

MEMORANDUM

State of Alaska

Department of Fish and Game
Division of Habitat

TO: Jackie Timothy
Southeast Regional Supervisor

DATE: Febraury 12, 2015

THRU: Kate Kanouse
Habitat Biologist IV

SUBJECT: Kensington Gold Mine:
2014 TTF EMP Studies

FROM: Gordon Willson-Naranjo ^{GWN}
Habitat Biologist II

PHONE NO: (907) 465-6646

Introduction

In 2013, Coeur Alaska, Inc. (Coeur) developed the Tailings Treatment Facility (TTF) Environmental Monitoring Plan (EMP) in consultation with Alaska Department of Fish and Game (ADF&G) Habitat Division, Alaska Department of Environmental Conservation Division of Water, and U.S. Forest Service (USFS) staff to satisfy study requirements in Coeur's Fish Habitat Permit (FH05-I-0050C) and the USFS record of decision.

This memorandum summarizes data collected in 2014 for the Kensington Gold Mine (KGM) TTF EMP. The studies required and detailed methods for data collection and analyses are described in Willson-Naranjo and Kanouse (2014).

2014 Studies

During 2014, year five of mining operations, we:

- Studied the geochemistry of tailings samples collected at the mill and in the TTF to evaluate sulfide content, acid generating potential, metals, nonmetals, metalloids, and other properties.
- Completed the second and third sample tray retrievals for the benthic macroinvertebrate habitability study. During the two sample events, we retrieved 80 sample trays and 8 sediment deposition trays from the north and south ends of the lake in June and October.
 - We previously included Ostrocods and Copepods in the benthic macroinvertebrate density calculations. After further research and discussion we removed these taxa from the calculations because they are predominantly planktonic, and we have a diverse sample of organisms that are less questionably benthic (Aaron Baldwin, Commercial Fisheries Biologist, ADF&G, Juneau, personal communication).
- Measured dissolved oxygen, temperature, and pH throughout the water column in Upper Slate Lake (USL) during late-summer and late-winter at 10 locations.

Tailings Geochemistry

Coeur Environmental Technicians collected quarterly tailings samples from the TTF and mill in June, March, August, and November of 2014. Coeur Environmental staff collected the 2013 samples from the TTF using a hand held aquatic substrate core sampler, in 2014 they used a Ponar benthic dredge (R. Bailey, Environmental Technician, Coeur Alaska, Juneau, personal communication).

The EMP requires quarterly samples to be tested using Acid Base Accounting (ABA) and Meteoric Water Mobility Procedure (MWMP). The tailings were fine and required a modification to the MWMP. Samples were placed with a known amount of water in a sealed container, and then shaken for 18 hours. The resulting leachate was then analyzed for metals concentrations and other properties. This method has the potential to inflate the concentrations of analytes because greater dissolution occurs during the agitation process (D. Stevie, Lab Manager, SVL Analytical, Idaho, personal communication).

On average, concentrations of the analytes were lower in the deposited tailings than in the slurry collected from the mill (Table 1), suggesting dilution occurs upon deposition in the TTF. Evidence of this has been observed in a laboratory setting, due possibly to dissolution of the more soluble minerals or through ion exchange (Mugo et al. 1999).

Tailings consistently show greater acid neutralizing potential (ANP) than acid generating potential (AGP), with an average ANP:AGP ratio of 74 for mill slurry and 90 for deposited tailings. Material with an ANP:AGP ratio > 3 poses little risk of acidification and formation of acid rock drainage (BLM 1996).

Along with the ABA and MWMP required for quarterly samples, the EMP requires a separate parameter suite be analyzed once a year during the third quarter. The annual sample, which can be taken concurrently with the quarterly, must be digested with nitric acid (EPA Method 3050) and analyzed using Inductively Coupled Plasma – Mass Spectrometry (ICP-MS)¹. Results for the annual sample, taken concurrently with the August quarterly sample, indicate that aluminum, barium, cobalt, copper, iron, lead, magnesium, nickel, potassium, vanadium, and zinc have greater concentrations in the mill slurry than in the deposited tailings (Table 2).

¹ The EMP requires EPA method 200.8 for the annual sample analysis. The analysis used in 2014 was EPA method 6020, which is the industry standard for ICP-MS of a solid (D. Stevie, Lab Manager, SVL Analytical, Idaho, personal communication).

Table 2.–2014 annual tailings geochemistry results.

Parameter	Unit	Mill Tailings	TTF Tailings
Aluminum	mg/kg	5820	6570
Calcium	mg/kg	34500	24900
Iron	mg/kg	13500	17900
Magnesium	mg/kg	6020	7330
Potassium	mg/kg	519	543
Sodium	mg/kg	85.6	60.7
Antimony	mg/kg	<0.3	<0.3
Arsenic	mg/kg	<0.75	<0.75
Barium	mg/kg	28.5	31.4
Beryllium	mg/kg	<0.1	<0.1
Cadmium	mg/kg	<0.1	<0.1
Chromium	mg/kg	1.69	1.2
Cobalt	mg/kg	4.06	6.49
Copper	mg/kg	12	28.5
Lead	mg/kg	0.893	1.1
Manganese	mg/kg	1090	782
Nickel	mg/kg	2.34	2.38
Selenium	mg/kg	<0.5	<0.5
Silver	mg/kg	<0.5	<0.5
Thallium	mg/kg	<0.1	<0.1
Vanadium	mg/kg	21.5	25.6
Zinc	mg/kg	27.7	33.3
Mercury	mg/kg	<0.033	<0.033

Tailings Habitability

On June 2, 2014, we retrieved four arrays, one from each transect, in USL. Visibility in the lake was good, and all arrays were collected without incident. We elutriated² the ten trays containing tailings (organisms are separated from benthos using a battery of air and water) onsite in the TTF water treatment plant.

Among the June 2014 samples we observed greater densities of benthic macroinvertebrates in the reference substrate compared to the paired upland soil and tailings. In the shallow trays we observed greater densities and number of benthic macroinvertebrate taxa in the north trays compared to the south trays. In the deep trays we observed the opposite, with greater densities and number of taxa among the south trays. Chironomidae was the dominant taxon in all samples (Tables 3, 4 and Figures 1, 2).

² Gordon Willson-Naranjo and Greg Albrecht, Habitat Biologists, ADF&G Habitat Division, to Jackie Timothy, Southeast Regional Supervisor, ADF&G Habitat Division. Memorandum: Benthic Macroinvertebrate Elutriation Trials Amendment; dated 12/17/2013.

Table 3.–June 2014 Benthic macroinvertebrate data for shallow (2–3 m depth) sample trays set on the north and south ends of USL.

June 2014				
Metric	Shallow Sample Trays			
	North		South	
	Upland Soil	Reference	Upland Soil	Reference
Mean Benthic Macroinvertebrate Density (insects/m ²)	9,938	15,969	5,123	10,677
Total Number of Taxa Observed	11	8	7	7
% EPT	0.3%	0.1%	0.3%	0.0%
% Chironomidae	80%	94%	79%	96%
Shannon Diversity (H)	0.31	0.11	0.32	0.08
Evenness (E) index	0.41	0.20	0.49	0.17

Table 4.–June 2014 benthic macroinvertebrate data for deep (7–9 m depth) sample trays set on the north and south ends of USL.

June 2014				
Metric	Deep Sample Trays			
	North		South	
	Tailings	Reference	Tailings	Reference
Mean Benthic Macroinvertebrate Density (insects/m ²)	969	1,354	1,923	2,446
Total Number of Taxa Observed	5	5	6	6
% EPT	4.8%	0.0%	0.0%	0.0%
% Chironomidae	81%	88%	93%	77%
Shannon Diversity (H)	0.16	0.18	0.13	0.29
Evenness (E) index	0.40	0.42	0.27	0.55

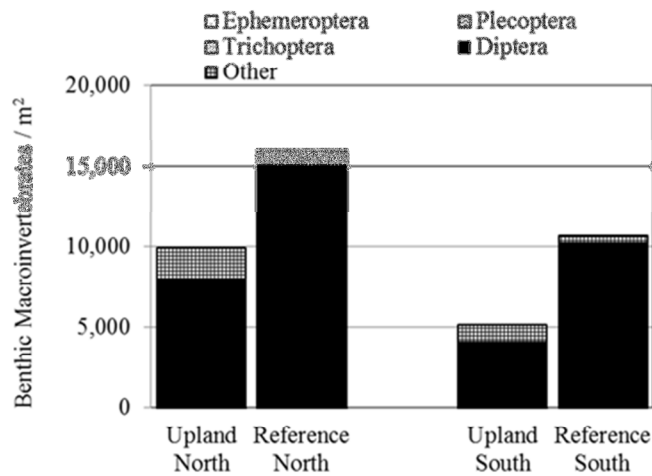


Figure 1.–June 2014 mean benthic macroinvertebrate densities for the shallow sample trays.

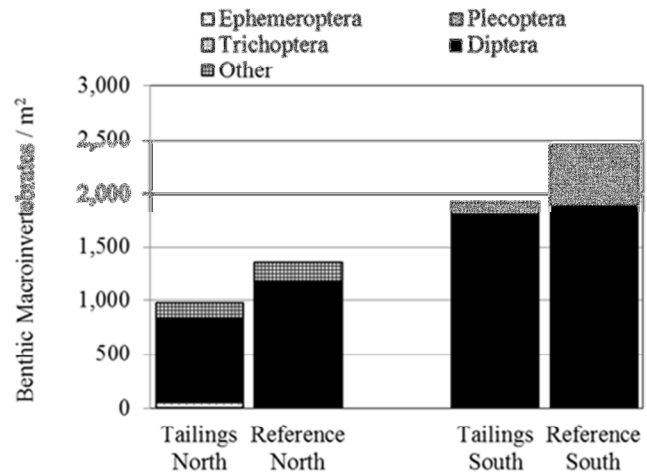


Figure 2.–June 2014 mean benthic macroinvertebrate densities for the deep sample trays.

On October 15, 2014, we retrieved four arrays, one from each transect in USL, and encountered several issues: The lines that connect arrays in a given transect, and act as a navigation aid for divers, came dislodged from both the deep and shallow transects on the south end. We were able to locate the shallow

arrays using a grid search pattern, and reconnected a navigation line to the remaining array. We were able to locate one deep array using original GPS data; however we were unable to locate the remaining deep array to attach another navigation line. While retrieving the deep array from the south end, a lid became dislodged on one reference tray. We did not include the subsequent data during analysis. We elutriated the ten tailings trays onsite in the water treatment plant. During the elutriation process one sample from the south end was spilled, and we did not use the subsequent data during analysis.

In the October samples we again observed greater densities and number of benthic macroinvertebrate taxa in the north trays compared to the south trays. In the deep trays, we observed greater densities of benthic macroinvertebrates in the reference substrate compared to the tailings, and the north trays had more taxa than the south trays. Chironomidae was the dominant taxon in all samples (Tables 5, 6 and Figures 3, 4).

Table 5.–October 2014 benthic macroinvertebrate data for shallow (2–3 m depth) sample trays set on the north and south ends of USL.

October 2014				
Metric	Shallow Sample Trays			
	North		South	
	Upland Soil	Reference	Upland Soil	Reference
Mean Benthic Macroinvertebrate Density (insects/m ²)	18,508	17,692	11,908	13,154
Total Number of Taxa Observed	11	11	9	9
% EPT	0.3%	0.0%	0.3%	0.6%
% Chironomidae	86%	87%	81%	82%
Shannon Diversity (H)	0.23	0.25	0.28	0.30
Evenness (E) index	0.26	0.28	0.40	0.40

Table 6.–October 2014 benthic macroinvertebrate data for deep (7–9 m depth) sample trays set on the north and south ends of USL.

October 2014				
Metric	Deep Sample Trays			
	North		South	
	Tailings	Reference	Tailings	Reference
Mean Benthic Macroinvertebrate Density (insects/m ²)	1,708	2,062	1,135	1,885
Total Number of Taxa Observed	5	7	4	6
% EPT	0.0%	0.7%	0.0%	0.0%
% Chironomidae	94%	68%	88%	80%
Shannon Diversity (H)	0.08	0.42	0.15	0.28
Evenness (E) index	0.32	0.66	0.41	0.54

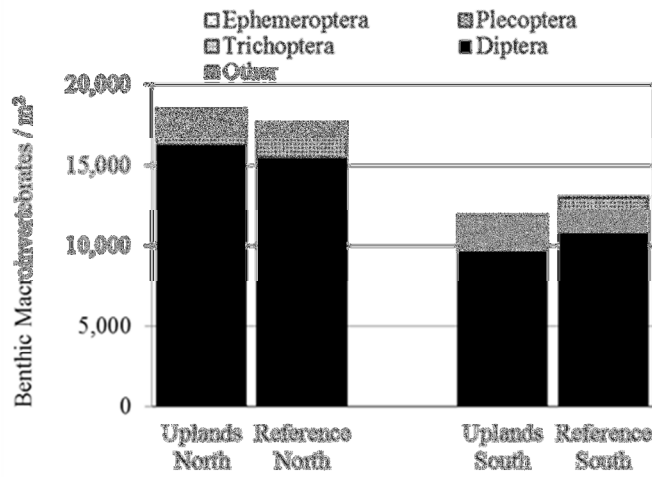


Figure 3.–October 2014 mean benthic macroinvertebrate densities for the shallow sample trays.

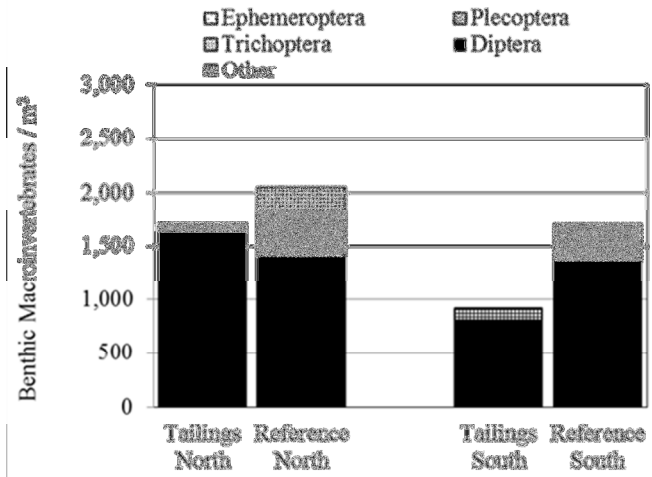


Figure 4.–October 2014 mean benthic macroinvertebrate densities for the shallow sample trays.

In the first year report (Willson-Naranjo and Kanouse 2014), we included Ostrocods and Copepods in our benthic macroinvertebrate density calculations. For the 2014 data, we removed these taxa from the metrics because they are predominantly planktonic. There is limited interaction between planktonic organisms and the substrate, however the purpose of this study is to evaluate habitability of tailings and we have documented organisms that have been identified as strictly benthic. We adjusted the October 2013 sample data to reflect this change (Tables 7, 8).

Table 7.–Revised October 2013 benthic macroinvertebrate data for shallow (2–3 m) sample trays set on the north and south ends of USL.

Metric	October 2013			
	Shallow Sample Trays			
	North		South	
	Upland Soil	Reference	Upland Soil	Reference
Mean Benthic Macroinvertebrate Density (insects/m ²)	21,031	13,096	7,046	6,308
Total Number of Taxa Observed	10	9	5	7
% EPT	0.1%	0.3%	0.0%	0.0%
% Chironomidae	93%	84%	86%	89%
Shannon Diversity (H)	0.14	0.27	0.24	0.20
Eveness (E) index	0.18	0.36	0.39	0.30

Table 8.—Revised October 2013 benthic macroinvertebrate data for deep (7–9 m) sample trays set on the north and south ends of USL.

Metric	October 2013			
	Deep Sample Trays			
	North		South	
	Tailings	Reference	Tailings	Reference
Mean Benthic Macroinvertebrate Density (insects/m ²)	1,046	2,708	600	2,769
Total Number of Taxa Observed	7	7	5	8
% EPT	5.9%	60.0%	0.0%	60.0%
% Chironomidae	68%	85%	41%	81%
Shannon Diversity (H)	0.37	0.25	0.48	0.30
Evenness (E) index	0.68	0.43	0.92	0.46

Figures 5–8 illustrate benthic macroinvertebrate density succession of the different substrate types from June 2013 (sample tray deployment) to October 2014. Among the shallow trays, the uplands soil had greater densities of benthic macroinvertebrates during the fall, and density increased in the reference trays over time. Among the deep trays, benthic macroinvertebrate densities were greater in the reference compared to the tailings and the south deep reference showed decreasing density over time.

The dominant taxon among all samples, during all sample events, was Chironomidae. Chironomidae exhibits a wide ecological range, varied emergence times, many feeding types (shredders, gatherers, filter feeders, miners, predators), and includes species that can be univoltine or multivoltine³ (Danks and Oliver 1972, Gerstmeier 1989, Merritt and Cummins 1996, Mousavi and Amundsen 2012). The level of taxonomic identification for this study precludes determination of reproduction, a metric which could explain the seasonal density pattern we see in the upland samples. It was impractical to identify Chironomidae to species for this pilot study because of the time, effort, and expertise required.

³ More than one generation per year.

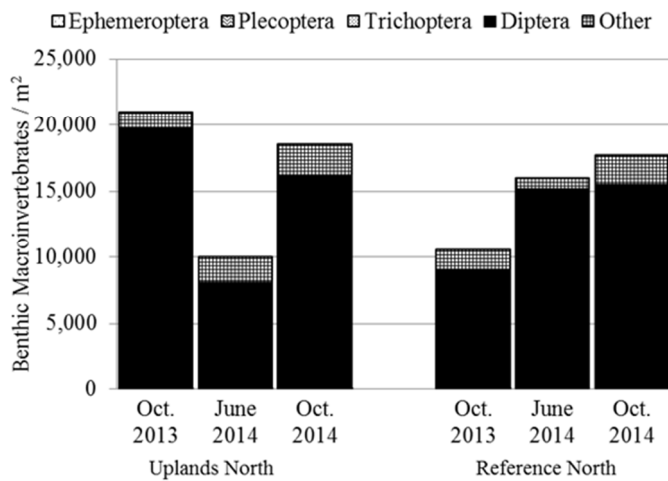


Figure 5.—Succession of benthic macroinvertebrates from inception of study to October 2014 in shallow trays on the north end.

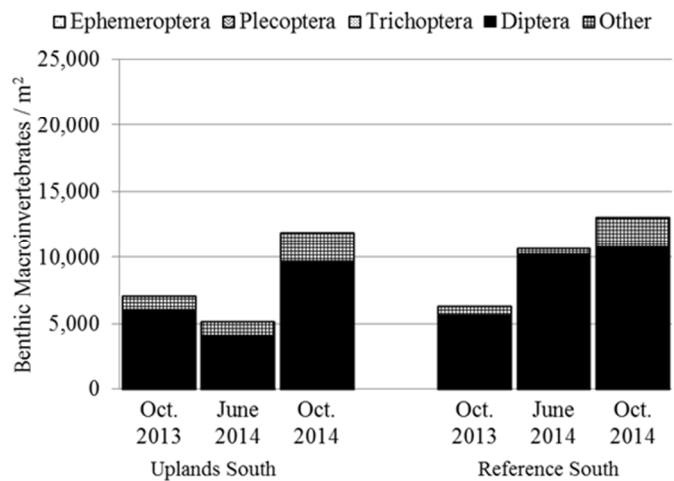


Figure 6.—Succession of benthic macroinvertebrates from inception of study to October 2014 in shallow trays on the south end.

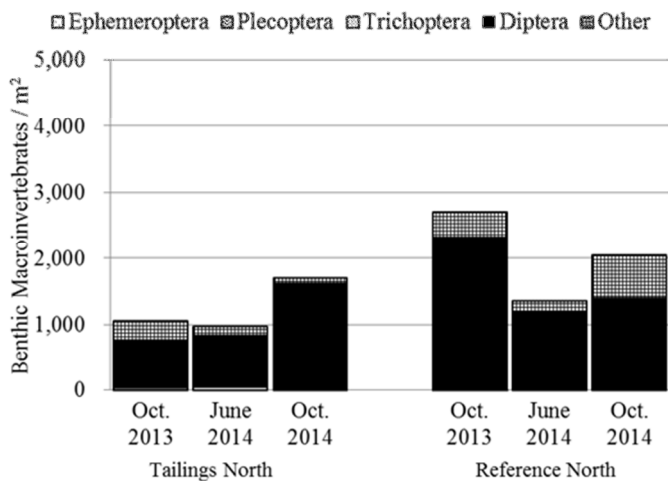


Figure 7.—Succession of benthic macroinvertebrates from inception of study to October 2014 in deep trays on the north end.

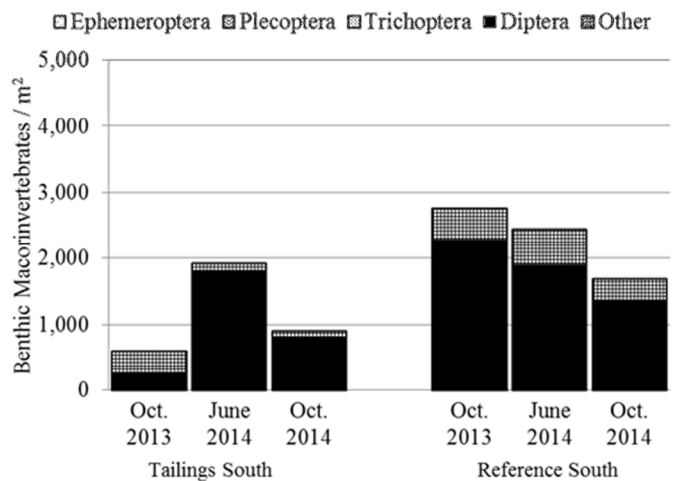


Figure 8.—Succession of benthic macroinvertebrates from inception of study to October 2014 in deep trays on the south end.

Quality assurance/quality control for taxonomic identification was performed by a Habitat biologist in-house⁴ on 10% of all benthic macroinvertebrate samples. The results indicate that we have consistently met our goal of 90% correct identification.

⁴ Habitat Biologist Ben Brewster performed QA/QC on four random samples from June 2014 and four random samples from October 2014.

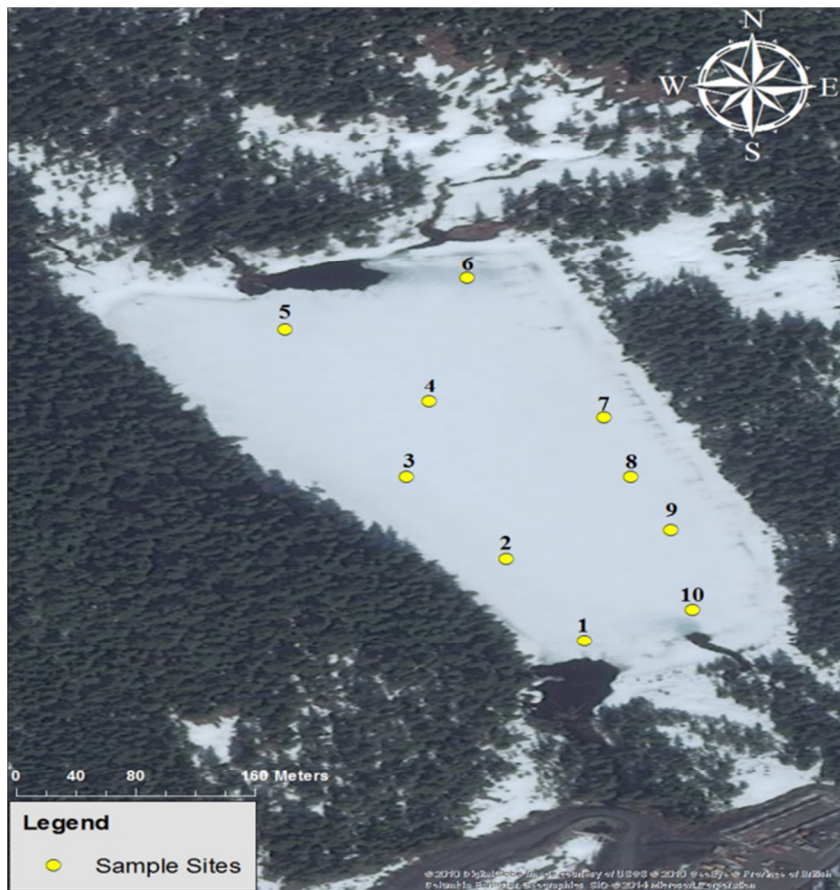
Sediment Trap Trays

During retrieval of the north deep array in October 2014, the lid for the sediment trap became dislodged during ascent, losing all the deposited material. More sediment was deposited in the deep trays compared to the shallow trays on the south end. More sediment was deposited in the shallow trays compared to the deep trays on the north end in June 2014 (Table 9). The same was true for the shallow trays on the north end in October 2013.

Table 9.–2014 dry weight (g) of sediment in sediment traps.

Sediment Trap location	Date of Retrieval		
	October, 2013	June, 2014	October, 2014
North Shallow	2.81	3.10	6.75
North Deep	2.01	2.84	-
South Shallow	1.17	1.72	3.12
South Deep	0.52	6.52	5.58

Dissolved Oxygen, Temperature and pH Profiles



On March 12, 2014 Coeur Environmental staff used a gas-powered ice auger to drill holes through 1.2 m of ice in USL, and Oakton 300 and 10 series meters with 20 m cables to measure dissolved oxygen (DO), temperature, and pH at 10 locations in the lake (Figure 9).

Figure 10 presents the parameter means for data collected at sample sites > 8.5 m depth. We observed a rapid decrease in dissolved oxygen below 7 m and near anoxic conditions near the lakebed, a slight thermocline between 0 m and 6 m depth with water temperature warmest near the lakebed, and consistent pH throughout the water column.

Figure 9.–Locations of sample sites in USL.

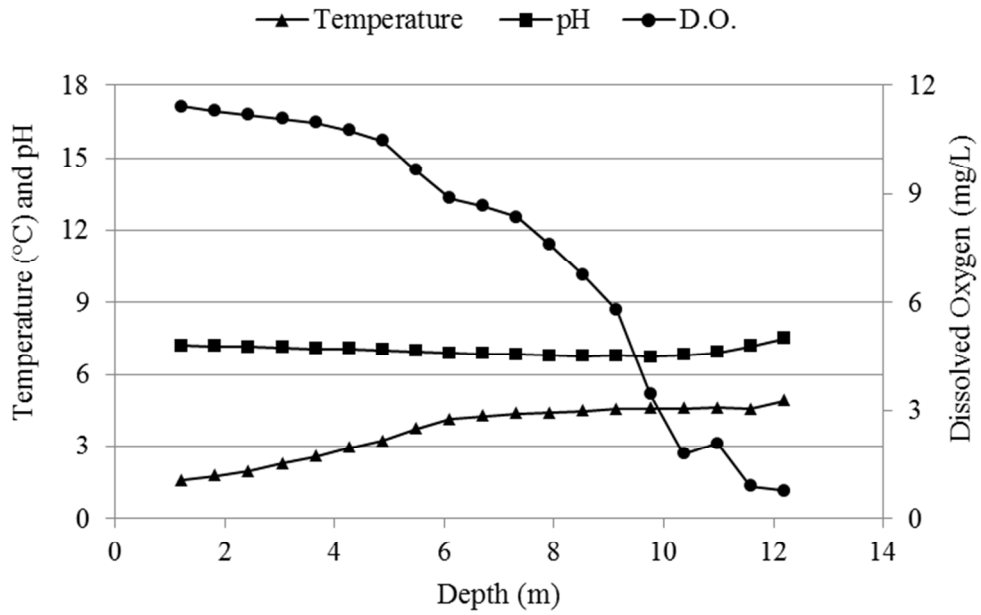


Figure 10.–March 2014 mean DO, temperature, and pH among data collected > 8.5 m depth in USL.

On August 27, 2014 Coeur Environmental staff used Oakton 300 and 10 series meters with 20 m cables to measure DO, temperature and pH at 10 locations in USL.

Figure 11 presents the parameter means for data collected at sample sites > 8.5 m depth. We observed a rapid decrease in dissolved oxygen below 7 m and near anoxic conditions near the lakebed, a thermocline between 3 m and 7 m depth with water temperature warmest near the surface, and consistent pH throughout the water column.

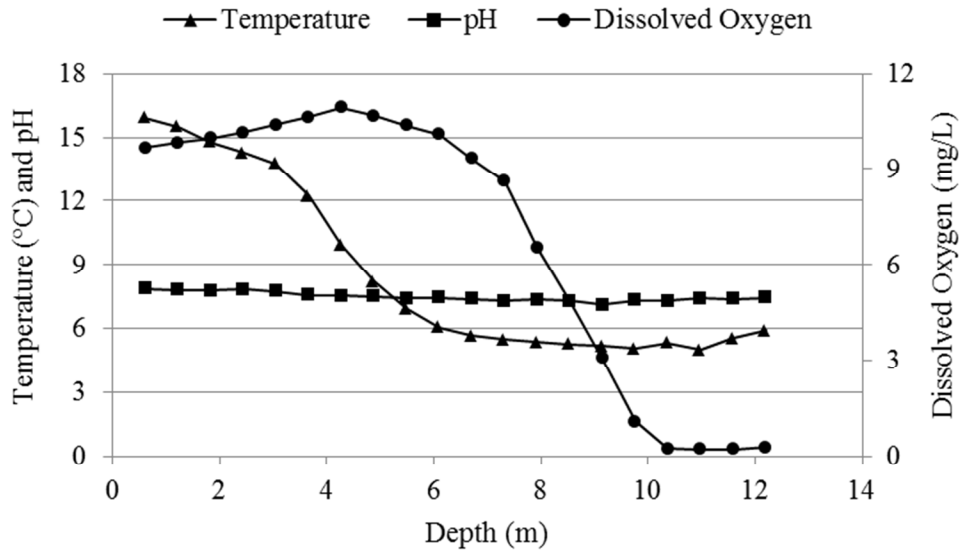


Figure 11.–August 2014 mean DO, temperature, and pH among data collected >8.5 m depth in USL.

Recommendations for 2015

One goal of this study is to determine habitability of mine tailings in the TTF upon cessation of mining. There is recruitment for invertebrates in USL from Upper Slate Creek which influences colonization of all the substrates. This may not be the case for the TTF because USL water will continue to be diverted around the TTF until such time as the water quality in the TTF meets Alaska water quality standards. There are five ephemeral drainages on the west abutment of the TTF that drain a large muskeg. In 2015 we will:

- Sample drainages on the TTF west abutment for presence/absence of potential benthic macroinvertebrate colonizers of the TTF.
- Collect Ponar grab samples from areas in the TTF where no tailings deposition has occurred in the past several months, to evaluate presence absence of benthic macroinvertebrates.
- Repeat a previous study⁵ examining stomach contents of threespine stickleback in the TTF.

These studies will provide information on benthic macroinvertebrate colonization in the TTF prior to reclamation.

Literature Cited

- BLM (Bureau of Land Management). 1996. Acid Rock Drainage Policy for Activities Authorized under 43 CFR 3802/3809. Instructional Memorandum No. 96-79.
- Danks, H.V. and D.R. Oliver. 1972. Seasonal emergence of some high arctic Chironomidae (Diptera). *Canadian Entomologist* 110: 667–669.
- Gerstmeier, R. 1989. Seasonal patterns in the abundance, size, and production of profundal Chironomidae in Starnberger (Bavaria, FRG). *Spiziana* 12: 261–273.
- Merritt, R.W. and K. W. Cummins, editors. 1996. An introduction to the aquatic insects of North America 3rd edition. Kendall/Hunt Publishing Co., Dubuque IA.
- Mousavi, S.K. and P.-A. Amundsen. 2012. Seasonal variations in the profundal Chironomidae (Diptera) assemblage of a subarctic lake. *Boreal Environmental Research*. 17: 102–112.
- Mugo, R. K, D. McDonald, and G. W. Poling. 1999. Subaqueous tailings disposal in freshwater and marine environments – results of predictive geochemical testing using tailings with different compositions. *Proceedings of Mining and the Environment II*: 99-108. Sudbury, Canada.
- Willson-Naranjo, G.R. and K.M. Kanouse. 2014. Kensington Gold Mine tailings treatment facility studies, 2013. Alaska Department of Fish and Game, Technical Report 14-03, Douglas, Alaska.

⁵ Ben Brewster, Habitat Biologists, ADF&G Habitat Division, to Jackie Timothy, Southeast Regional Supervisor, ADF&G Habitat Division. Memorandum: Tailings Treatment Facility threespine stickleback study dated 10/2/2013.

Email cc:

Al Ott, ADF&G Habitat, Fairbanks
ADF&G Habitat Staff, Juneau
Dave Harris, ADF&G CF, Juneau
Randy Bachman, ADF&G CF, Haines
Dan Teske, ADF&G SF, Juneau
Rich Chapell, ADF&G SF, Haines
Stephanie Sell, ADF&G WC, Juneau
Matthew Reece, USFS, Juneau
Steve Brockmann, USFWS, Juneau
Linda Speerstra, USACE, Sitka
HCD, NMFS, Juneau
Kevin Eppers, Coeur Alaska, Juneau