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PTI
ENVIRONMENTAL SERVICES

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May 17, 1996

Pat Maley
Santa Fe Pacific Gold Corporation
Twin Creeks Mine
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Subject: Interim results from a study of the chemical composition, limnology, and ecology of three existing Nevada pit lakes
PTI Project No. CA1Q0601

Dear Pat:

Attached are the interim results from observation, sampling, and analysis of three existing open-pit mine lakes in Nevada. These data were collected in August and September 1995 by scientists from PTI Environmental Services (PTI), Boulder, Colorado, and Resource Concepts, Inc. (RCI), Carson City, Nevada. The attached tables summarize the chemical composition, limnology, and ecology of the Anaconda, Aurora Partnership, and Boss pit lakes.

RCI provided descriptions of the wildlife habitat and near-shore zone of each lake (i.e., identified plant and insect species and abundance), recorded wildlife observations during the sampling event, and sampled the lake sediment and plants for trace-metal analysis. PTI characterized the physical and chemical composition of the lakes by measuring vertical profiles of field parameters (Eh, pH, temperature, dissolved oxygen, specific conductivity, and turbidity), and collected water samples for chemical composition and metals speciation analysis. PTI also collected phytoplankton and zooplankton samples for species identification and population density analyses, and insect samples for trace metal and speciation analysis.

The attached tables present the data in three sections, one for each lake. A table containing the sample location, sample depth, and analyte list is provided for each section, and is correlated to a figure displaying the sample locations. Data summaries include phytoplankton and zooplankton number and species, littoral zone characteristics, and a list of wildlife species observed during the sampling event. In addition, analytical results are presented for major ion, nutrient, and trace element concentrations in the water column, as well as trace element contents of plant tissue, insect tissue, and sediment samples. Finally, figures are provided showing vertical profiles of temperature, dissolved oxygen concentration, pH, specific conductance, Eh, and turbidity in each lake.

Results from winter sampling of the analog pit lakes in March 1996 will be provided after all of the analytical results are received. As always, if you have any questions, please feel free to call me or David Atkins at (303) 444-7270.

Sincerely,

Houston Kempton
Senior Geochemist

cc: John Young (SFPGC)
Sheila Anderson (RCI)
David Atkins (PTI)
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Tom Olsen (BLM, Reno)
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David Gaskin (NDEP)
Doug Zimmerman (NDEP)
Russ Fields (NDOM)
Linda Schevenell, Ph.D. (NBM&G)
Doug Hunt (NDOW)

Section 1

Anaconda Lake

Figure 1-1. Anaconda pit-lake pelagic zone sampling locations (looking east).

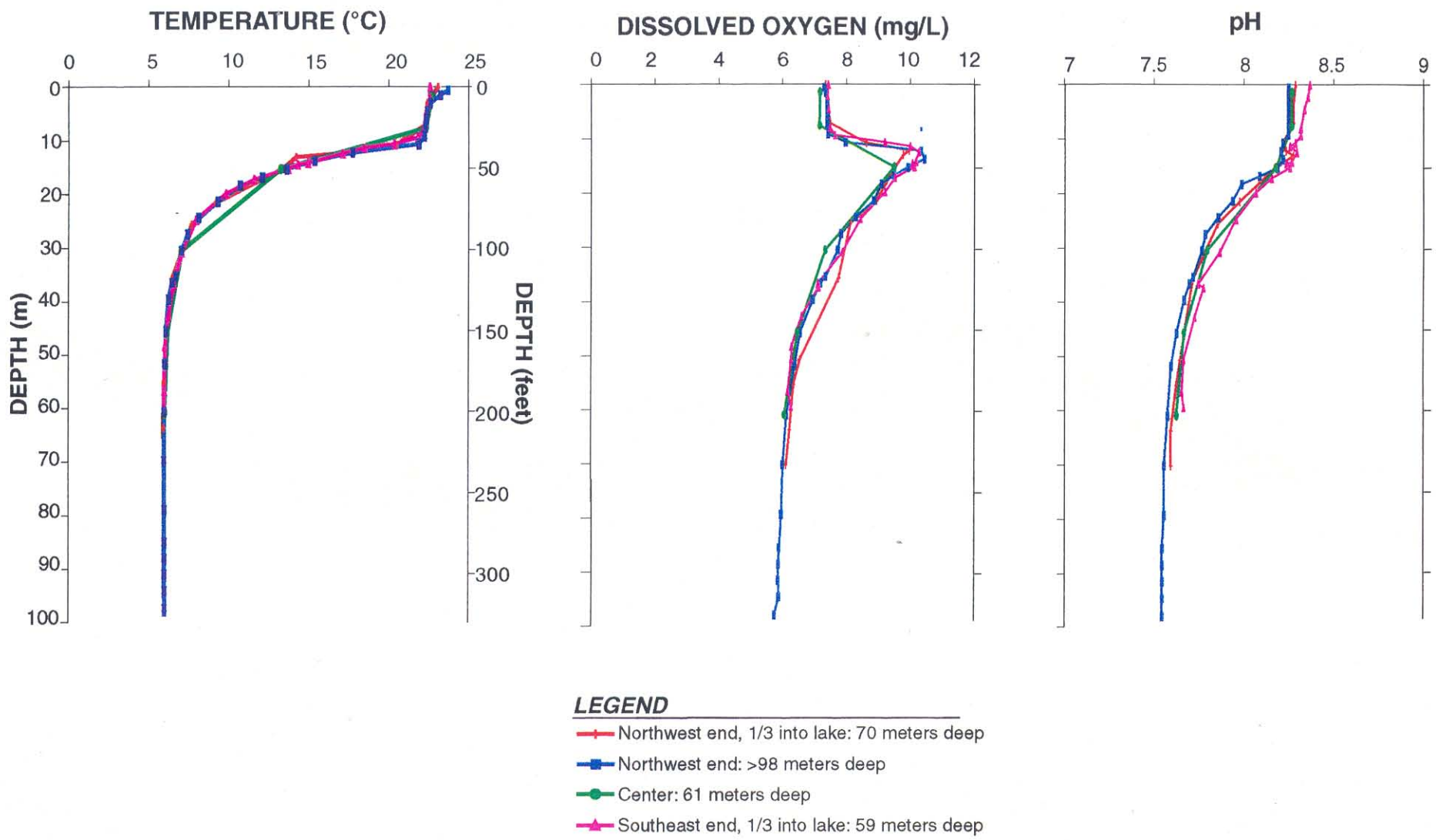

Figure 1-2. Anaconda pit-lake temperature, dissolved oxygen, and pH profiles.

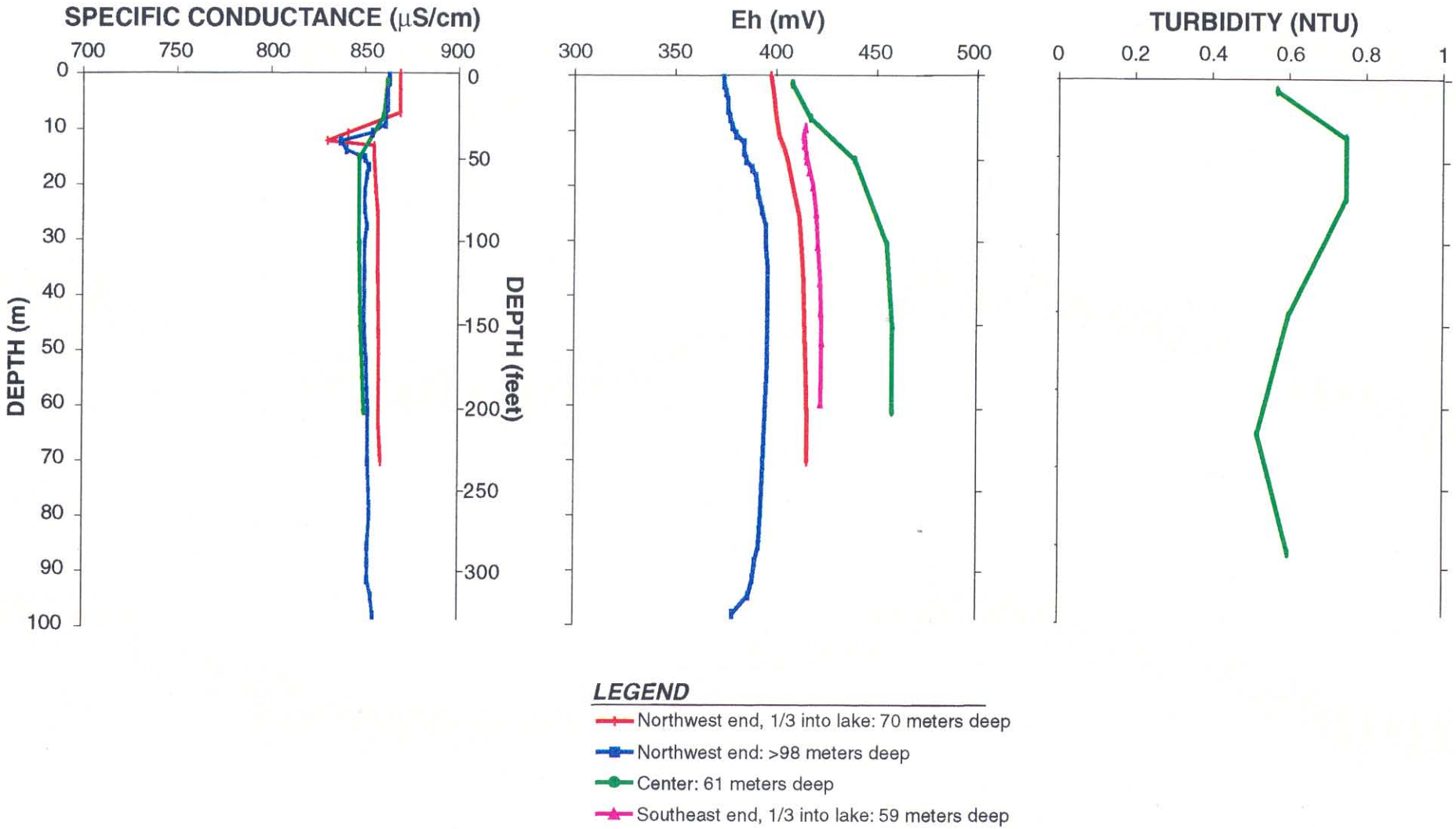

Figure 1-3. Anaconda pit-lake specific conductance, Eh, and turbidity profiles.

TABLE 1-1. ANACONDA LAKE SAMPLE DESCRIPTIONS AND ANALYTE LIST

Sample Locations	Interval (meters)	Sample Description	Analytes
A,B,C	23, 46[a]	Hypolimnion composite water	Arsenic speciation, chlorophyll, WAD CN^-, NH_4, NO_2+NO_3, total P, alkalinity, pH, Cl, F, SO_4, TDS, TOC, DOC, total and dissolved metals[b]
A,B,C	4.6	Epilimnion composite water	Arsenic speciation, chlorophyll, WAD CN^-, NH_4, NO_2+NO_3, total P, alkalinity, pH, Cl, F, SO_4, TDS, TOC, DOC, total and dissolved metals[b]
A	23	Hypolimnion water	Mercury speciation, Hg
A	4.6	Epilimnion water	Mercury speciation, Hg
A	23	Hypolimnion water	Sulfide
A	4.6	Epilimnion water	Sulfide
A	0-15	Phytoplankton	Number and speciation
A	0-30	Zooplankton	Number and speciation
B	23	Hypolimnion water	Mercury speciation, Hg
B	4.6	Epilimnion water	Mercury speciation, Hg
B	0-15	Phytoplankton	Number and speciation
B	0-30	Zooplankton	Number and speciation
C	0-15	Phytoplankton	Number and speciation
C	0-30	Zooplankton	Number and speciation
ANLZA, ANLZB	NA	Plant tissue	Mercury speciation, arsenic speciation, As, Ag, Cd, Cu, Hg, Pb, Sb, Se, Zn
ANLZA, ANLZB	NA	Sediment	Mercury speciation, arsenic speciation, Ag, As, Cd, Cu, Hg, Pb, Sb, Se, TOC, Zn
ANLZA	NA	Sediment	Mercury speciation, arsenic speciation, Ag, As, Cd, Cu, Hg, Pb, Sb, Se, TOC, Zn
ANLZA	NA	Insect tissue	Mercury speciation, arsenic speciation, Ag, As, Cd, Cu, Hg, Pb, Sb, Se, Zn

[a] Depth at 23 meters was sampled at Location C. Locations A and B were sampled at 46 meters in depth.

[b] Total and dissolved metals include antimony, arsenic, aluminum, barium, beryllium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, silica, selenium, silver, sodium, thallium, zinc.

TABLE 1-2. SUMMARY OF PHYTOPLANKTON SPECIES IDENTIFIED FROM THE EPILIMNION OF THE ANACONDA PIT LAKE
(Organisms/mL)

SPECIES LIST	PHYTOPLANKTON TOW ZONE			
	SITE A	SITE B	SITE B (dupicate)	SITE C
Sample depth interval (m)	0-15	0-15	0-15	0-15
Chlorophyta				
Chlamydomonas sp. 1	168	94	94	0
Chlamydomonas sp. 2	31	31	31	31
Chlorella minutissima	52,396	43,789	36,370	33,648
Oocystis lacustris	1,000	689	1,127	1,220
Percent contribution to tow	**76**	**88**	**67**	**66**
Cyanophyta				
Aphanothece sp	532	0	970	0
Jaaginema[1] *geminatum*	0	94	0	500
Jaaginema subtilissimum	16,370	5,728	17,278	17,840
Percent contribution to tow	**24**	**12**	**33**	**34**
Total density	70,517	50,425	55,870	53,239

[1] *Jaaginema (= Ocillatoria)*

TABLE 1-3. SUMMARY OF ZOOPLANKTON SPECIES IDENTIFIED FROM THE EPILIMNION OF THE ANACONDA PIT LAKE
(Total number of organisms)

SPECIES LIST	ZOOPLANKTON TOW ZONE		
	SITE A	SITE B	SITE C
Sample depth interval (m)	0-30	0-30	0-30
Number of tows	4	4	4
Copepoda			
Eucyclops agilis (male)	0	0	1
Paracyclops fimbriatus poppei (female)	4	2	0
Paracyclops fimbriatus poppei (male)	0	0	1
Cyclopoid nauplius	7	15	23
Percent contribution to tow	**0.3**	**0.2**	**0.4**
Rotifera			
bdelloid rotifer	2,685	7,200	4,560
Cephalodella sp.	0	4	8
Colurella sp.	210	525	900
Lepadella sp.	555	780	510
Lecane (L.) sp.	0	1	1
Lecane (M.) sp.	2	14	3
Percent contribution to tow	**99.7**	**99.8**	**99.6**
Total density	3,462	8,541	6,007

TABLE 1-4. SUMMARY OF LITTORAL ZONE SAMPLE AREA CHARACTERISTICS FOR THE ANACONDA PIT LAKE

PARAMETER	LITTORAL ZONE SAMPLE AREAS	
	ANLZA	ANLZB
Location	At point where access road enters pit lake at southeast shore	At point where access road enters pit lake (eastern exposure) on northeast shore
Approximate Area (ac)	1.41	0.31
Sediment Development		
Texture	• fractured rock and fines	• fines over fractured rock
Depth	• 0.0–0.6 cm	• 25–30 cm
Color	• light brown	• black with white cover over organic layers
Biological Structure	• detritus	• Macrophytes, detritus
Presence of Debris	• none	• Leaf litter
Oily Sheen	• none	• none
Odor	• none	• organic
Macrophytes	none	*Typha* sp. (cattails) *Ludwigia* sp. Salt Cedar (inundated)
Invertebrates	Chironomids Aquatic Beetles Aquatic True Bugs	Chironomid
Periphyton	Epilithic algae Epipelic algae	Epilithic algae Epipelic algae Epiphytic algae

TABLE 1-5. WILDLIFE SPECIES LIST FOR ANACONDA PIT LAKE

	Scientific Name	Common Name
BIRDS		
	Actitis macularia	Spotted Sandpiper
	Larus californicus	California Gull
	Podiceps auritus	Horned Grebe
	Podiceps nigricollis	Eared Grebe
	Salponctes obsoletus	Rock Wren
	Cathartes aura	Turkey Vulture
	Riparia riparia	Bank Swallow
MAMMALS		
	Unidentified	Bat
REPTILES		
	Unidentified	Lizard

Observation Dates: 8/23–8/25, and 8/28/95

TABLE 1-6. ANACONDA LAKE WATER COLUMN MAJOR ION AND NUTRIENT ANALYTICAL RESULTS

Analyte	Epilimnion (mg/L)	Hypolimnion (mg/L)
Chlorophyll (μg/L)	0 J	0 J
pH (s.u.)	7.15	7.17
Alkalinity ($CaCO_3$)	120	124
TDS	600	707
TOC	1.3	1.1
DOC	1.7 UJ	1.6 UJ
NH_4	0.01 U	0.01 U
NO_2 + NO_3	0.08	0.08
Phosphorus (total)	0.005 U	0.005 U
Chloride	41.1	37.8
Fluoride	1.3	1.4
Sulfate	292	291
Calcium (total)	90.6	92.8
Calcium (dissolved)	96.4	104
Magnesium (total)	15.7	15.1
Magnesium (dissolved)	17.0	17.2
Potassium (total)	5.59	5.25
Potassium (dissolved)	5.86	5.72
SiO_2 (total)	32.5	28.4
SiO_2 (dissolved)	35.6	33.4
Sodium (total)	78.6	73.8
Sodium (dissolved)	85.3	83.5

U = Not detected; value represents detection limit.
J = Estimated

TABLE 1-7. ANACONDA LAKE WATER COLUMNS TRACE ELEMENT ANALYTICAL RESULTS

Analyte	Epilimnion (µg/L)	Hypolimnion (µg/L)
WAD CN-	10 U	10 U
Sulfide	50 R	50 R
Antimony (total)	6.0	7.0
Antimony (dissolved)	6.0	7.0
Arsenic (total)	4.73	2.82
Arsenic (dissolved)	2.0 J	1.0 J
As^{+3}	0.29	0.24 U
As^{+5}	4.44	2.82
Monomethyl arsonic acid	0.24 U	0.24 U[a]
Dimethyl arsenic acid	0.24 U	0.24 U[a]
Aluminum (total)	33 UJ	36 UJ
Aluminum (dissolved)	17	21
Barium (total)	34	29
Barium (dissolved)	34	33
Beryllium (total)	1.0 U	1.0 U
Beryllium (dissolved)	1.0 U	1.0 U
Cadmium (total)	2.0 U	2.0 U
Cadmium (dissolved)	2.0 U	2.0 U
Chromium (total)	6.0 UJ	3.0 U
Chromium (dissolved)	3.0 U	3.0 U
Copper (total)	25 UJ	131
Copper (dissolved)	20 UJ	131
Iron (total)	17 U	20 UJ
Iron (dissolved)	17 U	17 U
Lead (total)	1.0 U	1.0 U
Lead (dissolved)	1.0 U	1.0 U
Manganese (total)	14	42
Manganese (dissolved)	13	46
Mercury (total)[b]	0.00252 [a]	0.00212 [a]
Mercury (dissolved)[b]	0.2 U	0.2 U
Methyl mercury[b]	0.0000335 U	0.0000335 U
Nickel (total)	21 U	21 U
Nickel (dissolved)	21 U	21 U
Selenium (total)	107 J	123 J
Selenium (dissolved)	92 J	112 J
Silver (total)	2.0 U	2.0 U
Silver (dissolved)	2.0 U	2.0 U
Thallium (total)	1.0 U	1.0 U
Thallium (dissolved)	1.0 U	1.0 U
Zinc (total)	4.0 UJ	9.0 UJ
Zinc (dissolved)	2.0 U	6.0 UJ

[a]Average of duplicate samples.

[b]For mercury analyses, total mercury and methyl mercury were analyzed using ultra-clean sampling techniques. Dissolved mercury was analyzed by ICP and thus has a higher detection limit.

U = Not detected; value represents detection limit.

J = Estimated.

R = Result was rejected.

TABLE 1-8. ANACONDA LAKE - METALS IN SEDIMENT, PLANT, AND MACROINVERTEBRATE TISSUE SAMPLES

Analyte	Epilimnion Water Concentration (µg/L)	Sediment[a] Site D (µg/g)	Sediment[a] Site E (µg/g)	Plant[b] Tissue (*Typha sp*) (µg/g)	Plant[b] Tissue (*Ludwigia sp*) (µg/g)	Macroinvertebrate[b] Tissue (Insect Composite) (µg/g)
%Moisture		62	39	95	97	81
Antimony (total)	6.0	5.73	6.33	0.00315 U	0.01914	0.08018
Arsenic (total)	4.73	8.73 J	22.6 J	0.0219	0.1527	0.0437 J
As^{+3}	0.29	0.005 U	0.005 U			
As^{+5}	4.44	3.1	2.5			
Monomethylarsonic acid	0.24 U	0.057 U	0.057 U	0.00025 U	0.00183	0.00551
Dimethylarsenic acid	0.24 U	0.052 U	0.052 U	0.00025 U	0.00015 U	0.00874
Cadmium (total)	2.0 U	0.122 J	0.181 J	0.0016 U	0.00672	0.05738 J
Copper (total)	25 UJ	1510 J	1280 J	2.57	34.2	110.58
Lead (total)	1.0 U	5.87 J	8.26 J	0.016	0.0456	0.3325 J
Mercury (total)	0.00252 [c]	0.319	0.196	0.000185	0.00432	0.3743
Methyl mercury	0.0000338 U[c]	0.00389	0.000151	0.000083	0.00039	0.3515
Selenium (total)	107 J	21.6 J	7.15 J	0.485	0.933	1.938 J
Silver (total)	2.0 U	0.298 J	0.451 J	0.00309 U	0.001854 U	0.011742 U
Zinc (total)	4.0 UJ	33	56.3	0.74 J	0.762 J	20.52

[a] Dry weight values.

[b] Wet weight values.

[c] Average of duplicate samples.

U = Not detected; value represents detection limit.

J = Estimated.

Note: Blank space indicates no analysis performed.

Section 2

Aurora Lake

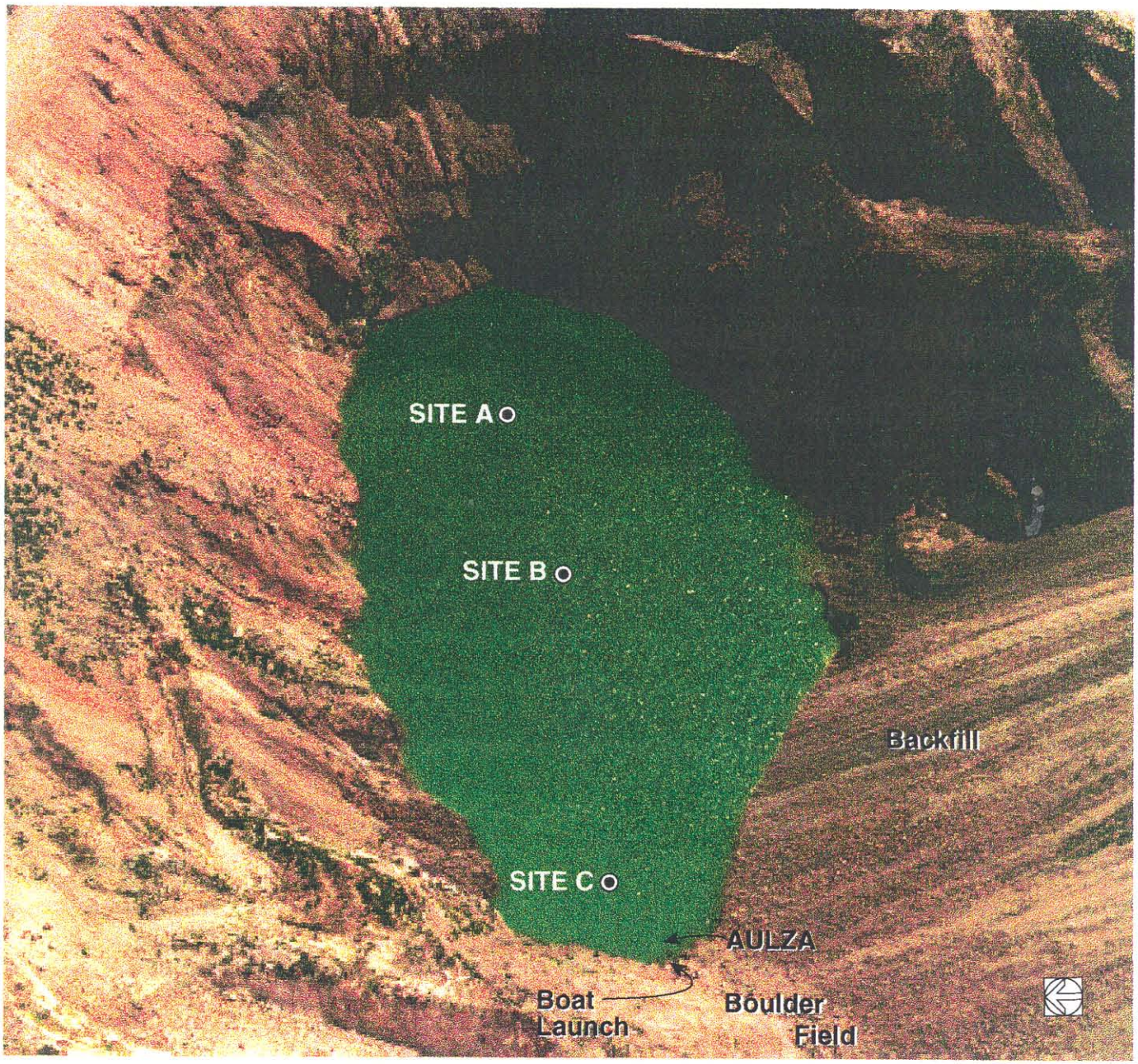

Figure 2-1. Aurora pit-lake pelagic zone sampling locations (looking east).

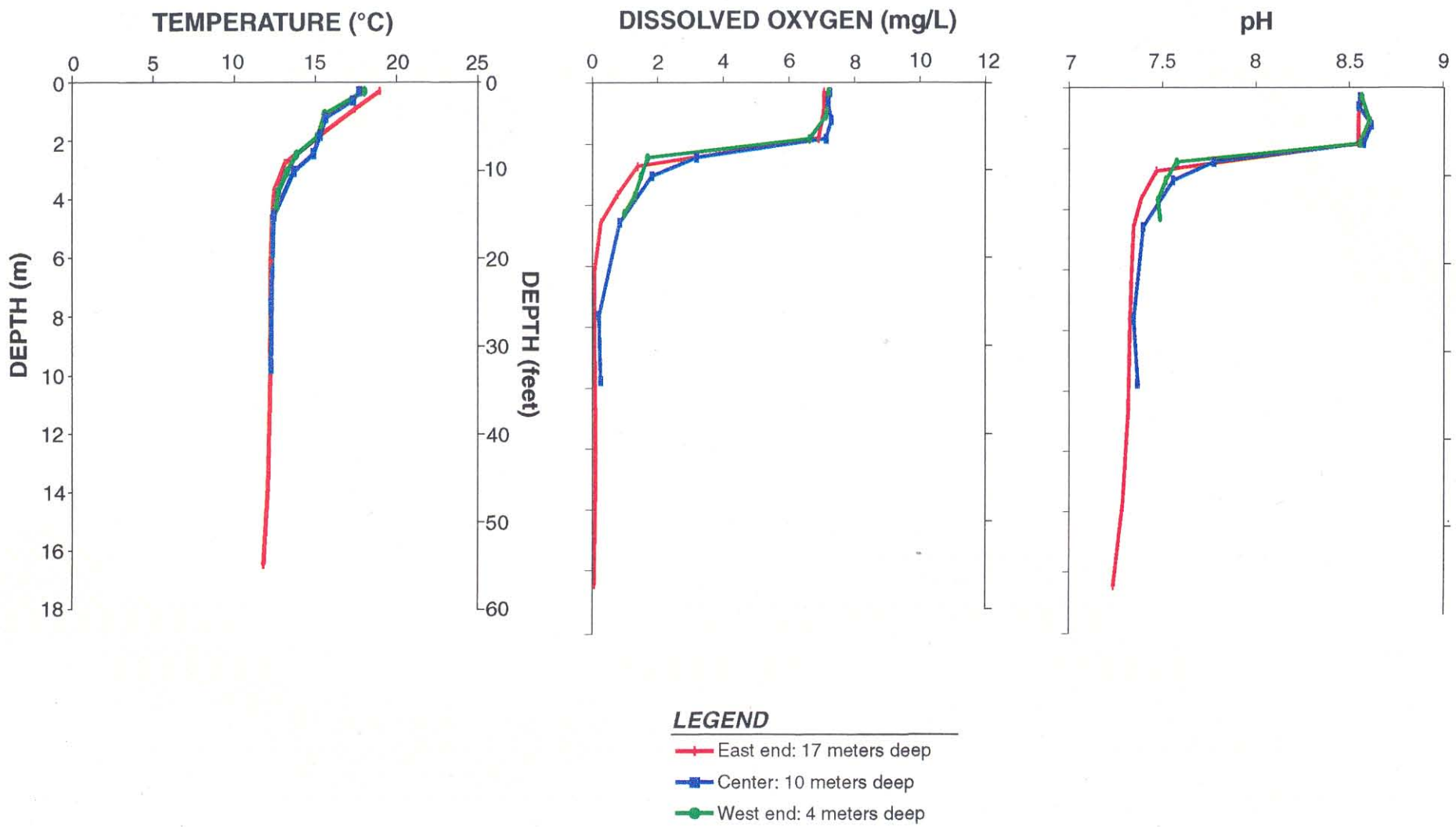

Figure 2-2. Aurora pit-lake temperature, dissolved oxygen, and pH profiles.

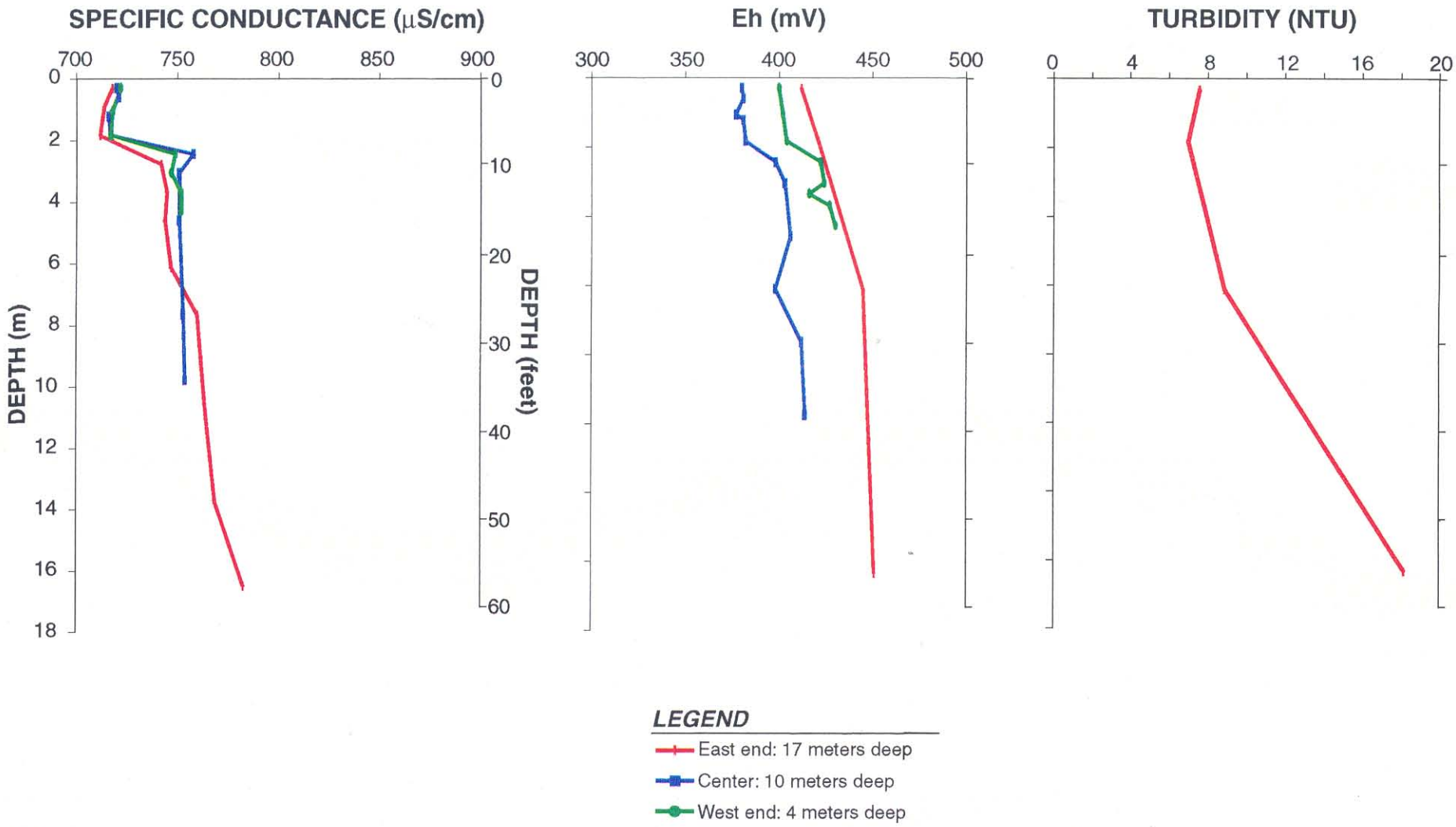

Figure 2-3. Aurora pit-lake specific conductance, Eh, and turbidity profiles.

TABLE 2-1. AURORA LAKE SAMPLE DESCRIPTIONS AND ANALYTE LIST

Sample Locations	Interval (meters)	Sample Description	Analyte
A,B,C	6.1	Hypolimnion composite water	Arsenic speciation, chlorophyll, WAD CN^-, NH_4, NO_2+NO_3, total P, alkalinity, pH, Cl, F, SO_4, TDS, TOC, DOC, total and dissolved metals[a]
A,B,C	1.1	Epilimnion composite water	Arsenic speciation, chlorophyll, WAD CN^-, NH_4, NO_2+NO_3, total P, alkalinity, pH, Cl, F, SO_4, TDS, TOC, DOC, total and dissolved metals[a]
A,B,C	NA	Composite zooplankton tissue	Mercury speciation, arsenic speciation, Ag, As, Cd, Cu, Hg, Pb, Sb, Se, Zn
A	6.1	Hypolimnion water	Mercury speciation, Hg
A	6.1	Hypolimnion water	Sulfide
A	1.1	Epilimnion water	Mercury speciation, Hg
A	1.1	Epilimnion water	Sulfide
A	0-15	Phytoplankton	Number and speciation
A	0-15	Zooplankton	Number and speciation
B	0-7.6	Phytoplankton	Number and speciation
B	0-7.6	Zooplankton	Number and speciation
C	0-4.6	Phytoplankton	Number and speciation
C	0-4.6	Zooplankton	Number and speciation
AULZA	NA	Sediment	Mercury speciation, arsenic speciation, Ag, As, Cd, Cu, Hg, Pb, Sb, Se, TOC, Zn
AULZA	NA	Insect tissue	Mercury speciation, arsenic speciation, Ag, As, Cd, Cu, Hg, Pb, Sb, Se, Zn

[a] Total and dissolved metals include antimony, arsenic, aluminum, barium, beryllium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, silica, selenium, silver, sodium, thallium, zinc.

TABLE 2-2. SUMMARY OF PELAGIC PHYTOPLANKTON SPECIES IDENTIFIED FROM THE AURORA PIT LAKE
(Organisms/mL)

SPECIES LIST	PLANKTON TOW ZONE			
	Site A	Site A (duplicate)	Site B	Site C
Sample depth interval (m)	0-15	0-15	0-7.6	0-4.6
Bacillariophyta (Diatoms)				
Fragilaria delicatissima	16	0	0	16
Fragilaria tenera	63	313	438	688
Nitzschia palea	16	0	31	250
Percent contribution to tow	**1**	**1**	**3**	**5**
Chlorophyta (Green algae)				
Chlamydomonas globosa	31	0	0	0
Chlorella minutissima	13,688	25,313	15,875	15,813
Chlorella sp.	63	0	0	0
Percent contribution to tow	**92**	**98**	**95**	**88**
Chryptophyta				
Chryptomonas sp.	438	63	438	250
Percent contribution to tow	**3**	**0.2**	**3**	**1**
Cyanophyta (Blue-green algae)				
Aphanothece sp	625	0	0	0
Jaaginema geminatum	0	0	0	938
Percent contribution to tow	**4**	**0**	**0**	**5**
Euglenophyta				
Euglena mubabillis	0	63	0	63
Percent contribution to tow	**0**	**0.2**	**0**	**0.3**
Total density	14,940	25,752	16,782	18,018

TABLE 2-3 SUMMARY OF PELAGIC ZOOPLANKTON SPECIES IDENTIFIED FROM THE AURORA PIT LAKE
(Total number of organisms)

SPECIES LIST	PLANKTON TOW ZONE		
	Site A	Site B	Site C
Sample depth interval (m)	0-15	0-7.6	0-4.6
Number of tows	1	1	1
Cladocera			
Daphnia pulex (female)	3,000	4,020	285
Daphnia schodleri (female)	465	990	1,005
Daphnia spp. *(male)*	165	60	90
Percent contribution to tow	**19**	**43**	**36**
Copepoda			
Eucyclops agilis (female)	0	3	1
Acanthocyclops vernalis (female)	4	6	1
Acanthocyclops vernalis (male)	12	6	14
Cyclopoid juvenile	1,755	2,175	390
Cyclopoid nauplius	345	225	735
Percent contribution to tow	**11**	**21**	**29**
Rotifera			
Epiphanes senta	1	0	0
Filinia longiseta	13,035	4,080	1,065
Polyarthra vulgaris	195	60	300
Percent contribution to tow	**70**	**36**	**35**
Total density	18,977	11,625	3,886

TABLE 2-4. SUMMARY OF LITTORAL ZONE SAMPLE AREA CHARACTERISTICS FOR THE AURORA PIT LAKE

PARAMETER	LITTORAL ZONE SAMPLE AREA
	AULZA
Location	Shallow area at west end of pit lake
Approximate Area (ac)	2.31
Sediment Development	
Texture	• fractured rock and sand with some fines
Depth	• 0.5–1.0 cm
Color	• light brown
Biological Structure	• none
Presence of Debris	• none
Oily Sheen	• none
Odor	• none
Macrophytes	none
Invertebrates	Backswimmers
	Aquatic Mites
	Water Boatsman
	Aquatic Wasps
	White flies
	Ephippia
	Chironomid larvae
	Nematodes
Periphyton	Blue-green algae (*Jaaginema*)
	Diatoms

TABLE 2-5. SPECIES LIST FOR AURORA PIT LAKE

Scientific Name	Common Name
BIRDS	
Actitis macularia	Spotted Sandpiper
Salponctes obsoletus	Rock Wren
Riparia riparia	Bank Swallow
Accipiter cooperii	Cooper's Hawk
MAMMALS	
Spermophilus townsendii	Townsend's Ground Squirrel
Unidentified	Bat

Observation Dates: 8/29/95–8/31/95

TABLE 2-6. AURORA LAKE WATER COLUMN MAJOR ION AND NUTRIENT ANALYTICAL RESULTS

Analyte	Epilimnion (mg/L)	Hypolimnion (mg/L)
Chlorophyll (μg/L)	0.85 J	0.5 J
pH (s.u.)	7.59	7.68
Alkalinity ($CaCO_3$)	89.1	106
TDS	478	524
TOC	1.9	1.6
DOC	3.0 UJ	1.9 UJ
NH_4	0.01 U	0.1 U
NO_2 + NO_3	3.86	4.64
Phosphorus (total)	0.02	0.03
Chloride	11.4	11.7
Fluoride	0.6	0.4
Sulfate	266	266
Calcium (total)	80.6	82.5
Calcium (dissolved)	86.1	84.3
Magnesium (total)	20.1	19
Magnesium (dissolved)	21.6	19.5
Potassium (total)	5.42 UJ	5.90 UJ
Potassium (dissolved)	6.45 UJ	5.33 UJ
SiO_2 (total)	18.8	18.1
SiO_2 (dissolved)	19.6	17.4
Sodium (total)	37.6	35.4
Sodium (dissolved)	40.3	36.2

U = Not detected; value represents detection limit.
J = Estimated

TABLE 2-7. AURORA LAKE WATER COLUMN TRACE ELEMENT ANALYTICAL RESULTS

Analyte	Epilimnion (μg/L)	Hypolimnion (μg/L)
WAD CN-	10 U	10 U
Sulfide	50 R	50 R
Antimony (total)	3.0	4.0
Antimony (dissolved)	3.0	4.0
Arsenic (total)	8.95	8.98
Arsenic (dissolved)	7.0 J	4.0 J
As^{+3}	0.24 U	0.24 U
As^{+5}	9.2	8.98
Monomethyl arsonic acid	0.24 U[a]	0.24 U
Dimethyl arsenic acid	0.365 [a]	0.24 U
Aluminum (total)	245	271
Aluminum (dissolved)	26 UJ	8.0 U
Barium (total)	78	71
Barium (dissolved)	76	68
Beryllium (total)	1.0 U	1.0 U
Beryllium (dissolved	1.0 U	1.0 U
Cadmium (total)	2.0 U	2.0 U
Cadmium (dissolved)	2.0 U	2.0 U
Chromium (total)	3.0 U	3.0 U
Chromium (dissolved)	4.0 UJ	3.0 U
Copper (total)	5.0 UJ	3.0 UJ
Copper (dissolved)	3.0 UJ	3.0 U
Iron (total)	839	174
Iron (dissolved)	17 U	17 U
Lead (total)	3.0 UJ	1.0 U
Lead (dissolved)	1.0 UJ	1.0 U
Manganese (total)	43	70
Manganese (dissolved)	1.0 U	57
Mercury (total)[b]	0.01585 [a]	0.0334
Mercury (dissolved)[b]	0.2 U	0.2 U
Methyl mercury[b]	0.000041	0.0000336 U
Nickel (total)	21 U	21 U
Nickel (dissolved)	21 U	21 U
Selenium (total)	11 J	11 J
Selenium (dissolved)	11 J	10 J
Silver (total)	2.0 U	2.0 U
Silver (dissolved)	2.0 U	2.0 U
Thallium (total)	1.0 UJ	1.0 U
Thallium (dissolved)	1.0 UJ	1.0 U
Zinc (total)	4.0 UJ	4.0 UJ
Zinc (dissolved)	2.0 UJ	7.0 UJ

[a]Average of duplicate samples.

[b]For mercury analyses, total mercury and methyl mercury were analyzed using ultra-clean sampling techniques. Dissolved mercury was analyzed by ICP and thus has a higher detection limit.

U = Not detected; value represents detection limit.

J = Estimated.

R = Result was rejected.

TABLE 2-8. AURORA LAKE - METALS IN SEDIMENT AND MACROINVERTEBRATE SAMPLES

Analyte	Epilimnion Water Concentration (µg/L)	Sediment[a] (µg/g)	Duplicate[a] Sediment (µg/g)	Macroinvertebrate[b] Tissue (Black Flies) (µg/g)	Zooplankton[b] Tissue *(Daphnia)* (µg/g)
% Moisture		48	30	95	96
Antimony (total)	3.0	12.2	16.5	0.01225	0.00252 U
Arsenic (total)	8.95	63.7 J	102 J	0.215 J	0.608 J
As^{+3}	0.24 U	0.005	0.009		
As^{+5}	9.2 [c]	8.6	9.5		
Monomethylarsonic acid	0.24 U[c]	0.057 U	0.057 U	0.034	0.0156
Dimethylarsenic acid	0.365 [c]	0.052 U	0.052 U	0.0018	0.232
Cadmium (total)	2.0 U	0.276 J	0.752 J	0.00515 J	0.772 J
Copper (total)	5.0 UJ	38.3 J	48.1 J	1.385	0.936
Lead (total)	3.0 UJ	6.81 J	9.59 J	0.0468 J	0.00728 J
Mercury (total)	0.01585 [c]	0.209	0.206	0.00695	0.0868
Methyl mercury	0.000041	0.000063 U	0.00006 U	0.000068	0.001332
Selenium (total)	11 J	0.52 J	0.71 J	0.0445 J	0.2552 J
Silver (total)	2.0 U	1.4 J	2.01 J	0.0147	0.02308
Zinc (total)	4.0 UJ	97.4	95.8	4.515	14.56

[a] Dry weight values.

[b] Wet weight values.

[c] Average of duplicate samples.

U = Not detected; value represents detection limit.

J = Estimated.

Section 3

Boss Lake

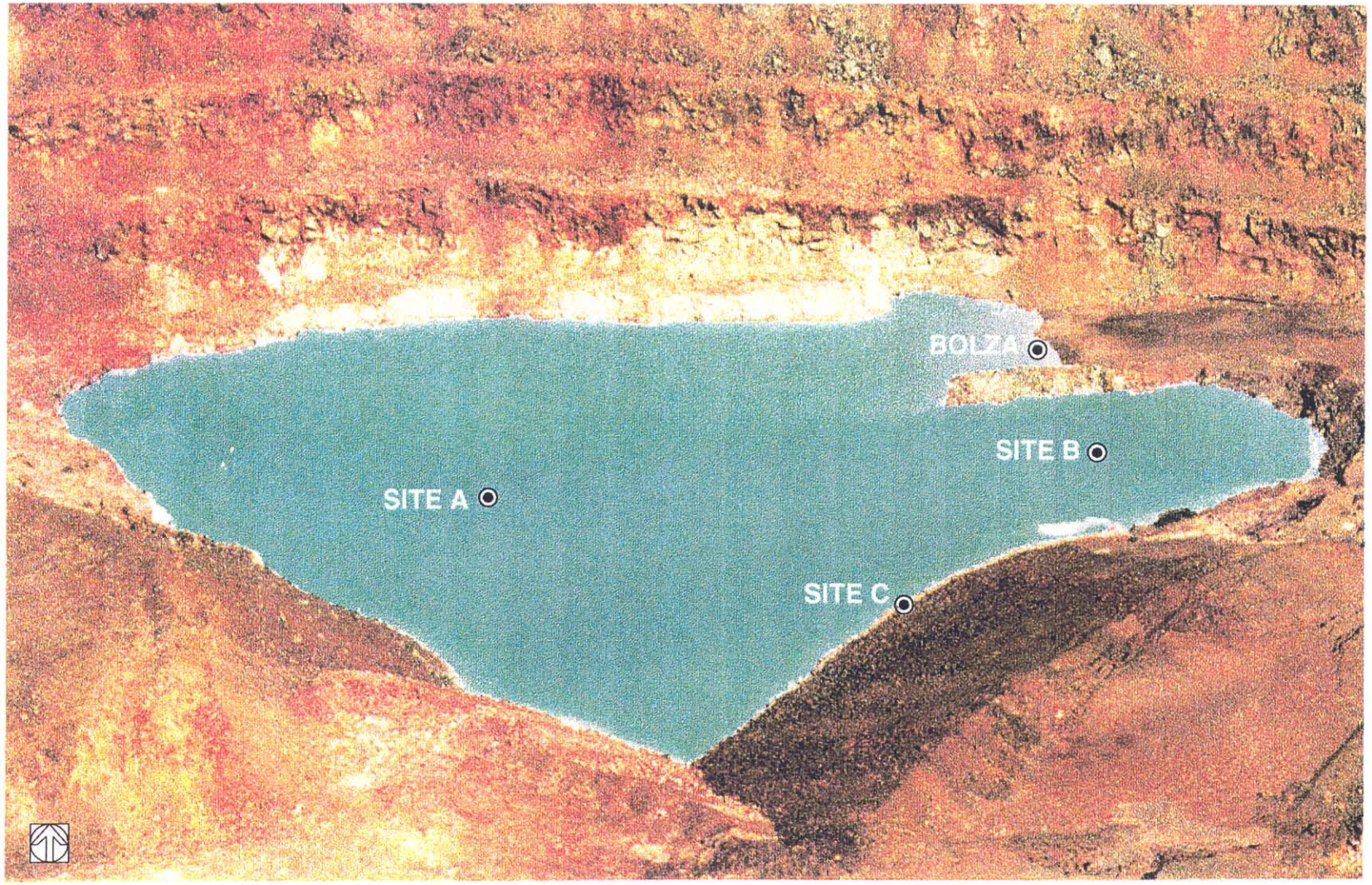

Figure 3-1. Boss pit-lake pelagic zone sampling locations (looking north).

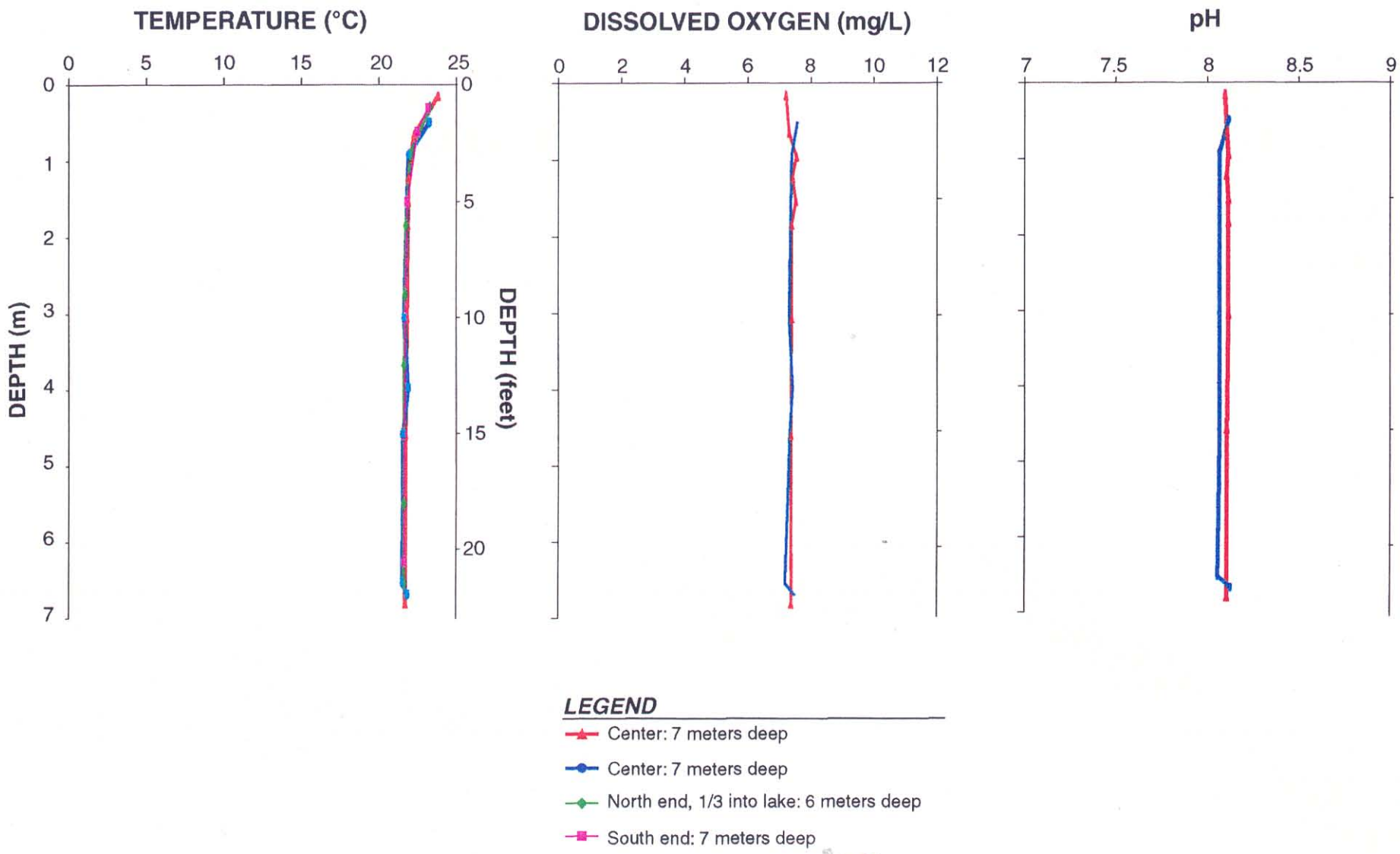

Figure 3-2. Boss pit-lake temperature, dissolved oxygen, and pH profiles.

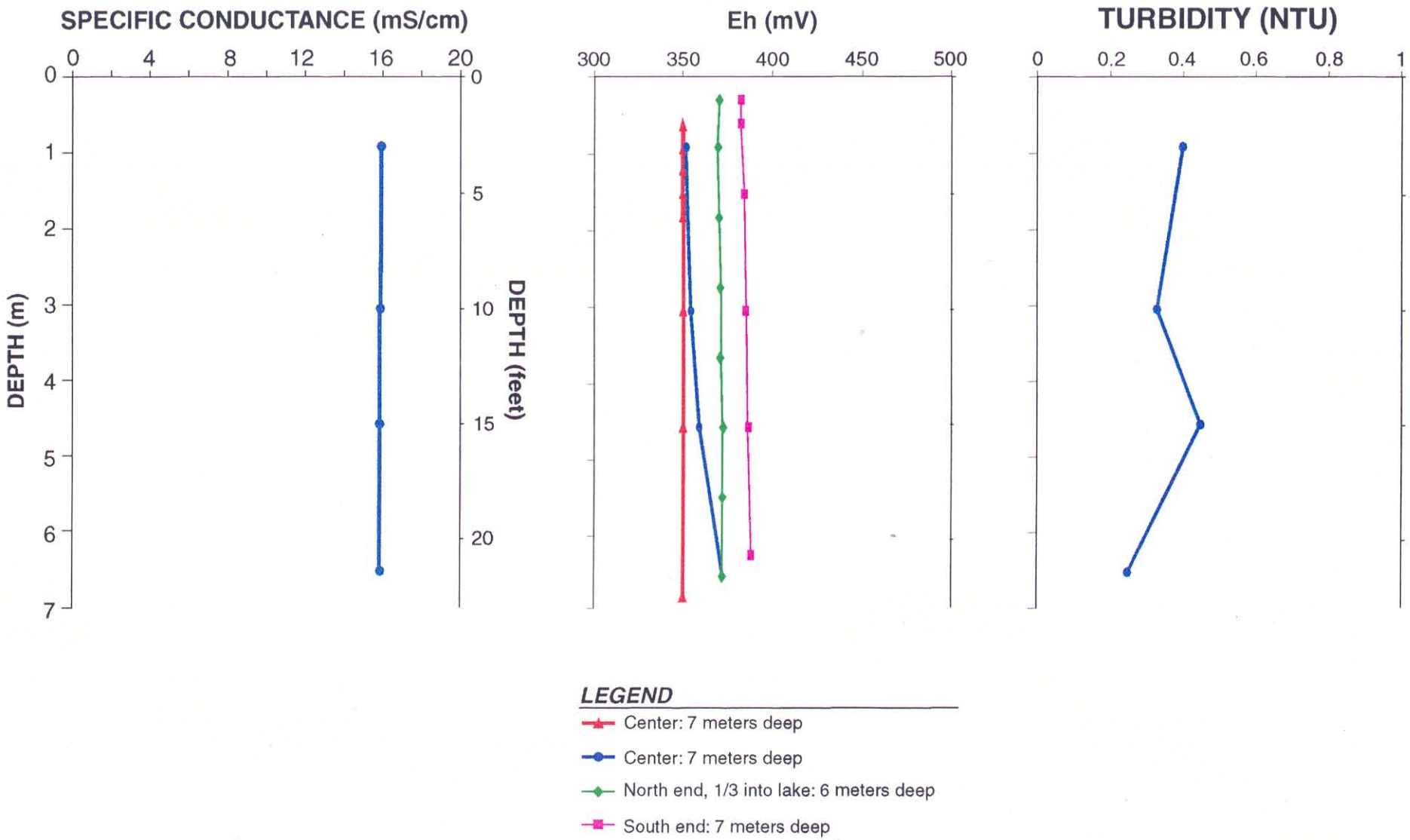

Figure 3-3. Boss pit-lake specific conductance, Eh, and turbidity profiles.

TABLE 3-1. BOSS LAKE SAMPLE DESCRIPTIONS AND ANALYTE LIST

Sample Locations	Interval (meters)	Sample Description	Analyte
A,B	2.8, 4.0[a]	Deep composite water	Arsenic speciation, chlorophyll, WAD CN^-, NH_4, NO_2+NO_3, total P, alkalinity, pH, Cl, F, SO_4, TDS, TOC, DOC, total and dissolved metals[b]
A,B	0.46	Shallow composite water	Arsenic speciation, chlorophyll, WAD CN^-, NH_4, NO_2+NO_3, total P, alkalinity, pH, Cl, F, SO_4, TDS, TOC, DOC, total and dissolved metals[b]
A	0-6	Phytoplankton	Number and speciation
A	0-6	Zooplankton	Number and speciation
A	4.0	Deep water	Mercury speciation, Hg
A	4.0	Deep water	Sulfide
A	0.46	Shallow water	Mercury speciation, Hg
A	0.46	Shallow water	Sulfide
B	0-3	Phytoplankton	Number and speciation
B	0-3	Zooplankton	Number and speciation
BOLZA	NA	Sediment	Mercury speciation, arsenic speciation, Ag, As, Cd, Cu, Hg, Pb, Sb, Se, TOC, Zn
B	NA	Insect tissue	Mercury speciation, arsenic speciation, Ag, As, Cd, Cu, Hg, Pb, Sb, Se, Zn
C	NA	Precipitate	Arsenic speciation, NO_2+NO_3, Cl, F, SO_4, total metals[c]
C	NA	Host-rock	Arsenic speciation, NO_2+NO_3, Cl^-, F, SO_4, total metals[c]

[a] Depth at 2.8 meters was sampled at Location B.

[b] Total and dissolved metals include antimony, arsenic, aluminum, barium, beryllium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, silica, selenium, silver, sodium, thallium, zinc.

[c] Total metals include aluminum, arsenic, barium, beryllium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, zinc.

TABLE 3-2. SUMMARY OF PELAGIC PHYTOPLANKTON SPECIES IDENTIFIED IN THE BOSS PIT LAKE
(Organisms/mL)

SPECIES LIST	PLANKTON TOW ZONE		
	SITE A	SITE A (duplicate)	SITE B
Sample depth interval (m)	0-6	0-6	0-3
Bacillariophyta (Diatoms)			
Achnanthes minutissima	0	3	0
Cymbella cesatii	85	14	5
Nitzschia fonticola	0	0	11
Percent contribution to tow	**0.2**	**0.1**	**0.2**
Chlorophyta (Green algae)			
Chlamydomonas sp. 3	63	313	438
Chlorococcum sp.	0	3	5
Monoraphidinium minutum	5	0	0
Percent contribution to tow	**0.2**	**2**	**4.7**
Chryptophyta			
Chroomonas sp.	0	0	8
Percent contribution to tow	**0**	**0**	**0.1**
Cyanophyta (Blue-green algae)			
Synechococcus sp.	0	250	0
Aphanothece sp.	0	7,500	7,500
Rhabdoglosa sp.	43,125	7,813	1,438
Percent contribution to tow	**99.6**	**97.9**	**95**
Pyrrophyta (Dynoflagellate)			
Gymnodinium palustre	16	0	0
Percent contribution to tow	**0.04**	**0**	**0**
Total density	43,294	15,896	9,655

TABLE 3-3. SUMMARY OF PELAGIC ZOOPLANKTON SPECIES IDENTIFIED IN THE BOSS PIT LAKE
(Total number of organisms)

SPECIES LIST	PLANKTON TOW ZONE	
	SITE A	SITE B
Sample depth interval (m)	0-6	0-3
Number of tows	5	5
Rotifera		
bdelloid rotifer	0	13
Brachionus urceolaris	9	9
Hexarthra sp.	0	1
Lecane (M.) sp.	180	480
rotifer A	5	41
Percent contribution to tow	**100**	**100**
Total density	194	544

TABLE 3-4. SUMMARY OF LITTORAL ZONE SAMPLE AREA CHARACTERISTICS FOR THE BOSS PIT LAKE

PARAMETER	LITTORAL ZONE SAMPLE AREAS (BOLZA)
Location	At point where haul road entered pit lake
Approximate Area (ac)	0.23
Sediment Development	• fractured rock and fines
Texture	• 10.5 cm
Depth	• 0.5 cm light brown silt
Color	10 cm black clayey silt
Biological Structure	• none
Presence of Debris	• none
Oily Sheen	• none
Odor	• organic
Macrophytes	none
Invertebrates	Soil Mites Mayflies Damselflies
Periphyton (epipelic)	Euglena Diatoms Bdelloid rotifer Nematodes

TABLE 3-5. SPECIES LIST FOR BOSS PIT LAKE AND PONDS

Scientific Name	Common Name
Species present at the Boss Pit Lake	
BIRDS	
Spizella breweri	Brewer's Sparrow
REPTILES	
Callisaurus draconoides	Zebratail Lizard
Species present at the adjacent cyanide heap leach solution collection ponds	
BIRDS	
Actitis macularia	Spotted Sandpiper
Podiceps auritus	Horned Grebe
Anas stepera	Gadwall
Himantopus mexicanus	Black-necked Stilt
Euphagus cyanocephalus	Brewer's Blackbird
Unidentified	Swallow

Observation Dates: 9/11/95–9/13/95

TABLE 3-6. BOSS LAKE WATER COLUMN MAJOR ION AND NUTRIENT ANALYTICAL RESULTS

Analyte	Shallow (mg/L)	Deep (mg/L)
Chlorophyll (μg/L)	0 J	0.2 J
pH (s.u.)	8.29	8.25
Alkalinity ($CaCO_3$)	102	101
TDS	12400	12700
TOC	1 UJ	1.9 J
DOC	1 UJ	1.2 UJ
NH_4	0.01 U	0.02 UJ
NO_2 + NO_3	25.2	24.4
Phosphorus (total)	0.51	0.53
Chloride	3130	3560
Fluoride	2.5 U	2.5 U
Sulfate	5150	5090
Calcium (total)	633	574
Calcium (dissolved)	613	662
Magnesium (total)	256	232
Magnesium (dissolved)	252	270
Potassium (total)	22.7	20.3
Potassium (dissolved)	20	23.7
SiO_2 (total)	18.8	17
SiO_2 (dissolved)	18.7	19.9
Sodium (total)	2490	2780
Sodium (dissolved)	2460	2640

U = Not detected; value represents detection limit.
J = Estimated.

TABLE 3-7. BOSS LAKE WATER COLUMN TRACE ELEMENT ANALYTICAL RESULTS

Analyte	Shallow (µg/L)	Deep (µg/L)
WAD CN-	10 U	10 U
Sulfide	50 R	50 R
Antimony (total)	28	26
Antimony (dissolved)	33	31
Arsenic (total)	1570	1240
Arsenic (dissolved)	1230	1170
As^{+3}	5.6	3.5
As^{+5}	1560	1240
Monomethyl arsonic acid	24.4 U	24.4 U
Dimethyl arsenic acid	24.4 U	24.4 U
Aluminum (total)	57 UJ	57 UJ
Aluminum (dissolved)	11 UJ	92 UJ
Barium (total)	1.0 U	1.0 U
Barium (dissolved)	1.0 U	1.0 U
Beryllium (total)	1.0 U	1.0 U
Beryllium (dissolved	1.0 U	1.0 U
Cadmium (total)	2.0 U	2.0 U
Cadmium (dissolved)	2.0 U	2.0 U
Chromium (total)	3.0 U	716
Chromium (dissolved)	3.0 U	9.0 UJ
Copper (total)	3.0 U	8.0
Copper (dissolved)	3.0 U	4.0 UJ
Iron (total)	18 UJ	2920
Iron (dissolved)	17 U	17 U
Lead (total)	1.0 U	1.0 U
Lead (dissolved)	1.0 U	1.0 U
Manganese (total)	1.0 U	63
Manganese (dissolved)	1.0 U	1.0 U
Mercury (total)[a]	0.0516	0.0496
Mercury (dissolved)[a]	0.2 U	0.2 U
Methyl mercury[a]	0.0000339 U	0.0000341 U
Nickel (total)	21 U	321
Nickel (dissolved)	21 U	21 U
Selenium (total)	50 J	74 J
Selenium (dissolved)	82 J	30 UJ
Silver (total)	2.0 U	2.0 U
Silver (dissolved)	2.0 U	7.0
Thallium (total)	1.0 J	1.0 UJ
Thallium (dissolved)	1.0 J	1.0 J
Zinc (total)	255	8.0
Zinc (dissolved)	2.0 U	3.0 U

[a] For mercury analyses, total mercury and methyl mercury were analyzed using ultra-clean sampling techniques. Dissolved mercury was analyzed by ICP and thus has a higher detection limit.

U = Not detected; value represents detection limit.

J = Estimated.

R = Result was rejected.

TABLE 3-8. BOSS LAKE - METALS IN SEDIMENT AND MACROINVERTEBRATE SAMPLES

Analyte	Shallow Water Concentration (µg/L)	Sediment[a] (µg/g)	Macroinvertebrate[b] Tissue (Insect Composite) (µg/g)
%Moisture		39	93
Antimony (total)	28	58	0.0819
Arsenic (total)	1570	1050 J	2.051 J
As^{+3}	5.6	14.5	
As^{+5}	1560	155	
Monomethylarsonic acid	24.4 U	1.1 U	0.0035 U
Dimethylarsenic acid	24.4 U	1 U	0.0035 U
Cadmium (total)	2.0 U	0.419 J	0.02422 J
Copper (total)	3.0 U	31 J	1.239 J
Lead (total)	1.0 U	14.5 J	0.04466 J
Mercury (total)	0.0516	0.213	0.01113
Methyl mercury	0.0000339 U	0.0003173	0.001645
Selenium (total)	50 J	2.44 J	0.1246 J
Silver (total)	2.0 U	2.12 J	0.05152 J
Zinc (total)	255	114	7

[a] Dry weight values.

[b] Wet weight values.

U = Not detected; value represents detection limit.

J = Estimated.

TABLE 3-9. BOSS LAKE CHEMICAL SOLID RESULTS

(All units mg/kg)

Analyte	Precipitate	Host Rock
Aluminum (total)	2900	5780
Arsenic (total)	302	998
As^{+3}	2.38	4.56
As^{+5}	300	993
Barium (total)	22.4	8.7
Beryllium (total)	0.2 U	0.2 U
Cadmium (total)	1	3.3
Calcium (total)	66700	4370
Chloride	150000	5430
Chromium (total)	9.5	50.7
Copper (total)	4.1	12.9
Fluoride	66.2	24.9
Iron (total)	6200	25400
Lead (total)	8 U	8 U
Magnesium (total)	12400	4700
Manganese (total)	250	143
Mercury (total)	3.1	1.1
Nickel (total)	7.5	26.5
Nitrate-N	611	37
Nitrite-N	130 U	6.3 U
$NO_2 + NO_3$	611	37
Potassium (total)	595	712
Selenium (total)	16.4	39.7
Silver (total)	15.8	1.2
Sodium (total)	111000	3910
Sulfate	200000	9060
Thallium (total)	8 U	8 U
Zinc (total)	17.5	40.6

U = Not detected; value represents detection limit.