GROVE POND
ARSENIC INVESTIGATION
Final

APPENDICES

Regional Oversight Contract
Work Assignment No. 112

Confidential

March 2002

EPA CONTRACT NO. 68-W-00-105

Submitted to:
U.S. Environmental Protection Agency
Region I

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Gannett Fleming
199 Wells Avenue ◆ Suite 210 ◆ Newton ◆ Massachusetts

APPENDIX A.

GEOPHYSICS REPORT

(M. Blackey, Geophysical Applications, Inc.)

Surface and Borehole Geophysical Surveys
Fort Devens – Grove Pond Investigation
Ayer, Massachusetts

Prepared for
GANNETT FLEMING, INC.
December 2000

GEOPHYSICAL
APPLICATIONS
INCORPORATED

December 6, 2000

Mr. Peter Golonka
GANNETT FLEMING, INC.
150 Wood Road
Braintree, MA 02184

Subject: Surface & Borehole Geophysical Surveys
Fort Devens – Grove Pond Investigation
Ayer, Massachusetts

Dear Mr. Golonka:

Geophysical Applications, Inc. performed surface and borehole geophysical surveys at the above-noted site to help Gannett Fleming characterize bedrock depths and soil stratigraphy.

The prescribed borehole-logging suite included natural gamma (all wells) and electromagnetic (EM) conductivity logging (PVC-cased wells). Additional logs recorded by a multi-parameter probe that contains the natural gamma sensor (especially fluid temperature and fluid resistivity), are provided herein as a courtesy to Gannett Fleming. The primary purpose of the borehole geophysical logs was to help identify silty strata in seven new and previously-drilled wells.

Surface geophysical survey methods included seismic refraction profiling and electrical resistivity soundings. The refraction profiling was intended to measure bedrock depths near the Town's existing water-supply wells. Two resistivity soundings were performed to check whether that technique could locate a silty layer encountered by a borehole near the Town wells.

METHODS OF INVESTIGATION

Survey Control

All borehole logs were referenced to depths below ground surface. The geophysical logging winch contains an optical depth encoder, to maintain depth measurements accurate within approximately ± 0.2 feet throughout each borehole.

Seismic traverse positions were determined by tape and compass measurements referenced to a previously-drilled piezometer and the Town pump houses. Ground elevations along the seismic traverses were measured with a Pentax electronic theodolite, referenced to a ground elevation value of 222.25 feet provided by Gannett Fleming for piezometer MW-92-1 (top of casing elevation = 224.15 feet, minus the measured stickup height of 1.9 feet).

All geophysical traverse locations, and logged boreholes, are shown on a site sketch prepared by Geophysical Applications (Figure 1).

Borehole Geophysical Logging

A Mount Sopris model MGX-II digital logging winch was used with Mount Sopris polyprobe and EM conductivity sondes to obtain geophysical log data. All geophysical logs were recorded at 0.1-foot depth increments, as determined by the logging winch's digital depth encoder.

The polyprobe provides an extensive suite of logs during a single run: fluid temperature, fluid resistivity, single-point resistance (SPR), spontaneous potential (SP), natural gamma, and normal resistivity (with electrode spacings of 8, 16, and 32 inches). Polyprobe logs were recorded at a relatively slow downward logging speed of 3 to 4 feet per minute, to help identify subtle anomalies. EM conductivity logs were recorded at slightly higher speeds, typically 6 to 8 feet per minute.

All geophysical logs were recorded on a laptop computer's hard drive, and transferred to floppy diskette as a backup precaution.

Post-survey plot scales were adjusted to display as much detail as possible on a single printed page. All logs from the same borehole were merged onto one log plot, to aid data correlation. Similar gamma-log plotting scales were utilized for all wells, to aid correlations between boreholes.

SPR and normal resistivity data recorded by the polyprobe are not presented in this report. These logs require the logging probe to be in direct electrical contact with the surrounding soil or rock formations. Electric logs obtained in PVC or steel-cased wells (as was the case during this survey) are therefore essentially meaningless.

Seismic Refraction

Refraction profiling was performed to help measure bedrock depths near the Town's pumping wells. A previous survey conducted by others yielded uncertain cross sections depicting bedrock approximately 60 feet below ground surface. The seismic source during that prior survey consisted only of sledgehammer blows on the ground surface, with a 12-channel seismograph. Gannett Fleming wished to confirm or disprove those interpretations with a seismic survey that included a more robust seismic source, along traverses arranged around the Town wells.

Refraction data were acquired during this survey using a 24-channel ABEM Terraloc Mark 6 seismograph with 15-foot geophone spacings. Seismic energy was generated with a Betsy® firing rod (in wooded areas) or a truck-mounted accelerated weight-drop device (AWD) in open areas. The AWD device uses a thick rubber band to strike an aluminum impact plate with a 90-pound hammer. The Betsy device fires a blank shotgun shell one or two feet below ground surface, in a small-diameter hole manually pre-drilled with a steel bar and sledge hammer.

High-pass filters set to 12 hertz, and relatively high-frequency 30-hertz geophones, minimized wind-noise interference. Geophones were coupled to the ground surface with spike bases.

Refraction seismograms were recorded using 0.25-millisecond sampling intervals, with record lengths of at least 128 milliseconds. Seismograms were stored on the ABEM's internal hard drive, and also on floppy diskette for backup data storage.

Seismic shot points were located at approximately 80-foot intervals along each 24-channel geophone spread. Additional offset shots were placed up to 160 feet beyond each array endpoint, where permitted by site conditions, to help profile bedrock near the endpoints. Four to six shot points were occupied along each geophone array to provide reversed seismic profiles. Depending upon ambient noise conditions, up to three shots were stacked at each shot point to enhance the recorded seismograms.

Refraction data analysis was performed by picking first-arrival times with the seismograph, followed by modeling with Rimrock Geophysics' SIPT2 delay-time interpretation software. This software uses a ray-tracing algorithm, in which calculated layer thicknesses beneath each geophone are varied to obtain good agreement between observed and modeled arrival times. These computer-generated interpretations were augmented with manual depth computations via the crossover-distance method, particularly in areas of deepest bedrock.

Resistivity Soundings

Wenner resistivity soundings were performed near the middle of refraction Lines 3 and 4. The purpose of these soundings was to evaluate the resistivity method's ability to detect the presence or absence of a silty layer disclosed by well MW-GF1.

Resistivity data were obtained using .an Advanced GeoSciences model Sting R1 resistivity meter, with four stainless steel electrodes and interconnecting cables. Electrodes were placed at the following A-spacings (distance between adjacent electrode stakes) using a fiberglass tape measure: 1, 2, 3, 5, 7, 10, 15, 20, 30, 40, 50, 70, 100, 150, and 200 feet.

The Sting repeated each resistivity measurement until the difference between successive readings was less than two percent (most readings repeated within less than ± 0.5 percent). Resistivity sounding models presented in this report were generated using Interpex' RESIX software.

Equipment Decontamination Procedures

Decontamination procedures consisted of an Alconox scrub and tap water rinse of borehole logging cables and probes between logging runs. Surface geophysical instrumentation was considered to have contacted only clean soils, and therefore did not require decontamination.

SURVEY LIMITATIONS

Measured log depths are estimated to be accurate within ± 0.2 feet, allowing for some slippage of the winch's depth-measurement wheel.

Geophysical log data respond primarily to soils, water, and well-construction materials immediately adjacent to each well. These logs do not generally detect materials located any distance from the logged hole (EM induction logs are focused to measure conductivity variations approximately one foot outside a borehole).

Seismic refraction depth computations are typically accurate within ± 10 percent (or ± 3 feet, whichever is greater), assuming that seismic velocity values increase with depth.

Resistivity-sounding depth computations are typically accurate within ± 15 to 20 percent, assuming that resistivity-observed strata are relatively horizontal and extend along the length of the electrode array.

RESULTS

Borehole geophysical logging

Geophysical log data are presented in Appendix A. Natural gamma and SP (spontaneous potential) logs are presented in the lefthand column for Gannett Fleming's new wells. Only gamma logs were recorded in piezometers 92-1 and 92-4. Steel risers in those piezometers prevented electric-log recording (SPR, EM induction, etc.). Note that high gamma counts typically represent an increase in clayey soils or mafic minerals.

EM induction logs are presented in the middle log-plot column, for each of Gannett Fleming's newer wells. Wells MW-GF1 and MW-GF2 exhibited very large variations in measured EM conductivity values. These very large and small conductivities were best shown via a logarithmic plot scale, spanning three logarithmic decades (10 to 10,000 milliSiemens per meter, or mS/m). Wells MW-GF3, MW-GF4, and MW-GF5 showed smaller EM conductivity variations that were best shown with linear plot scales. Consequently, all EM induction logs shown in this report are plotted using both linear and logarithmic plot scales. Note that the EM induction probe is designed to primarily represent variations in formation electrical properties, while minimizing the influence of borehole fluids or other materials within approximately one foot of the well casing.

Fluid temperature (FTemp) data values (blue lines in the right panel of each log plot) represent borehole-fluid temperature variations, as measured in degrees Celsius during this survey. Changes in slope of a temperature curve, or localized deviations from a curve's slope, typically represent groundwater flow into or out of a bedrock boring (FTemp logs are typically performed in uncased bedrock boreholes). In the absence of nearby groundwater withdrawal, FTemp curves in shallow overburden wells typically show a smooth, gradual decrease in temperature once the logging probe is greater than approximately 20 feet below ground surface. Wells MW-GF1, MW-GF2, MW-GF3, and MW-GF4 exhibited unusual FTemp variations that suggest water-flow outside these PVC-cased wells (possibly related to the nearby Town water-supply wells).

Fluid resistivity (FRes) logs (red lines in the right panel of each new well's log plot) represent changes in borehole-fluid electrical properties (units of ohm-meters). Note that <u>low</u> fluid resistivity values represent <u>high</u> fluid electrical-conductivity. FRes logs should show little variation at this site, except for where water is entering through well screens or casing joints. Abrupt FRes variations at the very bottom of a borehole (e.g. MW-GF3) probably represent only soft accumulated sediments in the probe's tip.

Specific interpretations regarding each well's geophysical logs are described below.

Geophysical logs recorded at MW-GF1 show several unusual conditions. The saw-toothed anomaly pattern on the SP log probably indicates joints between PVC screen or riser segments (note that these inflections occur at 10-foot intervals throughout most of the logged hole). FRes and FTemp variations between approximately 50 and 75 feet deep, suggest that slightly warm water is flowing past MW-GF1 towards a Town water supply well. A slight EM conductivity increase between 66 and 71 feet deep suggests a possible silty layer, but the MW-GF1 geologic log does not confirm this inference. Gamma and EM conductivity values from MW-GF1 increase at the very bottom of the borehole, possibly indicating an increase in clay minerals below approximately 102 feet deep. Negative EM conductivity values below 111 feet deep suggest a metallic object near the hole bottom. There is no noteworthy change evident in gamma or EM conductivity values near the silty layer disclosed by MW-GF1 split-spoon samples (approximately 20 to 24 feet deep).

MW-GF2 EM conductivity and gamma logs resemble those recorded at MW-GF1, with high values between 106 and 110 feet deep that might represent more-clayey soils. Varying bedrock mineralogy probably caused erratic EM conductivity and gamma values below 110 feet deep. Unusually warm water appears to flow past MW-GF2, probably towards a pumping Town water supply well, between approximately 25 and 55 feet deep. Slightly-high gamma counts between 10 and 21 feet deep may represent a subtle increase in clay-content or mafic minerals.

The MW-GF3 FTemp log shows two zones of unusually warm water, judged to represent water drawn towards a Town water supply well. One zone is approximately 33 to 55 feet deep, and the other is approximately 70 to 100 feet deep (immediately above the bedrock surface). A split-spoon sample showing some silt (16 to 18 feet deep) occurs near a localized EM conductivity high/low anomaly pattern. If the high-conductivity portion of this anomaly represents a silty layer near 16 to 17 feet deep, then another EM peak near 22 feet deep may represent another thin silty layer. Slightly high gamma counts between 25 and 71 feet deep may represent either slightly-increased clay content, or mafic materials within the sandy strata.

The MW-GF4 FTemp log shows unusually warm water between approximately 38 and 56 feet deep that may represent water flowing outside this well towards a Town water-supply well. The distinct FRes increase below 57 feet deep may represent electrically-conductive water, or possibly electrically-conductive soft sediments within the well. Slightly high gamma counts between 9 and 17 feet deep may represent slightly-increased clay content, or mafic minerals within sandy strata. Slightly-elevated EM conductivity values between approximately 19 and 28 feet deep might represent a subtle increase in silt content, but split-spoon samples are not available to confirm this inference.

BH-1 (formerly MW-GF5) was located within Grove Pond. Drilling and geophysical logging were performed from a small barge floated into place by Gannett Fleming's drilling subcontractor. Localized high gamma counts and low (or unchanged) EM conductivity values occur near 10, 25 to 30, 45, 48, and below 60 feet deep. Because these gamma anomalies do not coincide with high EM conductivity values, they probably represent mafic minerals instead of clay (clays usually are electrically conductive).

A gamma log recorded at piezometer 92-1 shows very little variation. A slight increase in gamma counts near 3 feet deep could represent slightly clay soils, mafic minerals, or clay used in well construction. Note that steel casing attenuates gamma counts, therefore this gamma log shows lower counts compared to the nearby PVC-cased wells.

The logging winch was also hand-carried uphill, to obtain a gamma log in piezometer 92-4. This log also shows relatively little variation. Slightly-higher gamma counts between 3 and 25 feet deep, and possibly 50 to 60 feet deep, may represent slightly-increased clay or mafic-mineral content.

Seismic refraction

Refraction cross sections from Lines 1 through 4 are shown on Figure 2. Calculated compressional (p-wave) seismic velocity values for each inferred layer are shown in units of feet per second (ft/sec).

All of these cross sections show seismically-similar strata. Each cross section's uppermost layer(s) (velocity range of 800 to 2,200 ft/sec) represents dry soils or fill materials. The middle layer on each cross section (calculated velocity range of 5,000 to 5,700 ft/sec) is judged to represent water-saturated sediments. Bedrock is the deepest layer shown on each cross section. The calculated bedrock velocity values of approximately 11,500 to 12,000 ft/sec typically represent sedimentary rocks, or metamorphic bedrock with some weathering or fracturing.

Most calculated bedrock elevations are near 105 to 120 feet. Shallower bedrock, approximately elevation 150 feet, is inferred towards the east end of Line 1.

Electrical resistivity soundings

Resistivity sounding models from this survey are presented in Appendix B. Depths and resistivity values for resistivity-inferred layers are also shown on the refraction cross sections (Figure 2).

Sounding PT-1 was centered near seismic Line 4, Station 1+76. Measured resistivity values from this sounding were best modeled using a three-layer sequence shown on Figure 2. This model shows electrically-resistive materials at the ground surface, and a moderate-resistivity layer 8 to 116 feet deep. Low-resistivity materials below the resistivity-inferred 116-foot depth probably represent electrically-conductive bedrock.

Resistivity sounding PT-2 was centered at Line 3 Station 1+95. This sounding was located on a moderately steep hillside, above (and south of) the Town supply wells. A three-layer resistivity model provided the best fit to these measured data values. This model (see Figure 2) shows a moderate-resistivity layer approximately three feet thick, a high-resistivity layer between 3 and 24.5 feet deep (probably unsaturated soils), and moderately-low resistivity materials greater than 24.5 feet deep (probably water-saturated soils). Bedrock was too deep to detect with this resistivity sounding (the east end of this array was bounded by a chainlink fence, and the west end was constrained by Grove Pond).

SUMMARY AND RECOMMENDATIONS

Seismic refraction profiling disclosed bedrock elevations between approximately 105 and 150 feet along the four traverses examined during this survey. The shallowest bedrock was towards the east end of Line 1, and relatively uniform bedrock elevations (approximately 105 to 120 feet) were observed elsewhere.

Resistivity soundings do not appear to have detected the silt layer disclosed 20 to 24 feet deep by MW-GF1. EM induction logs and natural gamma logs also do not confidently indicate the silt layer.

Fluid temperature logs disclosed some depth ranges where warm water may be flowing laterally towards one or more Town water-supply wells.

If additional refraction profiling is undertaken in wooded portions of this site, we suggest budgeting for a licensed explosive handler. Small, buried explosive charges will produce stronger seismic energy than the Betsy firing rod device utilized during this survey, at the observed bedrock depths of approximately 110 feet below ground surface.

* * * * *

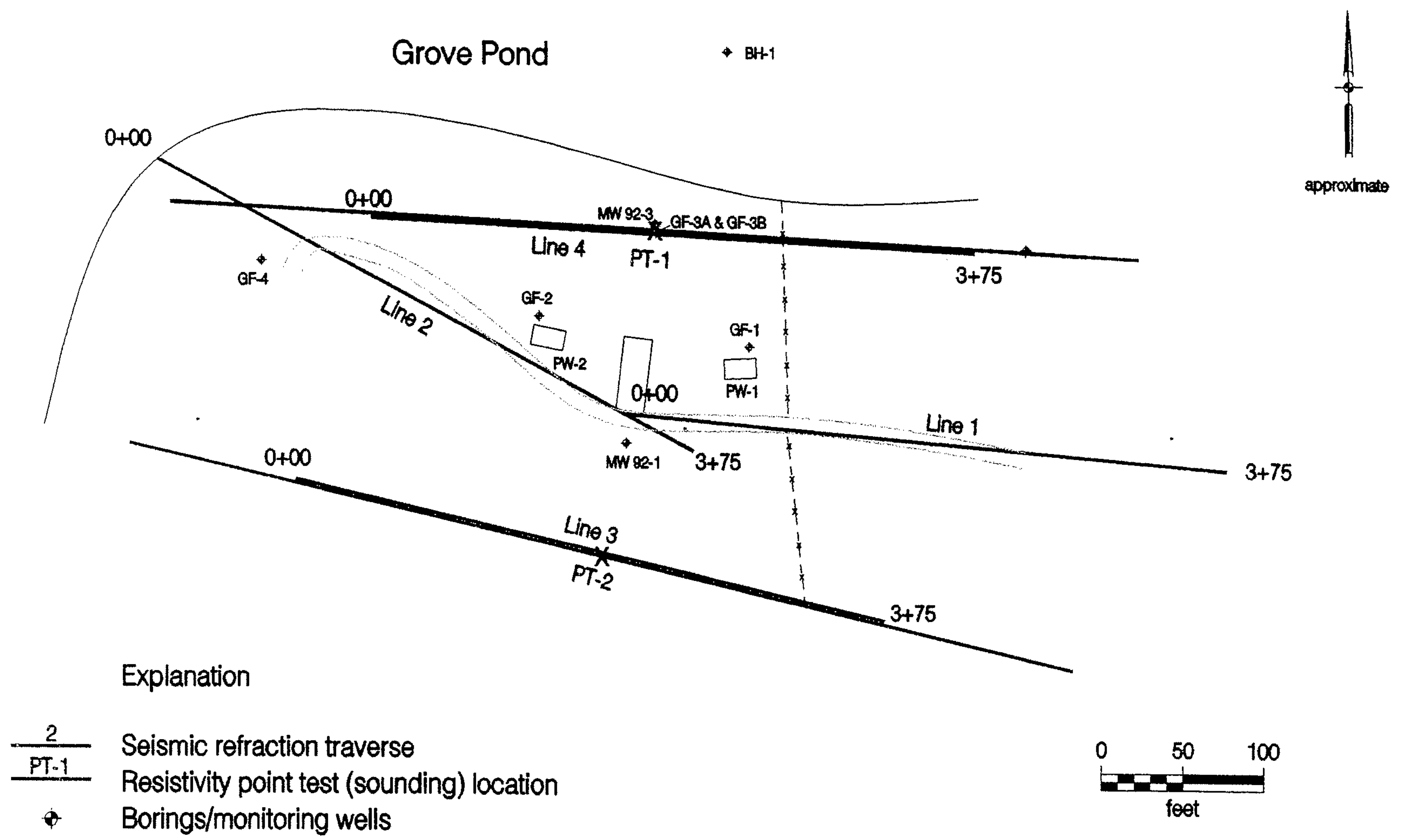
Please call the undersigned at 508/543-1388 if you have questions regarding our report. We appreciate this opportunity to provide geophysical services to Gannett Fleming, and we welcome inquiries regarding this survey.

Sincerely,

GEOPHYSICAL APPLICATIONS, INC.

M. Blackey
Mark E. Blackey
Principal and Geophysicist

99317 - 99317.rpt



Note:
Locations of geophysical traverses and physical features are approximate

99317 - 99317map.dwg
last modified 12/6/00

GEOPHYSICAL
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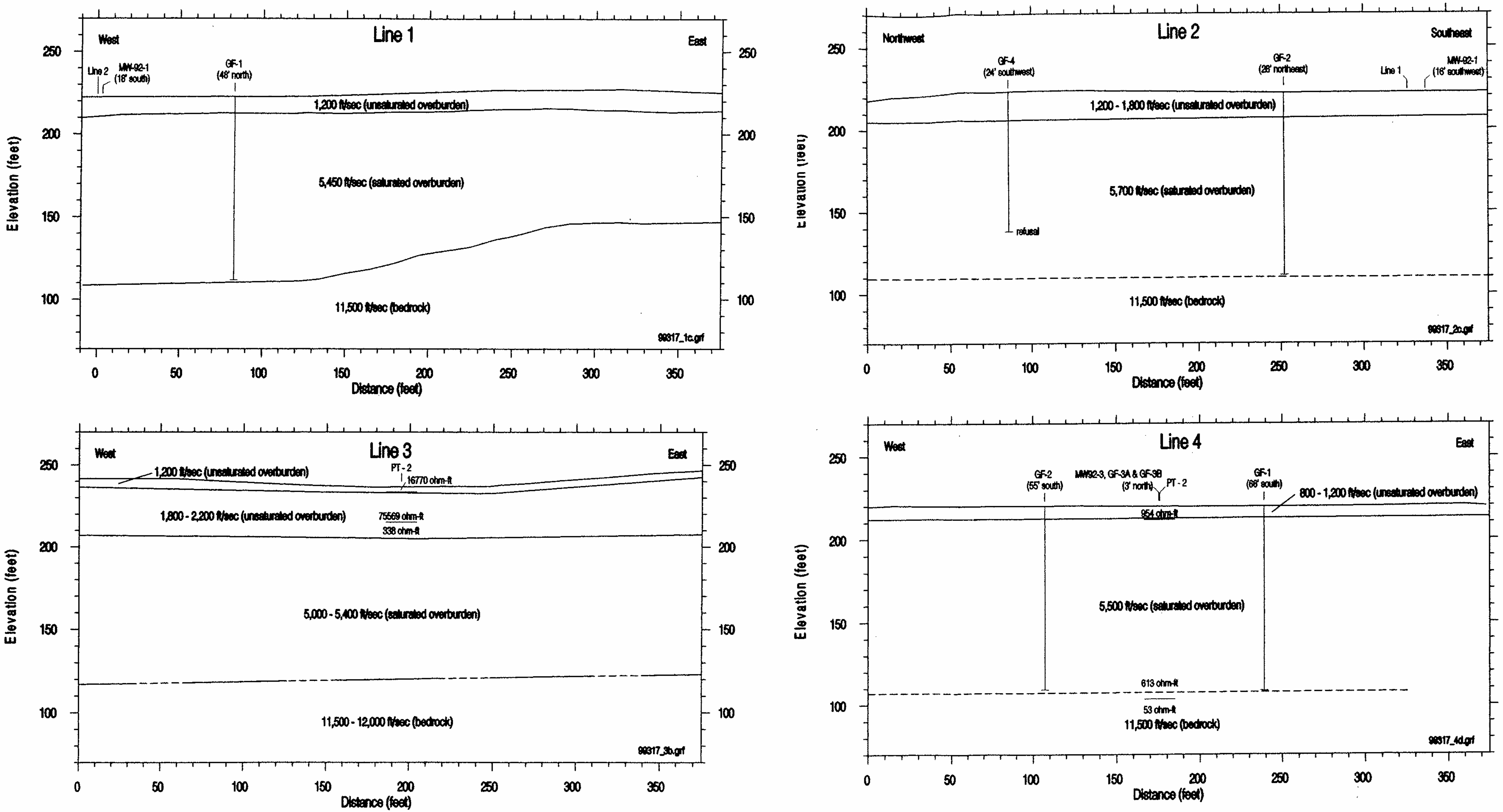
Figure 1
Geophysical Traverse Locations
Ft. Devens - Grove Pond Investigation
Ayer, Massachusetts
prepared for
GANNETT FLEMING, INC.



Notes:

1) Seismic velocity values are in units of feet per second (ft/sec)
2) Horizontal and vertical scales are 1 inch = 50 feet
3) Ground elevations were referenced to an elevation value of 224.15 feet at MW-92-1, top of casing
4) Seismic interfaces are dashed where approximate

99317 - 99817xs.dwg
last modified 12/6/00

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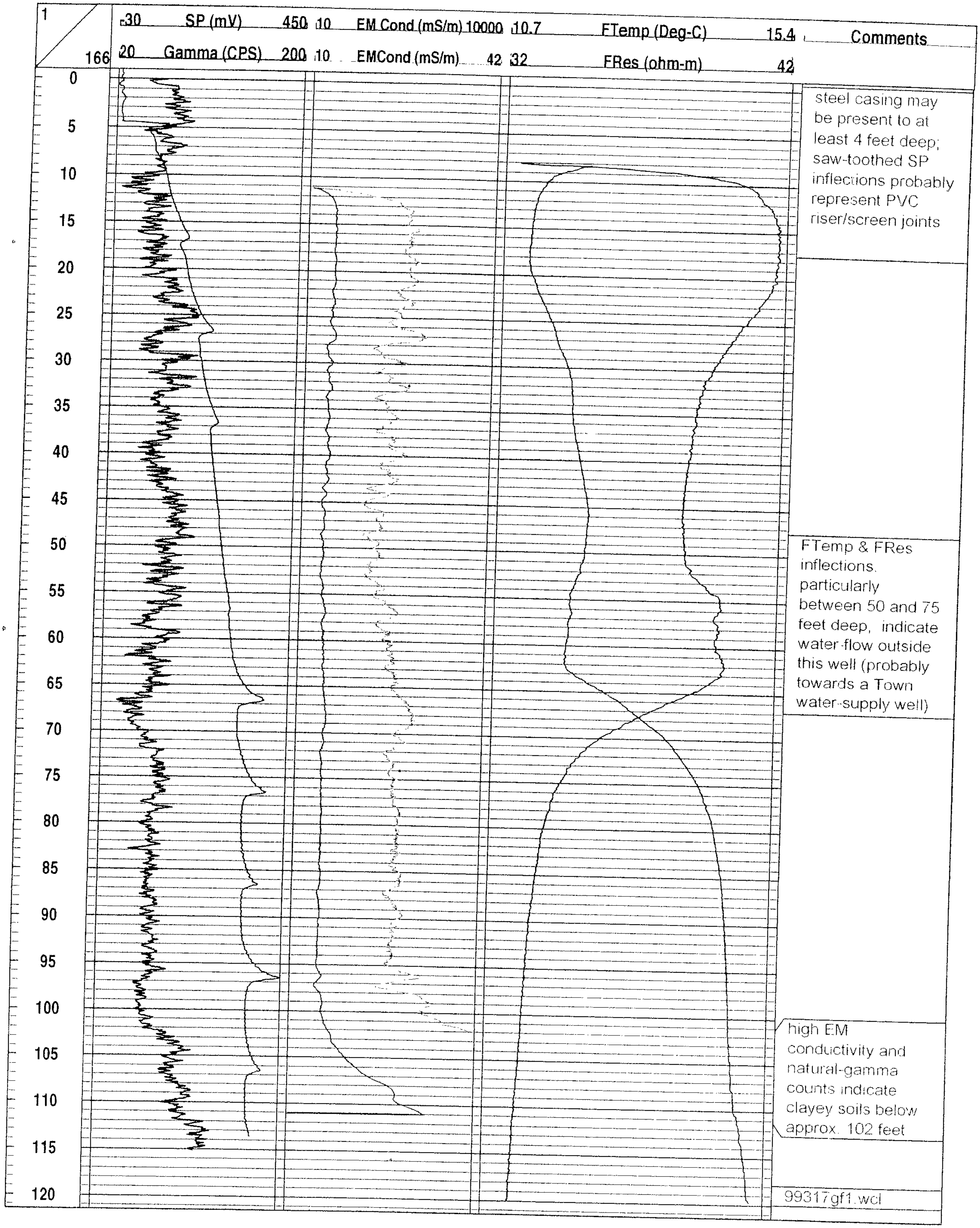
Figure 2
Seismic Refraction Cross Sections
Ft. Devens - Grove Pond Investigation
Ayer, Massachusetts
prepared for
GANNETT FLEMING, INC.

Appendix A

Borehole Geophysical Logs

Project - Well: Gannett-Fleming/Ayer, MA - MW-GF1



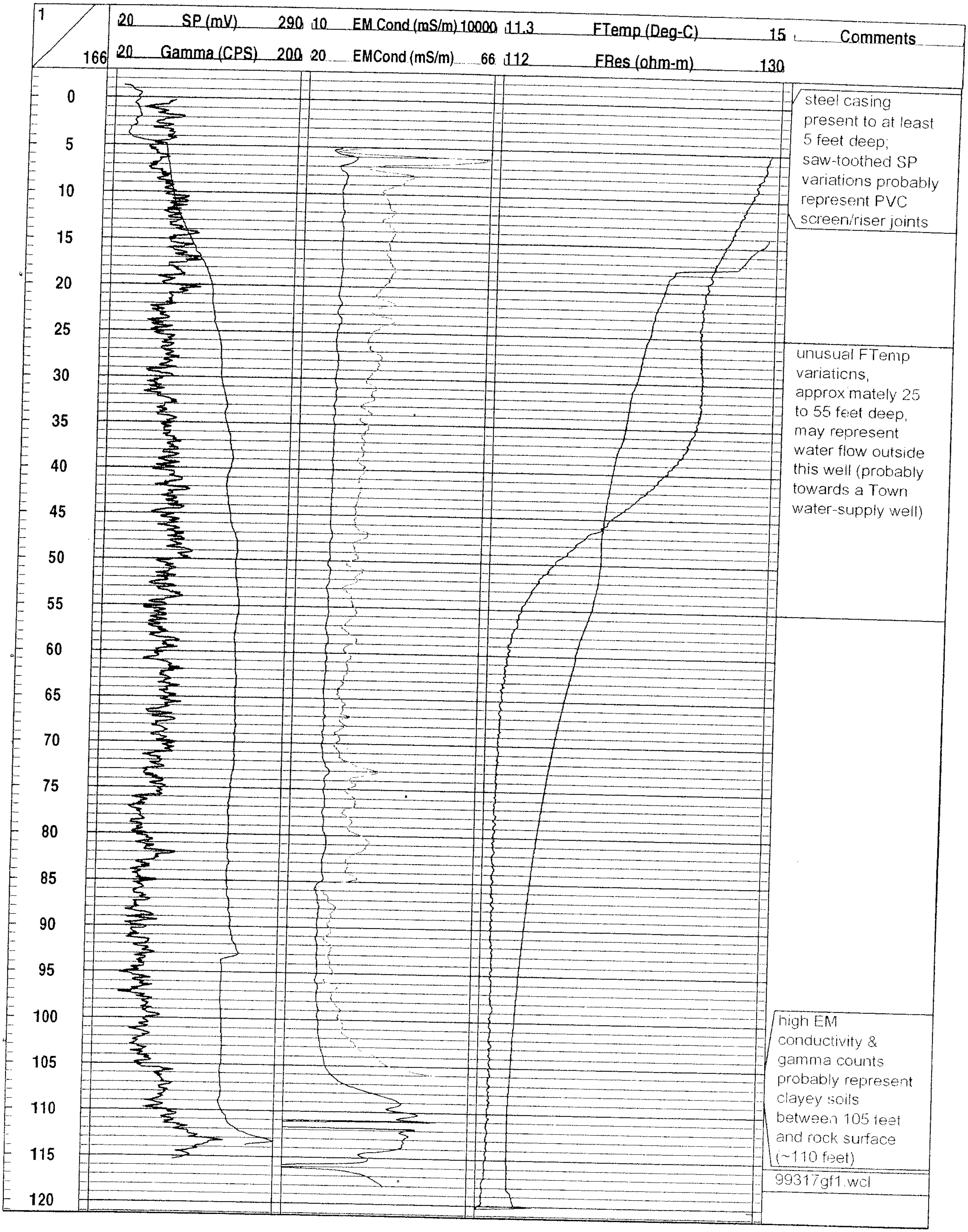
steel casing may be present to at least 4 feet deep; saw-toothed SP inflections probably represent PVC riser/screen joints

FTemp & FRes inflections, particularly between 50 and 75 feet deep, indicate water-flow outside this well (probably towards a Town water-supply well)

high EM conductivity and natural-gamma counts indicate clayey soils below approx. 102 feet

99317gf1.wcl

Project - Well: Gannett-Fleming/Ayer, MA - MW-GF2



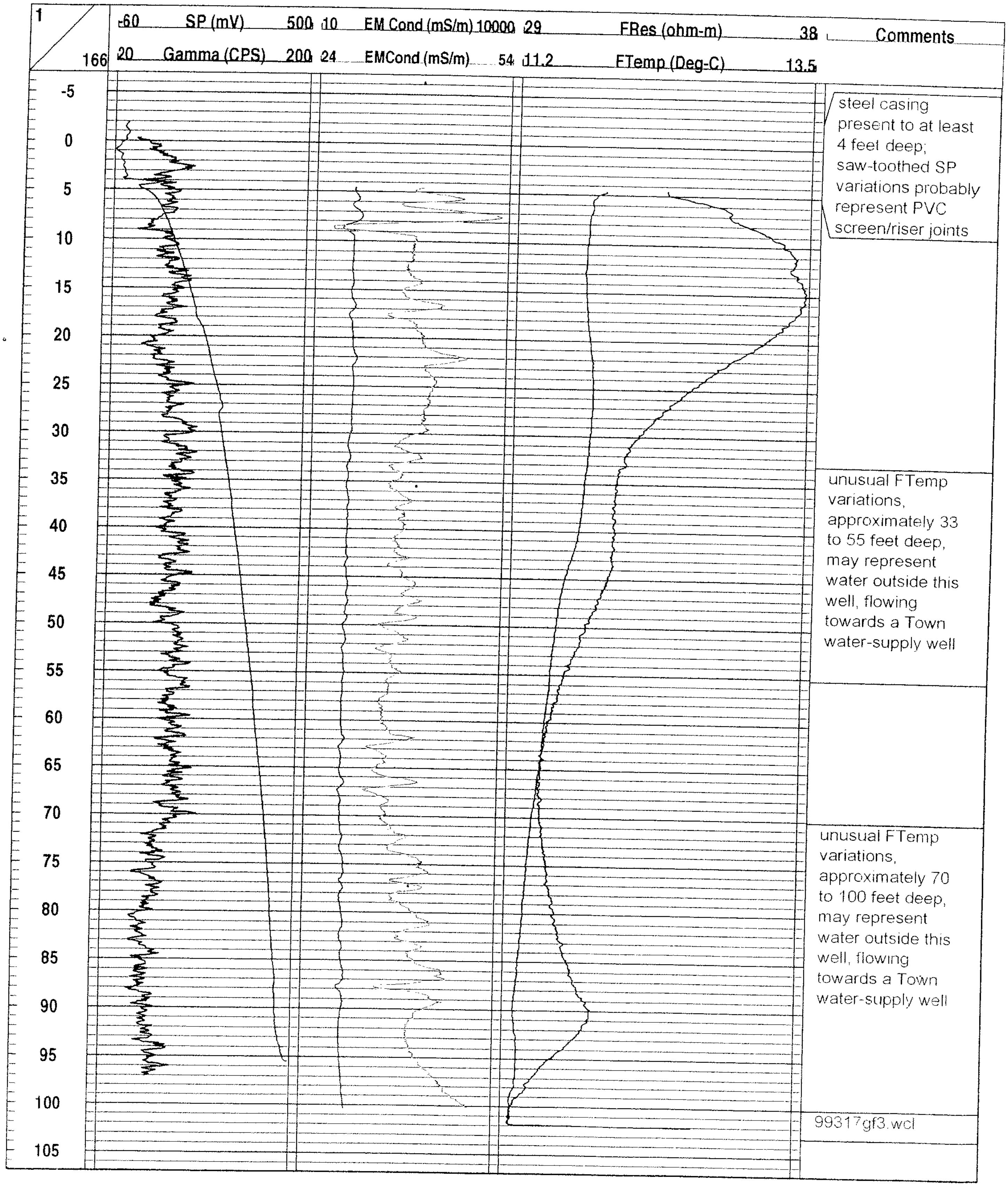
steel casing present to at least 5 feet deep; saw-toothed SP variations probably represent PVC screen/riser joints

unusual FTemp variations, approximately 25 to 55 feet deep, may represent water flow outside this well (probably towards a Town water-supply well)

high EM conductivity & gamma counts probably represent clayey soils between 105 feet and rock surface (~110 feet)

99317gf1.wcl

Project - Well: Gannett-Fleming/Ayer, MA - MW-GF3



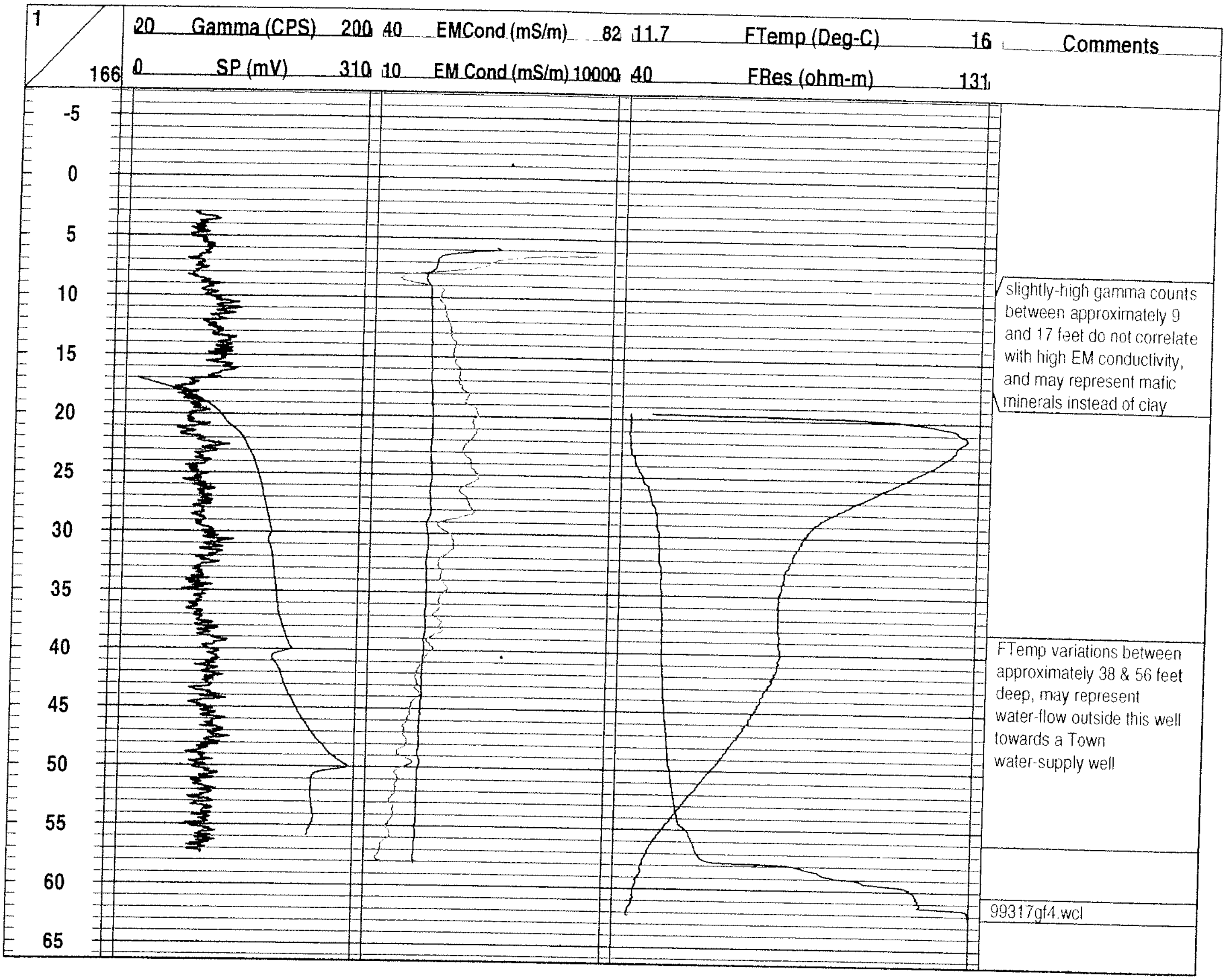
steel casing present to at least 4 feet deep; saw-toothed SP variations probably represent PVC screen/riser joints

unusual FTemp variations, approximately 33 to 55 feet deep, may represent water outside this well, flowing towards a Town water-supply well

unusual FTemp variations, approximately 70 to 100 feet deep, may represent water outside this well, flowing towards a Town water-supply well

99317gf3.wcl

Project - Well: Gannett-Fleming/Ayer, MA - MW-GF4

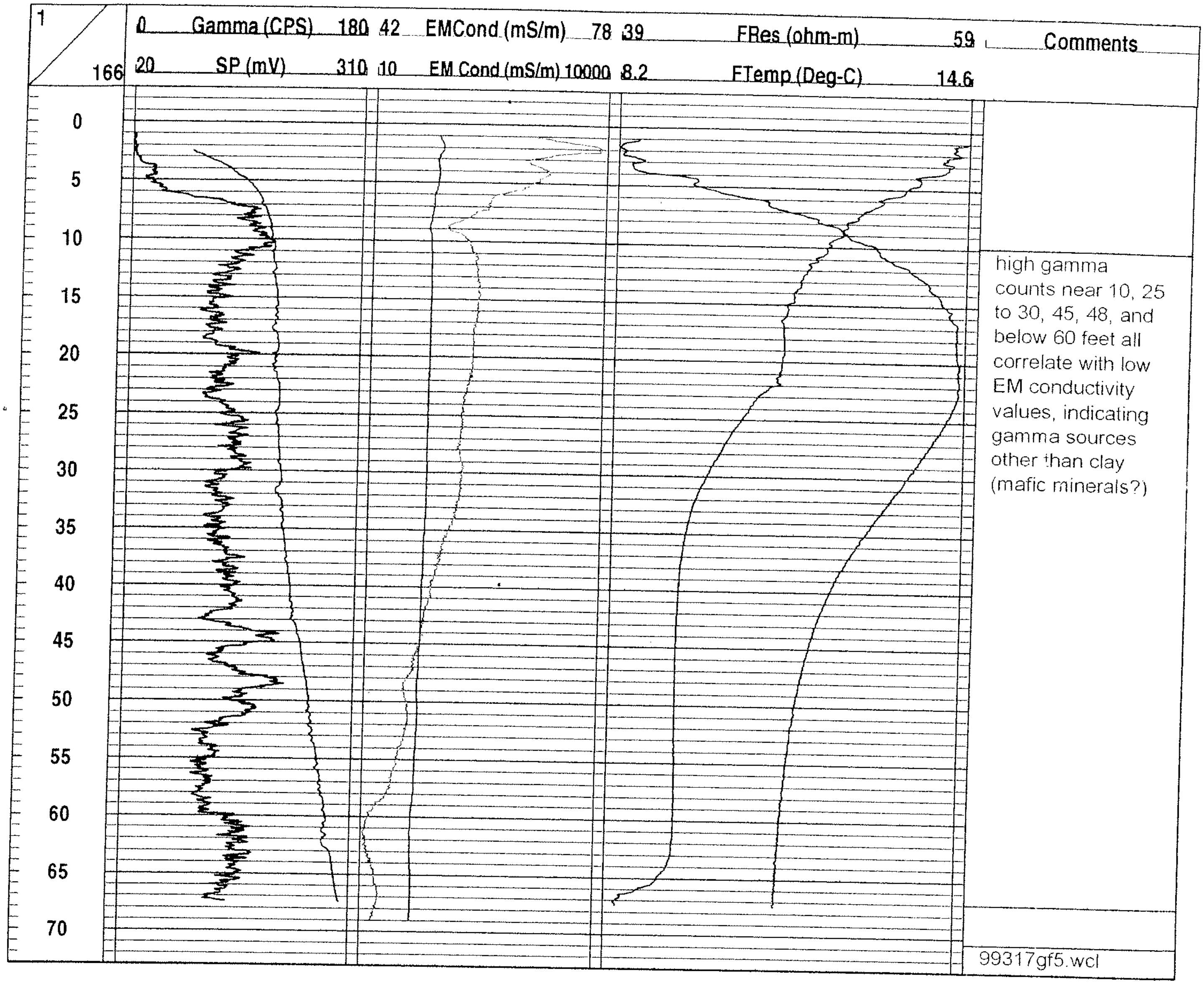


slightly-high gamma counts between approximately 9 and 17 feet do not correlate with high EM conductivity, and may represent mafic minerals instead of clay

FTemp variations between approximately 38 & 56 feet deep, may represent water-flow outside this well towards a Town water-supply well

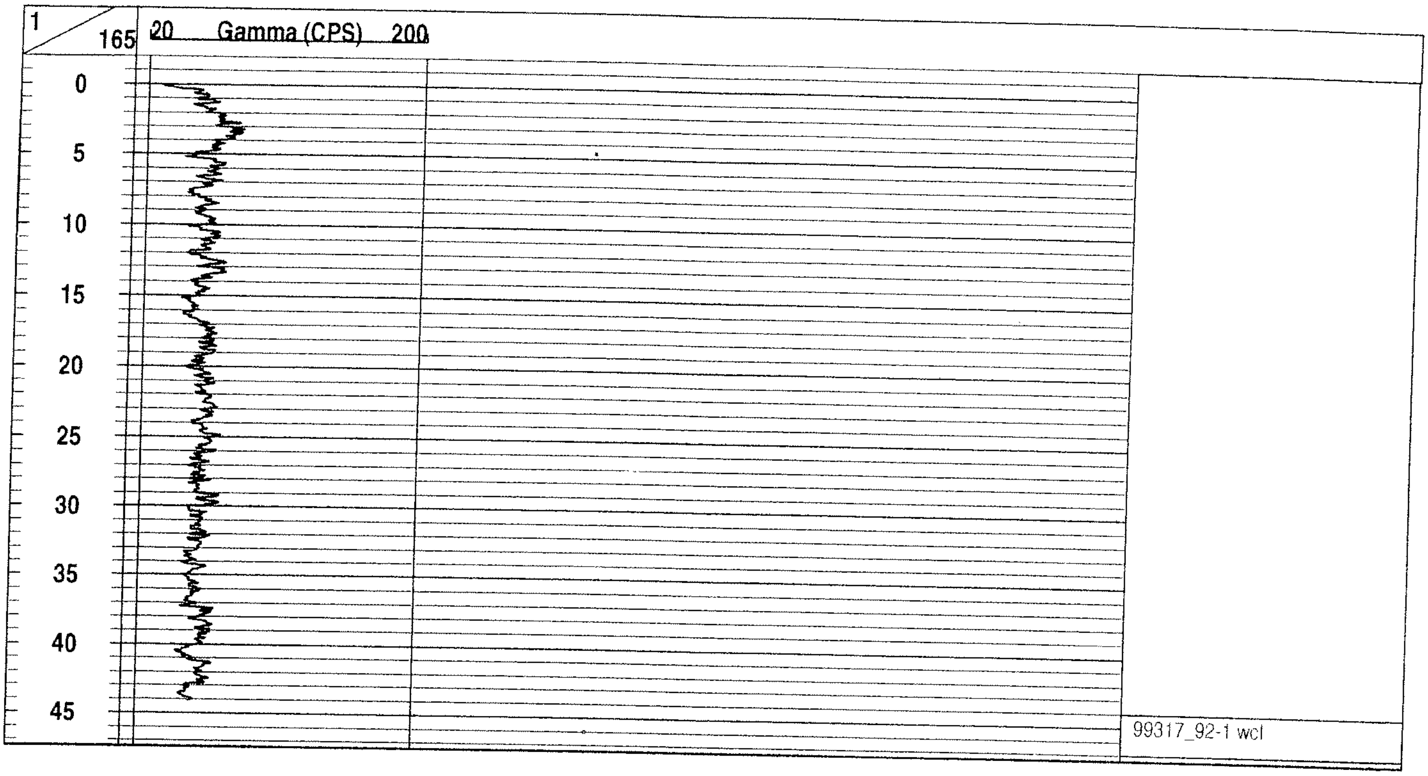
99317gf4.wcl

Project - Well: Gannett-Fleming/Ayer, MA - BH-1 (formerly MW-GF5)

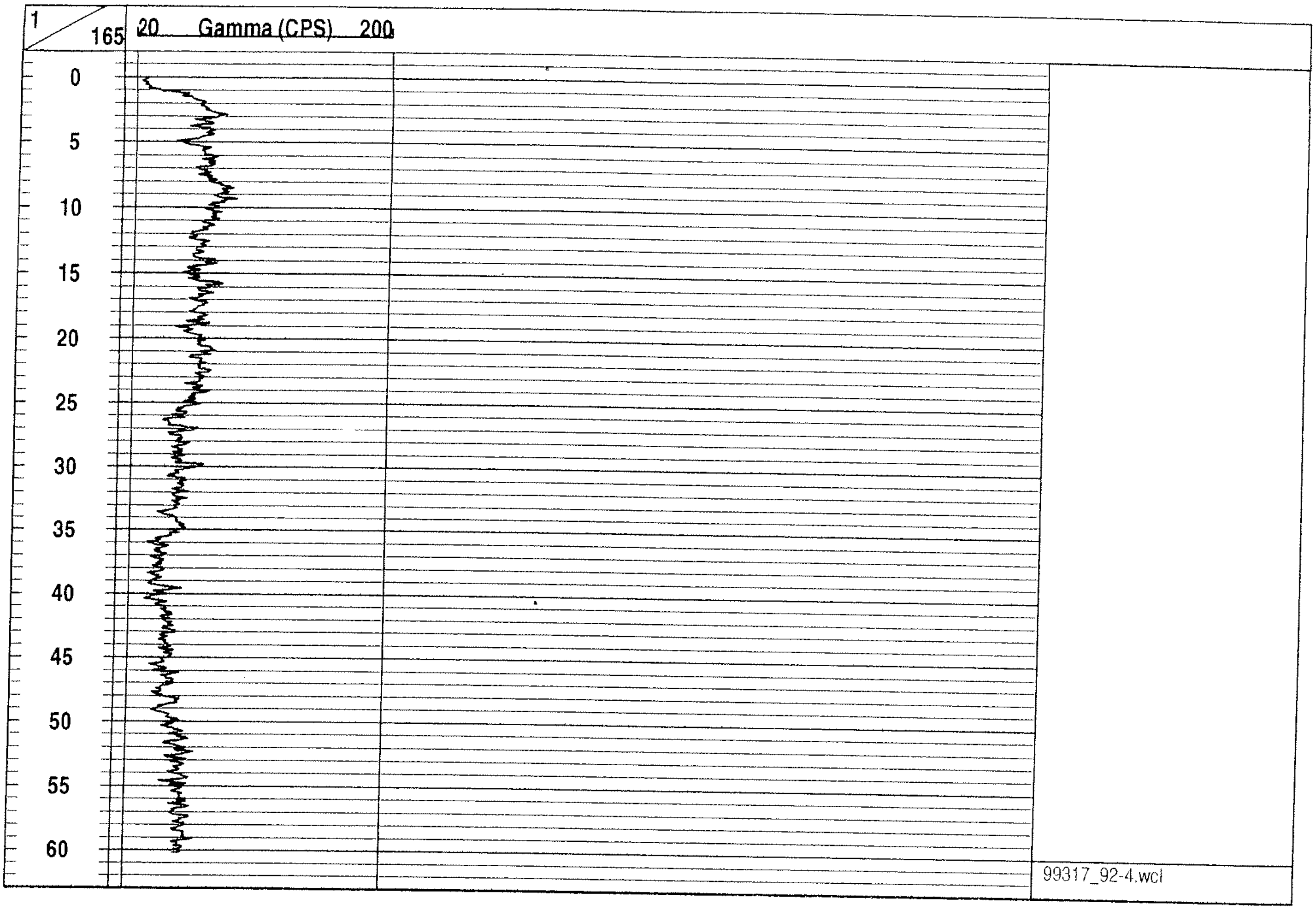


high gamma counts near 10, 25 to 30, 45, 48, and below 60 feet all correlate with low EM conductivity values, indicating gamma sources other than clay (mafic minerals?)

Project - Well: Gannett-Fleming/Ayer, MA - piezometer 92-1



Project - Well: Gannett-Fleming/Ayer, MA - piezometer 92-4 (uphill from Town wells)



Appendix B

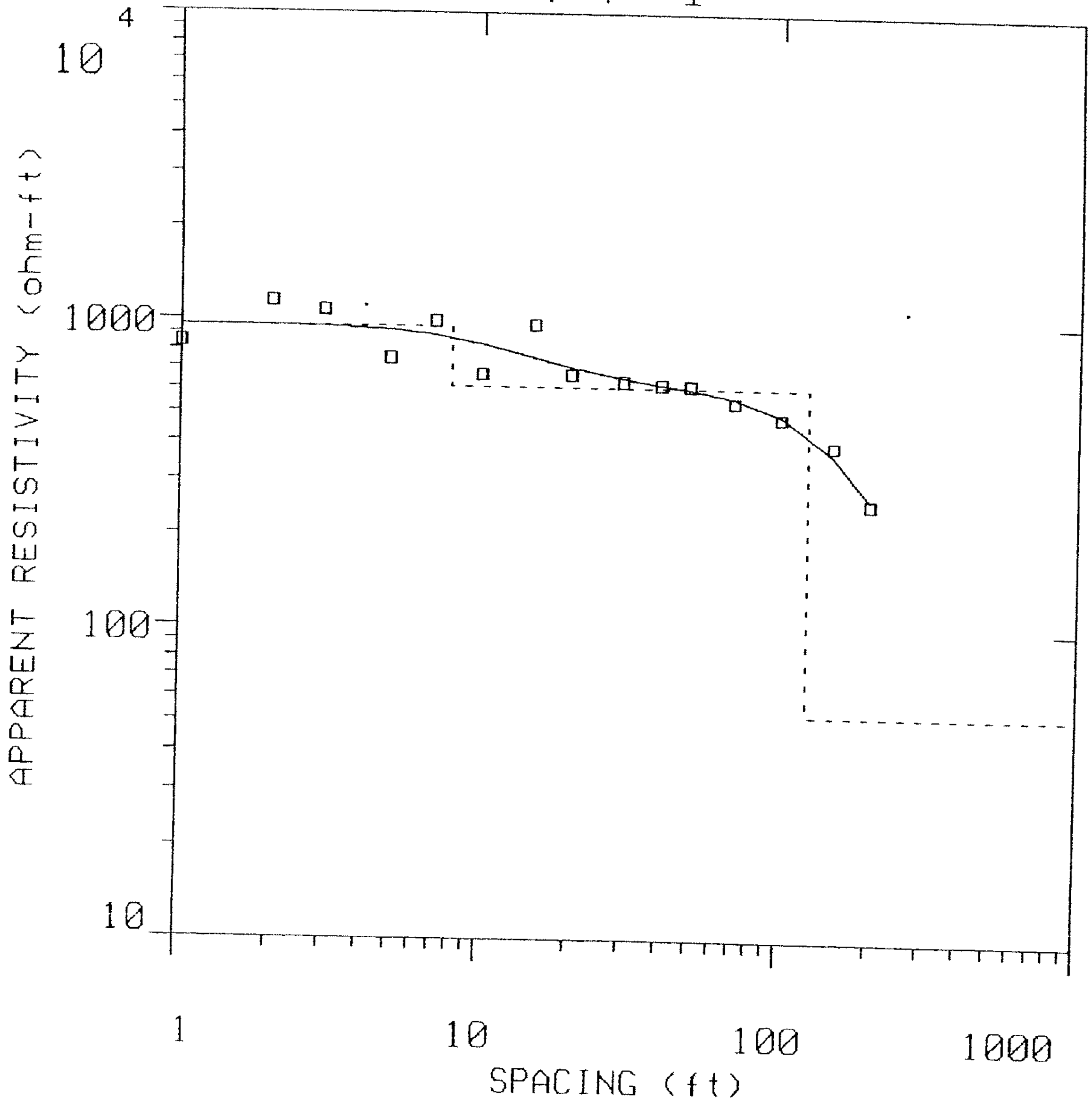
Electrical Resistivity Soundings

RESISTIVITY SOUNDING

JOB NUMBER 99317	LOCATION ℄ ≈ seismic Line 4, sta. 1+75.5	DATE ~~4~~ 10/6/99
SURVEY NUMBER PT-1	UNITS USED (METERS/FEET)	OPERATOR

RECORD NUMBER	ELECTRODE SPACING A (ft) ~~AB/2~~	Δ V/I (Ω) ~~(MN/2)~~	APPARENT RES. ρ_a (Ω-ft)	COMMENTS
2	1	134.2	842.9	$\sigma < 0.5\%$
3	2	90.97	~~571.6~~	1143.2 "
4	3	56.75	~~356.6~~	1069.7 "
6	5	23.95	~~150.5~~	752.4 "
7	7	15.77	~~991.1~~	991.0 "
8	10	10.70 ~~15.77~~	~~991.0~~	~~1008~~ 672.3 "
9	15	10.31	971.8	971.7 "
10	20	5.348	672.0	$\sigma = 1.2\%$
11	30	3.393	639.6	$\sigma = 0.4\%$
12	40	2.493	626.5	
13	50	1.988	624.4	σ 0.2%
14	70	1.256	552.4	" 0.1%
15	100	783.1mΩ	492.0	" 0.2%
16	150	425.5	401.0	" 0.7%
17	200	206.5	259.5	" 0.4%

PT-1



Layer	Resistivity (ohm-ft)	Depth Range (feet)
1	954	0-8
2	613	8-116.1
3	53	Greater than 116.1

RESISTIVITY SOUNDING

JOB NUMBER 99317

LOCATION ℄ ≈ seismic Line 3, sta. 1+95

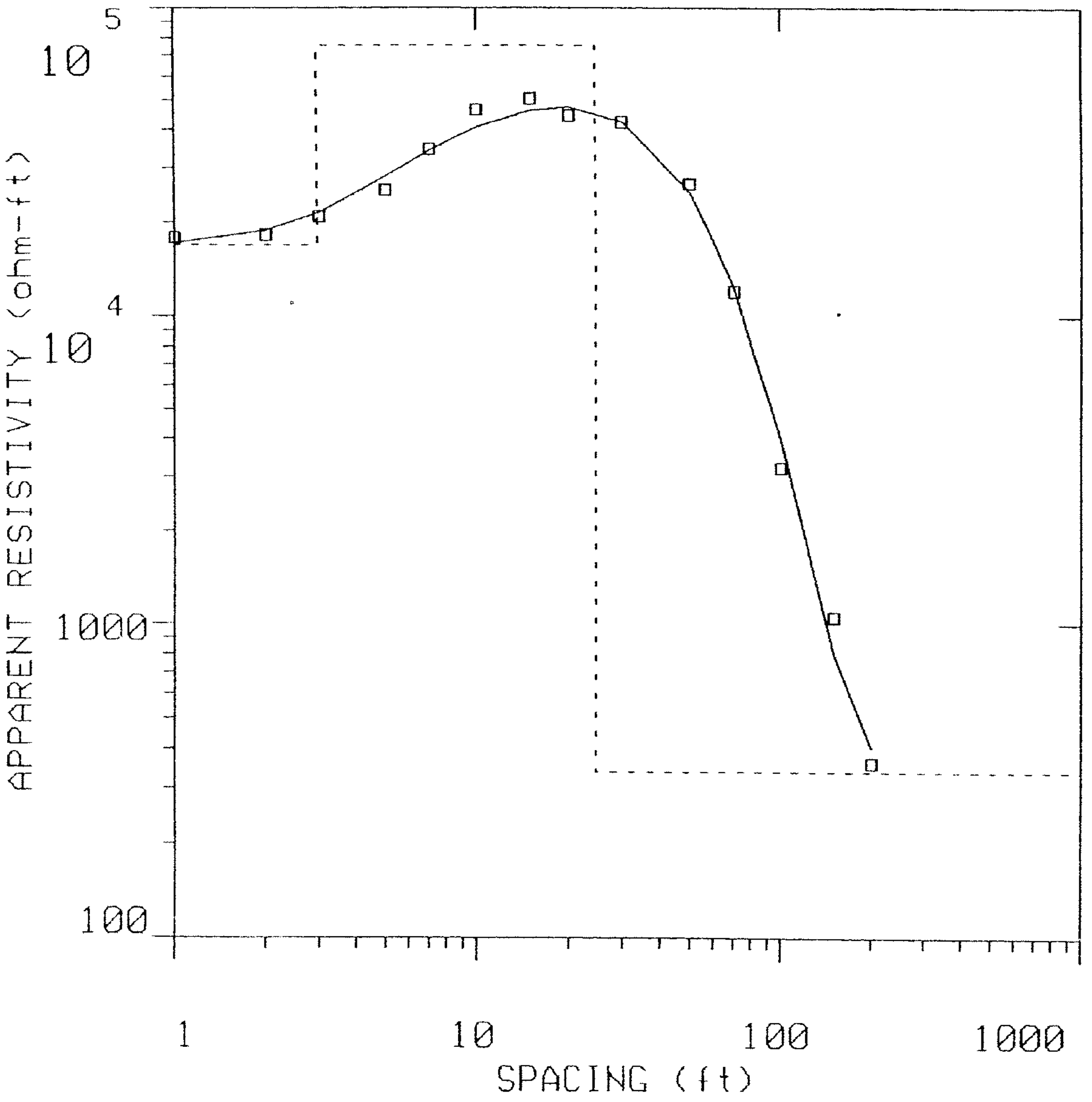
DATE 10/6/99

SURVEY NUMBER PT-2

UNITS USED (METERS/FEET) feet

OPERATOR MB/CVS

RECORD NUMBER	ELECTRODE SPACING A (ft) ~~AB/2~~	ΔV/I (Ω) ~~(MN/2)~~	APPARENT RES. ρa Ω-ft	COMMENTS	
18	1.0 ~~2.829 KΩ~~	2.829 KΩ ~~17.78 KΩ-ft~~	17.78 KΩ-ft	17,780Ω-ft	σ = 0.2%
19	2	1.445 KΩ	18.16 KΩ-ft.	18,160	
20	3	1.105 KΩ	20.82 KΩ-ft.	20,820	= 0.0%
21	5	810 Ω	25.45 KΩ-ft	25,450	
22	7	785.1 Ω	34.53 KΩ-ft	34,530	
23	10	739.0 Ω	46.43 KΩ-ft	46,430	= 0.0%
24	15	536.2 Ω	50.54 KΩ-ft	50,540	= 0.0%
25	20	354.6 Ω	44.56 KΩ-ft	44,560	
26	30	224.2 Ω	42.26 KΩ-ft	42,260	= 0.0%
27	50	84.63 Ω	26.59 KΩ-ft.	26,590	
28	70	27.25 Ω	11.98 KΩ-ft.	11,980	= 0.0%
29	100	5.126 Ω	3.221 KΩ-ft	3,221	
30	150	1.113 Ω	1.049 KΩ-ft.	1,049	
31	200	287.1 mΩ	360.8 Ω-ft.	360.8	


PT-2

Layer	Resistivity (ohm−ft)	Depth Range (feet)
1	16770	0−3
2	75569	3−21.5
3	338	Greater than 21.5

APPENDIX B.

PHASE II BORING LOGS

KEY TO PROGRAM SYMBOLS

Symbol	Description (name)
⁘	Extra fine gravel (3)
○	Fine gravel (Y)
⁘	Frac rock (X)
▨	Granite (/)
●	Gravel (8)
○	Gravel frac (9)
▨	Intrusive (V)
▦	Limestone (L)
▨	Metamorphic rocks ())
▥	MH fraction (?)
▥	ML fraction (=)
▤	Mudstone (7)
▨	Organics (J)
■	Paving (P)
▨	Peat (Q)
⁘	Sand (S)

Symbol	Description (name)
⁘	Sandstone (N)
▦	Schist ($)
▨	Sediment (2)
▤	Shale (>)
▽	Shell fragments (&)
▤	Siltstone (I)
✓	Topsoil (T)
▤	Weathered (W)
▨	EXTRA: alternating dot-dash pattern (|)
▤	EXTRA: dashed horizontal lines (%)
⁘	EXTRA: medium closely-spaced dots (6)
▤	EXTRA: narrow-spaced horizontal dashed lines (-)
⁘	EXTRA: random dot pattern (1)
∨	EXTRA: regularly spaced "V"'s (<)
▧	EXTRA: very narrow cross-hatching (!)
▤	EXTRA: dashed lines with 3 dots above each dash (.)

Symbol	Description (name)
●	EXTRA: large widely-spaced dots (*)
▲	EXTRA: small filled triangles ([)
△	EXTRA: semi-random triangle pattern (')
▨	EXTRA: zigzag lines (#)
∨	EXTRA: grass pattern ({)
~	EXTRA: tilde sign (})
□	EXTRA: randomly arranged square boxes (;)

Misc. Symbols

↑	Drill rejection (BOTTOM)
⌇	Boring continues (CONTINUE)
▽	Water table during drilling (LWATERNF)
▼	Water table at boring completion (LWATER)
▽	Water table during drilling (WATER)
▼	Water table at boring completion (FWATER)
▽	Water table during drilling (RWATERNF)
▼	Water table at boring completion (RWATER)
→	(RTARROW)

KEY TO PROGRAM SYMBOLS

Strata symbols

Symbol	Description (name)
▨	High plasticity clay (CH : C)
▥	Inorganic silts and clays (CH-MH : MC)
▨	Low plasticity clay (CL : O)
▨	Low-high plasticity clays (CL-CH : CO)
▥	Silty low plasticity clay (CL-ML : CZ)
▩	Fill (FILL : F)
▓	Clayey gravel (GC : O8)
▓	Clayey sand and gravel (GC-SC : DO8)
▓	Silty gravel (GM : Z8)
▓	Silty clayey gravel (GM-GC : ZO8)
▓	Silty sand and gravel (GM-SM : O8)
▓	Poorly graded gravel (GP : G)
▓	Poorly graded gravel with clay (GP-GC : DGO3)
▓	Poorly graded gravel with silt (GP-GM : DGZ3)
▓	Poorly graded gravel and sand (GP-SP : :G)
▓	Well graded gravel (GW : 83)

Symbol	Description (name)
▓	Well graded gravel with clay (GW-GC : 83O)
▓	Well graded gravel with silt (GW-GM : 83Z)
▓	Well graded gravel/ clayey gravel (GW-GP : 83G)
▓	Well graded gravel and sand (GW-SW : 83D)
▥	Elastic silt (MH : M)
▥	Silt (ML : Z)
≋	High plasticity organic clays (OH : 5)
≋	Low plasticity organic silts (OL : 4)
▩	Basalt (or generic rock) (ROCK :])
▨	Clayey sand (SC : DO)
▥	Silty sand (SM : 0)
▥	Poorly graded clayey silty sand (SM-SC : :ZO)
▥	Poorly graded silty fine sand (SM-ML : :Z)
░	Poorly graded sand (SP : :)
░	Poorly graded sand with clay (SP-SC : :R)
░	Poorly graded sand with silt (SP-SM : : =)

Symbol	Description (name)
░	Well graded sand (SW : D)
░	Well graded sand with clay (SW-SC : DR)
░	Well graded sand with silt (SW-SM : D =)
░	Interlayered well/poorly graded sand (SW-SP : D:)
▨	Silty sandy clay (VC : 0C)
▓	Variable gravel and silty sand mix (VG : 0G)
▥	Variable sand and silt mix (VS : OY)
△	Agglomerate (\)
□	Blank (E)
▨	CH fraction (U)
▨	CL fraction (R)
▤	Claystone (H)
○	Cobble frac (A)
●	Cobbles (B)
+	Competent (K)
▦	Dolomite (()

Date Started:	10-14-99	**DRILLING LOG**		Hole No.	**GF-1**
Date Finished:	10-21-99	**Gannett Fleming**		Sheet 1 of 5	
Soil Sampling:	111.0 Ft.			Location:	
Rock Sampling:	10.0 Ft.	Project:	Phase II Grove Pond Arsenic Investigation	Street:	
Total Depth of Hole:	121.0 Ft.	Drilling Agency:	American Drilling	N Coordinate:	
No. of Undist. Samples:	53	Driller:	Brad Brock	E Coordinate:	
Total Number of Core Boxes:	2	Bit Size and Type:	CME Sampler:	Elev. Top of Hole:	
Groundwater Observations		Casing Size: 4 inch	Spoon Size: 2 inch O.D.	Direction of Hole	
		Hollow-Stem: NA	Hammer Wt.: 140 lbs.	Vertical ☒ Inclined ☐	
		Drilling Fluid: Water	Hammer Drop: 30 inch	Degrees from Vertical 0°	
		Drill Rig: CME 75 Truck Rig		Inspector:	K. Blake

	Depth (ft.)	Sample No.	Blows or RQD	Rec (ft.)	Rec (%)	Legend	Soil Classification	Description of Materials	Remarks
5	4.0 - 6.0	SS-1	1-1-3-5	1.0	50			Moist, loose, brown, F-C SAND, little F-C gravel, trace silt.	
10	10.0 - 12.0	SS-2	4-3-4-4	1.0	50			Wet, loose, brown, F-C SAND, trace fine gravel and silt.	
	12.0 - 14.0	SS-3	4-5-6-6	1.0	50			Same as above	
15	14.0 - 16.0	SS-4	2-3-4-5	0.8	40			Same as above	
	16.0 - 18.0	SS-5	4-5-5-7	1.0	50			Same as above	
	18.0 - 20.0	SS-6	3-3-4-5	1.5	75			Wet, loose, brown fine SAND, trace VF sand and silt	
20	20.0 - 22.0	SS-7	7-6-5-5	2.0	100			Wet, medium dense, brown SILT, some fine sand lenses	
	22.0 - 24.0	SS-8	5-6-6-6	2.0	100			Wet, medium dense, brown SILT, trace sand	
25	24.0 - 26.0	SS-9	5-9-16-11	1.0	50			Wet, medium dense, brown F-C GRAVEL some F-C sand	
	26.0 - 28.0	SS-10	7-7-10-10	1.8	90			Wet, medium dense, brown F-C SAND, little fine gravel, trace silt	
	28.0 - 30.0	SS-11	12-17-15-12	0.8	40			Wet, dense, brown F-C gravel, some C sand, trace silt	
30	30.0 - 32.0	SS-12	11-12-13-12	0.5	25			Wet, medium dense, brown, F-C GRAVEL, some C- Sand, trace silt	

Remarks: * = rock in tip of spoon

DRILLING LOG

Gannett Fleming

Date Started:	10-14-99
Date Finished:	10-21-99
Soil Sampling:	111.0 Ft.
Rock Sampling:	10.0 Ft.
Total Depth of Hole:	121.0 Ft.
No. of Undist. Samples:	53
Total Number of Core Boxes:	2

Groundwater Observations

Project: Phase II Grove Pond Arsenic Investigation

Drilling Agency: American Drilling

Driller: Brad Brock

Bit Size and Type:		CME Sampler:	
Casing Size:	4 inch	Spoon Size:	2 inch O.D.
Hollow-Stem:	NA	Hammer Wt.:	140 lbs.
Drilling Fluid:	Water	Hammer Drop:	30 inch

Drill Rig: CME 75 Truck Rig

Hole No. GF-1

Sheet 2 of 5

Location:

Street:

N Coordinate:

E Coordinate:

Elev. Top of Hole:

Direction of Hole

Vertical ☒ Inclined ☐

Degrees from Vertical 0°

Inspector: K. Blake

Depth (ft.)	Sample No.	Blows or RQD	Rec (ft.)	Rec (%)	Legend	Soil Classification	Description of Materials	Remarks
32.0 - 34.0	SS-13	9-9-10-12	0.5	25			Wet, medium dense, brown F-C SAND and F-C GRAVEL trace silt	
34.0 - 36.0	SS-14	6-9-17-13	0.7	35			Wet, medium dense, brown M-C SAND, little F-C gravel, trace silt	
36.0 - 38.0	SS-15	8-10-16-17	0.4	20			Wet, dense, brown M-C SAND, little gravel, trace silt	
38.0 - 40.0	SS-16	6-8-8-11	0.8	40			Wet, medium dense, brown F-M SAND, little silt, lenses of gray coarse sand	
40.0 - 42.0	SS-17	13-14-15-14	0.6	30			Wet, medium dense, brown M-C SAND, little gravel trace silt	
42.0 - 44.0	SS-18	15-18-19-26	1.5	75			Wet, dense, F-C SAND, little gravel (layer of schist 1/2"), trace clay and silt.	
44.0 - 46.0	SS-19	14-18-19-19	1.0	50			Wet, dense, F-C SAND, little gravel, lenses of coarse gray sand	*
46.0 - 48.0	SS-20	8-10-19-20	1.0	50			Wet, medium dense, brown, F-C SAND, trace gravel and silt	
48.0 - 50.0	SS-21	12-11-12-14	0.7	35			Wet, medium dense, brown, M-C SAND, little F-C gravel, trace silt.	
50.0 - 52.0	SS-22	13-24-23-16	0.5	25			Wet, dense, brown, M-C SAND, some F-C gravel, trace clay	
52.0 - 54.0	SS-23	16-14-16-17	1.5	75			Wet, dense, brown, M-C SAND, some gravel, trace silt	
54.0 - 56.0	SS-24	13-14-14-15	1.0	50			Wet, medium dense, gray M-C SAND, little gravel, trace silt	
56.0 - 58.0	SS-25	12-18-15-18	0.2	8			Wet, dense, gray F-C SAND, little gravel	
							Wet, dense, gray/orange, fine SAND, trace silt (appears to be weathered schist)	

Remarks: * = rock in tip of spoon

DRILLING LOG

Gannett Fleming

Date Started:	10-14-99	Project: Phase II Grove Pond Arsenic Investigation		Hole No.	GF-1
Date Finished:	10-21-99	Drilling Agency: American Drilling		Sheet 3	of 5
Soil Sampling:	111.0 Ft.	Driller: Brad Brock		Location:	
Rock Sampling:	10.0 Ft.	Bit Size and Type:	CME Sampler:	Street:	
Total Depth of Hole:	121.0 Ft.	Casing Size: 4 inch	Spoon Size: 2 inch O.D.	N Coordinate:	
No. of Undist. Samples:	53	Hollow-Stem: NA	Hammer Wt.: 140 lbs.	E Coordinate:	
Total Number of Core Boxes:	2	Drilling Fluid: Water	Hammer Drop: 30 inch	Elev. Top of Hole:	
Groundwater Observations		Drill Rig: CME 75 Truck Rig		Direction of Hole Vertical ☒ Inclined ☐ Degrees from Vertical 0°	
				Inspector:	K. Blake

Depth (ft.)	Sample No.	Blows or RQD	Rec (ft.)	Rec (%)	Legend	Soil Classification	Description of Materials	Remarks
58.0 - 60.0	SS-26	18-18-23-21	0.1	4				
60.0 - 62.0	SS-27	10-11-11-20	1.0	50			Wet, medium dense, brown/gray, M-C SAND, some gravel, trace silt	
62.0 - 64.0	SS-28	14-14-19-23	2.0	100			Wet, dense, brown/gray, F-C SAND, little F-C gravel	
64.0 - 66.0	SS-29	9-9-9-10	0.8	40			Wet, medium dense, brown/gray F-C SAND, trace fine gravel, trace silt	
66.0 - 68.0	SS-30	9-10-11-15	0.9	45			Wet, medium dense, brown F-C SAND	
68.0 - 70.0	SS-31	6-8-11-14	1.3	65			Wet, medium dense, brown, F-C SAND, trace fine gravel and silt	
70.0 - 72.0	SS-32	12-11-11-12	1.6	80			Wet, medium dense, brown, F-C SAND, little fine gravel	
72.0 - 74.0	SS-33	20-39-40-38	0.7	35			Wet, dense, brown, F-C SAND, trace fine gravel	
74.0 - 76.0	SS-34	5-9-10-11	1.5	75			Wet, medium dense, brown, F-C SAND, trace fine gravel	
76.0 - 78.0	SS-35	11-13-17-13	0.0	0			Wet, dense, brown F-C SAND, little F-C gravel	
78.0 - 80.0	SS-36	6-9-10-11	0.5	25			Wet, medium dense, F-C SAND, little F-C gravel, trace silt	
80.0 - 82.0	SS-37	7-10-9-11	0.5	25			Same as above	
82.0 - 84.0	SS-38	10-12-10-10	0.5	25			Same as above	
84.0 - 86.0	SS-39	7-9-10-11	0.8	40			Wet, medium dense, brown, F-C SAND, and fine GRAVEL	
							Wet, medium dense, brown F-C SAND trace	

Remarks: * = rock in tip of spoon

Date Started:	10-14-99	**DRILLING LOG** Gannett Fleming		Hole No.	GF-1
Date Finished:	10-21-99			Sheet	4 of 5
Soil Sampling:	111.0 Ft.			Location:	
Rock Sampling:	10.0 Ft.	Project:	Phase II Grove Pond Arsenic Investigation	Street:	
Total Depth of Hole:	121.0 Ft.	Drilling Agency:	American Drilling	N Coordinate:	
No. of Undist. Samples:	53	Driller:	Brad Brock	E Coordinate:	
Total Number of Core Boxes:	2	Bit Size and Type:	CME Sampler:	Elev. Top of Hole:	
Groundwater Observations		Casing Size: 4 inch	Spoon Size: 2 inch O.D.	Direction of Hole	
		Hollow-Stem: NA	Hammer Wt.: 140 lbs.	Vertical ☒ Inclined ☐	
		Drilling Fluid: Water	Hammer Drop: 30 inch	Degrees from Vertical	0°
		Drill Rig:	CME 75 Truck Rig	Inspector:	K. Blake

	Depth (ft.)	Sample No.	Blows or RQD	Rec (ft.)	Rec (%)	Legend	Soil Classification	Description of Materials	Remarks
	86.0 - 88.0	SS-40	2-8-10-12	1.5	75			fine gravel, trace silt	
90	88.0 - 90.0	SS-41	13-9-9-10	1.5	75			Same as above	
	90.0 - 92.0	SS-42	5-5-9-11	1.5	75			Wet, medium dense, brown/gray, F-C SAND	
	92.0 - 94.0	SS-43	5-13-16-10	0.7	34			Wet, medium dense, gray F-C SAND and F-C GRAVEL	
95	94.0 - 96.0	SS-44							
100									
	102.0 - 104.0	SS-45							
105	104.0 - 106.0	SS-46							
	106.0 - 108.0	SS-47							
110									
	111.0 - 116.0	C-1		5.0	100			Black, METASILTSTONE with chlorite deposits	

Remarks: * = rock in tip of spoon

Date Started: 10-14-99
Date Finished: 10-21-99
Soil Sampling: 111.0 Ft.
Rock Sampling: 10.0 Ft.
Total Depth of Hole: 121.0 Ft.
No. of Undist. Samples: 53
Total Number of Core Boxes: 2
Groundwater Observations

DRILLING LOG
Gannett Fleming

Project: Phase II Grove Pond Arsenic Investigation
Drilling Agency: American Drilling
Driller: Brad Brock
Bit Size and Type:
CME Sampler:
Casing Size: 4 inch
Spoon Size: 2 inch O.D.
Hollow-Stem: NA
Hammer Wt.: 140 lbs.
Drilling Fluid: Water
Hammer Drop: 30 inch
Drill Rig: CME 75 Truck Rig

Hole No. **GF-1**
Sheet 5 of 5
Location:
Street:
N Coordinate:
E Coordinate:
Elev. Top of Hole:
Direction of Hole
Vertical ☒ Inclined ☐
Degrees from Vertical 0°
Inspector: K. Blake

	Depth (ft.)	Sample No.	Blows or RQD	Rec (ft.)	Rec (%)	Legend	Soil Classification	Description of Materials	Remarks
115						▨		Black, METASILTSTONE with chlorite deposits	
120	116.0 - 121.0	C-2		5.0	100	▨			121.0'
125 130 135 140								Bottom of Boring = 121.0 Ft.	

Remarks: * = rock in tip of spoon

DRILLING LOG

Gannett Fleming

Date Started: 10-21-99
Date Finished: 10-29-99
Soil Sampling: 111.0 Ft.
Rock Sampling: 10.0 Ft.
Total Depth of Hole: 121.0 Ft.
No. of Undist. Samples: 52
Total Number of Core Boxes: 2

Groundwater Observations

Project: Phase II Grove Pond Arsenic Investigation
Drilling Agency: American Drilling
Driller: Brad Brock
Bit Size and Type:
CME Sampler:
Casing Size: 4 inch
Spoon Size: 2 inch O.D.
Hollow-Stem: NA
Hammer Wt.: 140 lbs.
Drilling Fluid: Water
Hammer Drop: 30 inch
Drill Rig: CME 75 Truck Rig

Hole No. GF-2
Sheet 1 of 5
Location:
Street:
N Coordinate:
E Coordinate:
Elev. Top of Hole:

Direction of Hole
Vertical ☒ Inclined ☐
Degrees from Vertical 0°

Inspector: K. Blake

Depth (ft.)	Sample No.	Blows or RQD	Rec (ft.)	Rec (%)	Legend	Soil Classification	Description of Materials	Remarks
4.0 - 6.0	SS-1	1-1-1-1	0.6	29			Moist, very loose, brown, F-C SAND, trace iron deposits.	
6.0 - 8.0	SS-2	5-6-8-10	0.5	25			Moist (wet bottom 2"), medium dense, brown/tan F-C SAND, trace iron deposits.	
10.0 - 12.0	SS-3	15-12-16-18	1.0	50			Wet, medium dense, brown F-C SAND, some F-C gravel, trace silt.	
12.0 - 14.0	SS-4	10-11-12-11	1.5	75			Wet, medium dense, brown F-C SAND, some F-C gravel, trace silt.	
14.0 - 16.0	SS-5	10-10-9-5	1.0	50			Wet, medium dense, brown VF-C SAND and F-C GRAVEL.	
16.0 - 18.0	SS-6	9-13-16-16	1.5	75			Wet, medium dense, brown F-C SAND, little F-C gravel, trace silt (iron deposit). Also pieces of fractured granite	
18.0 - 20.0	SS-7	36-17-16-14	0.0	0			Rock (granite) in tip. No other recovery.	
20.0 - 22.0	SS-8	8-9-8-9	1.0	50			Wet, medium dense, brown, F-C SAND, trace F-C gravel.	
22.0 - 24.0	SS-9	8-8-25-27	1.4	70			Wet, dense, brown F-C SAND, trace F-C gravel.	
24.0 - 26.0	SS-10	15-25-24-25	0.7	35			Wet, dense, brown F-C SAND and F-C GRAVEL, trace silt.	
26.0 - 28.0	SS-11	14-14-26-12	1.0	50			Wet, dense, brown F-C SAND, little F-C gravel, trace clay, trace silt iron deposits	
28.0 - 30.0	SS-12	8-11-11-15	0.4	20			Wet, medium dense, brown, F-C SAND, trace F-C gravel, trace silt.	
30.0 - 32.0	SS-13	11-15-15-14	1.2	60			Wet, dense, brown, F-C SAND some F-C gravel.	

Remarks:

DRILLING LOG
Gannett Fleming

Date Started:	10-21-99
Date Finished:	10-29-99
Soil Sampling:	111.0 Ft.
Rock Sampling:	10.0 Ft.
Total Depth of Hole:	121.0 Ft.
No. of Undist. Samples:	52
Total Number of Core Boxes:	2

Groundwater Observations

Project: Phase II Grove Pond Arsenic Investigation
Drilling Agency: American Drilling
Driller: Brad Brock

Bit Size and Type:		CME Sampler:	
Casing Size:	4 inch	Spoon Size:	2 inch O.D.
Hollow-Stem:	NA	Hammer Wt.:	140 lbs.
Drilling Fluid:	Water	Hammer Drop:	30 inch

Drill Rig: CME 75 Truck Rig

Hole No.	GF-2
Sheet	2 of 5
Location:	
Street:	
N Coordinate:	
E Coordinate:	
Elev. Top of Hole:	

Direction of Hole
Vertical ☒ Inclined ☐
Degrees from Vertical 0°

Inspector: K. Blake

Depth (ft.)	Sample No.	Blows or RQD	Rec (ft.)	Rec (%)	Legend	Soil Classification	Description of Materials	Remarks
32.0 - 34.0	SS-14	10-10-16-17	1.8	90			Wet, medium dense, brown, F-C SAND, some F-C gravel.	
34.0 - 36.0	SS-15	8-9-10-15	1.2	60			Wet, medium dense, brown, F-C SAND, trace F-C Gravel, trace silt.	
36.0 - 38.0	SS-16	11-13-16-18	0.9	45			Wet, medium dense, brown F-C SAND, trace F-C gravel, trace iron deposits.	
38.0 - 40.0	SS-17	10-14-15-21	1.0	50			Wet, medium dense, brown F-C SAND, little F-C gravel, trace silt, trace extremely weathered mica schist and iron deposits.	
40.0 - 42.0	SS-18	21-22-21-15	0.0	0			Wet, dense, brown, F-C SAND and silt, trace F gravel.	
42.0 - 44.0	SS-19	16-26-18-24	1.8	90			Wet, dense, brown, F-C SAND, little F-C gravel, trace silt, trace extremely weathered mica schist (more than in 38-40 ft) and iron deposits.	
44.0 - 46.0	SS-20	12-19-19-19	1.0	50			Wet, dense, brown, F-C SAND, little F-C gravel, trace silt.	
46.0 - 48.0	SS-21	12-19-14-12	1.2	60			Wet, dense, brown, F-C SAND, little silt, trace F-C gravel.	
48.0 - 50.0	SS-22	12-13-12-17	1.1	55			Wet, medium dense, F-C GRAVEL with some silt, trace F-C sand.	
50.0 - 52.0	SS-23	25-36-18-21	1.0	50			Wet, very dense, brown, F-C SAND, little F-C gravel, trace silt and clay.	
52.0 - 54.0	SS-24	19-19-13-14	1.3	65			Wet, dense, brown, F-C SAND, trace F-C gravel and silt.	
54.0 - 56.0	SS-25	9-12-12-18	1.1	55			Wet, medium dense, brown, F-C SAND, trace F-C gravel.	
56.0 - 58.0	SS-26	12-17-12-24	2.0	100			Wet, medium dense, brown, F-C SAND, trace fine gravel.	
							Wet, medium dense, brown, F-C SAND, trace F-C gravel and silt.	

Remarks:

DRILLING LOG
Gannett Fleming

Date Started:	10-21-99
Date Finished:	10-29-99
Soil Sampling:	111.0 Ft.
Rock Sampling:	10.0 Ft.
Total Depth of Hole:	121.0 Ft.
No. of Undist. Samples:	52
Total Number of Core Boxes:	2
Groundwater Observations	

Project:	Phase II Grove Pond Arsenic Investigation		
Drilling Agency:	American Drilling		
Driller:	Brad Brock		
Bit Size and Type:		CME Sampler:	
Casing Size:	4 inch	Spoon Size:	2 inch O.D.
Hollow-Stem:	NA	Hammer Wt.:	140 lbs.
Drilling Fluid:	Water	Hammer Drop:	30 inch
Drill Rig:	CME 75 Truck Rig		

Hole No.	GF-2
Sheet	3 of 5
Location:	
Street:	
N Coordinate:	
E Coordinate:	
Elev. Top of Hole:	
Direction of Hole	Vertical ☒ Inclined ☐
Degrees from Vertical	0°
Inspector:	K. Blake

Depth (ft.)	Sample No.	Blows or RQD	Rec (ft.)	Rec (%)	Legend	Soil Classification	Description of Materials	Remarks
58.0 - 60.0	SS-27	9-12-14-16	1.1	55				
60.0 - 62.0	SS-28	8-15-23-21	0.9	45			Wet, dense, brown, F-C SAND, trace F-C gravel and silt.	
62.0 - 64.0	SS-29	12-16-20-23	1.0	50			Wet, dense, brown, F-C SAND, trace F-C gravel, iron deposits and silt.	
64.0 - 66.0	SS-30	11-21-22-29	0.9	45			Wet, dense, brown, F-C SAND and F-C GRAVEL.	
66.0 - 68.0	SS-31	16-24-32-56	1.5	75			Wet, very dense, brown, F-C SAND, little F-C gravel, trace silt.	
68.0 - 70.0	SS-32	20-26-34-29	1.8	90			Wet, very dense, brown/gray, F-C SAND, little F-C gravel and silt.	
70.0 - 72.0	SS-33	10-12-12-19	0.2	10			F-C GRAVEL (wash).	
72.0 - 74.0	SS-34	13-16-11-27	0.9	45			Wet, medium dense, gray, F-C SAND, trace F-C gravel and silt.	
74.0 - 76.0	SS-35	7-10-5-5	0.2	10			F-C GRAVEL (wash).	
76.0 - 78.0	SS-36	6-9-12-14	1.3	65			Wet, medium dense, gray, F-C SAND, trace F-C gravel.	
78.0 - 80.0	SS-37	3-3-7-11	0.0	0			No recovery.	
80.0 - 82.0	SS-38	4-5-8-12	1.4	70			Wet, medium dense, gray, fine grained SAND and SILT.	
82.0 - 84.0	SS-39	5-5-7-13	0.8	40			Wet, medium dense, gray, F-C SAND.	
84.0 - 86.0	SS-40	10-10-11-12	2.0	100			Wet, medium dense, gray, F-C SAND, trace silt, 1" lense of very fine grained sand at tip on spoon.	
							Wet, medium dense, gray, F-C SAND. Sand	

Remarks:

Date Started: 10-21-99	DRILLING LOG	Hole No.	GF-2
Date Finished: 10-29-99	Gannett Fleming	Sheet 4 of 5	
Soil Sampling: 111.0 Ft.		Location:	
Rock Sampling: 10.0 Ft.	Project: Phase II Grove Pond Arsenic Investigation	Street:	
Total Depth of Hole: 121.0 Ft.	Drilling Agency: American Drilling	N Coordinate:	
No. of Undist. Samples: 52	Driller: Brad Brock	E Coordinate:	
Total Number of Core Boxes: 2	Bit Size and Type: / CME Sampler:	Elev. Top of Hole:	
Groundwater Observations	Casing Size: 4 inch / Spoon Size: 2 inch O.D.	Direction of Hole	
	Hollow-Stem: NA / Hammer Wt.: 140 lbs.	Vertical ☒ Inclined ☐	
	Drilling Fluid: Water / Hammer Drop: 30 inch	Degrees from Vertical 0°	
	Drill Rig: CME 75 Truck Rig	Inspector:	K. Blake

Depth (ft.)	Sample No.	Blows or RQD	Rec (ft.)	Rec (%)	Legend	Soil Classification	Description of Materials	Remarks
86.0 - 88.0	SS-41	4-4-10-16	2.0	100			at bottom 1" of spoon more coarse.	
88.0 - 90.0	SS-42	2-5-7-12	1.9	95			Wet, medium dense, gray, F-C SAND, trace F gravel and silt.	
90.0 - 92.0	SS-43	6-6-12-18	2.0	100			Wet, medium dense, gray, F-C SAND, trace F gravel and silt. Two 1.5" lenses of fine gravel at 91.1 ft. and 91.8 ft. Lenses are probably wash.	
92.0 - 94.0	SS-44	9-8-12-9	1.1	55			Wet, medium dense, gray, F-C SAND trace silt.	
94.0 - 96.0	SS-45	3-3-8-10	1.6	80			Wet, medium dense, gray, F-C SAND.	
96.0 - 98.0	SS-46	5-15-34-26	1.4	70			Wet, dense, gray, F-C SAND.	
98.0 - 100.0	SS-47	5-7-10-15	0.8	40			Wet, medium dense, gray, F-C SAND, 1" lense of F gravel at approximately 99.5 or 99.6 feet.	
100.0 - 102.0	SS-48	6-9-14-24	0.0	0			Zero recovery.	
102.0 - 104.0	SS-49	6-8-25-37	2.0	100			Wet, dense, gray, F-C SAND.	
104.0 - 106.0	SS-50	7-10-16-24	0.0	0			Zero recovery.	
106.0 - 108.0	SS-51	18-11-10-22	2.0	100			Wet, medium dense, gray, F-C SAND.	
110.5 - 110.7	SS-52	60(2")	0.2	100			Black, very hard, weathered rock with clay.	111.0'
111.0 - 116.0	C-1		5.0	100			Black METASILTSTONE with chlorite deposits and trace iron deposits	

Remarks:

DRILLING LOG

Gannett Fleming

Date Started: 10-21-99
Date Finished: 10-29-99
Soil Sampling: 111.0 Ft.
Rock Sampling: 10.0 Ft.
Total Depth of Hole: 121.0 Ft.
No. of Undist. Samples: 52
Total Number of Core Boxes: 2
Groundwater Observations

Hole No. GF-2
Sheet 5 of 5
Location:
Street:
N Coordinate:
E Coordinate:
Elev. Top of Hole:

Project: Phase II Grove Pond Arsenic Investigation
Drilling Agency: American Drilling
Driller: Brad Brock
Bit Size and Type:
CME Sampler:
Casing Size: 4 inch
Spoon Size: 2 inch O.D.
Hollow-Stem: NA
Hammer Wt.: 140 lbs.
Drilling Fluid: Water
Hammer Drop: 30 inch
Drill Rig: CME 75 Truck Rig

Direction of Hole
Vertical ☒ Inclined ☐
Degrees from Vertical 0°

Inspector: K. Blake

	Depth (ft.)	Sample No.	Blows or RQD	Rec (ft.)	Rec (%)	Legend	Soil Classification	Description of Materials	Remarks
115						░			
120	116.0 - 121.0	C-2		5.0	100	░		Black METASILTSTONE with chlorite deposits and trace iron deposits	121.0'
125 130 135 140								Bottom of Boring = 121.0 Ft.	

Remarks:

DRILLING LOG
Gannett Fleming

Date Started:	11-1-99
Date Finished:	11-9-99
Soil Sampling:	104.0 Ft.
Rock Sampling:	3.0 Ft.
Total Depth of Hole:	107.0 Ft.
No. of Undist. Samples:	23
Total Number of Core Boxes:	0

Groundwater Observations

Project: Phase II Grove Pond Arsenic Investigation
Drilling Agency: American Drilling
Driller: Brad Brock

Bit Size and Type:		CME Sampler:	
Casing Size:	4 inch	Spoon Size:	2 inch O.D.
Hollow-Stem:	NA	Hammer Wt.:	140 lbs.
Drilling Fluid:	Water	Hammer Drop:	30 inch

Drill Rig: CME 75 Truck Rig

Hole No. **GF-3a**
Sheet 1 of 4
Location:
Street:
N Coordinate:
E Coordinate:
Elev. Top of Hole:

Direction of Hole
Vertical ☒ Inclined ☐
Degrees from Vertical 0°

Inspector: K. Blake/T. Finlayson

	Depth (ft.)	Sample No.	Blows or RQD	Rec (ft.)	Rec (%)	Legend	Soil Classification	Description of Materials	Remarks
0	0.0 - 2.0	SS-1	WH-12	0.5	25			Moist, very loose, brown F-M SAND and SILT, little organics	
5	5.0 - 7.0	SS-2	2-3-5-6	1.2	60			Wet, loose, brown/gray F-C SAND	
10	10.0 - 12.0	SS-3	8-8-8-8	1.6	80			Wet, medium dense, brown F-C SAND little silt, trace iron deposits and trace fine gravel	
	12.0 - 14.0	SS-4	8-10-13-14	1.5	75			Wet, medium dense, brown VF-F SAND little silt, lenses of coarse sand and trace iron deposits	
15	14.0 - 16.0	SS-5	11-11-10-13	2.0	100			Same as above	
	16.0 - 18.0	SS-6	12-15-13-14	2.0	100			Wet, medium dense, VF SAND and SILT	
20	20.0 - 22.0	SS-7	3-6-11-11	1.0	50			Wet, medium dense, brown/gray M-C SAND little fine gravel	
25	25.0 - 27.0	SS-8	2-2-4-4	0.6	30			Wet, loose, brown/gray VF-F SAND and silt	

Remarks: * = rock in tip of spoon
water table at 3 feet below ground surface

DRILLING LOG
Gannett Fleming

Date Started:	11-1-99
Date Finished:	11-9-99
Soil Sampling:	104.0 Ft.
Rock Sampling:	3.0 Ft.
Total Depth of Hole:	107.0 Ft.
No. of Undist. Samples:	23
Total Number of Core Boxes:	0
Groundwater Observations	

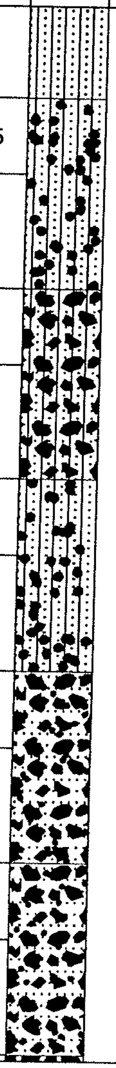
Project: Phase II Grove Pond Arsenic Investigation
Drilling Agency: American Drilling
Driller: Brad Brock

Bit Size and Type:		CME Sampler:	
Casing Size:	4 inch	Spoon Size:	2 inch O.D.
Hollow-Stem:	NA	Hammer Wt.:	140 lbs.
Drilling Fluid:	Water	Hammer Drop:	30 inch
Drill Rig:	CME 75 Truck Rig		

Hole No. GF-3a
Sheet 2 of 4
Location:
Street:
N Coordinate:
E Coordinate:
Elev. Top of Hole:

Direction of Hole
Vertical ☒ Inclined ☐
Degrees from Vertical 0°

Inspector: K. Blake/T. Finlayson



	Depth (ft.)	Sample No.	Blows or RQD	Rec (ft.)	Rec (%)	Legend	Soil Classification	Description of Materials	Remarks
30	30.0 - 32.0	SS-9	10-15-16-13	0.3	15			Wet, medium dense, gray/brown F-C SAND, trace silt, trace fine gravel	*
35	35.0 - 37.0	SS-10	11-12-14-11	0.7	35			Wet, meidum dense, black/brown F-C SAND and Fine GRAVEL, little silt	
40	40.0 - 42.0	SS-11	12-19-23-30	1.8	90			Wet, dense, gray/brown F-C SAND, trace fine gravel, trace clay trace iron deposits	
45	45.0 - 47.0	SS-12	6-8-5-5	1.0	50			Wet, medium dense, brown F-C gravel	
50	50.0 - 52.0	SS-13	11-9-10-14	0.8	40			Wet, medium dense, brown/gray Fine GRAVEL and M-C SAND, trace clay	
55									

Remarks: * = rock in tip of spoon
water table at 3 feet below ground surface

DRILLING LOG

Gannett Fleming

Date Started:	11-1-99
Date Finished:	11-9-99
Soil Sampling:	104.0 Ft.
Rock Sampling:	3.0 Ft.
Total Depth of Hole:	107.0 Ft.
No. of Undist. Samples:	23
Total Number of Core Boxes:	0

Groundwater Observations

Hole No.	GF-3a
Sheet	3 of 4
Location:	
Street:	
N Coordinate:	
E Coordinate:	
Elev. Top of Hole:	

Project: Phase II Grove Pond Arsenic Investigation

Drilling Agency: American Drilling

Driller: Brad Brock

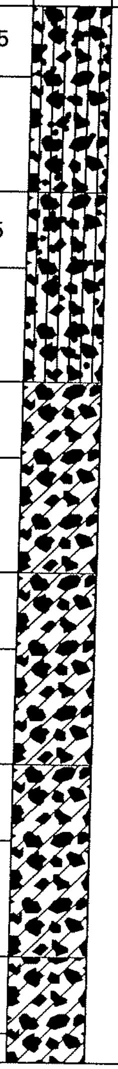
Bit Size and Type:		CME Sampler:	
Casing Size:	4 inch	Spoon Size:	2 inch O.D.
Hollow-Stem:	NA	Hammer Wt.:	140 lbs.
Drilling Fluid:	Water	Hammer Drop:	30 inch
Drill Rig:	CME 75 Truck Rig		

Direction of Hole

Vertical ☒ Inclined ☐

Degrees from Vertical 0°

Inspector: K. Blake/T. Finlayson

Depth (ft.)	Sample No.	Blows or RQD	Rec (ft.)	Rec (%)	Legend	Soil Classification	Description of Materials	Remarks
55.0 - 57.0	SS-14	7-7-14-11	1.5	75			Wet, medium dense, black/brown F-M GRAVEL and SILT, trace clay	
60.0 - 62.0	SS-15	7-7-6-7	0.3	15			Wet, medium dense, black/brown Fine GRAVEL, trace silt and trace sand	
65.0 - 67.0	SS-16	9-15-21-18	1.6	80			Wet, dense, brown F-C SAND some fine gravel, trace silt	
70.0 - 72.0	SS-17	4-3-7-9	0.7	35			Wet, medium dense, brown F-C SAND, some fine gravel, trace silt	
75.0 - 77.0	SS-18	2-3-5-7	2.0	100			Wet, loose, brown F-C SAND, trace fine gravel and silt. Bottom 2 inches of spoon had gray coarse sand.	
80.0 - 82.0	SS-19	3-4-10-21	0.0	0			Zero Recovery	

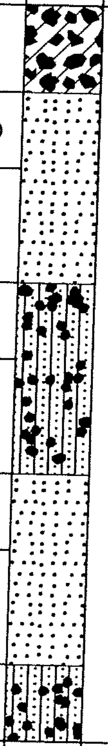
Remarks: * = rock in tip of spoon
water table at 3 feet below ground surface

DRILLING LOG
Gannett Fleming

Date Started:	11-1-99
Date Finished:	11-9-99
Soil Sampling:	104.0 Ft.
Rock Sampling:	3.0 Ft.
Total Depth of Hole:	107.0 Ft.
No. of Undist. Samples:	23
Total Number of Core Boxes:	0
Groundwater Observations	

Project:	Phase II Grove Pond Arsenic Investigation		
Drilling Agency:	American Drilling		
Driller:	Brad Brock		
Bit Size and Type:		CME Sampler:	
Casing Size:	4 inch	Spoon Size:	2 inch O.D.
Hollow-Stem:	NA	Hammer Wt.:	140 lbs.
Drilling Fluid:	Water	Hammer Drop:	30 inch
Drill Rig:	CME 75 Truck Rig		

Hole No.	GF-3a
Sheet	4 of 4
Location:	
Street:	
N Coordinate:	
E Coordinate:	
Elev. Top of Hole:	
Direction of Hole	Vertical ☒ Inclined ☐
Degrees from Vertical	0°
Inspector:	K. Blake/T. Finlayson



Depth (ft.)	Sample No.	Blows or RQD	Rec (ft.)	Rec (%)	Legend	Soil Classification	Description of Materials	Remarks
85								
85.0 - 87.0	SS-20	6-6-13-20	2.0	100			Wet, medium dense, gray F-C SAND	
90								
90.0 - 92.0	SS-21	9-11-24-28	2.0	100			Wet, dense, gray F-C SAND, trace fine gravel	
95								
95.0 - 97.0	SS-22	3-3-4-8	2.0	100			Wet, loose, gray F-M SAND	
100								
100.0 - 102.0	SS-23	19-15-13-6	0.4	20			Wet, medium dense, gray F-C GRAVEL and F-C SAND, trace silt	102.0'
							Bottom of Boring = 102.0 Ft.	
105								
110								

Remarks: * = rock in tip of spoon
water table at 3 feet below ground surface

DRILLING LOG
Gannett Fleming

Date Started:	11-9-99
Date Finished:	11-9-99
Soil Sampling:	14.0 Ft.
Rock Sampling:	0.0 Ft.
Total Depth of Hole:	14.0 Ft.
No. of Undist. Samples:	7
Total Number of Core Boxes:	0

Groundwater Observations

Project:	Phase II Grove Pond Arsenic Investigation		
Drilling Agency:	American Drilling		
Driller:	Brad Brock		
Bit Size and Type:		CME Sampler:	
Casing Size:	4 inch	Spoon Size:	2 inch O.D.
Hollow-Stem:	NA	Hammer Wt.:	140 lbs.
Drilling Fluid:	Water	Hammer Drop:	30 inch
Drill Rig:	CME 75 Truck Rig		

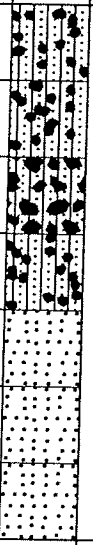
Hole No.	GF-3b
Sheet	1 of 1
Location:	
Street:	
N Coordinate:	
E Coordinate:	
Elev. Top of Hole:	

Direction of Hole

Vertical ☒ Inclined ☐

Degrees from Vertical 0°

Inspector: T. Finlayson

Depth (ft.)	Sample No.	Blows or RQD	Rec (ft.)	Rec (%)	Legend	Soil Classification	Description of Materials	Remarks
0.0 - 2.0	SS-1	WH-12	0.6	30			Moist, very loose, brown F-M SAND, trace F-C gravel, trace organics	
2.0 - 4.0	SS-2	2-3-2-4	2.0	100			Wet, loose, brown, F-C SAND, little silt, trace fine gravel	
4.0 - 6.0	SS-3	1-4-4-6	0.6	30			Wet, loose, brown, F-C SAND, and F-C GRAVEL, trace silt	
6.0 - 8.0	SS-4	6-9-13-16	2.0	100			Wet, medium dense, brown, F-C SAND, trace fine gravel, lens of iron deposits about 1/2" thick.	
8.0 - 10.0	SS-5	5-8-8-10	1.7	85			Wet, medium dense, brown, F-C SAND, trace iron deposits.	
10.0 - 12.0	SS-6	3-9-11-14	2.0	100			Wet, medium dense, brown, F-C SAND, trace silt and trace iron deposits	
12.0 - 14.0	SS-7	6-5-5-14	1.7	85			Same as above	14.0'
							Bottom of Boring = 14.0 Ft.	

Remarks:

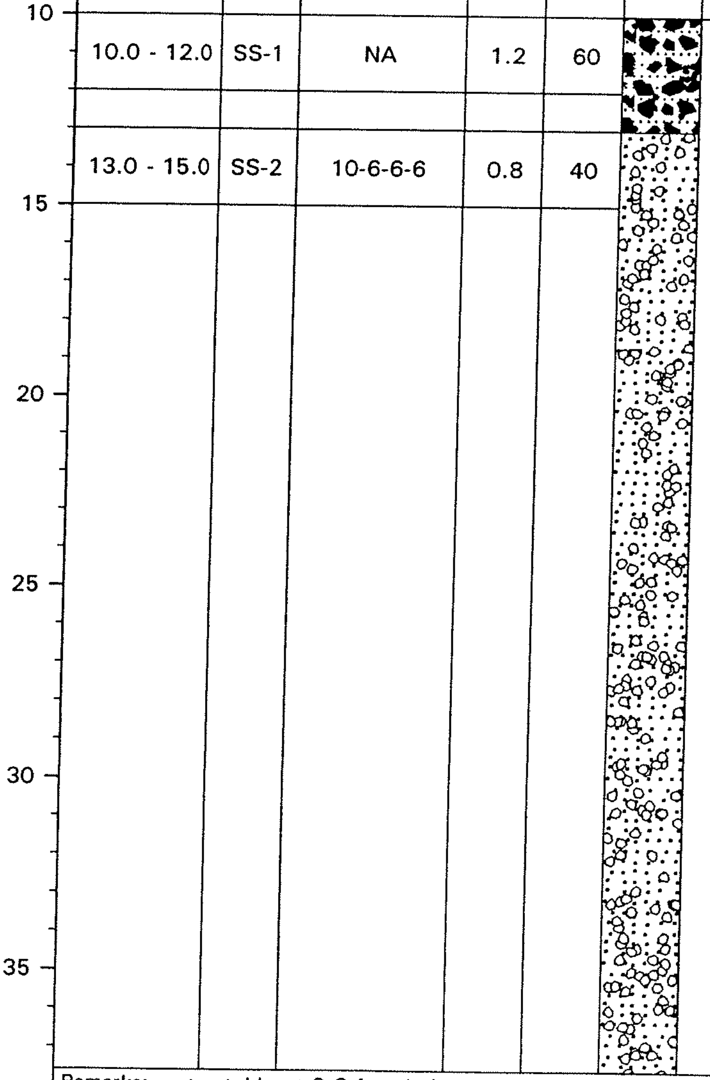
DRILLING LOG
Gannett Fleming

Date Started:	11-10-99
Date Finished:	11-12-99
Soil Sampling:	85.0 Ft.
Rock Sampling:	0.0 Ft.
Total Depth of Hole:	85.0 Ft.
No. of Undist. Samples:	3
Total Number of Core Boxes:	NA
Groundwater Observations	

Project:	Phase II Grove Pond Arsenic Investigation		
Drilling Agency:	American Drilling		
Driller:	Brad Brock		
Bit Size and Type:		CME Sampler:	
Casing Size:	4 inch	Spoon Size:	2 inch O.D.
Hollow-Stem:	NA	Hammer Wt.:	140 lbs.
Drilling Fluid:	Water	Hammer Drop:	30 inch
Drill Rig:	CME 75 Truck Rig		

Hole No.	GF-4
Sheet	1 of 3
Location:	
Street:	
N Coordinate:	
E Coordinate:	
Elev. Top of Hole:	
Direction of Hole	Vertical ☒ Inclined ☐
Degrees from Vertical	0°
Inspector:	K. Blake/T. Finlayson

Depth (ft.)	Sample No.	Blows or RQD	Rec (ft.)	Rec (%)	Legend	Soil Classification	Description of Materials	Remarks
10.0 - 12.0	SS-1	NA	1.2	60			Wet, medium dense, brown F-C SAND and F-C gravel, little silt.	
13.0 - 15.0	SS-2	10-6-6-6	0.8	40			Wet, medium dense, brown/gray, F-C SAND, some F-C gravel, trace silt.	



Remarks: water table at 9.8 feet below ground surface
Hit refusal at 85 feet. As a result of running sands from 52 feet to 85 feet, soils samples were not collected after the 50-52 foot interval.

Date Started: 11-10-99
Date Finished: 11-12-99
Soil Sampling: 85.0 Ft.
Rock Sampling: 0.0 Ft.
Total Depth of Hole: 85.0 Ft.
No. of Undist. Samples: 3
Total Number of Core Boxes: NA

Groundwater Observations

DRILLING LOG

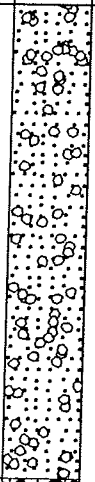
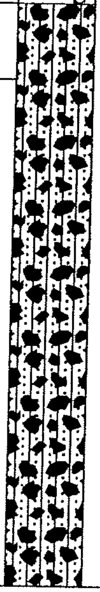
Gannett Fleming

Project: Phase II Grove Pond Arsenic Investigation
Drilling Agency: American Drilling
Driller: Brad Brock
Bit Size and Type:
CME Sampler:
Casing Size: 4 inch
Spoon Size: 2 inch O.D.
Hollow-Stem: NA
Hammer Wt.: 140 lbs.
Drilling Fluid: Water
Hammer Drop: 30 inch
Drill Rig: CME 75 Truck Rig

Hole No. GF-4
Sheet 2 of 3
Location:
Street:
N Coordinate:
E Coordinate:
Elev. Top of Hole:

Direction of Hole
Vertical ☒ Inclined ☐
Degrees from Vertical 0°

Inspector: K. Blake/T. Finlayson

Depth (ft.)	Sample No.	Blows or RQD	Rec (ft.)	Rec (%)	Legend	Soil Classification	Description of Materials	Remarks
40 45								
50.0 - 52.0	SS-3	8-8-10-16	1.5	75			Wet, medium dense, brown F-C SAND, little F-C gravel.	
55 60 65								

Remarks: water table at 9.8 feet below ground surface
Hit refusal at 85 feet. As a result of running sands from 52 feet to 85 feet, soils samples were not collected after the 50-52 foot interval.

DRILLING LOG
Gannett Fleming

Date Started: 11-19-99			Hole No. BH-1
Date Finished: 11-29-99			Sheet 1 of 3
Soil Sampling: 73.0 Ft.			Location:
Rock Sampling:	Project: Phase II Grove Pond Arsenic Investigation		Street:
Total Depth of Hole:	Drilling Agency: American Drilling		N Coordinate:
No. of Undist. Samples: 4	Driller: Brad Brock		E Coordinate:
Total Number of Core Boxes: NA	Bit Size and Type:	CME Sampler:	Elev. Top of Hole:
Groundwater Observations	Casing Size: 4 inch	Spoon Size: 2 inch O.D.	Direction of Hole
	Hollow-Stem: NA	Hammer Wt.: 140 lbs.	Vertical ☒ Inclined ☐
	Drilling Fluid: Water	Hammer Drop: 30 inch	Degrees from Vertical 0°
	Drill Rig: CME 75 Truck Rig		Inspector: K. Blake

	Depth (ft.)	Sample No.	Blows or RQD	Rec (ft.)	Rec (%)	Legend	Soil Classification	Description of Materials	Remarks
	18.0 - 20.0	SS-1	5-3-12-7	0.6	30			Wet, medium dense, gray, F-C SAND and F GRAVEL	
20									
25									
30									
35									
	38.0 - 40.0	SS-2	12-12-9-14	0.5	25			Wet, medium dense, brown, F-C SAND, some fine gravel.	
40									
45									

Remarks: All depths are from pond bottom (i.e. pond bottom is 0 feet)

Date Started: 11-19-99	DRILLING LOG Gannett Fleming	Hole No. BH-1	
Date Finished: 11-29-99		Sheet 2 of 3	
Soil Sampling: 73.0 Ft.		Location:	
Rock Sampling:	Project: Phase II Grove Pond Arsenic Investigation	Street:	
Total Depth of Hole:	Drilling Agency: American Drilling	N Coordinate:	
No. of Undist. Samples: 4	Driller: Brad Brock	E Coordinate:	
Total Number of Core Boxes: NA	Bit Size and Type:	CME Sampler:	Elev. Top of Hole:
Groundwater Observations	Casing Size: 4 inch	Spoon Size: 2 inch O.D.	Direction of Hole
	Hollow-Stem: NA	Hammer Wt.: 140 lbs.	Vertical ☒ Inclined ☐
	Drilling Fluid: Water	Hammer Drop: 30 inch	Degrees from Vertical 0°
	Drill Rig: CME 75 Truck Rig		Inspector: K. Blake

	Depth (ft.)	Sample No.	Blows or RQD	Rec (ft.)	Rec (%)	Legend	Soil Classification	Description of Materials	Remarks
50	50.0 - 52.0	SS-3	22-18-15-12	1.8	90			Wet, dense, brown, F-C SAND. (bottom 1 to 1.5" reddish/brown).	
55									
60	59.0 - 61.0	SS-4	43-21-9-13	0.2	12			Wet, medium dense, brown, F-M SAND. Gravel stuck in tip. May account for blow count of 43. May have been a gravel lense.	
65									
70									73.0'

Remarks: All depths are from pond bottom (i.e. pond bottom is 0 feet)

DRILLING LOG

Gannett Fleming

Date Started: 11-19-99
Date Finished: 11-29-99
Soil Sampling: 73.0 Ft.
Rock Sampling:
Total Depth of Hole:
No. of Undist. Samples: 4
Total Number of Core Boxes: NA

Groundwater Observations

Project: Phase II Grove Pond Arsenic Investigation
Drilling Agency: American Drilling
Driller: Brad Brock
Bit Size and Type:
CME Sampler:
Casing Size: 4 inch
Spoon Size: 2 inch O.D.
Hollow-Stem: NA
Hammer Wt.: 140 lbs.
Drilling Fluid: Water
Hammer Drop: 30 inch
Drill Rig: CME 75 Truck Rig

Hole No. BH-1
Sheet 3 of 3
Location:
Street:
N Coordinate:
E Coordinate:
Elev. Top of Hole:

Direction of Hole

Vertical ☒ Inclined ☐
Degrees from Vertical 0°

Inspector: K. Blake

Depth (ft.)	Sample No.	Blows or RQD	Rec (ft.)	Rec (%)	Legend	Soil Classification	Description of Materials	Remarks
							Bottom of Boring = 73.0 Ft.	
75								
80								
85								
90								
95								
100								

Remarks: All depths are from pond bottom (i.e. pond bottom is 0 feet)

APPENDIX C.

GROVE POND
SURFACE WATER AND SEDIMENT
SAMPLING REPORT

(ESAT)

Surface Water and Sediment Sampling, Fort Devens Superfund Site

Ayer, Massachusetts

Work Assignment No. 01-98-2-05

TDF No. 195

Task No. 5

Submitted to the:

Work Assignment Manager
Office of Environmental Measurement and Evaluation
USEPA - Region I
60 Westview Street
Lexington, Massachusetts 02142

Submitted by:

ESAT - Region I
Lockheed Martin Systems Support and Training Services Company
19 Crosby Drive
Bedford, Massachusetts 01730

November 25, 1998

EPA Contract 68-D6-0002

Fort Devens Superfund Site, Ayer, Massachusetts

Surface Water and Sediment Sampling

September 1998

1.0 INTRODUCTION

ESAT has completed collection of surface water and sediment samples at 16 locations associated with the Fort Devens Superfund Site in Ayer, Massachusetts. Sampling was performed to investigate the distribution of metals in surface water and sediment in Plow Shop Pond, Grove Pond, and Nonacoicus Brook, all of which are potentially impacted by the Fort Devens site. Sampling locations in the two ponds were intended to match locations where biological sampling took place during the summer of 1998. Specifically, the four locations sampled in each pond corresponded as closely as possible with locations used for emergent insect trap studies performed earlier in the year. Locations on Nonacoicus Brook were sampled because this stream begins as the outfall of Plow Shop Pond, which has been impacted by the Fort Devens site. The stream has not been extensively studied to determine the nature and extent of contamination originating from the site. Eight depositional areas were selected along Nonacoicus Brook, representing, to the extent possible, the full course of the brook from its origin at Plow Shop Pond to its confluence with the Nashua River.

At each sampling station, prior to sampling, ESAT measured water quality parameters, including pH, dissolved oxygen, specific conductance, and temperature. ESAT then noted the habitat surrounding the sampling station, recorded the latitude and longitude using Global Positioning System (GPS), and photographed the station. Surface water samples were collected for Target Analyte List (TAL) metals analysis, excluding mercury and cyanide. Sediment samples were collected for TAL metals analysis excluding mercury and cyanide, as well as analysis of grain size and total organic carbon (TOC).

All samples were kept in coolers in the field, and chain-of-custody procedures were followed up to delivery at the USEPA Office of Ecosystems Monitoring and Evaluation (OEME) facility in Lexington, Massachusetts. Following sample log-in at OEME, ESAT started the grain size analysis of sediments. Results of this analysis are presented in this report, as are the field-measured water quality parameters. Other parameters will be reported by OEME at a later date.

The scope of work, sample quantities and containers, field preservation procedures, and other details of the field activities are summarized in the Quality Assurance Project Plan (QAPP), which is included in this report as **Appendix A**. The following sections describe items not covered in the QAPP, such as the chronology of sampling activities, sampling equipment used at each location, and final selection of sample locations.

2.0 Chronology of Field Activities

2.1 Summary

Surface water and sediment sampling took place between September 9, 1998 and September 10, 1998. At each sampling station, ESAT took a GPS reading, made observations on the biological features of the station and surrounding area, and photographed the station. Surface water samples were taken for TAL metals, excluding mercury and cyanide. Water samples were preserved to pH<2 in the field using 1:1 nitric acid. Surface water parameters, including pH, conductivity, dissolved oxygen, and temperature, were measured at each location using field instruments. Sediment samples were taken for TAL metals excluding mercury and cyanide, total organic carbon (TOC), and grain size.

The observations regarding habitat, water quality parameters, and GPS readings from each station are summarized in **Appendix B** of this report. GPS readings were taken at the time and location of sampling for all stations on Nonacoicus Brook. The GPS readings for the two ponds were also taken at the time of sampling, however the readings were lost because the battery for data storage failed. The stations were revisited during the week following sampling and the GPS readings were retaken. At the conclusion of field activities, the GPS readings were downloaded and corrected against a known position at the OEME facility in Lexington, Massachusetts. This correction is necessary to correct field readings, because the satellite signals are routinely scrambled for reasons of National security, and must be compared with readings from a known point to obtain maximum accuracy.

Each sampling station, and the surrounding area, was photographed. **Appendix C** contains the photographs of each sampling station. For this station, a summary of observations is presented in place of photographs.

All sampling procedures, chain-of-custody procedures, sample quantities, and other specific elements of field work for this project are described in detail in the Quality Assurance Project Plan (QAPP), which is included in this report as **Appendix A**. The chronology below discusses the selection of sample locations, schedule of sampling, and any deviations from the QAPP.

2.2 Sampling Chronology

ESAT first visited the site with the EPA RPM Jim Byrne, on September 2, 1998. ESAT was shown the access points for Plow Shop Pond and Grove Pond, as well as the beginning of Nonacoicus Brook. ESAT discussed with Jim Byrne the possible sampling locations on Nonacoicus Brook, but did not explore the Brook extensively on that day.

On Tuesday, September 8, 1998, ESAT arrived at the access point for Grove Pond in the morning to meet Jim Byrne of EPA and Steve Mierzykowski of the U.S. Fish and Wildlife Service (USFWS), in order to determine the locations to be sampled. ESAT was not able to meet with either party that day, and sampling was postponed to Wednesday, September 9, 1998.

On Wednesday September 9, ESAT met with both Jim Byrne and Steve Mierzykowski. ESAT started sampling Grove Pond. Two ESAT members sampled stations GSEM-1, GSEM-2, and GSEM-4; all of which are in Grove Pond, on September 9. GSEM-3, however, was sampled the following day, September 10, 1998, as the first attempt to take a sediment sample at this location failed. The sediment substrate was very fine and the sample actually penetrated through the top screen of the Ponar sampler. Another attempt was made on September 10, 1998, this time with an Eckman sampler and was successful. For all other locations in Grove Pond, the Petit Ponar was used to obtain sediments at these stations. Grove Pond is fairly shallow and aquatic vegetation is prevalent as dense stands of pickerel weed, water lilies, and coontail. The waterfowl were plentiful on this pond as flocks of mallards, wood ducks, Canada geese, cormorants, teal, great blue heron were evident in all areas of the pond.

Jim Byrne and Bart Hoskins selected approximately six possible locations between the beginning of Nonacoicus Brook and the point where the Brook passes under Main Street in Ayer. This reach of Nonacoicus Brook is characterized by fairly steeply cut banks, with predominantly coarse sand substrate and occasional shallow riffle areas. The upper portion of the Brook is strewn with many freshwater mussel shells and live mussels. In addition, numerous sunfish and catfish, and one small pickerel, were observed in this section of the stream. The banks are overhung with red maple, speckled alder, and other trees and shrubs, with occasional heavy growth of grapes. Water depth ranged from less than one inch to as much as two feet in the deepest pools. Jim Byrne suggested that, of the six locations flagged, approximately four stations representing the best depositional areas should be sampled.

Nonacoicus brook starts at the waterfall which is an outlet for Plow Shop Pond. Immediately below the waterfall, there is a wide, shallow pooled area. The Brook leaves this pool in a series of meanders, and passes to the northwest under Scully Street, which is a residential road leading to an industrial park. Immediately beyond Scully Street is a deep pool, approximately ten feet deep in the center. This pool has a fairly hard substrate, and is lined around its edge with large rocks. Later attempts to sample this pond indicated no areas of soft sediment. Beyond the pool, Nonacoicus Brook passes under a railroad track and another residential street, before passing under Main Street and turning to the west toward the Nashua River.

During the reconnaissance on September 9, Jim Byrne and Bart Hoskins only reached the point where Nonacoicus Brook passes under Main Street, before returning to the vehicle and going to the Ayer Public Works facility located off Park Street in Ayer. Jim Byrne suggested that the access road for the facility might be a good access point for the next reach of Nonacoicus Brook. Nonacoicus Brook appeared to pass between the access road for the Public Works facility and Main Street in Ayer, however it was not confirmed at that time that the brook visible from the Public Works facility was, in fact, Nonacoicus Brook. Jim Byrne and Bart Hoskins then briefly visited the confluence of the Nashua River and Nonacoicus Brook, then returned to Grove Pond. Bart Hoskins sampled station NON-1. No other stations on Nonacoicus Brook were sampled on September 9.

On September 10, 1998, ESAT returned to the location of the access point for Plow Shop Pond, then split into two teams. One team to take the remaining pond samples, and the other team to finish the Nonacoicus Brook samples. The remaining pond samples were all taken using the pole-mounted Eckman sampler, because the substrate was too soft to trigger the Petit Ponar to close.

On Thursday, September 10, 1998, ESAT sampled Plow Shop Pond starting initially in the northwest section of the pond. The pond is large and in the center can reach depths up to fifteen feet. Unlike Grove Pond there were large areas of open water. The shoreline was, in most cases, steeply banked with thick stands of maples, oaks, and birches up to the water's edge. The only development is an industrial facility in the northwest portion of the pond. In addition, the landfill is visible from the southwest lobe of the pond.

The Nonacoicus Brook stations NON-2, NON-3, and NON-4 were all taken in the reach of Nonacoicus Brook between the waterfall and the railroad overpass before Main Street. These samples were taken in the best available depositional areas in this reach. No sample was taken in the pool below Scully Street as the substrate appeared to be hard throughout the pool.

The Nonacoicus Brook team then proceeded to the Public Works facility to attempt sampling from that area. It proved to be extremely difficult to cross on foot through areas of thick brush and tall reeds between the access road and the brook. Attempting this crossing with the canoe would have been even more difficult. It was decided that access would be better from behind residences on Main Street for this section of the stream. However, in the interest of time, it was decided that the team would first work up from the confluence with the Nashua River and return to take this station last. The designation NON-5 was reserved for this station.

The team drove to Bishop Road, and parked near the confluence of the Nashua River and Nonacoicus Brook. Two ESAT members started up Nonacoicus Brook with the canoe and the sampling equipment. The brook had patches of sandy substrate, interspersed with sections of deep soft mud. Water depth ranged from a few inches to approximately three feet. The banks on both sides were forested with mixed hardwood forest. Occasionally, stands of red-osier dogwood or red maple would dominate the banks. There were many downed trees across the brook, and the deep mud and shallow water made it necessary to portage the canoe in some areas. The brook ranged in width from approximately ten to twenty feet.

Ultimately it appeared to be not worthwhile to continue with the canoe because the water was consistently too shallow, however, not too much further upstream the brook became much deeper. The team proceeded on foot to the confluence of Willow Brook with Nonacoicus Brook. At this point, it was impractical to proceed further upstream without the canoe, as both the water and the sediment became suddenly deeper at this point. This point was designated NON-6, and surface water and sediment samples were taken using the sample container for water, and a plastic core tube for sediment. The stream at NON-6 was lined with emergent vegetation, with tall sedges, reed-canary grass, and purple loosestrife on the bordering wetlands. The higher ground on both sides was forested with mixed-hardwood forest.

The next station sampled was NON-7, a depositional area behind (upstream of) a beaver dam. The sediment at this station was a deep soft mud. Immediately below the dam the stream had noticeably sandier substrate, suggesting that the beaver dam was an effective sediment trap. Station NON-7 was sampled using the plastic core tube for sediment, and the sample container for surface water. Vegetation was similar at this location to that found at NON-6, except that a dense stand of red-osier dogwood was located on the southern bank of the brook.

Station NON-8 was sampled next. This station was located near the confluence of Nonacoicus Brook and the Nashua River. A depositional area was selected approximately 30 yards upstream of the confluence, in order to minimize any contribution of metals related to the Bishop Street bridge that passes over Nonacoicus Brook before the confluence. This station is in an area of the brook that is heavily forested on both banks, with very little understory. The brook is approximately 15 feet wide at this point, and between a few inches to about one foot in depth.

The Nonacoicus Brook Team went back up Main Street in Ayer to locate an access point for Station NON-5. A suitable location was found behind a small apartment building on Main Street. A steep bank sloped downward to the edges of a stream at this location. The water was too shallow (1-2 cm) to allow for a surface water sample to be taken near the bank, and the sediment was too deep to safely reach mid-stream. Only a sediment sample was taken at the bank. The stream was fairly wide, but very shallow, with a barely perceptible flow. Emergent vegetation grew thickly on both banks and the opposite bank supported a bordering wet meadow area that extended along the Public Works facility property.

The stream sampling concluded with sample NON-5. All ESAT team members returned to the OEME facility to place the samples under a chain-of-custody seal in a sample refrigerator for overnight storage.

On September 18, 1998, Dan Huber and Bart Hoskins returned to the site to retake the GPS readings on the two ponds. The original readings were lost when a memory backup battery failed in one of the GPS units. As part of this visit, another attempt was made to clarify the relationship between the upper reaches of Nonacoicus Brook and the area near the Public Works facility, by walking the entire upper end of the stream. The stream that was assumed to be Nonacoicus Brook near the Public Works facility was found to be the tributary that enters Nonacoicus Brook from the east, having originated near the center of Ayer. It is after this tributary joins Nonacoicus Brook that the brook changes from a sandy/gravelly substrate to a silt/mud substrate, possibly as a result of sediment carried from the tributary and its bordering wetlands. The sample designated NON-5 is therefore a sample from the tributary, which may be useful in determining the contribution of metals, if any, from the tributary to Nonacoicus Brook. Results of this round of sampling will help to determine whether additional sampling will be needed between stations NON-4 and NON-6, to characterize the reach of Nonacoicus Brook between these stations.

Each of the sample locations was photographed. The annotated photographs are contained in **Appendix C** of this report.

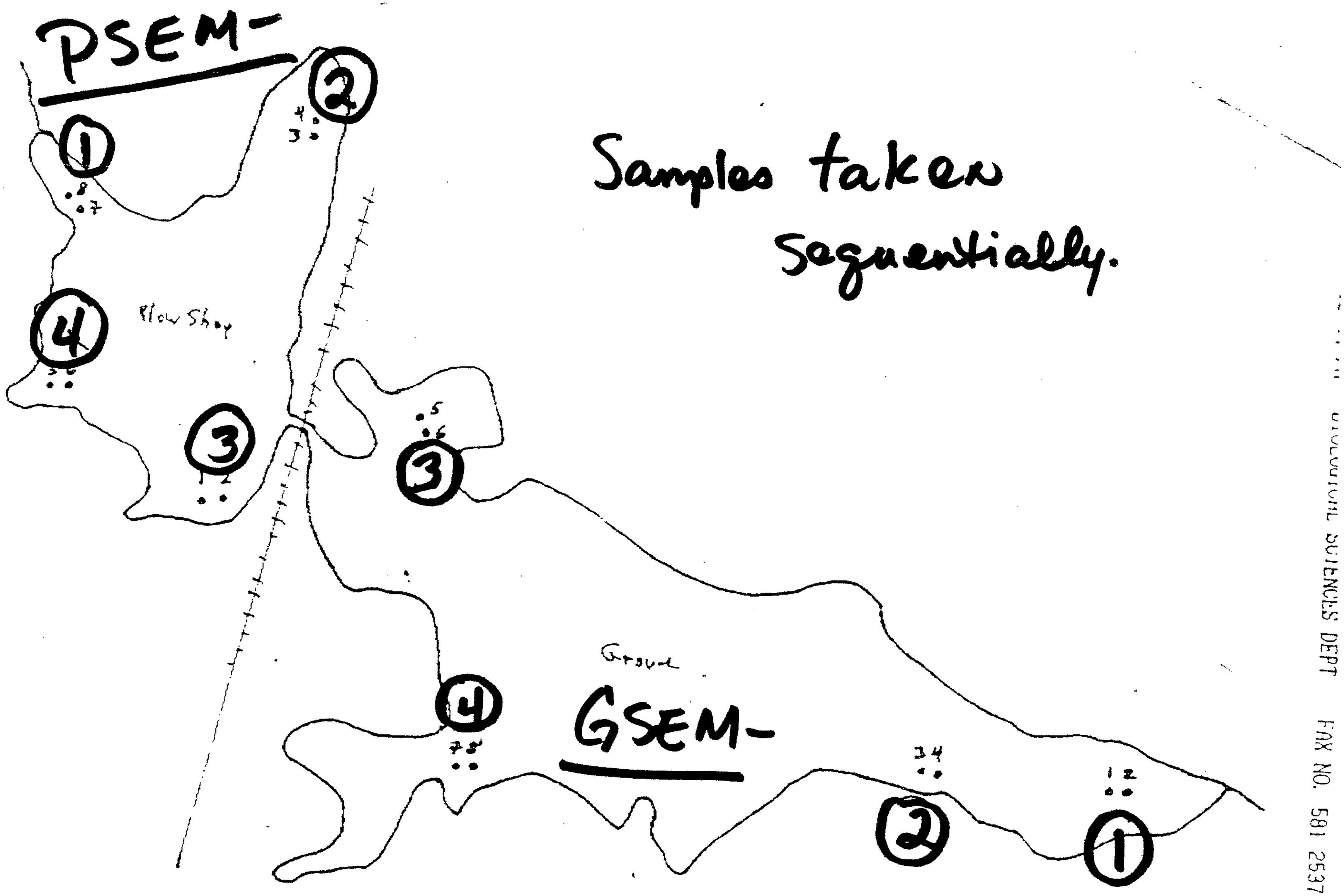
3.0 Laboratory Activities

All sediment samples from the Fort Devens site were analyzed for grain size in the OEME facility. The grain size analysis was performed using a modified ASTM method which involves spraying water over the sample rather than agitation of the sample to separate the size fractions using seives. This method reduces the dust produced in the processing of samples. The seive sizes used were standard mesh sizes 4, 10, 40, and 200. The results of the grain size analysis are summarized in **Appendix D**.

4.0 Conclusion

The surface water and sediment sampling were performed successfully at the two ponds. The sampling locations for this project should correspond well with those used for biological studies during the summer of 1998. The stream sampling locations, for the most part, were not clearly defined prior to the start of this project. Professional judgement was used in the field to locate depositional areas along the course of the brook. The upper and lower ends of Nonacoicus Brook were reasonably well characterized by the sample locations selected. The station that was intended to represent a.mid-point of Nonacoicus Brook was actually situated on a tributary to the Brook. Although the data from this station will be useful for characterizing the contribution, if any, of contamination to Nonacoicus Brook, it leaves a possible gap between stations NON-4 and NON-6. It should be noted, however, that it remains unclear how best to access this middle reach of the stream, as the passage from downstream or upstream is very difficult to negotiate. Possibly an access point can be found by following railroad right-of-ways on foot.

The results of this investigation will complement the biological sampling that took place during the summer of 1998. It is anticipated that the U.S. Geologic Survey (USGS) will be sampling the stations from this project for mercury and methylmercury. The combined results of these efforts should yield useful information regarding the extent of metals contamination in environmental media and within the food web at the Fort Devens site.



Samples taken Sequentially.

• 2 = USFWS Emergence Trap Station   Location of Emergence Traps

GSEM-
PSEM- ③ = ESAT designation,
Surface water/Sediment Sampling September 1998

Project name: Fort Devens
Sample location: GSEM-1 (Grove Pond)
Sampling team: Dan Huber and George Balog
Date: September 9, 1998
Time: 1055 hours
Weather: windy and overcast, temperature approximately 70° F.
GPS reading taken on September 18, 1998, 1115 hours
Latitude: N 42° 33' 07.112"
Longitude: W 71° 34' 44.204"
Elevation: 25 M HAE
PDOP: 3.26
Filename: V091815A

GSEM-1 is located in the eastern section of Grove Pond, towards the culvert and approximately 200 yards from Public Water Facility. Access to this location was via the unimproved ramp near the water depth gauge. The depth of water at GSEM-1 was estimated at three feet. Aquatic vegetation included duckweed, pickerel weed, and an abundance of elodea under the surface of the water. In addition, a small patch of purple flowered aquatic vegetation is approximately 25 feet to the north of GSEM-1. Mallards and wood ducks were seen and heard at this location.
The sediment sample was collected with a Ponar sampler. The sediment would best be described as soupy fine organic muck.

Surface water quality characteristics GSEM-1	
pH	7.6
Temp	19.2° C
DO	8.6 mg/L
Conductivity	212.1 μS
Salinity	0.1 ppt
Notes C-celsius mg/L-milligrams per liter μS-microsiemans ppt-parts per thousand	

Project name: Fort Devens
Sample location: GSEM-2 (Grove Pond)
Sampling team: Dan Huber and George Balog
Date: September 9, 1998
Time: 1305 hours
Weather: windy and overcast, temperature approximately 70° F.
GPS reading taken on September 18, 1998, 1125 hours
Latitude: N 42° 33' 07.538"
Longitude: W 71° 34' 52.815"
Elevation: 13 M HAE
PDOP: 3.29

Filename: V091815C

GSEM-2 is situated off the unimproved boat access, near the water depth gauge. This sample location is marked with a orange buoy labeled as #2, which is approximately 35 feet from the shoreline, and 100 feet northwest from the water depth gauge. Aquatic vegetation included duckweed, water lilies, and pickerel weed. An artificial swallow box near the shore is visible from this sample location. The sediment would best be described as soupy fine organic muck.

Surface water quality characteristics GSEM-2	
pH	7.7
Temp	19.3° C
DO	6.2 mg/L
Conductivity	215.5 μS
Salinity	0.1 ppt
Notes C-celsius mg/L-milligrams per liter μS-microsiemans ppt-parts per thousand	

Project name: Fort Devens
Sample location: GSEM-3 (Grove Pond)
Sampling team: Dan Huber and George Balog
Date: September 9, 1998
Time: 1455 hours
Weather: windy and overcast, temperature approximately 65° F
GPS reading taken on September 18, 1998, 1145 hours
Latitude: N 42° 33' 15.683"
Longitude: W 71° 34' 18.962"
Elevation: 121 M HAE
PDOP: 3.33
Filename: V091815D

GSEM-3 is situated in the northwest portion of Grove Pond approximately 150 feet from the shore line. A lawn area can be seem from this location with residential apartments in the background. A site reconnaissance conducted earlier in the morning found a dead Canada goose approximately 50 feet south of this sampling location. Aquatic vegetation included lilies and elodea. The shoreline also was heavily vegetated except for the north shore where the residential buildings are located. The first attempt to take a sediment sample at this location failed. The sediment was very fine and the sample actually penetrated through the top screen of the Ponar sampler. Another attempt was made on September 10, 1998, this time with an Eckman sampler and was successful. The sediment sample was taken approximately twelve feet away from the original staked location. The reason for the relocation was due to insufficient sample quantity.

Surface water quality characteristics GSEM-3	
pH	7.7
Temp	19.3° C
DO	10.5 mg/L
Conductivity	210.5 μS.
Salinity	0.1 ppt
Notes C-celsius mg/L-milligrams per liter μS-microsiemans ppt-parts per thousand	

Project name: Fort Devens
Sample location: GSEM-4 (Grove Pond)
Sampling team: Dan Huber and George Balog
Date: September 9, 1998
Time: 1615 hours
Weather: windy and overcast, temperature approximately 65° F.
GPS reading taken on September 18, 1998, 1155 hours
Latitude: N 42° 33' 05.988"
Longitude: W 71° 53' 12.718"
Elevation: 102 M HAE
PDOP: 2.97
Filename: V091815E

GSEM-4 is located just off shore in the southwestern portion of Grove Pond. From this vantage point, the Town of Ayer's Water Treatment facility is visible. The sample was collected in a thick patch of water lilies in about three feet of water. Again, the sediment would best be described as soupy fine organic muck.

Surface water quality characteristics GSEM-4	
pH	7.8
Temp	19.3° C
DO	10.8 mg/L
Conductivity	182.7 μS.
Salinity	0.1 ppt

Grain Size
(As percent retained)

SAMPLE LOCATION	Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt & Clay
	sieve #4 >4.75mm	sieve #10 <4.75mm >2mm	sieve #40 <2.0mm >0.425mm	sieve #200 <0.425mm >0.075mm	<0.075mm
GSEM-1	0	0	1.2	34.2	64.6
GSEM-2	0	0	2.8	49.1	48.1
GSEM-3	0	0	2.2	39.7	58.1
GSEM-4	0	0	1.2	50.6	48.2
NON-1	0.3	6.1	40.2	48.7	4.7
NON-2	0	1.6	24.7	71.7	2.0
NON-3	0	0	27.6	68.3	4.1
NON-4	0	1.7	14.3	78.8	5.2
NON-5	0	0	10.3	44.1	54.4
NON-6	0	6.25	10.1	71.4	12.25
NON-7	0	0.2	1.2	33.6	65.2
NON-8	0	0	0.8	53.9	45.3
NON-42	0	0.7	15.8	73.2	10.3
PSEM-1	0	0	1.9	55.1	43
PSEM-2	0	1.6	1.6	61.2	35.6
PSEM-3	0	0	12.5	50.6	36.9
PSEM-4	0	0	0.5	56.0	43.5

Note-The grain size analysis was performed using ASTM method D422-63. The results below are reported as percent, by dry mass, retained on the sieve number. The associated size range is also reported.

Fort Devens Sample tions September 9-10 1998

Screening-Level Ecological Risk Assessment

Fort Devens

Ayer, Massachusetts

U.S. Environmental Protection Agency
Region I New England
Office of Environmental Measurement and Evaluation
Office of Ecosystem Assessment

April 19, 1999

TAF

Screening of Inorganic Chemic. Surface Water - Grove Pond

Fort Devens, Ayer, Massachusetts

Analyte	GSEM-1	GSEM-2	GSEM-3	GSEM-4	Surface water benchmark chronic (total)	Surface water benchmark acute (total)	Source
Inorganics (ug/L)							
Aluminum	10.0 U	10.0 U	10.0 U	10.0 U	87	750	AWQC
Antimony	5.0 U	5.0 U	5.0 U	5.0 U	30	180	Tier II
Arsenic	10.0 U	10.0 U	10.0 U	10.0 U	190	360	AWQC
Barium	6.4	11.9	8.8	8.8	4.0	110	Tier II
Beryllium	1.0 U	1.0 U	1.0 U	1.0 U	0.66	35	Tier II
Cadmium	1.5 U	1.5 U	1.5 U	1.5 U	0.7 +	2.1 +	AWQC
Calcium	18,400	19,700	17,400	17,000	116,000	---	LCV
Chromium	3.0 U	3.0 U	3.0 U	3.0 U	11 (Cr VI)	16 (Cr VI)	AWQC
Cobalt	1.5 U	1.5 U	1.5 U	1.5 U	23	1500	Tier II
Copper	1.5 U	1.5 U	1.5 U	1.5 U	7.4 +	10.6 +	AWQC
Iron	390	270	320	190	1000	---	AWQC
Lead	5.0 U	5.0 U	5.0 U	5.0 U	1.6 +	41 +	AWQC
Magnesium	3,200	3,300	2,800	2,600	82,000	---	LCV
Manganese	108	268	68.6	20.3	120	2300	Tier II
Nickel	6.0 U	6.0 U	6.0 U	6.0 U	99 +	895 +	AWQC
Potassium	2,500	1,800	1,400	1,500	53,000	---	LCV
Selenium	20.0 U	20.0 U	20.0 U	20.0 U	5	20	AWQC
Silver	3.0 U	3.0 U	3.0 U	3.0 U	0.36	1.6 +	Tier II/AWQC
Sodium	30,500	29,400	29,200	22,100	680,000	---	LCV
Thallium	20.0 U	20.0 U	20.0 U	20.0 U	12	110	Tier II
Vanadium	1.5 U	1.5 U	1.5 U	1.5 U	20	280	Tier II
Zinc	12.0 U	12.0 U	12.0 U	12.0 U	67 +	74 +	AWQC
# of COPCs per location	1	2	1	1			
# exceeding chronic benchmark	1	2	1	1			
# exceeding acute benchmark	0	0	0	0			

Notes:

AWQC = Ambient water quality criteria; source document is the Federal Register; and EPA, 1988 for aluminum

Tier II = Secondary Chronic Values based on Great Lakes Tier II methodology; source document is Suter and Tsao (1996 revision).

LCV = Lowest Chronic Value for Daphnids, from Suter and Tsao (1996 revision).

+ = criterion adjusted to site-specific hadness of 58

▨ = indicates that the contaminant concentration exceeds the chronic criterion or benchmark

TAB

Screening - Level Ecological Risk Assessment of Inorganic Chemicals in Surface Water
Grove Pond - Fort Devens Site, Ayer, Massachusetts

Analyte	Maximum concentration	Location of maximum concentration	Average concentration	# of locations exceeding low benchmark	# of locations exceeding high benchmark	Surface water benchmark chronic (total)	Surface water benchmark acute (total)	Source	Retained as COPCs?	Reason
Inorganics (ug/L)										
Aluminum	U	N/A	5.0	0/4	0/4	87	750	AWQC	No	Analyte not detected
Antimony	U	N/A	2.5	0/4	0/4	30	180	Tier II	No	Analyte not detected
Arsenic	U	N/A	5.0	0/4	0/4	190	360	AWQC	No	Analyte not detected
Barium	11.9	GSEM-2	8.98	4/4	0/4	4	110	Tier II	Yes	Average/maximum concentrations exceed chronic benchmark
Beryllium	U	N/A	0.5	0/4	0/4	0.66	35	Tier II	No	Analyte not detected
Cadmium	U	N/A	0.75	0/4	0/4	0.74 +	2.1 +	AWQC	No	Analyte not detected
Calcium	19,700	GSEM-2	18,125	0/4	—	116,000	—	LCV	No	Micronutrient, concentrations below chronic value
Chromium	U	N/A	1.5	0/4	0/4	11 (Cr VI)	16 (Cr VI)	AWQC	No	Analyte not detected
Cobalt	U	N/A	0.75	0/4	0/4	23	1500	Tier II	No	Analyte not detected
Copper	U	N/A	0.75	0/4	0/4	7.4 +	10.6 +	AWQC	No	Analyte not detected
Iron	390	GSEM-1	292.5	0/4	—	1000	—	AWQC	No	Concentrations below benchmark
Lead	U	N/A	2.5	0/4	0/4	1.6 +	41 +	AWQC	No	Analyte not detected
Magnesium	3,300	GSEM-2	2,975	0/4	—	82,000	—	LCV	No	Micronutrient, concentrations below chronic value
Manganese	268	GSEM-2	116.2	1/4	0/4	120	2300	Tier II	Yes	Maximum concetration exceeds chronic benchmark
Nickel	U	N/A	3.0	0/4	0/4	99 +	895 +	AWQC	No	Analyte not detected
Potassium	2,500	GSEM-1	1800	0/4	—	53,000	—	LCV	No	Micronutrient, concentrations below chronic value
Selenium	U	N/A	10.0	0/4	0/4	5	20	AWQC	No	Analyte not detected
Silver	U	N/A	1.5	0/4	0/4	0.36	1.6 +	Tier II/AWQC	No	Analyte not detected
Sodium	30,500	GSEM-1	27,800	0/4	—	680,000	—	LCV	No	Micronutrient, concentrations below chronic value
Thallium	U	N/A	10.0	0/4	0/4	12	110	Tier II	No	Analyte not detected
Vanadium	U	N/A	0.75	0/4	0/4	20	280	Tier II	No	Analyte not detected
Zinc	U	N/A	6.0	0/4	0/4	67 +	74 +	AWQC	No	Analyte not detected

Notes:

AWQC = Ambient water quality criteria; source document is the Federal Register; and EPA, 1988 for aluminum.

Tier II = Secondary Chronic Values based on Great Lakes Tier II methodology; source document is Suter and Tsao (1996 revision).

LCV = Lowest Chronic Value for Daphnids, from Suter and Tsao (1996 revision).

+ = criterion adjusted to site-specific hadness of 58

— = no benchmark was available for this chemical

N/A = not applicable

▨ = Identifies a contaminant as a COPC

Ta.

Screening of Inorganic Chemicals in Sediment Samples of Grove Pond, Fort Devens, Ayer, Massachusetts
Fort Devens Site, Ayer, Massachusetts

Analyte	GSEM-1	GSEM-2	GSEM-3	GSEM-4	Sediment Benchmark (LOW)	Sediment Benchmark (HIGH)	Source
Inorganics mg/Kg d.w.							
Aluminum	14,000	11,000	5,400	21,000	—	58,030	ARCS
Antimony	5 UJ	5 UJ	5 UJ	5 UJ	2.0	25	NOAA
Arsenic	90 U	100 U	50 U	120 U	6	33	OMOE
Barium	115	90.3	170	73.0	20	—	EPA, 1997
Beryllium	1.2	1.0	0.95	3.1	—	—	—
Cadmium	39.4	[illegible]	6.8	12.5	0.6	10	OMOE
Calcium	5,700	5,900	215,000	5,100	—	—	—
Chromium	59.7	332	33,480	3,510	26	110	OMOE
Cobalt	34	28.8	3.5	42.5	50	—	OMOE
Copper	64.5	43.2	88	52.5	16	110	OMOE
Iron	22,000	21,000	8,700	20,000	20,000	40,000	OMOE
Lead	304	166	385	238	31	250	OMOE
Magnesium	3,880	2,240	1,650	1,430	—	—	—
Manganese	789	861	1,080	366	460	1,100	OMOE
Nickel	61.2	41.6	15.2	63.1	16	75	OMOE
Potassium	1,720	1,020	420 U	682	—	—	—
Selenium	10.2 U	10.3 U	10.4 U	10.1 U	5	—	—
Silver	2 UJ	2 UJ	2 UJ	2 UJ	1.0	3.7	NOAA
Sodium	492	485	753	288	—	—	—
Thallium	20.4 U	20.6 U	20.9 U	20.2 U	—	—	—
Vanadium	45.4	31.6	53.5	43	—	—	—
Zinc	632	380	297	472	120	820	OMOE
total organic carbon mg/kg	144,948	172,200	117,043	177,905			
# of COPCs per location	9	9	7	8			
# exceeding low benchmarks	7	7	5	6			
# exceeding high benchmarks	2	2	2	2			

NOTES:

OMOE = Ontario Ministry of the Environment sediment guidelines; source document is Jaagmagi et al. (1995).

NOAA = National Oceanic and Atmospheric Administration; source document is Long et al. (1995)

ARCS = Assessment and Remediation of Contaminated Sediments Program; source document is Jones et al. (1997 Revision)

BCMOEL = British Columbia Ministry of Environment Lands and Parks (1994)

USEPA (1997) = Guidelines for the Pollutional Classification of Harbor Sediments.

--- = Not Available

▨	Indicates that the chemical exceeds the low benchmark at this station
■	Indicates that the chemical exceeds the hight benchmark at this station

Tab.

Screening - Level Risk Assessment of Sediments from Grove Pond
Fort Devens Site, Ayer, Massachusetts

Analyte	Maximum concentration	Location of maximum concentration	Average concentration	# of locations exceeding low benchmark	# of locations exceeding high benchmark	Sediment Benchmark (LOW)	Sediment Benchmark (HIGH)	Source	Retained as COPC?	Reason
Inorganics mg/Kg d.w.										
Aluminum	21,000	GSEM-4	12,850	—	0/4	—	58030	ARCS	No	Concentrations below only benchmark
Antimony	U	—	2.5	0/4	0/4	2	25	NOAA	No	Analyte not detected
Arsenic	U	—	45	0/4	0/4	6	33	OMOE	No	Analyte not detected
Barium	170	GSEM-3	112.1	4/4	—	20	—	EPA 1977	Yes	Average/maximum concentration exceeds low benchmark
Beryllium	3.1	GSEM-4	1.56	—	—	—	—	—	No	No available benchmark
Cadmium	88.7	GSEM-1	32.83	4/4	3/4	0.6	10	OMOE	Yes	Average/maximum concentration exceeds high benchmark
Calcium	215,000	GSEM-3	57,925	—	—	—	—	NA	No	Micronutrient, no available benchmark
Chromium	33,400	GSEM-3	9,326.7	4/4	3/4	26	110	OMOE	Yes	Average/maximum concentration exceeds high benchmark
Cobalt	42.5	GSEM-4	27.2	0/4	—	50	—	OMOE	No	Concentrations below low benchmark
Copper	88	GSEM-3	62.05	4/4	0/4	16	110	OMOE	Yes	Average/maximum concentrations exceeds low benchmark
Iron	22,000	GSEM-1	17,925	3/4	0/4	20000	40000	OMOE	Yes	Maximum concentration exceeds low benchmark
Lead	386	GSEM-3	273.5	4/4	2/4	31	250	OMOE	Yes	Average/maximum concentrations exceed high benchmark
Magnesium	3,880	GSEM-1	2,300	—	—	—	—	NA	No	Micronutrient, no available benchmark
Manganese	1,080	GSEM-3	774	3/4	0/4	460	1100	OMOE	Yes	Average/maximum concentrations exceed low benchmark
Nickel	63.1	GSEM-4	45.3	3/4	0/4	16	75	OMOE	Yes	Average/maximum concentrations exceed low benchmark
Potassium	1720	GSEM-1	908	—	—	—	—	NA	No	Micronutrient, no available benchmark
Selenium	U	—	5.13	0/4	—	5	—	---	No	Analyte not detected
Silver	U	---	1.0	0/4	0/4	1	3.7	NOAA	No	Analyte not detected
Sodium	753	GSEM-3	504.5	—	—	—	—	NA	No	Micronutrient, no avilable benchmark
Thallium	U	—	10.26	—	—	—	—	—	No	Analyte not detected
Vanadium	53.5	GSEM-3	43.38	—	—	—	—	—	No	No available benchmark
Zinc	632	GSEM-1	445.3	4/4	0/4	120	820	OMOE	Yes	Average/maximum concentrations exceed low benchmark

NOTES:

OMOE = Ontario Ministry of the Environment sediment guidelines; source document is Jaagmagi et al. (1995).

NOAA = National Oceanic and Atmospheric Administration; source document is Long et al. (1995)

ARCS = Assessment and Remediation of Contaminated Sediments Program; source document is Jones et al (1997 Revision)

BCMOEL = British Columbia Ministry of Environment Lands and Parks (1994)

USEPA (1977) = Guidelines for the Pollutional Classification of Harbor Sediments.

--- = Not Available/Not Applicable

▨ = identifies a contaminant as a COPC

APPENDIX D.

SUPPLEMENTAL DATA

TABLE D-1
Historical Arsenic Data From the Town of Ayer Grove Pond Wells
Grove Pond Arsenic Investigation
Fort Devens

Well ID	Date	Filtered	Result (mg/L)	Source of Data
PW1&2	6/16/92	no	0.029	a.
PW1&2	6/16/92	yes	0.033	a.
PW1	10/5/92	unknown	0.026	b.
PW2	10/5/92	unknown	0.016	b.
PW1	6/9/93	no	0.0177	c.
PW1	6/9/93	yes	0.0207	c.
PW2	6/9/93	no	0.0206	c.
PW2	6/9/93	no	0.0185	c.
PW2	6/9/93	yes	0.0208	c.
PW2	6/9/93	yes	0.0215	c.
PW1	6/20/97	unknown	0.01	d.
PW2	6/20/97	unknown	0.02	d.
PW1	6/27/97	unknown	0.03	d.
PW2	6/27/97	unknown	0.02	d.
PW1	8/19/98	no	0.011	e.
PW2	8/19/98	no	0.013	e.
PW1	10/15/98	no	0.035	e.
PW2	10/15/98	no	0.033	e.

a. Memo from J.A. Desmond, DEP Water Supply Div., to Mr. W. Redfield,
Ayer Water Division, Public Works Dept., 8/5/92
b. From '92 CDM report on pump test results (As data in a.)
c. Memo from M. Rosenberg (CDM Federal Programs Corp.) to Jim Byrne, 8/18/93
d. Memo dated 10/28/97 from Tata & Howard, Inc. to Mr. James Kreidler, Jr.,
Town of Ayer (MADEP Water Supply Inorganics Report)
e. MADEP /Div. of Water Supply Inorganics Report (samples coll. by R. Linde)

TABLE D-2
Town of Ayer Arsenic Data
Grove Pond Arsenic Investigation
Fort Devens

Well ID	Date	Raw Sample	Treated Sample	MDL
PW1&2	7/29/98	0.019	ND	0.005
PW1&2	7/30/98	0.021	ND	0.005
PW1&2	7/31/98	0.026	ND	0.005
PW1&2	8/4/98	0.022	ND	0.005
PW1&2	8/5/98	0.022	ND	0.005
PW1&2	8/6/98	0.07	ND	0.005
PW1&2	8/7/98	0.04	ND	0.005
PW1&2	8/12/98	0.011	ND	0.005
PW1&2	8/19/98	0.021	ND	0.005
PW1	8/19/98	0.011	NA	0.005
PW2	8/19/98	0.013	NA	0.005
PW1&2	8/25/98	0.019	ND	0.005
PW1&2	8/31/98	0.014*	ND	0.005
PW1&2	9/11/98	0.013	ND	0.005
PW1&2	10/9/98	0.015	ND	0.005
PW1	10/15/98	0.035	NA	0.005
PW2	10/15/98	0.033	NA	0.005
PW1&2	11/18/98	NA	<.004	0.005
PW1&2	1/13/99	0.012	NA	0.005

Note: ND = not detected
NA = not analyzed
MDL = maximum detection limit
All samples reported in mg/L
* Laboratory data sheet reads 0.14 - assumed reporting error

TABLE D-3
Groundwater Analysis From Unnamed Commercial Well
Grove Pond Arsenic Investigation
Fort Devens

	Sample # 0415	Duplicate Sample	MDL	EPA Method
Aluminum	<0.02	<0.02	0.02	200.7
Antimony	<0.003	<0.003	0.003	200.9
Arsenic	0.021	0.018	0.004	200.9
Barium	0.007	0.007	0.001	200.7
Beryllium	<0.001	<0.001	0.001	200.7
Cadmium	<0.001	<0.001	0.001	200.9
Chromium	<0.009	<0.009	0.009	200.7
Copper	<0.003	<0.003	0.003	200.7
Iron	<0.01	<0.01	0.01	200.7
Lead	<0.001	<0.001	0.001	200.9
Manganese	0.158	0.159	0.001	200.7
Mercury	<0.0002	<0.0002	0.0002	245.1
Nickel	<0.03	<0.03	0.03	200.7
Selenium	<0.005	<0.005	0.005	200.9
Silver	<0.004	<0.004	0.004	200.7
Sodium	12	11.9	0.1	200.7
Thallium	<0.001	<0.001	0.001	200.9
Zinc	<0.003	<0.003	0.003	200.7

Note: All samples reported in mg/L
MDL = Minimum Detection Limit

TABLE D-4

Calculated Groundwater Background Values
Grove Pond Arsenic Investigation
Fort Devens

	EPA MCL (ug/L)	MASS MMCL (ug/L)	REGIII (ug/L)	MCP GW-1 (ug/L)	Background Values (ug/L)
Aluminum	50 - 200**	50 - 200**		110000	6870
Antimony	6		15	6	3.03
Arsenic	50	50	11	50	10.5
Barium	2000	2000	2600		39.6
Beryllium	4		0.019	4	5
Cadmium	5	5	18	5	4.01
Calcium					14700
Chromium	100	100		100	14.7
Cobalt					25
Copper	1300*	1300*	1400		8.09
Copper	1000**	1000**			
Iron	300**	300**			9100
Lead	15*	15*	0.0037	15	4.25
Magnesium					3480
Manganese	50**	50**	180		291
Mercury	2	2	11	2	0.243
Nickel	100		730	100	34.3
Potassium					2370
Selenium	50	50	180	50	3.02
Silver	100**	100**	180	40	4.6
Sodium					10800
Thallium	2			2	6.99
Vanadium			260		11
Zinc	5000**	5000**	11000	2000	21.1

Note: Background values for Devens soil and groundwater are taken from the Dec. 1993 RI, App.I, Vol. IV. All other information is from Table 3-4, 1993 Site Investigation Risk-Based Guidelines and Criteria, FT. Devens Main Post.

*Action Level

**Secondary MCL

APPENDIX E.

BEDROCK CORE ANALYSIS REPORT

(U. S. Geological Survey)

Photocopy this form for future orders or for orders of more than 25 samples.

	SAMPLE ID Please print carefully and double-check.		STANDARD					POLISHED				DBL POLISHED				OPTIONS						Special Instructions / Advice / Warnings / Sympathy / etc. (Attach separate sheet if necessary.)
			Std Thin Section	2X3 Thin Section	Grain Thin Section	Ultrathin Section	No Coverslip	Polished TS	Polished TS 1" Disc	2X3 Polished TS	Polished Blank	Doubly-Polished TS	DP TS 1" Disc	TEM Thin Section	Fluid Inclusion TS	Oriented	Blue Epoxy	K-Spar Stain	Plagioclase Stain	Calcite Stain	Fe-Carbonate Stain	
	1	11 (GF1 C-1										X										Cut perpendicular to
	2	1.17'–1.67')																				fracture w/ yellow mineral
	3																					on it. Section should end at fracture
2	4	12 "										X										Transverse section
	5																					~~away from edge of core~~
	6																					
3	7	13 (GF1 C-2										X										Cut to get largest surface
	8	3.67')																				area in section
	9																					
4	10	14 (GF2 C-2										X										Perpendicular to fracture
	11	4.83' - 5')																				to get red yellow minerals
	12																					at one edge.
5	13	15 "										X										Transverse section.
	14																					
	15																					
	16																					
	17																					
	18																					
	19																					
	20																					
	21																					
	22																					
	23																					
	24																					
	25																					

Thin sections

Sample #	Section		Remarks
9	GF1 C-2	4'-4½"	from crumbly end of core
10	GF2 C-2	32"-34"	competent rock.
11	GF1 C-1	14"-20" 1.17-1.67	thin section perpendicular to fracture with yellow mineral on both sides -- use remaining facing side to check with SEM probe?
12	"	"	Slice thru middle of core - get white veins.
13	GF1 C2	44" 3.67'	from crumbly end of core, Seems to be more black, more carbon.
14	GF-2 C2	58"-60"	⊥ to fracture w/ red mineral and a little yellow mineral. But in general this core has much less of the yellow mineral to me
15	"	"	Slice through middle of core -- get white veins.

Chain-of-Custody Record

Attachme

Study No.	Study Name Grove Pond rock cores	Contr
Samplers: (Signatures)		page___ of___

Sample Identification	Date	Time	Type *	Remarks and Observations
1. GF2 C-1 0.66-0.92'	12/17/99			State: Massachusetts Well #: GF2 Cty: Middlesex Lat. 42° 33' 5.0 Long 71° 34' 55.3
2. GF2 C-1 3.25-3.42'	"			Massachusetts Well # GF2 Cty Middlesex Lat: 42° 33' 5.0 Long: 71° 34' 55.
(*) [illegible] by Rob 3 GF2 C-2 1.58-1.83'	"			State: Massachusetts Well # GF2 Cty: Middlesex Lat. 42° 33' 5.0 Long. 71° 34' 55.3
4 GF2 C-2 4.50-4.67'	"			State: Massachusetts Well # GF2 Cty: Middlesex Lat 42° 33' 5.0 Long 71° 34' 55.3
5 GF1 C-1 0.92-1.08'	"			State: Massachusetts Well # GF1 Cty: Middlesex Lat. 42° 33' 4.8 Long 71° 34' 53.7
6 GF1 C-1 4.58-4.75'	"			State: Massachusetts Well # GF1 Cty: Middlesex Lat. 42° 33' 4.88 Long. 71° 34' 53.78
(*) [illegible] by Rob 7 GF1 C-2 1.00-1.67'	"			State: Massachusetts Well # GF1 Cty: Middlesex Lat 42° 33' 4.88' Long. 71° 34' 53.78
8 GF1 C-2 4.83-5.00'	"			State: MA Cty: Middlesex Lat: 42° 33' 4.88" Long. 71° 34' 53.78'

Relinquished by: (Signature) John O. Coleman	Date/Time 12/17/99	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks	

* W=water, S=sediment, P=plant, F=fish, B=benthos, O=other, define in remarks

12/17/99

Sample#	Section		Remarks
1 ~~2~~	GF2 C-1	8"-11" 0.66-0.92	broken from solid core both ends micaceous sheen; white viens; gr-blk
2	GF2 C-1	3'3"-3'5" 3.25-3.42	again new surfaces at each end, but from more weathered section of core Couple of breaks may have been along exising fractures that were a little weathered
3	GF-2 C-2	1'7"-1'10" 1.58-1.833	like 1
4	GF-2 C-2	4'6"-4'8" 4.50-4.67	from new section. ~~Break~~ Must be location of well screen?? On break w/ orange to yellow mineral stain
5	GF-1 C-1	11"-1'1" 0.92-1.08	From long section not broken rock 4 feet long. Broke along fracture where a brn red mineral was present and a second surface yellow mineral was present. Also pyrite.
6	GF-1 C-1	4'7"-4'9" 4.58-4.75	Breaks had sulfur yellow mineral and micaceous sheen
7	GF-1 C-2	1'-1'2" 1.00-1.67	Yellow min + brn red
8	GF-1 C-2	4'10"-5' 4.83-5.00	from higher weather, broken zone at well screen.
16	GF-1 C-1	51-54	Yellow on fracture surface. Other end fresh break surface looks like conglomerate w/ mafic/non mafic.

Preliminary characterization of Ayers, MA drill core

Introduction

Four samples of drill core from Ayers, MA were examined to identify the mineralogy of thin coatings on fractured surfaces of selected samples as part of a broader study to determine sources of elevated arsenic concentrations in ground water. This study was of a reconnaissance nature, and further work should be performed when geochemical data on the rocks are available. The rocks probably represent an inlier of Harvard conglomerate (R. Robinson, oral communication, 2000). Samples were examined under a binocular microscope, and different colored coatings were sampled for x-ray powder diffraction and scanning electron microscopy. No thin sections were examined for this study.

Methods

X-ray powder diffraction (XRD)

Coatings were scraped off fractured core surfaces with a spatula, or hand-picked from the surface using tweezers and a dissecting needle while viewing the sample under a binocular microscope. The coatings were lightly ground by hand in an agate mortar and pestle and mounted on 1" round zero-background quartz plates with toluene as a binder to make smear mounts. The mounts were run on a Scintag X1 automated x-ray powder diffractometer equipped with a Peltier detector using CuKa radiation operated at 45 kV and 40 Ma. Step scans were run over the range 3 to 80 degrees 2-theta using a stepping interval of 0.02 degrees 2-theta. Patterns were interpreted with the aid of Scintag and MDI Applications JADE search/match software and compared with reference patterns in the JCPDS database (International Centre for Diffraction Data, 1997). Minerals present in low concentration (less than 5 to 10%) may not be identified in mixtures, especially if well-crystallized minerals such as quartz tend to dominate the pattern. Note that the JCPDS reference patterns shown as best-fit matches for the unknowns are indicative of particular mineral groups, with mineral formulas shown for reference only, and are not intended to represent the exact identity or compoition of the unknowns.

Scanning electron microscopy(SEM)

A JEOL JSM-840 SEM was used for detailed examination of minerals to determine crystal shape, size, and texture, and to obtain qualitative information on composition using a PGT x-ray energy dispersive system (EDS). The SEM used in this study is also equipped with a back-scattered electron (BSE) detector and a secondary electron (SEI) detector. The SEM was operated at a voltage of 15 kV, and a specimen current of about 1 to 2 nA. A working distance of 39 mm was used to optimize EDS analysis. Hand-picked samples were attached to carbon planchets with superglue or sticky carbon tape and graphite paint and were coated with carbon. The spectra obtained with EDS provide qualitative for elements heavier than carbon. Elements present in concentrations below several hundred parts per million or more are not detected. Element mapping by electron microprobe on polished sections and quantitative point analysis of individual mineral grains are recommended to determine the distribution of arsenic, if any, should further studies be warranted. These techniques have been used successfully in documenting low-level As distributions in other studies, although care must be taken in analyzing for arsenic because of interferences between Mg (K- line) and As (L-line).

Sample descriptions and results

GF1 C-1 0.92'-1.08' (Sample No. 5, 12/17/99) Attachment 1

Waxy, yellow material was hand-picked from a very thin coating on split core. Insufficient quantities of material were obtained for a good quality smear mount and some of the black substrate core material remained attached to the yellow coating. A smear mount was prepared on a quartz plate (XRD pattern GF1-C1-d) and a few grains of the material were mounted on a carbon planchet for SEM study. The XRD pattern is consistent with chlorite (diagnostic 14 and 7 angstrom lines are present) and quartz. SEM confirms the presence of quartz (Si) and muscovite-type mica (10 angstrom peak on XRD, K-Al-Si on EDS spectrum). Note that the crystals coating material is very fine-grained (<10 micron crystals).

GF1 C-1 4.25' – 4.5' (Sample No. 16) Attachment 2

Thin waxy, yellow coating was hand-picked from split core fracture surface with a needle and grains were placed in a ceramic spot plate and lightly ground with a glass rod to make a powder for XRD. This material appears to be the same as the yellow coating on sample no. 5. The XRD pattern for this sample is GF1-C1-e.

The XRD pattern is consistent with a montmorillonite-type clay mineral, and the yellow-green color is consistent with the iron montmorillonite variety, nontronite. Nontronite is a smectite clay of variable composition, nominally $Na_{0.3}Fe^{3+}_2(Si,Al)_4O_{10}(OH)_2.nH_2O$. Calcium can be present instead of, or in addition to sodium. Si:Al ratios are variable from spot to spot, but all 5 points for which spectra were collected contained Si >Al>Fe>Ca; one of the 5 points showed minor Mg. No As was detected.

GF1 C-1 4.58' - 4.75' (Sample No. 6, 12/17/99) Attachment 3

This sample contains two types of fracture coatings. One coating is waxy, yellow to yellow-green and appears to be the sample material as observed in samples 5 and 16. The other material is a rusty, orange coating that looks like goethite or another iron oxyhydroxide mineral phase. Separate XRD and SEM mounts were prepared for the yellow (XRD pattern GF1-C1-c) and orange (GF1-C1-b) coatings.

Orange coating: XRD pattern is dominated by quartz and feldpsar, with subordinate peaks of goethite. The goethite probably forms a thin coating on the silicate grains giving the overall orange appearance of the coated surface. SEM data confirm the presence of quartz (Si is the only element on the EDS spectra), as well as Fe- and Mn-rich phases. The Mn-rich, Si-poor spectrum and the XRD pattern are consistent with the manganese carbonate mineral rhodochrosite. No EDS peaks are observed in the energy range where As would appear, although As could be present at concentrations of as much as several hundred ppm. X-ray mapping for K, Fe, Si, and As over an Fe-rich area did not indicate any concentration of As (note position in spectrum where As would occur on spectrum GF1_C1_1002). One of the Fe-rich areas was mapped to show the distribution on Fe, Si, O, K, and As and no As was detected.

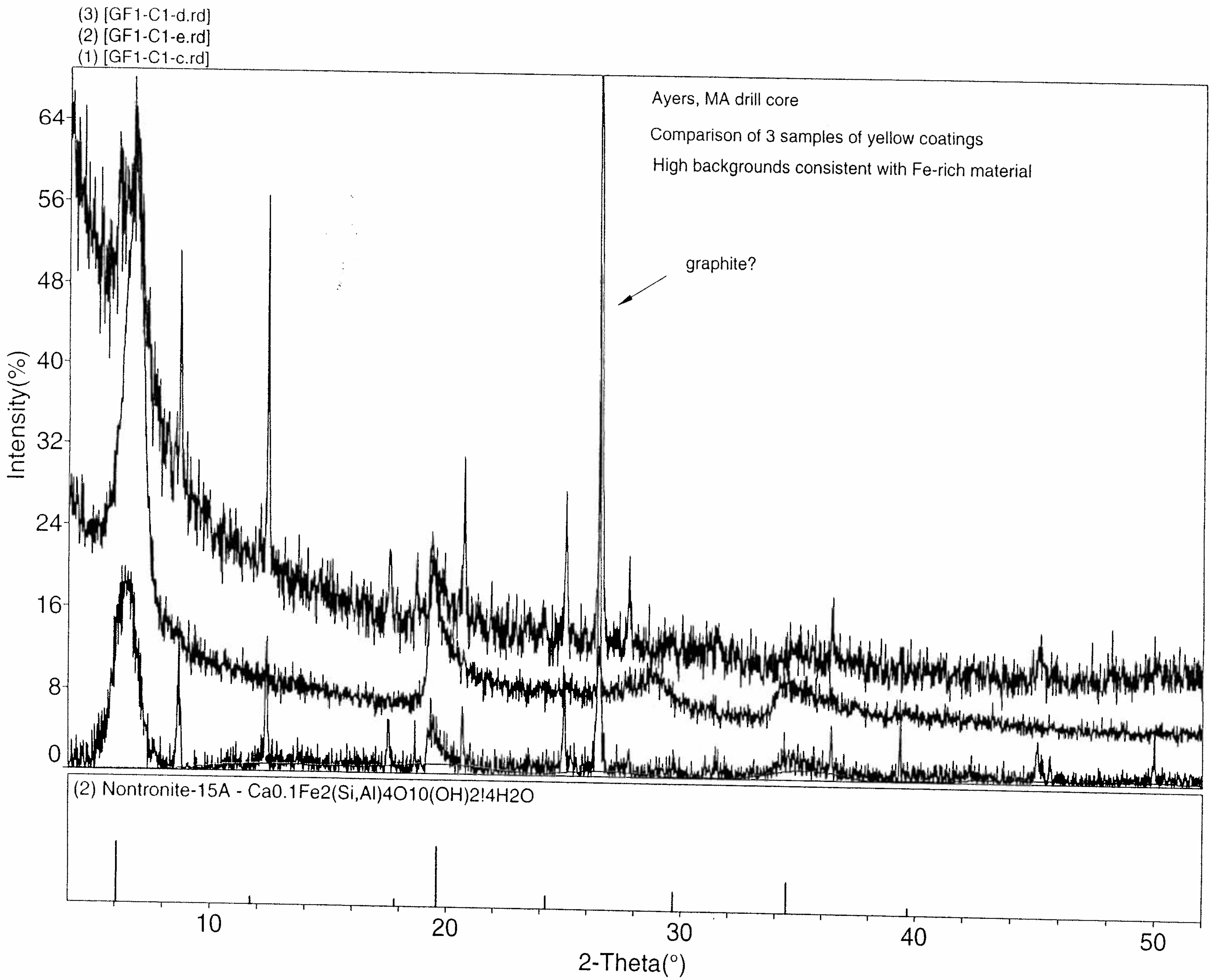
Yellow coating: XRD indicates a mixture of nontronite(?) clay, chlorite, mica, and quartz. SEM spectra are consistent with Si>Al>Fe>Ca>Mg+/- Ti. One of two areas mapped qualitatively suggests that there may be a local concentration of As (could be an artifact – need to confirm).

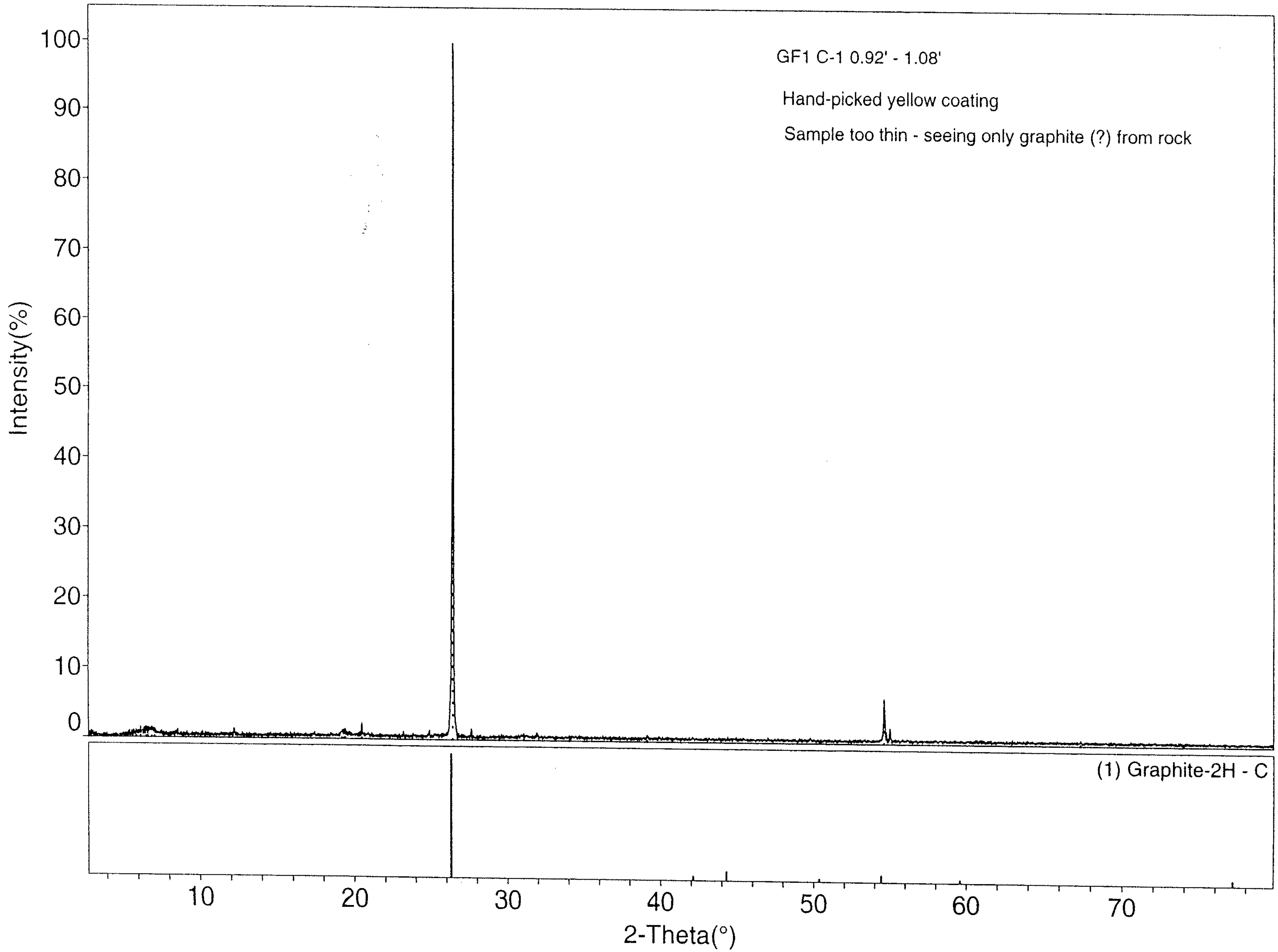
GF1 C-2 4.83' - 5.00' (Sample 8, 12/17/99) Attachment 4

Powdery, white coating on very sooty black drill core. XRD pattern (GF1 C-2-a): quartz, mica, feldspar, chlorite.

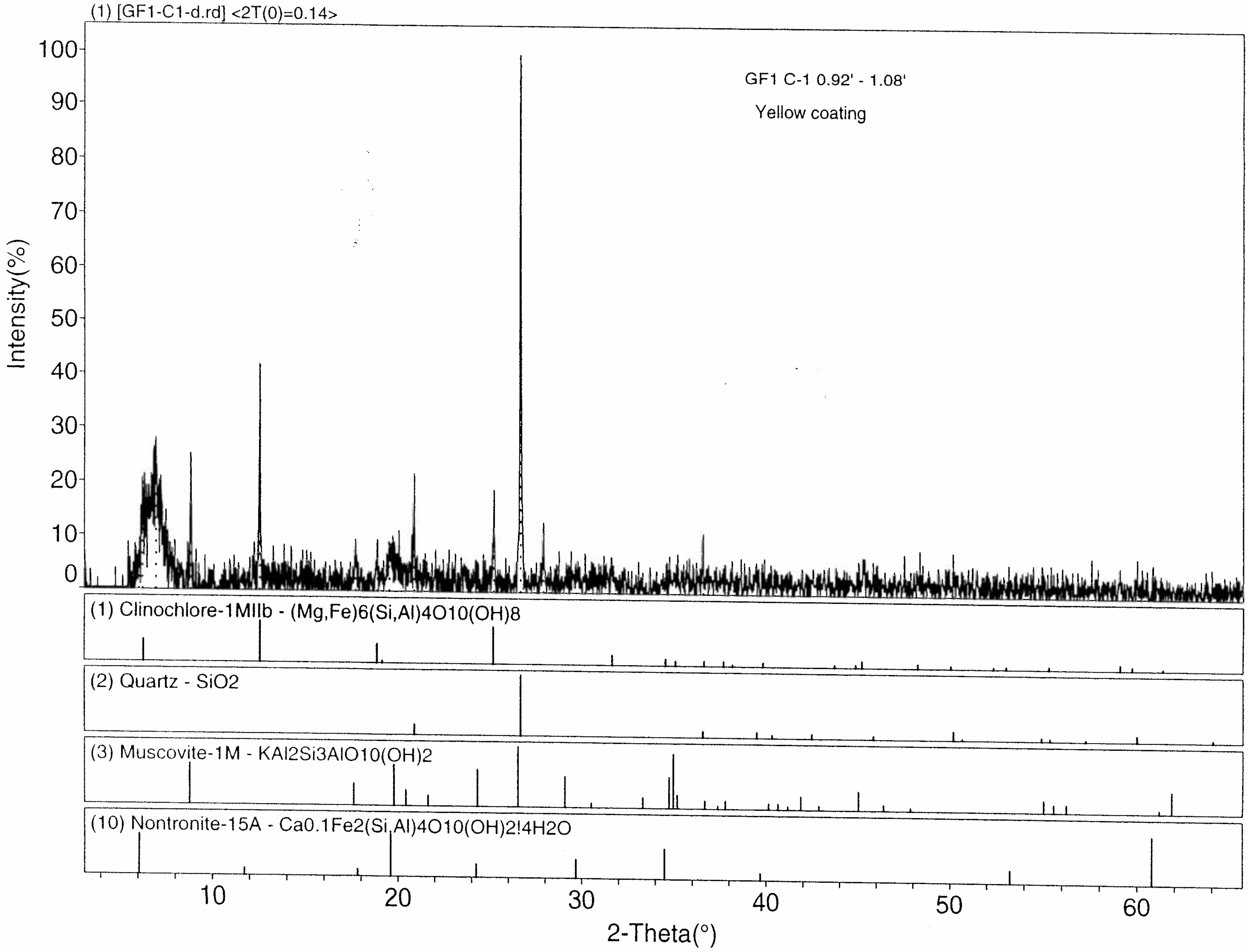
Summary and recommendations

No discrete arsenic mineral phases were identified in any of the coatings. An x-ray map of one of the areas of iron-rich yellow coating may indicate arsenic or may be an artifact due to excitation at a grain boundary. Yellow coatings appear to be iron-rich clays mixed with chlorite. Orange coatings are probably goethite. Arsenic could be present in clays or goethite at levels below the detection limits of the SEM. If whole-rock analyses indicate anomalous arsenic concentrations, further studies, preferably on polished thin sections should be pursued. Electron microprobe element mapping and point analyses of coatings and of any sulfide minerals present in the rock could confirm the distribution of arsenic, if present in these samples. A strong peak at about 26.5 degrees 2-theta in most patterns may reflect graphite in the core that remains attached to coatings or could be the strong line for quartz (some patterns clearly show the second strongest quartz peak at 20.9 degrees 2-theta; others do not; note that some micas have a strong peak in this range as well).


(3) [GF1-C1-d.rd]
(2) [GF1-C1-e.rd]
(1) [GF1-C1-c.rd]
Ayers, MA drill core
Comparison of 3 samples of yellow coatings
High backgrounds consistent with Fe-rich material
graphite?
Intensity(%)
64
56
48
40
32
24
16
8
0
(2) Nontronite-15A - Ca0.1Fe2(Si,Al)4O10(OH)2!4H2O
10
20
30
40
50
2-Theta(°)


GF1 C-1 0.92' - 1.08'
Hand-picked yellow coating
Sample too thin - seeing only graphite (?) from rock
Intensity(%)
100
90
80
70
60
50
40
30
20
10
0
(1) Graphite-2H - C
10
20
30
40
50
60
70
2-Theta(°)

Attachment 1


(1) [GF1-C1-d.rd] <2T(0)=0.14>
GF1 C-1 0.92' - 1.08'
Yellow coating
Intensity(%)
100
90
80
70
60
50
40
30
20
10
0
(1) Clinochlore-1MIIb - (Mg,Fe)6(Si,Al)4O10(OH)8
(2) Quartz - SiO2
(3) Muscovite-1M - KAl2Si3AlO10(OH)2
(10) Nontronite-15A - Ca0.1Fe2(Si,Al)4O10(OH)2!4H2O
10
20
30
40
50
60
2-Theta(°)

[GF1-C1-d.rd] GF1 C-1 0.92'-1.08' yellow **Peak ID Report**

SCAN: 3.0/80.0/0.02/1(sec), Cu, I(max)=283, 01/28/00 08:39

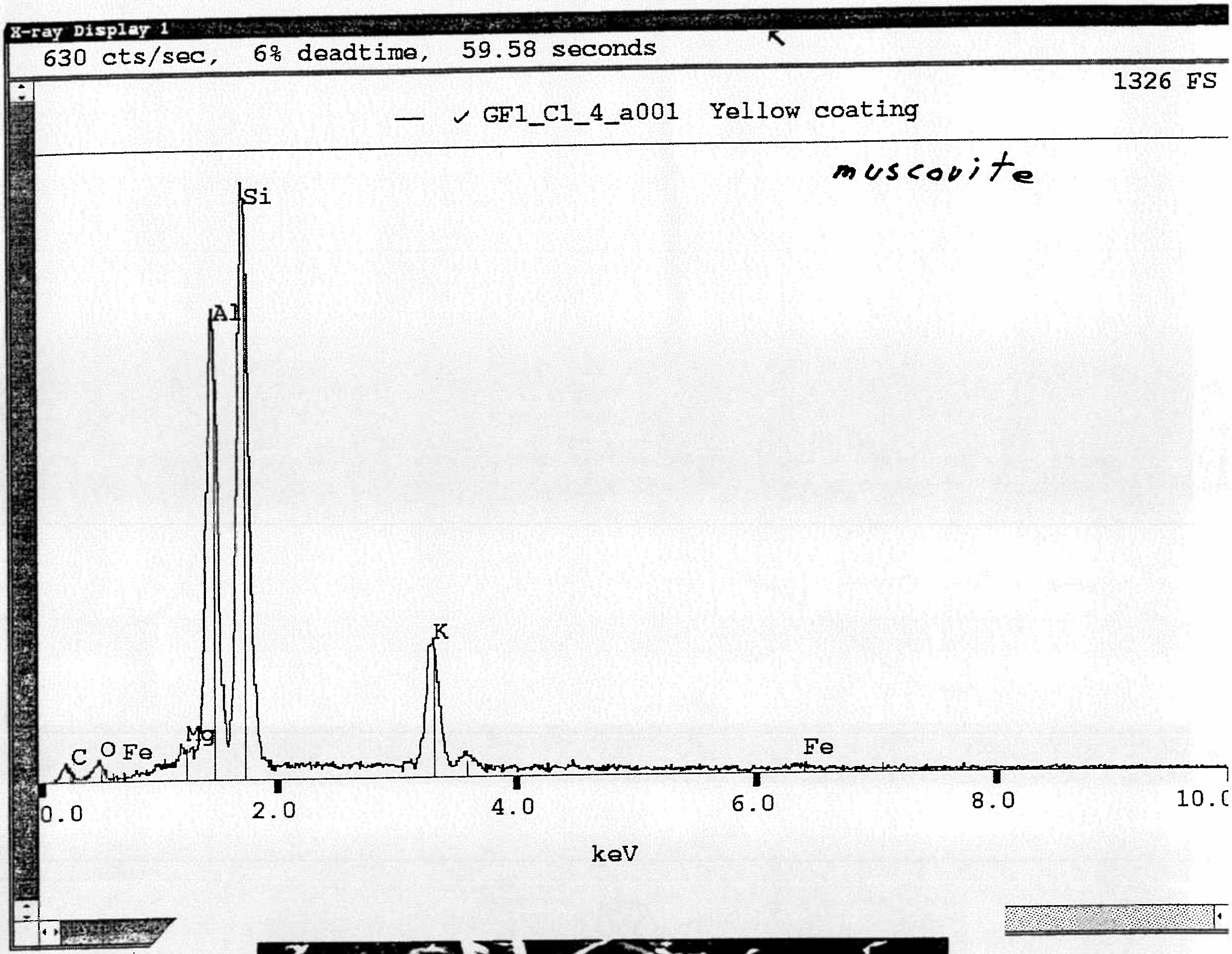
PEAK: 15-pts/Parabolic Filter, Threshold=3.0, Cutoff=0.1%, BG=3/1.0, Peak-Top=Summit

NOTE: Intensity = Counts, 2T(0)=0.14(°), Wavelength to Compute d-Spacing = 1.54056A(Cu/K-alpha1)

#	2-Theta	d(A)	Intensity	I%	Phase ID	d(A)	I%	h	k	l	2-Theta	Delta
1	6.047	14.6027	19	6.8	Nontronite-15A	14.6000	100.0	0	0	1	6.049	0.001
2	6.241	14.1501	52	18.7	Clinochlore-1...	14.1000	35.0	0	0	1	6.263	0.022
3	6.957	12.6948	69	24.8								
4	8.822	10.0154	62	22.3	Muscovite-1M	10.1000	100.0	0	0	1	8.748	-0.074
5	12.513	7.0679	112	40.3	Clinochlore-1...	7.0700	100.0	0	0	2	12.510	-0.004
6	17.682	5.0119	21	7.6	Muscovite-1M	5.0400	35.0	0	0	2	17.582	-0.099
7	18.858	4.7019	20	7.2	Clinochlore-1...	4.7100	30.0	0	0	3	18.825	-0.033
8	19.512	4.5458	18	6.5	Nontronite-15A	4.5300	100.0	1	0	0	19.580	0.069
9	20.849	4.2571	41	14.7	Quartz	4.2550	16.0	1	0	0	20.859	0.011
10	25.186	3.5330	33	11.9	Clinochlore-1...	3.5400	60.0	0	0	4	25.135	-0.050
11	26.636	3.3438	278	100.0	Quartz	3.3435	100.0	1	0	1	26.639	0.003
12	27.897	3.1955	31	11.2								
13	30.161	2.9606	12	4.3								
14	36.568	2.4552	25	9.0	Quartz	2.4569	9.0	1	1	0	36.543	-0.025
15	50.105	1.8191	16	5.8	Quartz	1.8180	13.0	1	1	2	50.138	0.033
16	68.142	1.3750	15	5.4	Quartz	1.3750	7.0	2	0	3	68.142	0.000

GF1 C-1
0.92-1.08'
yellow

GF1 C-1 0.92\'-1.08' yellow coating Photo A

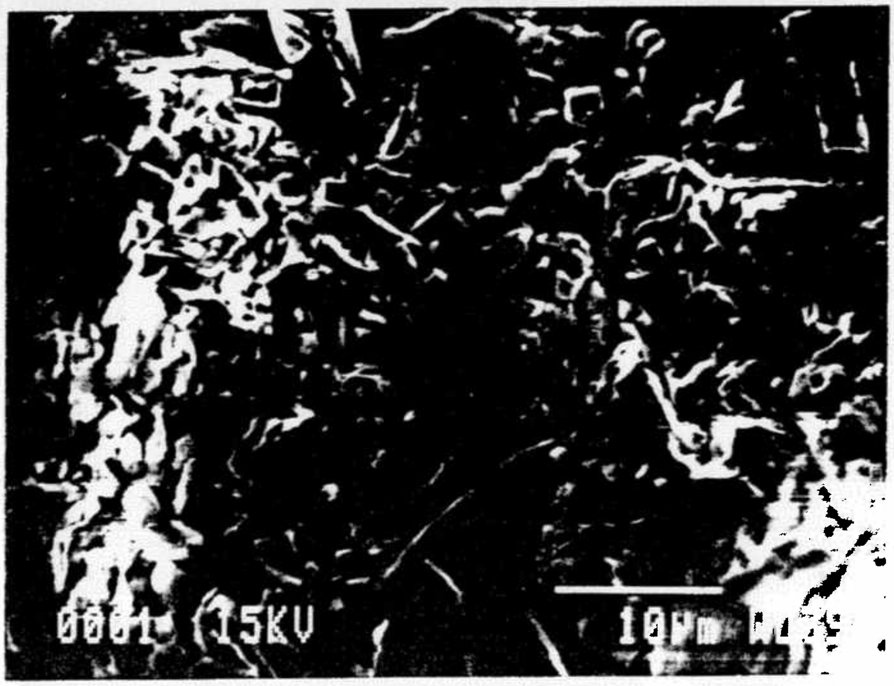

X-ray Display 1

630 cts/sec, 6% deadtime, 59.58 seconds

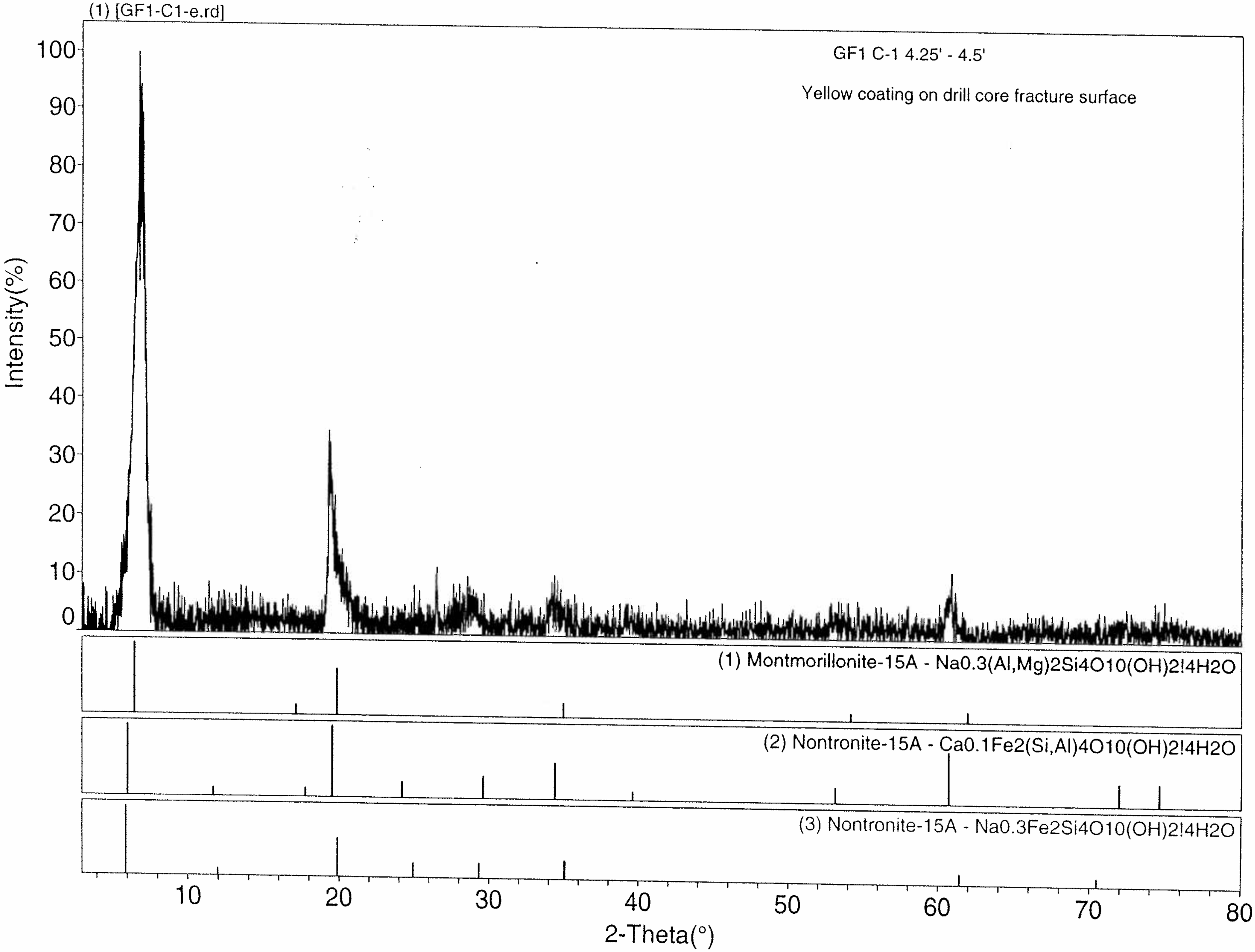
1326 FS

— ✓ GF1_C1_4_a001 Yellow coating

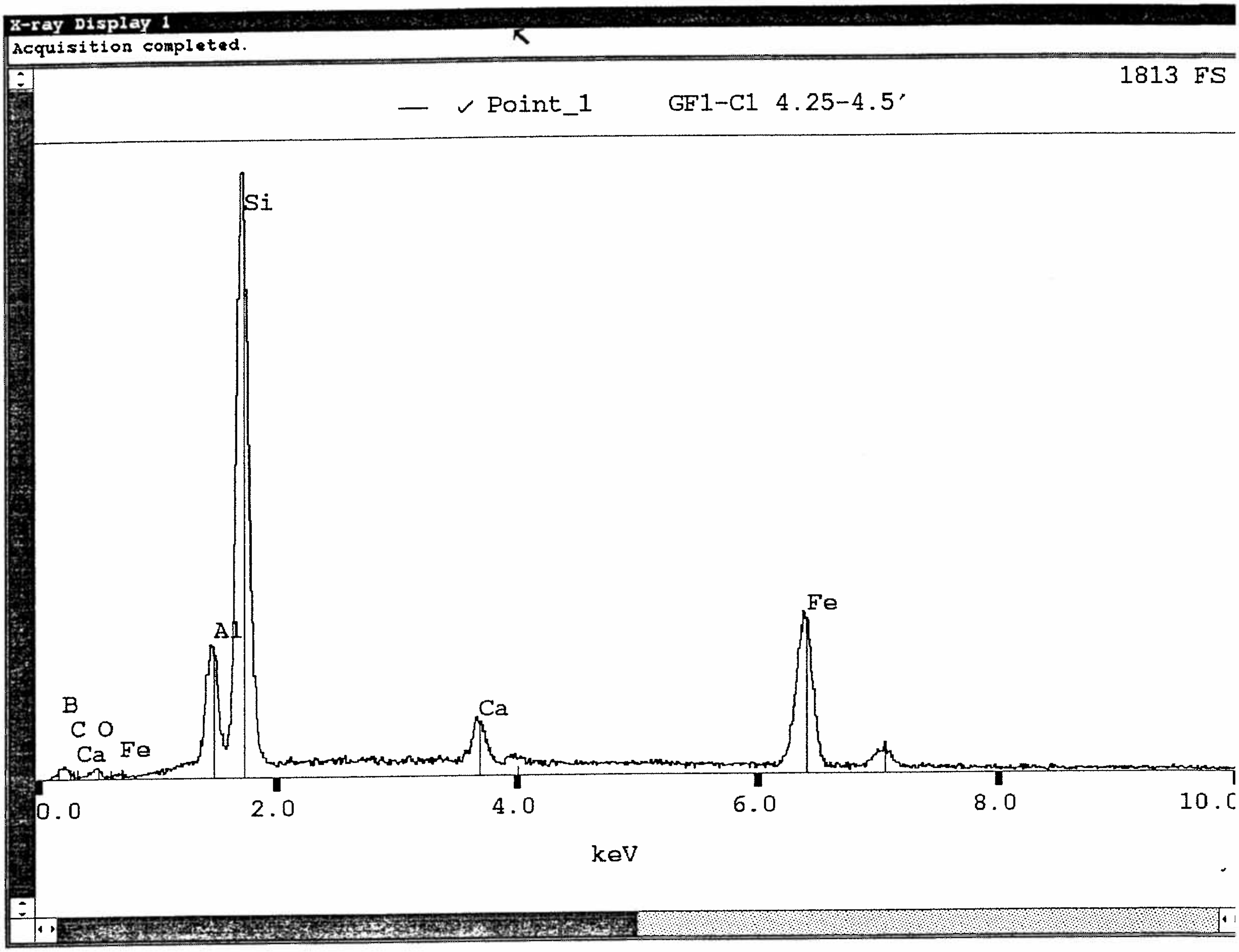
muscovite



Attachment 2


(1) [GF1-C1-e.rd]
GF1 C-1 4.25' - 4.5'
Yellow coating on drill core fracture surface
Intensity(%)
100
90
80
70
60
50
40
30
20
10
0
(1) Montmorillonite-15A - Na0.3(Al,Mg)2Si4O10(OH)2!4H2O
(2) Nontronite-15A - Ca0.1Fe2(Si,Al)4O10(OH)2!4H2O
(3) Nontronite-15A - Na0.3Fe2Si4O10(OH)2!4H2O
10
20
30
40
50
60
70
80
2-Theta(°)

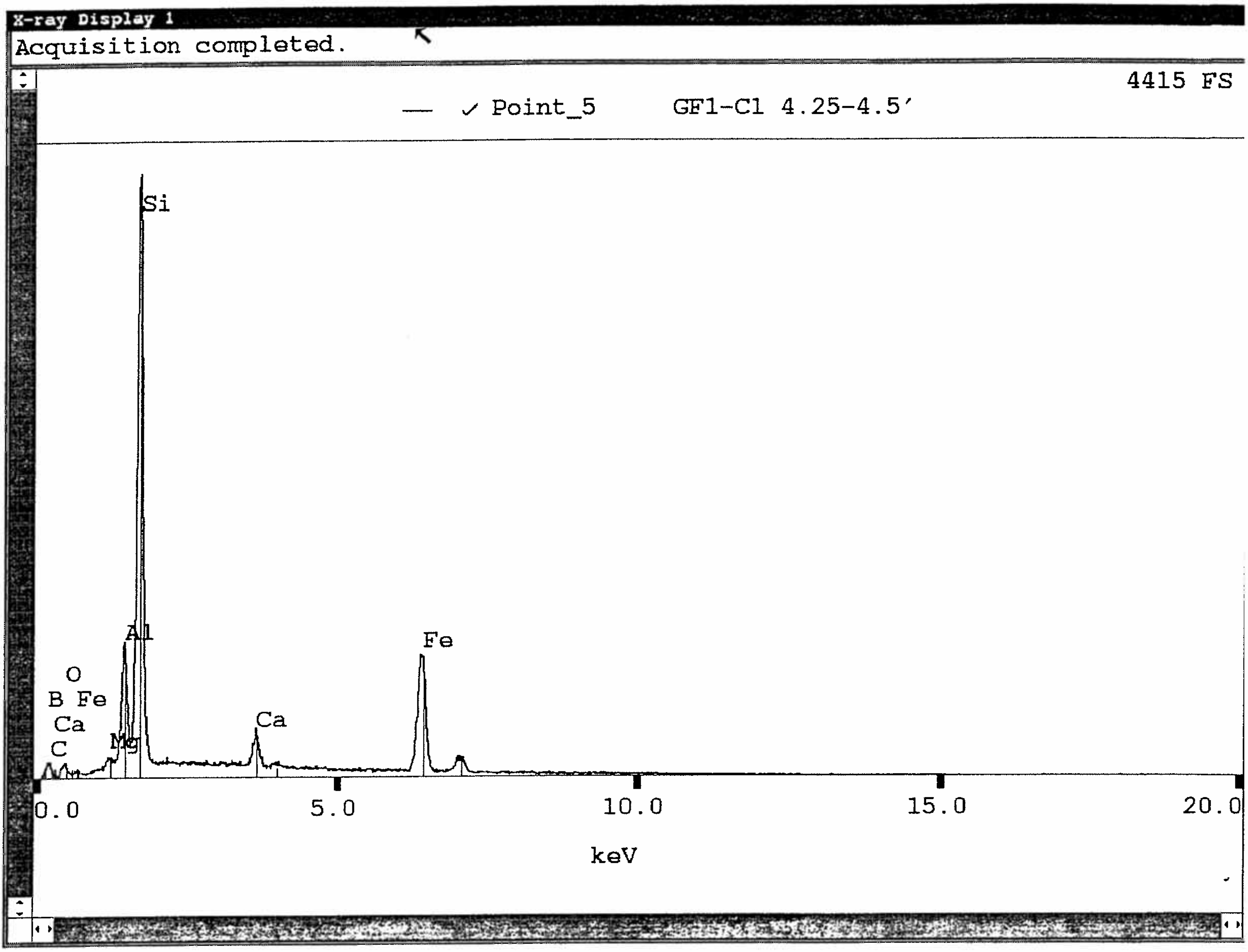
Waxy, yellow coating on Ayer, MA drill core



X-ray Display 1

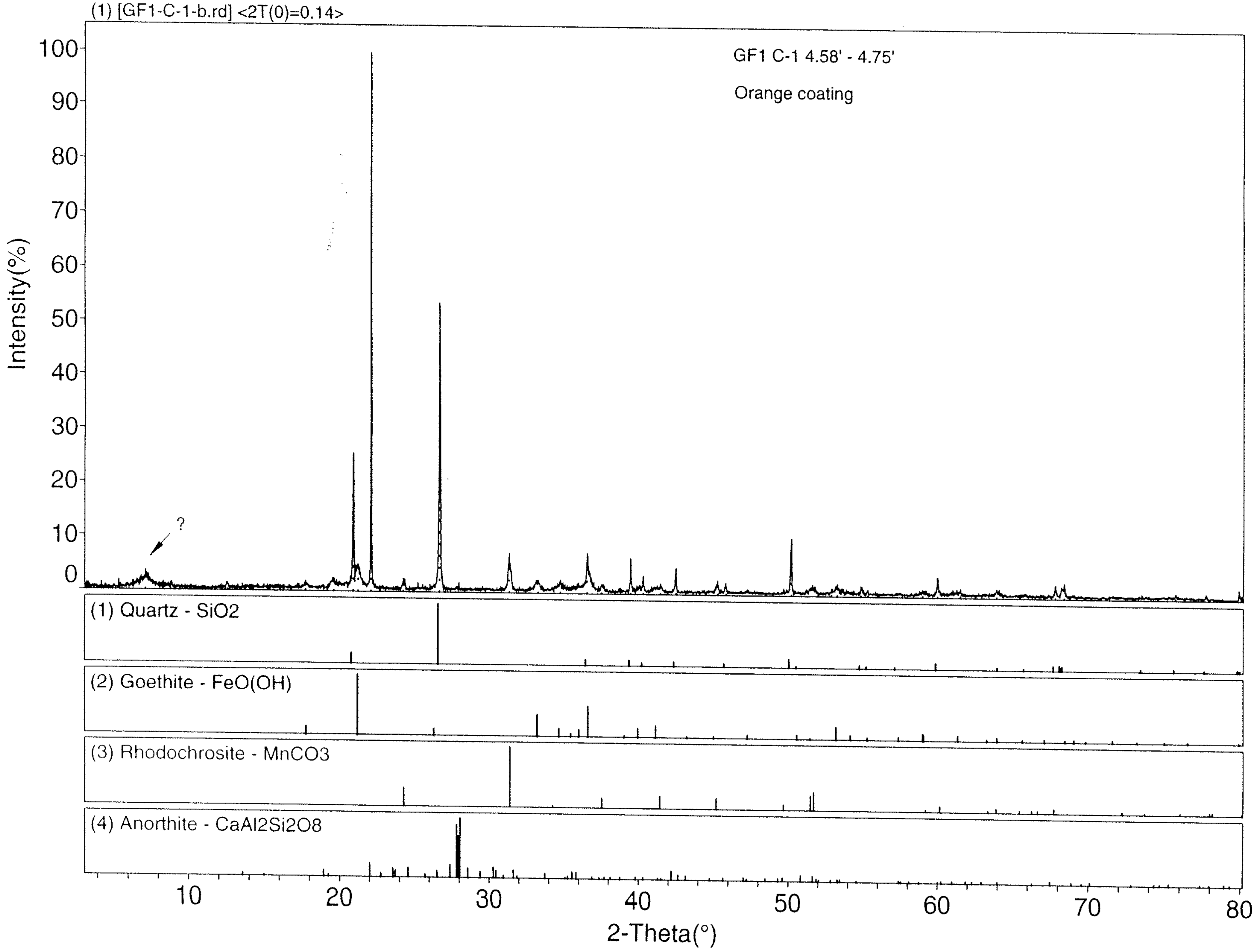
Acquisition completed.

Yellow coating on Ayer, MA drill core (nontronite)


Acquisition completed.

```
     Ca:  K line:   2648  L line:      0  M line:      0
     Fe:  K line:   9840  L line:     61  M line:      0
     Cu:  K line:     47  L line:     69  M line:      0
     Br:  K line:     20  L line:      0  M line:      0
     Fr:  K line:      0  L line:     20  M line:      0
     Pu:  K line:      0  L line:     16  M line:      0

   Normalized chi squared:    4.69

Element identification for Point_4:

   Precision: 3   Low end cutoff:  1000 eV

   Elements included: Fe
   Elements excluded: none

   Possible elements and net deconvoluted integrals:

     B :  K line:    152  L line:      0  M line:      0
     C :  K line:    169  L line:      0  M line:      0
     O :  K line:     40  L line:      0  M line:      0
     Al:  K line:   1304  L line:      0  M line:      0
     Si:  K line:   7791  L line:      0  M line:      0
     Ca:  K line:   1725  L line:      0  M line:      0
     Fe:  K line:  11297  L line:     42  M line:      0
     Nd:  K line:      0  L line:     74  M line:     27
     Rn:  K line:      0  L line:     33  M line:      0
     Ra:  K line:      0  L line:     27  M line:      0

   Normalized chi squared:    1.22

Element identification for Point_5:

   Precision: 3   Low end cutoff:  1000 eV

   Elements included: Fe
   Elements excluded: none

   Possible elements and net deconvoluted integrals:

     B :  K line:    576  L line:      0  M line:      0
     C :  K line:    670  L line:      0  M line:      0
     O :  K line:    744  L line:      0  M line:      0
     F :  K line:    102  L line:      0  M line:      0
     Al:  K line:   7194  L line:      0  M line:      0
     Si:  K line:  46562  L line:      0  M line:      0
     Ca:  K line:   2805  L line:      0  M line:      0
     Fe:  K line:  12746  L line:    118  M line:      0
     Br:  K line:     22  L line:   2772  M line:      0
     Ac:  K line:      0  L line:     43  M line:      0
     Pu:  K line:      0  L line:     28  M line:      0

   Normalized chi squared:    4.16
```

Attachment 3


(1) [GF1-C-1-b.rd] <2T(0)=0.14>
GF1 C-1 4.58' - 4.75'
Orange coating
?
Intensity(%)
100
90
80
70
60
50
40
30
20
10
0
(1) Quartz - SiO2
(2) Goethite - FeO(OH)
(3) Rhodochrosite - MnCO3
(4) Anorthite - CaAl2Si2O8
10
20
30
40
50
60
70
80
2-Theta(°)

[GF1-C-1-b.rd] GF1 C-1 4.58'-4.75' orange **Peak ID Report**

SCAN: 3.0/80.0/0.02/1(sec), Cu, I(max)=3382, 01/27/00 15:35

PEAK: 19-pts/Parabolic Filter, Threshold=3.0, Cutoff=0.1%, BG=3/1.0, Peak-Top=Summit

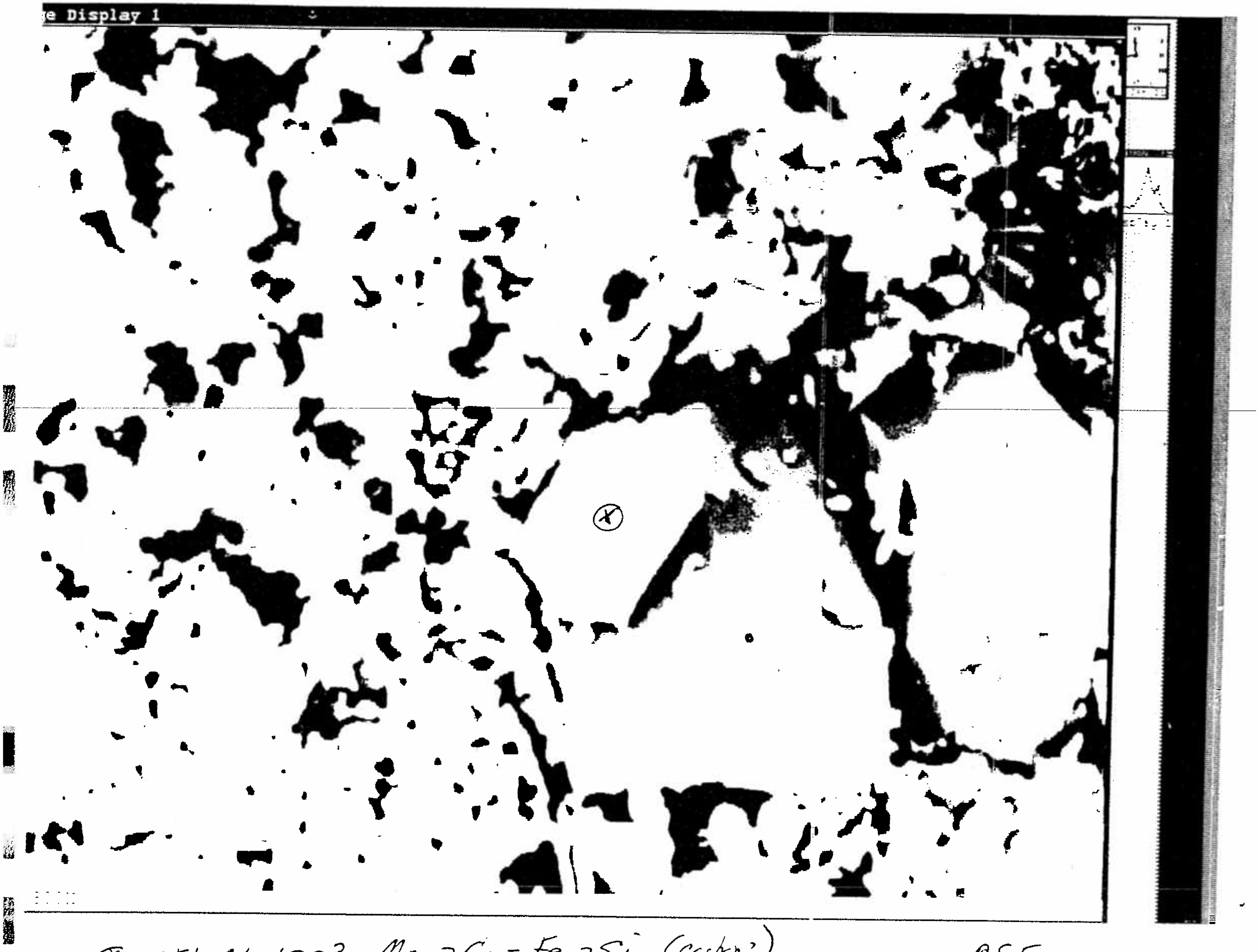
NOTE: Intensity = Counts, 2T(0)=0.14(°), Wavelength to Compute d-Spacing = 1.54056A(Cu/K-alpha1)

#	2-Theta	d(A)	Intensity	I%	Phase ID	d(A)	I%	h	k	l	2-Theta	Delta
1	7.142	12.3668	89	2.6								
2	8.790	10.0519	22	0.7								
3	12.536	7.0551	32	0.9								
4	17.710	5.0039	42	1.2	Goethite	4.9800	12.0	0	2	0	17.796	0.086
5	19.580	4.5301	61	1.8								
6	20.875	4.2519	824	24.5	Quartz	4.2550	16.0	1	0	0	20.859	-0.015
7	21.201	4.1873	129	3.8	Goethite	4.1830	100.0	1	1	0	21.223	0.022
8	22.057	4.0266	3370	100.0	Anorthite	4.0404	22.0	-2	0	2	21.981	-0.076
9	24.216	3.6723	66	2.0	Rhodochrosite	3.6670	29.0	0	1	2	24.251	0.035
10	26.641	3.3432	1800	53.4	Quartz	3.3435	100.0	1	0	1	26.639	-0.002
11	31.318	2.8538	227	6.7	Rhodochrosite	2.8500	100.0	1	0	4	31.361	0.043
12	33.263	2.6913	63	1.9	Goethite	2.6930	35.0	1	3	0	33.241	-0.022
13	34.741	2.5801	55	1.6	Goethite	2.5830	12.0	0	2	1	34.700	-0.041
14	36.543	2.4569	219	6.5	Quartz	2.4569	9.0	1	1	0	36.543	0.000
15	37.518	2.3953	34	1.0	Rhodochrosite	2.3950	15.0	1	1	0	37.522	0.004
16	39.444	2.2826	197	5.8	Quartz	2.2815	8.0	1	0	2	39.464	0.020
17	40.295	2.2363	89	2.6	Anorthite	2.2365	2.0	1	-5	2	40.291	-0.004
18	41.445	2.1769	47	1.4	Rhodochrosite	2.1780	19.0	1	1	3	41.423	-0.021
19	42.474	2.1265	146	4.3	Quartz	2.1277	6.0	2	0	0	42.449	-0.025
20	45.254	2.0021	72	2.1	Rhodochrosite	2.0050	17.0	2	0	2	45.186	-0.068
21	45.800	1.9795	58	1.7	Quartz	1.9799	4.0	2	0	1	45.792	-0.008
22	50.189	1.8162	337	10.0	Quartz	1.8180	13.0	1	1	2	50.138	-0.051
23	52.875	1.7301	25	0.7	Anorthite	1.7314	2.0	2	2	-8	52.832	-0.043
24	53.258	1.7186	53	1.6	Anorthite	1.7182	3.0	0	6	4	53.272	0.014
25	54.847	1.6725	40	1.2	Quartz	1.6717	4.0	2	0	2	54.873	0.026
26	55.311	1.6595	23	0.7	Goethite	1.6593	3.0	0	6	0	55.319	0.009
27	58.965	1.5651	27	0.8	Goethite	1.5637	10.0	1	5	1	59.023	0.059
28	59.949	1.5418	102	3.0	Quartz	1.5415	9.0	2	1	1	59.958	0.010
29	61.480	1.5070	35	1.0	Goethite	1.5091	8.0	0	0	2	61.384	-0.096
30	63.882	1.4560	33	1.0	Rhodochrosite	1.4560	5.0	2	1	4	63.881	-0.001
31	67.754	1.3819	67	2.0	Quartz	1.3821	6.0	2	1	2	67.742	-0.012
32	68.324	1.3717	81	2.4	Quartz	1.3719	5.0	3	0	1	68.316	-0.008
33	75.659	1.2559	23	0.7	Quartz	1.2559	3.0	3	0	2	75.658	-0.002

GFI C-1
4.58- 4.75'
ORANGE
15kV

1/31/00

GFI C-1 4.58-4.75'

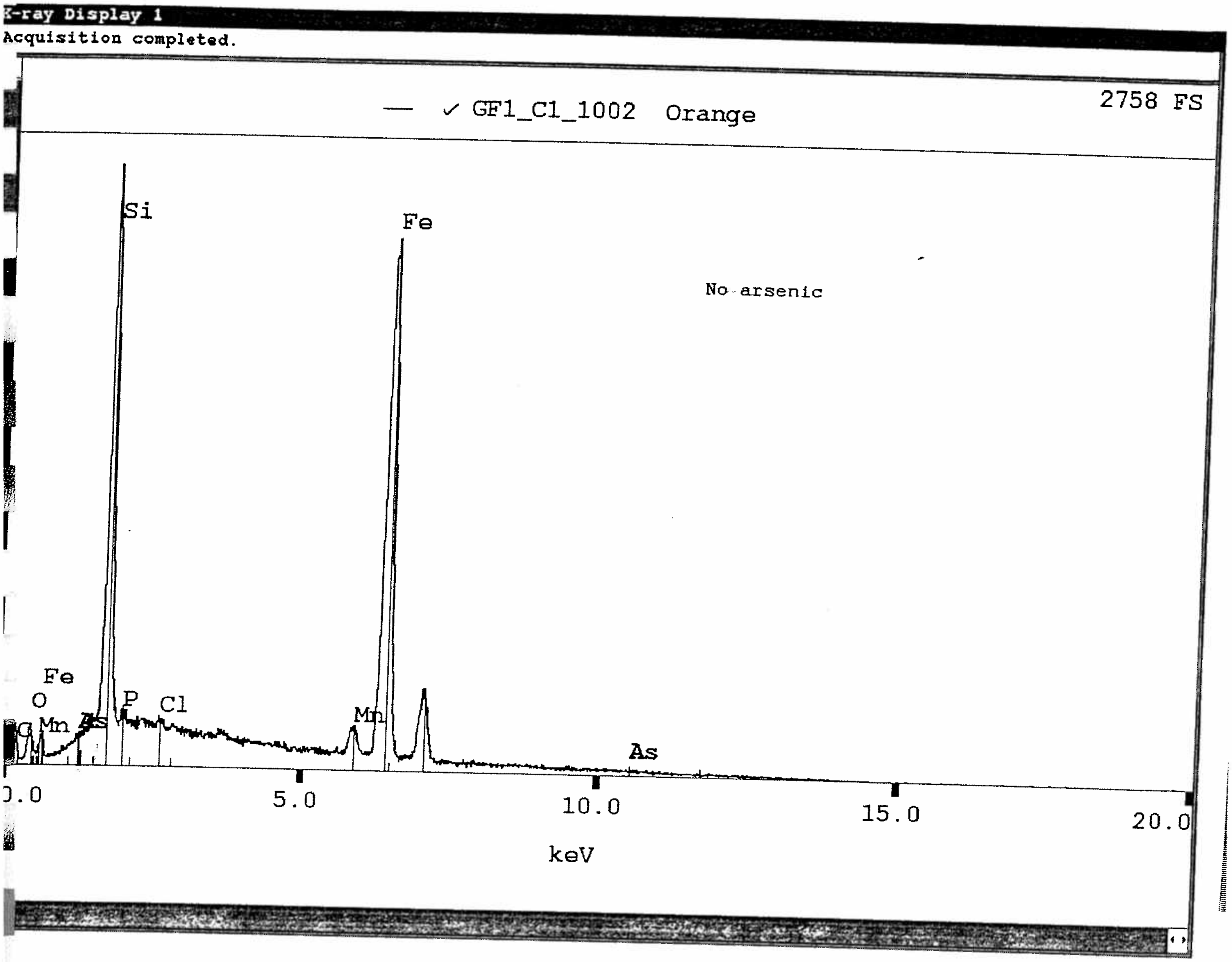


ⓧ GFI-C1-1003 Mn > Ca = Fe > Si (carbon?)

• GFI-C1-1004 Si = quartz

BSE
800X
WD= 15 for image
39 for EDS

GF1 C-1 4.58′-4.75′ orange coating on drill core



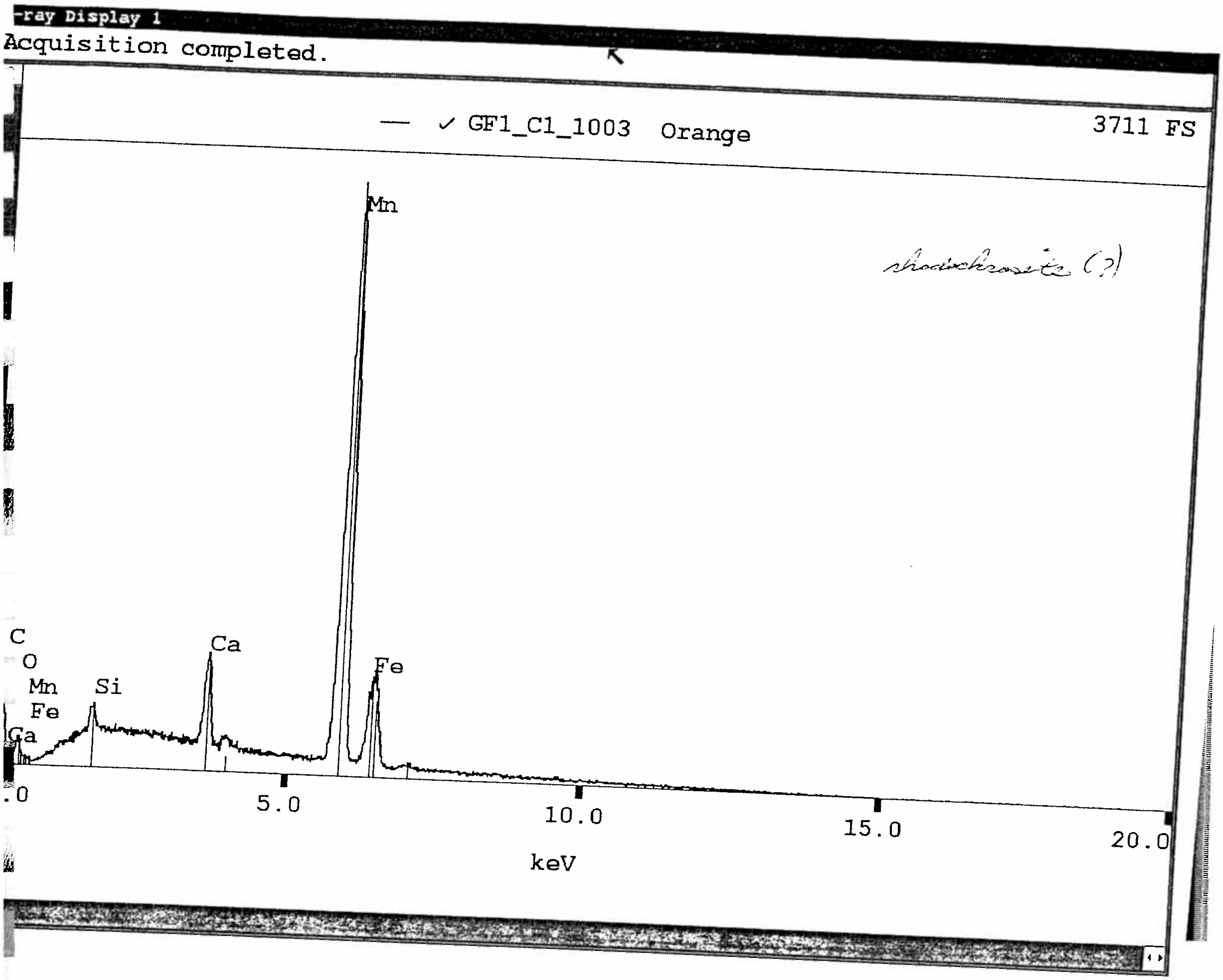
X-ray Display 1

Acquisition completed.

— ✓ GF1_C1_1002 Orange

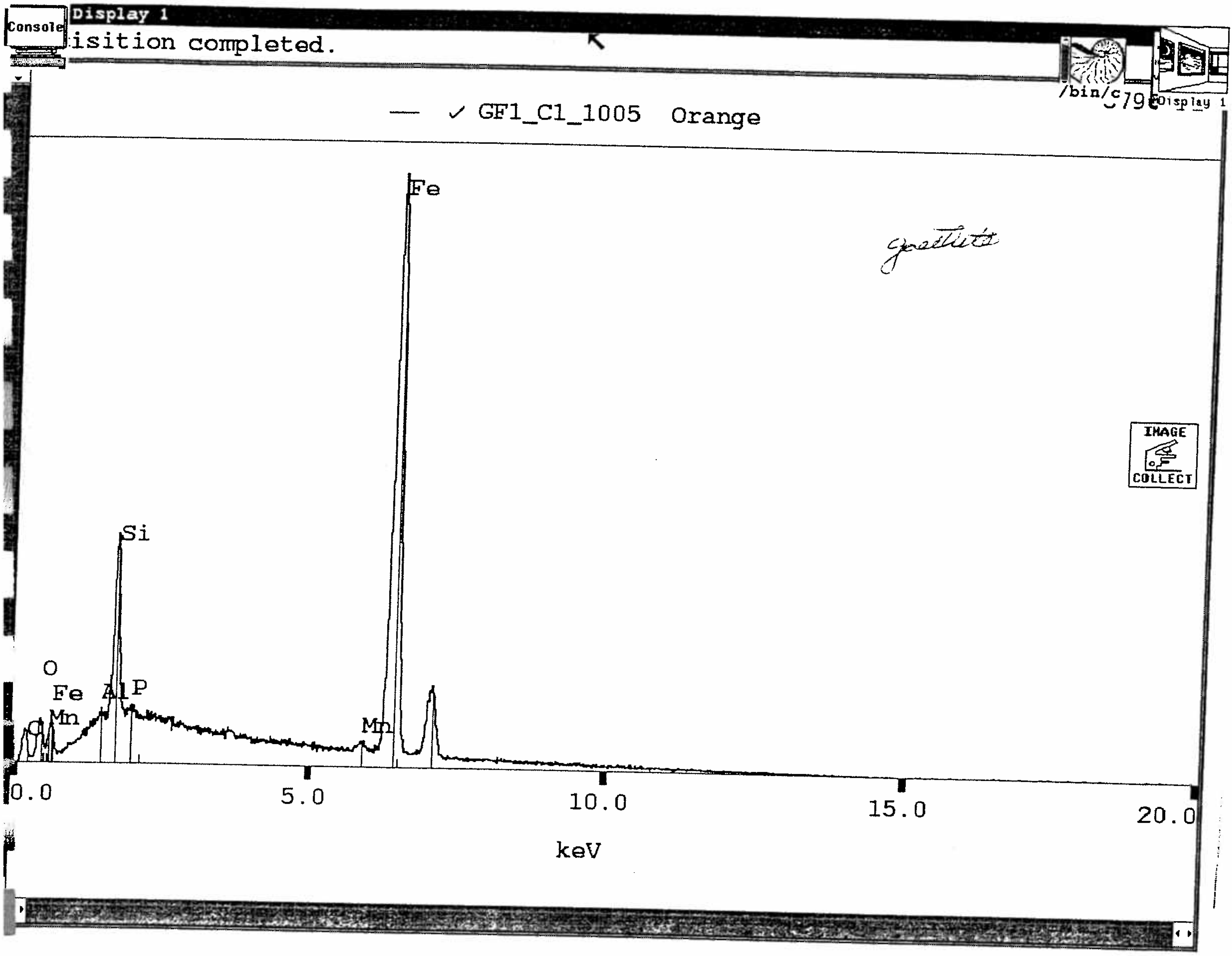
No arsenic

GF1 C-1 4.58'-4.75' orange coating on drill core



Acquisition completed.

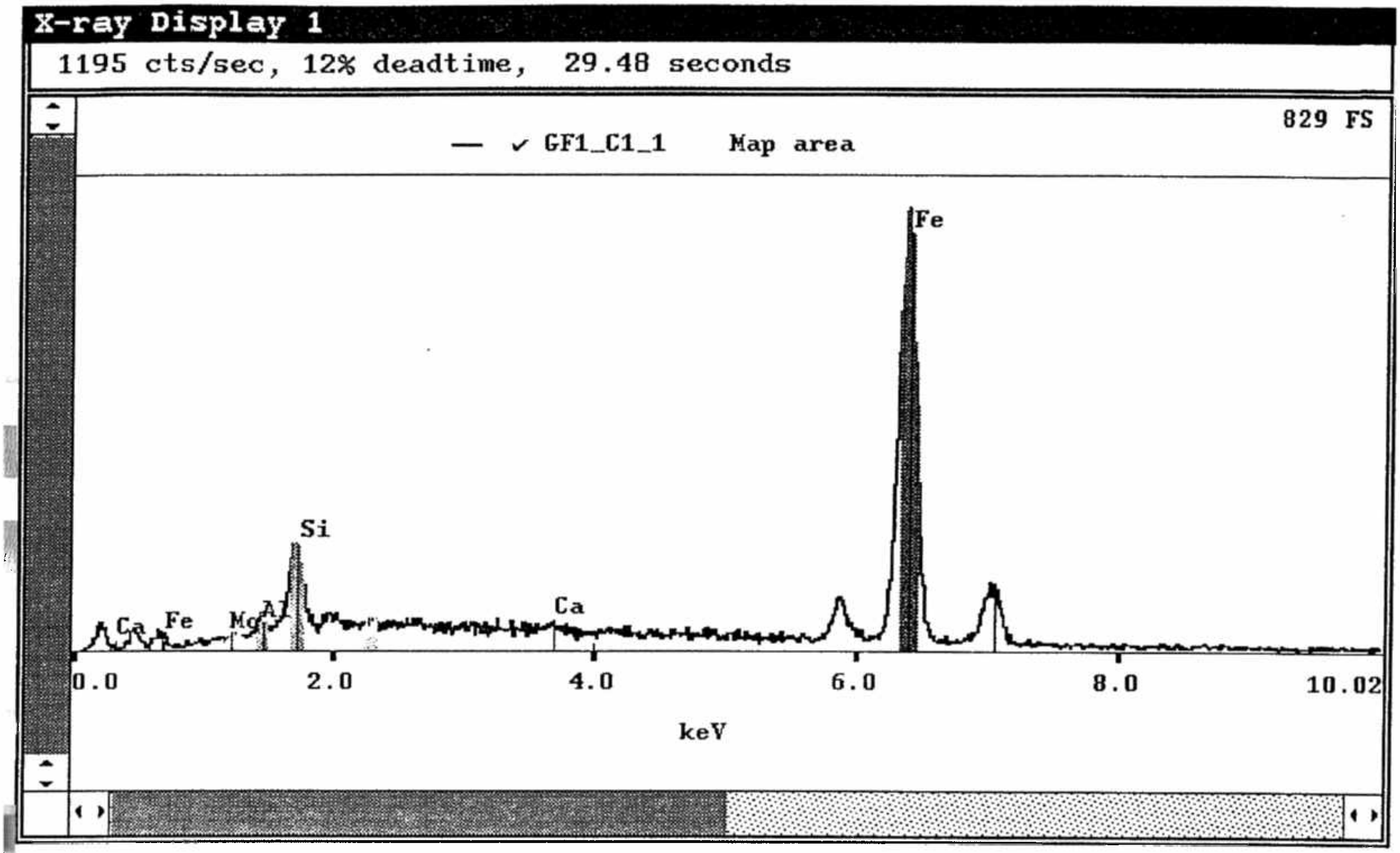
rhodochrosite (?)



isition completed.

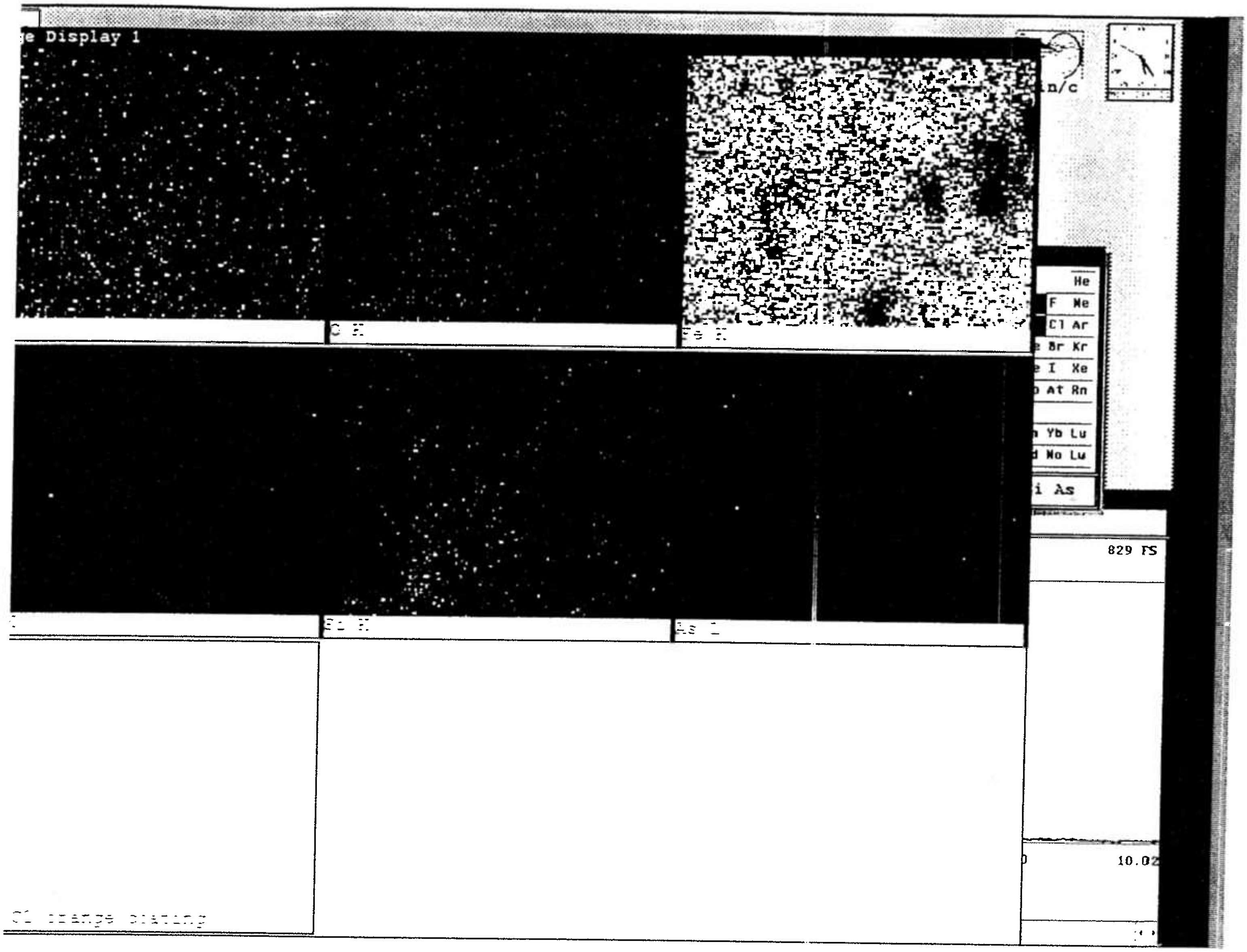
goethite

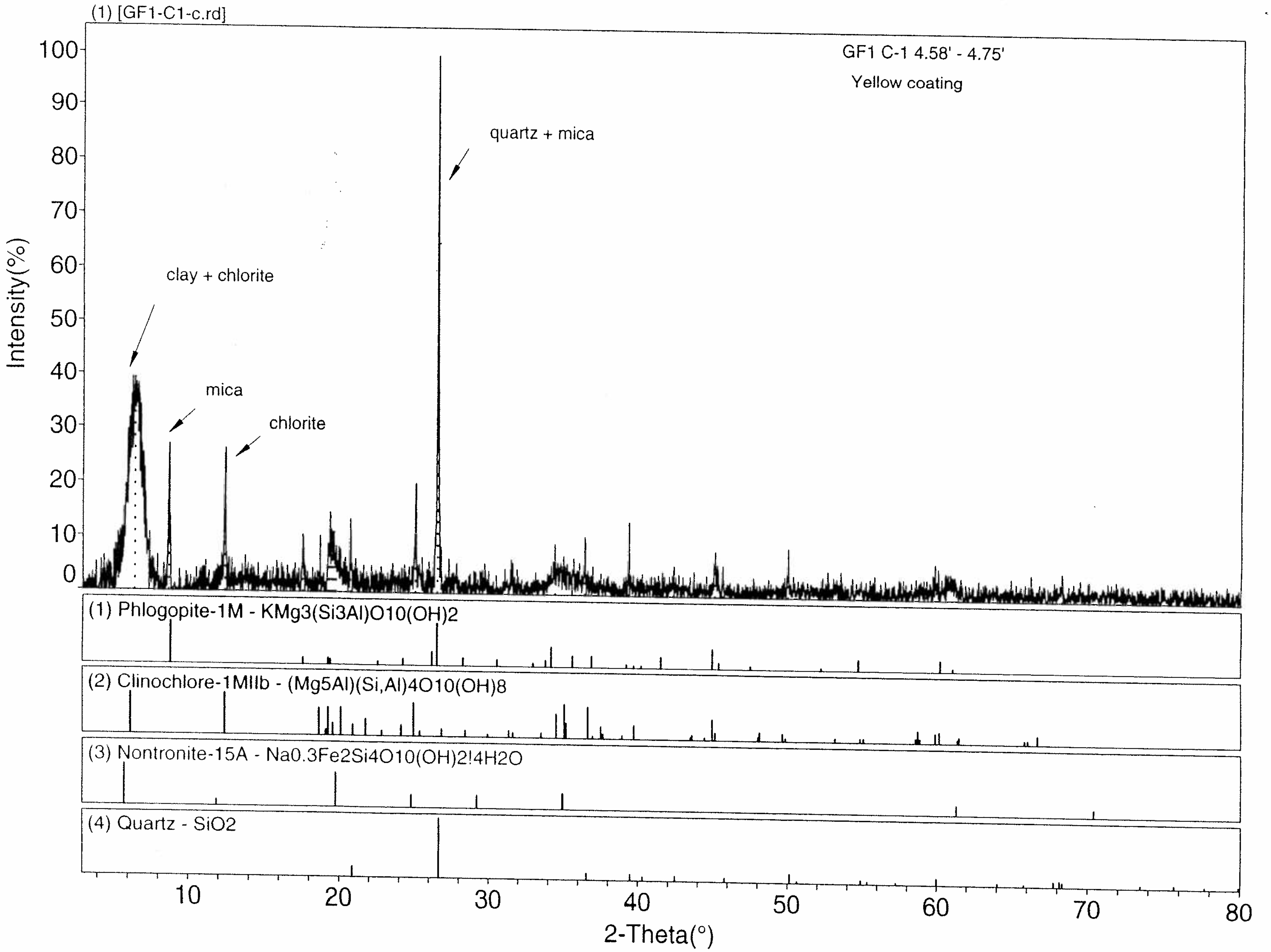
Map area for orange coating



X-ray Display 1

1195 cts/sec, 12% deadtime, 29.48 seconds

ge Display 1
in/c
C K
Fe K
He
F Ne
Cl Ar
e Br Kr
e I Xe
o At Rn
n Yb Lu
d No Lu
i As
829 FS
Si K
As L
10.02
C1 orange plating


(1) [GF1-C1-c.rd]
GF1 C-1 4.58' - 4.75'
Yellow coating
quartz + mica
clay + chlorite
mica
chlorite
Intensity(%)
100
90
80
70
60
50
40
30
20
10
0
(1) Phlogopite-1M - KMg3(Si3Al)O10(OH)2
(2) Clinochlore-1MIIb - (Mg5Al)(Si,Al)4O10(OH)8
(3) Nontronite-15A - Na0.3Fe2Si4O10(OH)2!4H2O
(4) Quartz - SiO2
10
20
30
40
50
60
70
80
2-Theta(°)

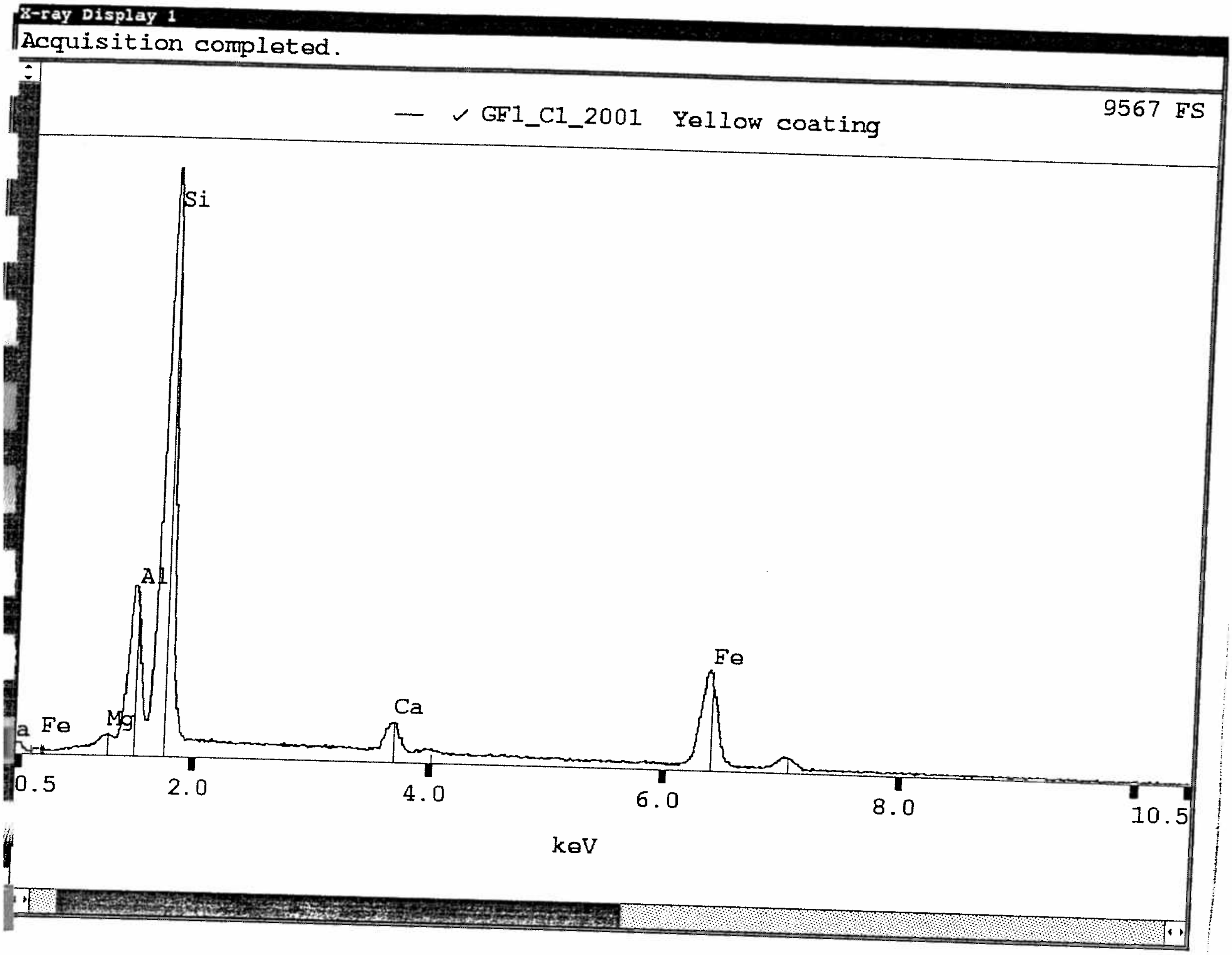
GF1 C-1
4.58- 4.75'
yellow

GF1 C-1 yellow
4.58-4.75'

GF1-C1-2002 Si ≥ Al ≥ Mg = Fe

WD=8 for imag
=39 for EDS

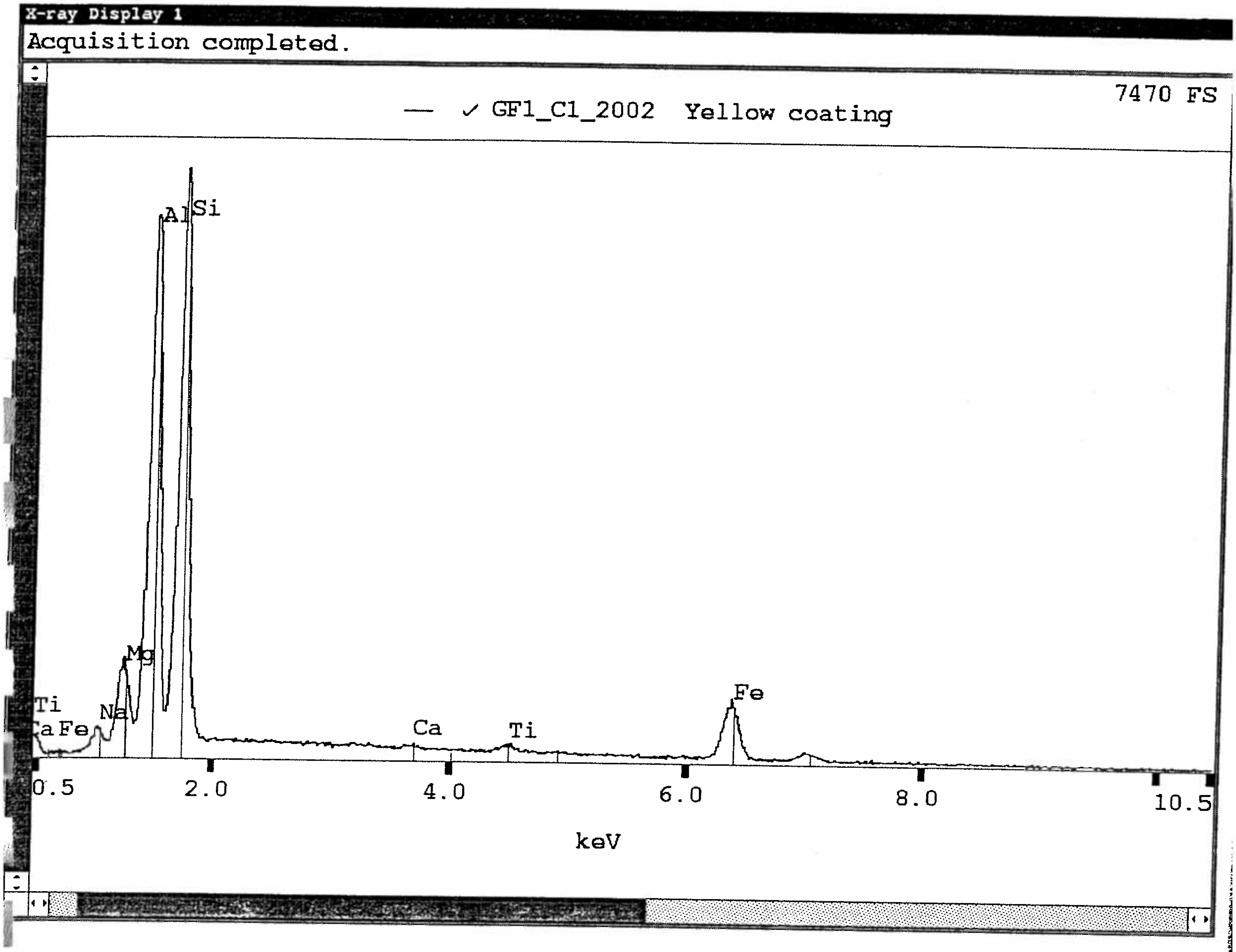
GF1 C-[2251 4.58′-4.75′ yellow coating



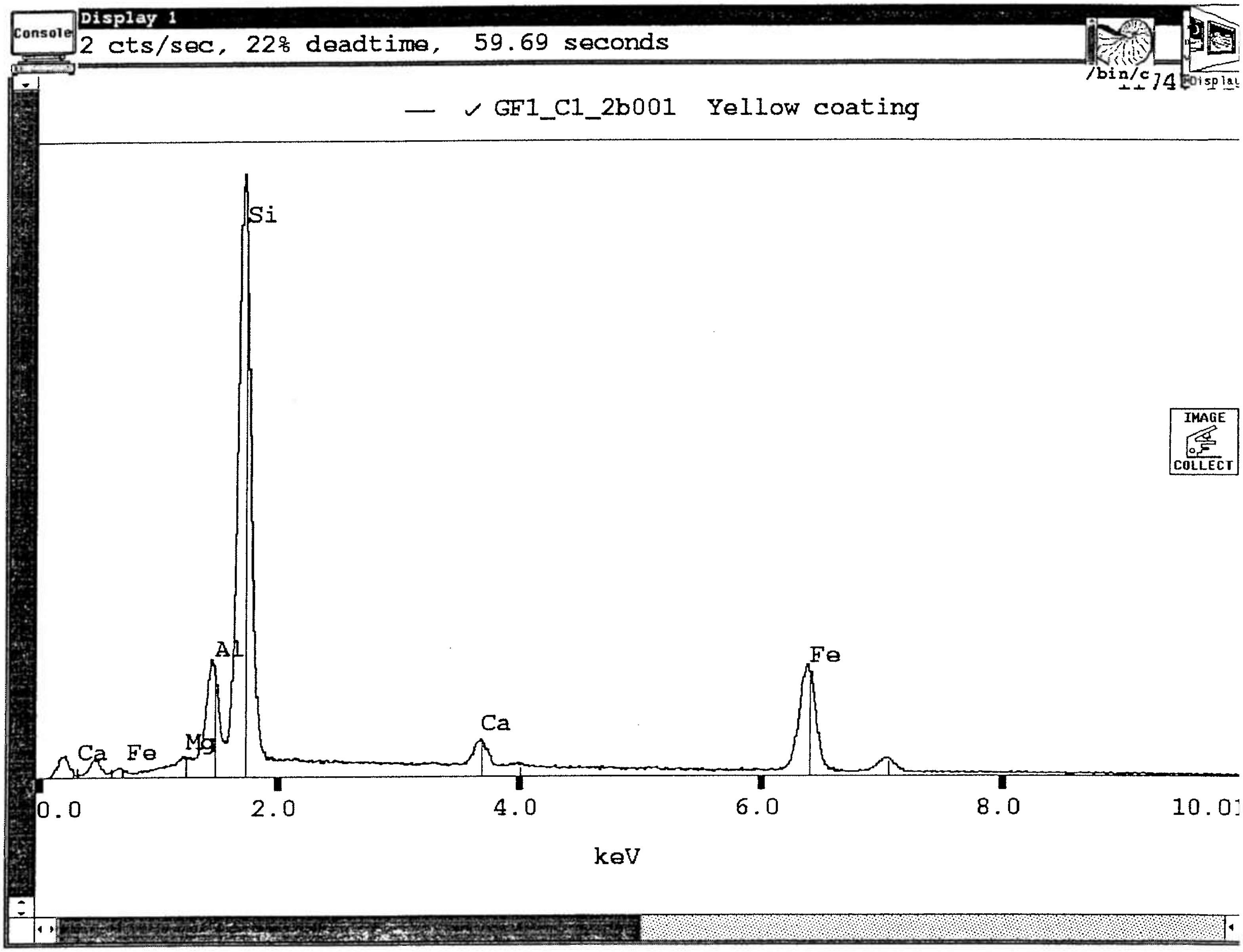
X-ray Display 1

Acquisition completed.

GF1 C-[2251 4.58'-4.75' yellow coating


X-ray Display 1

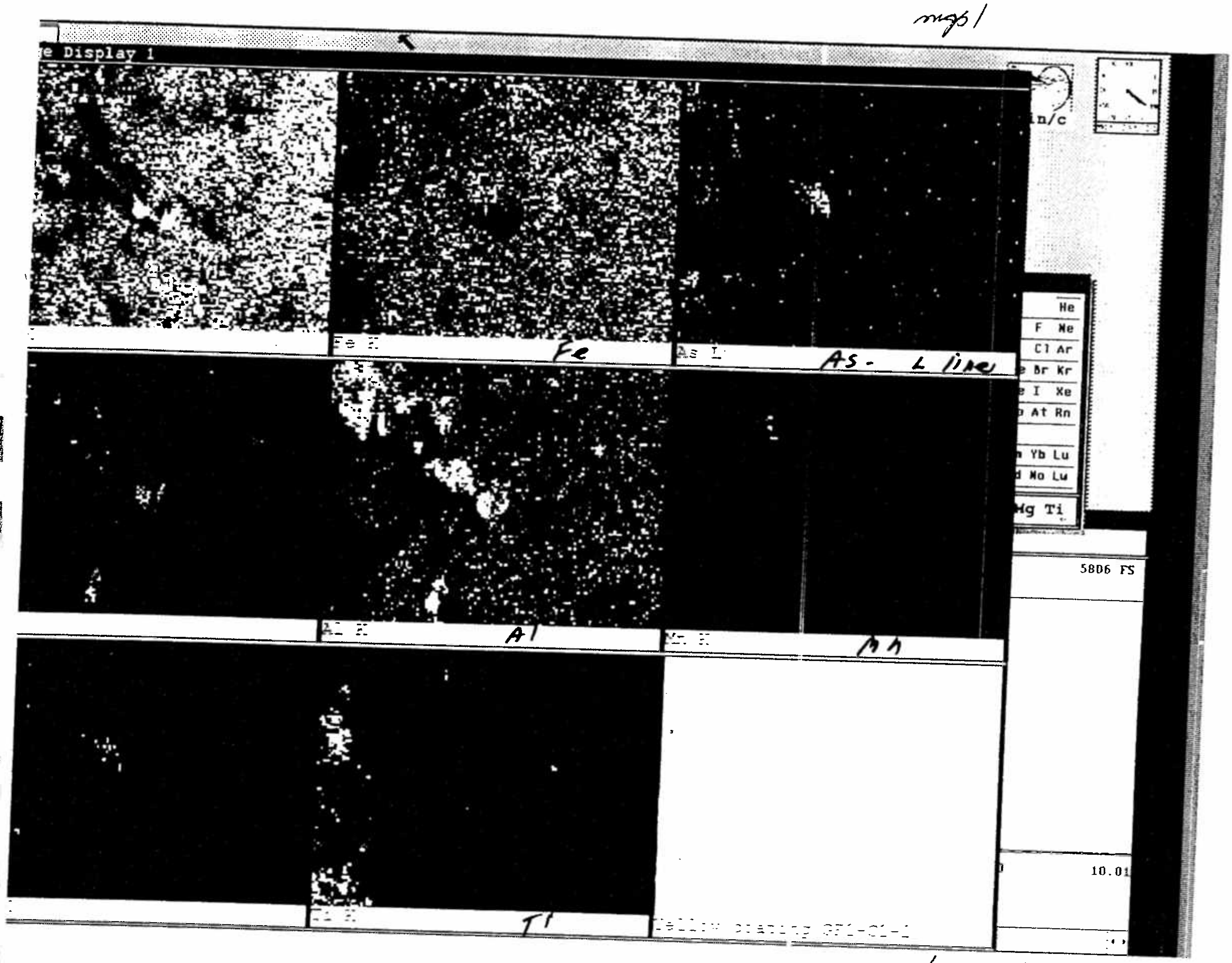
Acquisition completed.



2 cts/sec, 22% deadtime, 59.69 seconds

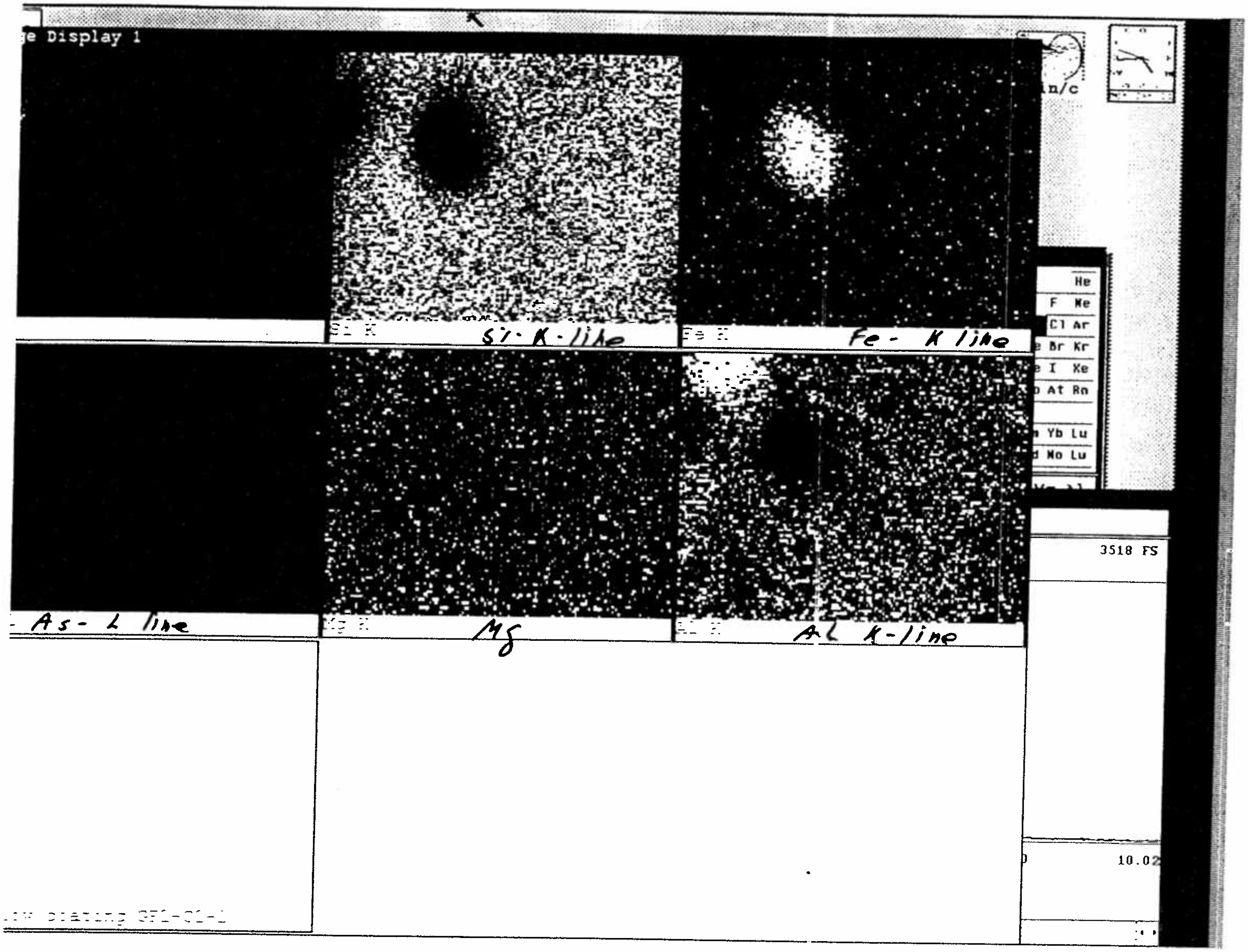
— ✓ GF1_C1_2b001 Yellow coating

GF1 C1 4.58-4.75
yellow
map1



As L + Mg K interference - Need to confirm As by probe + additional work

K line Scan As if Mg present



Si - K-line

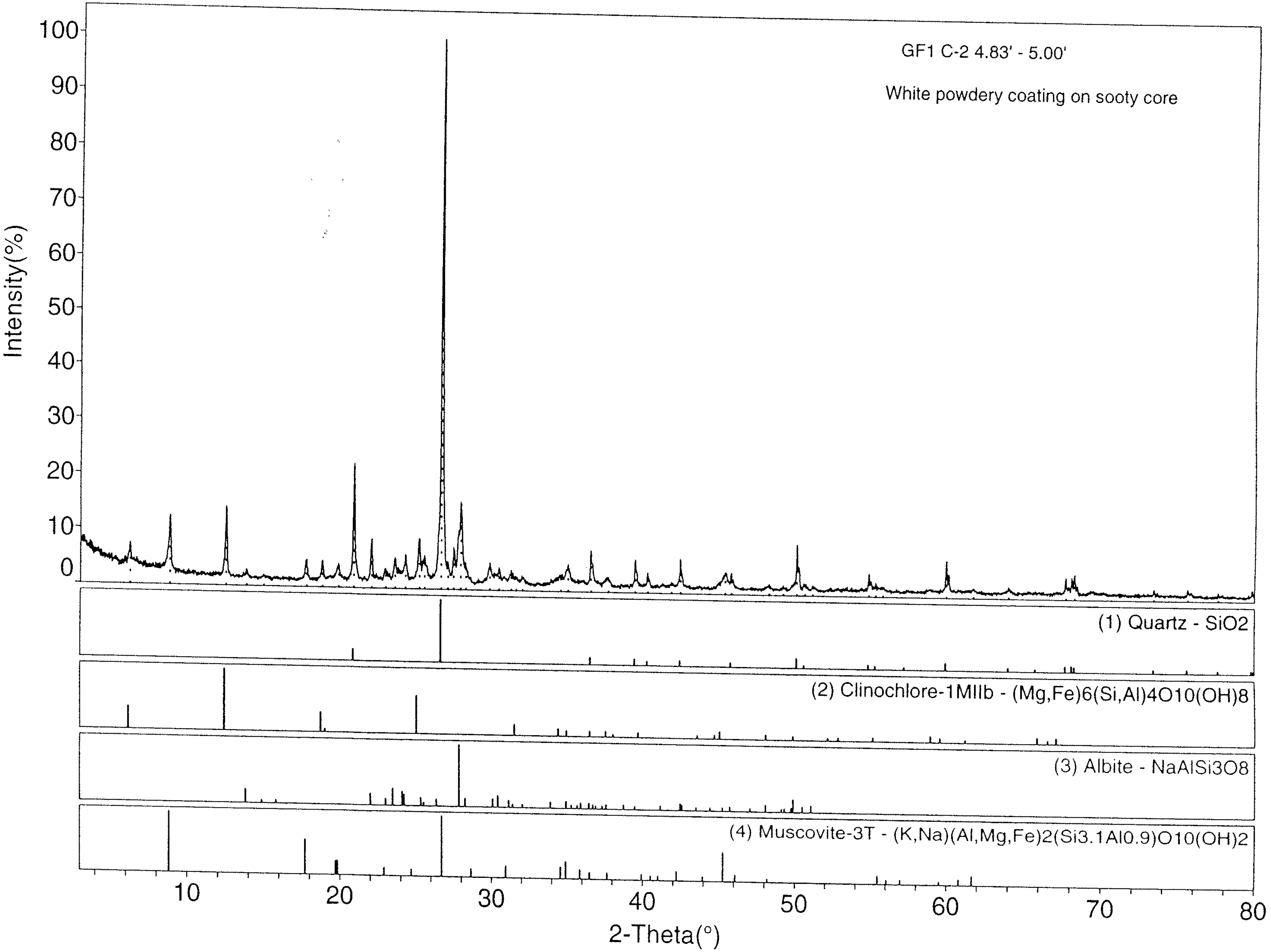
Fe - K line

As - L line

Mg

Al K-line

Attachment 4


GF1 C-2 4.83' - 5.00'
White powdery coating on sooty core
Intensity(%)
100
90
80
70
60
50
40
30
20
10
0
(1) Quartz - SiO2
(2) Clinochlore-1MIIb - (Mg,Fe)6(Si,Al)4O10(OH)8
(3) Albite - NaAlSi3O8
(4) Muscovite-3T - (K,Na)(Al,Mg,Fe)2(Si3.1Al0.9)O10(OH)2
10
20
30
40
50
60
70
80
2-Theta(°)

[GF1-C-2-a.rd] GF1 C-2 4.83'-5.00' (a)

Peak ID Report

SCAN: 3.0/80.0/0.02/1(sec), Cu, I(max)=4264, 01/27/00 09:22

PEAK: 19-pts/Parabolic Filter, Threshold=3.0, Cutoff=0.1%, BG=3/1.0, Peak-Top=Summit

NOTE: Intensity = Counts, 2T(0)=0.11(°), Wavelength to Compute d-Spacing = 1.54056A(Cu/K-alpha1)

#	2-Theta	d(A)	Intensity	I%	Phase ID	d(A)	I%	h	k	l	2-Theta	Delta
1	6.246	14.1382	161	3.9	Clinochlore-1...	14.1000	35.0	0	0	1	6.263	0.017
2	8.831	10.0051	412	9.9	Muscovite-3T	9.9700	100.0	0	0	3	8.862	0.031
3	12.492	7.0798	531	12.7	Clinochlore-1...	7.0700	100.0	0	0	2	12.510	0.017
4	13.834	6.3959	61	1.5	Albite	6.3900	20.0	0	0	1	13.847	0.013
5	14.967	5.9142	30	0.7	Albite	5.9400	2.0	-1	-1	1	14.902	-0.065
6	17.765	4.9885	154	3.7	Muscovite-3T	4.9900	55.0	0	0	6	17.760	-0.005
7	18.807	4.7145	138	3.3	Clinochlore-1...	4.7100	30.0	0	0	3	18.825	0.018
8	19.869	4.4648	112	2.7	Muscovite-3T	4.4600	20.0	1	0	1	19.891	0.021
9	20.868	4.2532	895	21.5	Quartz	4.2550	16.0	1	0	0	20.859	-0.009
10	22.045	4.0288	305	7.3	Albite	4.0300	16.0	-2	0	1	22.038	-0.007
11	22.966	3.8693	76	1.8	Muscovite-3T	3.8730	10.0	1	0	4	22.943	-0.022
12	23.588	3.7687	154	3.7	Albite	3.7800	25.0	1	1	1	23.516	-0.072
13	24.273	3.6638	179	4.3	Albite	3.6630	16.0	-1	-3	1	24.278	0.005
14	25.187	3.5328	296	7.1	Clinochlore-1...	3.5400	60.0	0	0	4	25.135	-0.052
15	25.530	3.4861	166	4.0	Albite	3.4840	2.0	-2	-2	1	25.546	0.016
16	26.633	3.3442	4170	100.0	Quartz	3.3435	100.0	1	0	1	26.639	0.006
17	27.068	3.2915	97	2.3								
18	27.455	3.2460	209	5.0								
19	27.912	3.1938	625	15.0	Albite	3.1960	100.0	0	0	2	27.893	-0.019
20	28.268	3.1544	128	3.1	Albite	3.1510	10.0	-2	2	0	28.299	0.031
21	29.850	2.9907	137	3.3	Albite	2.9640	10.0	1	-3	1	30.126	0.275
22	30.452	2.9330	95	2.3	Albite	2.9330	16.0	0	-2	2	30.452	0.000
23	31.269	2.8582	76	1.8	Albite	2.8660	8.0	1	3	1	31.182	-0.088
24	31.586	2.8303	34	0.8	Clinochlore-1...	2.8280	15.0	0	0	5	31.611	0.026
25	32.006	2.7940	37	0.9	Albite	2.7870	2.0	0	2	2	32.089	0.083
26	34.551	2.5938	58	1.4	Clinochlore-1...	2.5970	9.0	-2	0	2	34.507	-0.044
27	35.028	2.5596	129	3.1	Clinochlore-1...	2.5580	6.0	2	0	1	35.050	0.023
28	36.532	2.4576	251	6.0	Muscovite-3T	2.4570	8.0	1	1	4	36.541	0.009
29	37.687	2.3849	57	1.4	Muscovite-3T	2.3840	8.0	1	1	5	37.701	0.015
30	39.455	2.2820	198	4.7	Quartz	2.2815	8.0	1	0	2	39.464	0.009
31	40.287	2.2367	101	2.4	Quartz	2.2361	4.0	1	1	1	40.299	0.012
32	41.848	2.1569	33	0.8								
33	42.433	2.1285	216	5.2	Quartz	2.1277	6.0	2	0	0	42.449	0.016
34	45.390	1.9964	125	3.0	Muscovite-3T	1.9990	45.0	0	0	15	45.329	-0.062
35	45.803	1.9794	116	2.8	Quartz	1.9799	4.0	2	0	1	45.792	-0.011
36	48.286	1.8833	40	1.0	Muscovite-3T	1.8850	2.0	1	1	11	48.238	-0.048
37	49.209	1.8501	28	0.7	Albite	1.8510	2.0	-4	0	3	49.183	-0.027
38	50.116	1.8187	346	8.3	Quartz	1.8180	13.0	1	1	2	50.138	0.021
39	50.643	1.8010	29	0.7	Quartz	1.8017	1.0	0	0	3	50.621	-0.022
40	51.164	1.7839	32	0.8	Albite	1.7850	8.0	-2	0	4	51.129	-0.034
41	54.868	1.6719	110	2.6	Quartz	1.6717	4.0	2	0	2	54.873	0.005
42	55.315	1.6594	58	1.4	Quartz	1.6592	2.0	1	0	3	55.323	0.009
43	55.790	1.6464	32	0.8	Muscovite-3T	1.6540	10.0	1	1	14	55.512	-0.278
44	59.951	1.5417	232	5.6	Quartz	1.5415	9.0	2	1	1	59.958	0.007

[GF1-C-2-a.rd] GF1 C-2 4.83'-5.00' (a)

Peak ID Report

SCAN: 3.0/80.0/0.02/1(sec), Cu, I(max)=4264, 01/27/00 09:22

PEAK: 19-pts/Parabolic Filter, Threshold=3.0, Cutoff=0.1%, BG=3/1.0, Peak-Top=Summit

NOTE: Intensity = Counts, 2T(0)=0.11(°), Wavelength to Compute d-Spacing = 1.54056A(Cu/K-alpha1)

#	2-Theta	d(A)	Intensity	I%	Phase ID	d(A)	I%	h	k	l	2-Theta	Delta
45	61.711	1.5019	32	0.8	Muscovite-3T	1.5020	12.0	3	0	0	61.706	-0.005
46	64.025	1.4531	48	1.2	Quartz	1.4529	2.0	1	1	3	64.034	0.009
47	67.744	1.3821	122	2.9	Quartz	1.3821	6.0	2	1	2	67.742	-0.002
48	68.308	1.3720	142	3.4	Quartz	1.3719	5.0	3	0	1	68.316	0.008
49	73.456	1.2881	47	1.1	Quartz	1.2879	2.0	1	0	4	73.466	0.010
50	75.650	1.2561	54	1.3	Quartz	1.2559	3.0	3	0	2	75.658	0.007
51	77.650	1.2286	31	0.7	Quartz	1.2283	1.0	2	2	0	77.673	0.023

APPENDIX F.

BEDROCK CORE ANALYSIS BY ELECTRON MICROPROBE

(Prof. R. Hon)

Pyrite

Quant#	Label	Ele Wt% Fe	Ni	Co	Cu	S	As	Sb	Total	Atomic Fe	Ni	Co	Cu	S
1	Slide 11 G	46.44	0.0271		0.0162	55.44	0.0788		102.01	32.45	0.0180		0.0100	67.48
2	Slide 11 G	45.86	0.0147		0.0000	55.52	0.0598		101.46	32.16	0.0098		0.0000	67.80
3	Slide 11 G	45.54	0.1065		0.0366	55.35	0.0042		101.03	32.05	0.0713		0.0226	67.85
4	Slide 11 G	45.27	0.9609		0.0305	55.37	0.1210		101.75	31.71	0.6404		0.0188	67.56
5	Slide 11 G	44.28	1.2560		0.0836	55.61	0.0746		101.31	31.08	0.8386		0.0516	67.99
10	Slide 11 G	46.46	0.0880	0.0000	0.0000	54.53	0.0127		101.09	32.83	0.0592	0.0000	0.0000	67.11
11	Slide 11 G	46.01	0.4563	0.0000	0.0000	54.65	0.0140		101.13	32.48	0.3065	0.0000	0.0000	67.20
12	Slide 12 G	45.60	0.0245	0.0000	0.0153	54.04	0.2646		99.94	32.58	0.0167	0.0000	0.0096	67.25
13	Slide 12 G	46.64	0.0498	0.0000	0.0324	55.74	0.0471		102.50	32.43	0.0329	0.0000	0.0198	67.50
14	Slide 12 G	46.88	0.0253	0.0000	0.0000	56.72	0.1377		103.76	32.15	0.0165	0.0000	0.0000	67.76
15	Slide 12 G	46.15	0.0452	0.0000	0.0116	56.25	0.0682		102.53	32.00	0.0298	0.0000	0.0071	67.93
18	Slide 12 G	44.57	0.5239	0.0802	0.0311	55.15	0.0315		100.39	31.55	0.3528	0.0538	0.0194	68.01
19	Slide 12 G	44.72	0.9312	0.0000	0.0000	55.16	0.0348		100.85	31.56	0.6251	0.0000	0.0000	67.80
20	Slide 12 G	45.86	0.2279	0.0042	0.0421	55.43	0.0320		101.59	32.14	0.1519	0.0028	0.0259	67.66
21	Slide12 Gr	46.78	0.0018	0.0000	0.0367	56.87	0.0329	0.0480	103.76	32.06	0.0011	0.0000	0.0221	67.88
22	Slide12 Gr	46.19	0.0000	0.0000	0.0184	56.16	0.0226	0.0240	102.42	32.07	0.0000	0.0000	0.0112	67.91
23	Slide12 Gr	45.91	0.0000	0.0000	0.0000	56.88	0.0000	0.0170	102.81	31.66	0.0000	0.0000	0.0000	68.33
24	Slide12 Gr	47.39	0.0000	0.0000	0.0000	56.88	0.0837	0.0146	104.37	32.34	0.0000	0.0000	0.0000	67.61
25	Slide12 Gr	45.92	0.4271	0.0000	0.0000	57.40	0.0424	0.0215	103.81	31.38	0.2776	0.0000	0.0000	68.31
26	Slide13 Gr	46.61	0.5611	0.0000	0.0000	57.07	0.0000	0.0125	104.25	31.81	0.3642	0.0000	0.0000	67.83
27	Slide13 Gr	45.18	1.5428	0.0000	0.0118	57.06	0.0000	0.0318	103.83	30.93	1.0048	0.0000	0.0071	68.05
28	Slide13 Gr	47.07	0.0179	0.0000	0.0125	57.93	0.0239	0.0030	105.05	31.80	0.0115	0.0000	0.0074	68.17
29	Slide13 Gr	45.97	0.0119	0.0000	0.0000	58.72	0.0546	0.0395	104.80	30.99	0.0077	0.0000	0.0000	68.96
30	Slide13 Gr	46.29	0.0148	0.0000	0.0000	58.37	0.0172	0.0272	104.72	31.28	0.0095	0.0000	0.0000	68.70
31	Slide13 Mt	45.43	0.1078	0.0000	0.0000	56.14	0.0000	0.0111	101.68	31.70	0.0715	0.0000	0.0000	68.23
32	Slide13 Gr	44.71	1.7782	0.0000	0.0000	57.42	0.0136	0.0000	103.92	30.54	1.1552	0.0000	0.0000	68.30
33	Slide13 Gr	46.44	0.3393	0.0000	0.0000	56.45	0.0147	0.0000	103.24	32.00	0.2224	0.0000	0.0000	67.77
34	Slide13 Gr	46.23	0.5510	0.0000	0.0084	56.48	0.0000	0.0239	103.30	31.85	0.3611	0.0000	0.0051	67.78

	Fe	Ni	Co	Cu	S	As	Sb	Total
average	45.94	0.3604	0.0037	0.0138	56.24	0.0460	0.0196	102.62
st.dev.	0.77	0.5005	0.0167	0.0196	1.15	0.0561	0.0143	1.46
min	44.28	0.0000	0.0000	0.0000	54.04	0.0000	0.0000	99.94
max	47.39	1.7782	0.0802	0.0836	58.72	0.2646	0.0480	105.05

	Ele Wt%								Atomic					
Label	Fe	Ni	Co	Cu	S	As	Total	Fe	Ni	Co	Cu	S	As	CatTot
Slide 11 Grain 2a	6.15	5.55	24.01	0.16	21.93	42.82	100.61	5.89	5.05	21.78	0.14	36.58	30.56	100
Slide 11 Grain 2a	6.75	6.35	22.76	0.16	22.52	46.87	105.42	6.21	5.56	19.85	0.13	36.10	32.15	100
Slide 11 Grain 2b-1	7.44	6.38	18.82	0.17	22.40	44.02	99.22	7.20	5.88	17.26	0.14	37.76	31.77	100
Slide 11 Grain 2b-2	6.62	5.36	21.69	0.16	21.63	31.99	87.45	7.04	5.43	21.89	0.15	40.11	25.38	100
Slide 12 Grain 1	5.29	6.60	23.61	0.24	21.27	44.22	101.23	5.07	6.03	21.48	0.20	35.57	31.64	100
Slide 12 Grain 1	8.51	7.83	17.23	0.18	22.12	49.03	104.89	7.91	6.93	15.18	0.14	35.83	34.00	100

Fe	Ni	Co	Cu	S	As
6.15	5.55	24.01	0.16	21.93	42.82
6.75	6.35	22.76	0.16	22.52	46.87
7.44	6.38	18.82	0.17	22.40	44.02
6.62	5.36	21.69	0.16	21.63	31.99
5.29	6.60	23.61	0.24	21.27	44.22
8.51	7.83	17.23	0.18	22.12	49.03
average:					
6.79	6.35	21.35	0.18	21.98	43.16

Fe	Ni	Co	Cu	S	As
5.89	5.05	21.78	0.14	36.58	30.56
6.21	5.56	19.85	0.13	36.10	32.15
7.20	5.88	17.26	0.14	37.76	31.77
7.04	5.43	21.89	0.15	40.11	25.38
5.07	6.03	21.48	0.20	35.57	31.64
7.91	6.93	15.18	0.14	35.83	34.00

Stoichiometric Chem. Formula
CoAsS

	probe avg.		probe avg.	Stoichiometric
Co	21.35	Co+Fe+Ni	34.49	35.52%
As	43.16	As	43.16	45.16%
S	21.98	S	21.98	19.33%

As	Sb	CatTot	X	Y	Date	Time
0.0411		100	57.869	23.123	11/28/00	02:27PM
0.0313		100	57.784	23.175	11/28/00	02:34PM
0.0022		100	57.858	23.054	11/28/00	02:38PM
0.0632		100	68.084	43.447	11/28/00	03:14PM
0.0390		100	68.06	43.459	11/28/00	03:18PM
0.0067		100	65.698	37.417	11/28/00	04:28PM
0.0074		100	65.635	37.478	11/28/00	04:33PM
0.1409		100	24.628	38.029	11/28/00	05:10PM
0.0244		100	24.752	37.936	11/28/00	05:15PM
0.0704		100	24.551	37.988	11/28/00	05:20PM
0.0353		100	24.498	38.043	11/28/00	05:26PM
0.0166		100	30.234	24.152	11/28/00	05:53PM
0.0183		100	30.201	24.137	11/28/00	05:57PM
0.0167		100	30.446	24.161	11/28/00	06:02PM
0.0168	0.0151	100	63.931	37.761	12/12/00	11:43AM
0.0117	0.0076	100	63.961	37.713	12/12/00	11:51AM
0.0000	0.0054	100	61.737	40.616	12/12/00	12:03PM
0.0426	0.0046	100	53.729	39.783	12/12/00	12:12PM
0.0216	0.0067	100	53.785	39.757	12/12/00	12:17PM
0.0000	0.0039	100	25.928	25.523	12/12/00	12:26PM
0.0000	0.0100	100	26.015	25.574	12/12/00	12:31PM
0.0121	0.0009	100	18.897	46.92	12/12/00	01:51PM
0.0274	0.0122	100	18.788	46.881	12/12/00	01:56PM
0.0086	0.0084	100	18.687	46.905	12/12/00	02:03PM
0.0000	0.0036	100	10.937	20.44	12/12/00	02:45PM
0.0069	0.0000	100	5.905	44.808	12/12/00	02:56PM
0.0075	0.0000	100	6.437	31.028	12/12/00	03:02PM
0.0000	0.0075	100	14.025	60.749	12/12/00	03:08PM

		Ele Wt%				
Quant#	Label	Fe	Ni	Cu	S	As
1	Slide 11 Grain 1 center	46.44	0.03	0.02	55.44	0.08
2	Slide 11 Grain 1	45.86	0.01	0.00	55.52	0.06
3	Slide 11 Grain 1	45.54	0.11	0.04	55.35	0.00
4	Slide 11 Grain 2a	45.27	0.96	0.03	55.37	0.12
5	Slide 11 Grain 2a	44.28	1.26	0.08	55.61	0.07

		Ele Wt%					
Quant#	Label	Fe	Ni	Co	Cu	S	As
6	Slide 11 Grain 2a	6.15	5.55	24.01	0.16	21.93	42.82
7	Slide 11 Grain 2a	6.75	6.35	22.76	0.16	22.52	46.87
8	Slide 11 Grain 2b-1	7.44	6.38	18.82	0.17	22.40	44.02
9	Slide 11 Grain 2a	6.62	5.36	21.69	0.16	21.63	31.99
10	Slide 11 Grain 2a	46.46	0.09	0.00	0.00	54.53	0.01
11	Slide 11 Grain 2a	46.01	0.46	0.00	0.00	54.65	0.01
12	Slide 12 Grain 4 core	45.60	0.02	0.00	0.02	54.04	0.26
13	Slide 12 Grain 4	46.64	0.05	0.00	0.03	55.74	0.05
14	Slide 12 Grain 4 core	46.88	0.03	0.00	0.00	56.72	0.14
15	Slide 12 Grain 4	46.15	0.05	0.00	0.01	56.25	0.07
16	Slide 12 Grain 1	5.29	6.60	23.61	0.24	21.27	44.22
17	Slide 12 Grain 1	8.51	7.83	17.23	0.18	22.12	49.03
18	Slide 12 Grain 1	44.57	0.52	0.08	0.03	55.15	0.03
19	Slide 12 Grain 1	44.72	0.93	0.00	0.00	55.16	0.03
20	Slide 12 Grain 1	45.86	0.23	0.00	0.04	55.43	0.03

		Ele Wt%					
Quant#	Label	Fe	Ni	Co	Cu	S	As
21	Slide12 Grain3	46.78	0.0018	0	0.0367	56.87	0.0329
22	Slide12 Grain3b	46.19	0	0	0.0184	56.16	0.0226
23	Slide12 Grain5	45.91	0	0	0	56.88	0.0000
24	Slide12 Grain6	47.39	0	0	0	56.88	0.0837
25	Slide12 Grain6b	45.92	0.4271	0	0	57.4	0.0424
26	Slide13 Grain1center	46.61	0.5611	0	0	57.07	0.0000
27	Slide13 Grain1corner	45.18	1.5428	0	0.0118	57.06	0.0000
28	Slide13 Grain7r-center	47.07	0.0179	0	0.0125	57.93	0.0239
29	Slide13 Grain7r-corner	45.97	0.0119	0	0	58.72	0.0546
30	Slide13 Grain7b	46.29	0.0148	0	0	58.37	0.0172
31	Slide13 Multiple Pyrite	45.43	0.1078	0	0	56.14	0.0000
32	Slide13 Grain9	44.71	1.7782	0	0	57.42	0.0136
33	Slide13 Grain13	46.44	0.3393	0	0	56.45	0.0147
34	Slide13 Grain8	46.23	0.551	0	0.0084	56.48	0.0000

	Atomic					
Total	Fe	Ni	Cu	S	As	CatTot
102.01	32.45	0.02	0.01	67.48	0.04	100
101.46	32.16	0.01	0.00	67.80	0.03	100
101.03	32.05	0.07	0.02	67.85	0.00	100
101.75	31.71	0.64	0.02	67.56	0.06	100
101.31	31.08	0.84	0.05	67.99	0.04	100

	Atomic					
Total	Fe	Ni	Co	Cu	S	As
100.61	5.89	5.05	21.78	0.14	36.58	30.56
105.42	6.21	5.56	19.85	0.13	36.10	32.15
99.22	7.20	5.88	17.26	0.14	37.76	31.77
87.45	7.04	5.43	21.89	0.15	40.11	25.38
101.09	32.83	0.06	0.00	0.00	67.11	0.01
101.13	32.48	0.31	0.00	0.00	67.20	0.01
99.94	32.58	0.02	0.00	0.01	67.25	0.14
102.50	32.43	0.03	0.00	0.02	67.50	0.02
103.76	32.15	0.02	0.00	0.00	67.76	0.07
102.53	32.00	0.03	0.00	0.01	67.93	0.04
101.23	5.07	6.03	21.48	0.20	35.57	31.64
104.89	7.91	6.93	15.18	0.14	35.83	34.00
100.39	31.55	0.35	0.05	0.02	68.01	0.02
100.85	31.56	0.63	0.00	0.00	67.80	0.02
101.59	32.14	0.15	0.00	0.03	67.66	0.02

		Atomic					
Sb	Total	Fe	Ni	Co	Cu	S	As
0.048	103.76	32.062	0.0011	0	0.0221	67.883	0.0168
0.024	102.42	32.065	0	0	0.0112	67.905	0.0117
0.017	102.81	31.663	0	0	0	68.331	0
0.0146	104.37	32.339	0	0	0	67.614	0.0426
0.0215	103.81	31.381	0.2776	0	0	68.313	0.0216
0.0125	104.25	31.805	0.3642	0	0	67.827	0
0.0318	103.83	30.931	1.0048	0	0.0071	68.047	0
0.003	105.05	31.802	0.0115	0	0.0074	68.166	0.0121
0.0395	104.8	30.993	0.0077	0	0	68.959	0.0274
0.0272	104.72	31.278	0.0095	0	0	68.696	0.0086
0.0111	101.68	31.697	0.0715	0	0	68.228	0
0	103.92	30.536	1.1552	0	0	68.302	0.0069
0	103.24	32.004	0.2224	0	0	67.766	0.0075
0.0239	103.3	31.849	0.3611	0	0.0051	67.777	0

X	Y	Date	Time
57.869	23.123	11/28/00	02:27PM
57.784	23.175	11/28/00	02:34PM
57.858	23.054	11/28/00	02:38PM
68.084	43.447	11/28/00	03:14PM
68.06	43.459	11/28/00	03:18PM

CatTot	X	Y	Date	Time
100	68.038	43.465	11/28/00	03:25PM
100	68.024	43.46	11/28/00	03:29PM
100	68.03	43.462	11/28/00	03:56PM
100	68.07	43.17	11/28/00	04:14PM
100	65.698	37.417	11/28/00	04:28PM
100	65.635	37.478	11/28/00	04:33PM
100	24.628	38.029	11/28/00	05:10PM
100	24.752	37.936	11/28/00	05:15PM
100	24.551	37.988	11/28/00	05:20PM
100	24.498	38.043	11/28/00	05:26PM
100	30.25	24.134	11/28/00	05:44PM
100	30.24	24.152	11/28/00	05:48PM
100	30.234	24.152	11/28/00	05:53PM
100	30.201	24.137	11/28/00	05:57PM
100	30.446	24.161	11/28/00	06:02PM

Sb	CatTot	X	Y	Date	Time
0.0151	100	63.931	37.761	12/12/00	11:43AM
0.0076	100	63.961	37.713	12/12/00	11:51AM
0.0054	100	61.737	40.616	12/12/00	12:03PM
0.0046	100	53.729	39.783	12/12/00	12:12PM
0.0067	100	53.785	39.757	12/12/00	12:17PM
0.0039	100	25.928	25.523	12/12/00	12:26PM
0.01	100	26.015	25.574	12/12/00	12:31PM
0.0009	100	18.897	46.92	12/12/00	01:51PM
0.0122	100	18.788	46.881	12/12/00	01:56PM
0.0084	100	18.687	46.905	12/12/00	02:03PM
0.0036	100	10.937	20.44	12/12/00	02:45PM
0	100	5.905	44.808	12/12/00	02:56PM
0	100	6.437	31.028	12/12/00	03:02PM
0.0075	100	14.025	60.749	12/12/00	03:08PM

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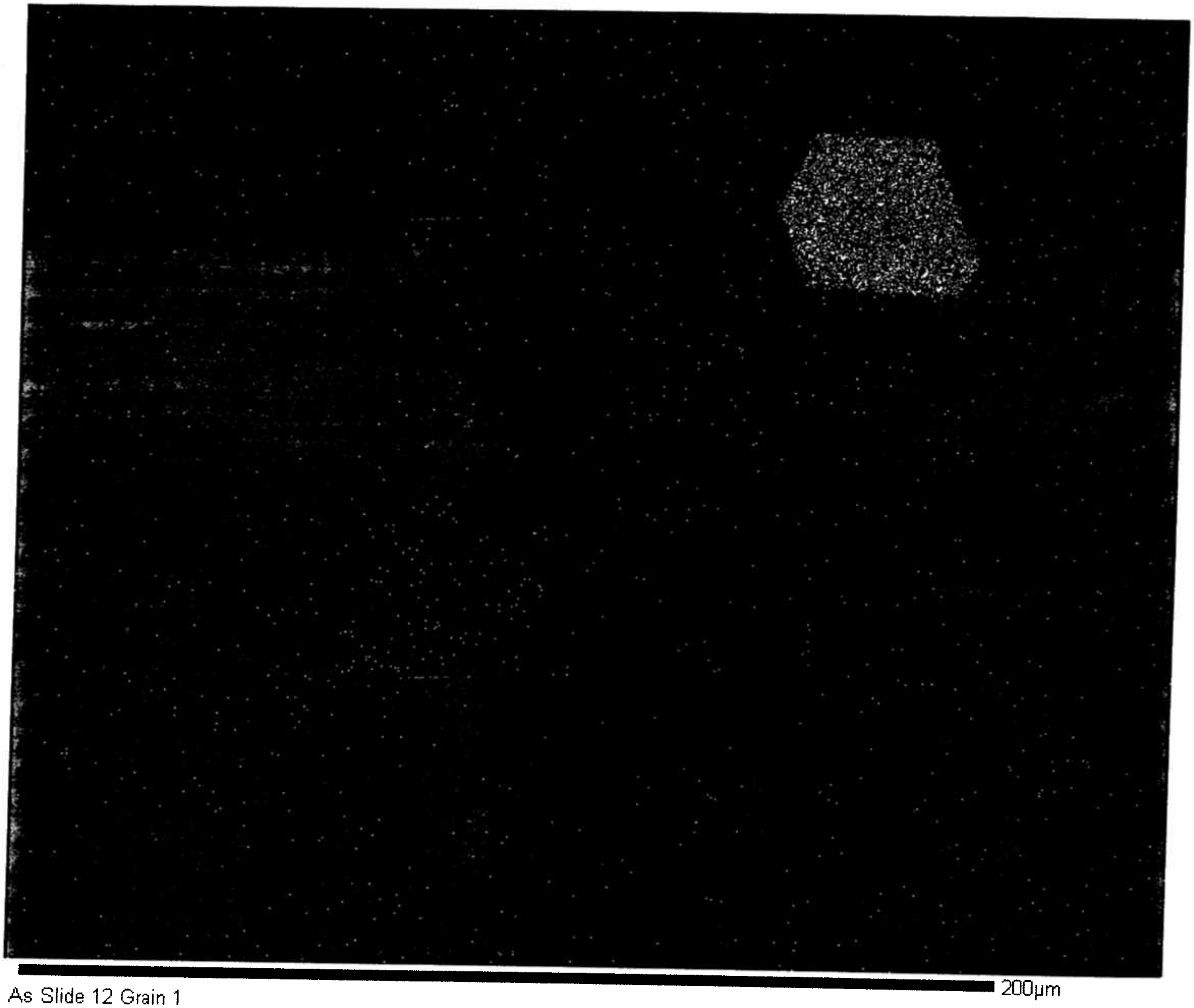

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HUMAN HEALTH RISK ASSESSMENT
Grove Pond
Ayer, Massachusetts

Work Assignment 112
PROJECT #38206

February 2002

Office Location:
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1.0 Risk Assessment Approach

1.1 Introduction

Grove Pond is a 60 acre, shallow pond with an average depth of approximately 5 - 6 feet. Grove Pond is part of the Fort Devens National Priorities List site. Previous investigations have determined that pond sediments contain a number of trace metals, including arsenic, cadmium, chromium, copper, lead, manganese, mercury, vanadium and zinc. These metals may present threats to human health via direct contact with the sediment. Recreational features of the pond include a playground, a boat ramp with use restrictions and "Catch and Release" fishing. There are water supply wells adjacent to the Pond. The Pond is also bordered by residential properties.

The objective of this human health risk assessment is to provide a quantitative estimate of risk posed to humans through exposure to metals presence in the sediment at Grove Pond. At the request of EPA, the recreational receptor was evaluated for exposure to metals in sediment at the site.

1.2 General Approach

To assess potential public health risks, three major aspects of chemical contamination and exposure must be considered: 1) the presence of chemicals with toxic characteristics; 2) the existence of pathways by which human receptors may contact site-related chemicals; and 3) the presence of human receptors. The absence of any of these three aspects would result in an incomplete exposure pathway and an absence of quantifiable risk.

The human health risk assessment consists of five major components:

- Data Evaluation (including COPC selection)
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization
- Uncertainty Analysis

Data usability, data quality and selection of contaminants of potential concern (COPC) are discussed in Section 2.0, Data Evaluation. Section 3.0, Exposure Assessment, identifies potential receptor populations, exposure pathways by which receptors may come in contact with contaminants at specified locations and determination of complete exposure pathways. Determination of the exposure point concentration of each COPC is presented in Section 3.0, as well. Equations and exposure input parameters to be used to estimate chemical intakes are also discussed in Section 3.0.

Section 4.0, Toxicity Assessment, discusses the chemical-specific toxicity criteria to be used for the identified COPCs which are used to quantify potential human risks. Section 5.0, Risk Characterization, provides the methods for calculating noncarcinogenic and carcinogenic risks for each receptor and provides summaries of the results of the risk evaluations. Qualitative evaluations of risk are also presented in Section 5.0.

A discussion of both inherent and study-specific uncertainties is presented in the Uncertainty Analysis Section 6.0. The summary and conclusions of the risk assessment are presented in Section 7.0.

1.3. Applicable Regulations and Guidance

The Human Health Risk Assessment (HHRA) was performed following standard EPA guidelines including the following documents:

- *Risk Assessment Guidance for Superfund (RAGS), Volume I, Part A* (EPA, 1989)

- *RAGS, Volume I, Part D* (EPA, 1998)
- *RAGS, Volume I, Part E, Dermal Risk Assessment Interim Guidance* (EPA, 2000b)
- *Standard Default Exposure Factors* (EPA, 1991)
- *Exposure Factors Handbook* (EPA, 1997a)
- *Supplemental Guidance to RAGS: Calculating the Concentration Term* (EPA, 1992c)
- *Supplemental Guidance to RAGS: Region 1 Risk Updates 1 through 5*

A complete list of references for the human health risk evaluation is provided at the end of this chapter. The majority of the tables to be included in this section are analogous to the standard tables required by the recent Risk Assessment Guidance for Superfund: Part D (RAGS Part D) (EPA, 1998). Data fields to be included in the tables presented in this risk assessment include the majority of data fields specified in the RAGS Part D guidance. The risk assessment report is structured as described in RAGS Part D.

2.0 Data Evaluation

The goal of the data evaluation step of a human health risk assessment is to develop a list of chemicals of potential concern (COPCs) for each environmental medium under consideration. This process involves determining what data are present, determining if the existing data is of suitable quality and quantity to include in a risk assessment, developing a list of screening criteria by which chemicals not anticipated to contribute significantly to the risk assessment may be eliminated, and finally developing a list of medium specific COPCs.

2.1 Data Summary

EPA (1989) recommends a multi-step process to evaluate available environmental data. An objective of the data evaluation is to ensure data of sufficient quality to be used to assess potential risks to human health. Simplified, the data evaluation process can be summarized by two main points:

- Gather all data available from the site investigation and sort by medium.
- Validate and evaluate the data submitted by the laboratory to ensure acceptability for use in the human health risk assessment.

For this recreational receptor-sediment only evaluation, sediment data were used from several sources. Below is a table presenting the information sources, authors (if available) and number of sediment samples which were compiled to perform this human health risk assessment:

Report	**Author**	**Date**	**Number of Sediment Samples**
Limited Environmental Investigation - Plastic Distribution Company	Environmental Compliance Services	September, 2000	10
Screening Level Ecological Risk Assessment	USEPA Region 1 Office of Ecological Assessment	April 19, 1999	4
Ongoing Phase II RI Investigation	Unknown	Unknown	23
Fort Devens Feasibility Study for Group 1A Sites	ABB Environmental Services	1995	51
Bioavailability and Potential Effects of Mercury and Selected Other Trace Metals on Biota in Plow Shop and Grove Ponds, Fort Devens	US Geological Survey	April 30, 2001	10

The total number of sediment samples collected was 98. Since analytical results were compiled from various sources, the total sample number for each inorganic analyte may differ. Table 2.1 presents the screening table for Chemicals of Potential Concern along with the frequency of detection for the metals evaluated. Uncertainties associated with compiling data from several sources are discussed in Section 6.2.

2.2. Selection of Chemicals of Potential Concern

This section presents the selection of Chemicals of Potential Concern (COPC) for all environmental media utilized in the human health risk assessment. The selection of COPCs was conducted in accordance with EPA (1989, 1994) guidance. The process is designed to narrow the focus of the risk assessment to those contaminants that may pose a threat to human health. The criteria used to limit the list of contaminants for future consideration is described below.

Selection Criteria

- **Risk-Based Screening.** Contaminants were screened against risk-based screening concentrations in order to further focus the risk assessment on the compounds that may have a toxic effect on human receptors. EPA Region IX produces a listing of Preliminary Remediation Goals (PRGs) which are updated annually and were accessed online at http://www.epa.gov/region09/waste/sfund/prg/. PRGs are chemical concentrations that correspond to a 1 E-6 cancer risk or a noncarcinogenic hazard quotient of 1 in soil, air and water.

  The more conservative residential PRGs were used for selected for screening of contaminants associated with the sediment samples evaluated for Grove Pond. Carcinogenic PRGs were used as published for screening of metals with carcinogenic endpoints. Noncarcinogenic PRGs were divided by a factor of 10 in order to account for the potential additive noncarcinogenic effects.

  Some COPCs were screened against PRGs which are noted in Table 2.1 as CAL-MOD. These PRGs California EPA PRGs where the CAL-EPA screening values which may be "significantly" more restrictive than the federal values and soil screening levels for protection of groundwater. (US EPA, 2001b)

Concentrations of chemicals which are below their respective risk-based screening value were not retained for further evaluation in the risk assessment.

- **Frequency of Detection.** Chemicals may be deleted from further consideration in the risk assessment if they are infrequently detected (EPA, 1989) or if the infrequent detection is shown not be indicative of a "hot spot." Contaminants detected infrequently at high concentrations are typically indicative of a hot spot, or highly localized area of contamination. Hot spot data should be evaluated in the risk assessment and are not eliminated from further consideration. However, contaminants detected infrequently and at low concentrations may be an analytical artifact and should not be carried through the risk assessment. Typically, a detected contaminant in less than 5% of at least 20 samples at a low concentration may be considered for removal from further consideration in the risk assessment, provided that the contaminant is not expected to be present based upon historic activities in the site. For conservatism, frequency of detection was not used to eliminate data from inclusion in the risk assessment.

- **Nutrients.** Essential human dietary nutrients were eliminated as COPC. EPA guidance considers calcium, chloride, iodine, magnesium, phosphorous, potassium and sodium, as essential nutrients. These essential nutrients were not retained for further evaluation in the risk assessment. However, the effect of omitting these chemicals from the quantitative risk analysis is discussed in the uncertainty section of this report.

- **Lead.** In the case of lead, insufficient information exists to develop risk-based screening values. Therefore, the EPA screening value (EPA, 1994a) of 400 mg/kg was used to screen sediments. This screening value was selected in accordance with EPA Region 1 guidance (EPA, November 1996.)

The data management procedures used for this risk assessment are explained in Appendix A. Data management with regard to screening procedures, and calculations of exposure point concentrations are also included in Appendix A.

The results of the screening process are presented in Table 2.1. The following metals have been identified as COPCs in sediment: aluminum, antimony, arsenic, barium, chromium, iron, lead, manganese, mercury and vanadium. Calcium, magnesium, potassium and sodium are essential nutrients, and are therefore not considered to be COPCs.

3.0 Exposure Assessment

Exposure is defined as the contact of a receptor with a chemical or physical agent (EPA 1989). An exposure assessment is the determination or estimation (qualitative or quantitative) of the magnitude, frequency, duration, and route of exposure. An exposure assessment is composed of the following steps:

- Characterization of the physical setting of the area, including contaminant sources
- Identification of potentially exposed populations
- Identification of potential exposure pathways
- Estimation of exposure concentrations
- Estimation of chemical intakes.

3.1 Characterization of the Physical Setting

A summary of the specific aspects of the physical setting, as they relate to the human health risk assessment, are presented below. Characterization of the physical setting will include current land uses and characteristics of site with regard to the human health risk assessment. The nature and extent of contamination will also be discussed in this section.

Grove Pond is a 60 acre, shallow pond with an average depth of 5 - 6 feet. Recreational features of the pond include a playground, a boat ramp with use restrictions and "Catch and Release" fishing. Expected recreational activities would including fishing and wading. Dense vegetation typically present on the pond surface would make the pond unattractive for swimming.

The pond is bordered on the west by a railroad causeway. Residences border the north end of the pond. There are water supply wells and a water treatment plant adjacent to the Pond at the southern end. The area is designated "Catch and Release" for recreational fishing.

3.2 Identification of Potential Exposure Pathways and Receptors

An exposure pathway describes the course a chemical or physical agent takes from the source to the exposed individual. A complete exposure pathway generally consists of three elements: (1) a source or chemical release from a source, (2) an exposure point where contact can occur, and (3) an exposure route (ie, ingestion) at the contact point. If any component is missing, the pathway is deemed incomplete and not quantitatively evaluated in the risk assessment. (EPA, 1989). Elimination of exposure pathways may occur based on professional judgement and evaluation of site-specific conditions, for example if the probability of exposure occurring is low or if the impact of the exposure pathway is expected to minor in comparison to other exposure pathways. (EPA, 1989.)

Table 1 presents the potential receptors and exposure pathways to be evaluated in this risk assessment. The most likely current receptors include recreational users exposed to contaminants in near-shore sediments while wading or fishing in Grove Pond. Other receptors and media will be evaluated in a future Remedial Investigation planned for the site.

The exposure parameters selected are intended to determine the Reasonable Maximum Exposure (RME) for each receptor scenario under current site conditions. The RME is the highest exposure that is reasonably expected to occur at a site. In accordance with the EPA-approved workplan for this risk assessment, Central Tendency risk characterizations were only to be performed for scenarios resulting in unacceptable risk and hazard indices under the RME scenario.

EPA has established default exposure assumptions for quantifying theoretical exposure doses of site contaminants. When default exposure parameters were not available, parameters were determined based on professional judgement to reflect the specific conditions at the site.

Default exposure assumptions were selected from the following sources:

EPA, 1989: Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.
EPA, 1991: EPA Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors." OSWER Directive 9285.6-03, March 25, 1991.
EPA, 1992: Dermal Exposure Assessment: Principles and Applications, Interim Report, EPA/600/8-91/011B.
EPA, 1994: USEPA, Region 1, Risk Update #2, August 1994.
EPA, 1995: Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment, EPA Region 4, Atlanta, GA, November 1995
EPA, 1997: EPA Exposure Factors Handbook, 1997.
EPA, 2000: Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part E, Supplement Guidance for Dermal Risk Assessment, Interim Guidance.

All exposure parameters for the RME exposure scenarios are presented in Tables 4.1 through 4.3. Any site-specific factors which were determined based on professional judgement are discussed below.

<u>Recreational User</u>

It is assumed that the recreational user (all ages) makes one visit per week, on average (52 visits per year). The recreational user is assumed to spend approximately 4 hours during each visit to Grove Pond.

The child recreational exposure duration is 6 years, from age 1-6. The youth recreational exposure duration is 10 years, from age 7-16. It order to complete the 30 year exposure duration, the adult exposure was assumed to be 14 years.

There is no default sediment ingestion rate. Therefore, the default soil ingestion rate of 100 mg/day was selected as the sediment ingestion rate. This ingestion rate was selected for all of the recreational receptors.

3.3 Estimation of Exposure Point Concentrations

According to USEPA guidance (December 1989, May 1992, September 1995), risk assessments are conducted using a representative Exposure Point Concentration (EPC). For this risk assessment, Exposure Point Concentrations (EPCs) were calculated for COPCs only.

Ideally, the EPC should be the true average concentration within the exposure unit. However, because of the uncertainty associated with estimating the true average concentration, the 95% upper confidence limit (UCL) of the arithmetic mean is used to determine the EPC.

In accordance with Region 1 guidance (EPA, 1994), the 95% UCLs were compared to the maximum concentration found for each analyte and the smaller of the two was chosen as the EPC and used for the dose calculations. In cases where the data set was small, the maximum concentration was used as the exposure point concentration. The data management portion, Appendix A, of this risk assessment provides a detailed description of the determination of the EPCs used in the risk assessment.

Table 3.1 present the 95% Upper Confidence Limits (UCLs), the Maximum Concentrations and the EPC selected for each COPC evaluated in sediment. The only exception to the selection of the 95% UCL as the RME EPC occurs in evaluation of lead. The TRW Interim Adult Lead Methodology recommends the use of the average lead in soil concentration when utilizing the Adult Lead Model.

3.4 Estimation of Exposure Doses and Intakes

The next step in the estimation of exposure is to determine the chemical-specific exposures for each pathway identified to be a complete exposure pathway. Exposure estimates are expressed in terms of the mass of the substance in contact with the body per unit body weight per unit time, typically mg of substance/kg of body weight per day. These exposures are termed "intakes" and are equivalent to administered or applied doses. These calculated intakes are expressed as the amount of chemical at the exchange boundary (ie, skin, lungs, gut) and available for absorption. The administered or applied dose is not equivalent to the amount of substance actually absorbed into the bloodstream. In the case of dermal exposure, intakes are multiplied by an absorption factor to determine the amount of the substance actually absorbed into the blood stream.

Calculation of intake factors or the daily dose for each chemical and receptor was performed for the appropriate exposure pathway. (e.g. ingestion and dermal). The equations are presented below.

The formula for the ingestion of sediment is presented below:

$$CDI(mg/kg-day) = \frac{CS\ x\ IR\ x\ CS\ x\ FI\ x\ EF\ x\ ED}{BW\ x\ AT} \qquad \text{Eq. 3.1}$$

where:

CDI = Chronic Daily Intake

CS = Chemical concentration in soil (mg/m^3)

IR = Ingestion Rate (mg soil/day)

CF = Conversion Factor (10^{-6} kg/mg)

FI = Fraction Ingested from Contaminated Source (unitless)

EF = Exposure Frequency (days/year)

ED = Exposure Duration (years)

BW = Body Weight (kg)

AT = Averaging Time (period over which exposure is averaged – days)

The absorbed dose formula for dermal exposure with chemicals in sediment is as follows:

$$CDI(mg / kg - day) = \frac{CS\ x\ CF\ x\ SA\ x\ AF\ x\ ABS\ x\ EF\ x\ ED}{BW\ x\ AT} \qquad \text{Eq. 3.2}$$

where:

CDI = Chronic Daily Intake

CS = Chemical concentration in soil (mg/m^3)

CF = Conversion Factor (10^{-6} kg/mg)

SA = Skin Surface Area Available for Contact (cm^2/event)

AF = Soil to Skin Adherence Factor (mg/cm^2)

ABS = Absorption Factor (unitless; see Table 4-4)

EF = Exposure Frequency (events/year)

ED = Exposure Duration (years)

BW = Body Weight (kg)

AT = Averaging Time (period over which exposure is averaged – days)

Lead Risk Evaluation

Typically, childhood exposure to lead is evaluated using the Integrated Biokinetic Exposure Uptake Biokinetic model. This model was not used for evaluation of either the child recreator's exposure to lead in soil due to the low exposure frequency inherit in the recreator's exposure. There is no model available for evaluation of the Recreational Youth's exposure to lead in soil. The IEUBK model can be applied to the 7-16 age group exposure, but was not utilized in this risk assessment due to the low exposure frequency for the Recreational Youth.

The U.S. EPA Technical Review Workgroup for Lead (TRW) has developed a model to predict blood-lead levels in adult receptors (U.S. EPA 1996). This model was run to assess potential adult recreational users for Grove Pond. Appropriate intake parameters were used for the adult recreational receptor to predict blood lead impacts for female recreators and their potential fetuses at the site. The TRW recommends a minimum exposure frequency of one day per week in order for the Adult Lead Model to be useful in evaluation of long term effects to exposure to lead in soil/sediment. The exposure frequency for the adult recreational receptor is 52 days per year, which meets the minimum requirements for use of the Adult Lead Model.

Blood Lead Level Calculation Equations are presented below:

$$PbB_{adult,central} = \frac{PbB_{adult,0} + PbS * BKSF * IRs * AFs * EFs}{AT} \qquad \text{Eq. 3.3}$$

and

$$PbB_{fetal,0.95} = PbB_{adult,central} * GSD^{1.645} * R_{fetal/maternal} \qquad \text{Eq. 3.4}$$

Where:

$PbB_{adult,central}$ = Central estimate of blood lead concentrations (ug/dL)

$PbB_{adult,0}$ = Typical adult blood level concentration (2.0 ug/dL; EPA, 1996)

$PbB_{fetal,0.95}$ = Goal for blood lead concentration among fetuses (ug/dL)

PbS = Sediment lead concentration (ug/g)

BKSF = Biokinetic slope factor (0.4 ug/dL per ug/day; EPA 1996)

IRs = Sediment Ingestion Rate (0.1 g/day)

AFs = Absolute gastrointestinal absorption fraction (0.12 unitless; EPA, 1996)

EFs = Exposure Frequency (52 days/year)
AT = Averaging Time (days)
GSD = Estimated value of individual geometric standard deviation (2.0 unitless; EPA, 1996)
R = Constant of proportionality between fetal blood lead conc. and maternal blood lead conc. (0.9 unitless; EPA, 1996)

4.0 Toxicity Assessment

The purpose of the toxicity assessment is to weigh available evidence regarding the potential for particular contaminants to cause adverse effects in exposed individuals and to provide, where possible, an estimate of the relationship between the extent of exposure to a contaminant and the increased likelihood of adverse effects (EPA, 1989). The toxicity assessment is composed of two parts:

- Hazard Identification - Hazard identification is the process of determining whether the exposure to a contaminant can cause an increase in the incidence of a particular adverse health effect. Hazard identification also involves characterizing the nature and strength of the evidence that adverse effects may occur as a result of exposure to an agent.

- Dose Response Evaluation - Does response evaluation is the process of quantitatively evaluating the toxicity information and characterizing the relationship between the dose of the contaminant received and the incidence of adverse health effects in the receptors. From this quantitative dose-response relationship, toxicity values can be derived to estimate the potential for adverse effects in receptors who may have been exposed to different concentrations of the specific agent.

Exposure to carcinogenic and non-carcinogenic toxic contaminants are responsible, by definition, for creating different toxic endpoints or effects. There are also differences in the biological processes through which carcinogenic and non-carcinogenic contaminants can cause adverse effects to a receptor. Therefore, the evaluation of carcinogenic and non-carcinogenic health effects are evaluated separately in human health risk assessments. The methods used to derive toxicity values for carcinogens and non-carcinogens are discussed below.

Toxicity values to be used in the quantitative risk assessment were chosen using the following hierarchy of toxicity information resources:

- The EPA's on-line IRIS database (EPA, 2001) containing toxicity values that have undergone the most rigorous Agency review
- The latest version of the annual HEAST, including all supplements (EPA, 1997b)
- Other EPA documents, memoranda, former Environmental Criteria and Assessment Office, or National Center for Environmental Assessment derivations for the Superfund Technical Support Center.

Noncarcinogenic toxicity values used in the risk assessment are provided in Table 5.1. Information regarding target organ effects are also presented in these tables. Carcinogenic toxicity values and weight of evidence information are presented in Table 6.1. Toxicity profiles for COPC's are presented in Appendix B.

Quantitative risk assessment cannot be performed for chemicals without chronic toxicity values. COPCs without toxicity values were evaluated qualitatively in the Uncertainty Discussion, Section 5.4 of this risk assessment. In some cases, toxicity information from a chemically and toxicologically similar may be used as a surrogate. Cases in which surrogate toxicity values are clearly indicated in the toxicity tables.

4.1 Noncarcinogenic Dose Response

A number of chemicals have been determined to have toxic effects other than carcinogenesis, such as respiratory illness, skin irritation, etc. In addition, chemicals may also be carcinogenic in addition to other toxic endpoints. The evaluation of noncancer effects (EPA 1989) involves:

- Qualitative identification of the adverse effect(s) associated with the chemical; these may differ depending on the duration (acute or chronic) or route (oral or inhalation) of exposure
- Identification of the critical effect for each duration of exposure (i.e., the first adverse effect that occurs as dose is increased)
- Estimation of the threshold dose for the critical effect for each duration of exposure
- Development of an uncertainty factor, i.e., quantification of the uncertainty associated with interspecies extrapolation, intraspecies variation in sensitivity, severity of the critical effect, slope of the dose-response curve, and deficiencies in the database, in regard to developing an RfD for human exposure
- Identification of the target organ for the critical effect for each route of exposure

The potential for noncarcinogenic health effects resulting from exposure to chemicals is assessed by comparing an exposure estimate (intake or dose) to a Reference Dose (RfD). RfDs are estimates (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. The RfD is expressed in units of mg/kg/day, and represents a daily intake of a contaminant per kilogram of body weight that is not sufficient to cause the threshold effect of concern. An RfD is specific to the chemical, the route of exposure, and the duration over which the exposure occurs. Separate RfDs are represented for the ingestion and dermal pathways.

RfDs are expressed as the administered dose. However, exposure estimates for the dermal pathway are expressed as an absorbed dose. Therefore, it is usually necessary to adjust oral toxicity values from administered to absorbed doses in order to evaluate the dermal exposure pathway. Dermal RfDs are derived from the corresponding oral values, provided there is no evidence to suggest that dermal exposure induces exposure route-specific effects that are not appropriately modeled by oral exposure data. Oral toxicity values are adjusted to account for oral absorption efficiencies of the specific chemical. Oral absorption efficiency values are referred to as Gastrointestinal Absorption Factors (GAFs). Chemical-specific GAF values were available from the toxicological resource the online database of the Risk Assessment Information System, Oak Ridge National Laboratory.

In the derivation of a dermal RfD, the oral RfD is multiplied by the gastrointestinal absorption factor (GAF), expressed as a decimal fraction. The resulting dermal RfD, therefore, is based on absorbed dose. The RfD based on absorbed dose is the appropriate value with which to compare a dermal dose, because dermal doses are expressed as absorbed rather than exposure dose.

RfD and RfC values are derived for both chronic and subchronic exposure. Under the assumption of monotoxicity (incidence, intensity, or severity of effects can increase but can not decrease, with increasing magnitude or duration of exposure), a chronic RfD may be considered sufficiently protective for subchronic exposure, but a subchronic RfD may not be protective for chronic exposure. Given the exposure durations involved in the scenarios at the site, chronic RfDs were used for the purposes of this risk assessment. Noncancer toxicity values are provided in Table 5.1.

4.1.1 Target Organ Toxicity

As a matter of science policy, EPA assumes dose-and effect- additivity for noncarcinogenic effects (EPA, 1989). This assumption provides the justification for adding the hazard quotients (HQ) or HIs in the risk characterization for noncancer effects resulting from exposure to multiple chemicals, pathways or media. EPA (1989), however, acknowledges that adding all HQ and HI values may overestimate hazard, because the assumption of additivity is probably appropriate only for those chemicals that exert their toxicity by the same mechanism.

Mechanism of toxicity data sufficient for predicting additivity with a high level of confidence are available for very few chemicals. In the absence of such data, EPA (1989) assumes that chemicals that act on the same target organ may do so by the same mechanism of toxicity, e.g., target organ serves as a surrogate for mechanism of toxicity. When the total HI for all media for a receptor exceeds 1 due to the contributions of several chemicals, it is appropriate to segregate the chemicals by route of exposure and mechanism of toxicity (i.e., target organ) and estimate separate HI values for each. Segregated target organ Hazard Indices for COPCs are provided in Tables 9.1 through 9.3. Further discussion concerning the Hazard Index calculation is presented in Section 5.1.

As a practical matter, since human environmental exposures are likely to involve near-or sub-threshold doses, the target organ chosen for a given chemical is the one associated with the critical effect. If more than one organ is affected at the threshold, the more severely affected organ is chosen. The target organ is also selected on the basis of duration of exposure (i.e., the target organ for chronic or subchronic exposure to low or moderate doses is selected rather than the target organ for acute exposure to high doses) and route of exposure. Because dermal RfD values are derived from oral RfD values, the oral target organ is adopted as the dermal target organ. For some chemicals, no target organ is identified. This occurs when no adverse effects are observed or when adverse effects such as reduced longevity or growth rate are not accompanied by recognized organ- or system-specific functional or morphologic alteration.

4.2 Carcinogenic Dose-Response

A number of chemicals are known, and many more are suspected, to be human carcinogens. The evaluation of potential carcinogenicity of a chemical includes both a qualitative and a quantitative aspect (EPA 1989). The qualitative aspect is a weight-of-evidence evaluation of the likelihood that a chemical might induce cancer in humans. The EPA weight-of-evidence classification is a system for characterizing the extent to which the available data indicate that an agent is a human carcinogen (EPA, 1989). EPA (1989) currently recognizes six weight-of-evidence classifications for carcinogenicity.

- Group A - Human Carcinogen. Human data are sufficient to identify the chemical as a human carcinogen.

- Group B1 - Probable Human Carcinogen. Human data indicate that a causal association is credible, but alternative explanations can not be dismissed.

- Group B2 - Probable Human Carcinogen. Human data are insufficient to support a causal association, but testing in animals support a causal association.

- Group C - Possible Human Carcinogen. Human data are inadequate or lacking, but animal data suggest a causal association, although the studies have deficiencies that limit interpretation.

- Group D - Not Classifiable as to Human Carcinogenicity. Human and animal data are lacking or inadequate.

- Group E - Evidence of Noncarcinogenicity to Humans. Human data are negative or lacking, and adequate animal data indicate no association with cancer.

EPA (1989) assumes that a small number of molecular events can create changes in a single cell that can lead to uncontrolled cellular proliferation and eventually to clinical cancer. This hypothesized mechanism for carcinogenesis is referred to "nonthreshold," because there is believed to be essentially no threshold below which harmful effects may possibly occur as a result of exposure.

The toxicity value for carcinogenicity, called a cancer slope factor (CSF), is an estimate of carcinogen potency. Potency estimates are developed only for chemicals in Groups A, B1, B2, and C (known or suspected carcinogens), and only if data are sufficient. The potency estimates are statistically derived from the dose-response curve from the best human or animal studies of the chemical. The CSFs should always be accompanied by the weight-of-evidence classification to indicate the strength of the evidence that the agent is a human carcinogen (EPA, 1989). The CSF is usually described as the "excess risk" per unit dose above the rate that might normally be expected in the general population. The CSF is calculated according to the following equation:

$$\left(p_{(d)} - p_{(0)}\right) / \left(1 - p_{(0)}\right) \qquad \text{Eq. 4.2}$$

where:

$p_{(d)}$ = the probability of cancer associated with dose = 1 mg/kg-day
$p_{(0)}$ = the background probability of developing cancer at dose = 0 mg/kg-day

The CSF is expressed as risk per mg/kg-day. To be appropriately conservative, the CSF is usually the 95 percent upper-bound on the slope of the dose-response curve extrapolated from high (experimental) doses to the low-dose range expected in environmental exposure scenarios.

The oral CSF is usually derived directly from the experimental dose data, because oral dose is usually expressed as mg/kg-day. When the test chemical is administered in the diet or drinking water, oral dose first must be estimated from the test chemical in the food or water, food or water intake data, and body weight data.

CSFs are expressed as the administered dose. However, exposure estimates for the dermal pathway are expressed as an absorbed dose. Therefore, it is usually necessary to adjust oral toxicity values from administered to absorbed doses in order to evaluate the dermal exposure pathway. Dermal CSFs are derived from the corresponding oral values, provided there is no evidence to suggest that dermal exposure induces exposure route-specific effects that are not appropriately modeled by oral exposure data. Oral toxicity values are adjusted to account for oral absorption efficiencies of the specific chemical. Oral absorption efficiency values are referred to as Gastrointestinal Absorption Factors (GAFs). Chemical-specific GAF values were available from the toxicological resource the online database of the Risk Assessment Information System, Oak Ridge National Laboratory.

The dermal CSF is derived by dividing the oral CSF by the GAF. The oral CSF is divided, rather than multiplied, by the GAF because CSFs are expressed as reciprocal dose. The EPA weight-of-evidence group and the oral and dermal CSFs for COPCs are presented in Table 6.1.

4.3 Compound-Specific Dose - Response

Evaluation of Noncarcinogenic Effects for Iron

Region 1 guidance (EPA, August 1999) does not endorse the use of provisional RfDs for iron. Therefore, any risks associated with these chemicals were evaluated qualitatively in the Uncertainty Section of the risk assessment.

Evaluation of Effects of Exposure to Lead in Sediment

As previously discussed, evaluation of effects of exposure to lead in sediment was conducted using the TRW Adult Lead Model. Results of the Adult Lead Model evaluation are presented in Table 7.4.

5.0 Risk Characterization

Risk characterization is the combination of the results of the exposure assessment and toxicity assessment to yield a quantitative expression of risk for the exposed receptors. This quantitative expression is the probability of developing cancer, or a nonprobabilistic comparison of estimated dose with a reference dose for noncancer effects. Quantitative estimates are developed for individual chemicals, exposure pathways, and exposure media for each receptor.

The risk characterizations presented in this risk assessment are based on the Reasonable Maximum

Exposure (RME) scenario and are generally used to guide risk management decisions. In accordance with the EPA-approved workplan for this risk assessment, Central Tendency risk characterizations were to be performed for scenario resulting in unacceptable risk and hazard indices under the RME scenario. No RME risk characterizations exceeded unacceptable risk and hazard indices; therefore, no Central Tendency evaluation was conducted.

Generally, risk characterization follows the methodology prescribed by EPA (1989a), as modified by more recent information and guidance. The EPA methods are, appropriately, designed to be health-protective, and tend to overestimate, rather than underestimate, risk. The risk results, however, are generally overly conservative, because risk characterization involves multiplication of the conservatism built into the estimation of source-term and exposure-point concentrations, the exposure (intake) estimates, and the toxicity dose-response assessments.

Although some chemicals induce both cancer and noncancer effects, the risks for each endpoint are calculated separately.

5.1 Non-cancer Risks

The Hazard Quotient (HQ) is the potential for noncarcinogenic effects as a result of exposure. The HQ is a ratio of exposure over a specified period of time to a referenced dose derived for a similar period of time. As a rule, the greater the value of the HQ above unity (HQ>1), the greater the level of concern.

Estimating risk or hazard by considering only one chemical at a time might significantly underestimate the risks associated with simultaneous exposures to several COPCs. To assess the potential for noncarcinogenic effects posed by more than one COPC, a Hazard Index (HI) is then calculated. The HI is equal to the sum of the hazard quotients.

The following risk equations were used to calculate hazard quotient (HQ):

Hazard Quotient Calculation Equation:

$$HQ = CDI / RfD$$

Eq. 5.1

where, HQ = hazard quotient (unitless)
CDI = chronic daily intake (mg/kg-day)
RfD = reference dose (mg/kg-day)

In cases where the HI exceeds 1.0, the Hazard Indices were segregated by target organ and associated critical effect. This approach more appropriately results in identification of endpoints that reflect adverse effects on the same organ system by the same mechanism. Segregation of HI requires identification of the major effect(s) of each COPC. The target organ effect were selected based on the target organ corresponding to the oral RfD listed in IRIS and HEAST or information in ATSDR profiles. In cases where a COPC affects more than one target organ, the HI was used to calculate the target organ effect for each target organ it affects.

The noncancer risk calculations for all receptors are presented in Tables 7.1 through 7.12.

5.2 Cancer Risks

For carcinogens, risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen.

Cancer Risk Calculation Equation:

$$CR = CDIxCSF$$

Eq. 5.2

where, CR = cancer risk (unitless)

CDI = chronic daily intake (mg/kg-day)

CSF = cancer slope factor ((mg/kg-day)$^{-1}$)

The cancer risk calculations for all receptors are presented in Tables 8.1 through 8.12.

5.3 Hazard Index and Cancer Risk Summaries

Adult Recreational User - A summary of the cancer risks and non-cancer hazard indices for the Adult Recreational User are presented in Table 9.1. This receptor is assumed to be exposed to sediment through incidental ingestion and dermal contact.

> Sediment - None of the hazard indices for the Adult Recreational User exceeded the USEPA target of 1.0. All calculated cancer risks associated with this receptor's exposure to sediment were within or below the USEPA target risk range of 1 E-04 to 1 E-06. The Adult Recreational User was also evaluated for potential exposure to lead in sediment. The Adult Lead Model was run and conclusions are presented in Table 7.4. Table 7.4 presents the conclusions that the fetal blood lead levels will be less than the EPA blood lead level of concern of 10 ug/dL.

Youth Recreational User - A summary of the cancer risks and non-cancer hazard indices for the Youth Recreational User are presented in Table 9.2. This receptor is also assumed to be exposed to sediment through incidental ingestion and dermal contact.

> Sediment - None of the hazard indices for the Youth Recreational User exceeded the USEPA target of 1.0. All calculated cancer risks associated with this receptor's exposure to sediment were within or below the USEPA target risk range of 1 E-04 to 1 E-06.

Child Recreational User - A summary of the cancer risks and non-cancer hazard indices for the Child

Recreational User are presented in Table 9.3. This receptor is also assumed to be exposed to sediment through incidental ingestion and dermal contact.

<u>Sediment</u> - None of the hazard indices for the Child Recreational User exceeded the USEPA target of 1.0. All calculated cancer risks associated with this receptor's exposure to sediment were within or below the USEPA target risk range of 1 E-04 to 1 E-06.

<u>Lifetime Recreational User</u> - The cancer risk to the lifetime recreational user was calculated by adding the individual cancer risks for the Child, Youth and Adult Recreational Users. The total lifetime cancer risk to the recreational user is presented in Table 7.1.

<u>Sediment</u> - The lifetime cancer risk to the lifetime recreational user was within the USEPA target risk range of 1E-05 to 1 E-06.

6.0 Uncertainty Analysis

6.1 Inherent Sources of Uncertainty

Since the assumptions and other aspects of risk assessments are intended to be conservative, some degree of uncertainty is inherent to the process. Inherent sources of uncertainty typically relate to four areas:

1.) the data evaluation process
2.) the exposure assessment;
3.) the toxicity assessment;
4.) the risk characterization.

Inherent sources of uncertainty relating to the data evaluation process include:

- Field Sampling location bias: sample locations were biased toward areas of highest contamination

- Use of one-half the detection limit for all non-detected values when calculating 95% UCL of the mean
- Lack of consideration of source depletion, natural degradation or attenuation of COPCs over time
- Limitations on the determination of background conditions

Inherent sources of uncertainty relating to the exposure assessment include:

- Assumption that exposure scenarios and contact with affected media will occur
- Selection of the 95% UCL of the mean or the maximum concentration for the exposure point concentration
- Assumption of frequent, routine exposure over prolonged durations
- Use of default exposure values for physiological parameters such as skin surface area, inhalation rate and soil ingestion rates
- Assumption that some pathways are negligible in comparison to others

Inherent sources of uncertainty relating to the toxicity analysis include:

- Use of published RfDs and SFs derived by standard EPA methods
- Derivation of dermal SFs and RfDs using GAF values
- Derivation of inhalation RfDs from published RfC values
- Derivation of toxicity values for cPAHs based on TEFs
- Lack of toxicity values for some chemicals or exposure routes
- Assumption of bioavailability of COPCs from soil

Inherent sources of uncertainty relating to the risk characterization include:

- Assumption of additivity of toxicological effects
- risk characterization does not consider antagonistic or synergistic effects. Little information is available to determine the potential for antagonism or synergism for the COPCs. Therefore, this uncertainty cannot be discussed for its impact on the risk

assessment, since it may either underestimate or overestimate potential human health risk.

6.2 Site-Specific Sources of Uncertainty

In addition to the uncertainties inherent in the risk assessment process, there are typically uncertainties associated with site-specific information, contaminants or conditions. The following site-specific sources of uncertainty apply to this site:

Sediment COPC Selection

Since screening values are not available for sediment, residential soil screening values were used in the selection of COPCs for sediment. This is considered a conservative approach which may actually overestimate potential risks.

Lack of Noncarcinogenic Assessment for Iron

Region 1 Guidance does not recommend the use of the provisional reference dose for calculation of noncarcinogenic effects of exposure to iron. Therefore, the hazard index for iron in sediment exposures was not calculated. This represents a potential for underestimation of potential risks associated with iron in sediment.

Overall Data Quality Uncertainty and Question of Representativeness

Data used in this human health risk evaluation were compiled from several sources. The differences inherent in the six separate sampling events undertaken at Grove Pond may introduce potential underestimation and overestimation of risks associated with the metals detected in sediment.

7.0 Summary and Conclusions.

7.1 Summary of Risk Characterization

Tables 10.1 through 10.3 present summaries of the cancer risks and noncancer hazard indices which exceeded or were within EPA acceptance criteria for each receptor evaluated in the risk assessment. These tables identify the chemicals which are driving the risks and present the hazard indices segregated by target organ. Section 6.0 presented the uncertainties associated with the risk evaluations and presented rationale for consideration in determining the chemicals of concern for this site which may require further evaluation and action.

7.2 Conclusions

Table 7-1 presents a Line-of-Evidence matrix for determination of chemicals of concern (COCs) based on the results of the human health risk assessment. Risks were evaluated for sediment for potential recreational receptors. Potential risks for the evaluated media, sediment, for the evaluated receptor (recreational), were accepta;le.

Table 7-1

HUMAN HEALTH RISK ASSESSMENT FOR GROVE POND

SUMMARY OF HUMAN HEALTH RISK CALCULATIONS BASED ON RME

	Carcinogenic Risks (ILCRs)	**Noncarcinogenic Risks (His)**
Current Use Scenarios		
Adult Recreational User	4.0×10^{-6}	1.0×10^{-1}
Youth Recreational User	4.5×10^{-6}	1.6×10^{-1}
Child Recreational User	7.8×10^{-6}	4.6×10^{-1}
Lifetime Recreational User	1.6×10^{-5}	Not Applicable

References for Human Health Risk Assessment

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USGS, 2001 U.S. Department of the Interior, U.S. Geological Survey, **Bioavailability and Potential Effects of Mercury and Selected Other Trace Metals on Biota in Plow Shop and Grove Ponds, Fort Devens, Massachusetts.** April, 2001.

TABLE 1

SELECTION OF EXPOSURE PATHWAYS

GROVE POND - Metals in Sediment Evaluation

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current	**Sediment**	Sediment	Grove Pond	Recreational User	Adult	Ingestion	On-Site	Quant	Onsite receptor may be exposed to sediment during recreational activities.
						Dermal	On-Site	Quant	Onsite receptor may be exposed to sediment during recreational activities.
					Youth	Ingestion	On-Site	Quant	Onsite receptor may be exposed to sediment during recreational activities.
						Dermal	On-Site	Quant	Onsite receptor may be exposed to sediment during recreational activities.
					Child	Ingestion	On-Site	Quant	Onsite receptor may be exposed to sediment during recreational activities.
						Dermal	On-Site	Quant	Onsite receptor may be exposed to sediment during recreational activities.

TABLE 2.1
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
GROVE POND - Metals in Sediment Evaluation

Scenario Timeframe:	Current
Medium:	Sediment
Exposure Medium:	Sediment
Exposure Point:	Sediment

CAS Number	Chemical	Minimum Concentration [1]	Maximum Concentration [1]	Units	Detection Frequency	Concentration Used for Screening [2]	Screening Toxicity Value [4]	Notes	COPC Flag	Rationale for Contaminant Deletion or Selection [5]
7429905	Aluminum	2.33E+03	9.00E+04	mg/kg	78/78	9.00E+04	7.61E+03	nc	Yes	ASL
7440360	Antimony	4.92E+01	1.17E+02	mg/kg	3/88	1.17E+02	3.13E+00	nc	Yes	ASL
7440382	Arsenic	4.16E+00	3.40E+02	mg/kg	69/98	3.40E+02	3.90E-01	c	Yes	ASL
7440393	Barium	7.40E+00	4.70E+02	mg/kg	64/78	4.70E+02	2.16E+00	nc	Yes	ASL
7440417	Beryllium	9.50E-01	1.41E+01	mg/kg	10/88	1.41E+01	5.37E+02	nc	No	BSL
7440439	Cadmium	4.89E-01	1.10E+02	mg/kg	53/98	1.10E+02	1.54E+01	nc	No	BSL
7440702	Calcium	1.50E+02	2.15E+05	mg/kg	78/78	2.15E+05	2.00E-01	NUT	No	NUT
18540299	Chromium	4.69E+00	4.98E+04	mg/kg	96/98	4.98E+04	3.01E+01	c	Yes	ASL
7440484	Cobalt	2.30E+00	5.34E+01	mg/kg	50/78	5.34E+01	4.69E+02	c	No	BSL
7440508	Copper	1.33E+00	2.40E+02	mg/kg	84/88	2.40E+02	2.91E+02	c	No	BSL
7439896	Iron	2.37E+03	4.28E+04	mg/kg	78/78	4.28E+04	2.35E+03	nc	Yes	ASL
7439921	Lead	3.29E+00	1.76E+03	mg/kg	89/98	1.76E+03	4.00E+02	nc	Yes	ASL
7439954	Magnesium	3.73E+02	5.30E+03	mg/kg	72/78	5.30E+03	NA	NUT	No	NUT
7439965	Manganese	2.65E+01	1.73E+03	mg/kg	78/78	1.73E+03	1.76E+02	nc	Yes	ASL
7439976	Mercury	2.45E-02	2.20E+02	mg/kg	57/71	2.20E+02	2.35E+00	nc	Yes	ASL
22967926	Methyl Mercury	2.80E-04	7.04E-02	mg/kg	10/10	7.04E-02	6.11E-01	nc	No	BSL
7440020	Nickel	1.98E+00	7.18E+01	mg/kg	81/88	7.18E+01	1.56E+02	nc	No	BSL
7440097	Potassium	4.25E+02	1.93E+03	mg/kg	17/78	1.93E+03	NA	NUT	No	NUT
7782492	Selenium	2.04E+00	7.80E+00	mg/kg	8/88	7.80E+00	3.91E+01	nc	No	BSL
7440235	Sodium	1.62E+02	7.02E+03	mg/kg	56/78	7.02E+03	NA	NUT	No	NUT
7440622	Vanadium	3.39E+00	1.11E+02	mg/kg	59/78	1.11E+02	5.47E+01	nc	Yes	ASL
7440666	Zinc	3.12E+00	7.55E+02	mg/kg	86/88	7.55E+02	2.35E+03	nc	No	BSL

(1) Minimum/maximum detected concentration.
(2) Maximum concentration used as screening value.
(3) Metals compared to twice the average background concentration when available as per EPA Region IV guidance.
(4) EPA Region IX Preliminary Remediation Goals.
(5) Rationale Codes

Selection Reason: Above Screening Level (ASL)

Deletion Reason:
No Toxicity Information Available (NTX) (Retained for qualitative evaluation)
Below Sceening Level (BSL)
Below Background Level (BBL)
Essential Nutrient (NUT)

Definitions:
NA = Not Applicable for Not Available
COPC = Chemical of Potential Concern
NUT = Essential Nutrient
nc = noncarcinogen
c = carcinogen
CAL Mod = California Modified

TABLE 3.1
MEDIUM - SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY
GROVE POND - Metals in Sediment Evaluation

Scenario Timeframe:	Current
Medium:	Sediment
Exposure Medium:	Sediment
Exposure Point:	Sediment

Chemical of Potential Concern	Units	Arithmetic Mean	Data Distribution Type	95% UCL	Maximum Detected Concentration	EPC Units	Reasonable Maximum Exposure		
							Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale
Aluminum	mg/kg	1.07E+04	Nonparametric	8.39E+03	9.00E+04	mg/kg	8.39E+03	95% UCL-NP	(4)
Antimony	mg/kg	6.35E+00	Nonparametric	1.56E+00	1.17E+02	mg/kg	1.56E+00	95% UCL-NP	(4)
Arsenic	mg/kg	6.69E+01	Nonparametric	6.16E+01	3.40E+02	mg/kg	6.16E+01	95% UCL-NP	(4)
Cadmium	mg/kg	1.09E+01	Nonparametric	7.14E+00	1.10E+02	mg/kg	7.14E+00	95% UCL-NP	(4)
Chromium	mg/kg	5.04E+03	Nonparametric	4.91E+02	4.71E+04	mg/kg	4.91E+02	95% UCL-NP	(4)
Iron	mg/kg	1.47E+04	Lognormal	1.70E+04	4.28E+04	mg/kg	1.70E+04	95% UCL-T	(4)
Lead	mg/kg	2.25E+02	Nonparametric	1.68E+02	1.76E+03	mg/kg	2.25E+02	Mean	(5)
Manganese	mg/kg	6.07E+02	Nonparametric	6.75E+02	1.72E+03	mg/kg	6.75E+02	95% UCL-NP	(4)
Mercury	mg/kg	1.41E+01	Nonparametric	3.61E+00	2.20E+02	mg/kg	3.61E+00	95% UCL-NP	(4)
Vanadium	mg/kg	2.91E+01	Nonparametric	3.05E+01	1.08E+02	mg/kg	3.05E+01	95% UCL-NP	(4)

(1) Fewer than 5 data points. The distribution type and 95% UCL were not evaluated.
(2) Distribution classified as nonparametric but the 95% UCL of the median was not evaluated due to the number of data points (<20).
(3) Maximum was lower than the 95% UCL or the 95% UCL was not evaluated.
(4) The 95% UCL was lower than the maximum detected value.
(5) Mean lead concentration used in Adult Lead Model.
Statistics: Maximum Detected Value (Max); 95% UCL of Normal Data (95% UCL-N); 95% UCL of Log-transformed Data (95% UCL-T); 95% UCL of Nonparametric Data (95% UCL-NP)

TABLE 4-1

VALUES USED FOR DAILY INTAKE CALCULATIONS

Grove Pond - Metals in Sediment Evaluation

Scenario Timeframe: Current
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Sediment
Receptor Population: Recreational User
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CSD	Chemical concentration in sediment	mg/kg	EPC	See Table	Chronic Daily Intake (CDI) (mg/kg-day) = (CSD x IR x FI x EF x ED x CF)/(BW x AT)
	IR	Ingestion rate	mg/day	100	Professional Judgment	
	FI	Fraction ingested	unitless	100%	Professional Judgment	
	EF	Exposure Frequency	days/year	52	Professional Judgment	
	ED	Exposure Duration	years	14	Professional Judgment	
	CF	Conversion factor	kg/mg	1.00E-06	- -	
	BW	Body weight	kg	70	EPA, 1994	
	AT-C	Averaging time (Cancer)	days	25,550	EPA, 1989	
	AT-N	Averaging time (Noncancer)	days	5,110	EPA, 1989	
Dermal	CSD	Chemical concentration in sediment	mg/kg	EPC	See Table	CDI (mg/kg-day) = (CSD x SA x AF x ABS x ET x EF x ED xCF)/(BW x AT)
	SA	Surface Area **	cm^2	5,200	EPA 1997, Table 6-4	
	AF	Soil-Skin Adherence factor	mg/cm^2	0.2	EPA, 1992	
	ABS	Absorption factor	unitless	chemical specific	See Table	
	ET	Exposure Time	fraction of a day	0.166	Professional Judgment	
	EF	Exposure Frequency	days/year	52	Professional Judgment	
	ED	Exposure Duration	years	14	Professional Judgment	
	CF	Conversion factor	kg/mg	1.00E-06	- -	
	BW	Body weight	kg	70	EPA, 1994	
	AT-C	Averaging time (Cancer)	days	25,550	EPA, 1989	
	AT-N	Averaging time (Noncancer)	days	5,110	EPA, 1989	

**Surface area value includes hands, forearms, lower legs and feet for adults.

EPA, 1989: Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

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EPA, 1997: EPA Exposure Factors Handbook, 1997.

EPA, 2000: Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part E, Supplement Guidance for Dermal Risk Assessment, Interim Guidance.

TABLE 4-2

VALUES USED FOR DAILY INTAKE CALCULATIONS

Grove Pond - Metals in Sediment Evaluation

Scenario Timeframe: Current
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Sediment
Receptor Population: Recreational User
Receptor Age: Youth (age 7-16)

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CSD	Chemical concentration in sediment	mg/kg	EPC	See Table	Chronic Daily Intake (CDI) (mg/kg-day) =
	IR	Ingestion rate	mg/day	100	Professional Judgment	(CSD x IR x FI x EF x ED x CF)/(BW x AT)
	FI	Fraction ingested	unitless	100%	Professional Judgment	
	EF	Exposure Frequency	days/year	52	Professional Judgment	
	ED	Exposure Duration	years	10	Age 7-16	
	CF	Conversion factor	kg/mg	1.00E-06	- -	
	BW	Body weight	kg	45	EPA, 1991	
	AT-C	Averaging time (Cancer)	days	25,550	EPA, 1989	
	AT-N	Averaging time (Noncancer)	days	3,650	EPA, 1989	
Dermal	CSD	Chemical concentration in sediment	mg/kg	EPC	See Table	CDI (mg/kg-day) =
	SA	Surface Area **	cm^2	5,200	EPA, 1997 Table 6-4	(CSD x SA x AF x ABS x ET x EF x ED xCF)/(BW x AT)
	AF	Soil-Skin Adherence factor	mg/cm^2	0.2	EPA, 1992	
	ABS	Absorption factor	unitless	chemical specific	See Table	
	ET	Exposure Time	fraction of a day	0.166	Professional Judgment	
	EF	Exposure Frequency	days/year	52	Professional Judgment	
	ED	Exposure Duration	years	10	Age 7-16	
	CF	Conversion factor	kg/mg	1.00E-06	- -	
	BW	Body weight	kg	45	EPA, 1991	
	AT-C	Averaging time (Cancer)	days	25,550	EPA, 1989	
	AT-N	Averaging time (Noncancer)	days	3,650	EPA, 1989	

**Surface area value includes hands, forearms, lower legs and feet for adults.

EPA, 1989: Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

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EPA, 1997: EPA Exposure Factors Handbook, 1997.

EPA, 2000: Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part E, Supplement Guidance for Dermal Risk Assessment, Interim Guidance.

TABLE 4-3

VALUES USED FOR DAILY INTAKE CALCULATIONS

Grove Pond - Metals in Sediment Evaluation

Scenario Timeframe: Current
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Sediment
Receptor Population: Recreational User
Receptor Age: Child 1-6

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CSD	Chemical concentration in sediment	mg/kg	EPC	See Table	Chronic Daily Intake (CDI) (mg/kg-day) =
	IR	Ingestion rate	mg/day	100	Professional Judgment	(CSD x IR x FI x EF x ED x CF)/(BW x AT)
	FI	Fraction ingested	unitless	100%	Professional Judgment	
	EF	Exposure Frequency	days/year	52	Professional Judgment	
	ED	Exposure Duration	years	6	Age 1-6	
	CF	Conversion factor	kg/mg	1.00E-06	- -	
	BW	Body weight	kg	15	EPA, 1994	
	AT-C	Averaging time (Cancer)	days	25,550	EPA, 1989	
	AT-N	Averaging time (Noncancer)	days	2,190	EPA, 1989	
Dermal	CSD	Chemical concentration in sediment	mg/kg	EPC	See Table	CDI (mg/kg-day) =
	SA	Surface Area **	cm^2	2,800	EPA, 1997 Table 6-6	(CSD x SA x AF x ABS x ET x EF x ED xCF)/(BW x AT)
	AF	Soil-Skin Adherence factor	mg/cm^2	0.2	EPA, 1992	
	ABS	Absorption factor	unitless	chemical specific	See Table	
	ET	Exposure Time	fraction of a day	0.166	Professional Judgment	
	EF	Exposure Frequency	days/year	52	Professional Judgment	
	ED	Exposure Duration	years	6	Age 1-6	
	CF	Conversion factor	kg/mg	1.00E-06	- -	
	BW	Body weight	kg	15	EPA, 1994	
	AT-C	Averaging time (Cancer)	days	25,550	EPA, 1989	
	AT-N	Averaging time (Noncancer)	days	2,190	EPA, 1989	

**Surface area value includes head, hands, forearms, lower legs and feet.

EPA, 1989: Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 1991: EPA Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors." OSWER Directive 9285.6-03, March 25, 1991.

EPA, 1992: Dermal Exposure Assessment: Principles and Applications, Interim Report, EPA/600/8-91/011B.

EPA, 1994: USEPA, Region 1, Risk Update #2, August 1994.

EPA, 1995: Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment, EPA Region 4, Atlanta, GA, November 1995

EPA, 1997: EPA Exposure Factors Handbook, 1997.

EPA, 2000: Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part E, Supplement Guidance for Dermal Risk Assessment, Interim Guidance.

TABLE 4-4
VALUES USED FOR DAILY INTAKE CALCULATIONS
Grove Pond - Metals in Sediment Evaluation
DERMAL ABS VALUES

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: NA
Exposure Point: NA
Receptor Population: NA
Receptor Age: NA

Exposure Route	Parameter Code	Parameter Definition	Paramater	ABS Value	RME Rationale/ Reference
Dermal	ABS	Absorption Factor	Arsenic	0.03	EPA, 2000
			Cadmium	0.001	EPA, 2000
			PAHs	0.13	EPA, 2000
			Other SVOCs	0.1	EPA, 2000
			VOCs	NA	EPA, 2000
			Other Inorganics	NA	EPA, 2000

EPA, 2000: Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part E, Supplement Guidance for Dermal Risk Assessment, Interim Guidance.

TABLE 5.1

NON-CANCER TOXICITY DATA -- ORAL/DERMAL

Grove Pond

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Oral to Dermal Adjustment Factor (1) (GAF)	Adjusted Dermal RfD	Units	Primary Target Organ/Effects	Combined Uncertainty/Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (2) (MM/DD/YY)
Aluminum	Chronic	1.00E+00	mg/kg-day	0.10	1.00E-01	mg/kg-day	Neurological effects	NA	EPA/NCEA	Tox Profile
Antimony	Chronic	4.00E-04	mg/kg-day	0.02	8.00E-06	mg/kg-day	Blood	1000	IRIS	09/20/01
Arsenic	Chronic	3.00E-04	mg/kg-day	0.41	1.23E-04	mg/kg-day	Hyperpigmentation/Keratosis	3	IRIS	01/10/00
Cadmium	Chronic	1.00E-03	mg/kg-day	0.01	1.00E-05	mg/kg-day	Kidney	10	IRIS	09/30/01
Chromium	Chronic	3.00E-03	mg/kg-day	0.02	6.00E-05	mg/kg-day	None Identified	300	IRIS	01/10/00
Iron	Chronic	NA (5))	mg/kg-day	NA	NA	mg/kg-day	NA	NA	NA	NA
Lead	Chronic	NA (4)	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	Chronic	1.40E-01	mg/kg-day	0.04	5.60E-03	mg/kg-day	CNS	1	IRIS	09/30/01
Mercury (3)	Chronic	3.00E-04	mg/kg-day	0.07	2.10E-05	mg/kg-day	Kidney	10	IRIS	03/27/00
Vanadium	Chronic	7.00E-03	mg/kg-day	0.01	7.00E-05	mg/kg-day	Blood	NA	HEAST	1997

NA = Not Available

RfD = Reference Dose

IRIS = Integrated Risk Information System, US Environmental Protection Agency, http://www.epa.gov/iris

EPA/NCEA = US Environmental Protection Agency/National Center for Environmental Assessment (as per EPA Region 3 RBC Tables, October 2000.)

HEAST = Health Effects Assessment Summary Tables, US Environmental Protection Agency, July 1997.

Surrogate 1 = Naphthalene used as a surrogate.

Surrogate 2 = 2-methyl-Naphthalene used as a surrogate.

(1) Oral Reference Dose * Gastrointestinal Absorption Factor (GAFs) = Adjusted Dermal Reference Dose

Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Part E, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance, 2000.

Chemical-Specific GAF values were obtained from the Oak Ridge National Laboratory TOX Information Site: http://risk.lsd.ornl.gov/cgi-bin/tox/

When chemical-specific GAF values were not available EPA Region 4 default value of 20% for inorganics was used.

(2) For IRIS values, the date that the IRIS database was searched is provided.

(3) Mercuric Chloride toxicity value used.

(4) Lead will be evaluated using the Adult Lead Model.

(5) Region 1 Guidance does not endorse the use of the provisional RfD for iron evaluation.

TABLE 6.1

CANCER TOXICITY DATA -- ORAL/DERMAL

Grove Pond

Chemical of Potential Concern	Oral Cancer Slope Factor	Oral to Dermal Adjustment Factor (GAF)	Adjusted Dermal Cancer Slope Factor (1)	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (2) (MM/DD/YY)
Aluminum	NA	0.10	NA	NA	NA	NA	NA
Antimony	NA	0.02	NA	NA	NA	NA	NA
Arsenic	1.50E+00	0.41	3.66E+00	$(mg/kg\text{-}day)^{-1}$	A	IRIS	01/10/00
Cadmium	NA	0.01	NA	NA	B1	IRIS	09/30/01
Chromium	NA	0.02	NA	NA	NA	NA	NA
Iron	NA	0.15	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	0.04	NA	NA	D	IRIS	09/30/01
Mercury	NA	0.07	NA	NA	NA	NA	NA
Vanadium	NA	0.01	NA	NA	NA	NA	NA

NA = Not Available

EPA Group:

A - Human carcinogen

B1 - Probable human carcinogen - indicates that limited human data are available

B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans

C - Possible human carcinogen

D - Not classifiable as a human carcinogen

E - Evidence of noncarcinogenicity

IRIS = Integrated Risk Information System, US Environmental Protection Agency, http://www.epa.gov/iris

EPA/NCEA = US Environmental Protection Agency/National Center for Environmental Assessment.
(as per EPA Region 3 RBC Tables, October 2000.)

HEAST = Health Effects Assessment Summary Tables, US Environmental Protection Agency, July 1997.

(1) Oral Cancer Slope Factor/Gastrointestinal Absorption Factor (GAFs) = Adjusted Dermal Cancer Slope Factor

Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Part E, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance, 2000.

Chemical-Specific GAF values were obtained from the Oak Ridge National Laboratory TOX Information Site: http://risk.lsd.ornl.gov/cgi-bin/tox/

When chemical-specific GAF values were not available EPA Region 4 default value of 20% for inorganics was used.

(2) For IRIS values, the date that the IRIS database was searched is provided.

TABLE 7.1
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
GROVE POND - Metals in Sediment Evaluation

Scenario Timeframe:	Current
Medium:	Sediment
Exposure Medium:	Sediment
Exposure Point	Sediment
Receptor Population:	Recreational User
Receptor Age:	Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation	Intake (Non-Cancer)	Intake Units	Reference Dose	Reference Dose Units	Hazard Quotient
Ingestion	Aluminum	8.39E+03	mg/Kg	8.39E+03	mg/Kg	R	1.71E-03	mg/kg/day	1.00E+00	mg/kg/day	1.71E-03
	Antimony	1.56E+00	mg/Kg	1.56E+00	mg/Kg	R	3.17E-07	mg/kg/day	4.00E-04	mg/kg/day	7.94E-04
	Arsenic	6.16E+01	mg/Kg	6.16E+01	mg/Kg	R	1.25E-05	mg/kg/day	3.00E-04	mg/kg/day	4.18E-02
	Cadmium	7.14E+00	mg/Kg	7.14E+00	mg/Kg	R	1.45E-06	mg/kg/day	1.00E-03	mg/kg/day	1.45E-03
	Chromium	4.91E+02	mg/Kg	4.91E+02	mg/Kg	R	9.99E-05	mg/kg/day	3.00E-03	mg/kg/day	3.33E-02
	Iron	1.70E+04	mg/Kg	1.70E+04	mg/Kg	R	3.46E-03	mg/kg/day	NA	mg/kg/day	--
	Lead	2.25E+02	mg/Kg	2.25E+02	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day	--
	Manganese	6.75E+02	mg/Kg	6.75E+02	mg/Kg	R	1.37E-04	mg/kg/day	1.40E-01	mg/kg/day	9.81E-04
	Mercury	5.01E+00	mg/Kg	5.01E+00	mg/Kg	R	1.02E-06	mg/kg/day	3.00E-04	mg/kg/day	3.40E-03
	Vanadium	3.05E+01	mg/Kg	3.05E+01	mg/Kg	R	6.21E-06	mg/kg/day	7.00E-03	mg/kg/day	8.87E-04
	(Total)										8.43E-02
Dermal	Aluminum	8.39E+03	mg/Kg	8.39E+03	mg/Kg	R	NA	mg/kg/day	1.00E-01	mg/kg/day	--
	Antimony	1.56E+00	mg/Kg	1.56E+00	mg/Kg	R	NA	mg/kg/day	8.00E-06	mg/kg/day	--
	Arsenic	6.16E+01	mg/Kg	6.16E+01	mg/Kg	R	6.49E-07	mg/kg/day	1.23E-04	mg/kg/day	5.28E-03
	Cadmium	7.14E+00	mg/Kg	7.14E+00	mg/Kg	R	2.51E-09	mg/kg/day	1.00E-05	mg/kg/day	2.51E-04
	Chromium	4.91E+02	mg/Kg	4.91E+02	mg/Kg	R	NA	mg/kg/day	6.00E-05	mg/kg/day	--
	Iron	1.70E+04	mg/Kg	1.70E+04	mg/Kg	R	NA	mg/kg/day	4.50E-02	mg/kg/day	--
	Lead	2.25E+02	mg/Kg	2.25E+02	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day	--
	Manganese	6.75E+02	mg/Kg	6.75E+02	mg/Kg	R	NA	mg/kg/day	5.60E-03	mg/kg/day	--
	Mercury	5.01E+00	mg/Kg	5.01E+00	mg/Kg	R	NA	mg/kg/day	2.10E-05	mg/kg/day	--
	Vanadium	3.05E+01	mg/Kg	3.05E+01	mg/Kg	R	NA	mg/kg/day	7.00E-05	mg/kg/day	--
	(Total)										5.53E-03
											8.99E-02

R = Route Specific EPC selected for hazard calculation

TABLE 7.2
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
GROVE POND - Metals in Sediment Evaluation

Scenario Timeframe:	Current
Medium:	Sediment
Exposure Medium:	Sediment
Exposure Point	Sediment
Receptor Population:	Recreational User
Receptor Age:	Youth (age 7-16)

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation	Intake (Non-Cancer)	Intake Units	Reference Dose	Reference Dose Units	Hazard Quotient
Ingestion	Aluminum	8.39E+03	mg/Kg	8.39E+03	mg/Kg	R	2.66E-03	mg/kg/day	1.00E+00	mg/kg/day	2.66E-03
	Antimony	1.56E+00	mg/Kg	1.56E+00	mg/Kg	R	4.94E-07	mg/kg/day	4.00E-04	mg/kg/day	1.23E-03
	Arsenic	6.16E+01	mg/Kg	6.16E+01	mg/Kg	R	1.95E-05	mg/kg/day	3.00E-04	mg/kg/day	6.50E-02
	Cadmium	7.14E+00	mg/Kg	7.14E+00	mg/Kg	R	2.26E-06	mg/kg/day	1.00E-03	mg/kg/day	2.26E-03
	Chromium	4.91E+02	mg/Kg	4.91E+02	mg/Kg	R	1.55E-04	mg/kg/day	3.00E-03	mg/kg/day	5.18E-02
	Iron	1.70E+04	mg/Kg	1.70E+04	mg/Kg	R	5.38E-03	mg/kg/day	NA	mg/kg/day	--
	Lead	2.25E+02	mg/Kg	2.25E+02	mg/Kg	R	7.12E-05	mg/kg/day	NA	mg/kg/day	--
	Manganese	6.75E+02	mg/Kg	6.75E+02	mg/Kg	R	2.14E-04	mg/kg/day	1.40E-01	mg/kg/day	1.53E-03
	Mercury	5.01E+00	mg/Kg	5.01E+00	mg/Kg	R	1.59E-06	mg/kg/day	3.00E-04	mg/kg/day	5.29E-03
	Vanadium	3.05E+01	mg/Kg	3.05E+01	mg/Kg	R	9.66E-06	mg/kg/day	7.00E-03	mg/kg/day	1.38E-03
	(Total)										1.31E-01
Dermal	Aluminum	8.39E+03	mg/Kg	8.39E+03	mg/Kg	R	NA	mg/kg/day	1.00E-01	mg/kg/day	--
	Antimony	1.56E+00	mg/Kg	1.56E+00	mg/Kg	R	NA	mg/kg/day	8.00E-06	mg/kg/day	--
	Arsenic	6.16E+01	mg/Kg	6.16E+01	mg/Kg	R	1.01E-06	mg/kg/day	1.23E-04	mg/kg/day	8.21E-03
	Cadmium	7.14E+00	mg/Kg	7.14E+00	mg/Kg	R	3.90E-09	mg/kg/day	1.00E-05	mg/kg/day	3.90E-04
	Chromium	4.91E+02	mg/Kg	4.91E+02	mg/Kg	R	NA	mg/kg/day	6.00E-05	mg/kg/day	--
	Iron	1.70E+04	mg/Kg	1.70E+04	mg/Kg	R	NA	mg/kg/day	4.50E-02	mg/kg/day	--
	Lead	2.25E+02	mg/Kg	2.25E+02	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day	--
	Manganese	6.75E+02	mg/Kg	6.75E+02	mg/Kg	R	NA	mg/kg/day	5.60E-03	mg/kg/day	--
	Mercury	5.01E+00	mg/Kg	5.01E+00	mg/Kg	R	NA	mg/kg/day	2.10E-05	mg/kg/day	--
	Vanadium	3.05E+01	mg/Kg	3.05E+01	mg/Kg	R	NA	mg/kg/day	7.00E-05	mg/kg/day	--
	(Total)										8.60E-03
											1.40E-01

R = Route Specific EPC selected for hazard calculation

TABLE 7.3
CALCULATION OF NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
GROVE POND - Metals in Sediment Evaluation

Scenario Timeframe:	Current
Medium:	Sediment
Exposure Medium:	Sediment
Exposure Point	Sediment
Receptor Population:	Recreational User
Receptor Age:	Child (age 1-6)

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation	Intake (Non-Cancer)	Intake Units	Reference Dose	Reference Dose Units	Hazard Quotient
Ingestion	Aluminum	8.39E+03	mg/Kg	8.39E+03	mg/Kg	R	7.97E-03	mg/kg/day	1.00E+00	mg/kg/day	7.97E-03
	Antimony	1.56E+00	mg/Kg	1.56E+00	mg/Kg	R	1.48E-06	mg/kg/day	4.00E-04	mg/kg/day	3.70E-03
	Arsenic	6.16E+01	mg/Kg	6.16E+01	mg/Kg	R	5.85E-05	mg/kg/day	3.00E-04	mg/kg/day	1.95E-01
	Cadmium	7.14E+00	mg/Kg	7.14E+00	mg/Kg	R	6.78E-06	mg/kg/day	1.00E-03	mg/kg/day	6.78E-03
	Chromium	4.91E+02	mg/Kg	4.91E+02	mg/Kg	R	4.66E-04	mg/kg/day	3.00E-03	mg/kg/day	1.55E-01
	Iron	1.70E+04	mg/Kg	1.70E+04	mg/Kg	R	1.61E-02	mg/kg/day	NA	mg/kg/day	--
	Lead	2.25E+02	mg/Kg	2.25E+02	mg/Kg	R	2.14E-04	mg/kg/day	NA	mg/kg/day	--
	Manganese	6.75E+02	mg/Kg	6.75E+02	mg/Kg	R	6.41E-04	mg/kg/day	1.40E-01	mg/kg/day	4.58E-03
	Mercury	5.01E+00	mg/Kg	5.01E+00	mg/Kg	R	4.76E-06	mg/kg/day	3.00E-04	mg/kg/day	1.59E-02
	Vanadium	3.05E+01	mg/Kg	3.05E+01	mg/Kg	R	2.90E-05	mg/kg/day	7.00E-03	mg/kg/day	4.14E-03
	(Total)										3.93E-01
Dermal	Aluminum	8.39E+03	mg/Kg	8.39E+03	mg/Kg	R	NA	mg/kg/day	1.00E-01	mg/kg/day	--
	Antimony	1.56E+00	mg/Kg	1.56E+00	mg/Kg	R	NA	mg/kg/day	8.00E-06	mg/kg/day	--
	Arsenic	6.16E+01	mg/Kg	6.16E+01	mg/Kg	R	1.63E-06	mg/kg/day	1.23E-04	mg/kg/day	1.33E-02
	Cadmium	7.14E+00	mg/Kg	7.14E+00	mg/Kg	R	6.30E-09	mg/kg/day	1.00E-05	mg/kg/day	6.30E-04
	Chromium	4.91E+02	mg/Kg	4.91E+02	mg/Kg	R	NA	mg/kg/day	6.00E-05	mg/kg/day	--
	Iron	1.70E+04	mg/Kg	1.70E+04	mg/Kg	R	NA	mg/kg/day	4.50E-02	mg/kg/day	--
	Lead	2.25E+02	mg/Kg	2.25E+02	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day	--
	Manganese	6.75E+02	mg/Kg	6.75E+02	mg/Kg	R	NA	mg/kg/day	5.60E-03	mg/kg/day	--
	Mercury	5.01E+00	mg/Kg	5.01E+00	mg/Kg	R	NA	mg/kg/day	2.10E-05	mg/kg/day	--
	Vanadium	3.05E+01	mg/Kg	3.05E+01	mg/Kg	R	NA	mg/kg/day	7.00E-05	mg/kg/day	--
	(Total)										1.39E-02
											4.07E-01

R = Route Specific EPC selected for hazard calculation

TABLE 7.4
CALCULATION OF LEAD RISK BASED ON EPA TRW MODEL
ADULT RECREATIONAL USER
GROVE POND - Metals in Sediment Evaluation

Scenario Timeframe:	Current
Medium:	Sediment
Exposure Medium:	Sediment
Exposure Point	Sediment
Receptor Population:	Recreational User
Receptor Age:	Adult

Paramater	Units	Reference
Central estimate of blood lead concentrations = PbBadult,central	Calculated, ug/dL	
Goal for blood lead concentration among fetuses = PbBfetal,0.95	Calculated, ug/dL	
Typical adult blood level concentration = PbBadult,0	2.0 ug/dL	EPA, 1996b
Sediment lead concentration = PbS	225 ug/g	Site-Specific
Biokinetic slope factor = BKSF	0.4 ug/dL per ug/day	EPA, 1996b
Intake rate of sediment = IRs	0.1 g/day	EPA, 2001a, FAQ sheet
Absolute gastrointestinal absorption fraction = AFs	0.12	EPA, 1996b
Exposure frequency - EFs	52 day/year	Site-Specific
Averaging Time = AT	365 days/year	EPA, 1996b
Estimated value oof the individual geometric standard deviation = GSD	1.8 unitless	EPA, 1996b
Constant of proportionality between fetal blood lead concentration and maternal blood lead concentration = R	0.9 unitless	EPA, 1996b

Blood Lead Level Calculations:

PbBadult,central = PbBadult,0 + BKSF*IRs*Afs*Efs/AT
PbBadult,central = 2.154 ug/dL

$PbB_{fetal,0.95} = PbB_{adult,central}*GSD^{1.645}*R_{fetal/maternal}$
PbBfetal,0.95 = 5.10 ug/dL

TABLE 8.1
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
GROVE POND - Metals in Sediment Evaluation

Scenario Timeframe:	Current
Medium:	Sediment
Exposure Medium:	Sediment
Exposure Point	Sediment
Receptor Population:	Recreational User
Receptor Age:	Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation	Intake (Cancer)	Intake Units	Slope Factor	Slope Factor Units	Cancer Risks
Ingestion	Aluminum	8.39E+03	mg/Kg	8.39E+03	mg/Kg	R	3.42E-04	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Antimony	1.56E+00	mg/Kg	1.56E+00	mg/Kg	R	6.35E-08	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Arsenic	6.16E+01	mg/Kg	6.16E+01	mg/Kg	R	2.51E-06	mg/kg/day	1.50E+00	mg/kg/day $^{-1}$	3.76E-06
	Cadmium	7.14E+00	mg/Kg	7.14E+00	mg/Kg	R	2.91E-07	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Chromium	4.91E+02	mg/Kg	4.91E+02	mg/Kg	R	2.00E-05	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Iron	1.70E+04	mg/Kg	1.70E+04	mg/Kg	R	6.92E-04	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Lead	2.25E+02	mg/Kg	2.25E+02	mg/Kg	R	9.16E-06	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Manganese	6.75E+02	mg/Kg	6.75E+02	mg/Kg	R	2.75E-05	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Mercury	5.01E+00	mg/Kg	5.01E+00	mg/Kg	R	2.04E-07	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Vanadium	3.05E+01	mg/Kg	3.05E+01	mg/Kg	R	1.24E-06	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	(Total)										3.76E-06
Dermal	Aluminum	8.39E+03	mg/Kg	8.39E+03	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Antimony	1.56E+00	mg/Kg	1.56E+00	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Arsenic	6.16E+01	mg/Kg	6.16E+01	mg/Kg	R	1.30E-07	mg/kg/day	1.88E+00	mg/kg/day $^{-1}$	2.44E-07
	Cadmium	7.14E+00	mg/Kg	7.14E+00	mg/Kg	R	5.02E-10	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Chromium	4.91E+02	mg/Kg	4.91E+02	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Iron	1.70E+04	mg/Kg	1.70E+04	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Lead	2.25E+02	mg/Kg	2.25E+02	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Manganese	6.75E+02	mg/Kg	6.75E+02	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Mercury	5.01E+00	mg/Kg	5.01E+00	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Vanadium	3.05E+01	mg/Kg	3.05E+01	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	-
	(Total)										2.44E-07
											4.01E-06

R = Route Specific EPC selected for hazard calculation
NA = Not Applicable

TABLE 8.2
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
GROVE POND - Metals in Sediment Evaluation

Scenario Timeframe:	Current
Medium:	Sediment
Exposure Medium:	Sediment
Exposure Point	Sediment
Receptor Population:	Recreational User
Receptor Age:	Youth (age 7-16)

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation	Intake (Cancer)	Intake Units	Slope Factor	Slope Factor Units	Cancer Risks
Ingestion	Aluminum	8.39E+03	mg/Kg	8.39E+03	mg/Kg	R	3.79E-04	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Antimony	1.56E+00	mg/Kg	1.56E+00	mg/Kg	R	7.06E-08	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Arsenic	6.16E+01	mg/Kg	6.16E+01	mg/Kg	R	2.79E-06	mg/kg/day	1.50E+00	mg/kg/day $^{-1}$	4.18E-06
	Cadmium	7.14E+00	mg/Kg	7.14E+00	mg/Kg	R	3.23E-07	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Chromium	4.91E+02	mg/Kg	4.91E+02	mg/Kg	R	2.22E-05	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Iron	1.70E+04	mg/Kg	1.70E+04	mg/Kg	R	7.69E-04	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Lead	2.25E+02	mg/Kg	2.25E+02	mg/Kg	R	1.02E-05	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Manganese	6.75E+02	mg/Kg	6.75E+02	mg/Kg	R	3.05E-05	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Mercury	5.01E+00	mg/Kg	5.01E+00	mg/Kg	R	2.27E-07	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Vanadium	3.05E+01	mg/Kg	3.05E+01	mg/Kg	R	1.38E-06	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	(Total)										4.18E-06
Dermal	Aluminum	8.39E+03	mg/Kg	8.39E+03	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Antimony	1.56E+00	mg/Kg	1.56E+00	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Arsenic	6.16E+01	mg/Kg	6.16E+01	mg/Kg	R	1.44E-07	mg/kg/day	1.88E+00	mg/kg/day $^{-1}$	2.71E-07
	Cadmium	7.14E+00	mg/Kg	7.14E+00	mg/Kg	R	5.57E-07	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Chromium	4.91E+02	mg/Kg	4.91E+02	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Iron	1.70E+04	mg/Kg	1.70E+04	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Lead	2.25E+02	mg/Kg	2.25E+02	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Manganese	6.75E+02	mg/Kg	6.75E+02	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Mercury	5.01E+00	mg/Kg	5.01E+00	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Vanadium	3.05E+01	mg/Kg	3.05E+01	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	(Total)										2.71E-07
											4.45E-06

R = Route Specific EPC selected for hazard calculation
NA = Not Applicable

TABLE 8.3
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
GROVE POND - Metals in Sediment Evaluation

Scenario Timeframe:	Current
Medium:	Sediment
Exposure Medium:	Sediment
Exposure Point	Sediment
Receptor Population:	Recreational User
Receptor Age:	Youth (age 1-6)

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation	Intake (Cancer)	Intake Units	Slope Factor	Slope Factor Units	Cancer Risks
Ingestion	Aluminum	8.39E+03	mg/Kg	8.39E+03	mg/Kg	R	6.83E-04	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Antimony	1.56E+00	mg/Kg	1.56E+00	mg/Kg	R	1.27E-07	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Arsenic	6.16E+01	mg/Kg	6.16E+01	mg/Kg	R	5.01E-06	mg/kg/day	1.50E+00	mg/kg/day $^{-1}$	7.52E-06
	Cadmium	7.14E+00	mg/Kg	7.14E+00	mg/Kg	R	5.81E-07	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Chromium	4.91E+02	mg/Kg	4.91E+02	mg/Kg	R	4.00E-05	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Iron	1.70E+04	mg/Kg	1.70E+04	mg/Kg	R	1.38E-03	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Lead	2.25E+02	mg/Kg	2.25E+02	mg/Kg	R	1.83E-05	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Manganese	6.75E+02	mg/Kg	6.75E+02	mg/Kg	R	5.50E-05	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Mercury	5.01E+00	mg/Kg	5.01E+00	mg/Kg	R	4.08E-07	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Vanadium	3.05E+01	mg/Kg	3.05E+01	mg/Kg	R	2.48E-06	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	(Total)										7.52E-06
Dermal	Aluminum	8.39E+03	mg/Kg	8.39E+03	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Antimony	1.56E+00	mg/Kg	1.56E+00	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Arsenic	6.16E+01	mg/Kg	6.16E+01	mg/Kg	R	1.40E-07	mg/kg/day	1.88E+00	mg/kg/day $^{-1}$	2.63E-07
	Cadmium	7.14E+00	mg/Kg	7.14E+00	mg/Kg	R	5.40E-10	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Chromium	4.91E+02	mg/Kg	4.91E+02	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Iron	1.70E+04	mg/Kg	1.70E+04	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Lead	2.25E+02	mg/Kg	2.25E+02	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Manganese	6.75E+02	mg/Kg	6.75E+02	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Mercury	5.01E+00	mg/Kg	5.01E+00	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	Vanadium	3.05E+01	mg/Kg	3.05E+01	mg/Kg	R	NA	mg/kg/day	NA	mg/kg/day $^{-1}$	--
	(Total)										2.63E-07
											7.79E-06

R = Route Specific EPC selected for hazard calculation
NA = Not Applicable

TABLE 9.1

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

GROVE POND - Metals in Sediment Evaluation

Scenerio Timeframe:	Current
Medium:	Sediment
Exposure Medium:	Sediment
Exposure Point	Sediment
Receptor Population:	Recreational User
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk			Chemical	Non-Carcinogenic Hazard Quotient			
				Ingestion	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Dermal	Exposure Routes Total
Sediment	Sediment	Sediment	Aluminum	--	--	--	Aluminum	Neurological effects	1.71E-03	--	1.71E-03
			Antimony	--	--	--	Antimony	Blood	7.94E-04	--	7.94E-04
			Arsenic	3.76E-06	2.44E-07	4.01E-06	Arsenic	Hyperpigmentation/Keratosis	4.18E-02	5.28E-03	4.71E-02
			Cadmium	--	--	--	Cadmium	Kidney	1.45E-03	2.51E-04	1.70E-03
			Chromium	--	--	--	Chromium	None Identified	3.33E-02	--	3.33E-02
			Iron	--	--	--	Iron	Liver	--	--	--
			Lead	--	--	--	Lead	CNS	--	--	--
			Manganese	--	--	--	Manganese	CNS	9.81E-04	--	9.81E-04
			Mercury	--	--	--	Mercury	Kidney	3.40E-03	--	3.40E-03
			Vanadium	--	-	--	Vanadium	Blood	8.87E-04	--	8.87E-04
			(Total)	3.76E-06	2.44E-07	4.01E-06	(Total)		8.43E-02	5.53E-03	8.99E-02
			Total across all exposure routes =			4.01E-06		Total across all exposure routes =			8.99E-02

NA = Not Applicable

TABLE 9.2
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
GROVE POND - Metals in Sediment Evaluation

Scenerio Timeframe:	Current
Medium:	Sediment
Exposure Medium:	Sediment
Exposure Point	Sediment
Receptor Population:	Recreational User
Receptor Age:	Youth (7-16)

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk			Chemical	Non-Carcinogenic Hazard Quotient			
				Ingestion	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Dermal	Exposure Routes Total
Sediment	Sediment	Sediment	Aluminum	--	--	--	Aluminum	Neurological effects	2.66E-03	--	2.66E-03
			Antimony	--	--	--	Antimony	Blood	1.23E-03	--	1.23E-03
			Arsenic	4.18E-06	2.71E-07	4.45E-06	Arsenic	Hyperpigmentation/Keratosis	6.50E-02	8.21E-03	7.32E-02
			Cadmium	--	--	--	Cadmium	Kidney	2.26E-03	3.90E-04	2.65E-03
			Chromium	--	--	--	Chromium	None Identified	5.18E-02	--	5.18E-02
			Iron	--	--	-	Iron	Liver	--	--	--
			Lead	--	--	--	Lead	CNS	--	--	--
			Manganese	--	--	--	Manganese	CNS	1.53E-03	--	1.53E-03
			Mercury	--	--	--	Mercury	Kidney	5.29E-03	--	5.29E-03
			Vanadium	--	--	--	Vanadium	Blood	1.38E-03	--	1.38E-03
			(Total)	4.18E-06	2.71E-07	4.45E-06	(Total)		1.31E-01	8.60E-03	1.40E-01
			Total across all exposure routes =			4.45E-06	Total across all exposure routes =				1.40E-01

NA = Not Applicable

TABLE 9.3
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
GROVE POND - Metals In Sediment Evaluation

Scenerio Timeframe:	Current
Medium:	Sediment
Exposure Medium:	Sediment
Exposure Point	Sediment
Receptor Population:	Recreational User
Receptor Age:	Child (1-6)

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk			Chemical	Non-Carcinogenic Hazard Quotient			
				Ingestion	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Dermal	Exposure Routes Total
Sediment	Sediment	Sediment	Aluminum	--	--	--	Aluminum	Neurological effects	7.97E-03	--	7.97E-03
			Antimony	--	--	--	Antimony	Blood	3.70E-03	--	3.70E-03
			Arsenic	7.52E-06	2.63E-07	7.79E-06	Arsenic	Hyperpigmentation/Keratosis	1.95E-01	1.33E-02	2.08E-01
			Cadmium	--	--	--	Cadmium	Kidney	6.78E-03	6.30E-04	7.41E-03
			Chromium	--	--	--	Chromium	None Identified	1.55E-01	--	1.55E-01
			Iron	--	--	--	Iron	Liver	--	--	--
			Lead	--	--	--	Lead	CNS	--	--	--
			Manganese	--	--	--	Manganese	CNS	4.58E-03	--	4.58E-03
			Mercury	--	--	--	Mercury	Kidney	1.59E-02	--	1.59E-02
			Vanadium	--	--	--	Vanadium	Blood	4.14E-03	--	4.14E-03
			(Total)	7.52E-06	2.63E-07	7.79E-06	(Total)		3.93E-01	1.39E-02	4.07E-01
			Total across all exposure routes =			7.79E-06		Total across all exposure routes =			4.07E-01

NA = Not Applicable

TABLE 10.1
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
GROVE POND - Metals in Sediment Evaluation

Scenerio Timeframe:	Current
Receptor Population:	Recreational User
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk		
				Ingestion	Dermal	Exposure Routes Total
Sediment	Sediment	Sediment	Arsenic	3.76E-06	2.44E-07	4.01E-06
			(Total)	3.76E-06	2.44E-07	4.01E-06
			Total across all exposure routes =			4.01E-06

TABLE 10.2
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
GROVE POND - Metals in Sediment Evaluation

Scenerio Timeframe:	Current
Receptor Population:	Recreational User
Receptor Age:	Youth (7-16)

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk		
				Ingestion	Dermal	Exposure Routes Total
Sediment	Sediment	Sediment	Arsenic	4.18E-06	2.71E-07	4.45E-06
			(Total)	4.18E-06	2.71E-07	4.45E-06
			Total across all exposure routes =			4.45E-06

TABLE 10.3

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

GROVE POND - Metals in Sediment Evaluation

Scenerio Timeframe:	Current
Receptor Population:	Recreational User
Receptor Age:	Child (1-6)

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk			Chemical	Non-Carcinogenic Hazard Quotient			
				Ingestion	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Dermal	Exposure Routes Total
Sediment	Sediment	Sediment	Arsenic	7.52E-06	2.63E-07	7.79E-06	Arsenic	Hyperpigmentation/Keratosis	1.95E-01	1.33E-02	2.08E-01
							Chromium	None Identified	1.55E-01	--	1.55E-01
			(Total)	7.52E-06	2.63E-07	7.79E-06	(Total)		3.50E-01	1.33E-02	3.64E-01
			Total across all exposure routes =			7.79E-06	Total across all exposure routes =				3.64E-01

APPENDIX A
DATA MANAGEMENT PROCEDURES
GROVE POND
SEDIMENT-ONLY EVALUATION

Appendix A
Grove Pond
Data Management Procedures

General Data Management Procedures

Field Duplicates Data

For data management purposes each field duplicate pair was combined to yield one set of sample results. There were three possible scenarios in combining the data:

1. Both members of the field duplicate pair had positive detections.

For parameters detected in both members of a field duplicate pair the measured concentrations were averaged for the combined data set.

2. Both members of the field duplicate pair were non-detect.

When both members of the pair were non-detect, the reporting limits were averaged and the combined result was listed as non-detect.

3. One member of the pair was non-detect and one had a positive detection.

In this instance, the positive result was averaged with one-half of the reporting limit for the non-detect member and the combined result was listed as a detection.

The following table provides an illustration of how these rules were applied.

Table 1- Illustration of Field Duplicate Data Consolidation Procedure

Parameter	Result (Sample)	Result (Duplicate)	Result (Combined)
Chromium	< 0.02 mg/L	0.05 mg/L	0.03 mg/L

Diluted Samples

Dilutions are necessary when one or more sample analytes exceed the corresponding calibration range of the method. Based on prior knowledge, visual observations or odors, laboratories will sometimes dilute samples prior to performing the initial sample analysis in order to protect their analytical instrumentation in anticipation of elevated analyte concentrations. When a sample is analyzed at multiple dilutions, the data user is provided with multiple results for each sample analyte. The data user, however, is generally only interested in a single result for each sample analyte and, as such, needs to reduce the data from multiple dilutions to a single data point for each sample analyte. A procedure commonly applied to this situation, and that which was used for the purposes of this investigation, is to disregard data that exceed the calibration range of the method and, of those data remaining, use the result which corresponds to the lowest sample dilution factor. One benefit of this data consolidation technique is that it results in the lowest reporting limits for non-detected analytes. The table below illustrates the application of the technique.

Table 2 - Illustration of Data Consolidation Procedure for Samples with Multiple Dilutions

Parameter	No Dilution	10 Fold Dilution	100 Fold Dilution	Consolidated Result
Chromium	< 0.02 ug/L	< 0.2 ug/L	< 2 ug/L	< 0.02 ug/L

Risk Screening Procedures

Human Health Risk Assessment Screening Process

Analytical data were subjected to a screening process to identify chemicals of potential concern (COPCs). The first step of the screening process was to identify parameters which were detected at least once. Parameters which were not detected in at least one sample were not carried forward in the quantitative HHRA.

The next step in the screening process was to determine if the list of detected parameters included any essential nutrients. Essential nutrients are generally not a concern from a toxicity perspective unless they are present at extremely high levels. EPA considers calcium, magnesium, potassium and sodium to be essential nutrients. These metals, when detected, were screened out on this basis. The remaining parameters were compared to risk based screening levels. These levels generally correspond to EPA Region 9 Preliminary Remediation Goals (PRGs) (EPA Region 9, 2001). The PRG values were accessed online.

In some instances, more than one PRG is available for a parameter (e.g. manganese) or the PRG table lists values for one or more specific chemical forms of a parameter (e.g. chromium). In these cases the most conservative PRGs available were used (Table 3).

Table 3 - Subjective Selection of PRGs

Parameter	PRGs Utilized
Cadmium	Cadmium (Water)
Chromium	Chromium (VI)
Manganese	Manganese (nonfood)
Mercury	Methylmercury

The screening values utilized for lead is 400 mg/Kg (soil). This value corresponds to the soil action level published by OSWER (OSWER, 1994).

With the risk based screening levels established, the maximum detected concentrations in each media were compared to the appropriate screening value. If the maximum detected value of a parameter did not exceed the risk based screening level, the parameter was not carried through the quantitative HHRA.

The screening process described above is illustrated in the flow chart shown in Figure 1.

Elevated Detection Limits

Analytical measurements in which a parameter was reported as not detected may still be of some concern if the reporting limit exceeds the risk based screening level. These results can not be evaluated in the quantitative risk assessments, but they are considered qualitatively in the Uncertainty Sections of the HHRA.

Exposure Point Concentrations

Determination of Exposure Point Concentrations (HHRA)

As described above in the section describing the Human Health Risk Assessment Screening Process, chemicals identified as COPCs are carried through a quantitative HHRA. In order to calculate the pathway specific risk for a receptor, exposure point concentrations (EPCs) need to be estimated. This section describes the procedure used to estimate EPCs for the COPCs.

The guidance provided by EPA Region I (EPA, 1994) is to use, as the EPC, the lesser of the 95% upper confidence limit UCL) of the mean or the maximum detected concentration for the Reasonable Maximum Exposure (RME) scenario.

For the purposes of computing the 95% UCL, non-detected parameters were assigned a concentration of half the reporting limit. In the event that the reporting limit for an undetected parameter exceeded twice the maximum detected concentration, that data point was disregarded. For parameters with fewer than five data points for a given media, the maximum was used as the EPC since reliable estimates of the 95% UCL of the mean are not possible with such limited data sets. If at least five data points were available, the data for the parameter was evaluated to determine if it was normally distributed. This determination was done using a Shapiro-Wilk Normality Test as recommended by EPA (EPA, 2000). For parameters passing the test at a 0.05 confidence level, 95% UCLs were calculated based on a normal distribution.

$$95\%\ \mathrm{UCL} = \bar{x} + t_{0.95,n-1} s/(n)^{1/2}$$

where $\bar{x}$ is the mean, n is the number of data points, s is the standard deviation of the data set and $t_{0.95,n-1}$ is the value of the t variate that cuts off 5% of the upper tail of the Student's t distribution with n data points.

If a parameter failed the test at the 0.05 confidence level, the data was lognormally transformed and retested via Shapiro-Wilk. If the transformed data passed the test at the 0.05 confidence level, a lognormal distribution was assumed and the 95% UCL was calculated using the H statistic as described in Gilbert (Gilbert, 1987).

$$95\%\ \text{UCL} = \exp[\bar{x} + (0.5)s^2 + (s)(H_{0.95})/(n - 1)^{1/2}]$$

where $\bar{x}$ and s are now the mean and standard deviation of the logtransformed data respectively, n is the number of data points and $H_{0.95}$ is the value of the H statistic corresponding to the 95% UCL.

For parameters with a minimum of twenty data points, which did not exhibit a normal or lognormal distribution as determined by the Shapiro-Wilk test, 95% UCLs of the median were calculated using the procedure described in Gilbert (Gilbert, 1987).

$$u = (0.5)(n + 1) + (1.645)[n(0.25)]^{1/2}$$

where n is the number of data points and u is the rank of the 95% UCL of the median.

To convert from the rank of the 95% UCL to the actual 95% UCL, one simply interpolates between the ranked data on either side of u. For example, if u was found to be 16.5, then the 95% UCL of the median would be exactly halfway between the 16th and 17th ranked data points.

If a data set for a parameter with fewer than twenty data points, the maximum detected value was used as the EPC in lieu of the nonparametric described above.

The process for estimating EPCs described above is illustrated in Figure 2.

APPENDIX B

Toxicological Profiles

Toxicological Profiles:

- Aluminum
- Antimony
- Arsenic
- Barium
- Chromium
- Iron
- Lead
- Manganese
- Mercury
- Vanadium

ALUMINUM

GENERAL BACKGROUND INFORMATION

Aluminum is one of the most ubiquitous elements in the environment. Increases in the acid content of rain have drastically increased the amount of aluminum present in biological ecosystems. Among humans, the average daily intake of aluminum is approximately 20 mg/day. Human exposure is a result of consumption aluminum-containing food and water, as well as pharmaceuticals. Increased amounts of aluminum have also been observed in individuals with Alzheimer's Disease (Klaassen, 1996).

PHARMACOKINETICS

The form in which individuals are exposed to aluminum greatly determines the absorption, distribution, and excretion of aluminum in mammals. Absorption through the gastrointestinal tract is largely dependent on pH. In humans, aluminum may be cleared through the urine. The highest concentrations of aluminum can be found in bone and lung. In general, aluminum does not accumulate in the blood to a great extent (Klaassen, 1996).

HUMAN TOXICOLOGICAL PROFILE

Aluminum has been associated with Alzheimer's disease in humans (Crapper- McLachlan 1986; Perl and Good 1988; Shore and Wyatt 1983). These patients have neurofibrillary tangles in the cerebral cortex and hippocampus, and these tangles often contain aluminum. Dementia associated with Parkinsonism and presence of neurofibrillary tangles has been associated with excessive aluminum and low levels of calcium and magnesium in the soil in Guam (Perl et al. 1982). It is not known whether aluminum is a causal agent in these neurodegenerative diseases.

There are a number of studies of workers in the aluminum industry that have been exposed to aluminum via inhalation. These workers often suffer from asthma, cough, and decreased pulmonary function. However, in a number of cases, workers were also exposed to other occupational toxicants such as polycyclic aromatic hydrocarbons, carbon monoxide, sulfur dioxide, hydrogen fluoride, and other respirable dusts. In addition, many workers also smoke cigarettes. Therefore, the specific adverse health effects resulting from aluminum have been difficult to determine conclusively (ATSDR, 1992).

Complete toxicity information regarding aluminum is unavailable on EPA's Integrated Risk Information System (IRIS). However, EPA's National Center for Environmental Assessment (NCEA) has made provisional ingestion and inhalation references doses (RfDs) available for use in quantitative human health risk assessment. Ingestion and inhalation RfDs for aluminum are 1.00e+00 and 1.00e-03 mg/kg/day, respectively.

MAMMALIAN TOXICOLOGICAL PROFILE

Several studies have examined the effects of aluminum on neurological functions, including neuromotor activity and cognitive capabilities. These studies show that it is difficult to develop an animal model showing neurotoxic effects from oral exposure to aluminum. Some animal studies show preferential uptake of aluminum into the brain, but others dispute this. Since animals do not develop Alzheimer's disease, they are not good models for determining the effects of aluminum on the neurological system of humans (ATSDR, 1992).

Only one study was located that addressed cancer in animals after inhalation exposure (Kobayashi et al. 1968). No reliable information can be obtained from this study because of serious flaws, including lack of sufficient numbers of animals, lack of sufficient controls, and lack of sufficient exposure duration information.

GENOTOXICITY

Some of the neurotoxic effects of aluminum can be partially explained by its genotoxic and subcellular effects on DNA in neurons and other cells. These include nuclear effects such as binding to DNA phosphate and bases, increasing histone-DNA binding, altering sister chromatid exchange, and decreasing cell division. Cytoplasmic effects include conformational changes in calmodulin and increasing intracellular calcium; although these effects may not specifically be caused by interactions with DNA, they will significantly affect neuronal functions. Since aluminum accumulates in DNA structures in the cell nucleus, it may alter protein-DNA interactions. This is particularly important for the calcium-binding protein, calmodulin. This can affect the calcium-modulated second messenger system which is activated by neurotransmitters. Interference with DNA and protein synthesis may also be part of the mechanism that is involved the creation of the neural filaments which compose the neurofibrillary tangles seen in Alzheimer's patients (Bertholf 1987).

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ANTIMONY

GENERAL BACKGROUND INFORMATION

Antimony is an alloy used in the metal industry for producing fire-proofing chemicals, ceramics, glassware, and pigments. It belongs to the same periodic group as arsenic and is categorized as a minor toxic metal. Medicinal uses of antimony include treatment of schistosomiasis and leishmaniasis. Antimony is a common air pollutant from industrial emissions, however, exposure the general population mainly results from ingestion of contaminated food (Goyer, 1996).

PHARMACOKINETICS

The metabolism of antimony is similar to that of arsenic. Antimony is slowly absorbed from the gastrointestinal tract, which may result in gastrointestinal irritation. In its trivalent form, antimony becomes concentrated in red blood cells and the liver, whereas the pentavalent form is found mostly in the plasma. Both forms of antimony are excreted in the urine and feces, however, trivalent elimination is greatest in the urine and pentavalent is mostly eliminated by gastrointestinal excretion (Casarett and Doull, 1996).

HUMAN TOXICOLOGICAL PROFILE

The human effects of antimony exposure were observed among 70 individuals that became acutely ill after drinking lemonade that contained concentrations of antimony. Symptoms of exposure included burning stomach pains, colic, nausea, and vomiting. The recovery time for ranged from three hours to several days (Dunn, 1928 and Monier-Williams, 1934).

Most of the information regarding antimony exposure has resulted from occupational exposure. Acute effects from exposure include rhinitis and pulmonary edema. Chronic effects observed include rhinitis, pharyngitis, tracheitis, and over the long term may lead to pneumoconiosis with obstructive lung disease and emphysema (Casarett and Doull, 1996). Antimony has been found to accumulate on lung tissue resulting in skin eruptions, or "antimony spots", on the lungs of workers with chronic antimony exposure (Elinder and Friberg, 1986).

A study conducted by Belyaeva reported that women workers of an antimony plant were found to have experienced increased spontaneous abortions when compared with a control group of non-exposed working women. Additionally, an increase in premature birth was observed among these women (Belyaeva, 1967).

MAMMALIAN TOXICOLOGICAL PROFILE

A study conducted by Scroeder examined the effects of 50 male and 50 female rats from ingestion of water containing 5 ppm potassium antimony tartrate. Although the growth rates of the rats were not affected, the rats treated with the antimony-containing water were observed to live approximately 107 fewer days when compared with controls. Decreases in blood glucose levels were observed among male subjects, and alterations in cholesterol was noted among both sexes. No increase in tumors was observed as a result of treatment. A No Observed Effect Level (NOEL) was not established for this study since only one dose of antimony was administered to the subjects. The exposure concentration of 5 ppm was expressed as 0.35 mg/kg bw/day, which was used to derive the current oral Reference Dose (RfD) value for antimony of 4.0E-04 mg/kg/day (IRIS 1997).

GENOTOXICITY

Oral exposure of rats to antimony was not found to produce excess tumors. However, an increase in chromosomal defects were observed when human lymphocytes were incubated with a soluble antimony salt. In addition, Syrian hamster embryo cells treated with antimony have been found to undergo neoplastic transformations (Paton and Allison, 1972).

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ARSENIC

GENERAL BACKGROUND INFORMATION

The toxicity of arsenic depends upon its chemical form along with the route, dose, and duration of exposure. In general, arsenites (As^{+3}) are potentially more toxic than arsenites, soluble arsenic compounds are potentially more toxic than insoluble compounds, and inorganic arsenic compounds are potentially more toxic than organic derivatives (U.S. EPA, 1985).

PHARMACOKINETICS

Absorption from the gastrointestinal tract is dependent upon the solubility of the specific arsenic compound and the dose. Absorption from the respiratory tract is also dependent upon the specific arsenic compound, along with particle size (see section on Relative Absorption Factors).

HUMAN TOXICOLOGICAL PROFILE

Depending upon dose and exposure route, arsenic is an irritant of the akin, mucous membranes, and the gastrointestinal tract. Acute toxicity from the ingestion of higher doses of arsenic may result in vomiting, diarrhea, convulsions, a severe drop in blood pressure, and cardiovascular effects. The lethal dose for humans is reported to be 1.0 to 2.6 mg/kg-bw (Vallee et al., 1960). Acute toxicity from inhalation exposure to arsenic adsorbed to particulate matter may result in conjunctivitis and pharyngitis. Subchronic effects included hyperpigmentation (melanosis), multiple arsenical keratoses, sensory-motor polyneuropathy, persistent chronic headache, lethargy, gastroenteritis, and mild iron deficiency anemia. Inhaled arsenic compounds have been reported to be associated with skin lesions, cardiovascular and respiratory effects, and peripheral neuropathy (Stokinger, 1981; IARC, 1980). Chronic oral exposure of humans to inorganic arsenic compounds has been reported to cause skin lesions, peripheral vascular disease, and peripheral neuropathy (Silver and Wainman, 1952). The incidence of blackfoot disease, a peripheral circulatory disease characterized by gangrene of the extremities, has reportedly been related to the presence of arsenic in the drinking water of residents of the southwest of Taiwan (Tseng, 1977). The symptoms of chronic inhalation exposure to arsenic compounds are similar to those associated with chronic oral toxicity.

MAMMALIAN TOXICOLOGICAL PROFILE

Oral LD_{50} values for trivalent arsenic vary from 15 to 293 mg/kg in rats and from 10-150 mg/kg in other test species (U.S. EPA, 1984). Chronic toxicity data from arsenic exposure to rats cannot be extrapolated to man as the rat is able to store this compound hound to hemoglobin in red blood cells (Lanz et al., 1950). This binding results in extremely slow excretion by rats compared to other species (Mealey et al., 1959). For this reason, dogs have been used to obtain experimental toxicity information Studies of the subchronic oral toxicity of diets containing sodium arsenite or sodium arsenate in dogs report that arsenite is potentially more toxic than arsenate. The NOEL (no observed effect level) was reported to be 50 mg/kg-diet for both substances (Byron et al., 1967) Schroeder and Balassa (1967) studied the chronic oral toxicity of arsenic on growth and survival in mice. Ingestion of water containing As^{+3} at 5 mg/L over two years is reported to have resulted in decreased survival and reduced median life span in male and female mice. No information regarding chronic inhalation exposure of experimental animals to arsenic could be located in the available literature. Animal studies to test the teratogenic potential of arsenic have been performed. Matsumoto et al. (1973) reported decreased fetal weight in oral doses of up to 40 mg-arsenate/kg-bw/day administered to pregnant mice for three consecutive days. Diets containing up to 100 mg-arsenite/kg-diet, however, were reported to have had no effect on offspring (Kojima, 1974). No data regarding the teratogenicity of inhaled arsenic could be found in the literature.

GENOTOXICITY

Nearly all results of gene mutation studies for arsenic (III) and arsenic (V) compounds have been negative. Arsenite and arsenate also have been inactive in gene-specific mutation assays in yeast and in cultured mammalian cells. In contrast, arsenic (III), arsenic (V), arsenite and arsenate have been found to result in chromosome aberrations and sister chromatid exchanges in cultured animal and human cells tested in vitro (ATSDR, 1987). There is limited evidence that occupational exposure to arsenic may cause chromosome changes in humans (Beckman et al., 1977). Beckman et al. (1977) reported an increase in gaps, chromatid aberrations and chromosome aberrations from mine workers at a smelter in northern Sweden.

The majority of tests in which experimental were exposed orally to a variety of arsenic compounds produced negative results regarding carcinogenicity (Hueper and Payne, 1962; Byron et al., 1967). A few studies have, however, reported tumorigenic effects of arsenic treatment (Schrauzer et al., 1978). Mixed results were reported in arsenic inhalation studies (Ishinishi et al., 1977; Ivankovic et al., 1979). Epidemiological studies conducted in the U.S. have failed to correlate the incidence of skin cancer with arsenic in drinking water (Morton et al., 1976; Goldsmith et al., 1972). A dose-response relationship between the occurrence of skin cancer and arsenic consumption in the drinking water of Taiwanese, however, was reported by Tseng et al. (1977). Arsenic exposure at certain doses may produce a pattern of skin disorders, hyperpigmentation, and keratosis that may develop into basal or squamous cell carcinoma (U.S. EPA, 1985). Several epidemiological studies of workers occupationally exposed to arsenic have reported a correlation between this exposure and mortality due to respiratory cancer (Higgins et al. 1982; Enterline and Marsh, 1982; Brown and Chu, 1983). Based upon epidemiological data, the EPA has classified arsenic as Group A - Human Carcinogen.

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BARIUM

GENERAL BACKGROUND INFORMATION

Barium is a silvery-white metal that occurs in nature in many different forms. The length of time that barium will remain in the environment following release to air, land, and water depends upon the form of barium that is released. Barium sulfate and barium carbonate, which are not easily dissolved in water, will be more persistent in the environment than more soluble barium compounds, such as barium acetate, barium chloride, barium hydroxide, barium nitrate and sulfide (ATSDR, 1987).

PHARMACOKINETICS

There is no available research regarding absorption of barium in humans from inhalation exposure. Animal studies suggest that rate and extent of absorption of barium from the respiratory tract is dependent on the level of exposure. Absorption may also be dependent on the amount of barium that reaches the alveolar spaces, clearance rates of the upper respiratory tract and the solubility of the associated barium compound (ATSDR, 1987).

Barium is very poorly absorbed from the gastrointestinal tract. The estimate of the International Commission for Radiation Protection (ICRP) is that gastrointestinal absorption of barium is less than 5%, based on human data. Studies of rats have shown that absorption of barium chloride is approximately 10 times more among younger animals when compared with older animals (ICRP 1973). Studies of barium concentrations in serum indicate that the peak absorption from the gastrointestinal system is with in one hour in dogs (Chou and Chin, 1943) and rats (McCauley and Washington, 1983).

There is no available research on the absorption of barium among humans from dermal exposure. Dermal contact with barium is not expected to be significant due to the high polarity of the most commonly encountered barium compounds, which makes it difficult to cross an intact skin surface.

HUMAN TOXICOLOGICAL PROFILE

A retrospective epidemiological study of two Illinois communities was evaluated exposure to barium in drinking water. The mean concentrations in each of the two communities were 0.1 mg Ba/L and 7.3 mg Ba/L. No significant differences in blood pressures, rates of hypertension, heart disease, stroke or kidney diseases were observed among members of the two communities. The results of this investigation concluded that the dosage associated with the elevated barium levels, 0.21 mg Ba/kg-day, is the No Observed Adverse Effect Level (NOAEL) for hypertension and kidney diseases (Brenniman and Levy, 1984).

Healthy male volunteers were administered barium chloride in drinking water. Subjects had no history of hypertension, diabetes, or cardiovascular disease. The concentrations of barium ranged from 0-10 ppm throughout the 10 week study period. Findings of the study indicate that no significant alterations in serum calcium levels were observed. Additionally, no significant changes were observed in plasma total cholesterol, triglyceride, LDL or HDL cholesterol, serum glucose, albumin, potassium levels or cardiac cycle intervals. Significant arrhythmias, ventricular irritability, or apparent conduction problems were observed among the individuals studied. The No Observed Adverse Effect Level (NOAEL) of 0.21 mg Ba/kg-day can be calculated from the 10 ppm concentrations administered to participants for the final four weeks of the study period (Wones, 1990).

MAMMALIAN TOXICOLOGICAL PROFILE

A study was conducted to examine the effects of rats exposed to barium via ingestion (McCauley, 1985). The McCauley study was the only study that examined the kidney for glomerular effects, as well as blood pressure. According to its findings, no adverse effects have been observed regarding blood pressure at levels of 1,000 ppm of barium in drinking water. The only effects that were observed were glomerular damage in rats administered 1,000 ppm (150 mg Ba/kg-day) of barium in drinking water. The NOAEL for glomerular effects from this study is 100 ppm (15 mg Ba/kg-day.

The National Toxicology Program (NTP) conducted subchronic and chronic studies of rats exposed to barium chloride dihydrate in drinking water. Chronic study findings indicate that no significant increases in mortality were observed among rats exposed to barium. In the subchronic study, it was found that toxicologically significant organ weight changes consisted of increased absolute and relative kidney weights. No chemical-related or biologically significant changes in serum electrolytes or hematology values were observed. Based on these findings, it was determined that the LOAEL of 2,500 ppm (75 mg Ba/kg/day) (NTP, 1994).

GENOTOXICITY

Limited information is available on the genotoxicity of barium compounds. To date, no invivo studies have been conducted. The conclusions of most invitro studies indicate that barium chloride and barium nitrate compounds did not induce gene mutations in bacterial assays with or without metabolic activation. A study of barium acetate and barium chloride found that neither compound decreased the fidelity of DNA synthesis in avian myeloblastosis virus DNA polymerase. A study of mammalian cells concluded that barium chloride did not induce sister chromatid exchanges or chromosomal aberrations (U.S. EPA, 1998).

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CHROMIUM

GENERAL BACKGROUND INFORMATION

Chromium is used in plating for corrosion resistance and decorative purposes (appliances, tools, automobiles, etc.), in the manufacture of alloys (including stainless steel and heat resistant alloys), and in printing, dyeing, photography, tanning, and numerous other industrial applications (ATSDR, 1989).

PHARMACOKINETICS

Absorption studies of chromium compounds indicate that it is absorbed by all routes of exposure (see section on Relative Absorption Factors) with chromium (VI) compounds being more readily absorbed than chromium (III) compounds. Once absorbed, chromium is rapidly distributed to all organs, including the developing fetus. Chromium VI is readily reduced to Cr III in vivo. Excretion occurs primary through the kidneys via urine (ATSDR, 1989).

HUMAN TOXICOLOGICAL PROFILE

In humans, the respiratory tract is the primary system of concern for chromium toxicity. Renal damage has also been observed. Hexavalent chromium has been shown to be highly toxic, causing ulceration of nasal mucosa and carcinoma of the lung following long-term occupational exposure. Cases of acute poisoning in man have been reported from the medical use of chromic acid.

Chronic exposures of workers in chromium-related industries have been observed to result in akin and nasopharyngeal irritation. Both Cr (III) an Cr (VI) can cause allergic contact dermatitis and irritation (Samitz and Shrager, 1966). Chromium was shown to be an allergen in recurrent contact dermatitis of the feet (Correia and Brandao, 1986). Hexavalent forms are responsible for effects on the upper respiratory system, including ulceration and perforation of the nasal septum, chronic rhinitis, and pharyngitis. Lindberg and Hedenstierna (1983) reported that subjective and objective evidence of adverse nasal effects were found at exposure levels of 2 to 20 ug Cr(VI)/m^3 but not at less than 1 ug/m^3. They also reported that workers exposed to 2 to 20 ug Cr(VI)/m^3 had slight transient decreases in measures of pulmonary mechanics (e.g., forced vital capacity, FVC) with recovery (no changes) seen by two (non-exposed) days later.

MAMMALIAN TOXICOLOGICAL PROFILE

In laboratory animal, Cr compounds are of low oral acute toxicity. Hexavalent chromium is more acutely toxic than Cr(III), with kidney failure being the primary symptom. The LC_{50} in rats for inhalation of sodium chromate(VI) was reported as 33 mg Cr/m^3/4H, and the LD_{50}'s for oral and dermal exposures were given as 16.7 mg Cr/kg and 514 mg Cr/kg, respectively (Gad et al., 1986). Chromium was found to localize in the proximal renal tubules when intraperitoneal doses of potassium dichromate were administered to rats 5 times weekly for 8 months (Berry et al., 1978). Low level hexavalent chromium exposure increases respiratory defense mechanisms while they are inhibited by long-term, high level exposure (Glaser et al., 1985). Chromium salts have been shown to be teratogenic and embryotoxic in mice and hamsters following intravenous or intraperitoneal injection. However, these are unnatural routes of administration for assessing effects of environmental exposures, and further research is needed (U.S. EPA, 1984).

GENOTOXICITY

Both Cr(III) and Cr(VI) have been shown to interact with DNA in bacterial systems. Cr(III) is generally considered to be a relatively inactive genotoxic agent since it is unable to cross cell membranes. It was recently shown, however, to cause chromosomal aberrations in human lymphocytes (Friedman et al., 1987). Hexavalent chromium has consistently caused transformations and mutations in a wide variety of in vitro assays (Bianchi and Lewis, 1985). Chromosomal damage has been observed in lymphocytes cultured from workers exposed to chromium. The epidemiologic studies of respiratory cancer in chromate production workers provide the bulk of the evidence for chromium carcinogenicity. Studies of chromate production facilities in the United States, Great Britain, and Japan have all found an association between occupational exposure to chromium and lung cancer (U.S. EPA, 1984). Workers were exposed to both Cr(VI) and Gr(III), and it is unclear whether Cr(VI) alone is the etiologic agent or whether Cr(III) is implicated as well. The U.S. EPA (1984) concluded that in rats, only calcium chromate had consistently produced lung tumors by several routes of administration, and that other Cr(VI) compounds produced local sarcomas or lung tumors in rats at the site of administration (subcutaneous, intraperitoneal, intermuscular, intrabroncheal, and intratracheal). Trivalent chromium compounds have not been found to be carcinogenic by any route of administration, but these compounds have not been studied as extensively.

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IRON

GENERAL BACKGROUND INFORMATION

The majority of scientific and medical research has indicated that iron is an essential metal. However, adverse health effects have been observed among individuals with accidental acute exposures and chronic iron overload, due to excess dietary iron or frequent blood transfusions (Klaassen, 1996).

PHARMACOKINETICS

Generally, about 2 to 15% of iron is absorbed from the gastrointestinal tract, whereas elimination of absorbed iron is only about 0.01% per day (percent of body burden or amount absorbed). The absorption of iron is greater during childhood, pregnancy, or blood loss. Usually, excess iron is removed from the body via excretion, although small amounts are contained in sweat, nails, and hair. About 0.5 mg of iron are excreted is excreted per day (Klaassen, 1996).

HUMAN TOXICOLOGICAL PROFILE

Acute iron toxicity is mostly due to accidental ingestion of iron-containing medicines by children. Severe toxicity in humans results after ingestion of more than 0.5g of iron or 2.5g of ferrous sulfate. The first symptom from exposure is vomiting, followed by signs of shock and metabolic acidosis, liver damage, and coagulation defects within the next few days. Other effects include renal failure and hepatic cirrhosis (Klaassen, 1996).

Inhalation exposure of metal industry workers to iron oxide fumes may result in deposition of iron in the lungs. An increase in lung cancer, tuberculosis, and interstitial fibrosis (Boyd, 1970). Smoking was a confounding factor in this study.

A provisional oral Reference Dose (RfD) of 3.00-01 mg/kg/day has been developed by EPA's Center for Environmental Assessment (NCEA).

MAMMALIAN TOXICOLOGICAL PROFILE

There is limited information on the toxicological effects of iron exposure in animals.

GENOTOXICITY

There is no available information on the potential genotoxic potential of iron.

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LEAD

GENERAL BACKGROUND INFORMATION

Lead is used extensively in the manufacture of storage batteries and was used in gasoline and paint. Lead is also a natural constituent of many 50118, for which concentrations normally range from 10 to 30 mg lead per kilogram of soil (U.S. EPA, 1980).

PHARMACOKINETICS

Lead can be absorbed by the oral, inhalation or dermal exposure routes (see section on Relative Absorption Factors). Gastrointestinal absorption of lead varies considerably depending upon chemical form, dietary intake, and age (Forbes and Reina, 1974; Barltrop and Meek, 1975). The deposition and absorption of inhaled lead depends upon particle size, chemical form and the rate and depth of breathing (Randall et al., 1975; Nozaki, 1966; Chamberlain et al., 1975). Once absorbed, lead is distributed to the various organs of the body, with most distribution occurring into mineralized tissues (ATSDR, 1990). Placental transfer to the developing fetus is possible (Bellinger et al., 1987). Inorganic lead is not known to be biotransformed within the body. Absorbed lead is excreted via the urinary or fecal routes (ATSDR, 1990).

HUMAN TOXICOLOGICAL PROFILE

Cases of acute lead poisoning in humans are not common and have not been studied in experimental animals as thoroughly as chronic lead poisoning. Symptoms of acute lead poisoning from deliberate ingestion by humans may include vomiting, abdominal pain, hemolysis, liver damage, and reversible tubular necrosis (U.S. EPA, 1984). Subacute exposures in humans reportedly may produce a variety of neurological effects including dullness, restlessness, irritability, poor attention span, headaches, muscular tremor, hallucinations, and loss of memory. Nortier et al., (1980) report encephalopathy and renal damage to be the most serious complications of chronic toxicity in man and the hematopoietic system to be the most sensitive. For this reason, most data on the effects of lead exposure in humans are based upon blood lead levels. The effects of lead on the formation of hemoglobin and other hemoproteins, causing decreased levels, are reportedly detectable at lower levels of lead exposure than in any other organ system (Betts et al., 1973). Peripheral nerve dysfunction is observed in adults at levels of 30 to 50 μg/dL-blood. Children's nervous systems are reported to be affected at levels of 15 μg/dL-blood and higher (Benignus et al., 1981). In high doses, lead compounds may potentially cause abortions, premature delivery, and early membrane rupture (Rom, 1976).

MAMMALIAN TOXICOLOGICAL PROFILE

Acute oral lethal doses of lead in animals depend upon chemical form, but generally range from 500 to 30,000 mg/kg. Several reproduction studies on the effects of subchronic oral exposure to lead in rats have been conducted (Kimmel et al., 1976; Grant et al., 1980; Fowler et al., 1980). These studies report that lead acetate administered in drinking water at various concentrations caused depressed body weights at 50 and 250 mg-Pb/L water, histological changes in the kidneys of offspring, cytokaryomegaly of the tubular epithelial cells of the inner cortex at concentrations greater than or equal to 25 mg/L and postnatal developmental delays at 50 to 250 mg/L. Higher oral doses of lead may result in decreased fertility and fetotoxic effects in a variety of species (Hilderbrand et al., 1973). A reduction in the number of offspring of rats and mice exposed to 25 mg Pb/L drinking water with a chromium deficient diet was reported by Schroeder et al. (1970). Chronic oral exposure of female Long-Evans rats to lead (5 mg/PB/L-water) reportedly resulted in slight effects on tissue excitability, systolic blood pressure, and cardiac ATP concentrations (Kopp et al., 1980a,b).

GENOTOXICITY

Results of in vitro studies with human lymphocyte cultures using lead acetate were nearly equally positive and negative. Results of in vivo tests are also contradictory but suggest that lead may have an effect on chromosomes (sister chromatid exchange).

Results for gene mutations, DNA modification, and recombinations in various microorganisms using lead acetate, lead nitrate and lead chloride were consistently negative with or without metabolic activation. Lead chloride has been reported to inhibit both DNA and RNA synthesis. In *in vitro* mammalian test systems, lead acetate gave conflicting results.

No epidemiological data regarding the oral carcinogenic potential of lead could be located in the available literature. Chronic inhalation may result in a statistically significant increase in deaths due to tumors in the digestive organs and respiratory systems in lead smelter workers and battery plant workers (Kang et al., 1980). Several studies have reported tumor formation in experimental animals orally administered specific lead resu1ts, not normally ingested by humans (Zawirska and Medras, 1972; Boyland et al., 1962; Ito 1973). The carcinogenicity of inhaled lead in experimental animals could not be located in the available literature. The U.S. EPA has classified lead and lead compounds as Group B2 Probable Human Carcinogens.

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MANGANESE

GENERAL BACKGROUND INFORMATION

Manganese is a naturally occurring substance found in many types of rock. Pure manganese is a silver-colored metal, somewhat like iron in its physical and chemical properties. Manganese does not occur in the environment as the pure metal. Rather, it occurs combined with other chemicals such as oxygen, sulfur, and chlorine.

Eating a small amount of manganese each day is important in maintaining health. The amount of manganese in a normal diet (about 2,000-9,000 mg/day) seems to be enough to meet daily needs, and no cases of illness from eating too little manganese have been reported in humans. In animals, eating too little manganese can interfere with normal growth, bone formation, and reproduction (ATSDR, 1992)

PHARMACOKINETICS

No studies were located regarding the amount of manganese that is absorbed by humans or animals following inhalation exposure to manganese dusts. In general, the extent of inhalation absorption is a function of particle size, since this determines the extent and location of particle deposition in the respiratory tract. The amount of manganese absorbed across the gastrointestinal tract in humans is rather variable, but typically averages about 3%-5% (Davidsson et al. 1988, 1989; Mena et al. 1969). No studies were located regarding absorption in humans or animals after dermal exposure to manganese. It is generally considered that uptake across intact skin is very limited for most inorganic metal ions.

Manganese is capable of existing in a number of oxidation states, and limited data suggest that manganese may undergo changes in valence within the body. Circumstantial support for this hypothesis comes from the observation that the valence of the manganese ion in several enzymes appears to be +3 (Leach and Lilburn 1978; Utter 1976), while most manganese intake from the environment is either as +2 or +4.

Humans exposed to manganese via inhalation excreted about 60% of the material originally deposited in the lung in the feces within 4 days (Mena et al. 1969). Humans ingesting tracer levels of radioactive manganese excreted the manganese within13-37 days (Davidsson et al. 1989; Mena et al. 1969; Sandstrom et al. 1986)

HUMAN TOXICOLOGICAL PROFILE

The Food and Nutrition Board of the National Research Council (NRC, 1989) determined an "estimated safe and adequate daily dietary intake" (ESADDI) of manganese to be 2-5 mg/day for adults. The range of the ESADDI also includes an "extra margin of safety" from the level of 10 mg/day, which the NRC considered to be safe for an occasional intake. While the NRC determined an ESADDI for manganese of 2-5 mg/day, some nutritionists feel that this level may be too low. Freeland-Graves et al. (1987) have suggested a range of 3.5-7 mg/day for adults based on a review of human studies. Based on these studies, an oral Reference Dose (RfD) of 1.4e-01 mg/kg-day has been developed to evaluate exposure to manganese via ingestion.

Roels et al. (1992) conducted a cross-sectional study of 92 male workers exposed to manganese dioxide (MnO_2) dust in a Belgian alkaline battery plant. Impaired neurological function was observed among workers exposed to manganese via inhalation. Based on this study, an inhalation RfD of 1.43e-05 mg/kg-day was developed for manganese.

MAMMALIAN TOXICOLOGICAL PROFILE

Several oral studies have been performed in rodents, also demonstrating biochemical changes in the brain following administration of 1 mg $MnCl_2.4H_2O$/mL in drinking water (approximately 38.9 mg Mn/kg-day) (ATSDR, 1992). However, rodents do not exhibit the same neurological deficits that humans do following exposure to manganese.

GENOTOXICITY

No studies were located regarding genotoxic effects in humans following oral or inhalation exposure to manganese. In male rats, repeated oral doses of 0.014 mg manganese/kg/day (as $MnCl_2$) for 80 days did not produce any significant chromosomal damage either in bone marrow or spermatogonial cells (Dikshith and Chandra 1978). Effects at higher doses were not investigated.

EPA has placed manganese in Class D; not classifiable as a human carcinogen since existing studies are inadequate to assess the carcinogenicity of manganese.

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MERCURY

GENERAL BACKGROUND INFORMATION

Mercury has been used in the past for medicinal purposes (Gosselin et al., 1984). There are a number of occupations associated with mercury exposure, particularly through inhalation. These include mining, smelting, chloralkali production, and the manufacture of mercury-containing products such as batteries, measuring devices (thermometers) and paints. Mercury has also been used agriculturally as a seed and cereal protectant and as a fungicide.

PHARMACOKINETICS

The pharmacokinetics and pharmacodynamics of mercury depend largely on its chemical form, organic, inorganic or elemental. Absorption efficiencies vary depending on route of exposure and chemical form (see section on Relative Absorption Factors). Distribution, metabolism and excretion depend largely on the lipid solubility, ionization state and molecular size of the specific chemical form (ATSDR, 1989).

HUMAN TOXICOLOGICAL PROFILE

Exposure to most forms of mercury is associated with a high degree of toxicity. Elemental (metallic) mercury causes behavioral effects and other nervous system damage. Inorganic mercury salts do not generally reach the brain, but will produce kidney damage. Divalent (mercuric) mercury is substantially more toxic in this regard than the monovalent (mercurous) form. Organic mercury compounds are also toxic. Symptoms of chronic mercury poisoning can be both neurological and psychological in nature as the central nervous system is the primary target organ. Hand and finger tremors, slurred or scanning speech patterns, and drunken, stupor-like (ataxic) gait are some motor-control impairments that have been observed in chronic mercurial toxicity. Visual disturbances may also occur, and the peripheral nervous system may be affected. A psychological syndrome known as erethism is know to occur. It is characterized by changes in behavior and personality including depression, fearfulness, restlessness, irritability, irascibility, timidity, indecision, and early embarrassment. Advanced cases may also experience memory loss, hallucination, and mental deterioration.

MAMMALIAN TOXICOLOGICAL PROFILE

In a study by Mitsumori et al. (1981), male and female mice were fed methyl mercury chloride in their diet for up to 78 weeks. Most of the high dose group died from neurotoxicity before the 26th week. Renal tumors developed in 13 of 16 males in the intermediate dosage group by 53 weeks while only 1 male in the control group developed tumors. No renal tumors occurred in exposed or control females. Studies on rats have reported similar effects such as damage to kidneys and the peripheral nervous system (U.S. EPA, 1980). Mice treated with alkyl mercury phosphate were reported to have an increased frequency of offspring with cleft palates (Oharazawa, 1968) while mice treated with methylmercury had offspring with significantly lowered birth weights and possible neurological damage (Fujita, 1969). No adequate epidemiological studies exist on the teratogenic effects of methylmercury on humans (U.S. EPA, 1980).

GENOTOXICITY

Skerfving et al. (1974) reported a statistical relationship between chromosome breaks and concentrations of methyl mercury in the blood of Swedish subjects on fish diets. Concentrations were reported to be from 14-116 ng Hg/ml in the blood of exposed subjects and from 3-18 ng/ml in nonexposed subjects.

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VANADIUM

GENERAL BACKGROUND INFORMATION

Vanadium is a white to gray metal with compounds widely distributed at low concentrations in the earth's crust. The average concentration of vanadium compounds in the earth's crust is 150 mg/kg. Elemental vanadium does not occur in nature, but its compounds exist in over 50 different mineral ores and in association with fossil fuels. It has six oxidation states (1-, 0, 2+, 3+, 4+, and 5+) of which 3+, 4+, and 5+ are the most common. The ion is generally bound to oxygen.

Vanadium is released naturally to air through the formation of continental dust, marine aerosols, and volcanic emissions. Anthropogenic sources include the combustion of fossil fuels, particularly residual fuel oils, which constitute the single largest overall release of vanadium to the atmosphere. These releases are generally in the form of vanadium oxides and contribute approximately two- thirds of atmospheric vanadium. Other anthropogenic sources include leachates from mining tailings, vanadium-enriched slag heaps, municipal sewage sludge, and certain fertilizers (ATSDR, 1992).

PHARMACOKINETICS

The absorption of vanadium through the gastrointestinal tract of animals is low. While vanadium is absorbed through the lungs, the rate and extent of absorption in humans is not known. No specific studies were located regarding absorption in humans or animals after dermal exposure to vanadium, although absorption by this route is generally considered to be very low (ATSDR, 1992).

No data have been located regarding the distribution of vanadium in humans immediately following exposure. Acute animal studies suggest that there is an initial accumulation of vanadium in the lungs, kidneys, and liver of rats, as well as high levels in the blood. However, retention of vanadium occurs primarily in the bone. When excessive amounts of vanadium are in the diet, the concentration of red blood cells tend to increase. Though there were no animal data on longer exposure to vanadium via the inhalation route, it seems likely that experimental studies would show distribution patterns similar to these seen with chronic human exposures. No studies were located regarding distribution in humans and animals after oral and dermal exposure to vanadium (ATSDR, 1992).

The metabolic pathway appears to be independent of route of exposure (Edel and Sabbioni 1988). Vanadium is an element, and as such, is not metabolized. The principal route of excretion of vanadium is the urine.

HUMAN TOXICOLOGICAL PROFILE

The toxic effects resulting from exposure to vanadium are largely confined to the respiratory system. Workers exposed to vanadium have more frequently suffered from bronchitis and bronchopneumonia. Other effects reported among workers include irritations of the skin and eyes, as well as gastrointestinal distress, nausea, vomiting, and kidney damage (Klaassen, 1996).

There are no reports of death in humans following inhalation, oral, or dermal exposure to vanadium. Humans are unlikely to be in contact with large enough amounts of vanadium to cause death (ATSDR, 1992).

MAMMALIAN TOXICOLOGICAL PROFILE

Studies in animals support the findings that vanadium primarily effects the respiratory system. The respiratory system responds to the particulate matter by increasing the number of leukocytes which are used to clear away the foreign matter. Respiratory distress lead to death in rats following intraperitoneal injections of sodium metavanadate (Donaldson et al. 1985).

The inhalation reference dose (RfD) that has been developed for vanadium is 7.00e-03 mg/kg/day. This RfD is based on a study of rats with a No Observed Adverse Effect Level of 5 ppm (HEAST, 1997).

GENOTOXICITY

The only information on genotoxicity of vanadium is from in vitro studies. The majority of these studies show positive effects in test systems using bacteria, yeast, and mouse cells in culture for end points such as recombination repair, gene mutation, or DNA synthesis. None of these studies showed any indication of a cytotoxic effect. These in vitro data indicate that vanadium has the potential for genotoxicity in humans. The mechanism for this action is not clear (ATSDR, 1992).

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ECOLOGICAL RISK ASSESSMENT
Grove Pond
Ayer, Massachusetts

PROJECT #38206.005

February 2002

Office Location:
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ATTACHMENTS

1.0 INTRODUCTION

Gannett Fleming, Inc. (GF) was tasked by the U.S. Environmental Protection Agency (USEPA) to perform an ecological risk assessment (ERA) as part of a Phase II investigation of contaminants in Grove Pond, a 60 acre impoundment adjacent to the Main Post of Fort Devens in Ayer, Massachusetts. While some samples were collected as part of this Phase II investigation, data used to conduct this ERA were also consolidated from previous studies (which focused primarily on inorganic contaminants), and as discussed in the following section of this report, data used for this risk assessment were not collected for risk assessment purposes in all cases.

Data Used in this Ecological Risk Assessment

The Phase II data used in this ERA were collected by Gannett Fleming, Inc. and by ESAT (EPA) in 1999. In addition, surface water, sediment, and biological tissue data were incorporated from outside sources. Results from the following investigations were used in this risk assessment:

- ABB-ES (1995). Draft Plow Shop Pond and Grove Pond Sediment Evaluation. Surface water and sediment data were collected as part of a Site Investigation to characterize the presence and distribution of contamination in Grove Pond and to perform human health and ecological preliminary risk evaluations. In April 1995, 48 sediment samples were collected at zero to 6 inches deep throughout Grove Pond. Six surface water samples were also collected at locations throughout the pond. Turbidity and total suspended solids (TSS) were not measured in the surface water samples, and it is not clear from the report whether the samples were filtered or not. Quality Control steps were performed on surface water and sediment data but the data were not validated according to USEPA guidelines. Sample results were not adjusted for blank detections and action levels were not established.

- USEPA (1999a). Screening Level Ecological Risk Assessment, Fort Devens, Ayer, MA. Surface water and sediment samples were collected and analyzed for inorganic contaminants, as part of a screening level ecological risk assessment for USEPA, Region 1 New England, Office of Environmental Measurement and Evaluation. Surface water and sediment samples were collected at four locations in Grove Pond in September 1998. Turbidity and total suspended solids (TSS) were not measured in the surface water samples, and it is not clear from the report whether the samples were filtered or not. Quality Control steps were performed on surface water and sediment data but it is not clear if the data were validated according to USEPA guidelines.

- Plastic Distributing Company (2000). Limited Environmental Investigation. Surface water and sediment samples were collected as part of a limited environmental investigation for the Massachusetts Department of Environmental Protection. The investigation was conducted to determine if the Plastic Distribution Company (the former Hartnet Tannery) was a continuing source of contamination to Grove Pond. Data from two sediment and two surface water (filtered) samples collected in 1999 were used for this ERA. Analyses were for inorganics only. Data from this report were not validated using EPA guidance.

- Meirzykowski and Karr (2000). Trace Element Exposure in Benthic Invertebrates from Grove Pond, Plow Shop Pond, and Nonacoicus Brook.
  The US Fish and Wildlife Service collected three crayfish samples in Grove Pond and analyzed for inorganics, plus methyl mercury. Samples were collected for USEPA as part of a limited screening-level contaminant study of benthic biota. Data were not validated.

- Mierzykowski et al. (1993). Concentrations of mercury and other environmental contaminants in fish from Grove Pond, Ayer, MA.
  Twenty-eight fish tissue samples were analyzed for inorganics in 1993. Data were taken from tables in Meirzykowski and Karr (2000). The original document was not reviewed for this ERA.

- EPA (2001). Metals in Frog Tissue.
  USEPA collected 18 frog tissue samples in July and August 1999. Samples were analyzed for inorganics, plus methyl mercury, and were validated using EPA guidance.

- Haines *et al.* (2001). Bioavailability and Potential Effects of Mercury and Selected Other Trace Metals on Biota in Plow Shop and Grove Ponds, Fort Devens, MA.
  Eleven surface water, 10 sediment, invertebrate (crayfish at 3 stations and odonata at 4 stations), and 20 tree swallow tissue samples were collected as part of a university investigation to determine the uptake of pond contaminants by aquatic invertebrates, and the transfer to insectivorous birds. Samples were analyzed for inorganics plus methyl mercury. Individual invertebrate sample results were not available. Results were reported rather as sample station means. It is unclear if water samples were filtered; TSS and turbidity were apparently not measured. Quality assurance including blanks, matrix spikes, duplicates, certified reference materials, etc., was performed but data were not validated using EPA guidance.

Data tables and figures showing sample locations from the above sources are presented in Appendix A. The concentration data from these reports, along with data collected as part of this Phase II investigation, are summarized in Tables 1 through 3 of this report. Table 1 presents surface water analytical data from 32 sample locations in Grove Pond. Table 2 presents surficial sediment data from 66 sample locations throughout Grove Pond. Table 3 presents biological tissue data from frog, fish, invertebrate (crayfish and odonata larvae), and tree swallow egg samples.

These external reports also present additional data which were not used in this risk assessment, either because they represent areas other than Grove Pond or they are not pertinent to evaluating ecological risk at this site. Examples of abiotic data available in the reports but not used in this ERA include pore water data and deep sediment data. Examples of biological tissue data available in the reports but not used in this ERA include tree swallow food boli, feather, and carcass data. The latter were not used because it was not anticipated that these items would make up a significant proportion of the diet of the two representative ecological receptors chosen for this ERA.

2.0 ECOLOGICAL RISK ASSESSMENT APPROACH

This screening level ecological risk assessment (SLERA) has been conducted according to procedures recommended in *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessment*, EPA 1997; the steps in this risk assessment follow Steps 1 and 2 of the Eight-Step process outlined by the EPA.

The principal components of this SLERA include:

- Problem Formulation: In this step, the objectives of the ERA are defined. Available information regarding stressors and potential receptors are incorporated to predict routes of exposure, and assessment and measurement endpoints are established.

- Risk Analysis: Risk analysis is directed by the Problem Formulation. Available data are evaluated to predict potential ecological exposure and effects.

- Risk Characterization: During this step, exposure and toxicity are integrated to estimate risk. Risk characterization also includes a recognition of uncertainties associated with the ERA.

3.0 PROBLEM FORMULATION

The problem formulation establishes the objectives, scope, and focus of the ERA and is the first phase of the ERA process. The problem formulation links the ERA to the regulatory and policy contexts of the assessment. The problem formulation addresses the habitats and potential categories of receptors at the site as well as the chemical fate and transport mechanisms that might exist at the site as they relate to exposure pathways. Components of the problem formulation phase include characterizing the ecosystem potentially at risk, identifying stressor characteristics, identifying assessment endpoints, developing a conceptual model , and preliminarily assessing ecological effects (USEPA 1997).

3.1 Ecological Risk Assessment Objectives

The objectives of the ecological risk assessment are as follows:

- To evaluate the threat posed by site contaminants in Grove Pond surface water and sediments to ecological receptors of concern and,
- To determine the need for further evaluation of effects at the site.

3.2 Ecological Setting and Site History

The evaluation of the ecological setting is prerequisite to identifying complete ecological exposure pathways, ecological assessment endpoints, representative ecological receptors, and exposure parameters.

Grove Pond is a shallow, 60-acre impoundment located adjacent to the Main Post of Fort Devens in Ayer, Massachusetts. It is the fifth in a chain of ponds in Ayer, MA. Grove Pond is roughly triangular in shape and is bordered on the west by a railroad causeway, on the north by residential and former industrial areas, and on the south by property owned by Fort Devens, the National Guard, and the town of Ayer, MA. A culvert in the railroad causeway connects Grove Pond to Plow Shop Pond, which is downstream.

The maximum depth of Grove Pond is 5 to 6 feet. The pond has been described as eutrophic (Meirzykowski and Karr 2000), although nutrient and temperature data to support this classification were not found in the reports reviewed for this ERA. Grove Pond seasonally supports dense growths of rooted vascular aquatic plants and emergent marsh plants (ABB 1995). The pond bottom has a layer of peat up to several feet thick (ABB 1995).

Various tree and shrub species fringe the edges of Grove Pond, including red maple (*Acer rubrum*), oak species (*Quercus* spp.), grey birch (*Betula populifolia*), white pine (*Pinus strobus*), sheep laurel (*Kalmia angustifolia*), and swamp azalea (*Rhododendrun viscosum*). Typical herbaceous components include various graminoids, cinnamon fern (*Osmunda cinnamomea*), and sphagnum moss (*Sphagnum* sp.) (ABB 1995).

Grove Pond provides habitat for many species of mammalian wildlife, including raccoon (*Procyon lotor*), mink (*Mustela vison*), muskrat (*Ondrata zibethicus*), and beaver (*Castor canadensis*) (ABB 1995). Species of birds that may be found in the area include mallard (*Anas platyrhynchos*), wood duck (*Aix sponsa*), great blue heron (*Ardea herodias*), and osprey (*Pandion haliaetus*) (ABB 1995). Green frogs (*Rana clamitans*) and painted turtles (*Chrysemys picta*) have been observed in Grove Pond and it is likely that other reptile and amphibian species inhabit the area (ABB 1995). Fish species observed in the pond include largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), bullhead (*Ameiurus* sp.), and chain pickerel (*Esox Niger*) (ABB 1995).

According to the Fort Devens Basewide Biological and Endangered Species Survey (ABB-ES 1993), no state or federally listed rare or endangered species occur in Grove Pond or its floodplain (as cited in ABB 1995).

Potential sources of contamination to Grove Pond include waste disposal from a former tannery, which was located on the northwest corner of the pond, inflow from Balch Pond upstream, inflow from Cold Spring Brook, runoff from the town of Ayer, and runoff from Fort Devens. Of particular concern are inorganic contaminants in Grove Pond sediments, including arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, vanadium, and zinc (ABB 1995; EPA 1999a). Semivolatile organic compounds (SVOCs) were detected in Grove Pond sediments, but predominantly at low concentrations (ABB 1995).

The transport and fate of these chemicals in the pond environment are primarily controlled by equilibria between the dissolved state and sorption to sediments. The metal-organic relationships increase in importance as the organic carbon content increases; fulvic and humic acids can affect sorption. Some metals, such as arsenic, are extremely soluble and mobile in the environment. Many other metals, such as nickel, selenium, zinc, and copper, have an affinity for hydrous iron and manganese oxides, as well as for organic materials, and are therefore preferentially adsorbed to solids. Because of the complexities of these interactions, relationships between chemical concentrations and ecological effects are also complex.

3.3 ECOLOGICAL EXPOSURE PATHWAY EVALUATION

Ecological receptors and exposure pathways were evaluated in accordance with the *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessment* (EPA 1997). Receptor populations that were reasonably anticipated to be exposed to chemicals of concern on the site were identified. A pathway completeness determination was made for each potential exposure pathway.

For an exposure pathway to be complete, a chemical must be able to travel from the source to the ecological receptors and be bioavailable to the receptor through one or more exposure routes. Ecological exposure pathways are generally considered complete when all of the following are present: a chemical that exhibits toxicity, an exposure point, an exposure route, and an ecological receptor. An exposure point is a location of potential contact between an organism and a chemical. The exposure route is the way a chemical comes in contact with an organism (e.g., by ingestion). Ecological receptors can be exposed to chemicals in various media, including: surface water, sediment, surface soil, plants, and aquatic and terrestrial prey species. This ERA focuses on potential exposure to surface water, sediment, and aquatic prey species.

Ecological receptors at Grove Pond that may be exposed to contaminants in pond media include aquatic biota (e.g., benthic macroinvertebrates, pelagic macroinvertebrates, and fish) as well as terrestrial birds and mammals that feed on pond biota. Aquatic biota may be exposed directly to contaminants in surface water and sediments. Terrestrial species may be exposed to site contaminants by ingesting aquatic biota with body burdens of bioaccumulated chemicals. They may also ingest surface water and sediment incidently while foraging in the pond.

Potential exposure scenarios are evaluated based on the current ecological conditions. There are no indications that future ecological conditions will be substantially different than present conditions. Under both the current and future exposure scenarios, ecological receptors could be exposed to chemicals via the aforementioned pathways.

3.4 ASSESSMENT AND MEASUREMENT ENDPOINTS

Assessment endpoints are expressions of the actual ecological value to be protected. Measurement endpoints are the aspects of the ecosystem which are measured to determine if the assessment endpoints are met. For this ERA, assessment and measurement endpoints were selected for aquatic communities and terrestrial wildlife.

3.4.1 Aquatic Communities

There are two assessment endpoints for aquatic communities: one for water column biota and one for benthic biota.

3.4.1.1 Water Column Biota

One aquatic community assessment endpoint is the protection of aquatic communities from sublethal and lethal acute toxic effects of chemicals in surface waters. The measurement endpoint is the comparison of site surface water concentrations, or exposure point concentrations (EPC), to EPA National Ambient Water Quality Criteria (NAWQC) - Criterion Continuous Concentration (CCC) and Criteria Maximum Concentration (CMC) benchmarks (EPA 1999b). For chemicals that do not have corresponding NAWQC benchmarks, Tier II Secondary Chronic Values (SCV) and Secondary Acute Values (SAV) (Suter and Tsao 1996) were used for screening. The EPC and ecological benchmarks for surface water are provided in Table 4. Average EPCs were calculated using ½ the detection limit for non-detects. If the maximum detected surface water concentration exceeded the water quality benchmark for a chemical, then the assessment endpoint was not met and the chemical was selected as a chemical of potential ecological concern (COPC). The selection of surface water COPCs is discussed in Section 3.6.

3.4.1.2 Benthic Biota

The other aquatic community assessment endpoint is the protection of aquatic communities from sublethal and lethal acute toxic effects of chemicals in sediments. The measurement endpoint is the comparison of sediment EPC to Ontario Ministry of the Environment (OME) Low-Effect Level (LEL) and Severe Effect Level (SEL) benchmarks (Persaud *et al.* 1993). For chemical that do not have corresponding Ontario Ministry of the Environment benchmarks, NOAA Effects Range-Low (ER-L) and Effects Range-Median (ER-M) benchmarks (Long *et al.* 1995) were used for screening. The EPC and ecological benchmarks for sediments are provided in Table 5. Average EPCs were calculated using ½ the detection limit for non-detects. If the maximum detected sediment concentration exceeded the sediment benchmark for a chemical, then the assessment endpoint was not met and the chemical was selected as a chemical of potential ecological concern (COPC). The selection of sediment COPCs is discussed in Section 3.6.

3.4.2 Terrestrial Wildlife

There are two assessment endpoints for terrestrial wildlife: one for mammals and one for birds.

3.4.2.1 Mammals

The terrestrial wildlife assessment endpoint is the protection of small mammals foraging in pond shallows, to insure that ingestion of chemicals in food items, sediment, and surface water does not have a negative impact on growth, survival, and reproduction. The ecological exposure routes of greatest significance are ingestion of aquatic biota, ingestion of water, and inadvertent ingestion of sediment. The raccoon was selected as the representative wildlife species because of its high ingestion of sediment (10 percent of diet), use of surface water for both drinking and foraging, and likelihood of inhabiting the site. The measurement endpoint is the calculation of a hazard quotient (HQ), which is the ratio of the estimated food web uptake of a given chemical to the literature toxicity reference value (TRV).

The TRVs used are No Observed Adverse Effects Level (NOAEL)-based benchmarks from Sample *et al.* (1996) and are presented in Table 6. The TRVs for the raccoon were adjusted from NOAELs for the test species using the following body weight conversion:

$$NOAEL_R = NOAEL_T(BW_T/BW_R)^{1/4}$$

Where:

$NOAEL_R$ is the raccoon NOAEL TRV.
$NOAEL_T$ is the NOAEL for the test species.
BW_T is the body weight for the test species.

BW_R is the body weight for the raccoon.

For chemicals for which the HQ exceeded 1, this assessment endpoint was not met, and potential deleterious effects on growth, survival, and reproduction in mammals foraging in the pond was assumed.

3.4.2.2 Birds

Protection of piscivorus birds, to insure that ingestion of chemicals in food items does not have a negative impact on growth, survival, and reproduction is the terrestrial wildlife endpoint for birds. The ecological exposure route of most significance is the ingestion of fish. The osprey was selected as the representative avian species because it is exclusively piscivorus and is know to occur in the area. The measurement endpoint is the calculation of a hazard quotient (HQ), which is the ratio of the estimated food web uptake of a given chemical to the literature toxicity reference value (TRV).

The TRVs used to calculate the HQ are NOAEL based benchmarks from Sample et al. (1996) and are presented in Table 6. For chemicals for which the HQ exceeded 1, this assessment endpoint was not met and a potential negative impact on growth, survival, and reproduction is assumed.

3.5 Conceptual Site Model (CSM)

The Conceptual Site Model (Figure 1) for Grove Pond is a representation of how COPCs might pose hazards to the pond ecosystem and ecological receptors. The CSM helps describe the origin, fate, transport, exposure pathways, and receptors of concern at the site.

The source of chemical stressor to pond receptors is the reservoir of chemical constituents concentrated in surficial sediments, from known and unknown sources in the watershed, including the former tannery in the northwestern corner of the pond.

Contaminants in sediments can be taken-up via direct contact by benthic organisms. Contaminants in sediments can also be ingested by terrestrial wildlife foraging in shallow parts of the pond. Sediment COPCs that go into solution in the overlying water can be absorbed by water column biota and can also be ingested by wildlife foraging in the pond. Finally, sediment COPCs can also migrate into the aquatic food web, via bioaccumulation in aquatic invertebrates, and become available to foraging aquatic biota as well as terrestrial wildlife.

3.6 Selection of Chemicals of Potential Ecological Concern (COPC)

Ecological COPCs are the analytes detected in site media (surface water and sediment) with concentrations that exceed available conservative benchmarks. Table 4 presents the benchmark screening used to select surface water COPCs. Table 5 presents the benchmarks screening used to select sediment COPCs. In each case, chemicals were selected as COPCs if maximum concentrations exceeded the most conservative benchmarks. Several chemicals did not have available benchmarks. These chemicals were also considered COPCs and are addressed in the uncertainties section.

3.6.1 Surface Water COPCs

Four inorganic chemicals (barium, copper, iron, lead, and manganese) were selected as COPCs. One organic constituent, bis(2-ethylhexyl)phthalate also exceeded its benchmarks and was selected as a COPC. Calcium, magnesium, potassium, and sodium were not retained as COPCs because they are considered essentially non-toxic and are essential nutrients in most organisms.

3.6.2 Sediment COPCs

Ten inorganic constituents (antimony, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel and zinc) were selected as COPCs because their concentrations exceeded benchmarks. Methylmercury (MeHg) is also carried through to the food web modeling as the majority of mercury ingested by upper level receptors is thought to be in the methyl form. Fifteen organic constituents (four pesticides and eleven PAHs, including total PAH) were retained as COPCs. Barium, beryllium, cobalt, selenium, vanadium, and six SVOCs did not have available benchmarks and were retained as COPCs. As was the case for surface water, calcium, magnesium, potassium, and sodium were not retained as COPCs because they are considered essentially non-toxic and are essential nutrients in most organisms.

3.6.3 Biological COPCs

Biological data were collected separately, from various literature sources. In order to use all available data, all chemicals detected in biological tissues were retained as COPCs for food web modeling, even if concentrations in surface water and sediment did not exceed ecological benchmarks.

4.0 RISK ANALYSIS

The Risk Analysis includes the estimate of potential ecological exposure and corresponding effects and is based on the problem formulation. The ecological exposure assessment involves the identification of potential exposure pathways and an estimate of the magnitude of exposure for selected ecological receptors. In the exposure assessment, the amount of COPCs in environmental media to which receptors are exposed is estimated. In this ERA, exposure point concentrations (EPC) were established for surface water, sediment, and biological tissues.

4.1 Risk Analysis for Aquatic Biota

This section presents an estimate of COPCs exposure for aquatic biota coming into contact with surface water and sediments in Grove Pond. The risk analysis also presents the {] used to estimate risk.

4.1.1 Surface Water Biota

Potential risk to aquatic organisms from COPCs in surface water were evaluated through comparisons of site data with literature-derived toxicity thresholds. A preliminary estimate of potential exposure was provided by establishing average and maximum exposure point concentrations (EPC) (Table 4). Exposure point concentrations were compared to available chronic and acute water quality benchmarks. Surface water benchmarks are those identified previously in Section 3.4.1.1.

4.1.2 Sediment Biota

Potential risk to aquatic organisms from COPCs in sediments were evaluated through comparisons of site data with literature-derived toxicity thresholds. A preliminary estimate of potential exposure was provided by establishing average and maximum exposure point concentrations (EPC) (Table 5). Exposure point concentrations were compared to available low-effect level and severe-effect level sediment benchmarks. Sediment benchmarks are those identified previously in Section 3.4.1.2.

4.2 Risk Analysis for Wildlife

This section presents an estimate of COPC exposure for terrestrial wildlife receptors foraging in Grove Pond. Representative wildlife species were selected for evaluation in a food web model that estimates exposure to receptors based on their trophic position. The raccoon and osprey were selected, as described in Section 3.4.2. For each receptor, exposure to chemicals in site media was determined. Exposure was estimated as a total daily dose which was then compared to the literature TRV to estimate risk.

Contaminant concentrations in surface water and sediments are often used with literature BCF/BSAF values to predict concentrations in site biota. This approach was taken for some chemicals at this site. However, site-specific biological data (Table 3) were also available for many inorganic COPCs. These data were used as biological EPC, in lieu of biological EPCs calculated using abiotic media concentrations and literature BCFs/BSAFs (Table 7, Table 8). EPCs for fish and invertebrates, for chemicals not specifically analyzed in fish or invertebrate tissue, and for chemicals for which BCFs are not available, were estimated from concentrations detected in frog tissue. The biological data used in this risk assessment were collected for purposes other than risk assessment in some instances and as previously discussed, there are significant uncertainties associated with data quality and usability for risk assessment. For this reason, risk estimates for mammals and birds foraging in Grove Pond are based on maximum concentrations in biological samples. This conservative approach was selected because of uncertainties associated with the data (e.g., detection limits, mean calculations). The uncertainties associated with only using concentration maxima are discussed in Section 6.0.

4.2.1 Mammals

The exposure equation for the raccoon includes ingestion of aquatic biota, sediment, and surface water. Since this is the initial screen, assumptions erring on overestimations are used. For example, it is assumed that the raccoon forages exclusively in Grove Pond. The maximum detected concentrations of biological and abiotic dietary items are used in the exposure calculation. Often in ecological risk assessments, the concentrations of COPC in dietary items is estimated by multiplying concentrations of COPCs in surface water or sediments by a literature bioaccumulation factor. In this evaluation, however, biological data are available for direct input into the food web model; the frog, fish, invertebrate, and tree swallow tissue data provide a direct representation of bioaccumulation into the raccoon diet.

Toxicity reference values (TRVs) are used to calculate the hazard quotient. For chemicals for which the HQ generated exceeded 1, the assessment endpoint was not met.

The Exposure Estimate Equation for the raccoon is:

Exposure (mg/kg-d) =

$$\frac{IR[(EPC_{FR} \text{ x } FR) + (EPC_{FI} \text{ x } FI) + (EPC_{IN} \text{ x } IN) + (EPC_{EG} \text{ x } EG) + (EPC_{SD} \text{ x } SD + (EPC_{SW} \text{ x } SW)] \text{ x } AUF}{BW}$$

Where:

IR = ingestion Rate (kg/d)
EPC_{FR} = maximum EPC in frog tissue (mg/kg)
FR = proportion of raccoon diet consisting of frogs (unitless)
EPC_{FI} = maximum EPC in fish tissue (mg/kg)
FI = proportion of raccoon diet consisting of fish (unitless)
EPC_{IN} = maximum EPC in invertebrate tissue (mg/kg)

IN = proportion of raccoon diet consisting of invertebrates (unitless)
EPC_{EG} = maximum EPC in swallow eggs (mg/kg)
EG = proportion of raccoon diet consisting of swallow eggs (unitless)
EPC_{SD} = maximum EPC in sediment (mg/kg)
SD = proportion of raccoon diet consisting of sediment (unitless)
EPC_{SW} = maximum EPC in surface (mg/L)
SW = water consumption rate (L/d)
AUF = area use factor (unitless)
BW = body weight (kg)

Values for the above exposure parameters are provided in Table 9. The EPCs are in Tables 4, 5, and 7.

4.2.2 Birds

The exposure equation for the osprey includes ingestion of fish and surface water. Since this is the initial screen, assumptions erring on overestimations are used. For example, it is assumed that the osprey forages exclusively in Grove Pond. The maximum detected concentrations in fish tissue and surface water were used in the exposure calculation. As explained in Section 4.2.1, rather than estimating the COPC concentrations in osprey diet using water concentrations and a bioaccumulation factor for fish, in this evaluation biological data are available for direct input into the food web model; the fish tissue data provide a direct representation of bioaccumulation into the osprey diet.

Maximum calculated exposures were divided by the TRV to calculate an HQ. If the HQ generated exceeded one, the assessment endpoint was not met.

The Exposure Estimate Equation for the osprey is:

$$\text{Exposure (mg/kg-d)} = \frac{IR[(EPC_{FI} \text{ x } FI) + (EPC_{SW} \text{ x } SW)] \text{ x } AUF}{BW}$$

Where:

IR = ingestion Rate (kg/d)
EPC_{FI} = maximum EPC in fish tissue (mg/kg)
FI = proportion of raccoon diet consisting of fish (unitless)
EPC_{SW} = maximum EPC in surface (mg/L)
SW = water consumption rate (L/d)
AUF = area use factor (unitless)
BW = body weight (kg)

Values for the above exposure parameters are provided in Table 9. The EPCs are in Tables 4 and 7.

5.0 RISK CHARACTERIZATION

Data on exposure and effects are integrated in the risk characterization to provide estimates of risk to Grove Pond biota. The approach considered to be protective of the greatest number of species in an ecological assessment is the use of conservative criteria that incorporate assumptions likely to overestimate risk in the hazard quotient approach. A small number of inorganic chemicals represent the most significant risk to ecological receptors in an around Grove Pond. To better understand potential risk caused by these metals, brief toxicity profiles are presented in Appendix B.

5.1 Risk Characterization for Aquatic Biota

This section presents the evaluation of risk to aquatic biota exposed to chemicals in surface water and sediments.

5.1.1 Surface Water Biota

The results of screening of surface water concentrations in Grove Pond against surface water ecological benchmarks indicates that risk to aquatic biota may exist. These results are summarized in Table 10.

Comparison of Maximum Surface Water Concentrations Against Benchmarks

Hazard quotients based on maximum site concentrations and chronic benchmarks exceeded one for five inorganic constituents and one organic constituent. Hazard quotients were between 1 and 10 for barium, copper, lead, and manganese. The HQ for bis(2-ethylhexyl)phthalate was 17 and the HQ for iron was 236.

Hazard quotients based on maximum site concentrations and acute benchmarks exceeded 1 for one inorganic constituent (copper) and one organic constituent (bis(2-ethylhexyl)phthalate). Bis 2-(ethylhexyl)phthalate was detected in surface water in the ABB (1995) report only. It was reported in rinseate and method blanks at up to 15 ug/L and was not considered a surface water contaminant in Grove Pond (ABB 1995).

Comparison of Average Surface Water Concentrations Against Benchmarks

Hazard quotients based on average site concentrations and chronic benchmarks exceeded 1 for four inorganic constituents and one organic constituents. HQs were between 1 and 10 for barium, lead, manganese, and bis(2-ethylhexyl)phthalate. The HQ for iron was 12.

No HQs based on average site concentrations and acute benchmarks exceeded 1.

5.1.2 Sediment Biota

The results of screening of sediment concentrations in Grove Pond against ecological benchmarks for sediments indicate that risk to benthic biota may exist. These results are summarized in Table 11.

Comparison of Maximum Sediment Concentrations Against Benchmarks

Hazard quotients based on maximum site concentrations and low effects screening levels exceeded 1 for 11 inorganic constituents and 12 organic constituents. HQs were between 1 and 10 for iron, manganese, nickel, zinc, endrin, 4-chlorophenylphenylether, benzo(k)fluoranthene, fluoranthene, flourene, phenanthrene, and PAH (total). HQs were between 10 and 100 for arsenic, copper, lead, 2-methylnaphthalene, anthracene, benzo(a)anthracene, chrysene, pyrene, and PAH (total). HQs were greater than 100 for cadmium, chromium, total mercury, and naphthalene.

Hazard quotients based on maximum site concentrations and medium/severe effects screening levels exceeded one for eight inorganic constituents and two organic constituents. HQs were between 1 and 10 for arsenic, copper, lead, manganese, nickel, 2-methylnaphthalene, and naphthalene. The HQs for cadmium were between 10 and 100. HQs were greater than 100 for chromium and total mercury.

Comparison of Average Sediment Concentrations Against Benchmarks

Hazard quotients based on average site concentrations and low effects screening levels exceeded 1 for nine inorganic constituents and nine organic constituents. HQs were between 1 and 10 for copper, lead, manganese, nickel, zinc, endrin, 2-methylnaphthalene, acenaphthylene, benzo(a)anthracene, chrysene, naphthalene, pyrene, and PAH (total). HQs were between 10 and 100 for arsenic, cadmium, and total mercury. The HQ was greater than 100 for chromium.

Hazard quotients based on average site concentrations and medium/severe effects screening levels exceeded 1 for five inorganic constituents but no organic constituents. HQs were between 1 and 10 for arsenic, cadmium, lead, and mercury. The HQ for chromium was 57.

While the HQs for antimony exceed one for both low-effect and medium/severe-effect levels, it was only detected in one of 64 sediment samples collected. Therefore, risk to benthic biota from exposure to antimony is probably not significant. Similarly, the low frequency of detection for endrin and many of the PAHs suggest that these chemicals do not pose significant risk to benthic biota.

5.2 Risk Characterization for Terrestrial Wildlife

Results from the food web modeling indicate that there is potential risk to wildlife receptors foraging in Grove Pond, with several HQs greater than one. Hazard Quotients calculations are shown in Table 12 (raccoon) and Table 13 (osprey), and are summarized in Table 14.

For the raccoon, eight inorganic contaminants and one organic contaminant had HQs greater than one. Hazard quotients for barium, cadmium, lead, mercury, vanadium, and PAH(total) were between 1 and 10. The HQ for arsenic was between 10 and 100 and that for chromium exceeded 100. Aluminum had the highest HQ at 1179. As discussed in the uncertainties section, however, it is thought that for most terrestrial organisms, aluminum compounds are generally not harmful and are considered to be toxicologically inert, except in cases of high experimental doses (Venugopal and Luckey 1978).

For the osprey, three inorganic contaminants had HQs greater than one. Hazard quotients for barium and selenium exceeded 1 slightly and only mercury had a HQ greater than 10.

6.0 UNCERTAINTY ANALYSIS

Uncertainty is inherent in many aspects of the ERA process, because of the inexact nature of various assumptions which influence the risk assessment results. Uncertainty lies within the identification of chemicals of potential concern, characterization of the nature and extent of contamination, use of a representative chemical concentration, exposure assessment and effects assessment. Factors contributing to the uncertainties in this ERA include the following:

- There are uncertainties associated with the quality of the data used in this ERA. Data were taken from various sources and not all data were collected expressly for use in risk assessment. The uncertainties associated with the data collected for this ERA instill some doubt as to the certainty of the EPCs established to characterize risk in Grove Pond. These uncertainties are listed below.
    - As noted in Section 1.0, not all data used in this ERA were validated according to USEPA guidance.
    - In most cases, it is unclear if surface water samples were filtered, and TSS and turbidity were apparently not measured. Therefore, it is not possible to eliminate the likelihood that exceedances of aquatic benchmarks in surface water might have been due to suspended particulate matter in surface water samples.
    - Individual sample results were not available for all biota; rather, station means were reported, so obtaining a true maximum EPC was not possible.
- There are uncertainties associated with chemicals which were not detected in the analyses, but for which the detection limits exceeded ecological benchmarks. Detection limits exceeded surface water ecological benchmarks for chronic effects for several metals; the detection limits for three metals, cadmium, copper, and silver exceeded acute benchmarks. Further, detection limits for sediments exceeded low effects levels in some instances for antimony, arsenic, cadmium, silver, DDD, DDE, endrin, and the PAHs; detection limits exceeded severe effects levels in some instances for antimony, arsenic, silver, 2-methylnaphthalene, and acenaphthylene.. Therefore, true comparisons against ecological benchmarks were not possible in all cases
- There are uncertainties associated with chemicals for which surface water and/or sediment screening benchmarks do not exist. The conservative approach was to retain these chemicals as COPCs.
- The use of benchmark screening as measurement endpoints may not adequately reflect the assessment endpoints. Using screening benchmarks to estimate effects of COPCs on aquatic communities may not be indicative of the status of communities at Grove Pond. There is uncertainty in the estimation of risks based on these screening values that would

be lessened with actual measurements of ecological effects (toxicity testing and/or benthic community surveys).

- While some of the biological EPCs used in the food web modeling were based on site-specific tissue data, some of the EPCs were calculated using surface water or sediment concentrations and literature BCF/BSAF values. There is uncertainty associated with these literature values as they do not necessarily reflect the conditions in Grove Pond which affect chemical bioavailability.

- There is inherent uncertainty in the derivation of toxicity benchmarks for ecological receptors for several reasons, including:

    - The use of NOAEL-based benchmarks for the TRVs may over-estimate risk to wildlife receptors, since this measurement endpoint does not reflect observed impacts.

    - Extrapolation from laboratory to field conditions is uncertain.

    - Extrapolation from laboratory test organisms to the raccoon and osprey is uncertain as species differ with respect to their capacities for absorption, metabolism, distribution, and excretion of chemicals, and differing sensitivities to effects.

    - Extrapolation is required from the form of chemical used in laboratory toxicity tests to field conditions, where different chemical forms likely occur. One important example is aluminum. The mammalian TRV for aluminum is based on toxicity tests in which $AlCl_3$ was used (Ondreicka et al. 1966), and the avian TRV for aluminum is based on toxicity tests in which $Al_2(SO_4)_2$ was used (Carriere et al. 1986). These chemical forms are unlikely to occur in raccoon or osprey diet and the TRV is probably overly conservative. This is particularly true for the raccoon, for which incidental ingestion of sediments is the main route of uptake of aluminum; aluminum likely in a form other than $AlCl_3$. It is thought that for most terrestrial organisms, aluminum compounds are generally not harmful and are considered to be toxicologically inert, except in cases of high experimental doses (Venugopal and Luckey 1978).

- The assumptions were made that mammals and birds, represented by the raccoon and osprey, spend equal time in all habitats of their range, and spend 100 percent of forage time in Grove Pond. Uncertainty exists in these assumptions as wildlife species spend unequal time in different habitats, depending on habitat suitability. These assumptions are likely overly conservative.

- Maximum EPC were used for the food web models. It is unlikely that a receptor would be consistently exposed to maximum concentrations while foraging in the pond. This assumption likely overestimates risk.

- There are uncertainties associated with estimates of dietary proportions for the raccoon. An effort was made to use literature values (USEPA 1993), as available, but literature values did not always match dietary items for which site-specific data were available (e.g. swallow egg data). Therefore, profession judgement was used to estimate the proportion of diet consisting of items not specifically addressed in the literature.

- Because the exact location of the sediment samples collected could not be determined, the spatial distribution of COPCs in sediments was not incorporated into this ERA. A closer examination of the exact locations of sediments, if possible, in conjunction with an examination of site conditions, could help elucidate which sediment samples were actually collected from areas mammals could access.

7.0 PRELIMINARY ECOLOGICAL RISK ASSESSMENT CONCLUSIONS

The results of screening of both surface water and sediment concentrations in Grove Pond against surface water ecological benchmarks indicates that risk to aquatic biota may exist. The greatest risk to aquatic biota is from exposure to inorganics in Grove Pond sediments, particularly chromium, mercury, and arsenic.

Results from the food web modeling indicate that there is potential risk to wildlife receptors foraging in Grove Pond. The greatest risk to mammals is from incidental ingestion of inorganics in sediments, particularly arsenic and chromium. The greatest risk to birds is from exposure to mercury bioaccumulated in fish tissue.

The scientific management decision point (SMDP) includes one of three possible recommendations:

1) There is need for further ecological risk assessment to reduce uncertainty,
2) There are enough data to conclude no substantial ecological risk, or
3) There are enough data to conclude substantial ecological impact and proceed to remediation.

The review of existing data and evaluation of risk in this ERA suggest that there is need for further ecological risk assessment to reduce uncertainty. This ERA has not included a site-specific effects determination. In order to determine if the exceedances of ecological benchmarks is resulting in toxicity to aquatic biota in Grove Pond, surface water and sediment toxicity testing along with ecological community health evaluations may be necessary. In order to more fully evaluate the risk to wildlife foraging in Grove Pond an evaluation of the spatial distribution of chemicals in sediments and prey items should be conducted, if the specific locations of sediment samples can be discerned. Additional site-specific tissue data, particularly fish tissue data for the piscivorous bird evaluation, should also be collected in order to more accurately evaluate risk to this class of receptor. Further evaluation should also include an assessment of risk based on more realistic exposure assumptions rather than using the most conservative assumptions, and on average site media concentrations, which requires that the quality of data be more thoroughly reviewed. The aforementioned work may be included with the further evaluation conducted as part of the Phase II Remedial Investigation.

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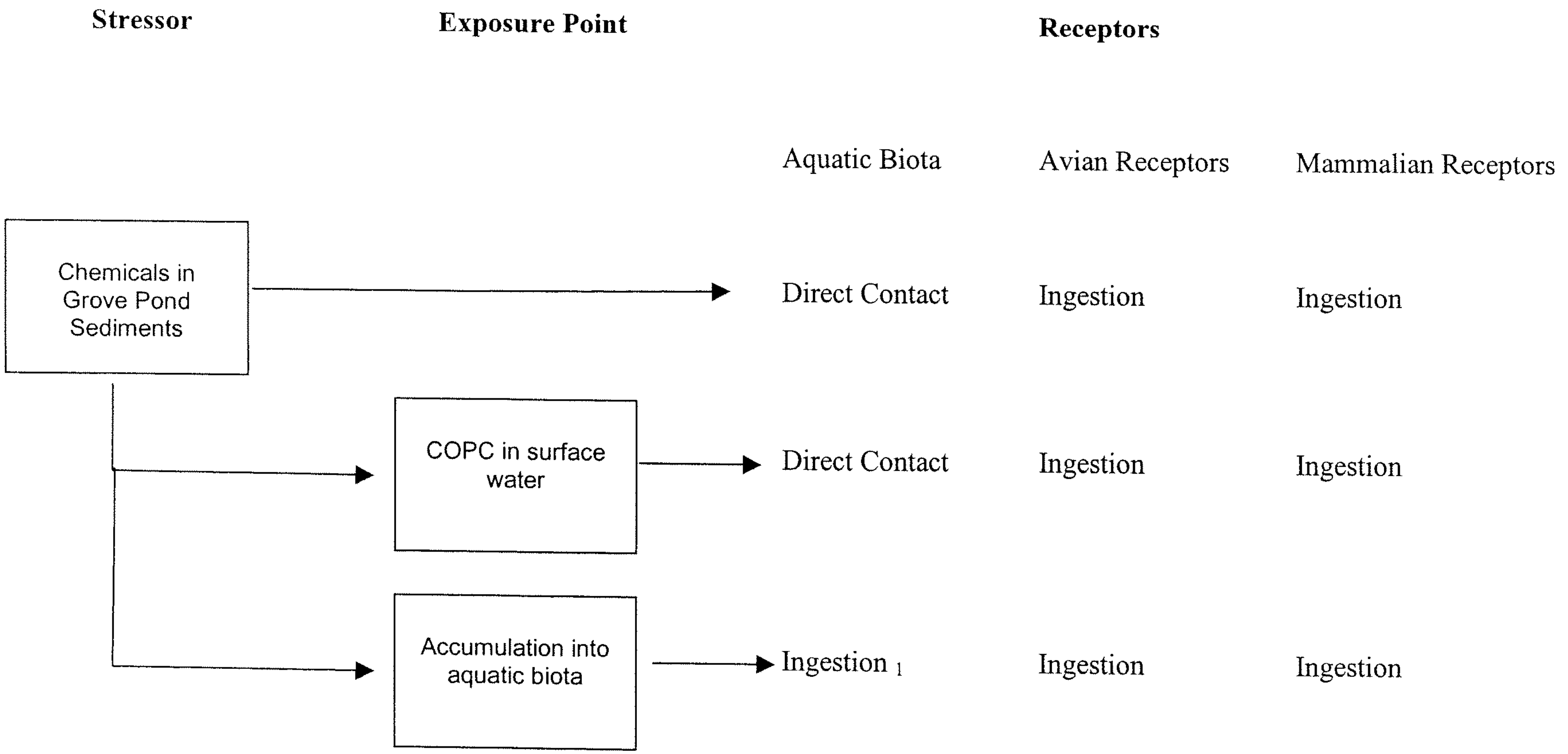
FIGURES

Figure 1. Conceptual Site Model



1. It is recognized that upper trophic level aquatic biota such as fish and predatory invertebrates ingest lower trophic level organisms with burdens of bioaccumulated COPCs. This exposure pathway was not evaluated in this ERA, however. Rather, risk to aquatic biota was estimated by comparing surface water and sediment chemical concentrations with ecological benchmarks for aquatic biota.

TABLES

Table 1. Grove Pond Surface Water Data

Analyte	(ABB-ES, Oct. 1995)						
	GRW-95-06X	GRW-95-07X	GRW-95-08X	GRW-95-09X	GRW-95-09X (dup)	GRW-95-10X	GRW-95-11X
PAL Metals (ug/L)							
aluminum							
antimony							
arsenic	< 2.54	< 2.54	3.94	< 2.54	< 2.54	< 2.54	< 2.54
barium	8	< 5	9.25	6.37	7	8.5	6.37
beryllium							
cadmium							
calcium	10500	10600	13500	11200	11800	13100	10900
chromium	< 6.02	< 6.02	39.8	6.76		< 6.02	< 6.02
Cr III							
Cr VI							
cobalt							
copper	9.89	< 8.09	< 8.09	< 8.09	< 8.09	< 8.09	< 8.09
iron	222	228	402	242	249	181	238
lead	< 1.26	< 1.26	2.39	3.04	< 1.26	< 1.26	< 1.26
magnesium	1950	1860	1970	1880	1980	1990	1860
manganese	46.6	97.4	100	53.5	58.4	39.3	73.8
mercury							
MeHg							
nickel							
potassium	1210	1780	1670	877	1580	1730	1420
selenium							
silver							
sodium	22400	22100	27400	23400	24600	19100	23100
thallium							
vanadium							
zinc							
PAL SVOCs (ug/L)							
bis(2-ethylhexyl) phthalate	51	24	9	< 4.8	16	26	45
PAL Water Quality Parameters (ug/L)							
total hardness	37000	36400	42800	34800	37200	41600	37200

Table 1. Grove Pond Surface Water Data

Analyte	MADEP (2000)		EPA (1999)				Phase II Data				
	SW-1	SW-2	GSEM-1	GSEM-2	GSEM-3	GSEM-4	SW001F	SW002F	SW003F	SW004F	SW005F
PAL Metals (ug/L)											
aluminum			< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
antimony	< 30	< 30	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
arsenic	< 30	< 30	< 10	< 10	< 10	< 10	4	2	3	5	7
barium			6.4	11.9	8.8	8.8	11.8	7.2	7.4	11.3	14
beryllium	< 5	< 5	< 1	< 1	< 1	< 1	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
cadmium	< 10	< 10	< 1.5	< 1.5	< 1.5	< 1.5	< 3	< 3	< 3	< 3	< 3
calcium			18400	19700	17400	17000	18700	18400	18500	18800	19100
chromium	< 10	< 10	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3
Cr III											
Cr VI											
cobalt			< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
copper	< 10	< 10	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
iron			390	270	320	190	330	160	170	400	800
lead	< 20	< 20	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
magnesium			3200	3300	2800	2600	3000	3100	3000	3100	3100
manganese			108	268	68.6	20.3	383	118	142	484	801
mercury	< 1	< 1					< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
MeHg											
nickel	< 10	< 10	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6
potassium			2500	1800	1400	1500	1400	1400	1600	1500	1700
selenium	< 30	< 30	< 20	< 20	< 20	< 20	< 10	< 10	< 10	< 10	< 10
silver	< 20	< 20	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3
sodium			30500	29400	29200	22100	27400	28800	31600	28100	29900
thallium	< 30	< 30	< 20	< 20	< 20	< 20	< 40	< 40	< 40	< 40	< 40
vanadium			< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
zinc	< 10	< 10	< 12	< 12	< 12	< 12	< 12	< 12	< 12	< 12	< 12
PAL SVOCs (ug/L)											
bis(2-ethylhexyl) phthalate											
PAL Water Quality Parameters (ug/L)											
total hardness											

Table 1. Grove Pond Surface Water Data

Analyte					Haines (2001) (unfiltered) - Max values for each sample location							
	SW006F	SW006 Dup	SW008	SW1	GV1	GV2	GV3	GV4	GV5	GV6	GV7	GV8
PAL Metals (ug/L)												
aluminum	< 10	< 10	< 100	34.6								
antimony	< 5	< 5	< 20	< 5								
arsenic	8	9	1	< 10	1.18	1.3	1.01	1.06	2.27	0.86	1.7	9.35
barium	18.4	17.7	7.5	13.2								
beryllium	< 0.5	< 0.5	< 2	< 0.5								
cadmium	< 3	< 3	< 3	< 1.5								
calcium	28000	28000	8800	10100								
chromium	< 3	< 3	< 3	< 1.5	1.43	0.24	0.33	0.06	0.46	0.22	1.43	46.5
Cr III					0.74	0.19	0.36	0.3	0.31	0.18	0.56	5.24
Cr VI					0.33	0.11	0.19	0.06	0.15	0.09	0.09	1.72
cobalt	< 1.5	< 1.5	< 3	< 1.5								
copper	< 1.5	< 1.5	< 3	< 1.5								
iron	280	200	77.6	236000								
lead	< 5	< 5	< 10	< 5	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
magnesium	3300	3300	1700	2300								
manganese	280	249	18	166								
mercury	< 0.5	< 0.5			0.00211	0.00177	0.00181	0.00235	0.00256	0.00186	0.00483	0.06733
MeHg					0.00044	0.00028	0.00012	0.00039	0.00055	0.0002	0.00251	0.00086
nickel	< 6	< 6	< 6	< 6								
potassium	1900	1900	< 2000	1800								
selenium	< 10	< 10	< 10	< 10								
silver	< 3	< 3	< 6	< 1.5								
sodium	45400	45100	22100	46900								
thallium	< 40	< 40	< 20	< 100								
vanadium	< 1.5	< 1.5	< 6	< 1.5								
zinc	< 12	< 12	< 6	10.1								
PAL SVOCs (ug/L)												
bis(2-ethylhexyl) phthalate												
PAL Water Quality Parameters (ug/L)												
total hardness												

Table 1. Grove Pond Surface Water Data

Analyte				
	GV9	GV10	GV11	GP Inlet
PAL Metals (ug/L)				
aluminum				
antimony				
arsenic	0.99	1.18	7.4	
barium				
beryllium				
cadmium				
calcium				
chromium	0.91	0.08	10.19	
Cr III	0.62	0.74	3.54	
Cr VI	0.22	0.21	0.72	
cobalt				
copper				
iron				
lead	< 1	< 1	1.05	
magnesium				
manganese				
mercury	0.00181	0.00272	0.0186	0.00272
MeHg	0.00025	0.00103	0.00113	
nickel				
potassium				
selenium				
silver				
sodium				
thallium				
vanadium				
zinc				
PAL SVOCs (ug/L)				
bis(2-ethylhexyl) phthalate				
PAL Water Quality Parameters (ug/L)				
total hardness				

Table 2. Grove Pond Sediment Data

Analyte	(ABB-ES, Oct. 1995)										
	GRD-95-08X	GRD-95-09X	GRD-95-10X	GRD-95-11X	GRD-95-12X	GRD-95-13X	GRD-95-14X	GRD-95-14Xdup	GRD-95-15X	GRD-95-16X	GRD-95-17X
PAL Metals (mg/kg)											
aluminum	3620	8640	12900	12400	4700	8540	5760	8300	5910	14100	8160
antimony	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09
arsenic	20.8	44.4	160	140	61.5	104	42.8	44.4	49.2	69.9	85.2
barium	39.2	81.9	118	117	54.4	72.9	46.5	58	< 5.18	88.2	< 5.18
beryllium	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
cadmium	17.1	28.9	27.6	110	23.7	8.73	< 0.7	4.94	< 0.7	< 0.7	20.9
calcium	1680	2200	3770	5430	4510	4630	2370	3090	4390	6360	4870
chromium	17.1	34.5	43.9	71	85.9	374	253	424	501	736	250
cobalt	5.5	18.5	53.4	39.4	14.5	18.8	10.5	16	< 1.42	24.2	< 1.42
copper	38.2	46.4	50.2	70.9	35.1	30.2	22.5	32.6	42.3	41.3	37
iron	10500	15500	29600	22100	8680	16300	8840	11200	9720	19900	24300
lead	123	178	492	361	86	100	405	453	190	221	143
magnesium	1340	3270	4410	3970	1180	1990	1490	2240	< 100	3940	2730
manganese	413	1040	912	859	503	769	56	80.6	337	366	449
mercury	< 0.05	< 0.05	0.442	< 0.05	1.12	4.91	1.11	0.722	1.54	2.18	1.72
MeHg											
nickel	28.5	42.3	54.4	71.8	27.9	24.3	15.2	20.5	31	37.6	38.2
potassium	661	1170	1470	1930	< 100	< 100	< 100	650	< 100	1230	< 100
selenium	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
silver											
sodium	424	1260	2430	4010	2460	3340	2110	2260	3890	3760	5590
thallium	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
vanadium	11.3	28.1	75.1	55.5	3.39	3.39	20.6	27.2	< 3.39	65.9	< 3.39
zinc	198	340	443	755	238	309	211	312	357	321	482
TOC	38100	107000	207000	205000	198000	267000	134000	421000	172000	256000	308000
PAL Pesticides/PCBs (mg/kg)+A5											
2,2-bis(para-chlorophenyl)-1,1,1-trichloroethane (DDT)	0.059 CM	< 0.00707 IO	< 0.00707 IO	< 0.00707 IO	< 0.00707 IO	< 0.00707 IO	< 0.00707 IO	3.3 CD	< <0.00707	< 0.00707 IO	< 0.00707
2,2-bis(para-chlorophenyl)-1,1-dichloroethane (DDD)	0.1 CM	0.0695 CIO	0.146 CIO	< 0.00826 IO	0.113 CIO	< 0.00826 IO	0.18 CIO	0.74 CD	0.38 C	0.43 CIO	< 0.00826
2,2-bis(para-chlorophenyl)-1,1-dichloroethene (DDE)	0.0321 CM	0.0436 CIO	0.173 CIO	0.101 CIO	0.0648 CIO	< 0.00765 IO	0.142 CIO	0.28 CD	0.254 C	0.264 CIO	0.215 C
endrin	< 0.00657 M	< 0.00657 IO	< 0.00657 IO	< 0.00657 IO	< 0.00657 IO	< 0.00657 IO	< 0.00657 IO	< 0.00657 D	< <0.00657	< 0.00657 IO	< 0.00657
PAL Semivolatile Organics (ug/g)	GRD-95-08X	GRD-95-09X	GRD-95-10X	GRD-95-11X	GRD-95-12X	GRD-95-13X	GRD-95-14X	GRD-95-14Xdup	GRD-95-15X	GRD-95-16X	GRD-95-17X
2-methylnaphthalene	< 1	< 0.5	< 1	< 1	4	< 0.2	< 0.2	< 0.2	< 0.049	< 0.2	< 0.2
4-bromophenylphenylether	< 0.7	< 0.3	< 0.7	< 0.7	< 0.2	< 0.2	< 0.2	< 0.2	1.7	< 0.2	< 0.2
4-chlorophenylphenylether	< 0.7	< 0.3	< 0.7	< 0.7	< 0.2	< 0.2	< 0.2	< 0.2	0.84	< 0.2	< 0.2
acenaphthylene	< 0.7	< 0.3	< 0.7	< 0.7	< 0.2	< 0.2	< 0.2	< 0.2	< 0.033	< 0.2	< 0.2
anthracene	< 0.7	< 0.3	< 0.7	< 0.7	< 0.2	< 0.2	< 0.2	< 0.2	2.4	< 0.2	< 0.2
benzo(a)anthracene	< 3	< 2	< 3	< 3	< 0.8	< 0.8	< 0.8	< 0.8	3.4	< 0.8	< 0.8
benzo(b)fluoranthene	< 4	< 2	< 4	< 4	< 1	< 1	< 1	< 1	< 0.21	< 1	< 1
benzo(k)fluoranthene	< 1	< 0.7	< 1	< 1	< 0.3	< 0.3	< 0.3	< 0.3	2.2	< 0.3	< 0.3
butylbenzyl phthalate	< 3	< 2	< 3	< 3	< 0.8	< 0.8	< 0.8	< 0.8	3	< 0.8	< 0.8
chrysene	< 2	< 1	< 2	< 2	< 0.6	< 0.6	< 0.6	< 0.6	3.7	< 0.6	< 0.6
di-n-butyl phthalate	< 1	< 0.6	< 1	< 1	< 0.3	< 0.3	< 0.3	< 0.3	3.3	< 0.3	< 0.3
dibenzofuran	< 0.7	< 0.4	< 0.7	< 0.7	< 0.2	< 0.2	< 0.2	< 0.2	0.62	< 0.2	< 0.2
fluoranthene	5	< 0.7	< 1	< 1	< 0.3	< 0.3	2	< 0.3	3.7	< 0.3	< 0.3
fluorene	< 0.7	< 0.3	< 0.7	< 0.7	< 0.2	< 0.2	< 0.2	< 0.2	1.1	< 0.2	< 0.2
hexachlorobenzene	< 0.7	< 0.3	< 0.7	< 0.7	< 0.2	< 0.2	< 0.2	< 0.2	1.7	< 0.2	< 0.2
naphthalene	< 0.7	< 0.4	< 0.7	< 0.7	< 0.2	< 0.2	< 0.2	< 0.2	< 0.037	< 0.2	< 0.2
phenathrene	3	< 0.3	< 0.7	< 0.7	< 0.2	< 0.2	< 0.2	< 0.2	2.7	< 0.2	< 0.2
pyrene	5	2	< 0.7	< 0.7	< 0.2	< 0.2	< 0.2	< 0.2	3.9	< 0.2	< 0.2

C = analysis was confirmed
J = low-spike recovery is low
I = low-spike recovery is high
O = low-spike recovery excessively different
M = high-spike recovery is high
< = below detection limit

Table 2. Grove Pond Sediment Data

Analyte	GRD-95-18X	GRD-95-19X	GRD-95-20X	GRD-95-21X	GRD-95-22X	GRD-95-23X	GRD-95-24X	GRD-95-24Xdup	GRD-95-25X	GRD-95-26X
PAL Metals (mg/kg)										
aluminum	7990	6470	7410	5300	6450	7760	8870	8410	5000	5520
antimony	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09 J	< 1.09 J	< 1.09J	< 1.09J	< 1.09J	< 1.09J
arsenic	108	41.8	110	70.7	9.23	28.1	240	270	100	110
barium	< 5.18	< 5.18	54.6	< 5.18	33.5	42.7	267	245	171	338
beryllium	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	3.12	< 0.5	< 0.5	< 0.5	< 0.5
cadmium	< 0.7	18.7	< 0.7	23.3	< <.7	8.52	< 0.7	< 0.7	< 0.7	3.07
calcium	5950	6180	6400	3430	1710	4420	24300	18400	65600	70400
chromium	342	214	2680	621	35.3	462	27700	26000	22900	19800
cobalt	< 1.42	19	< 1.42	16.2	4.44	< 1.42	21.1	20.3	< 1.42	12.3
copper	24.8	21.6	38.8	18.1	10.5	20.8	118	122	143	210
iron	11000	8850	19100	12300	16500	10600	18100	19300	8480	7780
lead	130	120	232	71	11.4	265	750	782	682	423
magnesium	1610	1520	1860	1710	4320	3420	2130	1990	2060	2330
manganese	688	322	792	468	145	408	1060	1210	989	620
mercury	11	0.772	2.07	1.65	< 0.05	0.624	57	86	4.32	16
MeHg										
nickel	< 1.71	22.2	20.9	27.7	19.3	32.1	41.9	32.3	18.7	25.3
potassium	< 100	< 100	< 100	< 100	1330	1270	< 100	< 100	< 100	< 100
selenium	4.14	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
silver										
sodium	3900	3320	2650	2530	698	1740	3500	3880	2270	1460
thallium	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
vanadium	< 3.39	< 3.39	59.2	< 3.39	15.3	30.5	111	104	60.4	62.6
zinc	139	225	237	223 J	125 J	135 J	526J	538J	281J	315J
TOC	166000	224000	137000	110000	68900	108000	318000	534000	249000	105000
PAL Pesticides/PCBs (mg/kg)+A5										
2,2-bis(para-chlorophenyl)-1,1,1-trichloroethane (DDT)	< 0.00707	< 0.00707	0.56 C	< 0.00707	< 0.00707	0.0726 C	< 0.00707	0.51 C	< 0.00707	< 0.00707
2,2-bis(para-chlorophenyl)-1,1-dichloroethane (DDD)	< 0.00826	0.0885 C	1.9 C	< 0.00826	< 0.00826	< 0.00826	0.8 C	0.81 C	0.39 C	0.073 C
2,2-bis(para-chlorophenyl)-1,1-dichloroethene (DDE)	< 0.00765	0.0972 C	0.93 C	< 0.00765	< 0.00765	< 0.00765	0.43 C	0.39 C	0.184 C	0.12 C
endrin	< 0.00657	< 0.00657	< 0.00657	< 0.00657	< 0.00657	< 0.00657	< 0.00657	< 0.00657	< 0.00657	< 0.00657
	GRD-95-18X	GRD-95-19X	GRD-95-20X	GRD-95-21X	GRD-95-22X	GRD-95-23X	GRD-95-24X	GRD-95-24Xdup	GRD-95-25X	GRD-95-26X
PAL Semivolatile Organics (ug/g)										
2-methylnaphthalene	< 0.2	< 0.1	< 0.1	< 0.049	< 2	< 0.1	< 0.049	< 0.049	< 0.049	< 0.049
4-bromophenylphenylether	< 0.2	< 0.07	< 0.07	< 0.033	< 1	< 0.07	< 0.033	< 0.033	< 0.033	< 0.033
4-chlorophenylphenylether	< 0.2	< 0.07	< 0.07	< 0.033	< 1	< 0.07	< 0.033	< 0.033	< 0.033	< 0.033
acenaphthylene	< 0.2	< 0.07	< 0.07	< 0.033	< 1	< 0.07	< 0.033	< 0.033	< 0.033	< 0.033
anthracene	< 0.2	< 0.07	< 0.07	< 0.033	< 1	< 0.07	< 0.033	< 0.033	< 0.033	< 0.033
benzo(a)anthracene	< 0.8	< 0.3	< 0.3	< 0.17	< 7	< 0.3	< 0.17	< 0.17	< 0.17	< 0.17
benzo(b)fluoranthene	< 1	< 0.4	< 0.4	< 0.21	< 8	< 0.4	< 0.21	< 0.21	< 0.21	< 0.21
benzo(k)fluoranthene	< 0.3	< 0.1	< 0.1	< 0.066	< 3	< 0.1	< 0.066	< 0.066	< 0.066	< 0.066
butylbenzyl phthalate	< 0.8	< 0.3	< 0.3	< 0.17	< 7	< 0.3	< 0.17	< 0.17	< 0.17	< 0.17
chrysene	< 0.6	< 0.2	< 0.2	< 0.12	< 5	< 0.2	< 0.12	< 0.12	< 0.12	< 0.12
di-n-butyl phthalate	< 0.3	< 0.1	< 0.1	< 0.061	< 2	< 0.1	< 0.061	< 0.061	< 0.061	< 0.061
dibenzofuran	< 0.2	< 0.07	< 0.07	< 0.035	< 1	< 0.07	< 0.035	< 0.035	< 0.035	< 0.035
fluoranthene	< 0.3	< 0.1	< 0.1	< 0.068	< 3	< 0.1	< 0.068	< 0.068	< 0.068	0.73
fluorene	< 0.2	< 0.07	< 0.07	< 0.033	< 1	< 0.07	< 0.033	< 0.033	< 0.033	< 0.033
hexachlorobenzene	< 0.2	< 0.07	< 0.07	< 0.033	< 1	< 0.07	< 0.033	< 0.033	< 0.033	< 0.033
naphthalene	< 0.2	< 0.07	< 0.07	< 0.037	< 1	< 0.07	< 0.037	< 0.037	< 0.037	0.37
phenathrene	< 0.2	< 0.07	< 0.07	< 0.033	< 1	< 0.07	< 0.033	< 0.033	< 0.033	0.33
pyrene	< 0.2	< 0.07	0.8	< 0.033	< 1	< 0.07	< 0.033	< 0.033	< 0.033	0.56

C = analysis was confirmed
J = low-spike recovery is low
I = low-spike recovery is high
O = low-spike recovery excessively different
M = high-spike recovery is high
< = below detection limit

Table 2. Grove Pond Sediment Data

Analyte	GRD-95-27X	GRD-95-28X	GRD-95-29X	GRD-95-30X	GRD-95-31X	GRD-95-32X	GRD-95-32DupX	GRD-95-33X	GRD-95-34X	GRD-95-35X	GRD-95-36X
PAL Metals (mg/kg)											
aluminum	8730	3530	6490	2330	6010	4830	3050	4390	6310	4690	3840
antimony	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09 J
arsenic	340	43.6	96	4.16	83.3	89.8	63	110	107	53	23.7
barium	470	70.2	131	< 5.18	259	313	145	186	189	70.9	33.9
beryllium	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
cadmium	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	16.7	7.3	3.96
calcium	83800	11200	67400	150	60600	87600	109000	148000	62300	4280	1680
chromium	40300	9980	20400	6.01	47100	49800	23800	30500	20800	3610	465
cobalt	< 1.42	< 1.42	< 1.42	< 1.42	< 1.42	< 1.42	< 1.42	< 1.42	< 1.42	9.52	5.3
copper	144	56.9	98.7	3.68	240	237	114	85.7	98.8	57.8	21.1
iron	15600	11300	18100	2370	19800	16300	9440	9710	21400	13900	8090
lead	739	313	563	3.29	1760	1150	615	387	578	262	74.8
magnesium	3260	908	1010	373	1930	1570	1090	1420	< 100	600	1000
manganese	1260	411	476	26.5	1540	1700	1730	1080	1190	380	243
mercury	220	2.78	69	< 0.05	5.77	15	88	72	17	3.4	0.92
MeHg											
nickel	19.7	21.1	18	3.95	35.3	< 1.71	< 1.71	< 1.71	45.4	22.4	12.8
potassium	< 100	< 100	724	< 100	< 100	< 100	< 100	< 100	< 100	< 100	487
selenium	3.02	< 0.25	3.23	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	2.1	< 0.25
silver											
sodium	5120	3120	3060	466	6370	5130	4390	3890	7020	2140	904
thallium	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
vanadium	66	30	58.6	< 3.39	85.4	75.6	48.4	98.9	78.2	39.6	12.4
zinc	639	197	429	< 8.03	474	356	266	316	549	241	103 J
TOC	156000	161000	260000	11100	211000	178000	186000	205000	213000	113000	99200
PAL Pesticides/PCBs (mg/kg)+A5											
2,2-bis(para-chlorophenyl)-1,1,1-trichloroethane (DDT)	< 0.00707 M	< 0.00707 M	1.5 M	< 0.00707 M	< 0.00707 M	< 0.00707 M	< 0.00707 M	< 0.00707 M	< 0.00707 M	< 0.00707 M	< 0.00707
2,2-bis(para-chlorophenyl)-1,1-dichloroethane (DDD)	0.157 CM	0.53 CM	0.17 CM	< 0.00826 M	0.56 CM	0.2 CM	< 0.00826 M	< 0.00826 M	< 0.00826 M	0.17 CM	0.084 C
2,2-bis(para-chlorophenyl)-1,1-dichloroethene (DDE)	0.195 CM	0.27 CM	0.47 CM	< 0.00765 M	0.98 CM	0.83 CM	0.62 CM	0.3 CM	0.231 CM	0.15 CM	0.0412 C
endrin	< 0.00657 M	< 0.00657 M	< 0.00657 M	< 0.00657 M	0.0278 M	< 0.00657 M	< 0.00657 M	< 0.00657 M	< 0.00657 M	< 0.00657 M	< 0.00657

PAL Semivolatile Organics (ug/g)	GRD-95-27X	GRD-95-28X	GRD-95-29X	GRD-95-30X	GRD-95-31X	GRD-95-32X	GRD-95-32DupX	GRD-95-33X	GRD-95-34X	GRD-95-35X	GRD-95-36X
2-methylnaphthalene	< 0.2	< 0.2	< 0.2	< 0.049	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.72
4-bromophenylphenylether	< 0.2	< 0.2	< 0.2	< 0.033	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.033
4-chlorophenylphenylether	< 0.2	< 0.2	< 0.2	< 0.033	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.033
acenaphthylene	< 0.2	< 0.2	< 0.2	< 0.033	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.18
anthracene	< 0.2	< 0.2	< 0.2	< 0.033	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.12
benzo(a)anthracene	< 0.8	< 0.8	< 0.8	< 0.17	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.17
benzo(b)fluoranthene	< 1	< 1	< 1	< 0.21	< 1	< 1	< 1	< 1	< 1	< 1	< 0.21
benzo(k)fluoranthene	< 0.3	< 0.3	< 0.3	< 0.066	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.066
butylbenzyl phthalate	< 0.8	< 0.8	< 0.8	< 0.17	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.17
chrysene	< 0.6	< 0.6	< 0.6	< 0.12	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	0.43
di-n-butyl phthalate	< 0.3	< 0.3	< 0.3	< 0.061	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.061
dibenzofuran	< 0.2	< 0.2	< 0.2	< 0.035	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.21
fluoranthene	< 0.3	< 0.3	< 0.3	< 0.068	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	0.66
fluorene	< 0.2	< 0.2	< 0.2	< 0.033	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.033
hexachlorobenzene	< 0.2	< 0.2	< 0.2	< 0.033	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.033
naphthalene	20	< 0.2	5	< 0.037	5	< 0.2	< 0.2	7	< 0.2	3	0.57
phenathrene	2	< 0.2	2	< 0.033	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	0.44
pyrene	3	< 0.2	3	< 0.033	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2	0.45

C = analysis was confirmed
J = low-spike recovery is low
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O = low-spike recovery excessively different
M = high-spike recovery is high
< = below detection limit

Table 2. Grove Pond Sediment Data

Analyte	GRD-95-37X	GRD-95-38X	GRD-95-39X	GRD-95-40X	GRD-95-41X	GRD-95-42X	GRD-95-43X	GRD-95-44X	GRD-95-45X	GRD-95-46X
PAL Metals (mg/kg)										
aluminum	15400	3370	6070	9420	19300	90000	6730	20300	64300	66600
antimony	< 1.09 J	< 1.09	< 1.09 J	< 1.09 J	< 1.09 J	< 1.09	< 1.09 J	< 1.09 J	< 1.09 J	< 1.09
arsenic	112	8.52	23.1	160	39	137	240	150	95	64.2
barium	180	13.4	38.9	56.9	< 5.18	< 5.18	< 5.18	34.2	< 5.18	< 5.18
beryllium	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	14.1	< 0.5
cadmium	21.9	< 0.7	3.48	9.3	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7
calcium	30400	732	2220	6860	4400	5090	3860	1210	9510	3380
chromium	22400	61.6	1020	562	728	3720	176	126	144	2010
cobalt	37.3	< 1.42	8.07	< 1.42	8.58	53.1	< 1.42	< 1.42	29.5	< 1.42
copper	126	5.85	13.7	23.6	20.5	137	23.9	76.6	54.5	68.8
iron	24700	3050	7540	22100	13100	17600	28400	42800	23300	10800
lead	748	7.85	58.3	78.2	69	230	130	64	81	110
magnesium	1850	470	1180	1390	5300	< 100	1010	1060	< 100	< 100
manganese	1220	105	504	709	110	885	204	657	35	53.6
mercury	23	0.128	1.51	1.34	1.05	2.59	0.469	4.22	< 0.05	0.872
MeHg										
nickel	59.7	4.23	18.4	31.2	24.8	69.9	< 1.71	< 1.71	38.3	34.1
potassium	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100
selenium	< 0.25	< 0.25	< 0.25	< 0.25	2.04	< 0.25	< 0.25	7.8	< 0.25	< 0.25
silver										
sodium	5200	698	942	2670	1380	5820	2600	1850	3690	3350
thallium	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
vanadium	86.4	< 3.39	15.5	< 3.39	32.1	< 3.39	< 3.39	25.7	< 3.39	59.9
zinc	654 J	19.1	81.7 J	188 J	72.3 J	448	84.6 J	< 8.03 J	150 J	134 J
TOC	336000	24400	66800	282000	87800	326000	274000	337000	249000	267000
PAL Pesticides/PCBs (mg/kg)+A5										
2,2-bis(para-chlorophenyl)-1,1,1-trichloroethane (DDT)	< 0.00707	< 0.00707	< 0.00707	< 0.00707	< 0.00707	< 0.00707	< 0.00707	< 0.00707	< 0.00707	< 0.00707
2,2-bis(para-chlorophenyl)-1,1-dichloroethane (DDD)	< 0.00826	< 0.00826	0.0444 C	< 0.00826	0.0492 C	< 0.00826	< 0.00826	< 0.00826	< 0.00826	0.5 C
2,2-bis(para-chlorophenyl)-1,1-dichloroethene (DDE)	0.142 C	< 0.00765	0.0231 C	< 0.00765	< 0.00765	< 0.00765	< 0.00765	< 0.00765	< 0.00765	0.193 C
endrin	< 0.00657	< 0.00657	< 0.00657	< 0.00657	< 0.00657	< 0.00657	< 0.00657	< 0.00657	< 0.00657	< 0.00657
PAL Semivolatile Organics (ug/g)	GRD-95-37X	GRD-95-38X	GRD-95-39X	GRD-95-40X	GRD-95-41X	GRD-95-42X	GRD-95-43X	GRD-95-44X	GRD-95-45X	GRD-95-46X
2-methylnaphthalene	< 0.1	< 0.2	< 0.1	< 0.049	< 0.049	< 0.049	< 0.1	< 0.049	< 0.049	< 0.049
4-bromophenylphenylether	< 0.07	< 0.2	< 0.07	< 0.033	< 0.033	< 0.033	< 0.07	< 0.033	< 0.033	< 0.033
4-chlorophenylphenylether	< 0.07	< 0.2	< 0.07	< 0.033	< 0.033	< 0.033	< 0.07	< 0.033	< 0.033	< 0.033
acenaphthylene	< 0.07	< 0.2	< 0.07	< 0.033	< 0.033	< 0.033	< 0.07	< 0.033	< 0.033	< 0.033
anthracene	< 0.07	< 0.2	< 0.07	< 0.033	< 0.033	< 0.033	< 0.07	< 0.033	< 0.033	< 0.033
benzo(a)anthracene	< 0.3	< 0.8	< 0.3	< 0.17	< 0.17	< 0.17	< 0.3	< 0.17	< 0.17	< 0.17
benzo(b)fluoranthene	< 0.4	< 1	< 0.4	< 0.21	< 0.21	< 0.21	< 0.4	< 0.21	< 0.21	< 0.21
benzo(k)fluoranthene	< 0.1	< 0.3	< 0.1	< 0.066	< 0.066	< 0.066	< 0.1	< 0.066	< 0.066	< 0.066
butylbenzyl phthalate	< 0.3	< 0.8	< 0.3	< 0.17	< 0.17	< 0.17	< 0.3	< 0.17	< 0.17	< 0.17
chrysene	< 0.2	< 0.6	< 0.2	< 0.12	< 0.12	< 0.12	< 0.2	< 0.12	< 0.12	< 0.12
di-n-butyl phthalate	< 0.1	< 0.3	< 0.1	< 0.061	< 0.061	< 0.061	< 0.1	< 0.061	< 0.061	< 0.061
dibenzofuran	< 0.07	< 0.2	< 0.07	< 0.035	< 0.035	< 0.035	< 0.07	< 0.035	< 0.035	< 0.035
fluoranthene	< 0.1	< 0.3	< 0.1	< 0.068	< 0.068	< 0.068	< 0.1	< 0.068	< 0.068	< 0.068
fluorene	< 0.07	< 0.2	< 0.07	< 0.033	< 0.033	< 0.033	< 0.07	< 0.033	< 0.033	< 0.033
hexachlorobenzene	< 0.07	< 0.2	< 0.07	< 0.033	< 0.033	< 0.033	< 0.07	< 0.033	< 0.033	< 0.033
naphthalene	< 0.07	< 0.2	< 0.07	< 0.037	< 0.037	< 0.037	< 0.07	< 0.037	< 0.037	< 0.037
phenathrene	< 0.07	< 0.2	< 0.07	< 0.033	< 0.033	< 0.033	< 0.07	< 0.033	< 0.033	< 0.033
pyrene	< 0.07	< 0.2	< 0.07	< 0.033	< 0.033	< 0.033	< 0.07	< 0.033	< 0.033	< 0.033

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Table 2. Grove Pond Sediment Data

Analyte										EPA (1999) Phase I			
	GRD-95-47X	GRD-95-48X	GRD-95-49X	GRD-95-50X	GRD-95-51X	GRD-95-52X	GRD-95-53X	GRD-95-54X	GRD-95-55X	GSEM-1	GSEM-2	GSEM-3	GSEM-4
PAL Metals (mg/kg)													
aluminum	6530	3620	8180	9990	13700	9950	6360	7210	6150	14000	11000	5400	21000
antimony	< 1.09	< <1.09	< <1.09	< <1.09	< <1.09	< <1.09 J	< 1.09 J	< 1.09 J	< 1.09 J	< 5J	< 5J	< 5J	< 5J
arsenic	61.8	31.2	35.7	170	126	83.9	220	40.5	72.9	< 90	< 100	< 50	< 120
barium	< 5.18	49.2	63.4	171	92.3	72.6	< 5.18	47.2	< 5.18	115	90.3	170	73
beryllium	< 0.5	< <.5	< <.5	< <.5	< <.5	< <.5	< 0.5	< 0.5	< 0.5	1.2	1	0.95	3.1
cadmium	< 0.7	8.25	< <.7	11.4	34.5	21.1	26.3	22.2	31	88.7	23.2	6.8	12.6
calcium	5240	2220	4620	116000	6810	6060	10500	5700	5810	5700	5900	215000	5100
chromium	1250	168	1260	20000	6650	1060	< 4.05	213	< 4.05	59.7	337	33400	3510
cobalt	19.6	7.93	< <1.42	24.8	41.1	< <1.42	< 1.42	< 1.42	< 1.42	34	28.8	3.5	42.5
copper	37.2	41.5	32.8	88.6	67.7	41.5	69	26	35.8	64.5	43.2	88	52.5
iron	11300	6320	8240	18700	19300	14100	34200	10400	13700	22400	21000	8700	20000
lead	180	1130	146	530	366	150	323	73	170	304	166	386	238
magnesium	< 100	658	1690	1620	1780	2040	1870	2150	1900	3880	2240	1650	1430
manganese	625	282	152	994	634	655	1030	378	507	789	861	1080	366
mercury	9.58	0.68	5.28	90	24	11	< 0.05	0.495	< 0.05				
MeHg													
nickel	26.7	19.3	< <1.71	47	58.3	39.6	45.2	33.9	43.4	61.2	41.6	15.2	63.1
potassium	< 100	< <100	< <100	< <100	1360	< <100	< 100	< 100	< 100	1720	1020	< 420	682
selenium	3.66	< <.25	< <.25	< <.25	< <.25	4.37	< 0.25	< 0.25	< 0.25	< 10.2	< 10.3	< 10.4	< 10.1
silver										< 2J	< 2J	< 2J	< 2J
sodium	3240	1580	2920	4580	4410	3950	5340	2230	3040	492	485	753	288
thallium	< 0.5	< <.5	< <.5	< <.5	< <.5	< <.5	< 0.5	< 0.5	< 0.5	< 20.4	< 20.6	< 20.9	< 20.2
vanadium	< 3.39	< <3.39	35	87.5	66.3	< <3.39	< 3.39	< 3.39	< 3.39	45.4	31.6	53.5	43
zinc	240	216 J	154 J	547 J	577 J	350 J	648 J	274 J	335 J	632	380	297	472
TOC	228000	91500	367000	329000	306000	240000	474000	131000	645000	144948	172200	117043	177905
PAL Pesticides/PCBs (mg/kg)+A5													
2,2-bis(para-chlorophenyl)-1,1,1-trichloroethane (DDT)	< 0.00707	0.22 C	< <0.00707	< <0.00707	< <0.00707	< <0.00707	< 0.00707	< 0.00707	< 0.00707				
2,2-bis(para-chlorophenyl)-1,1-dichloroethane (DDD)	2.5 C	0.1 C	0.23 C	< <0.00826	0.202 C	< <0.00826	0.224 C	0.524 C	0.26 C				
2,2-bis(para-chlorophenyl)-1,1-dichloroethene (DDE)	0.57 C	0.0404 C	0.177 C	0.204 C	< <0.023	< <0.00765	0.215 C	< 0.00765	0.17 C				
endrin	< 0.00657	< <0.00657	< <0.00657	< <0.00657	< <0.00657	< <0.00657	< 0.00657	< 0.00657	< 0.00657				
PAL Semivolatile Organics (ug/g)	GRD-95-47X	GRD-95-48X	GRD-95-49X	GRD-95-50X	GRD-95-51X	GRD-95-52X	GRD-95-53X	GRD-95-54X	GRD-95-55X				
2-methylnaphthalene	< 0.1	< <0.1	< <0.049	< <0.049	< <0.049	< <0.049	< 0.049	< 0.049	< 0.049				
4-bromophenylphenylether	< 0.07	< <0.07	< <0.033	< <0.033	< <0.033	< <0.033	< 0.033	< 0.033	< 0.033				
4-chlorophenylphenylether	< 0.07	< <0.07	< <0.033	< <0.033	< <0.033	< <0.033	< 0.033	< 0.033	< 0.033				
acenaphthylene	< 0.07	< <0.07	< <0.033	< <0.033	< <0.033	< <0.033	< 0.033	< 0.033	< 0.033				
anthracene	< 0.07	< <0.07	< <0.033	< <0.033	< <0.033	< <0.033	< 0.033	< 0.033	< 0.033				
benzo(a)anthracene	< 0.3	< <0.3	< <0.17	< <0.17	< <0.17	< <0.17	< 0.17	< 0.17	< 0.17				
benzo(b)fluoranthene	< 0.4	< <0.4	< <0.21	< <0.21	< <0.21	< <0.21	< 0.21	< 0.21	< 0.21				
benzo(k)fluoranthene	< 0.1	< <0.1	< <0.066	< <0.066	< <0.066	< <0.066	< 0.066	< 0.066	< 0.066				
butylbenzyl phthalate	< 0.3	< <0.3	< <0.17	< <0.17	< <0.17	< <0.17	< 0.17	< 0.17	< 0.17				
chrysene	< 0.2	< <0.2	< <0.12	< <0.12	< <0.12	< <0.12	< 0.12	< 0.12	< 0.12				
di-n-butyl phthalate	< 0.1	< <0.1	< <0.061	< <0.061	< <0.061	< <0.061	< 0.061	< 0.061	< 0.061				
dibenzofuran	< 0.07	< <0.07	< <0.035	< <0.035	< <0.035	< <0.035	< 0.035	< 0.035	< 0.035				
fluoranthene	< 0.1	< <0.1	< <0.068	< <0.068	< <0.068	< <0.068	< 0.068	< 0.068	< 0.068				
fluorene	< 0.07	< <0.07	< <0.033	< <0.033	< <0.033	< <0.033	< 0.033	< 0.033	< 0.033				
hexachlorobenzene	< 0.07	< <0.07	< <0.033	< <0.033	< <0.033	< <0.033	< 0.033	< 0.033	< 0.033				
naphthalene	< 0.07	< <0.07	< <0.037	1.1	< <0.037	< <0.037	< 0.037	< 0.037	< 0.037				
phenathrene	< 0.07	< <0.07	< <0.033	< <0.033	< <0.033	< <0.033	< 0.033	< 0.033	< 0.033				
pyrene	< 0.07	< <0.07	0.42	0.62	< <0.033	< <0.033	< 0.033	< 0.033	< 0.033				

C = analysis was confirmed
J = low-spike recovery is low
I = low-spike recovery is high
O = low-spike recovery excessively different
M = high-spike recovery is high
< = below detection limit

Table 2. Grove Pond Sediment Data

Analyte	Phase II Data											MADEP (2000)	
	SD-01	SD-02	SD-02 Dp	SD-03	SD-04	SD-05	SD-06	SD-07	SD-08	SD-09	SD-10	PZ-1A	PZ-2A
PAL Metals (mg/kg)													
aluminum	5150	11100	11500	12800	11300	11400	9240	6030	10300	8090	11700		
antimony	< 14J	< 36J	< 21J	< 30J	< 37J	< 39J	< 34J	< 20J	< 41J	< 15J	< 33J	< 4.12	117
arsenic	< 25	< 110	< 125	< 90	< 80	< 100	< 120	< 45	< 120	< 35	< 90	10.6	99.7
barium	34.2	92.5	96.8	97	86.1	81.6	99.5	44.4	85.8	43.6	82.1		
beryllium	< 0.71	< 1.8	1.2	< 1.5	< 1.8	< 1.9	< 1.7	< 1	< 2.1	< 0.73	< 1.7	< 0.678	< 1.26
cadmium	10J	51J	49J	8J	7J	13J	7J	4J	24J	12J	22J	< 1.37	< 2.52
calcium	3650	8680	6380	6300	6320	6130	11700	4370	6960	3130	5610		
chromium	94.1	284	340	284	153	198	5610	482	1000	219	213	280	4190
cobalt	6	31	33	23.4	18.8	24.7	8.3	6.8	28.4	8.3	24.1		
copper	16.4	52.8	52.6	33.3	33.6	37.2	124	21.6	81.1	17.7	37.9	6.73	23.7
iron	5780	22200	24500	20200	15300	20100	24300	8720	21800	8860	18000		
lead	75.8	235	251	114	123	147	277	80.5	221	79.8	223	11.9	143
magnesium	831	2470	2560	2640	2220	2490	3060	1020	2170	1250	2670		
manganese	237	1020	1090	1270	1080	857	284	595	1060	622	870		
mercury												1.7	21.2
MeHg													
nickel	14	50.4	51.9	26	24.3	30.1	27.5	14.2	43	16.9	35.8	6.87	10.9
potassium	< 1420	< 3590	< 2080	< 3010	< 3660	< 3870	< 3420	2010	< 4120	< 1460	< 3300		
selenium	< 14.2	< 35.9	< 20.8	< 30.1	< 36.6	< 38.7	< 34.2	< 20.1	< 41.2	< 14.6	< 33	< 4.12	< 7.57
silver	< 4.2	< 10.8	< 6.2	< 9	< 11	< 11.6	< 10.2	< 6	< 12.4	< 4.4	< 9.9	< 2.75	< 5.05
sodium	< 1420	< 3590	< 2080	< 3010	< 3660	< 3870	< 3420	< 2010	< 4120	< 1460	< 3300		
thallium	< 28.3	< 71.7	< 41.7	< 60.2	< 73.2	< 77.4	< 68.3	< 40.1	< 82.4	< 29.2	< 65.9	< 4.12	< 7.57
vanadium	17.9	38.4	39.7	26.7	27.1	30.4	40.4	14.1	34.2	16.5	31.5		
zinc	137	532	512	229	257	332	369	106	431	133	354	17.3	86.6
TOC													
PAL Pesticides/PCBs (mg/kg)+A5													
2,2-bis(para-chlorophenyl)-1,1,1-trichloroethane (DDT)													
2,2-bis(para-chlorophenyl)-1,1-dichloroethane (DDD)													
2,2-bis(para-chlorophenyl)-1,1-dichloroethene (DDE)													
endrin													
PAL Semivolatile Organics (ug/g)													
2-methylnaphthalene													
4-bromophenylphenylether													
4-chlorophenylphenylether													
acenaphthylene													
anthracene													
benzo(a)anthracene													
benzo(b)fluoranthene													
benzo(k)fluoranthene													
butylbenzyl phthalate													
chrysene													
di-n-butyl phthalate													
dibenzofuran													
fluoranthene													
fluorene													
hexachlorobenzene													
naphthalene													
phenathrene													
pyrene													

C = analysis was confirmed
J = low-spike recovery is low
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Table 2. Grove Pond Sediment Data

Analyte	Haines (2001)									
	GV1	GV2	GV3	GV4	GV5	GV6	GV7	GV8	GV9	GV10
PAL Metals (mg/kg)										
aluminum										
antimony										
arsenic	100.63	47.46	39.56	76.18	135.13	81.73	122.2	73.49	68.62	5.49
barium										
beryllium										
cadmium	57.972	20.972	11.393	9.949	4.712	10.888	2.022	3.157	6.438	0.489
calcium										
chromium	57.44	87.16	303.68	1408.25	8175.49	1608.58	26258.39	28831.01	2152.71	31.35
cobalt										
copper										
iron										
lead	369.07	92.45	57.07	107.51	239.17	108.1	704.7	726.67	85.18	8.58
magnesium										
manganese										
mercury	0.3431	0.2292	2.143	15.222	73.538	25.744	28.362	11.816	26.791	0.02452
MeHg	0.00206	0.00244	0.0092	0.01574	0.07044	0.04198	0.0379	0.00999	0.02467	0.00028
nickel										
potassium										
selenium										
silver										
sodium										
thallium										
vanadium										
zinc										
TOC										
PAL Pesticides/PCBs (mg/kg)+A5										
2,2-bis(para-chlorophenyl)-1,1,1-trichloroethane (DDT)										
2,2-bis(para-chlorophenyl)-1,1-dichloroethane (DDD)										
2,2-bis(para-chlorophenyl)-1,1-dichloroethene (DDE)										
endrin										
PAL Semivolatile Organics (ug/g)										
2-methylnaphthalene										
4-bromophenylphenylether										
4-chlorophenylphenylether										
acenaphthylene										
anthracene										
benzo(a)anthracene										
benzo(b)fluoranthene										
benzo(k)fluoranthene										
butylbenzyl phthalate										
chrysene										
di-n-butyl phthalate										
dibenzofuran										
fluoranthene										
fluorene										
hexachlorobenzene										
naphthalene										
phenathrene										
pyrene										
C = analysis was confirmed										
J = low-spike recovery is low										
I = low-spike recovery is high										
O = low-spike recovery excessively different										
M = high-spike recovery is high										
< = below detection limit										

Table 3. Grove Pond Biological Tissue Data

Maximimum concentrations detected in each class of prey item are presented
Concentrations are in mg/kg wet weight

Chemical	Frogs (n=18)	Source	Fish (n=28)	Source	Invertebrates (crayfish and odonates) (n=3 to 10)	Source	Tree Swallow Eggs (n=20)	Source
aluminum	108	EPA (2001)			30	Mierzykowski and Carr (2000)		
arsenic	0.478	EPA (2001)	nd	(Mierzykowski et al. 1993)a	1.72	Mierzykowski and Carr (2000); Haines and Longcore (2001)	0.95	Haines and Longcore (2001)
barium	13.7	EPA (2001)			37.5	Mierzykowski and Carr (2000)		
beryllium	nd	EPA (2001)						
boron	nd	EPA (2001)			nd	Mierzykowski and Carr (2000)		
cadmium	0.269	EPA (2001)	0.88	(Mierzykowski et al. 1993)a	1.07	Mierzykowski and Carr (2000); Haines and Longcore (2001)	0.53	Haines and Longcore (2001)
chromium	11.4	EPA (2001)	1.35	(Mierzykowski et al. 1993)a	3.54	Mierzykowski and Carr (2000); Haines and Longcore (2001)	0.61	Haines and Longcore (2001)
copper	59.2	EPA (2001)	1.27	(Mierzykowski et al. 1993)a	25.4	Mierzykowski and Carr (2000)		
iron	280	EPA (2001)			332	Mierzykowski and Carr (2000)		
lead	2.69	EPA (2001)	4.32	(Mierzykowski et al. 1993)a	0.89	Mierzykowski and Carr (2000); Haines and Longcore (2001)	0.47	Haines and Longcore (2001)
magnesium	438	EPA (2001)			404	Mierzykowski and Carr (2000)		
manganese	70.3	EPA (2001)			785	Mierzykowski and Carr (2000)		
mercury[b]	0.243	EPA (2001)	1.13	(Mierzykowski et al. 1993)a	0.051	Mierzykowski and Carr (2000); Haines and Longcore (2001)	1.075	Haines and Longcore (2001)
molybdenum	nd	EPA (2001)						
nickel	21.9	EPA (2001)	4.15	(Mierzykowski et al. 1993)a	2.14	Mierzykowski and Carr (2000)		
selenium	0.644	EPA (2001)	0.51	(Mierzykowski et al. 1993)a	nd	Mierzykowski and Carr (2000)		
strontium	30.7	EPA (2001)			156	Mierzykowski and Carr (2000)		
vanadium	0.308	EPA (2001)						
zinc	73.4	EPA (2001)	26.3	(Mierzykowski et al. 1993)a	34.7	Mierzykowski and Carr (2000)		

Samples are whole body except as otherwise noted (swallow tissues).

a. As cited in Mierzykowski and Carr (2000).

b. It is assumed that the majority of total mercury is methylmercury; therefore, the EPCs for mercury are the higher of total mercury concentrations and methylmercury concentrations.

Table 4. Summary Statistics for Surface Water Data and Comparisons to Benchmarks

			Exposure Point Concentration		Benchmark		Source[a]		
PAL Metals (ug/L)	**Frequency of Detection**	**Range**	**Average**	**Maximum**	**Acute (ug/L)**	**Chronic (ug/L)**	**Acute**	**Chronic**	**Surface Water COPC**
aluminum	1/13	nd-34.6	10.74	34.6	750	87	CMC	CCC	N
antimony	0/15	nd	nd	nd	180	30	SAV	SCV	N
arsenic	21/33	nd-9.95	4.06	9.95	340	150	CMC	CCC	N
barium	21/22	nd-18.4	**9.62**	**18.4**	110	4	SAV	SCV	Y
beryllium	0/15	nd	nd	nd	35	0.66	SAV	SCV	N
cadmium	0/15	nd	nd	nd	1.5b	1.1b	CMC	CCC	N
calcium	20/20	8800-28,000	16126	28000	NA	NA	NA	NA	N
chromium	13/32	nd-46.5	4.79	46.5	NA	NA	NA	NA	Y
Cr III	11/11	0.18-5.24	1.16	5.24	258b	34b	CMC	CCC	N
Cr VI	11/11	0.06-1.72	0.35	1.72	16	11	CMC	CCC	N
cobalt	0/13	nd	nd	nd	1500	23	SAV	SCV	N
copper	1/22	nd-9.89	2.48	**9.89**	5.4b	3.9b	CMC	CCC	Y
iron	20/20	77.6-236,000	**12068**	**236000**	NA	1000	NA	CCC	Y
lead	3/33	nd-3.04	**2.11**	**3.04**	22b	0.87b	CMC	CCC	Y
magnesium	20/20	1700-3300	2565	3300	NA	NA	NA	NA	N
manganese	20/20	18-801	**179**	**801**	2300	120	SAV	SCV	Y
mercury	12/21	nd-0.067	0.136	0.067	1.4	0.77	CMC	CCC	N
MeHg	11/11	0.00012-0.00251	0.00071	0.00251	0.099	0.0028	SAV	SCV	N
nickel	0/15	nd	nd	nd	207b	23b	CMC	CCC	N
potassium	19/20	nd-2500	1583	2500	NA	NA	NA	NA	N
selenium	0/15	nd	nd	nd	NA	5	NA	CCC	N
silver	0/15	nd	nd	nd	0.65b	0.36b	CMC	SCV	N
sodium	20/20	19,100-46,900	28930	46900	NA	NA	NA	NA	N
thallium	0/15	nd	nd	nd	110	12	SAV	SCV	N
vanadium	0/13	nd	nd	nd	280	20	SAV	SCV	N
zinc	1/15	nd-10.1	5.94	10.1	52b	52b	CMC	CCC	N
PAL SVOCs (ug/L)									
bis(2-ethylhexyl) phthalate	6/7	nd-51	24.8	**51**	27	3	SAV	SCV	Y

nd - indicates chemical not detected.
NA - indicates benchmark available.
Bold indicates concentration exceeds chronic benchmark.
Shaded indicates concentration exceeds acute benchmark.

a. Benchmarks are either EPA NAWQC (CMC and CCC) (EPA 1999) or Tier II Values (SAV and SCV) (Suter and Tsao 1996).
b. The NAWQC for several metals (cadmium, chromium III, copper, lead, nickel, silver, and zinc) are affected by water hardness. For these metals, the NAWQC were normalized to the site-specific mean hardness concentration of 38 mg/L.

Table 5. Summary Statistics for Sediment Data and Comparison to Benchmarks

			Exposure Point Concentration		Benchmark			
PAL Metals	**Frequency of Detection**	**Range**	**Average (mg/kg)**	**Maximum (mg/kg)**	**Low Effects Level**	**Severe or Medium Effects Level**	**Source[a]**	**Sediment COPC**
aluminum	66/66	2330-90,000	11358	90000	NA	NA		Y
antimony	1/64	nd-117	**4.7**	**117**	2	25	ER-L ER-M	Y
arsenic	55/69	nd-340	**78.34**	**340**	6	33	LEL SEL	Y
barium	48/62	nd-470	84.05	470	NA	NA		Y
beryllium	7/64	nd-14.1	0.68	14.1	NA	NA		Y
cadmium	49/74	nd-110	**12.69**	**110**	0.6	10	LEL SEL	Y
calcium	62/62	150-215,000	20770	215000	NA	NA		N
chromium	72/74	nd-47,100	**6313**	**47,100**	26	110	LEL SEL	Y
cobalt	38/64	nd-53.4	13.09	53.4	NA	NA		Y
copper	64/64	3.68-240	**58.34**	**240**	16	110	LEL SEL	Y
iron	62/62	2370-42,800	15826	**42800**	20000	40000	LEL SEL	Y
lead	74/74	3.29-1760	**277.86**	**1760**	31	250	LEL SEL	Y
magnesium	56/62	nd-5300	1834.68	5300	NA	NA		N
manganese	62/62	26.5-1715	**651.14**	**1715**	460	1100	LEL SEL	Y
mercury	52/60	nd-220	**15.78**	**220**	0.2	2	LEL SEL	Y
MeHg	14/14	0.00028-0.0769	0.027	0.077	NA	NA		Y
nickel	58/64	nd-71.8	**28.7**	**71.8**	16	75	LEL SEL	Y
potassium	15/62	nd-2010	537	2010	NA	NA		N
selenium	8/64	nd-7.8	3.24	7.8	NA	NA		Y
silver	0/16	nd	nd	nd	1	3.7	ER-L ER-M	N
sodium	52/62	nd-7020	2653.51	7020	NA	NA		N
thallium	0/64	nd	nd	nd	NA	NA		N
vanadium	45/62	nd-107.5	32.61	107.5	NA	NA		Y
zinc	62/64	nd-755	**298.61**	**755**	120	820	LEL SEL	Y
PAL Pesticides/PCBs (mg/kg)								
2,2-bis(para-chlorophenyl)-1,1,1-trichloroethane (DDT)	7/48	nd-3.3	**0.133**	**3.3**	0.008	14.91	LEL SEL[b]	Y
2,2-bis(para-chlorophenyl)-1,1-dichloroethane (DDD)	29/48	nd-2.5	**0.24**	**2.5**	0.008	1.26	LEL SEL[b]	Y
2,2-bis(para-chlorophenyl)-1,1-dichloroethene (DDE)	32/48	nd-0.98	**0.173**	**0.98**	0.005	3.99	LEL SEL[b]	Y
endrin	1/48	nd-0.0278	**0.0033**	**0.0278**	0.003	27.3	LEL SEL[b]	Y
PAL Semivolatile Organics (ug/g)								
2-methylnaphthalene	2/48	nd-4	**0.203**	**4**	0.07	0.67	ER-L ER-M	Y
4-bromophenylphenylether	1/48	nd-1.7	0.114	1.7	NA	NA		Y
4-chlorophenylphenylether	1/48	nd-0.84	0.097	0.84	NA	NA		Y
acenaphthylene	1/48	nd-0.18	**0.083**	**0.18**	0.044	0.64	ER-L ER-M	Y
anthracene	2/48	nd-2.4	0.131	**2.4**	0.22	77.7	LEL SEL[b]	Y
benzo(a)anthracene	1/48	nd-3.4	**0.442**	**3.4**	0.32	310.8	LEL SEL[b]	Y
benzo(b)fluoranthene	0/48	nd	nd	nd	NA	NA	LEL SEL[b]	N
benzo(k)fluoranthene	1/48	nd-2.2	0.184	**2.2**	0.24	281.4	LEL SEL[b]	Y
butylbenzyl phthalate	1/48	nd-3	0.434	3	NA	NA		Y
chrysene	2/48	nd-3.7	**0.344**	**3.7**	0.34	96.6	LEL SEL[b]	Y
di-n-butyl phthalate	1/48	nd-3.3	0.194	3.3	NA	NA		Y
dibenzofuran	2/48	nd-0.62	0.097	0.62	NA	NA		Y
fluoranthene	5/48	nd-5	0.375	**5**	0.75	214.2	LEL SEL[b]	Y
fluorene	1/48	nd-1.1	0.102	**1.1**	0.19	33.6	LEL SEL[b]	Y
hexachlorobenzene	1/48	nd-1.7	0.114	1.7	NA	NA		Y
naphthalene	8/48	nd-20	**0.946**	**20**	0.16	2.1	ER-L ER-M	Y
phenathrene	7/48	nd-3	0.304	**3**	0.56	199.5	LEL SEL[b]	Y
pyrene	11/48	nd-5	**0.513**	**5**	0.49	178.5	LEL SEL[b]	Y
PAH (Total)	na	0.625-34.4	**5.14**	**34.4**	4	2100	LEL SEL[b]	Y
TOC	52/52	11,100-645,000	209892	645000				

nd indicates that chemical not detected.
NA indicates that benchmark not available.
Bold indicates concentration exceeds Low Effects Level benchmark.
Shaded indicates concentration exceeds Severe/Medium Effects level.

a. Benchmarks are either OMOE SELs/LELs (Persaud et al. 1993) or NOAA ER-Ls/ER-Ms (Long et al. 1995).
b. SELs for organics normalized to a site average TOC concentration of 21%

Table 6. Toxicity Reference Values

Chemical	Raccoon TRVs				Osprey TRVs
	Mammalian Test Species	Test Species Body Weight (BW_T) (Kg)	Test Species NOAEL (mg/kg-d)	$NOAEL_{Raccoon}$ (mg/kg-d)	$NOAEL_{Osprey}$ (mg/kg-d)
aluminum	mouse	0.03	1.93	0.49	109.7
arsenic	mouse	0.03	0.126	0.03	5.14
barium	rat	0.35	5.1	2.41	20.8
beryllium	rat	0.35	0.66	0.31	0.66 [a]
boron	rat	0.35	28	13.24	28.8
cadmium	rat	0.35	1	0.47	1.45
chromium	rat	0.35	3.28	1.55	1
copper	mink	1	11.7	7.19	47
iron	NA	NA	NA	NA	NA
lead	rat	0.35	8	3.78	1.13
magnesium	NA	NA	NA	NA	NA
manganese	rat	0.35	88	41.61	997
mercury[b]	rat	0.35	0.032	0.02	0.0064
molybdenum	mouse	0.03	0.26	0.07	3.5
nickel	rat	0.35	40	18.91	77.4
selenium	rat	0.35	0.2	0.09	0.44
strontium	rat	0.35	263	124.37	124.37 [a]
vanadium	rat	0.35	0.21	0.10	11.4
zinc	rat	0.35	160	75.66	14.5
DDT				0.38	
DDE				0.38	
DDD				0.38	
PAH (Total)				0.27	

a. When an avian NOAEL was not available, the mammalian NOAEL was used as the avian TRV.
b. NOAELs are for methylmercury as it is assumed that the majority of mercury in dietary items is in the methylated form.

All TRVs were taken from Sample et al. (1996)

Table 7. Maximum Exposure Point Concentrations for Biological Tissues
Samples are whole body except as otherwise noted (swallow tissues).

Chemical	Frogs	Source	Fish[a,b]	Source	Invertebrates (crayfish and odonates)[a,b]	Source	Tree Swallow Eggs (n=20)	Source
Inorganics (ug/g wet weight)								
aluminum	108	EPA (2001)	0.09	Calculated from BCF	30	Mierzykowski and Carr (2000)	NA	
arsenic	0.478	EPA (2001)	nd	(Mierzykowski et al. 1993)[c]	1.72	Mierzykowski and Carr (2000); Haines and Longcore (2001)	0.95	Haines and Longcore (2001)
barium	13.7	EPA (2001)	11.65	Calculated from BCF	37.5	Mierzykowski and Carr (2000)	NA	
beryllium	nd	EPA (2001)	0	Calculated from BCF	12.7	Calculated from BSAF	NA	
boron	nd	EPA (2001)	nd	Frog EPC	nd	Mierzykowski and Carr (2000)	NA	
cadmium	0.269	EPA (2001)	0.88	(Mierzykowski et al. 1993)[c]	1.07	Mierzykowski and Carr (2000); Haines and Longcore (2001)	0.53	Haines and Longcore (2001)
chromium	11.4	EPA (2001)	1.35	(Mierzykowski et al. 1993)[c]	3.54	Mierzykowski and Carr (2000); Haines and Longcore (2001)	0.61	Haines and Longcore (2001)
copper	59.2	EPA (2001)	1.27	(Mierzykowski et al. 1993)[c]	25.4	Mierzykowski and Carr (2000)	NA	
iron	280	EPA (2001)	332	Invertebrate EPC	332	Mierzykowski and Carr (2000)	NA	
lead	2.69	EPA (2001)	4.32	(Mierzykowski et al. 1993)[c]	0.89	Mierzykowski and Carr (2000); Haines and Longcore (2001)	0.47	Haines and Longcore (2001)
magnesium	438	EPA (2001)	438	Frog EPC	404	Mierzykowski and Carr (2000)	NA	
manganese	70.3	EPA (2001)	70.3	Frog EPC	785	Mierzykowski and Carr (2000)	NA	
mercury[d]	0.243	EPA (2001)	1.13	(Mierzykowski et al. 1993)[c]	0.051	Mierzykowski and Carr (2000); Haines and Longcore (2001)	1.075	Haines and Longcore (2001)
molybdenum	nd	EPA (2001)	nd	Frog EPC	nd	Frog EPC	NA	
nickel	21.9	EPA (2001)	4.15	(Mierzykowski et al. 1993)[c]	2.14	Mierzykowski and Carr (2000)	NA	
selenium	154	EPA (2001)	0.51	(Mierzykowski et al. 1993)[c]	nd	Mierzykowski and Carr (2000)	NA	
strontium	30.7	EPA (2001)	156	Invertebrate EPC	156	Mierzykowski and Carr (2000)	NA	
vanadium	0.308	EPA (2001)	0.308	Frog EPC	0.308	Frog EPC	NA	
zinc	73.4	EPA (2001)	26.3	(Mierzykowski et al. 1993)[c]	34.7	Mierzykowski and Carr (2000)	NA	
Organics (ug/g wet weight)								
DDT	NA		NA		4.16	Calculated from BSAF	NA	
DDD	NA		NA		3.15	Calculated from BSAF	NA	
DDE	NA		NA		1.23	Calculated from BSAF	NA	
PAH Total	NA		NA		54.7	Calculated from BSAF	NA	

a. EPCs for fish and invertebrates, for chemicals not specifically analyzed in fish or invertebrate tissue, and for chemicals for which BCFs are not available, were estimated from concentrations detected in frog tissue.
b. Calculations of tissue concentrations based on BCFs is presented in Table 7.
c. As cited in Mierzykowski and Carr (2000).
d. It is assumed that the majority of total mercury is methylmercury; therefore, the EPCs for mercury are the higher of total mercury concentrations and methylmercury concentrations.

Table 8. Maximum Biological Exposure Point Concentrations Based on Bioconcentration Factors

For chemicals for which no site-specific tissue concentrations were available, maximum water concentrations were multiplied by the BCF to obtain a tissue EPC.

Chemical	Water Concentration (mg/L)	Sediment Concentration (mg/kg dry)	BCF (Water to Fish)$^{a,\,b}$	EPC_{Fish} (using BCF) (mg/kg wet)	BSAF (Sediment to Invert)$^{a,\,b}$	EPC_{Invert} (using BCF) (mg/kg wet)
Inorganics						
aluminum	0.0346		2.7	0.09	invertebrate tissue data available	
arsenic	0.00995		fish tissue data available		invertebrate tissue data available	
barium	0.0184		633	11.65	invertebrate tissue data available	
beryllium	nd	14.1	62	0.00	0.9	12.69
boron	na				invertebrate tissue data available	
cadmium	nd		fish tissue data available		invertebrate tissue data available	
chromium	0.0465		fish tissue data available		invertebrate tissue data available	
copper	0.00989		fish tissue data available		invertebrate tissue data available	
iron	236		na		invertebrate tissue data available	
lead	0.00304		fish tissue data available		invertebrate tissue data available	
magnesium	3.3		na		invertebrate tissue data available	
manganese	0.801		na		invertebrate tissue data available	
mercury	0.00000251		fish tissue data available		invertebrate tissue data available	
molybdenum	na	na	na		na	na
nickel	nd		fish tissue data available		invertebrate tissue data available	
selenium	nd		fish tissue data available		invertebrate tissue data available	
strontium	na		na		invertebrate tissue data available	
vanadium	nd	107.5	na		na	na
zinc	0.0101		fish tissue data available		invertebrate tissue data available	
Organics						
DDT	nd	3.3	na		1.26	4.16
DDD	nd	2.5	na		1.26c	3.15
DDE	nd	0.98	na		1.26c	1.23
PAH Total	nd	34.4	na		1.59d	54.7

na indicates that either a chemical was not analyzed for or the BCF/BSAF was not available.

a. BCFs are from USEPA. 1999. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities.

b. BCFs are in (Mg COCP/Kg wet tissue)/(mg dissolved COPC/L water) or (Mg COCP/Kg wet tissue)/(mg COPC/kg dry sediment).

c. BSAF extrapolated from BSAF for DDT.

d. BSAF is for benzo(a)pyrene.

Table 9. Exposure Parameters for Selected Ecological Receptors

Raccoon					
Parameter		**Symbol**	**Value**	**Units**	**Reference**
Body Weight[a]		BW	7.00E+00	Kg	USEPA, 1993
Ingestion Rate		IR	4.50E-01	Kg/day	Sample & Suter, 1994 Red Fox data used as surrogate
Percentage of Diet[b]					
	Invertebrates (including crayfish)	IN	0.55	unitless	USEPA, 1993
	fish	FI	0.016	unitless	USEPA, 1993
	frogs	FR	0.285	unitless	USEPA, 1993
	eggs	EG	0.057	unitless	USEPA, 1993
	sediment	SD	0.1	unitless	
Water Consumption Rate		SW	0.38	L/day	Sample & Suter, 1994 Red Fox data used as surrogate
Area Use Factor		AUF	Assumed=1	unitless	
Osprey					
Parameter		**Symbol**	**Value**	**Units**	**Reference**
Body Weight[c]		BW	1.69	Kg	
Ingestion Rate		IR	3.54E-01	Kg/day	
Percentage of Diet					
	fish	FI	1	unitless	
Water Consumption Rate		SW	0.088	L/day	
Area Use Factor		AUF	Assumed=1	unitless	

a. Mean adult body weight.

b. The conservative assumption was made that raccoons forage exclusively in Grove Pond. It was assumed therefore, that the diet for the two receptors was made-up entirely of Grove Pond biota (with no terrestrial components other than bird eggs). It was assumed that the diet was made-up of fish, crayfish and other invertebrates, frogs, and bird eggs. The dietary proportions were approximated, based on the relative proportion each of the above items represented in raccoon diet in EPA (1993). The proportion for frogs was based on the relative proportions provided for amphibians, reptiles, and terrestrial vertebrates. The proportion for eggs was based on those proportions provided for items classified as "unspecified" and carrion.

c. Mean body weight for adult osprey in Massachusetts.

Table 10. Hazard Quotients for Aquatic Receptors - Surface Water

	EPC		Benchmark		HQ_{Max}		$HQ_{Average}$	
PAL Metals (ug/L)	**Average**	**Maximum**	**Chronic (ug/L)**	**Acute (ug/L)**	**Chronic**	**Acute**	**Chronic**	**Acute**
aluminum	10.74	34.6	87	750	0.4	0.05	0.1	0.01
antimony	nd	nd	30	180	NC	NC	NC	NC
arsenic^{b}	4.06	9.95	150	340	0.07	0.03	0.03	0.01
barium	9.62	18.4	4	110	**4.6**	0.2	**2.4**	0.09
beryllium	nd	nd	0.66	35	NC	NC	NC	NC
cadmium	nd	nd	1.1	1.5	NC	NC	NC	NC
calcium	16126	28000	NA	NA	NC	NC	NC	NC
chromium^{b}	4.79	46.5	NA	NA	NC	NC	NC	NC
Cr III^{b}	1.16	5.24	34	258	0.2	0.02	0.03	0.00
Cr VI^{b}	0.35	1.72	11	16	0.2	0.1	0.03	0.02
cobalt	nd	nd	23	1500	NC	NC	NC	NC
copper	2.48	9.89	3.9	5.4	**2.5**	**1.8**	0.6	0.5
iron	12068	236000	1000	NA	**236**	NC	**12**	NC
lead^{b}	2.11	3.04	0.87	22	**3.5**	0.1	**2.4**	0.10
magnesium	2565	3300	NA	NA	NC	NC	NC	NC
manganese	179	801	120	2300	**6.7**	0.3	**1.5**	0.08
mercury^{b}	0.136	0.067	0.77	1.4	0.09	0.05	0.2	0.10
MeHg^{b}	0.00071	0.00251	0.0028	0.099	0.9	0.03	0.3	0.01
nickel	nd	nd	23	207	NC	NC	NC	NC
potassium	1583	2500	NA	NA	NC	NC	NC	NC
selenium	nd	nd	5	NA	NC	NC	NC	NC
silver	nd	nd	0.36	0.65	NC	NC	NC	NC
sodium	28930	46900	NA	NA	NC	NC	NC	NC
thallium	nd	nd	12	110	NC	NC	NC	NC
vanadium	nd	nd	20	280	NC	NC	NC	NC
zinc	5.94	10.1	52	52	0.2	0.2	0.1	0.1
PAL SVOCs (ug/L)								
bis(2-ethylhexyl) phthalate	24.8	51	3	27	**17.0**	**1.9**	**8.3**	0.9

nd - indicates the chemical was not detected.
NA - columns indicates that benchmark not available.
NC - indicates HQ could not be calculated because chemical was not detected or lacked a benchmark.

Table 11. Hazard Quotients for Aquatic Receptors - Sediment

	EPC		Benchmark		HQ - Max		HQ - Average	
PAL Metals (mg/kg)	**Average**	**Maximum**	**Low Effects Level**	**Medium or Severe Effects Level**	**Low Effects**	**Medium or Severe Effects**	**Low Effects**	**Medium or Severe Effects**
aluminum	11358	90000	NA	NA	NA	NA	NA	NA
antimony	4.7	117	2	25	**59**	**4.7**	**2.4**	0.2
arsenic	78.34	340	6	33	**57**	**10**	**13**	**2.4**
barium	84.05	470	NA	NA	NA	NA	NA	NA
beryllium	0.68	14.1	NA	NA	NA	NA	NA	NA
cadmium	12.69	110	0.6	10	**183**	**11**	**21**	**1.3**
calcium	20770	215000	NA	NA	NA	NA	NA	NA
chromium	6313	47,100	26	110	**1812**	**428**	**243**	**57**
cobalt	13.09	53.4	NA	NA	NA	NA	NA	NA
copper	58.34	240	16	110	**15**	**2.2**	**3.6**	0.5
iron	15826	42800	20000	40000	**2.1**	1.1	0.8	0.4
lead	277.86	1760	31	250	**57**	**7**	**9**	**1.1**
magnesium	1834.68	5300	NA	NA	NA	NA	NA	NA
manganese	651.14	1715	460	1100	**3.7**	**1.6**	**1.4**	0.6
mercury	15.78	220	0.2	2	**1100**	**110**	**79**	**8**
MeHg	0.027	0.077	NA	NA	NA	NA	NA	NA
nickel	28.7	71.8	16	75	**4.5**	**1.0**	**1.8**	0.4
potassium	537	2010	NA	NA	NA	NA	NA	NA
selenium	3.24	7.8	NA	NA	NA	NA	NA	NA
silver	nd	nd	1	3.7	NA	NA	NA	NA
sodium	2653.51	7020	NA	NA	NA	NA	NA	NA
thallium	nd	nd	NA	NA	NA	NA	NA	NA
vanadium	32.61	107.5	NA	NA	NA	NA	NA	NA
zinc	298.61	755	120	820	**6.3**	0.9	**2.5**	0.4
PAL Pesticides/PCBs (mg/kg)								
2,2-bis(para-chlorophenyl)-1,1,1-trichloroethane (DDT)	0.133	3.3	NA	NA	NA	NA	NA	NA
2,2-bis(para-chlorophenyl)-1,1-dichloroethane (DDD)	0.24	2.5	NA	NA	NA	NA	NA	NA
2,2-bis(para-chlorophenyl)-1,1-dichloroethene (DDD)	0.173	0.98	NA	NA	NA	NA	NA	NA
endrin	0.0033	0.0278	0.003	27.3	**9.3**	0.001	**1.1**	0.000
PAL Semivolatile Organics (ug/g)								
2-methylnaphthalene	0.203	4	0.07	0.67	**57**	**6.0**	**2.9**	0.3
4-bromophenylphenylether	0.114	1.7	NA	NA	NA	NA	NA	NA
4-chlorophenylphenylether	0.097	0.84	NA	NA	NA	NA	NA	NA
acenaphthylene	0.083	0.18	0.044	0.64	**4.1**	0.3	**1.9**	0.1
anthracene	0.131	2.4	0.22	77.7	**11**	0.031	0.6	0.002
benzo(a)anthracene	0.442	3.4	0.32	310.8	**11**	0.011	**1.4**	0.001
benzo(b)fluoranthene	nd	nd	NA	NA	NA	NA	NA	NA
benzo(k)fluoranthene	0.184	2.2	0.24	281.4	**9.2**	0.008	0.8	0.001
butylbenzyl phthalate	0.434	3	NA	NA	NA	NA	NA	NA
chrysene	0.344	3.7	0.34	96.6	**11**	0.038	**1.0**	0.004
di-n-butyl phthalate	0.194	3.3	NA	NA	NA	NA	NA	NA
dibenzofuran	0.097	0.62	NA	NA	NA	NA	NA	NA
fluoranthene	0.375	5	0.75	214.2	**6.7**	0.023	0.5	0.002
fluorene	0.102	1.1	0.19	33.6	**5.8**	0.033	0.5	0.003
hexachlorobenzene	0.114	1.7	NA	NA	NA	NA	NA	NA
naphthalene	0.946	20	0.16	2.1	**125**	**9.5**	**5.9**	0.5
phenathrene	0.304	3	0.56	199.5	**5.4**	0.015	0.5	0.002
pyrene	0.513	5	0.49	178.5	**10**	0.028	**1.0**	0.003
PAH (Total)	5.14	34.4	4	2100	**8.6**	0.016	**1.3**	0.002

Table 12. Uptake and Hazard Quotient Calculations - Raccoon

Chemical	EPCs								
	Sediment (mg/kg)	Surface Water (mg/L)	Frog (mg/kg)	Fish (mg/kg)	Invertebrates (mg/kg)	Swallow Eggs (mg/kg)	Uptake[a] (mg/kg-d)	TRV (mg/kg-d)	HQ
aluminum	90000	0.035	108	0.09	30	NA	581.61	0.49	**1178**
arsenic	340	0.010	0.478	nd	1.72	0.95	2.28	0.03	**71**
barium	470	0.018	13.7	11.65	37.5	NA	4.61	2.41	**1.9**
cadmium	110	nd	0.269	0.88	1.07	0.53	0.76	0.47	**1.6**
chromium	47,100	0.047	11.4	1.35	3.54	0.61	303.14	1.55	**195**
copper	240	0.010	59.2	1.27	25.4	NA	3.53	12.19	0.29
iron	42800	236	280	332	332	NA	298.12	NA	NA
lead	1760	0.003	2.69	4.32	0.89	0.47	11.41	3.78	**3.0**
magnesium	5300	3.3	438	438	404	NA	56.91	NA	NA
manganese	1715	0.801	70.3	70.3	785	NA	40.16	41.61	0.97
mercury[b]	0.077	2.51E-06	0.243	1.13	0.051	1.075	0.03	0.02	**2.26**
nickel	71.8	nd	21.9	4.15	2.14	NA	0.94	18.91	0.05
selenium	7.8	nd	0.644	0.51	nd	NA	0.06	0.09	0.7
strontium	NA	NA	30.7	156	156	NA	6.24	124.37	0.05
vanadium	107.5	nd	0.308	0.308	0.308	NA	0.71	0.10	**7.1**
zinc	755	0.010	73.4	26.3	34.7	NA	7.45	75.66	0.10
DDT	3.3	nd	NA	NA	4.16	NA	0.21	0.38	0.54
DDE	2.5	nd	NA	NA	3.15	NA	0.16	0.38	0.41
DDD	0.98	nd	NA	NA	1.23	NA	0.06	0.38	0.16
PAH (Total)	34.4	nd	NA	NA	54.7	NA	2.63	0.27	**9.76**

NA in EPC columns indicates chemical not analyzed.

NA in TRV and HQ columns indicates TRV not available and HQ could not be calculated.

nd - indicates the chemical not detected.

a. Uptake is calculated as: IR (EPC_{FR} x FR + EPC_{FI} x FI + EPC_{IN} x IN + EPC_{EG} x EG + EPC_{SD} x SD + EPC_{SW} x SW) x AUF/BW

(For inorganics, the swallow eggs term was not included for chemicals for which it is designated NA. For pesticides and PAHs, only the invertebrate term was used).

Exposure parameters as presented in Table 8 are the following:

BW	7	Kg
IR	4.50E-01	Kg/day
IN	0.55	unitless
FI	0.016	unitless
FR	0.285	unitless
EG	0.057	unitless
SD	0.1	unitless
SW	0.38	L/day
AUF	1	unitless

b. The sediment and surface water EPCs for incidental ingestion by the raccoon, are those for methylmercury.

Table 13. Uptake and Hazard Quotient Calculations - Osprey

Chemical	EPCs Surface Water (mg/L)	Fish (mg/kg)	Uptake[a] (mg/kg-d)	TRV (mg/kg-d)	HQ
aluminum	0.035	0.09	0.02	0.49	0.04
arsenic	0.010	nd	0.00	0.03	0.0
barium	0.018	11.65	2.44	2.41	**1.0**
cadmium	nd	0.88	0.18	0.47	0.39
chromium	0.047	1.35	0.29	1.55	0.18
copper	0.010	1.27	0.27	7.19	0.04
iron	236	332	82	NA	NA
lead	0.003	4.32	0.91	3.78	0.24
magnesium	3.3	438	92	NA	NA
manganese	0.801	70.3	15	41.61	0.35
mercury[b]	2.51E-06	1.13	0.24	0.02	**15.64**
nickel	nd	4.15	0.87	18.91	0.05
selenium	nd	0.51	0.11	0.09	**1.1**
strontium	NA	156	32.68	124.37	0.26
vanadium	nd	0.308	0.06	0.10	0.65
zinc	0.010	26.3	5.51	75.66	0.07

NA in EPC columns indicates chemical not analyzed.

NA in TRV and HQ columns indicates TRV not available and HQ could not be calculated.

nd - indicates the chemical not detected.

a. Uptake is calculated as: $((IR \times EPC_{FI} \times FI) + (SW \times EPC_{SW}))*AUF/BW$

Exposure parameters as presented in Table 8 are the following:

BW	1.69	Kg
IR	3.54E-01	Kg/day
FI	1	unitless
SW	0.088	L/day
AUF	1	unitless

b. The surface water EPC for incidental ingestion by the osprey is that for methylmercury.

NA - indicates that chemical was not analyzed in sediments or surface water.

nd - indicates the chemical was not detected.

Table 14. Hazard Quotients for Wildlife Receptors

Chemical	HQ Raccoon	HQ Osprey
aluminum	**1178**	0.04
arsenic	**71**	0.0
barium	**1.9**	**1.0**
cadmium	**1.6**	0.4
chromium	**195**	0.2
copper	0.3	0.04
iron	NA	NA
lead	**3.0**	0.2
magnesium	NA	NA
manganese	0.97	0.4
mercury	2.3	**16**
nickel	0.05	0.05
selenium	0.7	**1.1**
strontium	0.1	0.3
vanadium	**7.1**	0.6
zinc	0.1	0.1
DDT	0.5	NA
DDE	0.4	NA
DDD	0.2	NA
PAH (Total)	**10**	NA

Table 10. Hazard Quotients for Aquatic Receptors - Surface Water

	EPC		**Benchmark**		**HQ$_{Max}$**		**HQ$_{Average}$**	
PAL Metals (ug/L)	**Average**	**Maximum**	**Chronic (ug/L)**	**Acute (ug/L)**	**Chronic**	**Acute**	**Chronic**	**Acute**
aluminum	10.74	34.6	87	750	0.4	0.05	0.1	0.01
antimony	nd	nd	30	180	NC	NC	NC	NC
arsenic^b	4.06	9.95	150	340	0.07	0.03	0.03	0.01
barium	9.62	18.4	4	110	**4.6**	0.2	**2.4**	0.09
beryllium	nd	nd	0.66	35	NC	NC	NC	NC
cadmium	nd	nd	1.1	1.5	NC	NC	NC	NC
calcium	16126	28000	NA	NA	NC	NC	NC	NC
chromium^b	4.79	46.5	NA	NA	NC	NC	NC	NC
Cr III^b	1.16	5.24	34	258	0.2	0.02	0.03	0.00
Cr VI^b	0.35	1.72	11	16	0.2	0.1	0.03	0.02
cobalt	nd	nd	23	1500	NC	NC	NC	NC
copper	2.48	9.89	3.9	5.4	**2.5**	**1.8**	0.6	0.5
iron	12068	236000	1000	NA	**236**	NC	**12**	NC
lead^b	2.11	3.04	0.87	22	**3.5**	0.1	**2.4**	0.10
magnesium	2565	3300	NA	NA	NC	NC	NC	NC
manganese	179	801	120	2300	**6.7**	0.3	**1.5**	0.08
mercury^b	0.136	0.067	0.77	1.4	0.09	0.05	0.2	0.10
MeHg^b	0.00071	0.00251	0.0028	0.099	0.9	0.03	0.3	0.01
nickel	nd	nd	23	207	NC	NC	NC	NC
potassium	1583	2500	NA	NA	NC	NC	NC	NC
selenium	nd	nd	5	NA	NC	NC	NC	NC
silver	nd	nd	0.36	0.65	NC	NC	NC	NC
sodium	28930	46900	NA	NA	NC	NC	NC	NC
thallium	nd	nd	12	110	NC	NC	NC	NC
vanadium	nd	nd	20	280	NC	NC	NC	NC
zinc	5.94	10.1	52	52	0.2	0.2	0.1	0.1
PAL SVOCs (ug/L)								
bis(2-ethylhexyl) phthalate	24.8	51	3	27	**17.0**	**1.9**	**8.3**	0.9

nd - indicates the chemical was not detected.

NA - columns indicates that benchmark not available.

NC - indicates HQ could not be calculated because chemical was not detected or lacked a benchmark.

Table 11. Hazard Quotients for Aquatic Receptors - Sediment

	EPC		Benchmark		HQ - Max		HQ - Average	
PAL Metals (mg/kg)	**Average**	**Maximum**	**Low Effects Level**	**Medium or Severe Effects Level**	**Low Effects**	**Medium or Severe Effects**	**Low Effects**	**Medium or Severe Effects**
aluminum	11358	90000	NA	NA	NA	NA	NA	NA
antimony	4.7	117	2	25	**59**	**4.7**	**2.4**	0.2
arsenic	78.34	340	6	33	**57**	**10**	**13**	**2.4**
barium	84.05	470	NA	NA	NA	NA	NA	NA
beryllium	0.68	14.1	NA	NA	NA	NA	NA	NA
cadmium	12.69	110	0.6	10	**183**	**11**	**21**	**1.3**
calcium	20770	215000	NA	NA	NA	NA	NA	NA
chromium	6313	47,100	26	110	**1812**	**428**	**243**	**57**
cobalt	13.09	53.4	NA	NA	NA	NA	NA	NA
copper	58.34	240	16	110	**15**	**2.2**	**3.6**	0.5
iron	15826	42800	20000	40000	**2.1**	1.1	0.8	0.4
lead	277.86	1760	31	250	**57**	**7**	**9**	**1.1**
magnesium	1834.68	5300	NA	NA	NA	NA	NA	NA
manganese	651.14	1715	460	1100	**3.7**	**1.6**	**1.4**	0.6
mercury	15.78	220	0.2	2	**1100**	**110**	**79**	**8**
MeHg	0.027	0.077	NA	NA	NA	NA	NA	NA
nickel	28.7	71.8	16	75	**4.5**	**1.0**	**1.8**	0.4
potassium	537	2010	NA	NA	NA	NA	NA	NA
selenium	3.24	7.8	NA	NA	NA	NA	NA	NA
silver	nd	nd	1	3.7	NA	NA	NA	NA
sodium	2653.51	7020	NA	NA	NA	NA	NA	NA
thallium	nd	nd	NA	NA	NA	NA	NA	NA
vanadium	32.61	107.5	NA	NA	NA	NA	NA	NA
zinc	298.61	755	120	820	**6.3**	0.9	**2.5**	0.4
PAL Pesticides/PCBs (mg/kg)								
2,2-bis(para-chlorophenyl)-1,1,1-trichloroethane (DDT)	0.133	3.3	NA	NA	NA	NA	NA	NA
2,2-bis(para-chlorophenyl)-1,1-dichloroethane (DDD)	0.24	2.5	NA	NA	NA	NA	NA	NA
2,2-bis(para-chlorophenyl)-1,1-dichloroethene (DDD)	0.173	0.98	NA	NA	NA	NA	NA	NA
endrin	0.0033	0.0278	0.003	27.3	**9.3**	0.001	**1.1**	0.000
PAL Semivolatile Organics (ug/g)								
2-methylnaphthalene	0.203	4	0.07	0.67	**57**	**6.0**	**2.9**	0.3
4-bromophenylphenylether	0.114	1.7	NA	NA	NA	NA	NA	NA
4-chlorophenylphenylether	0.097	0.84	NA	NA	NA	NA	NA	NA
acenaphthylene	0.083	0.18	0.044	0.64	**4.1**	0.3	**1.9**	0.1
anthracene	0.131	2.4	0.22	77.7	**11**	0.031	0.6	0.002
benzo(a)anthracene	0.442	3.4	0.32	310.8	**11**	0.011	**1.4**	0.001
benzo(b)fluoranthene	nd	nd	NA	NA	NA	NA	NA	NA
benzo(k)fluoranthene	0.184	2.2	0.24	281.4	**9.2**	0.008	0.8	0.001
butylbenzyl phthalate	0.434	3	NA	NA	NA	NA	NA	NA
chrysene	0.344	3.7	0.34	96.6	**11**	0.038	**1.0**	0.004
di-n-butyl phthalate	0.194	3.3	NA	NA	NA	NA	NA	NA
dibenzofuran	0.097	0.62	NA	NA	NA	NA	NA	NA
fluoranthene	0.375	5	0.75	214.2	**6.7**	0.023	0.5	0.002
fluorene	0.102	1.1	0.19	33.6	**5.8**	0.033	0.5	0.003
hexachlorobenzene	0.114	1.7	NA	NA	NA	NA	NA	NA
naphthalene	0.946	20	0.16	2.1	**125**	**9.5**	**5.9**	0.5
phenathrene	0.304	3	0.56	199.5	**5.4**	0.015	0.5	0.002
pyrene	0.513	5	0.49	178.5	**10**	0.028	**1.0**	0.003
PAH (Total)	5.14	34.4	4	2100	**8.6**	0.016	**1.3**	0.002

Table 12. Uptake and Hazard Quotient Calculations - Raccoon

Chemical	Sediment (mg/kg)	Surface Water (mg/L)	Frog (mg/kg)	EPCs Fish (mg/kg)	Invertebrates (mg/kg)	Swallow Eggs (mg/kg)	Uptake[a] (mg/kg-d)	TRV (mg/kg-d)	HQ
aluminum	90000	0.035	108	0.09	30	NA	581.61	0.49	**1178**
arsenic	340	0.010	0.478	nd	1.72	0.95	2.28	0.03	**71**
barium	470	0.018	13.7	11.65	37.5	NA	4.61	2.41	**1.9**
cadmium	110	nd	0.269	0.88	1.07	0.53	0.76	0.47	**1.6**
chromium	47,100	0.047	11.4	1.35	3.54	0.61	303.14	1.55	**195**
copper	240	0.010	59.2	1.27	25.4	NA	3.53	12.19	0.29
iron	42800	236	280	332	332	NA	298.12	NA	NA
lead	1760	0.003	2.69	4.32	0.89	0.47	11.41	3.78	**3.0**
magnesium	5300	3.3	438	438	404	NA	56.91	NA	NA
manganese	1715	0.801	70.3	70.3	785	NA	40.16	41.61	0.97
mercury[b]	0.077	2.51E-06	0.243	1.13	0.051	1.075	0.03	0.02	**2.26**
nickel	71.8	nd	21.9	4.15	2.14	NA	0.94	18.91	0.05
selenium	7.8	nd	0.644	0.51	nd	NA	0.06	0.09	0.7
strontium	NA	NA	30.7	156	156	NA	6.24	124.37	0.05
vanadium	107.5	nd	0.308	0.308	0.308	NA	0.71	0.10	**7.1**
zinc	755	0.010	73.4	26.3	34.7	NA	7.45	75.66	0.10
DDT	3.3	nd	NA	NA	4.16	NA	0.21	0.38	0.54
DDE	2.5	nd	NA	NA	3.15	NA	0.16	0.38	0.41
DDD	0.98	nd	NA	NA	1.23	NA	0.06	0.38	0.16
PAH (Total)	34.4	nd	NA	NA	54.7	NA	2.63	0.27	**9.76**

NA in EPC columns indicates chemical not analyzed.

NA in TRV and HQ columns indicates TRV not available and HQ could not be calculated.

nd - indicates the chemical not detected.

a. Uptake is calculated as: IR (EPC_{FR} x FR + EPC_{FI} x FI + EPC_{IN} x IN + EPC_{EG} x EG + EPC_{SD} x SD + EPC_{SW} x SW) x AUF/BW

(For inorganics, the swallow eggs term was not included for chemicals for which it is designated NA. For pesticides and PAHs, only the invertebrate term was used).

Exposure parameters as presented in Table 8 are the following:

BW	7	Kg
IR	4.50E-01	Kg/day
IN	0.55	unitless
FI	0.016	unitless
FR	0.285	unitless
EG	0.057	unitless
SD	0.1	unitless
SW	0.38	L/day
AUF	1	unitless

b. The sediment and surface water EPCs for incidental ingestion by the raccoon, are those for methylmercury.

Table 13. Uptake and Hazard Quotient Calculations - Osprey

	EPCs				
Chemical	Surface Water (mg/L)	Fish (mg/kg)	Uptake[a] (mg/kg-d)	TRV (mg/kg-d)	HQ
aluminum	0.035	0.09	0.02	0.49	0.04
arsenic	0.010	nd	0.00	0.03	0.0
barium	0.018	11.65	2.44	2.41	**1.0**
cadmium	nd	0.88	0.18	0.47	0.39
chromium	0.047	1.35	0.29	1.55	0.18
copper	0.010	1.27	0.27	7.19	0.04
iron	236	332	82	NA	NA
lead	0.003	4.32	0.91	3.78	0.24
magnesium	3.3	438	92	NA	NA
manganese	0.801	70.3	15	41.61	0.35
mercury[b]	2.51E-06	1.13	0.24	0.02	**15.64**
nickel	nd	4.15	0.87	18.91	0.05
selenium	nd	0.51	0.11	0.09	**1.1**
strontium	NA	156	32.68	124.37	0.26
vanadium	nd	0.308	0.06	0.10	0.65
zinc	0.010	26.3	5.51	75.66	0.07

NA in EPC columns indicates chemical not analyzed.
NA in TRV and HQ columns indicates TRV not available and HQ could not be calculated.
nd - indicates the chemical not detected.
a. Uptake is calculated as: ((IR x EPC_{FI} x FI) + (SW x EPC_{SW}))*AUF/BW

Exposure parameters as presented in Table 8 are the following:

BW	1.69	Kg
IR	3.54E-01	Kg/day
FI	1	unitless
SW	0.088	L/day
AUF	1	unitless

b. The surface water EPC for incidental ingestion by the osprey is that for methylmercury.
NA - indicates that chemical was not analyzed in sediments or surface water.
nd - indicates the chemical was not detected.

Table 14. Hazard Quotients for Wildlife Receptors

Chemical	HQ Raccoon	HQ Osprey
aluminum	**1178**	0.04
arsenic	**71**	0.0
barium	**1.9**	**1.0**
cadmium	**1.6**	0.4
chromium	**195**	0.2
copper	0.3	0.04
iron	NA	NA
lead	**3.0**	0.2
magnesium	NA	NA
manganese	0.97	0.4
mercury	2.3	**16**
nickel	0.05	0.05
selenium	0.7	**1.1**
strontium	0.1	0.3
vanadium	**7.1**	0.6
zinc	0.1	0.1
DDT	0.5	NA
DDE	0.4	NA
DDD	0.2	NA
PAH (Total)	**10**	NA

Appendix 1

Figures and Data Tables from External Reports

ORIGINAL

**U.S. Army
Environmental
Center**

FORT DEVENS
FEASIBILITY STUDY
FOR GROUP 1A SITES

DRAFT
PLOW SHOP POND AND GROVE POND SEDIMENT EVALUATION
DATA ITEM A009

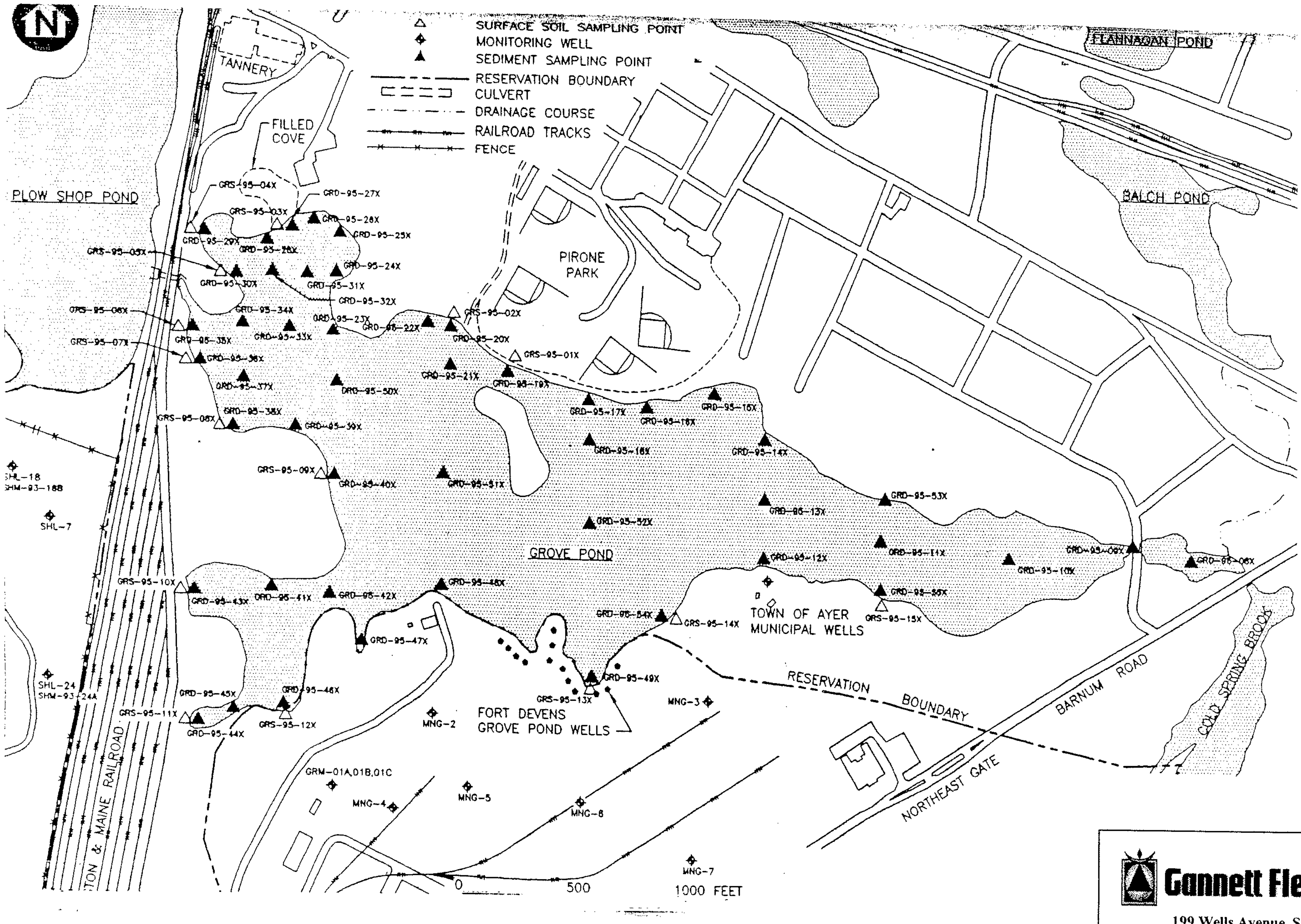
VOLUME I
SECTIONS 1.0 - 8.0

CONTRACT DAAA15-91-D-0008
DELIVERY ORDER NUMBER 0004

U.S. ARMY ENVIRONMENTAL CENTER
ABERDEEN PROVING GROUND, MARYLAND

OCTOBER 1995

AEC Form 45, 1 Feb 93 replaces THAMA Form 45 which is obsolete.



Gannett Fleming

199 Wells Avenue, Suite 210
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FIGURE 1-2
Grove Pond Soil Sediment Sample Locations
Grove Pond Arsenic Investigation
Fort Devens

Note : Plan Detail from 1995 ABB Report

TABLE 4-2
GROVE POND SEDIMENT SAMPLE ANALYTICAL RESULTS

PLOW SHOP POND AND GROVE POND SEDIMENT EVALUATION
FORT DEVENS, MA

ANALYTE	GRD-95-08X	GRD-95-09X	GRD-95-10X	GRD-95-11X	GRD-95-12X	GRD-95-13X	GRD-95-14X
PAL METALS (µg/g)							
Aluminum	3620	8640	12900	12400	4700	8540	5760
Antimony	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09
Arsenic	20.8	44.4	160	140	61.5	104	42.8
Barium	39.2	81.9	118	117	54.4	72.9	46.5
Beryllium	< .5	< .5	< .5	< .5	< .5	< .5	< .5
Cadmium	17.1	28.9	27.6	110	23.7	8.73	< .7
Calcium	1680	2200	3770	5430	4510	4630	2370
Chromium	17.1	34.5	43.9	71	85.9	374	253
Cobalt	5.5	18.5	53.4	39.4	14.5	18.8	10.5
Copper	38.2	46.4	50.2	70.9	35.1	30.2	22.5
Iron	10500	15500	29600	22100	8680	16300	8840
Lead	123	178	492	361	86	100	405
Magnesium	1340	3270	4410	3970	1180	1990	1490
Manganese	413	1040	912	859	503	769	56
Mercury	< .05	< .05	.442	< .05	1.12	4.91	1.11
Nickel	28.5	42.3	54.4	71.8	27.9	24.3	15.2
Potassium	661	1170	1470	1930	< 100	< 100	< 100
Selenium	< .25	< .25	< .25	< .25	< .25	< .25	< .25
Sodium	424	1260	2430	4010	2460	3340	2110
Thallium	< .5	< .5	< .5	< .5	< .5	< .5	< .5
Vanadium	11.3	28.1	75.1	55.5	< 3.39	< 3.39	20.6
Zinc	198	340	443	755	238	309	211
PAL PESTICIDES/PCBS (µg/g)							
2,2-bis (para-chlorophenyl)-1,1,1-trichloroethane	.059 CM	< .00707 IO	< .00707 IO	< .00707 IO	< .00707 IO	< .00707 IO	< .00707 IO
2,2-bis(p-chlorophenyl)-1,1-dichloroethane	.1 CM	.0695 CIO	.146 CIO	< .00826 IO	.113 CIO	< .00826 IO	.18 CIO
2,2-bis(p-chlorophenyl)-1,1-dichloroethene	.0321 CM	.0436 CIO	.173 CIO	.101 CIO	.0648 CIO	< .00765 IO	.142 CIO
Endrin	< .00657 M	< .00657 IO	< .00657 IO	< .00657 IO	< .00657 IO	< .00657 IO	< .00657 IO

NOTES:

µg/g = micrograms per gram
C = analysis was confirmed
J = low-spike recovery is low
I = low-spike recovery is high
O = low-spike recovery excessively different
M = high-spike recovery is high
D = duplicate
< = less than

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TABLE 4-2
GROVE POND SEDIMENT SAMPLE ANALYTICAL RESULTS

PLOW SHOP POND AND GROVE POND SEDIMENT EVALUATION
FORT DEVENS, MA

ANALYTE	GRD-95-08X	GRD-95-09X	GRD-95-10X	GRD-95-11X	GRD-95-12X	GRD-95-13X	GRD-95-14X
PAL SEMIVOLATILE ORGANICS (µg/g)							
2-methylnaphthalene	< 1	< .5	< 1	< 1	4	< .2	< .2
4-bromophenylphenyl Ether	< .7	< .3	< .7	< .7	< .2	< .2	< .2
4-chlorophenylphenyl Ether	< .7	< .3	< .7	< .7	< .2	< .2	< .2
Acenaphthylene	< .7	< .3	< .7	< .7	< .2	< .2	< .2
Anthracene	< .7	< .3	< .7	< .7	< .2	< .2	< .2
Benzo[a]anthracene	< 3	< 2	< 3	< 3	< .8	< .8	< .8
3,4-benzofluoranthene / Benzo[b]fluoranthene	< 4	< 2	< 4	< 4	< 1	< 1	< 1
Benzo[k]fluoranthene	< 1	< .7	< 1	< 1	< .3	< .3	< .3
Butylbenzyl Phthalate	< 3	< 2	< 3	< 3	< .8	< .8	< .8
Chrysene	< 2	< 1	< 2	< 2	< .6	< .6	< .6
Di-n-butyl Phthalate	< 1	< .6	< 1	< 1	< .3	< .3	< .3
Dibenzofuran	< .7	< .4	< .7	< .7	< .2	< .2	< .2
Fluoranthene	5	< .7	< 1	< 1	< .3	< .3	2
9h-fluorene / Fluorene	< .7	< .3	< .7	< .7	< .2	< .2	< .2
Hexachlorobenzene	< .7	< .3	< .7	< .7	< .2	< .2	< .2
Naphthalene / Tar Camphor	< .7	< .4	< .7	< .7	< .2	< .2	< .2
Phenanthrene	3	< .3	< .7	< .7	< .2	< .2	< .2
Benzo[def]phenanthrene / Pyrene	5	2	< .7	< .7	< .2	< .2	< .2
OTHER (µg/g)							
Total Organic Carbon	38100	107000	207000	205000	198000	267000	134000

NOTES:
µg/g = micrograms per gram
C = analysis was confirmed
J = low-spike recovery is low
I = low-spike recovery is high
O = low-spike recovery excessively different
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D = duplicate
< = less than

TABLE 4-2
GROVE POND SEDIMENT SAMPLE ANALYTICAL RESULTS

PLOW SHOP POND AND GROVE POND SEDIMENT EVALUATION
FORT DEVENS, MA

ANALYTE	GRD-95-14X (duplicate)	GRD-95-15X	GRD-95-16X	GRD-95-17X	GRD-95-18X	GRD-95-19X	GRD-95-20X
PAL METALS (µg/g)							
Aluminum	8300 D	5910	14100	8160	7990	6470	7410
Antimony	< 1.09 D	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09
Arsenic	44.4 D	49.2	69.9	85.2	108	41.8	110
Barium	58 D	< 5.18	88.2	< 5.18	< 5.18	< 5.18	54.6
Beryllium	< .5 D	< .5	< .5	< .5	< .5	< .5	< .5
Cadmium	4.94 D	< .7	< .7	20.9	< .7	18.7	< .7
Calcium	3090 D	4390	6360	4870	5950	6180	6400
Chromium	424 D	501	736	250	342	214	2680
Cobalt	16 D	< 1.42	24.2	< 1.42	< 1.42	19	< 1.42
Copper	32.6 D	42.3	41.3	37	24.8	21.6	38.8
Iron	11200 D	9720	19900	24300	11000	8850	19100
Lead	453 D	190	221	143	130	120	232
Magnesium	2240 D	< 100	3940	2730	1610	1520	1860
Manganese	80.6 D	337	366	449	688	322	792
Mercury	.722 D	1.54	2.18	1.72	11	.772	2.07
Nickel	20.5 D	31	37.6	38.2	< 1.71	22.2	20.9
Potassium	650 D	< 100	1230	< 100	< 100	< 100	< 100
Selenium	< .25 D	< .25	< .25	< .25	4.14	< .25	< .25
Sodium	2260 D	3890	3760	5590	3900	3320	2650
Thallium	< .5 D	< .5	< .5	< .5	< .5	< .5	< .5
Vanadium	27.2 D	< 3.39	65.9	< 3.39	< 3.39	< 3.39	59.2
Zinc	312 D	357	321	482	139	225	237
PAL PESTICIDES/PCBS (µg/g)							
2,2-bis (para-chlorophenyl)-1,1,1-trichloroethane	3.3 CD	< .00707	< .00707 IO	< .00707	< .00707	< .00707	.56 C
2,2-bis(p-chlorophenyl)-1,1-dichloroethane	.74 CD	.38 C	.43 CIO	< .00826	< .00826	.0885 C	1.9 C
2,2-bis(p-chlorophenyl)-1,1-dichloroethene	.28 CD	.254 C	.264 CIO	.215 C	< .00765	.0972 C	.93 C
Endrin	< .00657 D	< .00657	< .00657 IO	< .00657	< .00657	< .00657	< .00657

NOTES:
µg/g = micrograms per gram
C = analysis was confirmed
J = low-spike recovery is low
I = low-spike recovery is high
O = low-spike recovery excessively different
M = high-spike recovery is high
D = duplicate
< = less than

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TABLE 4-2
GROVE POND SEDIMENT SAMPLE ANALYTICAL RESULTS

PLOW SHOP POND AND GROVE POND SEDIMENT EVALUATION
FORT DEVENS, MA

ANALYTE	GRD-95-14X (duplicate)	GRD-95-15X	GRD-95-16X	GRD-95-17X	GRD-95-18X	GRD-95-19X	GRD-95-20X
PAL SEMIVOLATILE ORGANICS (µg/g)							
2-methylnaphthalene	< .2 D	< .049	< .2	< .2	< .2	< .1	< .1
4-bromophenylphenyl Ether	< .2 D	1.7	< .2	< .2	< .2	< .07	< .07
4-chlorophenylphenyl Ether	< .2 D	.84	< .2	< .2	< .2	< .07	< .07
Acenaphthylene	< .2 D	< .033	< .2	< .2	< .2	< .07	< .07
Anthracene	< .2 D	2.4	< .2	< .2	< .2	< .07	< .07
Benzo[a]anthracene	< .8 D	3.4	< .8	< .8	< .8	< .3	< .3
3,4-benzofluoranthene / Benzo[b]fluoranthene	< 1 D	< .21	< 1	< 1	< 1	< .4	< .4
Benzo[k]fluoranthene	< .3 D	2.2	< .3	< .3	< .3	< .1	< .1
Butylbenzyl Phthalate	< .8 D	3	< .8	< .8	< .8	< .3	< .3
Chrysene	< .6 D	3.7	< .6	< .6	< .6	< .2	< .2
Di-n-butyl Phthalate	< .3 D	3.3	< .3	< .3	< .3	< .1	< .1
Dibenzofuran	< .2 D	.62	< .2	< .2	< .2	< .07	< .07
Fluoranthene	< .3 D	3.7	< .3	< .3	< .3	< .1	< .1
9h-fluorene / Fluorene	< .2 D	1.1	< .2	< .2	< .2	< .07	< .07
Hexachlorobenzene	< .2 D	1.7	< .2	< .2	< .2	< .07	< .07
Naphthalene / Tar Camphor	< .2 D	< .037	< .2	< .2	< .2	< .07	< .07
Phenanthrene	< .2 D	2.7	< .2	< .2	< .2	< .07	< .07
Benzo[def]phenanthrene / Pyrene	< .2 D	3.9	< .2	< .2	< .2	< .07	.8
OTHER (µg/g)							
Total Organic Carbon	421000 D	172000	256000	308000	166000	224000	137000

NOTES:

µg/g = micrograms per gram
C = analysis was confirmed
J = low-spike recovery is low
I = low-spike recovery is high
O = low-spike recovery excessively different
M = high-spike recovery is high
D = duplicate
< = less than

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TABLE 4-2
GROVE POND SEDIMENT SAMPLE ANALYTICAL RESULTS

PLOW SHOP POND AND GROVE POND SEDIMENT EVALUATION
FORT DEVENS, MA

ANALYTE	GRD-95-21X	GRD-95-22X	GRD-95-23X	GRD-95-24X	GRD-95-24X (duplicate)	GRD-95-25X	GRD-95-26X
PAL METALS (µg/g)							
Aluminum	5300	6450	7760	8870	8410 D	5000	5520
Antimony	< 1.09	< 1.09 J	< 1.09 J	< 1.09 J	< 1.09 DJ	< 1.09 J	< 1.09 J
Arsenic	70.7	9.23	28.1	240	270 D	100	110
Barium	< 5.18	33.5	42.7	267	245 D	171	338
Beryllium	< .5	< .5	3.12	< .5	< .5 D	< .5	< .5
Cadmium	23.3	< .7	8.52	< .7	< .7 D	< .7	3.07
Calcium	3430	1710	4420	24300	18400 D	65600	70400
Chromium	621	35.3	462	27700	26000 D	22900	19800
Cobalt	16.2	4.44	< 1.42	21.1	20.3 D	< 1.42	12.3
Copper	18.1	10.5	20.8	118	122 D	143	210
Iron	12300	16500	10600	18100	19300 D	8480	7780
Lead	71	11.4	265	750	782 D	682	423
Magnesium	1710	4320	3420	2130	1990 D	2060	2330
Manganese	468	145	408	1060	1210 D	989	620
Mercury	1.65	< .05	.624	57	86 D	4.32	16
Nickel	27.7	19.3	32.1	41.9	32.3 D	18.7	25.3
Potassium	< 100	1330	1270	< 100	< 100 D	< 100	< 100
Selenium	< .25	< .25	< .25	< .25	< .25 D	< .25	< .25
Sodium	2530	698	1740	3500	3880 D	2270	1460
Thallium	< .5	< .5	< .5	< .5	< .5 D	< .5	< .5
Vanadium	< 3.39	15.3	30.5	111	104 D	60.4	62.6
Zinc	223	125 J	135 J	526 J	538 D	281 J	315 J
PAL PESTICIDES/PCBS (µg/g)							
2,2-bis (para-chlorophenyl)-1,1,1-trichloroethane	< .00707	< .00707	.0726 C	< .00707	.51 CD	< .00707	< .00707
2,2-bis(p-chlorophenyl)-1,1-dichloroethane	< .00826	< .00826	< .00826	.8 C	.81 CD	.39 C	.073 C
2,2-bis(p-chlorophenyl)-1,1-dichloroethene	< .00765	< .00765	< .00765	.43 C	.39 CD	.184 C	.12 C
Endrin	< .00657	< .00657	< .00657	< .00657	< .00657 D	< .00657	< .00657

NOTES:
µg/g = micrograms per gram
C = analysis was confirmed
J = low-spike recovery is low
I = low-spike recovery is high
O = low-spike recovery excessively different
M = high-spike recovery is high
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< = less than

TABLE 4-2
GROVE POND SEDIMENT SAMPLE ANALYTICAL RESULTS

PLOW SHOP POND AND GROVE POND SEDIMENT EVALUATION
FORT DEVENS, MA

ANALYTE	GRD-95-21X		GRD-95-22X		GRD-95-23X		GRD-95-24X		GRD-95-24X (duplicate)			GRD-95-25X		GRD-95-26X	
PAL SEMIVOLATILE ORGANICS (µg/g)															
2-methylnaphthalene	<	.049	<	2	<	.1	<	.049	<	.049	D	<	.049	<	.049
4-bromophenylphenyl Ether	<	.033	<	1	<	.07	<	.033	<	.033	D	<	.033	<	.033
4-chlorophenylphenyl Ether	<	.033	<	1	<	.07	<	.033	<	.033	D	<	.033	<	.033
Acenaphthylene	<	.033	<	1	<	.07	<	.033	<	.033	D	<	.033	<	.033
Anthracene	<	.033	<	1	<	.07	<	.033	<	.033	D	<	.033	<	.033
Benzo[a]anthracene	<	.17	<	7	<	.3	<	.17	<	.17	D	<	.17	<	.17
3,4-benzofluoranthene / Benzo[b]fluoranthene	<	.21	<	8	<	.4	<	.21	<	.21	D	<	.21	<	.21
Benzo[k]fluoranthene	<	.066	<	3	<	.1	<	.066	<	.066	D	<	.066	<	.066
Butylbenzyl Phthalate	<	.17	<	7	<	.3	<	.17	<	.17	D	<	.17	<	.17
Chrysene	<	.12	<	5	<	.2	<	.12	<	.12	D	<	.12	<	.12
Di-n-butyl Phthalate	<	.061	<	2	<	.1	<	.061	<	.061	D	<	.061	<	.061
Dibenzofuran	<	.035	<	1	<	.07	<	.035	<	.035	D	<	.035	<	.035
Fluoranthene	<	.068	<	3	<	.1	<	.068	<	.068	D	<	.068		.73
9h-fluorene / Fluorene	<	.033	<	1	<	.07	<	.033	<	.033	D	<	.033	<	.033
Hexachlorobenzene	<	.033	<	1	<	.07	<	.033	<	.033	D	<	.033	<	.033
Naphthalene / Tar Camphor	<	.037	<	1	<	.07	<	.037	<	.037	D	<	.037		.37
Phenanthrene	<	.033	<	1	<	.07	<	.033	<	.033	D	<	.033		.33
Benzo[def]phenanthrene / Pyrene	<	.033	<	1	<	.07	<	.033	<	.033	D	<	.033		.56
OTHER (µg/g)															
Total Organic Carbon		110000		68900		108000		318000		534000	D		249000		105000

NOTES:
µg/g = micrograms per gram
C = analysis was confirmed
J = low-spike recovery is low
I = low-spike recovery is high
O = low-spike recovery excessively different
M = high-spike recovery is high
D = duplicate
< = less than

TABLE 4-2
GROVE POND SEDIMENT SAMPLE ANALYTICAL RESULTS

PLOW SHOP POND AND GROVE POND SEDIMENT EVALUATION
FORT DEVENS, MA

ANALYTE	GRD-95-26X (3 ft. deep)	GRD-95-27X	GRD-95-27X (5 ft. deep)	GRD-95-28X	GRD-95-28X (1 ft. deep)	GRD-95-29X	GRD-95-29X (6 ft. deep)
PAL METALS (µg/g)							
Aluminum	7800	8730	4250	3530	3140	6490	5610
Antimony	21.2 J	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09
Arsenic	1300	340	78	43.6	7.29	96	20.9
Barium	326	470	64.9	70.2	11.6	131	50.5
Beryllium	< .5	< .5	< .5	< .5	< .5	< .5	< .5
Cadmium	3.59	< .7	< .7	< .7	< .7	< .7	< .7
Calcium	113000	83800	13800	11200	4950	67400	2070
Chromium	44000	40300	3900	9980	1330	20400	853
Cobalt	21	< 1.42	< 1.42	< 1.42	< 1.42	< 1.42	< 1.42
Copper	96.6	144	22.7	56.9	7.37	98.7	18.4
Iron	13900	15600	2770	11300	2370	18100	6700
Lead	1000	739	95	313	34.7	563	15.3
Magnesium	3200	3260	1110	908	282	1010	< 100
Manganese	890	1260	127	411	64.5	476	50.2
Mercury	150	220	28	2.78	1.5	69	< .05
Nickel	14.9	19.7	9.61	21.1	< 1.71	18	< 1.71
Potassium	737	< 100	< 100	< 100	< 100	724	< 100
Selenium	< .25	3.02	2.02	< .25	< .25	3.23	1.72
Sodium	2970	5120	2950	3120	601	3060	3090
Thallium	2.35	< .5	< .5	< .5	< .5	< .5	< .5
Vanadium	50	66	< 3.39	30	5.71	58.6	< 3.39
Zinc	363 J	639	75.2	197	21.9	429	< 8.03
PAL PESTICIDES/PCBS (µg/g)							
2,2-bis (para-chlorophenyl)-1,1,1-trichloroethane	< .00707	< .00707 M	< .00707 M	< .00707 M	< .00707 M	1.5 CM	< .00707 M
2,2-bis(p-chlorophenyl)-1,1-dichloroethane	.0484 C	.157 CM	< .00826 M	.53 CM	.0285 CM	.17 CM	< .00826 M
2,2-bis(p-chlorophenyl)-1,1-dichloroethene	< .00765	.195 CM	< .00765 M	.27 CM	.0144 CM	.47 CM	< .00765 M
Endrin	< .00657	< .00657 M	< .00657 M	< .00657 M	< .00657 M	< .00657 M	< .00657 M

NOTES:
µg/g = micrograms per gram
C = analysis was confirmed
J = low-spike recovery is low
I = low-spike recovery is high
O = low-spike recovery excessively different
M = high-spike recovery is high
D = duplicate
< = less than

TABLE 4-2
GROVE POND SEDIMENT SAMPLE ANALYTICAL RESULTS

PLOW SHOP POND AND GROVE POND SEDIMENT EVALUATION
FORT DEVENS, MA

ANALYTE	GRD-95-26X (3 ft. deep)	GRD-95-27X	GRD-95-27X (5 ft. deep)	GRD-95-28X	GRD-95-28X (1 ft. deep)	GRD-95-29X	GRD-95-29X (6 ft. deep)
PAL SEMIVOLATILE ORGANICS (µg/g)							
2-methylnaphthalene	.52	< .2	< .2	< .2	< .049	< .2	< 1
4-bromophenylphenyl Ether	< .033	< .2	< .2	< .2	< .033	< .2	< .7
4-chlorophenylphenyl Ether	< .033	< .2	< .2	< .2	< .033	< .2	< .7
Acenaphthylene	< .033	< .2	< .2	< .2	< .033	< .2	< .7
Anthracene	.27	< .2	< .2	< .2	.081	< .2	< .7
Benzo[a]anthracene	< .17	< .8	< .8	< .8	< .17	< .8	< 3
3,4-benzofluoranthene / Benzo[b]fluoranthene	< .21	< 1	< 1	< 1	< .21	< 1	< 4
Benzo[k]fluoranthene	< .066	< .3	< .3	< .3	< .066	< .3	< 1
Butylbenzyl Phthalate	< .17	< .8	< .8	< .8	< .17	< .8	< 3
Chrysene	.58	< .6	< .6	< .6	< .12	< .6	< 2
Di-n-butyl Phthalate	< .061	< .3	< .3	< .3	< .061	< .3	< 1
Dibenzofuran	< .035	< .2	< .2	< .2	< .035	< .2	< .7
Fluoranthene	1	< .3	< .3	< .3	.33	3	< 1
9h-fluorene / Fluorene	< .033	< .2	< .2	< .2	< .033	< .2	< .7
Hexachlorobenzene	< .033	< .2	< .2	< .2	< .033	< .2	< .7
Naphthalene / Tar Camphor	30	20	3	< .2	< .037	5	5
Phenanthrene	.77	2	< .2	< .2	.25	2	< .7
Benzo[def]phenanthrene / Pyrene	.88	3	< .2	< .2	.33	3	< .7
OTHER (µg/g)							
Total Organic Carbon	243000	156000	102000	161000	12500	260000	185000

NOTES:

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I = low-spike recovery is high
O = low-spike recovery excessively different
M = high-spike recovery is high
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TABLE 4-2
GROVE POND SEDIMENT SAMPLE ANALYTICAL RESULTS

PLOW SHOP POND AND GROVE POND SEDIMENT EVALUATION
FORT DEVENS, MA

ANALYTE	GRD-95-30X	GRD-95-30X (4 ft. deep)	GRD-95-31X	GRD-95-32X	GRD-95-32X (duplicate)	GRD-95-32X (3 ft. deep)	GRD-95-33X
PAL METALS (µg/g)							
Aluminum	2330	2060	6010	4830	3050 D	3350	4390
Antimony	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09 D	< 1.09	< 1.09
Arsenic	4.16	2.86	83.3	89.8	63 D	8.35	110
Barium	< 5.18	< 5.18	259	313	145 D	18.5	186
Beryllium	< .5	< .5	< .5	< .5	< .5 D	< .5	< .5
Cadmium	< .7	< .7	< .7	< .7	< .7 D	< .7	< .7
Calcium	150	392	60600	87600	109000 D	11800	148000
Chromium	6.01	19.2	47100	49800	23800 D	2100	30500
Cobalt	< 1.42	< 1.42	< 1.42	< 1.42	< 1.42 D	< 1.42	< 1.42
Copper	3.68	2.61	240	237	114 D	10.3	85.7
Iron	2370	1280	19800	16300	9440 D	1740	9710
Lead	3.29	3.51	1760	1150	615 D	52.8	387
Magnesium	373	184	1930	1570	1090 D	700	1420
Manganese	26.5	14.4	1540	1700	1730 D	160	1080
Mercury	< .05	.0808	5.77	15	88 D	3	72
Nickel	3.95	< 1.71	35.3	< 1.71	< 1.71 D	4.33	< 1.71
Potassium	< 100	< 100	< 100	< 100	< 100 D	229	< 100
Selenium	< .25	< .25	< .25	< .25	< .25 D	< .25	< .25
Sodium	466	1190	6370	5130	4390 D	842	3890
Thallium	< .5	< .5	< .5	< .5	< .5 D	< .5	< .5
Vanadium	< 3.39	< 3.39	85.4	75.6	48.4 D	7.48	98.9
Zinc	< 8.03	< 8.03	474	356	266 D	23.1	316
PAL PESTICIDES/PCBS (µg/g)							
2,2-bis (para-chlorophenyl)-1,1,1-trichloroethane	< .00707 M	< .00707 M	< .00707 M	< .00707 M	< .00707 DM	< .00707 M	< .00707 M
2,2-bis(p-chlorophenyl)-1,1-dichloroethane	< .00826 M	< .00826 M	.56 CM	.2 CM	< .00826 DM	.0146 CM	< .00826 M
2,2-bis(p-chlorophenyl)-1,1-dichloroethene	< .00765 M	< .00765 M	.98 CM	.83 CM	.62 CDM	.057 CM	.3 CM
Endrin	< .00657 M	< .00657 M	.0278 CM	< .00657 M	< .00657 DM	< .00657 M	< .00657 M

NOTES:
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TABLE 4-2
GROVE POND SEDIMENT SAMPLE ANALYTICAL RESULTS

PLOW SHOP POND AND GROVE POND SEDIMENT EVALUATION
FORT DEVENS, MA

ANALYTE	GRD-95-30X	GRD-95-30X (4 ft. deep)	GRD-95-31X	GRD-95-32X	GRD-95-32X (duplicate)	GRD-95-32X (3 ft. deep)	GRD-95-33X
PAL SEMIVOLATILE ORGANICS (µg/g)							
2-methylnaphthalene	< .049	< .049	< .2	< .2	< .2 D	< .049	< .2
4-bromophenylphenyl Ether	< .033	< .033	< .2	< .2	< .2 D	< .033	< .2
4-chlorophenylphenyl Ether	< .033	< .033	< .2	< .2	< .2 D	< .033	< .2
Acenaphthylene	< .033	< .033	< .2	< .2	< .2 D	< .033	< .2
Anthracene	< .033	< .033	< .2	< .2	< .2 D	< .033	< .2
Benzo[a]anthracene	< .17	< .17	< .8	< .8	< .8 D	< .17	< .8
3,4-benzofluoranthene / Benzo[b]fluoranthene	< .21	< .21	< 1	< 1	< 1 D	< .21	< 1
Benzo[k]fluoranthene	< .066	< .066	< .3	< .3	< .3 D	< .066	< .3
Butylbenzyl Phthalate	< .17	< .17	< .8	< .8	< .8 D	< .17	< .8
Chrysene	< .12	< .12	< .6	< .6	< .6 D	< .12	< .6
Di-n-butyl Phthalate	< .061	< .061	< .3	< .3	< .3 D	< .061	< .3
Dibenzofuran	< .035	< .035	< .2	< .2	< .2 D	< .035	< .2
Fluoranthene	< .068	< .068	< .3	< .3	< .3 D	< .068	< .3
9h-fluorene / Fluorene	< .033	< .033	< .2	< .2	< .2 D	< .033	< .2
Hexachlorobenzene	< .033	< .033	< .2	< .2	< .2 D	< .033	< .2
Naphthalene / Tar Camphor	< .037	.13	5	< .2	< .2 D	.44	7
Phenanthrene	< .033	< .033	< .2	< .2	< .2 D	< .033	< .2
Benzo[def]phenanthrene / Pyrene	< .033	< .033	< .2	< .2	< .2 D	< .033	< .2
OTHER (µg/g)							
Total Organic Carbon	11100	16000	211000	178000	186000 D	28600	205000

NOTES:

µg/g = micrograms per gram
C = analysis was confirmed
J = low-spike recovery is low
I = low-spike recovery is high
O = low-spike recovery excessively different
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< = less than

TABLE 4-2
GROVE POND SEDIMENT SAMPLE ANALYTICAL RESULTS

PLOW SHOP POND AND GROVE POND SEDIMENT EVALUATION
FORT DEVENS, MA

ANALYTE	GRD-95-33X (3 ft. deep)	GRD-95-34X	GRD-95-35X	GRD-95-36X	GRD-95-36X (1 ft. deep)	GRD-95-37X	GRD-95-38X
PAL METALS (µg/g)							
Aluminum	5350	6310	4690	3840	3320	15400	3370
Antimony	< 1.09	< 1.09	< 1.09	< 1.09 J	< 1.09 J	< 1.09 J	< 1.09
Arsenic	12.7	107	53	23.7	8.85	112	8.52
Barium	< 5.18	189	70.9	33.9	15.2	180	13.4
Beryllium	< .5	< .5	< .5	< .5	< .5	< .5	< .5
Cadmium	< .7	16.7	7.3	3.96	< .7	21.9	< .7
Calcium	2210	62300	4280	1680	798	30400	732
Chromium	214	20800	3610	465	98.4	22400	61.6
Cobalt	< 1.42	< 1.42	9.52	5.3	3.2	37.3	< 1.42
Copper	3.78	98.8	57.8	21.1	8.21	126	5.85
Iron	2170	21400	13900	8090	6720	24700	3050
Lead	9.43	578	262	74.8	24.4	748	7.85
Magnesium	655	< 100	600	1000	1240	1850	470
Manganese	38.6	1190	380	243	67.3	1220	105
Mercury	.455	17	3.4	.92	.683	23	.128
Nickel	4.57	45.4	22.4	12.8	7.49	59.7	4.23
Potassium	178	< 100	< 100	487	384	< 100	< 100
Selenium	< .25	< .25	2.1	< .25	< .25	< .25	< .25
Sodium	620	7020	2140	904	327	5200	698
Thallium	< .5	< .5	< .5	< .5	< .5	< .5	< .5
Vanadium	< 3.39	78.2	39.6	12.4	6.1	86.4	< 3.39
Zinc	< 8.03	549	241	103 J	44.2 J	654 J	19.1
PAL PESTICIDES/PCBS (µg/g)							
2,2-bis (para-chlorophenyl)-1,1,1-trichloroethane	< .00707 M	< .00707 M	< .00707 M	< .00707	< .00707	< .00707	< .00707
2,2-bis(p-chlorophenyl)-1,1-dichloroethane	< .00826 M	< .00826 M	.17 CM	.084 C	< .00826	< .00826	< .00826
2,2-bis(p-chlorophenyl)-1,1-dichloroethene	< .00765 M	.231 CM	.15 CM	.0412 C	< .00765	.142 C	< .00765
Endrin	< .00657 M	< .00657 M	< .00657 M	< .00657	< .00657	< .00657	< .00657

NOTES:
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TABLE 4-2
GROVE POND SEDIMENT SAMPLE ANALYTICAL RESULTS

PLOW SHOP POND AND GROVE POND SEDIMENT EVALUATION
FORT DEVENS, MA

ANALYTE	GRD-95-33X (3 ft. deep)	GRD-95-34X	GRD-95-35X	GRD-95-36X	GRD-95-36X (1 ft. deep)	GRD-95-37X	GRD-95-38X
PAL SEMIVOLATILE ORGANICS (µg/g)							
2-methylnaphthalene	< .049	< .2	2	.72	.12	< .1	< .2
4-bromophenylphenyl Ether	< .033	< .2	< .2	< .033	< .033	< .07	< .2
4-chlorophenylphenyl Ether	< .033	< .2	< .2	< .033	< .033	< .07	< .2
Acenaphthylene	< .033	< .2	< .2	.18	.072	< .07	< .2
Anthracene	< .033	< .2	< .2	.12	.087	< .07	< .2
Benzo[a]anthracene	< .17	< .8	< .8	< .17	.33	< .3	< .8
3,4-benzofluoranthene / Benzo[b]fluoranthene	< .21	< 1	< 1	< .21	.39	< .4	< 1
Benzo[k]fluoranthene	< .066	< .3	< .3	< .066	.13	< .1	< .3
Butylbenzyl Phthalate	< .17	< .8	< .8	< .17	< .17	< .3	< .8
Chrysene	< .12	< .6	< .6	.43	.37	< .2	< .6
Di-n-butyl Phthalate	< .061	< .3	< .3	< .061	< .061	< .1	< .3
Dibenzofuran	< .035	< .2	< .2	.21	< .035	< .07	< .2
Fluoranthene	< .068	< .3	2	.66	.84	< .1	< .3
9h-fluorene / Fluorene	< .033	< .2	< .2	< .033	< .033	< .07	< .2
Hexachlorobenzene	< .033	< .2	< .2	< .033	< .033	< .07	< .2
Naphthalene / Tar Camphor	.2	< .2	3	.57	.18	< .07	< .2
Phenanthrene	< .033	< .2	1	.44	.22	< .07	< .2
Benzo[def]phenanthrene / Pyrene	< .033	< .2	2	.45	.55	< .07	< .2
OTHER (µg/g)							
Total Organic Carbon	17200	213000	113000	99200	7610	336000	24400

NOTES:

µg/g = micrograms per gram
C = analysis was confirmed
J = low-spike recovery is low
I = low-spike recovery is high
O = low-spike recovery excessively different
M = high-spike recovery is high
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TABLE 4-2
GROVE POND SEDIMENT SAMPLE ANALYTICAL RESULTS

PLOW SHOP POND AND GROVE POND SEDIMENT EVALUATION
FORT DEVENS, MA

ANALYTE	GRD-95-39X	GRD-95-40X	GRD-95-41X	GRD-95-42X	GRD-95-43X	GRD-95-44X	GRD-95-45X
PAL METALS (µg/g)							
Aluminum	6070	9420	19300	90000	6730	20300	64300
Antimony	< 1.09 J	< 1.09 J	< 1.09 J	< 1.09	< 1.09 J	< 1.09 J	< 1.09 J
Arsenic	23.1	160	39	137	240	150	95
Barium	38.9	56.9	< 5.18	< 5.18	< 5.18	34.2	< 5.18
Beryllium	< .5	< .5	< .5	< .5	< .5	< .5	14.1
Cadmium	3.48	9.3	< .7	< .7	< .7	< .7	< .7
Calcium	2220	6860	4400	5090	3860	1210	9510
Chromium	1020	562	728	3720	176	126	144
Cobalt	8.07	< 1.42	8.58	53.1	< 1.42	< 1.42	29.5
Copper	13.7	23.6	20.5	137	23.9	76.6	54.5
Iron	7540	22100	13100	17600	28400	42800	23300
Lead	58.3	78.2	69	230	130	64	81
Magnesium	1180	1390	5300	< 100	1010	1060	< 100
Manganese	504	709	110	885	204	657	35
Mercury	1.51	1.34	1.05	2.59	.469	4.22	< .05
Nickel	18.4	31.2	24.8	69.9	< 1.71	< 1.71	38.3
Potassium	< 100	< 100	< 100	< 100	< 100	< 100	< 100
Selenium	< .25	< .25	2.04	< .25	< .25	7.8	< .25
Sodium	942	2670	1380	5820	2600	1850	3690
Thallium	< .5	< .5	< .5	< .5	< .5	< .5	< .5
Vanadium	15.5	< 3.39	32.1	< 3.39	< 3.39	25.7	< 3.39
Zinc	81.7 J	188 J	72.3 J	448	84.6 J	< 8.03 J	150 J
PAL PESTICIDES/PCBS (µg/g)							
2,2-bis (para-chlorophenyl)-1,1,1-trichloroethane	< .00707	< .00707	< .00707	< .00707	< .00707	< .00707	< .00707
2,2-bis(p-chlorophenyl)-1,1-dichloroethane	.0444 C	< .00826	.0492 C	< .00826	< .00826	< .00826	< .00826
2,2-bis(p-chlorophenyl)-1,1-dichloroethene	.0231 C	< .00765	< .00765	< .00765	< .00765	< .00765	< .00765
Endrin	< .00657	< .00657	< .00657	< .00657	< .00657	< .00657	< .00657

NOTES:

µg/g = micrograms per gram
C = analysis was confirmed
J = low-spike recovery is low
I = low-spike recovery is high
O = low-spike recovery excessively different
M = high-spike recovery is high
D = duplicate
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TABLE 4-2
GROVE POND SEDIMENT SAMPLE ANALYTICAL RESULTS

PLOW SHOP POND AND GROVE POND SEDIMENT EVALUATION
FORT DEVENS, MA

ANALYTE	GRD-95-39X	GRD-95-40X	GRD-95-41X	GRD-95-42X	GRD-95-43X	GRD-95-44X	GRD-95-45X
PAL SEMIVOLATILE ORGANICS (μg/g)							
2-methylnaphthalene	< .1	< .049	< .049	< .049	< .1	< .049	< .049
4-bromophenylphenyl Ether	< .07	< .033	< .033	< .033	< .07	< .033	< .033
4-chlorophenylphenyl Ether	< .07	< .033	< .033	< .033	< .07	< .033	< .033
Acenaphthylene	< .07	< .033	< .033	< .033	< .07	< .033	< .033
Anthracene	< .07	< .033	< .033	< .033	< .07	< .033	< .033
Benzo[a]anthracene	< .3	< .17	< .17	< .17	< .3	< .033	< .033
3,4-benzofluoranthene / Benzo[b]fluoranthene	< .4	< .21	< .21	< .21	< .4	< .17	< .17
Benzo[k]fluoranthene	< .1	< .066	< .066	< .066	< .1	< .21	< .21
Butylbenzyl Phthalate	< .3	< .17	< .17	< .17	< .3	< .066	< .066
Chrysene	< .2	< .12	< .12	< .12	< .2	< .17	< .17
Di-n-butyl Phthalate	< .1	< .061	< .061	< .061	< .1	< .12	< .12
Dibenzofuran	< .07	< .035	< .035	< .035	< .07	< .061	< .061
Fluoranthene	< .1	< .068	< .068	< .068	< .1	< .035	< .035
9h-fluorene / Fluorene	< .07	< .033	< .033	< .033	< .07	< .068	< .068
Hexachlorobenzene	< .07	< .033	< .033	< .033	< .07	< .033	< .033
Naphthalene / Tar Camphor	< .07	< .037	< .037	< .037	< .07	< .033	< .033
Phenanthrene	< .07	< .033	< .033	< .033	< .07	< .037	< .037
Benzo[def]phenanthrene / Pyrene	< .07	< .033	< .033	< .033	< .07	< .033	< .033
OTHER (μg/g)							
Total Organic Carbon	66800	282000	87800	326000	274000	337000	249000

NOTES:
μg/g = micrograms per gram
C = analysis was confirmed
J = low-spike recovery is low
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O = low-spike recovery excessively different
M = high-spike recovery is high
D = duplicate
< = less than

TABLE 4-2
GROVE POND SEDIMENT SAMPLE ANALYTICAL RESULTS

PLOW SHOP POND AND GROVE POND SEDIMENT EVALUATION
FORT DEVENS, MA

ANALYTE	GRD-95-46X	GRD-95-47X	GRD-95-48X	GRD-95-49X	GRD-95-50X	GRD-95-50X (5 ft. deep)	GRD-95-51X
PAL METALS (µg/g)							
Aluminum	66600	6530	3620	8180	9990	3400	13700
Antimony	< 1.09 J	< 1.09	< 1.09	< 1.09 J	< 1.09 J	< 1.09 J	< 1.09 J
Arsenic	64.2	61.8	31.2	35.7	170	5.61	126
Barium	< 5.18	< 5.18	49.2	63.4	171	18.1	92.3
Beryllium	< .5	< .5	< .5	< .5	< .5	< .5	< .5
Cadmium	< .7	< .7	8.25	< .7	11.4	< .7	34.5
Calcium	3380	5240	2220	4620	116000	2440	6810
Chromium	2010	1250	168	1260	20000	123	6650
Cobalt	< 1.42	19.6	7.93	< 1.42	24.8	< 1.42	41.1
Copper	68.8	37.2	41.5	32.8	88.6	3.15	67.7
Iron	10800	11300	6320	8240	18700	3680	19300
Lead	110	180	1130	146	530	3.59	366
Magnesium	< 100	< 100	658	1690	1620	1410	1780
Manganese	53.6	625	282	152	994	53.5	634
Mercury	.872	9.58	.68	5.28	90	1.9	24
Nickel	34.1	26.7	19.3	< 1.71	47	9.18	58.3
Potassium	< 100	< 100	< 100	< 100	< 100	273	1360
Selenium	< .25	3.66	< .25	< .25	< .25	.917	< .25
Sodium	3350	3240	1580	2920	4580	684	4410
Thallium	< .5	< .5	< .5	< .5	< .5	< .5	< .5
Vanadium	59.9	< 3.39	< 3.39	35	87.5	< 3.39	66.3
Zinc	134 J	240	216 J	154 J	547 J	21.7 J	577 J
PAL PESTICIDES/PCBS (µg/g)							
2,2-bis (para-chlorophenyl)-1,1,1-trichloroethane	< .00707	< .00707	.22 C	< .00707	< .00707	< .00707	< .00707
2,2-bis(p-chlorophenyl)-1,1-dichloroethane	.5 C	2.5 C	.1 C	.23 C	< .00826	< .00826	.202 C
2,2-bis(p-chlorophenyl)-1,1-dichloroethene	.193 C	.57 C	.0404 C	.177 C	.204 C	< .00765	< .023
Endrin	< .00657	< .00657	< .00657	< .00657	< .00657	< .00657	< .00657

NOTES:

µg/g = micrograms per gram
C = analysis was confirmed
J = low-spike recovery is low
I = low-spike recovery is high
O = low-spike recovery excessively different
M = high-spike recovery is high
D = duplicate
< = less than

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TABLE 4-2
GROVE POND SEDIMENT SAMPLE ANALYTICAL RESULTS

PLOW SHOP POND AND GROVE POND SEDIMENT EVALUATION
FORT DEVENS, MA

ANALYTE	GRD-95-46X	GRD-95-47X	GRD-95-48X	GRD-95-49X	GRD-95-50X	GRD-95-50X (5 ft. deep)	GRD-95-51X
PAL SEMIVOLATILE ORGANICS (μg/g)							
2-methylnaphthalene	< .049	< .1	< .1	< .049	< .049	< .049	< .049
4-bromophenylphenyl Ether	< .033	< .07	< .07	< .033	< .033	< .033	< .033
4-chlorophenylphenyl Ether	< .033	< .07	< .07	< .033	< .033	< .033	< .033
Acenaphthylene	< .033	< .07	< .07	< .033	< .033	< .033	< .033
Anthracene	< .033	< .07	< .07	< .033	< .033	< .033	< .033
Benzo[a]anthracene	< .17	< .3	< .3	< .17	< .17	< .17	< .17
3,4-benzofluoranthene / Benzo[b]fluoranthene	< .21	< .4	< .4	< .21	< .21	< .21	< .21
Benzo[k]fluoranthene	< .066	< .1	< .1	< .066	< .066	< .066	< .066
Butylbenzyl Phthalate	< .17	< .3	< .3	< .17	< .17	< .17	< .17
Chrysene	< .12	< .2	< .2	< .12	< .12	< .12	< .12
Di-n-butyl Phthalate	< .061	< .1	< .1	< .061	< .061	< .061	< .061
Dibenzofuran	< .035	< .07	< .07	< .035	< .035	< .035	< .035
Fluoranthene	< .068	< .1	< .1	< .068	< .068	< .068	< .068
9h-fluorene / Fluorene	< .033	< .07	< .07	< .033	< .033	< .033	< .033
Hexachlorobenzene	< .033	< .07	< .07	< .033	< .033	< .033	< .033
Naphthalene / Tar Camphor	< .037	< .07	< .07	< .037	1.1	< .037	< .037
Phenanthrene	< .033	< .07	< .07	< .033	< .033	< .033	< .033
Benzo[def]phenanthrene / Pyrene	< .033	< .07	< .07	.42	.62	< .033	< .033
OTHER (μg/g)							
Total Organic Carbon	267000	228000	91500	367000	329000	86900	306000

NOTES:

μg/g = micrograms per gram
C = analysis was confirmed
J = low-spike recovery is low
I = low-spike recovery is high
O = low-spike recovery excessively different
M = high-spike recovery is high
D = duplicate
< = less than

TABLE 4-2
GROVE POND SEDIMENT SAMPLE ANALYTICAL RESULTS

PLOW SHOP POND AND GROVE POND SEDIMENT EVALUATION
FORT DEVENS, MA

ANALYTE	GRD-95-52X	GRD-95-52X (5 ft. deep)	GRD-95-53X	GRD-95-54X	GRD-95-55X
PAL METALS (µg/g)					
Aluminum	9950	4820	6360	7210	6150
Antimony	< 1.09 J	< 1.09 J	< 1.09 J	< 1.09 J	< 1.09 J
Arsenic	83.9	18.3	220	40.5	72.9
Barium	72.6	20.4	< 5.18	47.2	< 5.18
Beryllium	< .5	< .5	< .5	< .5	< .5
Cadmium	21.1	< .7	26.3	22.2	31
Calcium	6060	2400	10500	5700	5810
Chromium	1060	18.9	< 4.05	213	< 4.05
Cobalt	< 1.42	4.54	< 1.42	< 1.42	< 1.42
Copper	41.5	4.03	69	26	35.8
Iron	14100	4150	34200	10400	13700
Lead	150	3.21	323	73	170
Magnesium	2040	1500	1870	2150	1900
Manganese	655	80.3	1030	378	507
Mercury	11	< .05	< .05	.495	< .05
Nickel	39.6	10.2	45.2	33.9	43.4
Potassium	< 100	343	< 100	< 100	< 100
Selenium	4.37	< .25	< .25	< .25	< .25
Sodium	3950	606	5340	2230	3040
Thallium	< .5	< .5	< .5	< .5	< .5
Vanadium	< 3.39	10.2	< 3.39	< 3.39	< 3.39
Zinc	350 J	< 8.03 J	648 J	274 J	335 J
PAL PESTICIDES/PCBS (µg/g)					
2,2-bis (para-chlorophenyl)-1,1,1-trichloroethane	< .00707	< .00707	< .00707	< .00707	< .00707
2,2-bis(p-chlorophenyl)-1,1-dichloroethane	< .00826	< .00826	.224 C	.0524 C	.26 C
2,2-bis(p-chlorophenyl)-1,1-dichloroethene	< .00765	< .00765	.215 C	< .00765	.17 C
Endrin	< .00657	< .00657	< .00657	< .00657	< .00657

NOTES:
µg/g = micrograms per gram
C = analysis was confirmed
J = low-spike recovery is low
I = low-spike recovery is high
O = low-spike recovery excessively different
M = high-spike recovery is high
D = duplicate
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TABLE 4-2
GROVE POND SEDIMENT SAMPLE ANALYTICAL RESULTS

PLOW SHOP POND AND GROVE POND SEDIMENT EVALUATION
FORT DEVENS, MA

ANALYTE	GRD-95-52X	GRD-95-52X (5 ft. deep)	GRD-95-53X	GRD-95-54X	GRD-95-55X
PAL SEMIVOLATILE ORGANICS (µg/g)					
2-methylnaphthalene	< .049	< .049	< .049	< .049	< .049
4-bromophenylphenyl Ether	< .033	< .033	< .033	< .033	< .033
4-chlorophenylphenyl Ether	< .033	< .033	< .033	< .033	< .033
Acenaphthylene	< .033	< .033	< .033	< .033	< .033
Anthracene	< .033	< .033	< .033	< .033	< .033
Benzo[a]anthracene	< .17	< .17	< .17	< .17	< .17
3,4-benzofluoranthene / Benzo[b]fluoranthene	< .21	< .21	< .21	< .21	< .21
Benzo[k]fluoranthene	< .066	< .066	< .066	< .066	< .066
Butylbenzyl Phthalate	< .17	< .17	< .17	< .17	< .17
Chrysene	< .12	< .12	< .12	< .12	< .12
Di-n-butyl Phthalate	< .061	< .061	< .061	< .061	< .061
Dibenzofuran	< .035	< .035	< .035	< .035	< .035
Fluoranthene	< .068	< .068	< .068	< .068	< .068
9h-fluorene / Fluorene	< .033	< .033	< .033	< .033	< .033
Hexachlorobenzene	< .033	< .033	< .033	< .033	< .033
Naphthalene / Tar Camphor	< .037	< .037	< .037	< .037	< .037
Phenanthrene	< .033	< .033	< .033	< .033	< .033
Benzo[def]phenanthrene / Pyrene	< .033	< .033	< .033	< .033	< .033
OTHER (µg/g)					
Total Organic Carbon	240000	42800	474000	131000	645000

NOTES:

µg/g = micrograms per gram
C = analysis was confirmed
J = low-spike recovery is low
I = low-spike recovery is high
O = low-spike recovery excessively different
M = high-spike recovery is high
D = duplicate
< = less than

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TABLE 4-5
GROVE POND SITE INVESTIGATION SURFACE WATER SAMPLE ANALYTICAL RESULTS

PLOW SHOP POND AND GROVE POND SEDIMENT EVALUATION
FORT DEVENS, MA

ANALYTE	GRW-95-06X	GRW-95-07X	GRW-95-08X	GRW-95-09X	GRW-95-09X (duplicate)	GRW-95-10X	GRW-95-11X
PAL CATIONS/ANIONS (µg/L)							
Chloride	44000	44000	53000	46000	46000 D	37000	44000
Sulfate	< 10000	< 10000	10000	< 10000	< 10000 D	14000	< 10000
PAL METALS (µg/L)							
Arsenic	< 2.54	< 2.54	3.94	< 2.54	< 2.54 D	< 2.54	< 2.54
Barium	8	< 5	9.25	6.37	7 D	8.5	6.37
Calcium	10500	10600	13500	11200	11800 D	13100	10900
Chromium	< 6.02	< 6.02	39.8	6.76	8.43 D	< 6.02	< 6.02
Copper	9.89	< 8.09	< 8.09	< 8.09	< 8.09 D	< 8.09	< 8.09
Iron	222	228	402	242	249 D	181	238
Lead	< 1.26	< 1.26	2.39	3.04	< 1.26 D	< 1.26	< 1.26
Magnesium	1950	1860	1970	1880	1980 D	1990	1860
Manganese	46.6	97.4	100	53.5	58.4 D	39.3	73.8
Potassium	1210	1780	1670	877	1580 D	1730	1420
Sodium	22400	22100	27400	23400	24600 D	19100	23100
PAL SEMIVOLATILE ORGANICS (µg/L)							
Bis(2-ethylhexyl) Phthalate	51	24	9	< 4.8	16 D	26	45
PAL WATER QUALITY PARAMETERS (µg/L)							
Alkalinity	18000	20000	25000	21000	21000 D	21000	21000
Nitrite, Nitrate-non Specific	43.1	19.5	132	54.2	< 10 D	260	< 10
Nitrogen By Kjeldahl Method	381	476	486	< 183	448 D	724	448
Total Hardness	37000	36400	42800	34800	37200 D	41600	37200
OTHER (µg/L)							
Total Organic Carbon	4580	4480	4850	5500	4840 D	4840	4440

NOTES:
µg/L = micrograms per liter
D = duplicate
< = less than

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Screening-Level Ecological Risk Assessment

Fort Devens

Ayer, Massachusetts

U.S. Environmental Protection Agency
Region I New England
Office of Environmental Measurement and Evaluation
Office of Ecosystem Assessment

April 19, 1999

[redacted] [redacted] [redacted]TAE [redacted] [redacted]

Screening of Inorganic Chemic urface Water - Grove Pond
Fort Devens, Ayer, Massachusetts

Analyte	GSEM-1		GSEM-2		GSEM-3		GSEM-4		Surface water benchmark chronic (total)	Surface water benchmark acute (total)	Source
Inorganics (ug/L)											
Aluminum	10.0	U	10.0	U	10.0	U	10.0	U	87	750	AWQC
Antimony	5.0	U	5.0	U	5.0	U	5.0	U	30	180	Tier II
Arsenic	10.0	U	10.0	U	10.0	U	10.0	U	190	360	AWQC
Barium	6.4		11.9		8.8		8.8		4.0	110	Tier II
Beryllium	1.0	U	1.0	U	1.0	U	1.0	U	0.66	35	Tier II
Cadmium	1.5	U	1.5	U	1.5	U	1.5	U	0.7 +	2.1 +	AWQC
Calcium	18,400		19,700		17,400		17,000		116,000	---	LCV
Chromium	3.0	U	3.0	U	3.0	U	3.0	U	11 (Cr VI)	16 (Cr VI)	AWQC
Cobalt	1.5	U	1.5	U	1.5	U	1.5	U	23	1500	Tier II
Copper	1.5	U	1.5	U	1.5	U	1.5	U	7.4 +	10.6 +	AWQC
Iron	390		270		320		190		1000	---	AWQC
Lead	5.0	U	5.0	U	5.0	U	5.0	U	1.6 +	41 +	AWQC
Magnesium	3,200		3,300		2,800		2,600		82,000	---	LCV
Manganese	108		268		68.6		20.3		120	2300	Tier II
Nickel	6.0	U	6.0	U	6.0	U	6.0	U	99 +	895 +	AWQC
Potassium	2,500		1,800		1,400		1,500		53,000	---	LCV
Selenium	20.0	U	20.0	U	20.0	U	20.0	U	5	20	AWQC
Silver	3.0	U	3.0	U	3.0	U	3.0	U	0.36	1.6 +	Tier II/AWQC
Sodium	30,500		29,400		29,200		22,100		680,000	---	LCV
Thallium	20.0	U	20.0	U	20.0	U	20.0	U	12	110	Tier II
Vanadium	1.5	U	1.5	U	1.5	U	1.5	U	20	280	Tier II
Zinc	12.0	U	12.0	U	12.0	U	12.0	U	67 +	74 +	AWQC
# of COPCs per location	1		2		1		1				
# exceeding chronic benchmark	1		2		1		1				
# exceeding acute benchmark	0		0		0		0				

Notes:

AWQC = Ambient water quality criteria; source document is the Federal Register; and EPA, 1988 for aluminum

Tier II = Secondary Chronic Values based on Great Lakes Tier II methodology; source document is Suter and Tsao (1996 revision).

LCV = Lowest Chronic Value for Daphnids, from Suter and Tsao (1996 revision).

+ = criterion adjusted to site-specific hadness of 58

▨ = indicates that the contaminant concentration exceeds the chronic criterion

Ta.

Screening of Inorganic Chemicals in Sediment Samples of Grove Pond, Fort Devens, Ayer, Massachusetts
Fort Devens Site, Ayer, Massachusetts

Analyte	GSEM-1	GSEM-2	GSEM-3	GSEM-4	Sediment Benchmark (LOW)	Sediment Benchmark (HIGH)	Source
Inorganics mg/Kg d.w.							
Aluminum	14,000	11,000	5,400	21,000	---	58,030	ARCS
Antimony	5 UJ	5 UJ	5 UJ	5 UJ	2.0	25	NOAA
Arsenic	90 U	100 U	50 U	120 U	6	33	OMOE
Barium	115	90.3	170	73.0	20	---	EPA, 1997
Beryllium	1.2	1.0	0.95	3.1	---	---	---
Cadmium	88.7	23.2	6.8	12.6	0.6	10	OMOE
Calcium	5,700	5,900	215,000	5,100	---	---	---
Chromium	59.7	337	83,400	3,510	26	110	OMOE
Cobalt	34	28.8	3.5	42.5	50	---	OMOE
Copper	64.5	43.2	88	52.5	16	110	OMOE
Iron	22,000	21,000	8,700	20,000	20,000	40,000	OMOE
Lead	304	166	386	238	31	250	OMOE
Magnesium	3,880	2,240	1,650	1,430	---	---	---
Manganese	789	861	1,080	366	460	1,100	OMOE
Nickel	61.2	41.6	15.2	63.1	16	75	OMOE
Potassium	1,720	1,020	420 U	682	---	---	---
Selenium	10.2 U	10.3 U	10.4 U	10.1 U	5	---	---
Silver	2 UJ	2 UJ	2 UJ	2 UJ	1.0	3.7	NOAA
Sodium	492	485	753	288	---	---	---
Thallium	20.4 U	20.6 U	20.9 U	20.2 U	---	---	---
Vanadium	45.4	31.6	53.5	43	---	---	---
Zinc	632	380	297	472	120	820	OMOE
total organic carbon mg/kg	144,948	172,200	117,043	177,905			
# of COPCs per location	9	9	7	8			
# exceeding low benchmarks	7	7	5	6			
# exceeding high benchmarks	2	2	2	2			

NOTES:

OMOE = Ontario Ministry of the Environment sediment guidelines; source document is Jaagmagi et al. (1995).

NOAA = National Oceanic and Atmospheric Administration; source document is Long et al. (1995)

ARCS = Assessment and Remediation of Contaminated Sediments Program; source document is Jones et al. (1997 Revision)

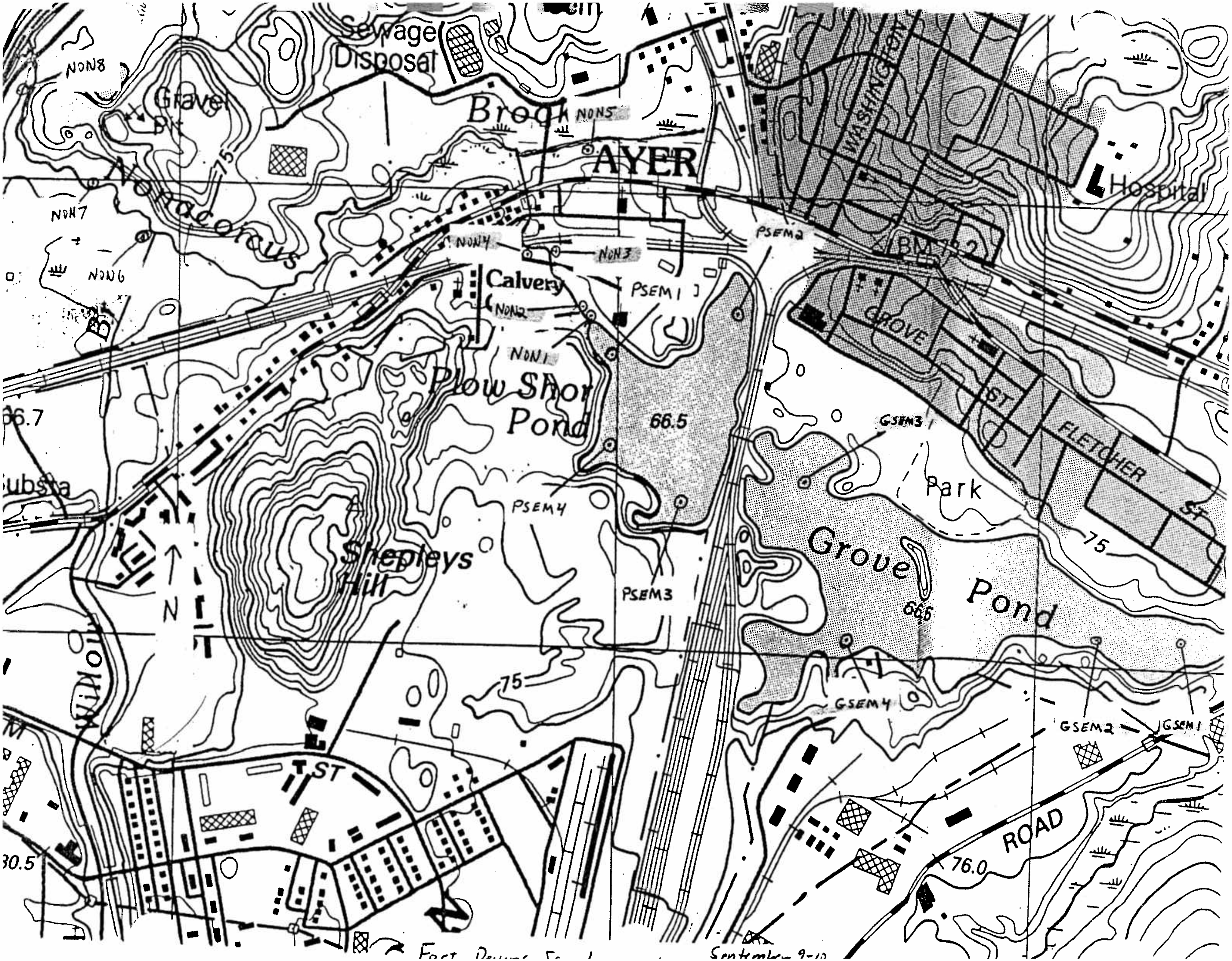
BCMOEL = British Columbia Ministry of Environment Lands and Parks (1994)

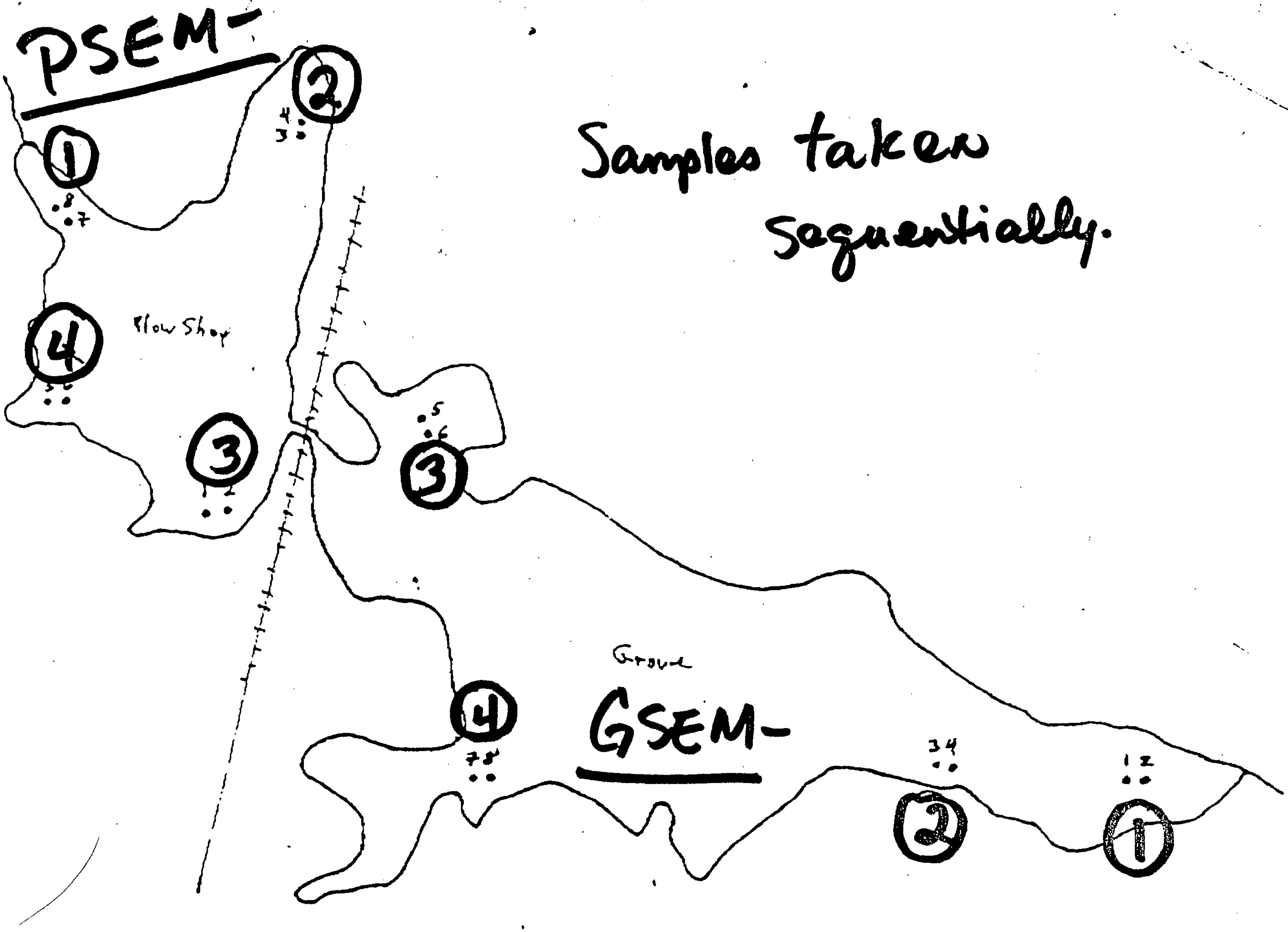
USEPA (1997) = Guidelines for the Pollutional Classification of Harbor Sediments.

--- = Not Available

▨ Indicates that the chemical exceeds the low benchmark

■ Indicates that the chemical exceeds the


Sewage Disposal
NON8
Gravel Pit
Brook
NON5
AYER
Hospital
WASHINGTON
Nonacoicus
75
NON7
NON6
NON4
NON3
PSEM2
BM 232
Calvery
NON2
PSEM1
NON1
GROVE
ST
FLETCHER
ST
66.7
Plow Shop Pond
66.5
GSEM3
Park
Substa
PSEM4
Shepleys Hill
N
Grove Pond
66.5
PSEM3
75
GSEM4
GSEM2
GSEM1
ST
ROAD
76.0
80.5
Fort Devens
September 9-10



Samples taken sequentially.

• 2 = USFWS Emergence Trap Station   Location of Emergence Traps

GSEM-
PSEM- ③ = ESAT designation,
surface water/sediment Sampling September 1998

rec'd at EPA 12/11/00

ENVIRONMENTAL COMPLIANCE SERVICES, Inc.

LIMITED ENVIRONMENTAL INVESTIGATION
PLASTIC DISTRIBUTION COMPANY
1 BLIGH STREET
AYER, MASSACHUSETTS
APPENDIX A-F

Prepared For:

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Ayer, Massachusetts

Table 9 (5 of 5)
Concentrations of
Total Priority Pollutant 13 Metals
Detected in Soil and Grove Pond Sediment
(EPA Methods 200.7 and 245.1)

	Results/Method Detection Limits[1]								Method 1 Standards[2]	
Sample Location	PZ-1A	PZ-1A	PZ-1B	PZ-2A	PZ-2A	PZ-2A	PZ-2A	PZ-2A		
Sampling Date	11/2/99	11/2/99	11/2/99	11/2/99	11/2/99	11/2/99	11/2/99	11/2/99	GW-3	
Depth below grade (inches)	0-6	6-12	54-60 [3]	0-6	6-12	12-18	18-24	24-30	S-2	S-3
Total Priority Pollutant 13 Metals (mg/Kg)										
Antimony	ND/4.12	ND/3.20	ND/3.00	117	114	ND/3.33	ND/3.20	ND/3.39	40	40
Arsenic	10.6	4.59	5.30	99.7	148	13.7	15.0	ND/3.39	2,500	5,000
Beryllium	ND/0.678	ND/0.534	ND/0.500	ND/1.26	ND/1.28	ND/0.555	ND/0.533	ND/0.566	800	3
Cadmium	ND/1.37	ND/1.07	ND/1.00	ND/2.52	ND/2.57	ND/1.11	ND/1.07	ND/1.13	80	80
Chromium	280	96.3	36.2	4,190	4,310	35.6	19.4	10.2	2,500	5,000
Copper	6.73	3.10	2.60	23.7	27.7	1.33	1.60	ND/1.13	*	*
Lead	11.9	6.84	5.60	143	61.1	9.32	10.4	12.9	600	600
Mercury	1.70	ND/0.223	ND/0.213	21.2	4.16	ND/0.240	ND/0.230	ND/0.241	60	60
Nickel	6.87	4.27	4.90	10.9	3.59	4.99	6.50	3.17	700	700
Selenium	ND/4.12	ND/3.20	ND/3.00	ND/7.57	ND/7.70	ND/3.33	ND/3.20	ND/3.39	2,500	2,500
Silver	ND/2.75	ND/2.14	ND/2.00	ND/5.05	ND/5.13	ND/2.22	ND/2.13	ND/2.26	200	200
Thallium	ND/4.12	ND/3.20	ND/3.00	ND/7.57	ND/7.70	ND/3.33	ND/3.20	ND/3.39	30,000	100,000
Zinc	17.3	8.12	9.10	86.8	15.1	10.3	12.0	3.73	2,500,000	5,000,000

NOTES: ND = Not detected at the method detection limit. *No MCP Standard.

[1] Results in milligrams per kilogram (mg/Kg).

[2] Method 1 Standards for Soil Categories 2 (S-2) and 3 (S-3) from 310 CMR 40.0975(6)(a), Table 3 and 4, respectively.

[3] The sample was labeled 6-12 but was collected approximately 54-60 inches below the Pond bottom.

Shaded value indicates concentration exceeds standard.

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Ayer, Massachusetts

RTN 2-10138

Table 11 (3 of 6)
Concentrations of
Soluble and Total Priority 13 Metals and Soluble and Total Mercury
Detected in Groundwater and Surface water
(EPA Methods 200.7 and 245.1)

Sample Location	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	NAWQC [2]		MCP[4]
	Results/Method Detection Limits[1]								
Sampling Date	11/19/99	11/19/99	11/19/99	11/19/99	11/18/99	11/18/99	CMC [3]	CCC [3]	GW-3
Total Priority Pollutant 13 Metals (mg/L)									
Antimony	ND/0.015	ND/0.030	ND/0.015	ND/0.015	ND/0.015	ND/0.015	*	*	0.3
Arsenic	0.026	ND/0.030	0.050	ND/0.015	0.055	ND/0.015	0.34	0.15	0.4
Beryllium	ND/0.0025	ND/0.005	ND/0.0025	ND/0.0025	ND/0.0025	ND/0.0025	*	*	0.05
Cadmium	ND/0.005	ND/0.010	ND/0.005	ND/0.005	ND/0.005	ND/0.005	0.0024	0.0015	0.01
Chromium	0.093	0.014	0.022	0.189	ND/0.005	0.006	0.365	0.047	2
Copper	ND/0.005	ND/0.010	ND/0.005	ND/0.005	ND/0.005	ND/0.005	0.008	0.0056	*
Lead	ND/0.010	ND/0.020	ND/0.010	ND/0.010	ND/0.010	ND/0.010	0.036	0.0014	0.03
Mercury	ND/0.001	ND/0.001	ND/0.001	ND/0.001	ND/0.001	ND/0.001	*	*	0.001
Nickel	ND/0.005	ND/0.010	ND/0.005	ND/0.005	ND/0.005	ND/0.005	0.295	0.033	0.08
Selenium	ND/0.015	ND/0.030	ND/0.015	ND/0.015	ND/0.015	ND/0.015	*	*	0.08
Silver	ND/0.007	ND/0.007	ND/0.007	ND/0.007	ND/0.010	ND/0.010	0.0014	*	0.007
Thallium	ND/0.015	ND/0.030	ND/0.015	ND/0.015	ND/0.015	ND/0.015	*	*	0.4
Zinc	0.011	0.006	0.006	0.020	ND/0.005	ND/0.005	0.074	0.074	0.9
Soluble Priority Pollutant 13 Metals (mg/L)									
Antimony	ND/0.030	ND/0.030	ND/0.030	ND/0.030	ND/0.030	ND/0.030	*	*	0.3
Arsenic	ND/0.030	ND/0.030	0.044	ND/0.030	0.047	ND/0.030	0.34	0.15	0.4
Beryllium	ND/0.005	ND/0.005	ND/0.005	ND/0.005	ND/0.005	ND/0.005	*	*	0.05
Cadmium	ND/0.010	ND/0.010	ND/0.010	ND/0.010	ND/0.010	ND/0.010	0.0024	0.0015	0.01
Chromium	0.071	0.011	0.017	0.110	ND/0.010	ND/0.010	0.365	0.047	2
Copper	ND/0.010	ND/0.010	ND/0.010	ND/0.010	ND/0.010	ND/0.010	0.008	0.0056	*
Lead	ND/0.020	ND/0.020	ND/0.020	ND/0.020	ND/0.020	ND/0.020	0.036	0.0014	0.03
Mercury	ND/0.001	ND/0.001	ND/0.001	ND/0.001	ND/0.001	ND/0.001	*	*	0.001
Nickel	ND/0.010	ND/0.010	ND/0.010	ND/0.010	ND/0.010	ND/0.010	0.295	0.033	0.08
Selenium	ND/0.030	ND/0.030	ND/0.030	ND/0.030	ND/0.030	ND/0.030	*	*	0.08
Silver	ND/0.020	ND/0.020	ND/0.020	ND/0.020	ND/0.020	ND/0.020	0.0014	*	0.007
Thallium	ND/0.030	ND/0.030	ND/0.030	ND/0.030	ND/0.030	ND/0.030	*	*	0.4
Zinc	ND/0.010	ND/0.010	ND/0.010	0.016	ND/0.010	ND/0.010	0.074	0.074	0.9

NOTES:

[1] Results in milligrams per liter (mg/L) or micrograms per liter (µg/L) as noted.

[2] Criteria based on National Recommended Water Quality Criteria for Priority Toxic Pollutants in Freshwater (EPA Part IV Federal Register December 10, 1998) in terms of dissolved metal in the water column. Values converted from hardness of 100 mg/L from published EPA data using site specific criteria.

[3] CMC = Criteria Maximum Concentration; CCC = Criteria Continuous Concentration.

[4] Method 1 Standards for Groundwater from 310 CMR 40.0974(2), Table 1.

ND = Not detected at the method detection limit.

* No NAWQC and/or MCP Standard.

Bold indicates concentration exceeds GW-3 Standard.

Shaded indicates concentration exceeds CCC; underlined indicates concentration exceeds CMC.

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Table 11 (4 of 6)
Concentrations of
Soluble and Total Priority 13 Metals and Soluble and Total Mercury
Detected in Groundwater and Surface water
(EPA Methods 200.7 and 245.1)

Sample Location	MW-7	MW-8	MW-9	PZ-1R	PZ-2R	SW-1	SW-2	NAWQC [2]		MCP[4]
	Results/Method Detection Limits[1]									
Sampling Date	11/18/99	11/18/99	11/18/99	11/18/99	11/19/99	11/18/99	11/19/99	CMC [3]	CCC [3]	GW-3
Total Priority Pollutant 13 Metals (mg/L)										
Antimony	ND/0.015	ND/0.015	ND/0.015	ND/0.015	ND/0.015	NS	NS	*	*	0.3
Arsenic	ND/0.015	0.190	ND/0.015	0.102	0.098	NS	NS	0.34	0.15	0.4
Beryllium	ND/0.0025	ND/0.0025	ND/0.0025	ND/0.0025	ND/0.005	NS	NS	*	*	0.05
Cadmium	ND/0.005	ND/0.005	ND/0.005	ND/0.005	ND/0.005	NS	NS	0.0024	0.0015	0.01
Chromium	ND/0.005	0.007	ND/0.005	0.175	ND/0.005	NS	NS	0.365	0.047	2
Copper	ND/0.005	ND/0.005	ND/0.005	ND/0.005	ND/0.005	NS	NS	0.008	0.0056	*
Lead	ND/0.010	ND/0.020	ND/0.010	ND/0.010	ND/0.010	NS	NS	0.036	0.0014	0.03
Mercury	ND/0.001	ND/0.001	ND/0.001	ND/0.001	ND/0.001	NS	NS	*	*	0.001
Nickel	0.009	0.012	0.006	0.032	ND/0.005	NS	NS	0.295	0.033	0.08
Selenium	ND/0.015	ND/0.015	ND/0.015	ND/0.015	ND/0.015	NS	NS	*	*	0.08
Silver	ND/0.010	0.038	ND/0.010	ND/0.010	ND/0.007	NS	NS	0.0014	*	0.007
Thallium	ND/0.015	ND/0.015	ND/0.015	ND/0.015	ND/0.015	NS	NS	*	*	0.4
Zinc	ND/0.005	ND/0.005	0.018	**2.4****	**1.82****	NS	NS	0.074	0.074	0.9
Soluble Priority Pollutant 13 Metals (mg/L)										
Antimony	ND/0.030	ND/0.030	ND/0.030	ND/0.030	ND/0.030	ND/0.030	ND/0.030	*	*	0.3
Arsenic	ND/0.030	0.168	ND/0.030	ND/0.030	0.076	ND/0.030	ND/0.030	0.34	0.15	0.4
Beryllium	ND/0.005	ND/0.005	ND/0.005	ND/0.005	ND/0.010	ND/0.005	ND/0.005	*	*	0.05
Cadmium	ND/0.010	ND/0.010	ND/0.010	ND/0.010	ND/0.010	ND/0.010	ND/0.010	0.0024	0.0015	0.01
Chromium	ND/0.010	ND/0.010	ND/0.010	0.069	ND/0.010	ND/0.010	ND/0.010	0.365	0.047	2
Copper	ND/0.010	ND/0.010	ND/0.010	ND/0.010	ND/0.010	ND/0.010	ND/0.010	0.008	0.0056	*
Lead	ND/0.020	ND/0.020	ND/0.020	ND/0.020	ND/0.020	ND/0.020	ND/0.020	0.036	0.0014	0.03
Mercury	ND/0.001	ND/0.001	ND/0.001	ND/0.001	ND/0.001	ND/0.001	ND/0.001	*	*	0.001
Nickel	ND/0.010	ND/0.010	ND/0.010	0.015	ND/0.010	ND/0.010	ND/0.010	0.295	0.033	0.08
Selenium	ND/0.030	ND/0.030	ND/0.030	ND/0.030	ND/0.030	ND/0.030	ND/0.030	*	*	0.08
Silver	ND/0.020	ND/0.020	ND/0.020	ND/0.020	ND/0.020	ND/0.020	ND/0.020	0.0014	*	0.007
Thallium	ND/0.030	ND/0.030	ND/0.030	ND/0.030	ND/0.030	ND/0.030	ND/0.030	*	*	0.4
Zinc	ND/0.010	ND/0.010	ND/0.010	**2.31****	**1.77****	ND/0.010	ND/0.010	0.074	0.074	0.9

NOTES:

[1] Results in milligrams per liter (mg/L) or micrograms per liter (µg/L) as noted.

[2] Criteria based on National Recommended Water Quality Criteria for Priority Toxic Pollutants in Freshwater (EPA Part IV Federal Register December 10, 1998) in terms of dissolved metal in the water column. Values converted from hardness of 100 mg/L from published EPA data using site specific criteria.

[3] CMC = Criteria Maximum Concentration; CCC = Criteria Continuous Concentration.

[4] Method 1 Standards for Groundwater from 310 CMR 40.0974(2), Table 1.

ND = Not detected at the method detection limit.

* No NAWQC and/or MCP Standard.

** Rejected data.

Bold indicates concentration exceeds GW-3 Standard.

Shaded indicates concentration exceeds CCC; underlined indicates concentration exceeds CMC.

U.S. Fish and Wildlife Service
Maine Field Office
Special Project Report: FY00-MEFO-1-EC

Trace Element Exposure in Benthic Invertebrates from Grove Pond, Plow Shop Pond, and Nonacoicus Brook

Ayer, Massachusetts

Prepared by:

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September 2000

Figure 1. Mussel sampling locations

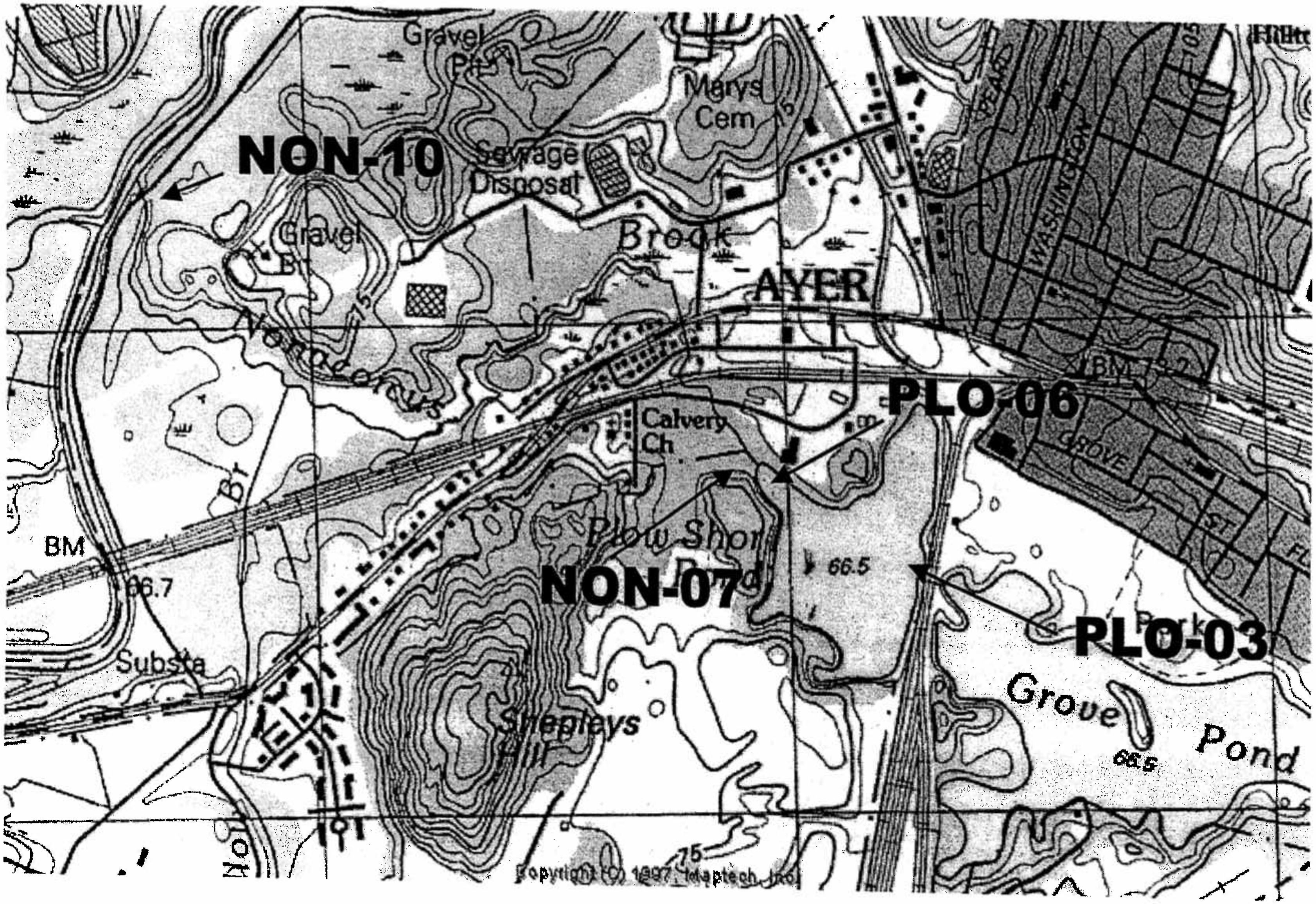

Figure 2. Crayfish sampling locations

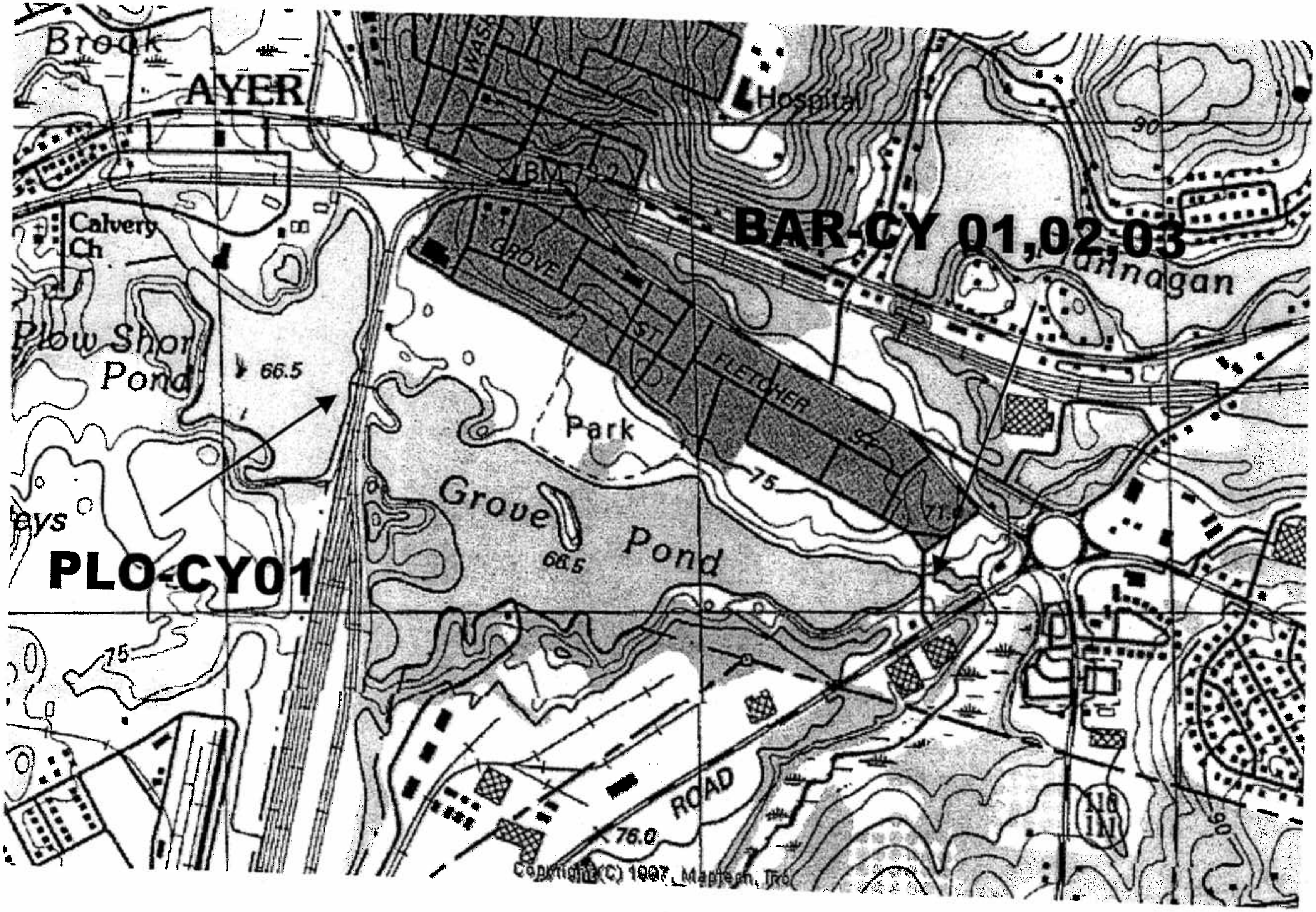

Table 1. Trace elements in wholebody fish from Plow Shop Pond and Grove Pond, *u* g/g WW.

Analyte	Largemouth Bass				Bullhead				Bluegill			
	Plow Shop Pond (n=5)		Grove Pond (n=10)		Plow Shop Pond (n=5)		Grove Pond (n=8)		Plow Shop Pond (n=5)		Grove Pond (n=10)	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
As	nd		nd		nc	(nd-0.30)	nc		nc	(nd-1.30)	nd	
Cd	nc	(nd-0.09)	0.05	(0.03-0.88)	nd		0.04	(0.01-0.19)	nd		0.09	(0.05-0.24)
Cr	0.43	(0.32-0.65)	0.51	(0.35-1.16)	0.42	(0.25-0.42)	0.48	(0.29-1.35)	0.66	(0.48-0.93)	0.70	(0.39-1.23)
Cu	0.58	(0.44-0.90)	0.46	(0.29-1.05)	0.76	(0.43-1.30)	0.68	(0.50-1.27)	0.51	(0.44-0.60)	0.58	(0.37-0.79)
Hg	1.40	(0.65-2.70)	0.32	(0.10-1.13)	0.28	(0.09-0.40)	0.04	(0.01-0.14)	0.37	(0.19-0.54)	0.16	(0.08-0.24)
Ni	na		0.19	(0.07-4.15)	na		0.18	(0.05-0.87)	na		0.16	(0.06-0.80)
Pb	nd		0.38	(0.14-4.32)	nc	(nd-0.18)	0.42	(0.18-1.12)	nc	(nd-0.16)	0.48	(0.16-1.38)
Se	0.40	(0.26-0.54)	0.32	(0.22-0.51)	0.27	(0.24-0.31)	0.23	(0.13-0.39)	0.55	(0.42-0.67)	0.33	(0.27-0.38)
Zn	16	(13-19)	12.81	(11.0-16.4)	16	(12-22)	13.17	(10.0-20.5)	25	(22-30)	21.38	(16.7-26.3)

u g/g = parts-per-million, WW = wet weight
nd = non-detect, nc = not calculated (i.e., too few detections), na = not available

Plow Shop Pond data from: ABB Environmental Services. 1993. Fort Devens Feasibility Studies for Group 1A Sites - Draft Remedial Investigation Addendum Report, Data Item A009. Contract No. DAAA15-91-D-0008, Delivery Order No. 0004, Project No. 07005-1. Portland, ME.

Grove Pond data from: Mierzykowski S.E., A.R. Major and K.C. Carr. 1993. Concentrations of mercury and other environmental contaminants in fish from Grove Pond, Ayer, Massachusetts. USFWS New England Field Office. Spec. Proj. Rep. FY93-NEFO-4-EC. Old Town, ME.

Table 8. Trace elements of concern in mussel composite samples, *u* g/g WW.

WET WEIGHT VALUES

Sample No.	As	Cd	Cr	Pb	Hg	MeHg	Ratio MeHg/Hg
Nonacoicus Brook - below Plow Shop Pond dam							
NON-07A	1.01	0.25	0.66	0.09	0.0585	0.0297	0.51
NON-07B	0.89	0.25	0.58	nd	0.0581	0.0286	0.49
NON-07C	1.17	0.20	0.53	nd	0.0609	0.0299	0.49
Mean	1.02	0.24	0.59	nc	0.0592	0.0294	0.50
St Dev	0.140	0.027	0.069		0.00149	0.00072	
Nonacoicus Brook - 100 m. before confluence with Nashua River							
NON-10A	1.13	0.90	5.17	1.16	0.1434	0.0402	0.28
NON-10B	1.01	0.73	4.74	0.96	0.1257	0.0445	0.35
NON-10C	1.17	0.66	5.31	1.17	0.1333	0.0444	0.33
Mean	1.10	0.76	5.07	1.10	0.1341	0.0430	0.32
St Dev	0.084	0.123	0.294	0.120	0.00891	0.00243	
Plow Shop Pond - alongside culvert from Grove Pond							
PLO-03A	0.71	0.39	0.72	0.10	0.0557	0.0264	0.47
PLO-03B	0.66	0.24	0.65	0.07	0.0481	0.0188	0.39
PLO-03C	0.40	0.34	0.68	0.07	0.0411	0.0080	0.19
Mean	0.59	0.32	0.68	0.08	0.0483	0.0177	0.35
St Dev	0.168	0.074	0.036	0.014	0.00725	0.00926	
Plow Shop Pond - above Plow Shop Pond dam							
PLO-06A	0.79	0.34	0.44	0.06	0.0434	0.0073	0.17
PLO-06B	0.93	0.36	0.70	0.06	0.0413	0.0117	0.28
PLO-06C	0.83	0.19	0.55	nd	0.0427	0.0071	0.17
Mean	0.85	0.30	0.57	nc	0.0425	0.0087	0.21
St Dev	0.074	0.095	0.130		0.00108	0.00261	

u g/g = ppm, WW = wet weight
nd = non-detect, nc = not calculated
All mussels were Eastern Elliptio (*Elliptio complanata*)

Table 9. Trace elements of concern in crayfish composite samples, *u* g/g WW.

WET WEIGHT VALUES

Sample No.	As	Cd	Cr	Pb	Hg	MeHg	Ratio MeHg/Hg
Grove Pond - below Barnum Gate bridge							
BAR-CY01	1.18	1.07	1.19	0.89	0.0244	0.0255	1.05
BAR-CY02	1.33	0.31	0.80	0.45	0.0218	0.0266	1.22
BAR-CY03	1.72	0.29	0.56	0.67	0.0349	0.0257	0.74
Mean	1.41	0.56	0.85	0.67	0.0270	0.0260	0.96
St Dev	0.282	0.446	0.317	0.216	0.00692	0.00058	
Plow Shop Pond - alongside culvert from Grove Pond							
PLO-CY01	1.62	0.11	0.48	0.28	0.0465	0.0429	0.92

u g/g = ppm, WW = wet weight

All crayfish were from the genus *Orconectes* spp.

Table 10. Other trace elements in mussel composite samples, *u* g/g WW

WET WEIGHT VALUES

Sample No.	Al	B	Ba	Cu	Fe	Mg	Mn	Ni	Se	Sr	Zn
Nonacoicus Brook - below Plow Shop Pond dam											
NON-7A	nd	nd	61.4	0.65	667	129.0	870	nd	0.16	18.1	21.2
NON-7B	nd	nd	46.9	0.58	503	124.0	692	nd	0.16	15.7	19.5
NON-7C	nd	nd	44.6	0.57	574	110.0	581	nd	0.21	13.6	17.7
Mean	nd	nd	51.0	0.60	581	121.0	714	nd	0.18	15.8	19.5
St Dev			9.108	0.047	82.2	9.85	145.8		0.025	2.25	1.75
Nonacoicus Brook - 100 m. before confluence with Nashua River											
NON-10A	35.90	nd	65.4	1.33	727	130.0	976	0.19	0.31	21.0	24.6
NON-10B	32.60	nd	53.9	1.16	606	119.0	942	0.20	0.31	18.2	22.0
NON-10C	40.40	nd	53.0	1.50	678	124.0	1079	0.21	0.32	19.3	22.5
Mean	36.30	nd	57.4	1.33	670	124.3	999	0.20	0.31	19.5	23.0
St Dev	3.915		6.91	0.170	60.9	5.51	71.3	0.008	0.005	1.41	1.38
Plow Shop Pond - alongside culvert from Grove Pond											
PLO-03A	1.12	0.40	84.8	0.64	1002	110.0	1042	0.11	0.17	25.4	21.7
PLO-03B	nd	0.35	80.5	0.75	1103	119.0	791	nd	0.15	23.7	21.8
PLO-03C	nd	0.47	95.1	0.68	1372	89.5	862	0.12	0.17	26.2	17.8
Mean	nc	0.40	86.8	0.69	1159	106.2	898	nc	0.16	25.1	20.4
St Dev	nc	0.058	7.50	0.054	191.3	15.12	129.4	nc	0.013	1.28	2.28
Plow Shop Pond - above Plow Shop Pond dam											
PLO-06A	nd	nd	55.9	0.63	643	81.1	509	0.10	0.18	12.4	14.6
PLO-06B	nd	nd	51.3	0.76	623	96.7	631	0.15	0.18	15.3	17.3
PLO-06C	nd	nd	32.0	0.73	364	104.0	593	nd	0.18	12.0	18.6
Mean	nd	nd	46.4	0.71	543	93.9	578	nc	0.18	13.2	16.8
St Dev			12.68	0.066	155.6	11.70	62.43	nc	0.003	1.80	2.04

u g/g = ppm, WW = wet weight
nd = non-detect, nc = not calculated
All mussels are Eastern Elliptio (*Elliptio complanata*)

Table 11. Other trace elements in crayfish composite samples, *u* g/g WW

WET WEIGHT VALUES

Sample No.	Al	B	Ba	Cu	Fe	Mg	Mn	Ni	Se	Sr	Zn
Grove Pond - below Barnum Gate Bridge											
BAR-CY01	30.00	nd	37.5	25.40	224.0	402.0	726.0	2.14	nd	120.0	34.7
BAR-CY02	20.60	nd	25.6	16.00	224.0	382.0	647.0	0.88	nd	145.0	25.5
BAR-CY03	29.60	nd	28.5	15.50	332.0	404.0	785.0	0.76	nd	156.0	25.0
Mean	26.73	nd	30.5	18.97	260.0	396.0	719.3	1.26		140.3	28.4
St Dev	5.315		6.21	5.577	62.35	12.17	69.24	0.762		18.45	5.46
Plow Shop Pond - alongside culvert from Grove Pond											
PLO-CY01	2.94	nd	37.7	24.40	349.0	388.0	278.0	0.27	nd	157.0	23.3

u g/g = ppm, WW = wet weight

nd = non-detect

All crayfish were from the genus *Orconectes* sp.

DRY WEIGHT VALUES

Table 12. Trace elements of concern in mussel composite samples, *u* g/g DW.

Sample No.	% Moisture	As	Cd	Cr	Pb	Hg	MeHg	Ratio MeHg/Hg
Nonacoicus Brook - below Plow Shop Pond dam								
NON-07A	82.0	5.63	1.41	3.68	0.51	0.325	0.165	0.51
NON-07B	83.0	5.24	1.47	3.39	nd	0.342	0.168	0.49
NON-07C	82.2	6.57	1.15	2.96	nd	0.342	0.168	0.49
Mean		5.81	1.34	3.34	nc	0.336	0.167	0.50
St Dev		0.684	0.170	0.362		0.0098	0.0017	
Nonacoicus Brook - 100 m. before confluence with Nashua River								
NON-10A	84.1	7.13	5.64	32.50	7.32	0.902	0.253	0.28
NON-10B	84.6	6.55	4.71	30.80	6.24	0.816	0.289	0.35
NON-10C	84.7	7.64	4.31	34.70	7.66	0.871	0.290	0.33
Mean		7.11	4.89	32.67	7.07	0.863	0.277	0.32
St Dev		0.545	0.682	1.955	0.741	0.0436	0.0211	
Plow Shop Pond - alongside culvert from Grove Pond								
PLO-03A	85.0	4.73	2.58	4.80	0.65	0.371	0.176	0.47
PLO-03B	86.7	4.96	1.82	4.88	0.53	0.362	0.141	0.39
PLO-03C	87.3	3.12	2.70	5.32	0.59	0.324	0.063	0.19
Mean		4.27	2.37	5.00	0.59	0.352	0.127	0.36
St Dev		1.003	0.477	0.280	0.060	0.0249	0.0580	
Plow Shop Pond - above Plow Shop Pond dam								
PLO-06A	84.5	5.09	2.19	2.86	0.41	0.280	0.047	0.17
PLO-06B	85.2	6.30	2.46	4.74	0.39	0.279	0.079	0.28
PLO-06C	84.9	5.48	1.25	3.66	nd	0.283	0.047	0.17
Mean		5.62	1.97	3.75	nc	0.281	0.058	0.21
St Dev		0.618	0.635	0.943		0.0021	0.0186	

u g/g = ppm, DW = dry weight
nd = non-detect, nc = not calculated
All mussels were Eastern Elliptio (*Elliptio complanata*)

Table 13. Trace elements of concern in crayfish composite samples, *u* g/g DW.

DRY WEIGHT VALUES

Sample No.	% Moisture	As	Cd	Cr	Pb	Hg	MeHg	Ratio MeHg/Hg
Grove Pond - below Barnum Gate bridge								
BAR-CY01	72.9	4.35	3.95	4.38	3.27	0.0899	0.0942	1.05
BAR-CY02	69.3	4.32	1.00	2.62	1.48	0.0711	0.0867	1.22
BAR-CY03	68.0	5.39	0.90	1.74	2.08	0.1090	0.0804	0.74
Mean		4.69	1.95	2.91	2.28	0.0900	0.0871	0.97
St Dev		0.609	1.732	1.344	0.911	0.01895	0.00691	
Plow Shop Pond - alongside culvert from Grove Pond								
PLO-CY01	70.4	5.47	0.37	1.62	0.96	0.1570	0.1450	0.92

u g/g = ppm, DW = dry weight
All crayfish were from the genus *Orconectes* spp.

Table 14. Other trace elements in mussel composite samples, *u* g/g DW

DRY WEIGHT VALUES

Sample No.	Al	B	Ba	Cu	Fe	Mg	Mn	Ni	Se	Sr	Zn
Nonacoicus Brook - below Plow Shop Pond dam											
NON-7A	nd	nd	341	3.63	3706	714	4833	nd	0.91	100.0	118.0
NON-7B	nd	nd	276	3.40	2958	732	4073	nd	0.94	92.4	115.0
NON-7C	nd	nd	251	3.19	3223	620	3264	nd	1.16	76.3	99.4
Mean	nd	nd	289	3.41	3296	689	4057	nd	1.00	89.6	110.8
St Dev			46.5	0.220	379.3	60.1	784.6		0.137	12.10	9.99
Nonacoicus Brook - 100 m. before confluence with Nashua River											
NON-10A	226.0	nd	411	8.37	4572	820	6140	1.20	1.94	132.0	155.0
NON-10B	212.0	nd	350	7.54	3934	773	6119	1.31	1.98	118.0	143.0
NON-10C	264.0	nd	347	9.79	4432	810	7051	1.36	2.06	126.0	147.0
Mean	234.0	nd	369	8.57	4313	801	6437	1.29	1.99	125.3	148.3
St Dev	26.91		36.1	1.138	335.3	24.8	532.1	0.082	0.061	7.02	6.11
Plow Shop Pond - alongside culvert from Grove Pond											
PLO-03A	7.48	2.65	565	4.29	6683	730	6949	0.74	1.11	169.0	145.0
PLO-03B	nd	2.63	605	5.65	8291	898	5947	nd	1.10	178.0	164.0
PLO-03C	nd	3.67	749	5.36	10805	705	6788	0.93	1.34	206.0	140.0
Mean	nc	2.98	640	5.10	8593	778	6561	nc	1.18	184.3	149.7
St Dev		0.595	96.8	0.716	2077.5	105.0	538.1		0.136	19.30	12.66
Plow Shop Pond - above Plow Shop Pond dam											
PLO-06A	nd	nd	361	4.08	4147	523	3287	0.66	1.18	79.8	94.0
PLO-06B	nd	nd	347	5.11	4208	654	4262	1.01	1.20	104.0	117.0
PLO-06C	nd	nd	212	4.84	2413	688	3928	nd	1.17	79.7	124.0
Mean	nd	nd	307	4.68	3589	622	3826	nc	1.18	87.8	111.7
St Dev			82.3	0.534	1019.2	87.1	495.5		0.015	14.00	15.70

u g/g = ppm, DW = dry weight
nd = non-detect, nc = not calculated
All mussels are Eastern Elliptio (*Elliptio complanata*)

Table 15. Other trace elements in crayfish composite samples, *u* g/g DW

DRY WEIGHT VALUES

Sample No.	Al	B	Ba	Cu	Fe	Mg	Mn	Ni	Se	Sr	Zn
Grove Pond - below Barnum Gate bridge											
BAR-CY01	111.00	nd	138.0	93.70	825.0	1484.0	2679.0	7.88	nd	442.0	128.0
BAR-CY02	67.00	nd	83.4	52.10	730.0	1244.0	2107.0	2.88	nd	472.0	83.2
BAR-CY03	92.60	nd	88.9	48.30	1006.0	1262.0	2452.0	2.38	nd	487.0	78.1
Mean	90.20	nd	103.4	64.70	853.7	1330.0	2412.7	4.38	nd	467.0	96.4
St Dev	22.098		30.06	25.187	140.22	133.67	288.02	3.041		22.91	27.46
Plow Shop Pond - alongside culvert from Grove Pond											
PLO-CY01	9.92	nd	128.0	82.40	1180.0	1312.0	940.0	0.92	nd	530.0	78.7

u g/g = ppm, DW = dry weight
nd = non-detect
All crayfish were from the genus *Orconectes* sp.

U.S. EPA. 2001. Data Report, Metals in Frog Tissue. U.S. EPA Office of Environmental Measurement and Evaluation, Lexington, MA. February 2001.

[redacted]a Summary Table
Inorganic Frog Tissue Analysis
ug/g (Wet Weight)

SITE NAME: Fort Devens - Ayer, MA
CASE NO.: IR001, SDG NO.: 000021
LABORATORY: Southwest Research Institute

INORGANIC ELEMENTS	METHOD DETECTION LIMITS ug/g, ppm	SAMPLE NUMBER: SAMPLE LOCATION: LABORATORY NUMBER:	000021 GPF08 150141	000022 GPF09 150142	000023 GPF10 150143	000024 GPF11 150144	000025 GPF12 150145	000026 GPF13 150146	000027 GPF14 150147	QUANTITATION LIMITS
Aluminum	2.0	P	7.36 J	10.3 J	4.96 J	17.2 J	2.28 J	86.8 J	18.7 J	ug/g, ppm
Arsenic	0.010	HY	0.167 J	0.0582 J	0.081 J	0.124 J	0.0349 J	0.478 J	0.206 J	5.0
Barium	0.20	P	1.92 U	2.13 U	3.09	4.88	1.80 U	13.7	12.0	0.50
Beryllium	0.025	PM	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	1.0
Boron	0.50	P	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	0.716 UJ	0.10
Cadmium	0.03	PM	0.100 U	0.100 U	0.100 U	0.0533 J	0.100 U	0.269	0.219	2.0
Chromium	0.20	P	0.370 J	0.226 J	0.500 U	1.08	1.37	4.20	0.643	0.10
Copper	0.20	P	31.2	0.890 U	4.40	1.70 U	59.2	3.79	3.40 U	0.50
Iron	2.0	P	91.9 J	40.2 J	27.1 J	60.4 J	29.3 J	188 J	53.9 J	0.50
Lead	0.05	PM	1.51	0.270 U	0.213 U	0.292 U	2.06	0.768 J	0.516 U	5.0
Magnesium	2.0	P	270	268	235	273	258	251	242	0.50
Manganese	0.35	P	13.6	6.83	20.4	44.4	6.72	38.9	27.3	5.0
Mercury	0.010	CV	0.0546 J	0.0429 J	0.0304 J	0.0277 J	0.108 J	0.0557 J	0.0605 J	1.0
Molybdenum	0.50	P	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	0.20
Nickel	0.20	P	2.70 J	0.500 UJ	0.500 UJ	0.500 UJ	11.0 J	0.416 J	0.500 UJ	2.0
Selenium	0.010	HY	0.253 J	0.147 J	0.161 J	0.148 J	0.194 J	0.637 J	0.644 J	0.50
Strontium	0.20	P	11.0 J	10.2 J	8.33 J	11.9 J	13.0 J	10.8 J	8.09 J	0.50
Vanadium	0.20	P	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.201 J	0.500 U	0.50
Zinc	0.20	P	30.7	14.6	13.9	15.5	39.3	73.4	58.0	0.50
Methyl Mercury	0.0020	AA	0.0578	0.0539	0.0409	0.0326	0.131	0.0592	0.0441	1.0
		% SOLIDS:	20.3	18.3	19.6	19.6	21.6	18.8	11.5	0.00046
		% LIPIDS:	1.14	1.08	2.30	2.04	1.75	2.11	1.93	
		DATE SAMPLED:	07/28/99	07/29/99	07/29/99	07/29/99	08/02/99	08/02/99	08/02/99	

NALYTICAL METHODS:

- ICP
M - ICP/MS
Y - Hydride AA
V - Cold Vapor
A - CH3-Hg AA

QUALIFIERS:

U - Value is non-detected and sample detection limit is reported.
J - Quantitation is approximate due to limitations identified in the quality control review (Data Review).
UJ - Value is non-detected and sample detection limit is estimated.
R - Value is rejected.

Positive results reported by the laboratory which are < QL and > or = MDL are flagged (J) on the Data Summary Table as estimated values. All other necessary qualifications are defined in Table I.

[illegible] Sur[illegible]y Ta[illegible]
Inorganic Frog Tissue Analysis
ug/g (Wet Weight)

ITE NAME: Fort Devens - Ayer, MA
ASE NO.: IR001, SDG NO.: 000021
ABORATORY: Southwest Research Institute

NORGANIC LEMENTS	METHOD DETECTION LIMITS ug/g, ppm		000028	000029	000030	000031	000032	000033	000034	QUANTITATION LIMITS ug/g, ppm
		SAMPLE LOCATION:	GPF15	GPF16	GPF17	GPF18	GPF19	GPF20	GPF21	
		LABORATORY NUMBER:	150148	150149	150150	150151	150152	150153	150154	
luminum	2.0	P	23.5 J	108 J	41.4 J	9.24 J	22.6 J	15.8 J	10.1 J	5.0
rsenic	0.010	HY	0.113 J	0.291 J	0.122 J	0.0624 J	0.266 J	0.0392 J	0.0883 J	0.50
arium	0.20	P	8.04	7.51	5.84	2.02 U	9.94	4.16	3.22 U	1.0
eryllium	0.025	PM	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.10
oron	0.50	P	2.00 U	2.00 U	0.727 UJ	0.609 UJ	2.00 U	2.00 U	2.00 U	2.0
admium	0.03	PM	0.0548 J	0.0665 J	0.0499 J	0.100 U	0.0662 J	0.100 U	0.155 J	0.10
hromium	0.20	P	0.996	11.4	0.998	0.244 J	1.19	0.261 J	0.544	0.50
opper	0.20	P	3.60	6.02	8.44	1.22 U	3.55	1.55 U	1.76 U	0.50
ron	2.0	P	101 J	280 J	82.6 J	28.9 J	82.4 J	37.7 J	40.9 J	5.0
ead	0.05	PM	0.678 J	0.847	2.69	0.213 U	0.253 U	0.212 U	0.352 U	0.50
agnesium	2.0	P	278	397	438	295	274	361	295	5.0
anganese	0.35	P	9.55	70.3	30.9	6.55	29.0	18.0	5.01	1.0
ercury	0.010	CV	0.0186 J	0.136 J	0.0536 J	0.0612 J	0.0850 J	0.0364 J	0.0444 J	0.20
olybdenum	0.50	P	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.0
ickel	0.20	P	0.500 UJ	15.5 J	21.9 J	0.500 UJ	0.209 J	0.500 UJ	0.500 UJ	0.50
elenium	0.010	HY	0.174 J	0.177 J	0.291 J	0.359 J	0.142 J	0.154 J	0.147 J	0.50
trontium	0.20	P	12.4 J	26.4 J	30.0 J	13.7 J	10.4 J	16.0 J	7.99 J	0.50
anadium	0.20	P	0.500 U	0.308 J	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.50
inc	0.20	P	17.1	22.0	28.7	14.7	16.9	19.8	19.1	1.0
ethyl Mercury	0.0020	AA	0.00436	0.243	0.0522	0.0429	0.0562	0.0189	0.0608	0.00046
		% SOLIDS:	19.7	22.6	21.2	21.2	18.2	15.8	22.6	
		% LIPIDS:	2.72	1.48	1.32	2.32	1.54	1.83	1.89	
		DATE SAMPLED:	08/02/99	08/03/99	08/03/99	08/03/99	08/03/99	08/04/99	08/05/99	

NALYTICAL METHODS:

- ICP
M - ICP/MS
Y - Hydride AA
V - Cold Vapor
A - CH3-Hg AA

QUALIFIERS:

U - Value is non-detected and sample detection limit is reported.
J - Quantitation is approximate due to limitations identified in the quality control review (Data Review).
UJ - Value is non-detected and sample detection limit is estimated.
R - Value is rejected.

Positive results reported by the laboratory which are < QL and > or = MDL are flagged (J) on the Data Summary Table as estimated values. All other necessary qualifications are defined in Table I.

[redacted]ata Summary Table
Inorganic Frog Tissue Analysis
ug/g (Wet Weight)

SITE NAME: Fort Devens - Ayer, MA
CASE NO.: IR001, SDG NO.: 000021
LABORATORY: Southwest Research Institute

INORGANIC ELEMENTS	METHOD DETECTION LIMITS ug/g, ppm						QUANTITATION LIMITS ug/g, ppm
		SAMPLE NUMBER:	000035	000036	000037	000038	
		SAMPLE LOCATION:	GPF22	GPF23	GPF24	GPF25	
		LABORATORY NUMBER:	150155	150156	150157	150158	
Aluminum	2.0	P	42.5 J	3.94 J	37.4 J	14.8 J	5.0
Arsenic	0.010	HY	0.278 J	0.0649 J	0.122 J	0.0924 J	0.50
Barium	0.20	P	7.69	8.31	3.21 U	3.65	1.0
Beryllium	0.025	PM	0.100 U	0.100 U	0.100 U	0.100 U	0.10
Boron	0.50	P	2.00 U	2.00 U	2.00 U	2.00 U	2.0
Cadmium	0.03	PM	0.0727 J	0.100 U	0.0520 J	0.0504 J	0.10
Chromium	0.20	P	1.39	0.267 J	0.453 J	0.559	0.50
Copper	0.20	P	9.07	1.40 U	2.30 U	3.66	0.50
Iron	2.0	P	160 J	45.7 J	73.4 J	45.5 J	5.0
Lead	0.05	PM	1.24	0.517 J	0.284 U	0.259 U	0.50
Magnesium	2.0	P	362	253	230	235	5.0
Manganese	0.35	P	59.9	5.70	15.0	13.9	1.0
Mercury	0.010	CV	0.239 J	0.0138 J	0.0961 J	0.0862 J	0.20
Molybdenum	0.50	P	2.00 U	2.00 U	2.00 U	2.00 U	2.0
Nickel	0.20	P	0.486 J	0.500 UJ	0.500 UJ	1.71 J	0.50
Selenium	0.010	HY	0.244 J	0.182 J	0.237 J	0.242 J	0.50
Strontium	0.20	P	30.7 J	7.79 J	8.02 J	7.62 J	0.50
Vanadium	0.20	P	0.500 U	0.500 U	0.500 U	0.500 U	0.50
Zinc	0.20	P	23.5	20.1	14.1	17.1	1.0
Methyl Mercury	0.0020	AA	0.222	0.00654	0.108	0.0928	0.00046
		% SOLIDS:	23.7	20.8	19.1	18.9	
		% LIPIDS:	1.82	3.43	2.61	2.57	
		DATE SAMPLED:	08/05/99	08/05/99	08/05/99	08/05/99	

ANALYTICAL METHODS:

P - ICP
PM - ICP/MS
HY - Hydride AA
CV - Cold Vapor

AA - CH3-Hg AA

QUALIFIERS:

U - Value is non-detected and sample detection limit is reported.
J - Quantitation is approximate due to limitations identified in the quality control review (Data Review).
UJ - Value is non-detected and sample detection limit is estimated.
R - Value is rejected.

Positive results reported by the laboratory which are < QL and > or = MDL are flagged (J) on the Data Summary Table as estimated values. All other necessary qualifications are defined in Table I.

Final Report

Bioavailability and Potential Effects of Mercury and Selected Other Trace Metals on Biota in Plow Shop and Grove Ponds, Fort Devens, Massachusetts

Submitted by

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5768 South Annex A
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Submitted to

U. S. Environmental Protection Agency
Region 1
1 Congress St., Suite 1100 (HBT)
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Table 2. Mean and range of water concentrations of selected metals.

	As, µg/L		Cr III, µg/L		Cr VI, µg/L		Total Cr, µg/L		Total Hg, ng/L		Methyl Hg, ng/L		MeHg:THg	Pb, µg/L	
Location	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range		Mean	Range
GV1	1.18	-	0.47	0.20-0.74	0.19	0.04-0.33	0.65	0.23-1.43	1.95	1.79-2.11	0.22	0.06-0.37	0.113	<1.0	-
GV2	1.30	-	0.21	0.18-0.23	0.11	0.08-0.14	0.27	0.19-0.40	1.66	1.55-1.77	0.24	0.11-0.36	0.145	<1.0	-
GV3	1.01	-	0.28	0.20-0.36	0.13	0.07-0.19	0.26	0.20-0.33	1.65	1.48-1.81	0.09	0.05-0.12	0.055	<1.0	-
GV4	1.06	-	0.23	0.16-0.30	0.05	0.04-0.06	0.22	0.21-0.23	2.06	1.76-2.35	0.23	0.09-0.36	0.112	<1.0	-
GV5	1.65	1.03-2.27	0.30	0.29-0.31	0.13	0.10-0.15	0.49	0.44-0.58	2.44	2.35-2.56	0.40	0.13-0.55	0.164	<1.0	-
GV6	0.86	-	0.15	0.12-0.18	0.08	0.06-0.09	0.22	0.17-0.26	1.68	1.49-1.86	0.20	-	0.119	<1.0	-
GV7	1.70	-	0.46	-	0.07	0.05-0.09	1.17	1.01-1.43	4.08	3.33-4.83	1.39	0.31-2.46	0.341	<1.0	-
GV8	5.75	2.15-9.35	5.24	-	1.72	-	19.34	6.07-46.50	31.02	5.36-67.33	0.61	0.31-0.81	0.020	<1.0	-
GV9	0.99	-	0.45	0.27-0.62	0.15	0.08-0.22	0.49	0.26-0.91	1.75	1.69-1.81	0.16	0.07-0.25	0.091	<1.0	-
GV10	2.60	0.94-4.26	0.19	0.16-0.22	0.07	0.05-0.09	0.23	0.17-0.31	1.58	0.82-2.72	0.48	0.03-1.03	0.304	<1.0	-
GV11	4.72	2.04-7.40	3.54	-	0.72	-	9.36	4.59-13.30	17.85	17.10-18.60	0.77	0.40-1.13	0.043	1.05	-
Mean	2.50	0.86-9.35	0.73	0.12-5.24	0.22	0.04-1.72	3.46	0.17-46.50	5.47	0.82-67.33	0.45	0.03-2.46	0.082	-	-
PS1	2.39	2.14-2.75	0.28	-	0.12	-	0.64	0.40-0.88	2.34	1.07-4.81	0.33	0.06-0.51	0.141	<1.0	-
PS2	13.00	-	0.24	-	0.09	-	0.31	0.28-0.33	2.43	-	0.14	-	0.058	<1.0	-
PS3	1.57	-	0.28	-	0.07	-	0.36	0.32-0.40	3.53	-	0.10	-	0.028	<1.0	-
PS4	1.48	-	0.29	-	0.07	-	0.30	0.24-0.36	2.51	-	0.21	-	0.084	<1.0	-
PS5	1.30	-	0.26	-	0.05	-	0.31	0.25-0.36	2.04	1.57-2.40	0.09	-	0.044	<1.0	-
PS6	1.22	-	0.28	-	0.10	-	0.41	0.37-0.45	2.44	-	0.06	-	0.025	<1.0	-
PS7	1.04	-	0.23	-	0.07	-	0.45	0.37-0.52	2.39	-	0.10	-	0.042	<1.0	-
PS8	1.16	-	0.24	-	0.10	-	0.39	0.35-0.42	2.74	-	0.21	-	0.077	<1.0	-
PS9	1.20	-	0.19	-	0.04	-	0.39	0.36-0.41	2.32	-	0.22	-	0.095	<1.0	-
PS10	1.58	-	0.22	-	0.06	-	0.37	0.35-0.38	1.98	1.34-2.67	0.18	-	0.091	<1.0	-
Mean	2.56	1.04-13.00	0.25	0.19-0.29	0.08	0.04-0.12	0.39	0.24-0.88	2.29	1.07-4.81	0.19	0.06-0.51	0.083	-	-

Table 3. Stream discharge, mercury concentration, and mercury input and output.

	Grove Pond Inlet			Plow Shop Pond Outlet		
Date	Flow, L/s	Hg Conc., ng/L	Hg Amount, mg/d	Flow, L/s	Hg Conc., ng/L	Hg Amount, mg/d
7/2/98	1217	1.91	200.8	1610	1.67	232.3
8/26/98	126	0.85	9.3	57	1.25	6.2
5/19/99	494	0.98	41.8	675	2.93	170.9
9/24/99	76	2.55	16.7	11	3.23	3.1
3/22/00	1104	1.51	144.0	1085	4.81	451.0
6/22/00	1582	2.72	372.0	2161	1.91	357.0
Mean	766.5	1.75	130.7	933.2	2.63	203.4

Table 5. Concentration of trace metals in surficial sediment at the sample sites.

Location	% Moisture	% Volatile Organics	Total Hg ng/g dry	Methyl Hg ng/g dry	MeHg:THg	As µg/g dry	Cd µg/g dry	Cr µg/g dry	Pb µg/g dry
GV1	83.59	36.73	343.10	2.06	0.00600	100.63	57.972	57.44	369.07
GV2	79.64	18.16	229.20	2.44	0.01065	47.46	20.972	87.16	92.45
GV3	80.54	41.16	2143.00	9.20	0.00429	39.56	11.393	303.68	57.07
GV4	84.17	35.66	15222.00	15.74	0.00103	76.18	9.949	1408.25	107.51
GV5	81.95	38.58	73538.00	70.44	0.00096	135.13	4.712	8175.49	239.17
GV6	82.53	43.58	25744.00	41.98	0.00163	81.73	10.888	1608.58	108.10
GV7	85.48	43.32	28362.00	37.90	0.00134	122.20	2.022	26258.39	704.70
GV8	80.43	40.09	11816.00	9.99	0.00085	73.49	3.157	28831.01	726.67
GV9	84.85	46.53	26791.00	24.67	0.00092	68.62	6.438	2152.71	85.18
GV10	24.76	1.10	24.52	0.28	0.01142	5.49	0.489	31.35	8.58
PS1	84.46	49.27	47420.00	65.38	0.00138	256.67	8.920	3541.52	1214.31
PS2	84.67	31.17	4060.00	5.70	0.00140	1767.03	4.213	650.27	67.57
PS3	85.90	40.05	45360.00	81.89	0.00181	210.62	13.852	3534.16	218.25
PS4	75.23	30.55	14957.00	52.99	0.00354	90.41	6.145	1203.78	278.28
PS5	53.49	15.69	2323.00	9.28	0.00399	114.27	0.792	454.17	31.50
PS6	70.25	34.14	25326.00	27.48	0.00109	70.36	3.945	1347.15	76.49
PS7	83.52	44.02	25631.00	34.76	0.00136	164.79	3.892	1529.40	141.75
PS8	85.51	53.70	49076.00	25.38	0.00052	245.79	6.450	2641.65	157.91
PS9	87.71	29.95	58548.00	62.55	0.00107	220.40	12.708	4080.97	220.95
PS10	70.42	29.73	20148.00	1.13	0.00006	2891.98	2.540	946.98	58.41
NB1	16.73	0.50	34.40	0.15	0.00436	9.37	0.002	10.08	5.92
NB2	20.27	0.99	131.90	0.83	0.00629	7.05	0.053	16.42	5.30
NB3	19.38	0.68	42.09	0.29	0.00689	7.58	0.032	21.98	4.92
NB4	23.09	1.70	270.00	2.10	0.00778	12.00	0.082	19.11	7.36

Table 11. Mean concentrations of trace metals in benthic invertebrates from the ponds. All values are µg/g wet weight. Means for one metal and one organism with the same superscript letter are not significantly different (ANOVA, $p<0.05$). Means with no letters are not different.

Lake	Organism	Location	As		Cd		Cr		Hg		Methyl Hg		MeHg:THg	Pb	
			Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range		Mean	Range
Grove	Cambaridae	Army Wells	0.76^{a}	0.63-0.88	0.12	0.05-0.14	2.13	0.97-3.54	0.043	0.038-0.049	0.033	0.013-0.046	0.767	0.35	0-0.76
		Ayer Wells	0.69^{a}	-	0.15	-	1.96	-	0.029	-	0.021	-	0.724	0.44	-
		Inlet	0.08^{b}	-	0.03	-	0.33	-	0.031	-	0.038	-	1.226	0.05	-
		Tannery	-	-	-	-	-	-	-	-	-	-		-	-
	Corduliidae	Army Wells	0.83	0.61-1.17	0.14	0.05-0.23	1.30	0.48-2.37	0.032	0.016-0.041	0.029	0.017-0.040	0.906	0.21	0-0.48
		Ayer Wells	0.53	0.52-0.54	0.14	0.10-0.17	1.22	0.81-1.63	0.044	0.037-0.051	0.021	0.019-0.023	0.477	0.19	0.16-0.23
		Inlet	0.86	0.72-1.01	0.13	0.09-0.18	0.92	0.51-1.34	0.029	0.026-0.032	0.019	0.018-0.020	0.655	0.18	0.11-0.26
		Tannery	0.60	0.48-0.71	0.06	0.05-0.06	2.05	1.94-2.15	0.030	0.028-0.031	0.017	0.010-0.024	0.567	0.07	0-0.15
Plow Shop	Cambaridae	North	0.78^{a}	0.71-0.84	0.11	0.10-0.12	2.16	1.62-2.70	0.035	0.031-0.038	0.026^{a}	0.025-0.028	0.743	0.16	0-0.33
		Outlet	0.92^{a}	-	0.13	-	2.42	-	0.056	-	0.025^{a}	-	0.446	0.17	-
		Red Cove	1.11^{b}	1.01-1.19	0.38	0.15-0.62	2.23	1.21-3.06	0.046	0.034-0.059	0.039^{b}	0.035-0.042	0.848	0.27	0.16-0.47
		Roundhouse	-	-	-	-	-	-	-	-	-	-		-	-
	Corduliidae	North	1.17^{ab}	1.16-1.17	0.11^{a}	0.09-0.14	2.54	1.89-3.19	0.037^{a}	0.029-0.046	0.029^{a}	0.021-0.037	0.784	0.25^{a}	0.24-0.26
		Outlet	2.14^{c}	1.83-2.45	0.2^{b}	0.19-0.21	1.59	1.11-2.07	0.066^{b}	0.063-0.069	0.054^{b}	0.052-0.056	0.818	0.27^{a}	0.25-0.28
		Red Cove	1.71^{bc}	1.69-1.73	0.14^{ab}	0.13-0.15	1.23	0.77-1.68	0.041^{a}	0.040-0.042	0.029^{a}	0.027-0.032	0.707	0.15^{b}	0.14-0.16
		Roundhouse	0.62^{a}	0.52-0.73	0.11^{a}	0.09-0.13	0.99	0.65-1.32	0.023^{a}	0.015-0.031	0.023^{a}	0.015-0.030	1.000	0.27^{a}	0.26-0.28

Table 13. Concentrations of trace metals in food boli, eggs, carcasses, and feathers of Tree Swallows at Devens, MA, 1998 and 1999.

Type of sample	Trace metal, units	Mean, [SE] *n*, Range			
		1998		1999	
		Grove Pond	Plow Shop Pond	Grove Pond	Plow Shop Pond
Food boli	Hg ng/g			198.2 [14] 10, 140-272	195 [8.3] 3, 187-211
	As ug/g			4.2 [2.6] 2, 1.55-6.81 80%<LOD 8, (0.59-0.88)[a]	100%<LOD 3 (0.63-0.82)
	Cd ug/g	No samples analyzed	No samples analyzed	0.78 [0.11] 10, 0.32-1.39	1.43 [0.78] 3, 0.56-2.99
	Cr ug/g			197.0 [113] 10, 7.7-1113	117 [38.7] 3, 56-189
	Pb ug/g			2.46 [0.81] 10, 0.69-5.38	1.25 [0.23] 3, 0.79-1.57
Eggs	Hg	836 [102] 6, 353-1020	786 [93] 4, 636-1059	462 [57] 14, 231-1075	539 [88.5] 9, 299-945
	As	0.68 [0.124] 3, 0.45-0.95 50%<LOD 3, (<0.4)	0.58 [0.0] 1 75%<LOD 3, (<0.4)	100%<LOD 14, (0.25-0.33)	100%<LOD 9, (0.25-.29)
	Cd	0.53 [0.0] 1 83%<LOD 5, (<0.4)	100%<LOD 4, (<0.4)	100%<LOD 14, (0.007)	100%<LOD 9, (0.007)
	Cr	0.46 [0.07] 3, 0.38-0.61 50%<LOD 3, (<0.4)	0.44 [0.02] 3, 0.41-0.47 25%<LOD 1, (<0.4)	100%<LOD 14, (0.26-0.33)	100%<LOD 9, (0.25-0.29)
	Pb	0.47 [0.0] 1 83%<LOD 5, (<0.04)	100%<LOD 4, (<0.4)	0.325 [0.049] 4, 0.20-0.40 71%<LOD 10, (0.26-0.31)	0.419 [0.05] 2, 0.37-0.47 78%<LOD 7, (0.25-0.29)
Carcass	Hg	49.6 [6.8] 8, 35.5-93.9	48.8 [3.93] 4, 42.7-59.9	65.9 [7.7] 13, 37-121	61.6 [5.8] 8, 37.5-92.8
	As	0.39 [0.06] 8, 0.14-0.64	0.53 [0.35] 2, 0.17-0.88 50%<LOD 2, (<0.4)	100%<LOD 13 (0.17-0.2)	100%<LOD 8, (0.18-0.35)
	Cd	0.11 [0.02] 8, 0.04-0.23	0.078 [0.01] 4, 0.05-0.1	0.209 [0.15] 2, 0.054-0.36 85%<LOD 11, (0.005)	0.11 [0.006] 2, 0.104-0.116 75%<LOD 6, (0.004-0.005)
	Cr	0.96 [0.39] 8, 0.23-3.58	0.178 [0.02] 4, 0.13-0.2	0.65 [0.16] 8, 0.23-1.44 38%<LOD 5, (0.17-0.19)	100%<LOD 8, (0.18-0.35)
	Pb	0.10 [0.0] 1 87%<LOD 7, (<0.04)	0.28 [0.0] 1 75%<LOD 3, (<0.4)	100%<LOD 13, (0.17-0.20)	1.95[0.0] 1 88%<LOD 7, (0.18-0.35)
Feathers	Hg	2130 [131] 8, 1623-2609	2554 [244] 4, 2084-3103	2206 [187] 13, 1343-3900	2415 [226] 8, 1317-3158
	As	2.3 [0.37] 8, 1.47-4.54	7.4 [2.2] 4, 3.29-13.82	0.37 [0.054] 4, 0.21-0.46 69%<LOD 9, (0.37-0.40)	100%<LOD 8, (0.36-0.40)
	Cd	0.34 [0.15] 6, 0.10-1.04 25%<LOD 2, (>0.1)	0.21 [0.0] 1 75%<LOD3, (<0.4)	0.32 [0.19] 2, 0.13-0.51 85%<LOD 11, (0.009-0.01)	0.11 [0.006] 2, 0.104-0.116 75%<LOD 6, (0.009-0.01)
	Cr	0.46 [0.03] 6, 0.38-0.60 25%<LOD 2, (<0.4)	0.42 [0.03] 3 0.37-0.21 25%<LOD 1, (<0.4)	100%<LOD 13, (0.37-0.41)	100%<LOD 8, (0.36-0.40)
	Pb	0.61 [0.12] 4, 0.41-0.94 50%<LOD 4, (<0.4)	0.51 [0.0] 1 75%<LOD 3, (<0.4)	0.61 [0.0] 1 92%<LOD 12, (0.37-0.41)	3.926 [0.0] 1 87%<LOD 7, (0.36-0.40)

[a] Mean calculated but not statistically analyzed when >50% of samples equaled limit of detection (LOD)in parentheses.

Table 14. Concentrations of trace metals in food boil, eggs, carcasses, and feathers of Tree Swallows at Acadia National Park, 1999.

Type of sample	Trace metal, units	Mean [SE], *n*, Range	
		Aunt Betty Pond	Hodgdon Pond
Food boli	Hg ng/g	291.2 [53.6] 8, 124-527	161.3 [13] 5, 139-211
	As ug/g	100%>LOD 8, (0.64-0.92)[a]	100%<LOD 5, (0.75-1.41)
	Cd ug/g	1.03 [0.14] 8, 0.507-1.52	1.21 [0.21] 5, 0.78-1.98
	Cr ug/g	20.7 [7.65] 8, 2.87-70.2	26.8 [6.8] 5, 15-53
	Pb ug/g	1.09 [0.13] 8, 0.8-1.42	1.26 [0.14] 5, 0.92-1.60
Eggs	Hg	530.7 [67.0] 14, 278-1313	360 [78] 6, 97-606
	As	100%<LOD 14, (0.36-0.88)	100%<LOD 6, (0.35-0.39)
	Cd	100%<LOD 14, (0.009-0.02)	100%<LOD 6, (0.009-0.011)
	Cr	100%<LOD 14, (0.36-0.88)	100%<LOD 6, (0.35-039)
	Pb	1.38 [0.0] 1, 93% <LOD 14, (0.36-0.88)	100%<LOD 6, (0.35-0.39)
Carcass	Hg	72.9 [4.6] 13, 46-105	55.1 [4.6] 7, 40-79
	As	0.34 [0.0] 1, 93%<LOD 12, (0.18-0.20)	100%<LOD 7, (0.18-0.20)
	Cd	0.059[0.006] 5, 0.048-0.082 62%<LOD 8, (0.005)	0.115 [0.03] 6, 0.069-0.27 14%<LOD 1, (0.005)
	Cr	0.363 [0.13] 6, 0.105-0.985 54%<LOD 7, (0.18-0.20)	1.396 [0.49] 6, 0.45-3.62 14%<LOD 1, (0.005)
	Pb	100%<LOD 13, (0.18-0.20)	100%<LOD 7, (0.18-0.20)
Feathers	Hg	3286 [187] 13, 2327-4575	1933 [76] 7, 1539-2107
	As	100%<LOD 13, (0.37-0.40)	100%<LOD 7, (0.37-0.40)
	Cd	0.389 [0.184] 6, 0.103-1.291 54%<LOD 7, (0.009-0.01)	0.31 [0.13] 5, 0.09- 0.76 28%<LOD 2, (0.009-0.01)
	Cr	100%<LOD 13, (0.38-0.40)	100%<LOD 7, (0.38-0.40)
	Pb	100%<LOD 13, (0.38-0.40)	100%<LOD 7, (0.38-0.40)

[a] Mean calculated even when >50% of the samples without detectable amounts (<LOD, limit of detection), which are in parentheses. When >50% of a pond's samples exceeded the LOD samples were statistical analyzed after appropriate log transformations.

Figure 1. Location of water sample collection stations.

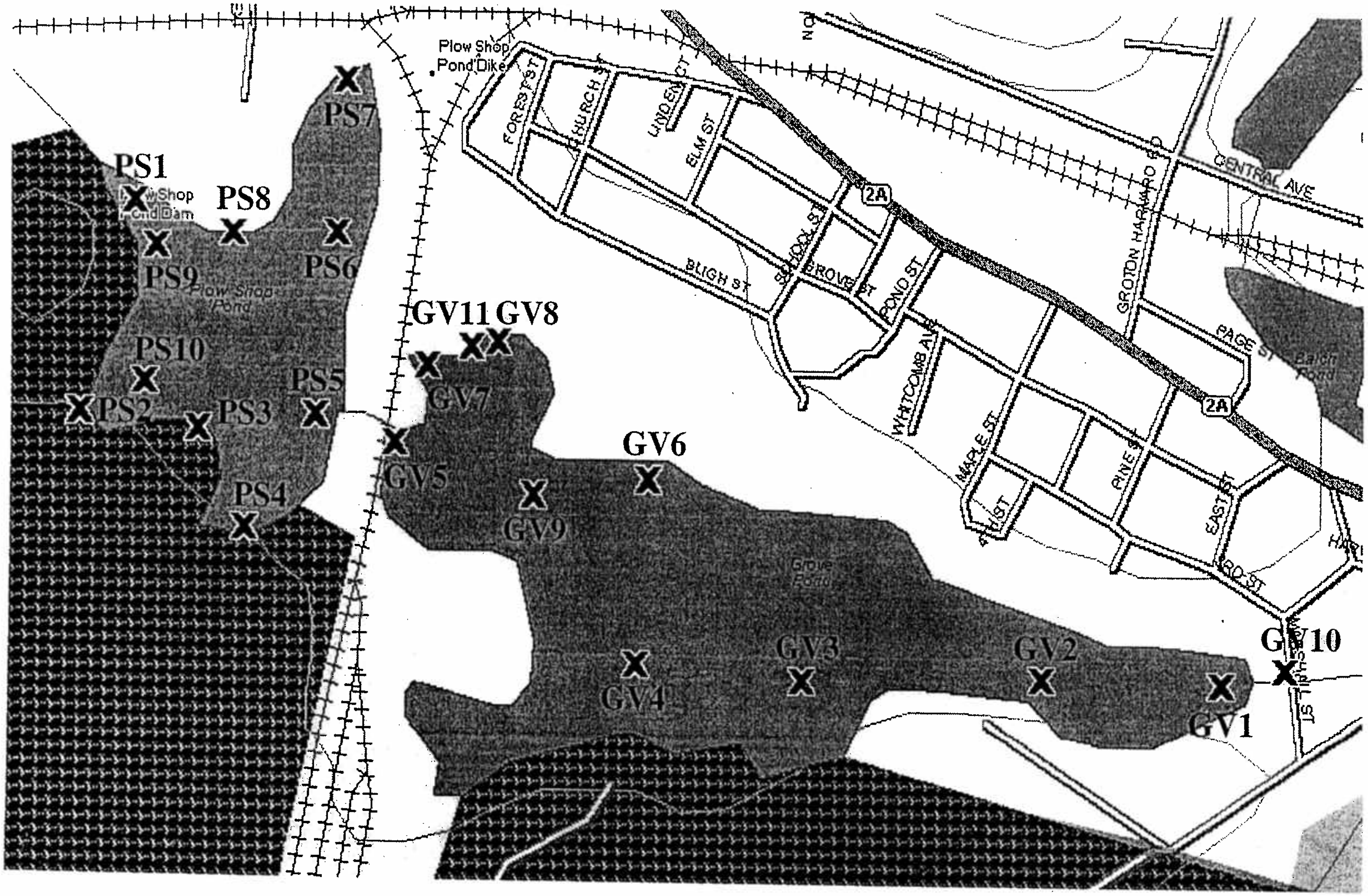


Figure 4. Location of surficial sediment sample collection stations.

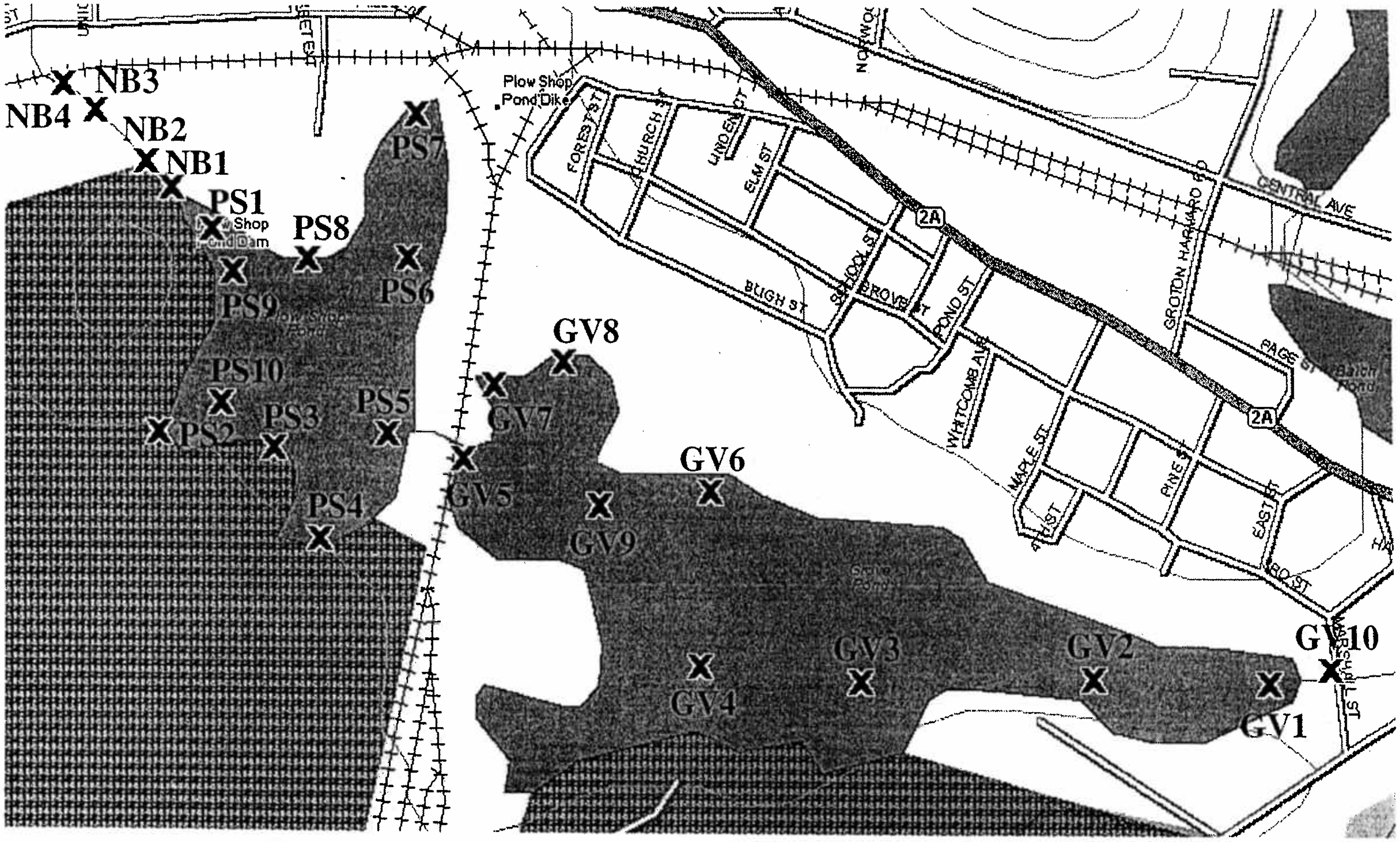


Figure 8. Emergent insect trap and benthic invertebrate collection locations in the two ponds.

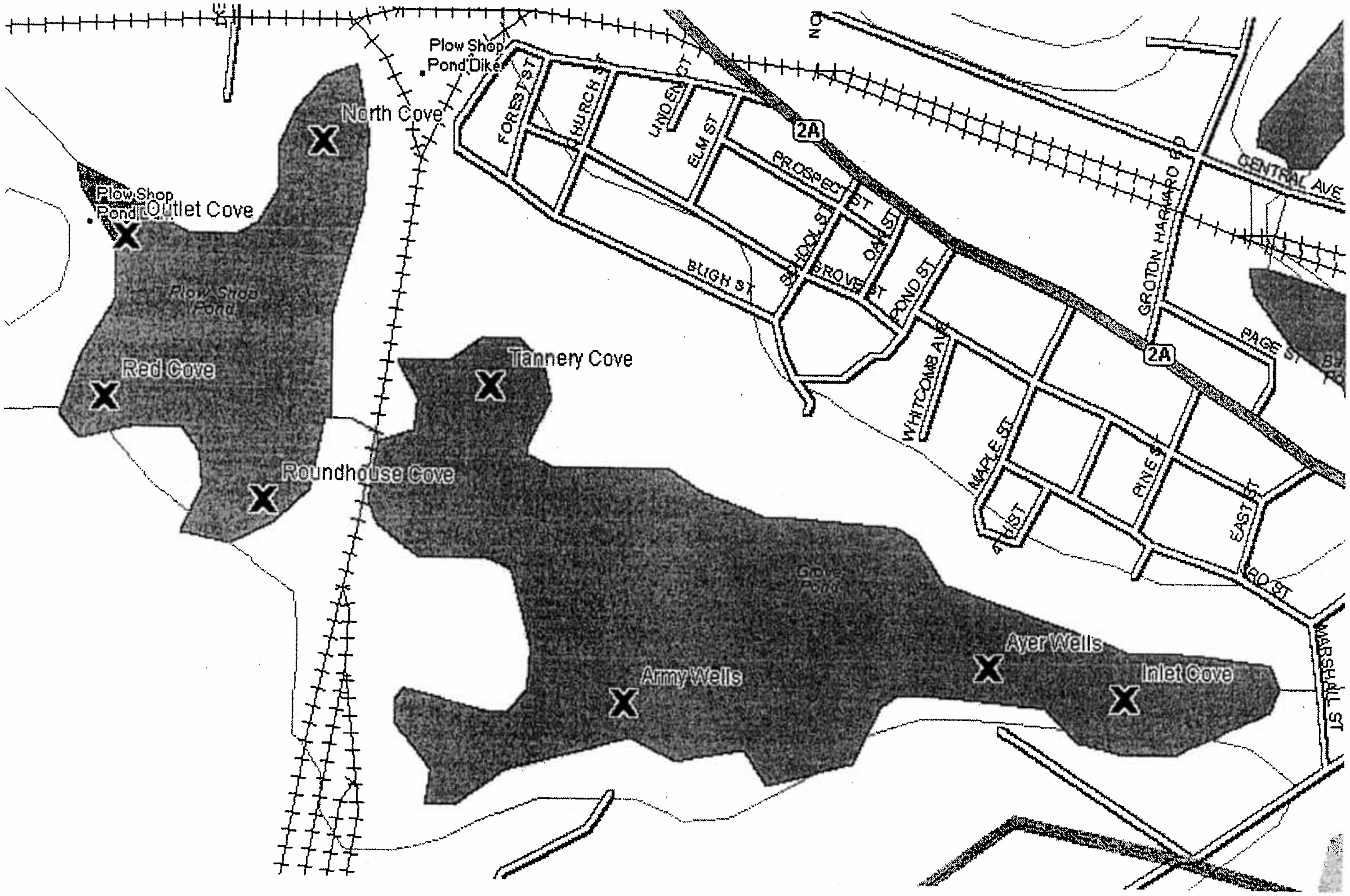
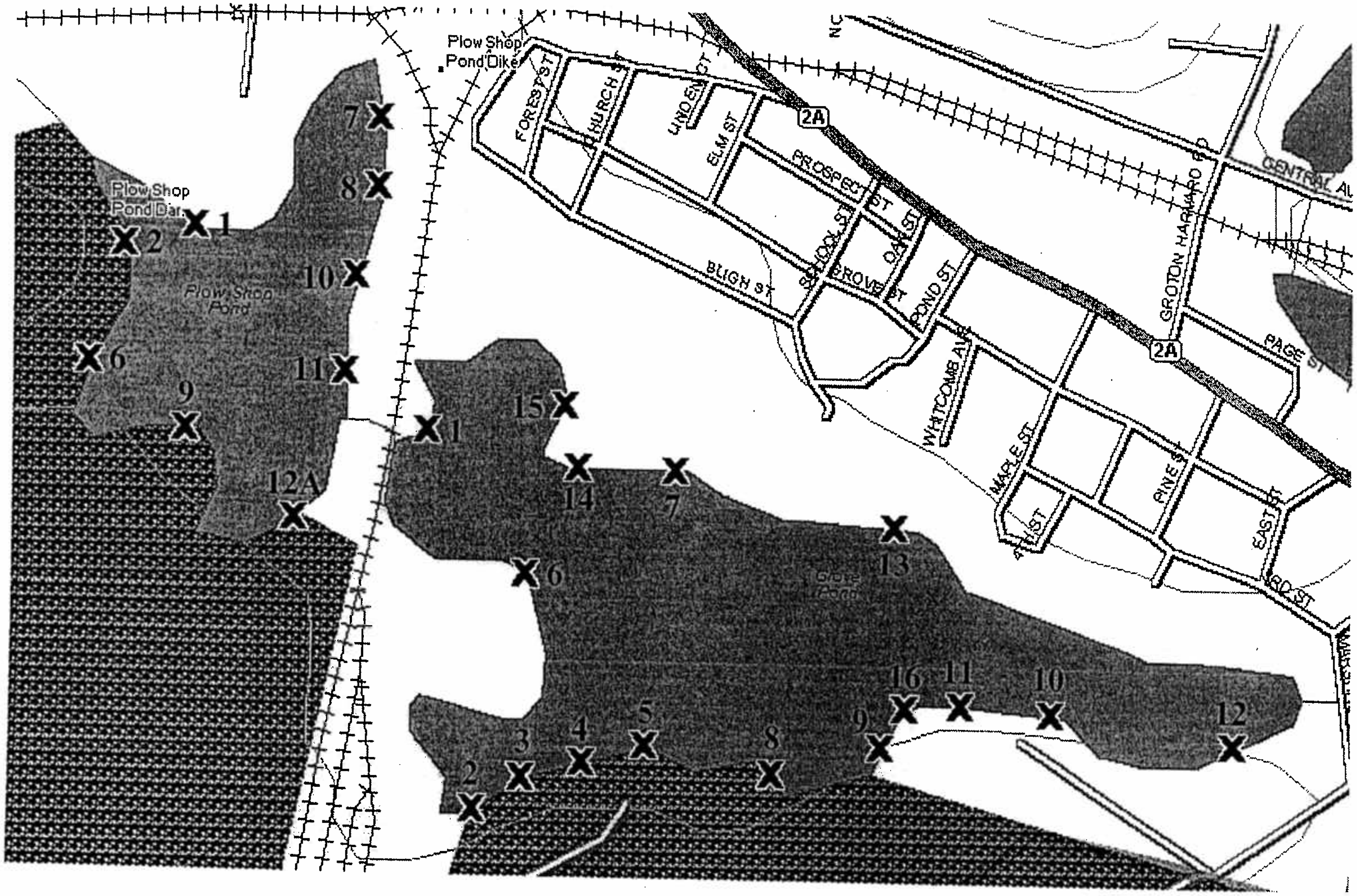


Figure 9. Location of tree swallow nest boxes at the two ponds.



Appendix 2

Toxicity Profiles for Primary Contaminants of Potential Concern to Ecological Receptors

Arsenic

Arsenic in surface water can undergo a series of transformations such as oxidation-reduction, ligand exchange, biotransformation, and adsorption. Arsenic is extremely mobile in aquatic systems. Bioconcentration in aquatic systems occurs primarily in algae and lower invertebrates, but biomagnification does not appear to be significant. Plants can accumulate arsenic through root uptake (EPA 1979). Arsenic is readily biomethylated and demethylated to forms of different toxicities (Burton 1992).

Chromium

Chromium is an essential trace element in humans and some species of laboratory animals. At high environmental concentrations, Cr is a mutagen, teratogen, and carcinogen. No biomagnification of Cr has been observed in food chains, and concentrations are usually highest at the lowest trophic levels. Toxic and sublethal properties of Cr are modified by a variety of biological and abiotic factors. Sensitivity to Cr varies widely, even among closely related species. Chromium is most frequently found in the environment in the trivalent (+3) and hexavalent (+6) oxidation states, both of which are toxic, although hexavalent chromium (Cr+6) is the more biologically active Cr chemical species and is the toxic as its oxidizing potential is high and it easily penetrates biological membranes. In general, the toxicity of trivalent chromium to mammals is low (Eisler 1986).

Lead

Lead is neither essential nor beneficial to wildlife. Organolead compounds are typically more toxic than inorganic compounds, food chain biomagnification is generally negligible, and younger organisms tend to be more sensitive to lead exposure than older individuals. Lead produces adverse biochemical, histopathological, neuropsychological, fetotoxic, teratogenic, and reproductive effects. (Eisler 1988).

Mercury

Mercury and its compounds have no known beneficial biological function. Elemental mercury or mercuric salts with relatively low toxicity can be transformed into forms with very high toxicity through biological and other processes. Methylmercury is one of the very high toxicity forms of mercury. The central nervous system is a major target of methylmercury induced toxicity. Mercury has a propensity to bioaccumulate and biomagnify up trophic levels. Accumulation in aquatic biota is relatively rapid and depuration is slow. Mercury toxicity can cause adverse effects on growth, development, reproduction, blood and tissue chemistry, metabolism, and behavior (Eisler 1987).