm tap water or deionized water (DIW) to remove all soap residue.

4. Using a Teflon squeeze bottle, rinse with a minimum amount of methanol. Place the used methanol in a waste container for proper disposal (see Water Resources Division [WRD] memorandum 94.07, Appendix).
5. Allow to air dry (cover loosely with aluminum foil to avoid airborne contamination). If complete air drying is not possible, rinse three times with VG water.
6. Wearing vinyl gloves, reassemble the sampler.
7. Wrap areas that will come in contact with the sample with aluminum foil, and place in a sealable plastic bag. Use a large sealed container to protect the sampler in storage and during transport.
8. Rinse the sampler (without the vials) with 2 to 3 L of native water prior to sampling.

SAMPLE COLLECTION PROCEDURES

Preparation

The timing of the VOC sampling should be planned to avoid possible contamination by other collection and processing activities (such as procedures and equipment that use methanol). Before beginning any other activity collect and process the VOC samples at the site. The entire sampling and processing procedure (removing it from the storage container, loading the sampler, sampling, and acidifying the sample) should be done at streamside, well away from other processing activities.

Routine Sampling

VOC samples should be collected where the stream velocity represents the average flow, which is typically near mid-channel in the cross section. The following procedure is designed to produce a single-vertical point sample. When collecting samples for VOC analyses, special care must be taken to avoid contamination from any oily film and debris floating on the stream surface. The samples should be collected directly into the prebaked 40-mL amber-glass vials as follows:

1. Reclean the sampler, if necessary (see 'Equipment Cleaning' section).
2. Transport the sampler to the collection site and rinse three times with native water or submerge it in the stream for several minutes.
3. In a protected area, away from any direct source of contamination and wearing vinyl gloves, uncap four 40-mL unlabeled vials and place them in the sampler. Secure and lock the sampler top in position. Store the vial caps in a protected area.
4. Lower the sampler into the stream near mid-channel to about one half of the total depth at that vertical. Add weights if the stream velocity is great enough to pull the sampler downstream.

5. Collect a sample by holding the sampler in one position until the sampler is full. Air bubbles will rise to the surface while the sampler is being filled, but may be difficult to see. This takes about 3 to 4 minutes. The sample will be retained in the vial during the last 15 to 20 seconds of sampling.

6. Remove the sampler when bubbles are no longer present or after about 5 minutes, and return to a protected area at the side of the stream for processing.

Dip Sampling

In very shallow streams where the VOC sampler cannot be submerged, a representative sample usually can be obtained manually by immersing an open vial (dip sample) near the centroid of flow. Wearing vinyl gloves, lower a 40-mL vial to about one half of the stream depth. Point the vial into the stream current, remove the cap, allow the vial to fill, then slowly bring it to the surface. Add hydrochloric acid (HCL), carefully cap the vial, and check for air bubbles that may be trapped in the vial. A dip sample should never be taken when it is possible to use the sampler. Consistent procedures will avoid the possibility of a sampling bias.

SAMPLE PROCESSING PROCEDURES

Biodegradation and chemical reactions, such as oxidation and volatilization, can change many of the compounds present in natural waters before analyses in a laboratory. Therefore, samples must be preserved as soon as possible after collection. The method of preserving VOCs includes the addition of 1:1 HCL and refrigeration to 4°C to arrest microbiological activity and to minimize volatilization. Great care must be exercised in the field to prevent compound loss or sample contamination. Because exhaust fumes and adhesives in field vehicles may be a source of contamination, processing samples streamside can best prevent contamination. Evaluate trip and field blanks to confirm that the processing area is appropriate.

To preserve the samples, add 1:1 HCL to lower the pH to 2 or less, and immediately place the vials on ice. To determine the volume of acid to add, collect a hand dipped test sample in a used 40-mL vial. Add HCL to the test sample to lower the sample pH to less than 2.0. Two drops of HCL should be adequate for most conditions; however, some environmental samples may require additional HCL. At no time should you use more than six drops of HCL. Alkacid test ribbons can be used to estimate the pH.

By following this sequence for sample preservation, the risk of contaminating a sample is reduced. Acid should be stored and transported properly (see WRD memorandum 94.06, Appendix). These procedures are summarized below.

1. Wearing vinyl gloves, open the sampler carefully at streamside.

2. Using metal tongs, slowly lift each vial from the sampler reservoir. Do this carefully to avoid losing the convex meniscus.

3. Add drops (usually two, but no more than six) of 1:1 HCL to lower the pH to less than 2, and cap the vial.

4. Agitate the vial and check for air bubbles. Discard if bubbles are present.
5. Three vials from the same sampler set are required for one complete sample. Resample completely, if necessary.
6. Label the samples, wrap each with a foam sleeve, and place them on ice.
7. Clean the sampler and store it properly (see 'Equipment Cleaning' section).

The minimum information required on each vial is the site identification (ID) number, date and time sampled, preservation, and schedule number, as shown on the example below:

```
    09498500
04-24-1997 @ 1200
  HCL to
```

FIELD MEASUREMENTS

Water temperature, specific conductance, pH, dissolved oxygen, and alkalinity could change dramatically within minutes or hours after sample collection. Immediate analysis in the field is required if the results are to be representative of in-stream conditions.

Water temperature and dissolved oxygen should be measured directly from the stream, and several readings are required in the cross section to obtain a stream average. A composite stream sample should be collected for specific conductance, pH, and alkalinity. A single field meter that measures specific conductance, water temperature, pH, and dissolved oxygen directly in the stream may be used. Detailed information on the procedures, equipment, and supplies necessary for the field analyses is presented in reports by Shelton (1994) and Wilde and Radtke (in press).

QUALITY ASSURANCE AND QUALITY CONTROL

The sources of variability and bias introduced by sample collection and processing affect the interpretation of water-quality data. Quality-assurance (QA) plans ensure that the data collected are compatible and of sufficient quality to meet program objectives. These guidelines and the Study Unit design guidelines for NAWQA should be used when preparing QA plans. Specific details for QA plans are described by Shampine and others (1992).

Investigators in each Study Unit must document the quality of their data by collecting quality-control (QC) samples. A series of QC samples (blanks, replicates, and spikes) must be obtained during VOC investigations because the quality of the data collected, and the validity of any interpretation, cannot be evaluated without QC data. Detailed procedures for preparing QC samples for VOCs, and the recommended frequencies, are described in Mueller and others (1997).

Field Blanks

Field blanks are used to determine whether (1) equipment-cleaning protocols adequately remove residual contamination from previous use, (2) sampling and sample-processing procedures result in contamination, and (3) equipment handling and transport periods of sample collection do not introduce contamination. Field blanks for VOCs are collected immediately before processing a routine environmental sample. Load four 40-mL vials into the sampler. Pour VG water into a clean (see `Equipment Cleaning' section) stainless-steel cannister, and then collect two 40-mL vials from the cannister for the cannister-blank sample. Submerge the sampler containing four 40-mL vials in the cannister and allow to fill. Remove the vials and process the field and cannister blanks in the same manner as the environmental sample. Process the samples using the NWQL analytical schedule for environmental samples. If analytical results indicate carryover of residues, perform additional field tests to determine the source of the contamination. A more rigorous cleaning procedure might be necessary. Field blanks produce the most valuable QC data to evaluate potential contamination.

Trip Blanks

Trip blanks are used to determine whether external VOCs from bottle handling and analytical processes, independent of the field sample processing scheme, are contaminating the samples. Trip blanks are provided upon request and are prepared and distributed to each Study Unit by the NWQL. These trip blanks bottles should be stored and transported with the other bottles used for collecting the environmental sample, and then submitted for analysis in the same manner. Trip blanks should never be opened in the field. If analytical results indicate that samples have been contaminated, additional blanks should be processed to identify the source. Trip blanks should only be prepared with field blanks.

Field-Matrix Spikes

Field-matrix spikes are designed to (1) assess recoveries from field matrices and (2) assist in evaluating the precision of results for the range of target analytes in different matrices. Biases and interferences can result from sample matrices and from other processes that occur from the time the sample vial is preserved in the field to the time the vial is analyzed in the laboratory. After collecting the environmental sample, immediately collect a second set of four vials for the field-matrix spikes and preserve each using HCL. Add a standard spike solution using a microliter gas-tight syringe. Matrix-spike kits (solution and syringe) with instructions are available from the NWQL. Label two vials `FS' (field spike) and two vials `FSR' (field-spike replicate). Record the lot number and volume of the spike solution on the field notes and on the NWQL analytical services request (ASR) form. Send each set of vials-two FS and two FSR-as separate sample sets, including the environmental sample, to the laboratory for analyses.

Replicate Samples

Sample replicates are designed to provide information needed to (1) estimate the precision of concentration values determined from the combined sample-processing and analytical method and (2) evaluate the consistency of identifying target analytes for VOCs. Each replicate sample is an aliquot of the environmental sample collected in the same sampler, processed at the same time, and stored and shipped in the same way. Compare the analytical results to determine if accurate, consistent data can be reproduced.

DOCUMENTATION

All field activities and site information should be documented on standard surface-water-quality field notes (Shelton, 1994). A complete documentation will aid in future analyses of the collected information.

Field notes should include the following information:

1. Station name and number.
2. Date and time (1 minute earlier than environmental sample).
3. Gage height, discharge, or both; stage conditions.
4. Type of sample (single-vertical point sample).
5. Sampler (VOC sampler).
6. Sampling method (bridge, cableway, wading).
7. Depth and width of stream at sampling location.
8. Location within the cross section (midstream).
9. Depth of sampling (mid depth).
10. Field analyses and calibration (temperature, conductance, pH, alkalinity, oxygen).
11. Detailed alkalinity titration.
12. Type of samples collected (VOC, major ions, quality control, and others).
13. Name of sample collector(s).
14. Site information: color and odor of the stream, weather conditions, and others.

SAMPLE IDENTIFICATION

Consistent specific identification of samples is essential for national data aggregation. For this reason, a data-coding strategy has been developed for the NAWQA Program. Use the following instructions for coding information onto the water quality field notes and on the NWQL ASR forms. The most critical codes for proper sample identification are the station ID number, sample medium, and sample type. Different sample-time coding is specified to distinguish among multiple samples collected during the same site visit. VOC samples will have a time 1 minute earlier than all other environmental samples to segregate the VOC analytical results from other analyses. For QC samples, the time codes are used to establish a rationale for associating the necessary sample codes with each individual sample. Do not use fictitious station ID numbers for routine QC samples.

VOC Environmental Sample

STATION ID - Same as other environmental sample
DATE - Same as other environmental sample
TIME - One minute earlier than the other environmental samples
SAMPLE MEDIUM - `9' (surface water)
SAMPLE TYPE - `9' (regular)
Parameter 71999 (Sample purpose) - `15' (NAWQA)
Parameter 99111 (QA data with sample) - `10' (blank)

Field Blank

STATION ID - Same as environmental sample
DATE - Same as environmental sample
TIME - Exact time of preparation (different from other blanks)
SAMPLE MEDIUM - `Q' (QA sample, artificial)
SAMPLE TYPE - `2' (blank)
COMMENTS - `PREVIOUS SAMPLE AT:' station ID, date/time
Parameter 71999 (Sample purpose) - `15' (NAWQA)
Parameter 99102 (Type of blank sample) - `100' (field)
Parameter 99104 (Blank lot number) - Enter first five digits
Parameter 99101 (Source of blank solution) - `10' (NWQL)

Cannister Blank

STATION ID - Same as environmental sample
DATE - Same as environmental sample
TIME - One minute earlier than field blank (different from other blanks)
SAMPLE MEDIUM - `Q' (QA sample, artificial)
SAMPLE TYPE - `B' (other)
COMMENTS - `CANNISTER BLANK'
Parameter 71999 (Sample purpose) - `15' (NAWQA)
Parameter 99102 (Type of blank sample) - `100' (field)
Parameter 99104 (Blank lot number) - Enter first five digits
Parameter 99101 (Source of blank solution) - `10' (NWQL)

Trip Blank

STATION ID - Same as environmental sample
DATE - Same as environmental sample
TIME - Exact time of preparation (end of trip)
SAMPLE MEDIUM - `Q' (QA sample, artificial)
SAMPLE TYPE - `2' (blank)
Parameter 71999 (Sample purpose) - `15' (NAWQA)
Parameter 99102 (Type of blank sample) - `30' (trip)
Parameter 99101 (Source of blank solution) - `10' (NWQL)
Parameter 99109 (Start date YMMDD) - Date blanks received from NWQL
Parameter 99110 (End date YMMDD) - Date trip blanks shipped to NWQL

Field-Matrix Spike

STATION ID - Same as environmental sample
DATE - Same as environmental sample
TIME - `SPIKE (FS)' 6 minutes later than environmental sample (HH:X6)
`SPIKE REPLICATE (FSR)' 7 minutes later than environmental sample (HH:X7)
SAMPLE MEDIUM - `R' (QA surface water)
SAMPLE TYPE - `1' (spike)
COMMENTS - `FS or FSR', `SCH 9090 spike lot number______'
Parameter 71999 (Sample purpose) - `15' (NAWQA)
Parameter 99104 (Spike lot number) - Enter first five digits
Parameter 99105 (Replicate type) - `10' (concurrent)
Parameter 99106 (Spike type) - `10' (field)
Parameter 99107 (Spike source) - `10' (NWQL)
Parameter 99108 (Spike volume) - volume used, in milliliters

Replicate Samples

STATION ID - Same as environmental sample
DATE - Same as environmental sample
TIME - Same as VOC environmental sample
SAMPLE MEDIUM - `9' (surface water)
SAMPLE TYPE - `7' (replicate)
Parameter 99111 (QA data with sample) - `30' (replicate sample)
Parameter 99105 (Replicate type) - `10' (concurrent)
Parameter 71999 (Sample purpose) - `15' (NAWQA)

SHIPPING

Samples should be shipped by overnight express mail to the NWQL the same day of collection. A NWQL ASR form must be included with each sample. Place all glass vials in padded sleeves or pack in some other suitable manner to prevent breakage during shipment. Insulated water coolers (1 or 5 gal in volume) make good shipping containers. Chill with an adequate amount of ice to maintain the sample temperature between 0 and 4°C. The amount of ice needed depends on the length of time in transit from field to laboratory and on the season of the year. Ice should be placed inside a double plastic bag in the shipping container. Protect the NWQL ASR form and return labels from the ice by placing them in a sealable plastic bag and fastened it to the inside of the cooler lid with tape. Detailed guidelines on shipping samples are discussed in NWQL memorandum 95.04 (Appendix).

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APPENDIX-SELECTED TECHNICAL MEMORANDUMS

These Water Resources Division (WRD) and National Water Quality Laboratory (NWQL) memorandums are available in U.S. Geological Survey offices, nationwide:

WRD 94.06 SAFETY: Storage, transport, handling, and disposal of hydrochloric acid

WRD 94.07 SAFETY: Storage, transport, handling and disposal of methyl alcohol

NWQL 95.04 OPERATIONS: Shipping to the National Water Quality Laboratory

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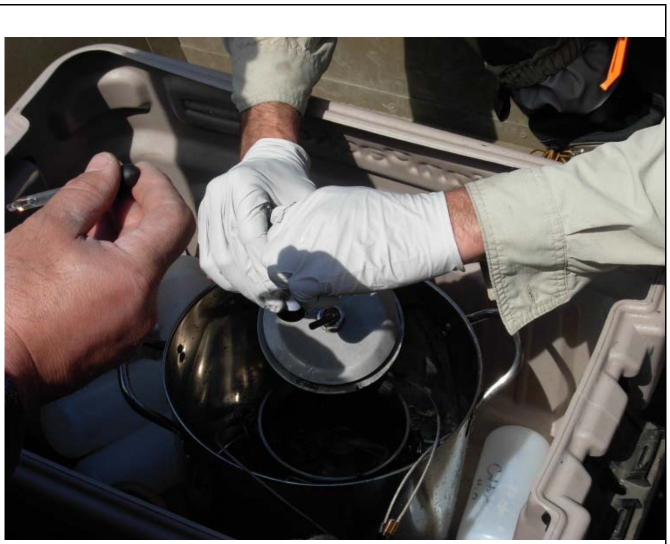
Appendix C. Site Photographs

Photograph 1. Sampling LS-3 on 8/13/08.	
Photograph 2. Measuring discharge on 5/24/09 at LS-1.	

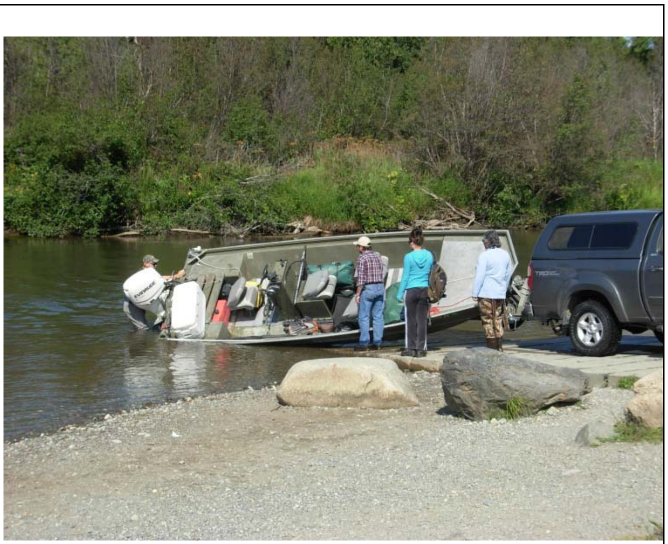
Photograph 3. Adding preservative to water sample.	
Photograph 4. PUF 5/24/09 from upstream.	

Photograph 5. PUF on 6/7/09 from downstream.	
Photograph 6. Removing the hydrocarbon sampler from the water.	

Photograph 7. Exhaust from a 2-cycle motor on 8/8/09.	
Photograph 8. Exhaust from a 2-cycle motor on 8/10/09.	

Photograph 9. PUF at 05:30 on 8/8/09.	
Photograph 10. PUF at 06:00 on 8/10/09.	

Photograph 11. Exhaust from 2-cycle on 8/10/09.	
Photograph 12. Fishing guide boats on Guides 8/10/09.	

Photograph 13. Launch mishaps.	
Photograph 14. Little Susitna at 32 km below the PUF.	

Photograph 15. Nick Ettema removing invertebrate sample from drift net.

Photograph 16. Collecting invertebrate drift samples 8/17/09.

Photograph 17. Identifying juvenile fish samples at 9 km above the PUF.

Photograph 18. Megan Cookingham and a juvenile Chinook salmon.