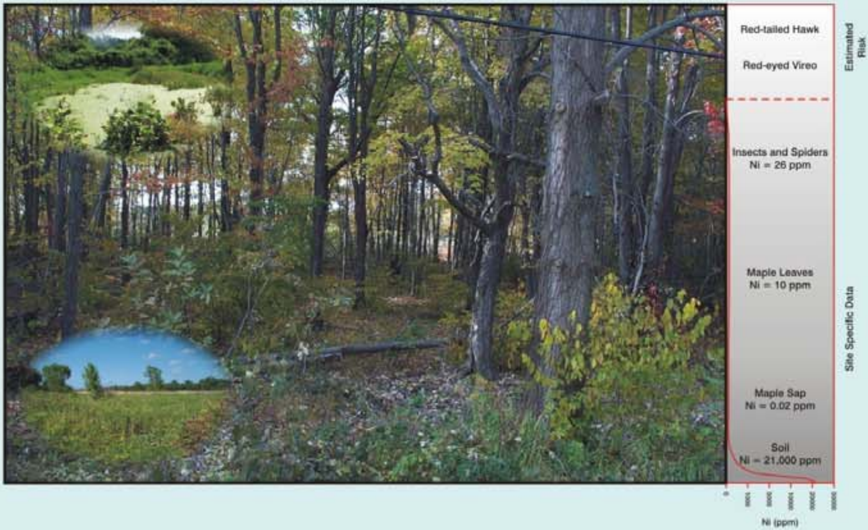
COMMUNITY BASED RISK ASSESSMENT
PORT COLBORNE, ONTARIO

ECOLOGICAL RISK ASSESSMENT
NATURAL ENVIRONMENT



Volumes II-V

September 2004

Jacques Whitford

INCO

PORT COLBORNE CBRA – ECOLOGICAL RISK ASSESSMENT

NATURAL ENVIRONMENT

VOLUME III

SUPPORTING DATA

Project No. ONT33828

Prepared for

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ERA-NATURAL ENVIROMENT
Port Colborne Community Based Risk Assessment

Supporting Data

FIELD DATA

Representative Field Sampling Pictures

Insect Field Sampling

Woodlot Insect Sampling

Earthworm Sampling

Frog Sampling

Maple Leaf Sampling

Vole Sampling

Field Data for Surface Water

Site Identification Number	Data Sampled	Time Sampled	Water Temperature (Celcius)	Water Depth (centimeters)	Water pH	Substrate
S1	1 May, 2001	11:36	19.4	7	7.11	2cm fine organic over fine sand
S2	1 May, 2001	12:00	19.9	11	6.72	Organic
S3A	1 May, 2001	12:25	18.9	23	7.1	715 cm organic
S3B	1 May, 2001	12:25	18.9	23	7.1	715 cm organic
S4	1 May, 2001	1:15	19.4	20	7.07	2 cm Organic over Clay
S5	1 May, 2001	1:04	24.6	16	7.07	1cm Organic over Clay
S6	1 May, 2001	3:25	26.9	13	7.86	>15cm mixed Organic Layer
S7A	1 May, 2001	3:50	20.6	25	7.16	20cm Organic over Clay
S7B	1 May, 2001	3:50	20.6	25	7.16	20cm Organic over Clay
S8	1 May, 2001	3:00	20	23	7.11	2cm mesic Organic over Clay
S9	1 May, 2001	1:40	24.9	13	7.04	Leaves over Clay
S10	1 May, 2001	1:54	22.9	21	6.66	>15cm Organic over Clay
S11	1 May, 2001	2:15	19.9	33	7.06	Leaves over Clay
S12	1 May, 2001	2:40	24.9	10	6.85	Leaves over Clay
S13	15 May, 2001	10:50	11.8	25	6.45	1cm Silt over Clay
S14	15-May-01	11:10	12.4	20	6.25	2cm Gravel and Sand over Bedrock
S15	14 May, 2001	11:45	13.5	12	6.96	0.5cm Gravel over Clay
S16	14 May, 2001	1:05	12.8	56	7.03	20cm Silt over Clay
S17A	14 May, 2001	2:00	22.1	12	7.32	Leaves over Red Clay
S18	14 May, 2001	2:20	19.8	17	7.36	Wood and Garbage over Clay
S19	14 May, 2001	2:40	18	24	7.57	Red Clay
S20A	14 May, 2001	4:30	20	65	7.62	Silty Clay
S21	14 May, 2001	3:05	13.8	5	7.31	Clay
S22	14 May, 2001	4:00	19.8	43	7.31	Clayey Silt
S23	14 May, 2001	5:00	17.2	23	7.15	Organic
S24	14 May, 2001	5:15	18.4	28	7.14	20cm Leaves and Organic over Clay
S25A	14 May, 2001	5:20	19.5	30	7.32	2cm fabric Organic over Clay
S25B	14 May, 2001	5:20	19.5	30	7.32	2cm fabric Organic over Clay
S25B Replicate						
S26	14 May, 2001	6:00	20.1	14	7.45	Clay
S27	1 Aug, 2001	11:30	25	10	9.75	Fine Sediment over Limestone Bedrock
S28	1 Aug, 2001	1:30	20.2	17	7.04	Organic over Clay
S29	1 Aug, 2001	2:00	25	25	7.58	Thin organic over Clay
S30	1 Aug, 2001	2:30	24.7	35	7.98	Limestone Rubble, fine silt
S31	12 Oct, 2001	8:40	15.1	35	7.31	10mm organic over SiCl
S31B	12 Oct, 2001	8:40	15.1	35	7.31	10mm organic over SiCl
S32A	12 Oct, 2001	9:35	15.3	15	7.11	30mm silt some organic over clay
S33	12 Oct, 2001	9:50	14.6	35	7.38	15mm Si over SiCl
S34	12 Oct, 2001	10:20	15.2	20	7.13	Deep Mesic Organic
S35	12 Oct, 2001	10:36	15.8	15	7.22	10mm fine Si over Clay
S36	12 Oct, 2001	11:04	15.3	15	7.16	10mm Si some Organic over Clay

Site Identification Number	Data Sampled	Time Sampled	Water Temperature (Celcius)	Water Depth (centimeters)	Water pH	Substrate
S37	12 Oct, 2001	11:14	16	40	7.64	40mm Si some Organic over Clay

Note: B indicates a Duplicate water sample submitted by JWEL

Replicate indicates a second analysis run by PSC on the same sample

Amphibian Survey Field Data

Species	Station Number																											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Chorus Frog	0^0	1^2	1^2	3^2	1^2	1^2	1^2	1^2	3^2	3^3	1^2	1^1	3^2	0^0	1^2	1^3	3^3	1^2	3^3	2^3	1^1	2^1	1^1	1^2	1^1	1^2	0^0	0^0	2^2
Spring Peeper	1^2	1^4	1^2	3^4	3^3	1^1	1^2	3^4	3^4	3^4	3^4	1^3	3^4	1^1	2^4	1^3	3^4	1^3	3^4	1^4	1^3	2^3	0^0	3^4	3^4	1^2	1^1	0^0	3^4
Wood Frog	0^0	0^0	0^0	1^1	0^0	0^0	0^0	1^1	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	1^1	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	1^1
American Toad	1^1	1^2	1^3	3^4	2^2	1^4	1^1	1^1	1^3	3^3	3^2	1^3	3^3	1^1	3^3	1^3	0^0	1^2	1^3	2^2	1^2	1^2	1^2	1^1	1^3	0^0	0^0	0^0	1^3
Fowler's Toad	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^1	0^0	0^0	0^0	1^1	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0
Northern Leopard	0^0	0^0	0^0	1^2	0^0	0^0	0^0	1^2	1^1	1^1	1^1	0^0	1^2	0^0	1^2	0^0	0^0	0^0	1^1	1^3	1^1	0^0	0^0	0^0	0^0	0^0	0	0^0	0^0
Green Frog	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	1^1	0^0	0^0	0^0	0^0	1^1	0^0	0^0	0^0	0^0	0^0	1^1	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0
Bullfrog	0^0	0^0	0^0	1^2	0^0	0^0	0^0	0^0	0^0	1^1	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0
Gray Treefrog	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0	0^0

Explanation of numeric values: The whole number represents the highest chorous code value recorded during the four visits at any given station for that species.

The exponent value represents the number of times a species was recorded during the four visits. Therefore, a value of 2 indicates that a species was recorded only twice out of four visits.

Field Data Summary of Earthworm Sampling (2001 Field Program)

High Sites

High Woodlots

Site Code	Date Collected	APTB	Combined Species Weight	LURB	Combined Species Weight	Total Number Individuals	Total Weights
W-H-1-1	27 September, 2001	6-0-0	0.03	1-0-0	0.01	7	0.04
W-H-1-2	27 September, 2001	1-0-0	0.1	12-0-0	3.47	13	3.57
W-H-1-3	27 September, 2001	1-0-0	0.03	37-1-0	10.57	39	10.6
Site Totals		8	0.16	51	14.05	59	14.21

Site Code	Date Collected	APTB	Combined Species Weight	LURB	Combined Species Weight	Total Number Individuals	Total Weights
W-H-2-1	27 September, 2001	0	0	0	0	0	0
W-H-2-2	27 September, 2001	0	0	1-0-0	0.01	1	0.01
W-H-2-3	27 September, 2001	1-0-0	0.04	0	0	1	0.04
Site Totals		1	0.04	1	0.01	2	0.05

High Fields

Site Code	Date Collected	APTB	Combined Species Weight	LURB	Combined Species Weight	Total Number Individuals	Total Weights
W-H-3-1	28 September, 2001	1-0-0	0.04	10-0-1	2.26	12	2.3
W-H-3-2	28 September, 2001	0	0	27-0-1	6.78	28	6.78
W-H-3-3	28 September, 2001	0	0	9-0-0	3.06	9	3.06
Site Totals		1	0.04	48	12.1	49	12.14

Site Code	Date Collected	APTB	Combined Species Weight	LURB	Combined Species Weight	LUTS	Combined Species Weight	Total Number Individuals	Total Weights
W-H-4-1	28 September, 2001	1-0-0	0.05	7-0-0	2.21	0	0	8	2.26
W-H-4-2	28 September, 2001	0	0	48-1-0	13.19	0	0	49	13.19
W-H-4-3	28 September, 2001	0	0	13-0-0	4.45	4-1-0	10.09	18	4.45
Site Totals		1	0.05	69	19.85	5	10.09	75	19.9

Site Code	Date Collected	LUTS	Combined Species Weight	LURB	Combined Species Weight	Total Number Individuals	Total Weights
W-H-5-1	28 September, 2001	4-0-0	2.62	12-0-0	2.84	16	5.46
W-H-5-2	28 September, 2001	3-1-1	13.68	17-0-1	2.92	23	16.6
Site Totals		9	16.3	30	5.76	39	22.06

Moderate Sites

Moderate Woodlots

Site Code	Date Collected	APTB	Combined Species Weight	LURB	Combined Species Weight	ALCH	Combined Species Weight	Total Number Individuals	Total Weights
W-M-1-1	27 September, 2001	4-0-0	0.24	21-0-0	2.23	4-0-0	0.44	29	2.91
W-M-1-2	27 September, 2001	1-0-0	0.01	15-0-0	1.59	0	0	16	1.6
W-M-1-3	27 September, 2001	5-0-0	0.41	5-1-0	1.54	0	0	11	1.95
Site Totals		10	0.66	42	5.36	4	0.44	56	6.46

Site Code	Date Collected	APTB	Combined Species Weight	LURB	Combined Species Weight	Total Number Individuals	Total Weights
W-M-2-1	27 September, 2001	0	0	18-2-0	3.52	20	3.52
W-M-2-2	27 September, 2001	0	0	10-1-0	2.3	11	2.3
W-M-2-3	27 September, 2001	2-0-0	0.03	10-2-0	4.55	14	4.58
Site Totals		2	0.03	43	10.37	45	10.4

Moderate Fields

Site Code	Date Collected	APTB	Combined Species Weight	LURB	Combined Species Weight	Total Number Individuals	Total Weights
W-M-3-1	28 September, 2001	3-0-0	0.05	4-0-0	0.42	7	0.47
W-M-3-2	28 September, 2001	0	0	40-1-0	4.43	41	4.43
W-M-3-3	28 September, 2001	5-0-0	0.26	16-0-0	1.23	21	1.49
Site Totals		8	0.31	61	6.08	69	6.39

Site Code	Date Collected	APTB	Combined Species Weight	LURB	Combined Species Weight	LUTS	Combined Species Weight	Total Number Individuals	Total Weights
W-M-4-1	28 September, 2001	4-0-0	0.5	0	0	19-4-0	25.62	27	26.12
W-M-4-2	28 September, 2001	6-0-0	0.55	19-0-0	4.05	4-1-0	5.77	30	10.37
W-M-4-3	28 September, 2001	7-0-0	0.96	16-0-0	4.32	7-0-3	149.35	33	154.63
Site Totals		17	2.01	35	8.37	38	180.74	90	191.12

Control Sites

Control Woodlots

Site Code	Date Collected	ALCH	Combined Species Weight	APTB	Combined Species Weight	LURB	Combined Species Weight	LUTS	Combined Species Weight	Total Number Individuals	Total Weights
W-C-1-1	27 September, 2001	0	0	8-1-0	1.91	20-0-0	2.35	1-0-0	0.51	30	4.77
W-C-1-2	27 September, 2001	0	0	10-0-0	1.87	22-0-0	3.11	0	0	32	4.98
W-C-1-3	27 September, 2001	1-0-0	0.07	3-0-0	0.03	27-0-0	4.18	1-0-0	2.08	32	6.36
Site Totals		1	0.07	22	3.81	69	9.64	2	2.59	94	16.11

Site Code	Date Collected	APTB	Combined Species Weight	LURB	Combined Species Weight	Total Number Individuals	Total Weights
W-C-2-1	27 September, 2001	0	0	0	0	0	0
W-C-2-2	27 September, 2001	0	0	0-0-2	1.91	2	1.91
W-C-2-3	27 September, 2001	1-0-0	0.01	2-0-0	0.61	3	0.62
Site Totals		1	0.01	4	2.52	5	2.53

Control Fields

Site Code	Date Collected	APTB	Combined Species Weight	LURB	Combined Species Weight	Total Number Individuals	Total Weights
W-C-3-1	28 September, 2001	3-0-0	0.42	2-0-0	0.05	5	0.47
W-C-3-2	28 September, 2001	0-1-0	0.88	8-0-0	0.68	9	1.56
W-C-3-3	28 September, 2001	0	0	1-0-0	0.18	1	0.18
Site Totals		4	1.3	11	0.91	15	2.21

Site Code	Date Collected	ALCH	Combined Species Weight	APTB	Combined Species Weight	LURB	Combined Species Weight	LUTS	Combined Species Weight	Total Number Individuals	Total Weights
W-C-4-1	28 September, 2001	5-0-0	0.45	14-0-0	1.78	7-0-0	0.72	2-3-0	11.48	31	14.43
W-C-4-2	28 September, 2001	1-0-0	0.14	5-0-0	0.21	6-2-0	1.63	1-0-0	2.51	15	4.49
W-C-4-3	28 September, 2001	9-0-0	0.85	11-0-0	0.68	6-1-0	1.41	0	0	27	2.94
Site Totals		15	1.44	30	2.67	22	3.76	6	13.99	73	21.86

Site Code	Date Collected	EIFO	Combined Species Weight	LURB	Combined Species Weight	LUTS	Combined Species Weight	Total Number Individuals	Total Weights
W-C-5-1	28 September, 2001	0	0	7-1-1	1.67	0	0	9	1.67
W-C-5-2	28 September, 2001	0	0	4-1-0	1.25	0-1-0	3.48	6	4.73
W-C-5-3	28 September, 2001	1-0-0	0.08	0	0	2-0-0	0.42	3	0.5
Site Totals			0.08		2.92		3.9	18	6.9

Legend

ALCH - Allolobophora chlorotica
APTB - Aporrectodea tuberculata
EIFO - Eisenia foetida
LUTS - Lumbricus terrestris
LURB - Lumbricus rubellus

2002 Earthworm Sampling Fields Data

Site Name	Quadrate One	Quadrate Two	Average Value	soil	area
OW-H-1	34	49	41.5	organic	Study Area
OW-H-2	27		n/a	organic	Study Area
OW-H-3	23	39	31	organic	Study Area
CW-H-4	14	14	14	clay	Study Area
CW-H-5	43		n/a	clay	Study Area
OW-H-6	27		n/a	organic	Study Area
CW-H-7	7	23	15	clay	Study Area
CW-H-8	38	31	34.5	clay	Study Area
CW-H-9	39		n/a	clay	Study Area
CW-H-10	16	27	21.5	clay	Study Area
CW-H-11	4		n/a	clay	Study Area
CW-H-12	16		n/a	clay	Study Area
CW-H-13	22		n/a	clay	Study Area
OW-C-14	14		n/a	organic	Reference
OW-C-15	18	28	23	organic	Reference
CW-C-16	15	28	21.5	clay	Reference
CW-C-17	5		n/a	clay	Reference
CW-C-18	19		n/a	clay	Reference
CW-C-19	18		n/a	clay	Reference
CW-C-20	12		n/a	clay	Reference
OW-C-21	8	16	12	organic	Reference
OW-C-22	20		n/a	organic	Reference
OW-C-23	26	23	24.5	organic	Reference
OW-H-24	23	19	21	organic	Study Area
CW-H-25	11		n/a	clay	Study Area
OW-H-26	7		n/a	organic	Study Area
OW-H-27	15		n/a	organic	Study Area
OW-H-28	30		n/a	organic	Study Area
OW-H-29	17		n/a	organic	Study Area
OW-H-30	35		n/a	organic	Study Area

*n/a-there must be two values in order to take an average

2002 Earthworm Woodlot Survey

Reuter Road Woodlot

Site Code	Species	# Juveniles	# Adults	#Clitellate Adults	Total Weight (Grams)
RW-H-1	APTB	1			1.06
	LURB	2		2	
RW-H-2	LURB		1	1	0.95
RW-H-3	LURB	1			0.05
RW-H-4	LURB	9		1	1.51
RW-H-5	LURB	19	3	3	12.2
	LUTS	5			
	APTB	1			

Snider Road Woodlot

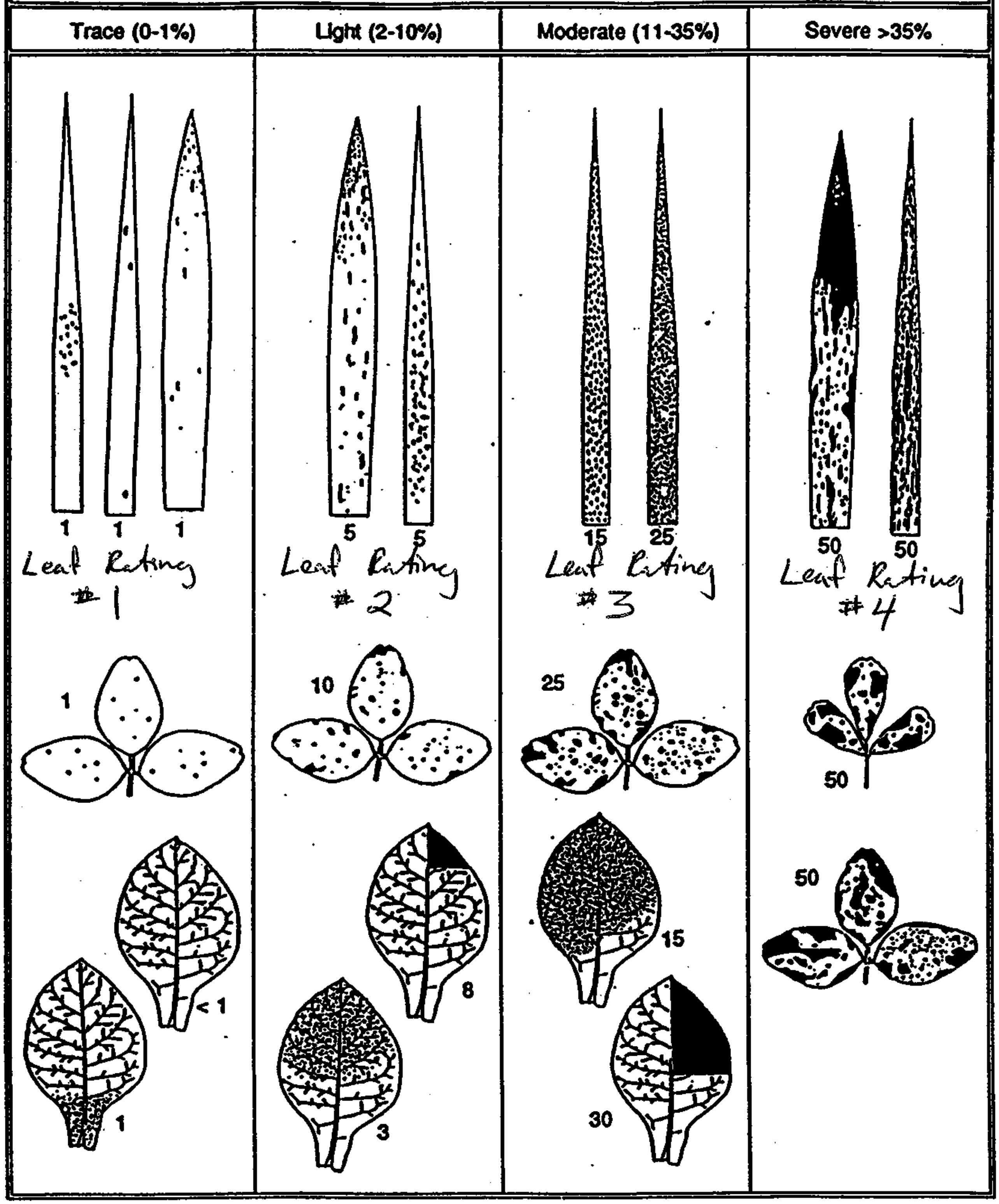
Site Code	Species	# Juveniles	# Adults	#Clitellate Adults	Total Weight (Grams)
SW-H-1	LURB	2			0.52
	APTB	2			
SW-H-2	LURB	34	5	9	14.4
	DERU			2	
	APTB	1			
	LUTS	1			
SW-H-3	LUTS	6		1	9.53
	APTB	8			
	LURB	28			

Species Codes
APTB - Aporrectodea tuberculata
DERU - Dendrodrilus rubidus
LUTS - Lumbricus terrestris
LURB - Lumbricus rubellus

Maple Leaf Rating

Site and Tree Code	Date Sampled	Leaf Rating												Number of Leaves with Galls
L-H-1-1	11-Sep-01	2	2	2	3	2	2	2	2	2	2	2	2	9
L-H-1-2	11-Sep-01	2	3	3	3	2	2	2	2	2	3	2	2	2
L-H-1-3	11-Sep-01	2	2	2	2	2	1	2	2	2	2	2	2	0
L-H-2-1	11-Sep-01	2	2	2	2	2	2	2	2	2	2	2	2	12
L-H-2-2	11-Sep-01	2	2	2	2	2	2	3	3	2	2	2	2	0
L-H-2-3	11-Sep-01	2	2	1	2	1	1	2	2	2	2	2	1	1
L-H-3-1	11-Sep-01	2	2	3	2	2	1	2	2	2	2	2	2	0
L-H-3-2	11-Sep-01	2	2	3	2	3	2	3	2	2	3	2	2	1
L-H-3-3	11-Sep-01	2	3	2	2	2	2	2	2	2	2	2	2	0
L-H-4-1	12-Sep-01	1	2	2	1	2	1	2	1	1	2	2	3	9
L-H-4-2	12-Sep-01	2	2	3	2	2	2	2	3	2	2	2	2	8
L-H-4-3	12-Sep-01	2	2	2	2	2	2	2	3	2	3	2	3	12
L-H-5-1	11-Sep-01	2	2	1	2	2	2	2	2	2	2	2	2	1
L-H-5-2	11-Sep-01	2	2	2	2	2	1	2	2	1	2	3	2	0
L-H-5-3	11-Sep-01	2	2	2	2	2	1	3	2	2	2	2	2	1
L-M-1-1	13-Sep-01	2	1	2	2	2	2	3	2	2	1	2	2	6
L-M-1-2	13-Sep-01	2	2	2	2	2	2	2	2	2	2	1	2	1
L-M-1-3	13-Sep-01	1	2	2	2	2	2	2	2	2	2	2	2	5
L-M-2-1	14-Sep-01	3	2	2	2	3	2	2	2	2	3	2	3	12
L-M-2-2	14-Sep-01	2	2	1	2	2	2	3	3	2	2	2	2	9
L-M-2-3	14-Sep-01	3	3	2	3	4	2	2	2	2	2	2	2	4
L-M-3-1	11-Sep-01	2	2	3	3	2	2	3	2	3	2	3	2	12
L-M-3-2	11-Sep-01	2	2	2	2	2	2	2	2	1	2	1	2	0
L-M-3-3	11-Sep-01	2	2	2	2	2	1	2	1	1	1	2	2	12
L-M-4-1	13-Sep-01	2	3	2	2	2	2	4	2	3	4	3	2	0
L-M-4-2	13-Sep-01	1	1	1	2	2	2	2	1	2	2	2	2	0
L-M-4-3	13-Sep-01	2	3	4	3	3	2	2	2	2	2	3	2	0
L-M-5-1	14-Sep-01	2	2	1	2	2	2	1	1	2	2	2	2	0
L-M-5-2	14-Sep-01	2	3	2	2	3	3	3	2	2	3	2	3	5
L-M-5-3	14-Sep-01	2	2	2	2	2	1	2	2	1	2	2	2	8
L-M-6-1	13-Sep-01	1	2	2	1	2	2	3	2	3	2	2	2	4
L-M-6-2	13-Sep-01	2	2	2	2	2	2	2	2	2	2	2	2	4
L-M-6-3	13-Sep-01	2	2	2	2	2	2	2	2	2	2	2	2	6
L-C-1-1	13-Sep-01	3	2	2	2	3	3	3	2	3	2	2	3	0
L-C-1-2	13-Sep-01	2	2	2	2	2	2	2	2	2	2	2	2	0
L-C-1-3	13-Sep-01	2	2	2	2	2	2	2	2	2	2	3	2	8
L-C-2-1	13-Sep-01	3	2	2	2	3	3	2	2	2	3	2	2	0
L-C-2-2	13-Sep-01	2	2	2	2	2	2	2	2	2	2	2	2	0
L-C-2-3	13-Sep-01	2	2	3	2	3	2	2	2	2	2	2	2	6
L-C-3-1	13-Sep-01	2	2	2	2	2	2	2	3	2	2	1	2	12
L-C-3-2	13-Sep-01	2	3	2	2	3	2	2	2	2	2	2	2	11
L-C-3-3	13-Sep-01	2	2	1	2	2	2	2	2	2	2	3	3	0
L-C-4-1	14-Sep-01	3	2	2	2	2	1	2	3	3	3	2	2	3
L-C-4-2	14-Sep-01	2	2	3	2	3	3	2	2	2	2	2	2	4
L-C-4-3	14-Sep-01	2	2	2	2	2	2	2	2	2	2	2	1	5
L-C-5-1	14-Sep-01	3	2	2	2	2	2	2	3	2	2	2	2	3
L-C-5-2	14-Sep-01	2	2	2	3	2	3	2	2	2	2	2	3	7
L-C-5-3	14-Sep-01	2	2	2	2	2	2	2	2	2	1	2	2	0

Figure 1: Foliar Injury Rating Key

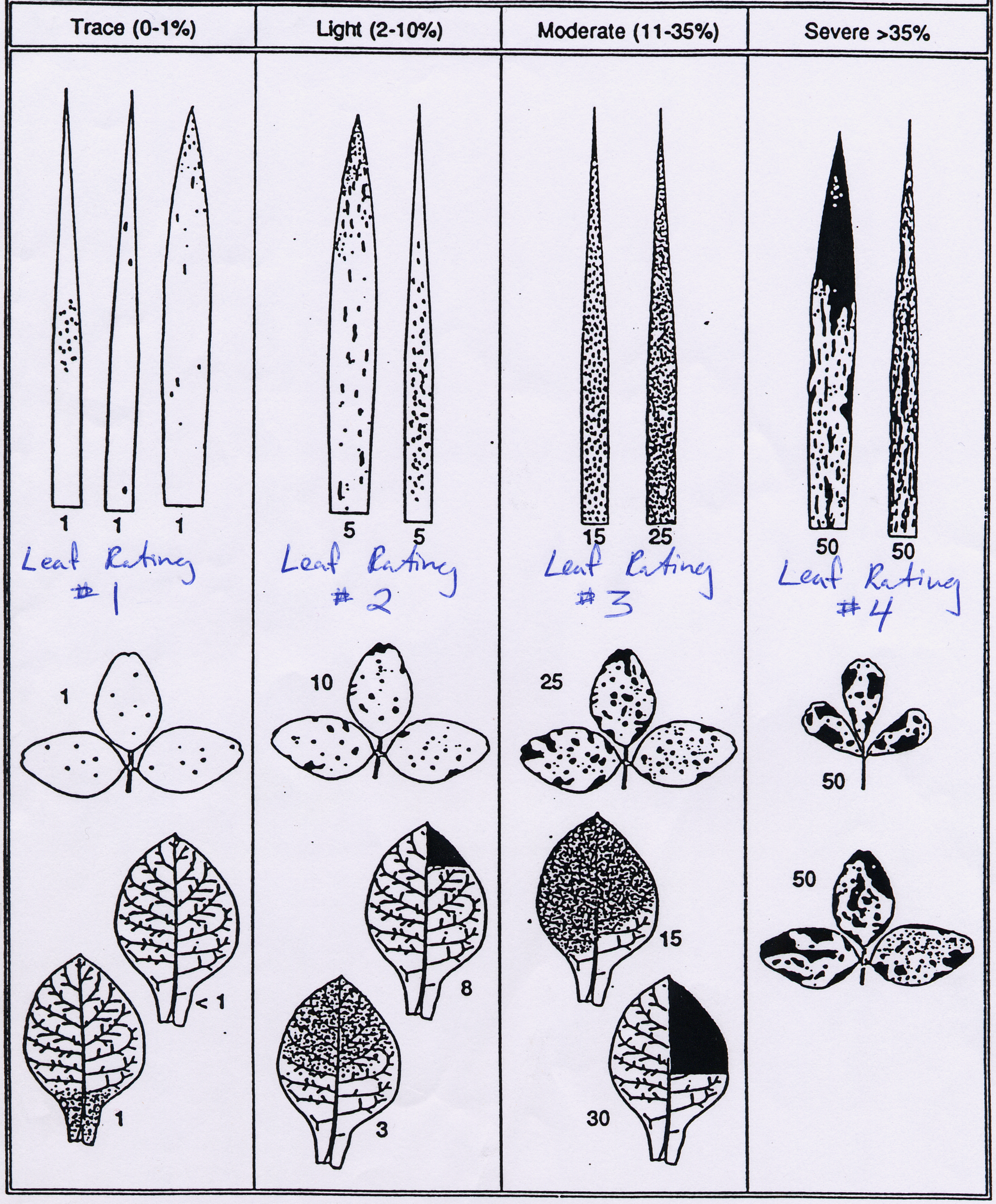


MAPLE DOSE RESPONSE EXPERIMENTAL DATA

MAPLE DOSE RESPONSE EXPERIMENTAL DATA

Soil	Seed	Soil_Ni	Replicate	Class1	Class2	Class3	Class4	Class_drop	Leaf_Number	Plant_Ht	Germ_succ
Clay	Control	0	1	9	2	0	0	0	11	264	3
Clay	Control	0	2	10	0	0	0	0	10	260	3
Clay	Control	0	3	6	3	1	0	0	10	307	2
Clay	Control	500	1	8	2	0	0	0	10	247	5
Clay	Control	500	2	10	2	0	0	0	12	338	4
Clay	Control	500	3	10	0	0	0	0	10	250	5
Clay	Control	1500	1	8	2	0	0	0	10	284	3
Clay	Control	1500	2	10	0	2	0	0	12	326	4
Clay	Control	1500	3	7	0	1	0	0	8	190	2
Clay	Control	3000	1	8	0	0	0	0	8	263	4
Clay	Control	3000	2	6	4	0	0	0	10	174	2
Clay	Control	3000	3	4	4	3	0	1	12	366	4
Clay	Test	0	1	5	0	0	0	1	6	85	1
Clay	Test	0	2	8	2	2	0	0	12	391	4
Clay	Test	0	3	6	4	0	0	0	10	287	2
Clay	Test	500	1	9	1	0	0	0	10	290	2
Clay	Test	500	2	8	3	1	0	0	12	370	3
Clay	Test	500	3	10	0	0	0	0	10	298	2
Clay	Test	1500	1	8	0	2	0	0	10	370	5
Clay	Test	1500	2	10	2	0	0	0	12	504	2
Clay	Test	1500	3	12	0	0	0	0	12	339	1
Clay	Test	3000	1	8	0	1	1	2	12	386	4
Clay	Test	3000	2	6	2	0	0	0	8	248	2
Clay	Test	3000	3	9	1	0	0	0	10	372	4
Organic	Control	0	1	6	2	2	0	0	10	357	5
Organic	Control	0	2	6	2	2	0	0	10	389	4
Organic	Control	0	3	6	4	2	0	0	12	415	5
Organic	Control	500	1	6	0	6	0	0	12	398	4
Organic	Control	500	2	4	3	3	0	0	10	328	5
Organic	Control	500	3	10	0	2	0	0	12	391	4
Organic	Control	1500	1	6	2	2	0	0	10	367	4
Organic	Control	1500	2	6	2	2	0	0	10	410	4
Organic	Control	1500	3	7	1	3	1	0	12	389	3
Organic	Control	3000	1	6	2	0	2	0	10	334	4
Organic	Control	3000	2	9	1	0	0	0	10	311	2
Organic	Control	3000	3	6	3	4	1	0	14	335	3
Organic	Test	0	1	6	0	6	2	0	14	309	3
Organic	Test	0	2	6	2	2	0	0	10	311	2
Organic	Test	0	3	4	1	3	2	0	10	241	3
Organic	Test	500	1	8	2	2	0	0	12	312	2
Organic	Test	500	2	10	0	2	0	0	12	432	2
Organic	Test	500	3	10	1	1	0	0	12	477	4
Organic	Test	1500	1	8	2	2	0	0	12	503	3
Organic	Test	1500	2	9	3	0	0	0	12	356	3
Organic	Test	1500	3	9	3	0	0	0	12	419	3
Organic	Test	3000	1	9	2	0	1	0	12	492	3
Organic	Test	3000	2	6	2	2	2	0	12	424	4
Organic	Test	3000	3	6	6	0	0	0	12	366	3

Figure 1: Foliar Injury Rating Key



EARTHWORM TOXICITY EXPERIMENTAL DATA

Test: Ecotoxicity testing: Jacques-Whitford: Phase 2 Acute *E. andrei* test
Set-up Date: 5-Mar-02
7-Day Check: 12-Mar-02
Process Date: 19-Mar-02
Species: *Eisenia andrei*
Soil Type: organic field-collected soil
Notes: RS is experimental control soil

Conc. (%)	Rep	7-day chk No. alive	14-d process No. alive
RS	1	5	5
RS	2	5	5
RS	3	5	5
RS	4	5	5
RS	5	5	5
RS	6	5	5
0	1	5	5
0	2	5	5
0	3	5	5
0	4	5	5
0	5	5	5
0	6	5	5
5	1	5	5
5	2	5	5
5	3	5	5
5	4	5	5
5	5	5	5
5	6	5	5
12	1	5	5
12	2	5	5
12	3	5	5
12	4	5	5
12	5	5	5
12	6	5	5
25	1	5	5
25	2	5	5
25	3	5	5
25	4	5	5
25	5	5	5
25	6	5	5
50	1	5	5
50	2	5	5
50	3	5	5
50	4	5	5
50	5	5	5
50	6	5	5
80	1	5	5
80	2	5	5
80	3	5	5
80	4	5	5
80	5	5	5
80	6	5	5
100	1	5	5
100	2	5	5
100	3	5	5
100	4	5	5
100	5	5	5
100	6	5	5

ADULT 35 DAY REPRODUCTION ON ORGANIC SOIL

Test: Ecotoxicity testing: Jacques-Whitford: Phase 2 Chronic *E. andrei* test
Set-up Date: February 7 2002
35-d Adult Removal: March 14 2002
Process Date: (63-d) April 11 2002
Species: *Eisenia andrei*
Soil Type: RS, organic-Ni contam diluted with organic control soil
Notes: RS is experimental control soil

Soil	Rep	35-Day No. alive adults	Comments c = cocoons, j = juveniles
RS	1	2	c,j
RS	2	2	j
RS	3	2	c
RS	4	2	
RS	5	2	c
RS	6	2	c
RS	7	2	c
RS	8	2	c
RS	9	2	c
RS	10	2	j
0	1	2	c
0	2	2	j
0	3	2	j
0	4	2	c
0	5	2	c
0	6	2	c,j
0	7	2	c,j
0	8	2	c,j
0	9	2	c
0	10	2	c,j
5	1	2	c
5	2	2	c,j
5	3	2	c,j
5	4	2	c,j
5	5	2	c
5	6	2	c
5	7	2	c,j
5	8	2	c
5	9	2	c,j
5	10	2	j
12	1	2	c
12	2	2	c
12	3	2	c,j
12	4	2	c,j
12	5	2	c,j
12	6	2	c
12	7	2	c
12	8	2	c,j
12	9	2	c,j
12	10	2	c,j

Test: Ecotoxicity testing: Jacques-Whitford: Phase 2 Chronic *E. andrei* test
Set-up Date: February 7 2002
35-d Adult Removal: March 14 2002
Process Date: (63-d) April 11 2002
Species: *Eisenia andrei*
Soil Type: RS, organic-Ni contam diluted with organic control soil
Notes: RS is experimental control soil

Soil	Rep	35-Day No. alive adults	Comments c = cocoons, j = juveniles
25	1	2	c,j
25	2	2	,cj
25	3	2	c
25	4	2	c
25	5	2	c
25	6	2	c
25	7	2	c,j
25	8	2	c,j
25	9	2	c,j
25	10	2	c,j
50	1	2	c,j
50	2	2	c
50	3	2	c
50	4	2	j
50	5	2	
50	6	2	c
50	7	2	
50	8	2	c,j
50	9	2	
50	10	2	
80	1	2	c
80	2	2	
80	3	2	c
80	4	2	
80	5	2	
80	6	2	c,j
80	7	2	j
80	8	2	c
80	9	2	j
80	10	2	
100	1	2	
100	2	2	
100	3	2	
100	4	2	
100	5	2	
100	6	2	c
100	7	2	c
100	8	2	
100	9	2	
100	10	2	

RESULTS OF 35 DAY REPRODUCTION ON ORGANIC SOIL

Test: Ecotoxicity testing: Jacques-Whitford: Phase 2 Chronic *E. andrei* test
Set-up Date: February 7 2002
35-d Adult Removal: March 14 2002
Process Date: (63-d) April 11 2002
Species: *Eisenia andrei*
Soil Type: RS, organic-Ni contam diluted with organic control soil
Notes: RS is experimental control soil

Soil (% contam)	**Rep**	No. Alive Juveniles	No. Full Cocoons	No. Empty Cocoons	Boat weight (g)	Boat + wet weight (g)	Boat + dry weight (g)	Wet Mass (g)	Dry Mass (g)
RS	1	23	3	1	0.9553	2.0347	1.1939	1.0794	0.2386
RS	2	18	0	1	0.9499	1.8724	1.1450	0.9225	0.1951
RS	3	19	1	2	0.9527	1.3868	1.0498	0.4341	0.0971
RS	4	19	1	4	0.9546	1.4047	1.0442	0.4501	0.0896
RS	5	33	0	4	0.9513	1.7182	1.1212	0.7669	0.1699
RS	6	29	4	10	0.9496	1.8488	1.1364	0.8992	0.1868
RS	7	8	0	2	0.9550	1.3500	1.0535	0.3950	0.0985
RS	8	9	7	1	0.9523	1.0936	0.9820	0.1413	0.0297
RS	9	21	0	5	0.9460	1.3078	1.0336	0.3618	0.0876
RS	10	25	1	4	0.9483	1.7232	1.1022	0.7749	0.1539
0	1	10	1	4	0.9594	1.4399	1.0472	0.4805	0.0878
0	2	58	2	12	0.9611	2.2973	1.1992	1.3362	0.2381
0	3	54	2	7	0.9586	1.7038	1.0987	0.7452	0.1401
0	4	21	2	7	0.9591	1.6477	1.064	0.6886	0.1049
0	5	8	2	2	0.9592	1.2316	1.0082	0.2724	0.0490
0	6	25	1	1	0.9576	1.4372	1.0350	0.4796	0.0774
0	7	12	2	2	0.9580	1.3055	1.0125	0.3475	0.0545
0	8	40	0	8	0.9556	1.5567	1.0732	0.6011	0.1176
0	9	14	4	7	0.9556	1.4455	1.0352	0.4899	0.0796
0	10	43	1	6	0.9518	1.7558	1.0785	0.8040	0.1267
5	1	13	7	2	0.9540	1.2904	1.0159	0.3364	0.0619
5	2	24	2	5	0.9503	1.5727	1.0666	0.6224	0.1163
5	3	25	2	6	0.9484	1.5194	1.0526	0.5710	0.1042
5	4	34	4	7	0.9577	1.5062	1.0518	0.5485	0.0941
5	5	39	1	2	0.9508	1.4415	1.0250	0.4907	0.0742
5	6	12	0	1	0.9559	1.0290	0.9665	0.0731	0.0106
5	7	21	1	3	0.9549	1.6119	1.0599	0.6570	0.1050
5	8	21	3	5	0.9539	1.1881	0.9989	0.2342	0.0450
5	9	29	0	5	0.9546	1.5813	1.0570	0.6267	0.1024
5	10	13	2	0	0.9536	1.3781	1.0171	0.4245	0.0635
12	1	22	1	4	0.9550	1.6435	1.0785	0.6885	0.1235
12	2	18	0	5	0.9538	1.5676	1.0589	0.6138	0.1051
12	3	11	5	5	0.9514	1.5367	1.0656	0.5853	0.1142
12	4	17	2	2	0.9519	1.6495	1.0677	0.6976	0.1158
12	5	29	0	5	0.9546	1.8114	1.1158	0.8568	0.1612
12	6	4	0	1	0.9546	1.1203	0.9796	0.1657	0.0250
12	7	12	5	5	0.9564	1.4434	1.0307	0.4870	0.0743
12	8	15	0	4	0.9568	1.4805	1.0441	0.5237	0.0873
12	9	17	0	2	0.9599	1.3592	1.0205	0.3993	0.0606
12	10	23	0	5	0.9629	1.6212	1.0808	0.6583	0.1179

Test: Ecotoxicity testing: Jacques-Whitford: Phase 2 Chronic *E. andrei* test
Set-up Date: February 7 2002
35-d Adult Removal: March 14 2002
Process Date: (63-d) April 11 2002
Species: *Eisenia andrei*
Soil Type: RS, organic-Ni contam diluted with organic control soil
Notes: RS is experimental control soil

Soil (% contam)	**Rep**	No. Alive Juveniles	No. Full Cocoons	No. Empty Cocoons	Boat weight (g)	Boat + wet weight (g)	Boat + dry weight (g)	Wet Mass (g)	Dry Mass (g)
25	1	31	1	11	0.9607	1.3109	1.0264	0.3502	0.0657
25	2	31	0	5	0.9585	1.3231	1.0305	0.3646	0.0720
25	3	21	2	4	0.9615	1.8040	1.0979	0.8425	0.1364
25	4	20	1	8	0.9547	1.3451	1.0210	0.3904	0.0663
25	5	26	1	1	0.9603	1.3461	1.0186	0.3858	0.0583
25	6	14	1	2	0.9588	1.3904	1.0062	0.4316	0.0474
25	7	16	1	2	0.9531	1.2747	1.0210	0.3216	0.0679
25	8	23	0	1	0.9535	1.3288	1.0057	0.3753	0.0522
25	9	18	1	2	0.9594	1.4477	1.0346	0.4883	0.0752
25	10	22	1	8	0.9562	1.5532	1.0724	0.5970	0.1162
50	1	24	1	1	0.9588	1.1538	0.9903	0.1950	0.0315
50	2	15	2	2	0.9532	1.1318	0.9861	0.1786	0.0329
50	3	8	2	2	0.9524	1.0583	0.9706	0.1059	0.0182
50	4	20	1	5	0.9530	1.1135	0.9830	0.1605	0.0300
50	5	10	0	2	0.9583	1.1573	0.9877	0.1990	0.0294
50	6	21	1	3	0.9623	1.0878	0.9869	0.1255	0.0246
50	7	7	1	1	0.9610	1.1292	0.9767	0.1682	0.0157
50	8	18	0	4	0.9560	1.1047	0.9840	0.1487	0.0280
50	9	18	0	1	0.9490	1.1244	0.9744	0.1754	0.0254
50	10	16	1	4	0.9501	1.0806	0.9735	0.1305	0.0234
80	1	10	0	1	0.9512	1.0314	0.9614	0.0802	0.0102
80	2	9	0	1	0.9560	1.0176	0.9669	0.0616	0.0109
80	3	10	2	4	0.9527	1.0202	0.9643	0.0675	0.0116
80	4	3	0	1	0.9559	0.9900	0.9614	0.0341	0.0055
80	5	3	0	0	0.9509	1.0085	0.9592	0.0576	0.0083
80	6	10	1	0	0.9494	1.1026	0.9716	0.1532	0.0222
80	7	14	1	0	0.9506	1.0440	0.9675	0.0934	0.0169
80	8	8	1	0	0.9553	0.9918	0.9617	0.0365	0.0064
80	9	3	4	2	0.9506	0.9788	0.9543	0.0282	0.0037
80	10	6	2	0	0.9524	1.0268	0.9631	0.0744	0.0107
100	1	0	0	1	*				
100	2	0	5	0	*				
100	3	0	0	0	*				
100	4	0	0	0	*				
100	5	0	0	2	*				
100	6	0	1	0	*				
100	7	0	3	1	*				
100	8	0	0	0	*				
100	9	0	0	0	*				
100	10	0	0	0	*				

*no weight data were entered as there were no juveniles

ADULT 35 DAY REPRODUCTION ON CLAY

Test:	Ecotoxicity testing: Jacques-Whitford: Phase 2 Chronic *E. andrei* test
Set-up Date:	February 5 2002
35-d Adult Removal	March 12 2002
Process Date:	(63-d) April 9 2002
Species:	*Eisenia andrei*
Soil Type:	RS, heavy clay-Ni contam diluted with heavy clay control soil
Notes:	RS is experimental control soil

Soil	Rep	35-Day No. alive adults	Comments c = cocoons, j = juveniles
RS	1	2	c
RS	2	2	c
RS	3	2	c
RS	4	2	
RS	5	2	c
RS	6	2	c
RS	7	2	j
RS	8	2	
RS	9	2	j
RS	10	2	j
0	1	0	1 dead*, moisture content good
0	2	2	c
0	3	2	c
0	4	2	c
0	5	2	c
0	6	1	1 dead, c
0	7	1	1 dead, c
0	8	2	c
0	9	2	
0	10	1	j
5	1	2	c
5	2	1	1 dead
5	3	2	nematodes
5	4	1	1 dead, c
5	5	2	
5	6	2	c
5	7	2	
5	8	2	
5	9	2	
5	10	2	c
12	1	2	
12	2	1	c
12	3	2	c
12	4	2	
12	5	2	
12	6	2	
12	7	1	1 dead, c
12	8	1	1 dead
12	9	0	
12	10	2	

Test:	Ecotoxicity testing: Jacques-Whitford: Phase 2 Chronic *E. andrei* test
Set-up Date:	February 5 2002
35-d Adult Removal	March 12 2002
Process Date:	(63-d) April 9 2002
Species:	*Eisenia andrei*
Soil Type:	RS, heavy clay-Ni contam diluted with heavy clay control soil
Notes:	RS is experimental control soil

Soil	Rep	35-Day No. alive adults	Comments c = cocoons, j = juveniles
25	1	1	
25	2	2	
25	3	2	c
25	4	1	
25	5	2	c
25	6	2	c
25	7	2	c
25	8	1	
25	9	2	
25	10	2	
50	1	2	
50	2	2	c
50	3	2	
50	4	2	
50	5	1	c
50	6	2	
50	7	2	
50	8	2	
50	9	2	c
50	10	2	
80	1	1	
80	2	2	
80	3	1	1 dead
80	4	2	
80	5	1	1 dead
80	6	2	c
80	7	2	
80	8	2	
80	9	1	
80	10	2	
100	1	2	
100	2	2	j
100	3	2	c
100	4	2	
100	5	2	
100	6	2	
100	7	2	
100	8	1	
100	9	2	
100	10	2	c

*the significance of seeing a dead worm, as opposed to a worm missing, is that the death was recent

RESULTS OF 35 DAY REPRODUCTION ON CLAY

Test: Ecotoxicity testing: Jacques-Whitford: Phase 2 Chronic *E. andrei* test
Set-up Date: February 5 2002
35-d Adult Removal: March 12 2002
Process Date: (63-d) April 9 2002
Species: *Eisenia andrei*
Soil Type: RS, heavy clay-Ni contam diluted with heavy clay control soil
Notes: RS is experimental control soil

Soil (% contam)	**Rep**	No. Alive Juveniles	No. Full Cocoons	No. Empty Cocoons	Boat weight (g)	Boat + wet weight (g)	Boat + dry weight (g)	Wet Mass (g)	Dry Mass (g)
RS	1	11	1	2	0.9464	1.4725	1.0416	0.5261	0.0952
RS	2	7	1	7	0.9551	1.0911	0.9777	0.1360	0.0226
RS	3	3	2	0	0.9493	1.1653	0.9929	0.2160	0.0436
RS	4	3	2	1	0.9537	1.0596	0.9745	0.1059	0.0208
RS	5	6	1	2	0.9519	1.2300	1.0024	0.2781	0.0505
RS	6	22	1	4	0.9528	1.4850	1.0691	0.5322	0.1163
RS	7	8	1	3	0.9534	1.3776	1.0308	0.4242	0.0774
RS	8	4	1	2	0.9515	1.1067	0.9887	0.1552	0.0372
RS	9	*	*	*	0.9543	1.1721	1.0094	0.2178	0.0551
RS	10	15	0	5	0.9506	1.4164	1.0489	0.4658	0.0983
0	1	3	0	0	1.0026	1.3166	1.0648	0.3140	0.0622
0	2	6	0	2	0.9801	1.3020	1.0376	0.3219	0.0575
0	3	7	0	3	0.9789	1.1048	1.0057	0.1259	0.0268
0	4	8	0	0	0.9837	1.3000	1.0429	0.3163	0.0592
0	5	15	1	3	0.9897	1.2155	1.0304	0.2258	0.0407
0	6	5	0	0	0.9842	1.0498	0.9943	0.0656	0.0101
0	7	6	0	2	0.9831	1.1492	1.0103	0.1661	0.0272
0	8	5	1	0	0.9876	1.3148	1.0599	0.3272	0.0723
0	9	3	1	0	0.9861	0.9988	0.9894	0.0127	0.0033
0	10	12	0	0	0.9862	1.2261	1.0266	0.2399	0.0404
5	1	9	0	3	0.9890	1.2468	1.0395	0.2578	0.0505
5	2	1	0	0	0.9848	0.9879	0.9856	0.0031	0.0008
5	3	6	0	2	0.9894	1.0382	0.9991	0.0488	0.0097
5	4	0	1	0	**				
5	5	3	0	1	0.9932	1.0261	0.9991	0.0329	0.0059
5	6	12	0	0	0.9858	1.1948	1.0187	0.2090	0.0329
5	7	5	2	0	0.9827	1.0675	1.0007	0.0848	0.0180
5	8	6	0	0	0.9879	1.0682	1.0016	0.0803	0.0137
5	9	5	1	0	0.9827	1.0444	0.9954	0.0617	0.0127
5	10	0	0	0	0.9734	1.0412	0.9884	0.0678	0.0150
12	1	8	3	1	0.9924	1.0318	1.0009	0.0394	0.0085
12	2	1	4	3	0.9955	0.9970	0.9961	0.0015	0.0006
12	3	3	0	0	0.9969	1.0283	1.0029	0.0314	0.0060
12	4	7	2	0	0.9910	1.0835	1.0111	0.0925	0.0201
12	5	8	1	3	0.9849	1.1411	1.0164	0.1562	0.0315
12	6	3	0	0	0.9816	1.0573	0.9935	0.0757	0.0119
12	7	10	2	0	0.9914	1.1530	1.0221	0.1616	0.0307
12	8	1	0	0	0.9934	1.0228	0.9982	0.0294	0.0048
12	9	0	0	0	**				
12	10	7	0	0	0.9951	1.1901	1.0260	0.1950	0.0309

Test: Ecotoxicity testing: Jacques-Whitford: Phase 2 Chronic *E. andrei* test
Set-up Date: February 5 2002
35-d Adult Removal: March 12 2002
Process Date: (63-d) April 9 2002
Species: *Eisenia andrei*
Soil Type: RS, heavy clay-Ni contam diluted with heavy clay control soil
Notes: RS is experimental control soil

Soil (% contam)	**Rep**	No. Alive Juveniles	No. Full Cocoons	No. Empty Cocoons	Boat weight (g)	Boat + wet weight (g)	Boat + dry weight (g)	Wet Mass (g)	Dry Mass (g)
25	1	0	2	0	**				
25	2	0	2	0	**				
25	3	0	0	0	**				
25	4	0	0	0	**				
25	5	0	0	0	**				
25	6	5	0	0	0.9829	1.0206	0.9890	0.0377	0.0061
25	7	0	2	0	0.9944	1.0017	0.9958	0.0073	0.0014
25	8	3	1	0	0.9881	1.0480	1.0013	0.0599	0.0132
25	9	0	0	0	**				
25	10	0	3	0	**				
50	1	0	2	0	0.9994	1.0053	1.0002	0.0059	0.0008
50	2	1	3	1	0.9855	0.9877	0.9863	0.0022	0.0008
50	3	0	0	0	**				
50	4	0	0	0	**				
50	5	0	1	0	**				
50	6	0	3	0	**				
50	7	0	0	0	**				
50	8	0	1	0	**				
50	9	0	0	0	**				
50	10	0	0	0	**				
80	1	0	0	0	**				
80	2	0	0	0	**				
80	3	0	1	0	**				
80	4	0	0	0	**				
80	5	0	0	0	**				
80	6	0	0	0	**				
80	7	0	3	0	**				
80	8	0	1	0	**				
80	9	0	1	0	**				
80	10	0	0	0	**				
100	1	0	1	0	**				
100	2	1	2	0	0.9754	0.9926	0.9787	0.0172	0.0033
100	3	0	2	0	**				
100	4	1	0	0	0.9839	*	1.0016	*	0.0177
100	5	0	0	0	**				
100	6	0	0	0	**				
100	7	0	0	0	**				
100	8	0	0	0	**				
100	9	0	0	0	**				
100	10	0	1	0	**				

* data missing
**no weight data were entered as there were no juveniles

STATISTICAL OUTPUT

Frog CoCs

Frog liver nickel-water

Analysis of Deviance Table

```
Gaussian model

Response: log(Liver.Ni)

Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                    59   34.90434
     wni  1 1.143036        58   33.76131 2.157764 0.1474465
    Soil  1 3.528232        57   30.23308 6.660415 0.0125054
wni:Soil  1 0.568108        56   29.66497 1.072445 0.3048451
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(Liver.Ni) ~ wni * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
       Min         1Q      Median        3Q      Max
 -1.683027 -0.5921173 -0.01271621 0.4537754 1.750817

Coefficients:
                 Value Std. Error    t value
(Intercept) -1.2788456  0.1480005 -8.6408171
        wni  7.1743759  8.1965628  0.8752908
       Soil -0.3742333  0.1480005 -2.5285942
   wni:Soil  8.4882728  8.1965628  1.0355893

(Dispersion Parameter for Gaussian family taken to be 0.5297316 )

    Null Deviance: 34.90434 on 59 degrees of freedom

Residual Deviance: 29.66497 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Frog liver copper-water

Analysis of Deviance Table

```
Gaussian model

Response: log(Liver.Cu)

Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                     59   100.6659
     wcu  1 3.495251         58    97.1706 2.022474 0.1605326
    Soil  1 0.324162         57    96.8465 0.187571 0.6666093
wcu:Soil  1 0.066945         56    96.7795 0.038736 0.8446842
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(Liver.Cu) ~ wcu * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
      Min         1Q    Median        3Q      Max
 -5.60996 -0.3518759 0.3926081 0.6182237 1.737014

Coefficients:
                  Value Std. Error     t value
(Intercept)   5.0357749  0.2813971  17.8956183
        wcu -50.6113186 36.7747145  -1.3762532
       Soil   0.1178949  0.2813971   0.4189627
   wcu:Soil  -7.2378459 36.7747145  -0.1968158

(Dispersion Parameter for Gaussian family taken to be 1.728206 )

    Null Deviance: 100.6659 on 59 degrees of freedom

Residual Deviance: 96.77953 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Frog liver cobalt-water

Analysis of Deviance Table

```
Gaussian model

Response: log(Liver.Co)

Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                     59   23.28976
     wco  1 1.157271         58   22.13249 2.964866 0.0906115
    Soil  1 0.182070         57   21.95042 0.466454 0.4974391
wco:Soil  1 0.092032         56   21.85838 0.235781 0.6291645
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(Liver.Co) ~ wco * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
       Min         1Q      Median        3Q      Max
 -2.067627 -0.2827837 -0.04863352 0.4057409 1.543744

Coefficients:
                    Value Std. Error    t value
(Intercept)   -0.58007986  0.1032206 -5.6198090
        wco -100.50312606 59.0694321 -1.7014405
       Soil   -0.02409818  0.1032206 -0.2334630
   wco:Soil  -28.68251108 59.0694321 -0.4855728

(Dispersion Parameter for Gaussian family taken to be 0.3903283 )

    Null Deviance: 23.28976 on 59 degrees of freedom

Residual Deviance: 21.85838 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Frog liver arsenic-water

Analysis of Deviance Table

```
Gaussian model

Response: log(Liver.As)

Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                    59   25.60137
     was  1 0.009552        58   25.59182  0.02633 0.8716764
    Soil  1 4.883334        57   20.70849 13.46242 0.0005438
was:Soil  1 0.395141        56   20.31335  1.08933 0.3011048
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(Liver.As) ~ was * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
       Min         1Q      Median       3Q      Max
 -1.443104 -0.3561012 -0.05681002 0.336698 1.474666

Coefficients:
                  Value  Std. Error    t value
(Intercept)  -0.5276204   0.1458574 -3.6173719
        was  41.3835728 143.8094118  0.2877668
```

```
       Soil   -0.4156427   0.1458574 -2.8496512
   was:Soil  150.0951725 143.8094118  1.0437090
```

(Dispersion Parameter for Gaussian family taken to be 0.3627383)

Null Deviance: 25.60137 on 59 degrees of freedom

Residual Deviance: 20.31335 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1

Frog liver nickel-sediment

Analysis of Deviance Table

Gaussian model

Response: log(Liver.Ni)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			59	34.90434		
sni	1	1.951454	58	32.95289	4.178859	0.04564410
Soil	1	4.599840	57	28.35305	9.850134	0.00270851
sni:Soil	1	2.202027	56	26.15102	4.715438	0.03414508

Summary

*** Generalized Linear Model ***

```
Call: glm(formula = log(Liver.Ni) ~ sni * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
       Min         1Q       Median        3Q      Max
 -1.504998 -0.5043776 -0.002263632 0.3794276 1.845875
```

Coefficients:

	Value	Std. Error	t value
(Intercept)	-1.5893838202	0.155192215	-10.241388827
sni	0.0023446777	0.000791025	2.964100636
Soil	0.0003699222	0.155192215	0.002383639
sni:Soil	-0.0017177155	0.000791025	-2.171506017

(Dispersion Parameter for Gaussian family taken to be 0.4669825)

Null Deviance: 34.90434 on 59 degrees of freedom

Residual Deviance: 26.15102 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1

Frog liver copper-sediment

Analysis of Deviance Table

```
Gaussian model

Response: log(Liver.Cu)

Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                    59   100.6659
     scu  1 2.017671        58    98.6482 1.226626 0.2727988
    Soil  1 0.448023        57    98.2002 0.272371 0.6038037
scu:Soil  1 6.086042        56    92.1141 3.699957 0.0595030
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(Liver.Cu) ~ scu * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
     Min         1Q    Median        3Q      Max
 -5.2691 -0.2446785 0.1345331 0.6682114 2.086358

Coefficients:
                   Value  Std. Error     t value
(Intercept)  4.622506282 0.461752979  10.0107774
        scu  0.001665092 0.008643606   0.1926385
       Soil -0.742429031 0.461752979  -1.6078489
   scu:Soil  0.016626211 0.008643606   1.9235272

(Dispersion Parameter for Gaussian family taken to be 1.644896 )

    Null Deviance: 100.6659 on 59 degrees of freedom

Residual Deviance: 92.11415 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Frog liver cobalt-sediment

Analysis of Deviance Table

```
Gaussian model

Response: log(Liver.Co)

Terms added sequentially (first to last)
         Df  Deviance Resid. Df Resid. Dev   F Value     Pr(F)
    NULL                     59   23.28976
     sco  1 0.3206876         58   22.96907 0.7909952 0.3776041
    Soil  1 0.2209486         57   22.74812 0.5449830 0.4634575
sco:Soil  1 0.0444386         56   22.70368 0.1096105 0.7418237
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(Liver.Co) ~ sco * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
       Min         1Q      Median        3Q      Max
 -2.063498 -0.3341881 0.006160501 0.3708667 1.679353

Coefficients:
                   Value Std. Error     t value
(Intercept) -0.930037291 0.27693371 -3.35833906
        sco  0.022082114 0.02446912  0.90244839
       Soil  0.026727276 0.27693371  0.09651146
   sco:Soil -0.008101106 0.02446912 -0.33107476

(Dispersion Parameter for Gaussian family taken to be 0.4054229 )

    Null Deviance: 23.28976 on 59 degrees of freedom

Residual Deviance: 22.70368 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Frog liver arsenic-sediment

Analysis of Deviance Table

```
Gaussian model

Response: log(Liver.As)

Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                    59   25.60137
     sas  1 1.021597         58   24.57978  2.80953 0.0992810
    Soil  1 4.040242         57   20.53953 11.11120 0.0015258
sas:Soil  1 0.176882         56   20.36265  0.48645 0.4884012
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(Liver.As) ~ sas * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
       Min         1Q      Median        3Q      Max
 -1.456864 -0.4032523 -0.02207134 0.3598035 1.485156

Coefficients:
                   Value Std. Error     t value
(Intercept) -0.453374370 0.34665382 -1.30785915
        sas -0.002093991 0.08992138 -0.02328690
       Soil -0.034061195 0.34665382 -0.09825709
   sas:Soil -0.062716481 0.08992138 -0.69745904

(Dispersion Parameter for Gaussian family taken to be 0.3636188 )

    Null Deviance: 25.60137 on 59 degrees of freedom

Residual Deviance: 20.36265 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Frog GI Tract nickel-water

Analysis of Deviance Table

```
Gaussian model

Response: log(GI.Ni)

Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                    59   127.4122
     wni  1 6.162237        58   121.2499 2.941041 0.0918845
    Soil  1 0.474771        57   120.7752 0.226593 0.6359135
wni:Soil  1 3.440741        56   117.3344 1.642157 0.2053107
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(GI.Ni) ~ wni * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
      Min         1Q    Median       3Q      Max
 -3.06683 -0.9978212 0.0300711 1.192199 2.678857

Coefficients:
                  Value Std. Error   t value
(Intercept)   1.4735624  0.2943432  5.006272
        wni  30.5734968 16.3013108  1.875524
       Soil  -0.3699271  0.2943432 -1.256788
```

```
   wni:Soil  20.8895856 16.3013108  1.281467
```

(Dispersion Parameter for Gaussian family taken to be 2.095257)

Null Deviance: 127.4122 on 59 degrees of freedom

Residual Deviance: 117.3344 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1

Frog GI Tract copper-water

Analysis of Deviance Table

Gaussian model

Response: log(GI.Cu)

```
Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                   59   36.20471
     wcu  1 0.262349        58   35.94236 0.436905 0.5113305
    Soil  1 0.950732        57   34.99163 1.583308 0.2135059
wcu:Soil  1 1.365210        56   33.62642 2.273563 0.1372183
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(GI.Cu) ~ wcu * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
       Min         1Q      Median        3Q      Max
 -1.310152 -0.5724545 -0.04433428 0.4876973 2.293993

Coefficients:
                  Value Std. Error     t value
(Intercept)   3.2082727  0.1658701  19.3420763
        wcu   2.2803401 21.6769358   0.1051966
       Soil   0.0725435  0.1658701   0.4373512
   wcu:Soil -32.6852155 21.6769358  -1.5078338
```

(Dispersion Parameter for Gaussian family taken to be 0.6004718)

Null Deviance: 36.20471 on 59 degrees of freedom

Residual Deviance: 33.62642 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1

Frog GI Tract cobalt-water

Analysis of Deviance Table

```
Gaussian model

Response: log(GI.Co)

Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                    59   80.15422
     wco  1 8.602679        58   71.55154 6.748940 0.0119644
    Soil  1 0.005573        57   71.54596 0.004372 0.9475149
wco:Soil  1 0.164375        56   71.38159 0.128955 0.7208683
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(GI.Co) ~ wco * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
      Min         1Q      Median        3Q      Max
 -2.39104 -0.8877797 -0.04358878 0.7600654 2.665153

Coefficients:
                    Value  Std. Error    t value
(Intercept)    0.33635402   0.1865307  1.8032100
        wco -279.31507859 106.7448369 -2.6166613
       Soil    0.05128226   0.1865307  0.2749266
   wco:Soil  -38.33242169 106.7448369 -0.3591033

(Dispersion Parameter for Gaussian family taken to be 1.274671 )

    Null Deviance: 80.15422 on 59 degrees of freedom

Residual Deviance: 71.38159 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Frog GI Tract arsenic-water

Analysis of Deviance Table

```
Gaussian model

Response: log(GI.As)

Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                    59   55.53508
     was  1 1.989226        58   53.54586 2.162156 0.1470429
    Soil  1 1.331248        57   52.21461 1.446977 0.2340748
was:Soil  1 0.693503        56   51.52111 0.753792 0.3889840
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(GI.As) ~ was * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
       Min         1Q     Median        3Q      Max
 -1.587697 -0.6915002 -0.2728905 0.7730561 1.847474

Coefficients:
                    Value  Std. Error    t value
(Intercept)   -0.09369345   0.2322899 -0.4033471
        was -297.49974553 229.0283102 -1.2989649
       Soil   -0.32012449   0.2322899 -1.3781251
   was:Soil  198.84506511 229.0283102  0.8682117

(Dispersion Parameter for Gaussian family taken to be 0.9200197 )

    Null Deviance: 55.53508 on 59 degrees of freedom

Residual Deviance: 51.52111 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Frog GI Tract nickel-sediment

Analysis of Deviance Table

```
Gaussian model

Response: log(GI.Ni)

Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                    59   127.4122
     sni  1 28.95303        58    98.4591 20.41635 0.0000327
    Soil  1  2.53924        57    95.9199  1.79056 0.1862666
sni:Soil  1 16.50464        56    79.4153 11.63831 0.0012057
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(GI.Ni) ~ sni * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
       Min         1Q     Median        3Q      Max
 -3.147382 -0.7693714 0.07894476 0.9934611 2.592975

Coefficients:
                   Value  Std. Error   t value
(Intercept)  0.595839121 0.270444130  2.203187
        sni  0.007786280 0.001378472  5.648488
       Soil  0.553324801 0.270444130  2.045986
   sni:Soil -0.004702652 0.001378472 -3.411497

(Dispersion Parameter for Gaussian family taken to be 1.41813 )

    Null Deviance: 127.4122 on 59 degrees of freedom

Residual Deviance: 79.41525 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Frog GI Tract copper-sediment

Analysis of Deviance Table

```
Gaussian model

Response: log(GI.Cu)

Terms added sequentially (first to last)
         Df  Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                    59   36.20471
     scu  1 0.2334784       58   35.97123 0.378768 0.5407565
    Soil  1 0.9900048       57   34.98123 1.606068 0.2102902
scu:Soil  1 0.4619816       56   34.51925 0.749465 0.3903395
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(GI.Cu) ~ scu * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
      Min        1Q      Median        3Q      Max
 -1.37795 -0.5767212 0.003964875 0.4443828 2.537488

Coefficients:
                    Value  Std. Error     t value
(Intercept)  3.2806252629 0.282668360  11.6059161
        scu -0.0007609137 0.005291301  -0.1438047
       Soil  0.0997609341 0.282668360   0.3529257
```

```
   scu:Soil -0.0045807664 0.005291301  -0.8657165

(Dispersion Parameter for Gaussian family taken to be 0.6164151 )

    Null Deviance: 36.20471 on 59 degrees of freedom

Residual Deviance: 34.51925 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Frog GI Tract cobalt-sediment

Analysis of Deviance Table

```
Gaussian model

Response: log(GI.Co)

Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                   59   80.15422
     sco  1  0.87540        58   79.27882 0.709818 0.4030881
    Soil  1  0.00698        57   79.27184 0.005661 0.9402935
sco:Soil  1 10.20883        56   69.06301 8.277871 0.0056692
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(GI.Co) ~ sco * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
       Min         1Q      Median       3Q      Max
 -2.829626 -0.7504347 -0.06496177 0.705172 2.776714

Coefficients:
                  Value Std. Error   t value
(Intercept) -0.79601382  0.4830037 -1.648049
        sco  0.07451375  0.0426769  1.745997
       Soil  1.31595927  0.4830037  2.724533
   sco:Soil -0.12278694  0.0426769 -2.877129

(Dispersion Parameter for Gaussian family taken to be 1.233268 )

    Null Deviance: 80.15422 on 59 degrees of freedom

Residual Deviance: 69.06301 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Frog GI Tract arsenic-sediment

Analysis of Deviance Table

```
Gaussian model

Response: log(GI.As)

Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value      Pr(F)
    NULL                    59   55.53508
     sas  1 6.525914        58   49.00917 8.818687 0.00438360
    Soil  1 4.250184        57   44.75899 5.743416 0.01991425
sas:Soil  1 3.318439        56   41.44055 4.484318 0.03866056
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(GI.As) ~ sas * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
       Min         1Q     Median        3Q      Max
 -1.403865 -0.7793438 -0.1290226 0.7213994 2.132516

Coefficients:
                 Value Std. Error   t value
(Intercept) -2.2759026  0.4945288 -4.602164
        sas  0.5096436  0.1282799  3.972904
       Soil  0.7423209  0.4945288  1.501067
   sas:Soil -0.2716482  0.1282799 -2.117621

(Dispersion Parameter for Gaussian family taken to be 0.7400097 )

    Null Deviance: 55.53508 on 59 degrees of freedom

Residual Deviance: 41.44055 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Frog body nickel-water

Analysis of Deviance Table

```
Gaussian model

Response: log(Body.Ni)

Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                    59   60.66344
     wni  1 1.140152        58   59.52329  1.40908 0.2402197
    Soil  1 8.186108        57   51.33718 10.11700 0.0023956
wni:Soil  1 6.025126        56   45.31206  7.44630 0.0084777
```

Summary

```
Call: glm(formula = log(Body.Ni) ~ wni * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
       Min         1Q     Median        3Q      Max
 -1.708381 -0.4059748 -0.1435111 0.5362193 2.213917

Coefficients:
                  Value Std. Error   t value
(Intercept)  -1.1072635  0.1829145 -6.053447
        wni  14.4410523 10.1301694  1.425549
       Soil  -0.7626068  0.1829145 -4.169197
   wni:Soil  27.6431106 10.1301694  2.728791

(Dispersion Parameter for Gaussian family taken to be 0.8091438 )

    Null Deviance: 60.66344 on 59 degrees of freedom

Residual Deviance: 45.31206 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Frog body copper-water

Analysis of Deviance Table

```
Gaussian model

Response: log(Body.Cu)

Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                    59   37.03795
     wcu  1 2.998625        58   34.03933 5.234178 0.0259452
    Soil  1 0.033957        57   34.00537 0.059273 0.8085385
wcu:Soil  1 1.923351        56   32.08202 3.357259 0.0722286
```

Summary

```
Call: glm(formula = log(Body.Cu) ~ wcu * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
        Min         1Q      Median        3Q      Max
 -0.9936909 -0.5831502 -0.09504448 0.3442478 2.617953

Coefficients:
                  Value Std. Error    t value
(Intercept)   2.6355628  0.1620163  16.267270
        wcu -36.2009156 21.1732934  -1.709744
       Soil  -0.2600796  0.1620163  -1.605268
   wcu:Soil  38.7954535 21.1732934   1.832282

(Dispersion Parameter for Gaussian family taken to be 0.5728932 )

    Null Deviance: 37.03795 on 59 degrees of freedom
```

Residual Deviance: 32.08202 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1

Frog body cobalt-water

Analysis of Deviance Table

Gaussian model

Response: log(Body.Co)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			59	33.22687		
wco	1	2.942040	58	30.28483	6.55993	0.0131510
Soil	1	4.660053	57	25.62477	10.39062	0.0021139
wco:Soil	1	0.509532	56	25.11524	1.13611	0.2910490

Summary

```
Call: glm(formula = log(Body.Co) ~ wco * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
       Min         1Q     Median        3Q      Max
 -2.148467 -0.2990473 0.02295595 0.4278174 1.569498
```

Coefficients:

	Value	Std. Error	t value
(Intercept)	-2.240576	0.1106435	-20.250409
wco	-151.736573	63.3173108	-2.396447
Soil	-0.206188	0.1106435	-1.863534
wco:Soil	-67.489063	63.3173108	-1.065886

(Dispersion Parameter for Gaussian family taken to be 0.4484865)

Null Deviance: 33.22687 on 59 degrees of freedom

Residual Deviance: 25.11524 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1

Frog body arsenic-water

Analysis of Deviance Table

Gaussian model

Response: log(Body.As)

```
Terms added sequentially (first to last)
         Df   Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                      59   3.503884
     was  1 0.00044903        58   3.503435 0.007334 0.9320592
    Soil  1 0.07304265        57   3.430393 1.192987 0.2794046
was:Soil  1 0.00169793        56   3.428695 0.027732 0.8683407
```

Summary

```
Call: glm(formula = log(Body.As) ~ was * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
        Min         1Q        Median         3Q
 -0.3880552 -0.1016675 -0.0005253898 0.08065401
      Max
 1.221383

Coefficients:
                  Value  Std. Error      t value
(Intercept) -1.25406370  0.05992418 -20.92750842
        was  2.11787899 59.08278797   0.03584596
       Soil -0.02670256  0.05992418  -0.44560580
   was:Soil -9.83898437 59.08278797  -0.16652878

(Dispersion Parameter for Gaussian family taken to be 0.0612267 )

    Null Deviance: 3.503884 on 59 degrees of freedom

Residual Deviance: 3.428695 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Frog body nickel-sediment

Analysis of Deviance Table

Gaussian model

Response: log(Body.Ni)

```
Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value         Pr(F)
    NULL                    59   60.66344
     sni  1 17.26951        58   43.39393 37.61090 0.00000009236
    Soil  1  9.28509        57   34.10884 20.22179 0.00003518224
sni:Soil  1  8.39575        56   25.71310 18.28492 0.00007478233
```

Summary

```
Call: glm(formula = log(Body.Ni) ~ sni * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
       Min         1Q     Median        3Q      Max
 -1.316417 -0.3544137 -0.1891128 0.3193735 2.165166

Coefficients:
                  Value   Std. Error     t value
(Intercept) -1.97329910 0.1538873019 -12.8230144
        sni  0.00583025 0.0007843738   7.4329999
       Soil  0.14798514 0.1538873019   0.9616462
   sni:Soil -0.00335405 0.0007843738  -4.2760866

(Dispersion Parameter for Gaussian family taken to be 0.4591624 )

    Null Deviance: 60.66344 on 59 degrees of freedom

Residual Deviance: 25.7131 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Frog body copper-sediment

Analysis of Deviance Table

```
Gaussian model

Response: log(Body.Cu)

Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                    59   37.03795
     scu  1 5.906218        58   31.13174 10.94487 0.0016443
    Soil  1 0.021915        57   31.10982  0.04061 0.8410196
scu:Soil  1 0.890351        56   30.21947  1.64992 0.2042585
```

Summary

```
Call: glm(formula = log(Body.Cu) ~ scu * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
      Min         1Q     Median        3Q      Max
 -1.32479 -0.5002288 -0.1323427 0.3459414 2.833968

Coefficients:
                   Value  Std. Error   t value
(Intercept)  1.515965028 0.264478243  5.731908
        scu  0.017572208 0.004950798  3.549369
       Soil  0.297925830 0.264478243  1.126466
   scu:Soil -0.006359256 0.004950798 -1.284491

(Dispersion Parameter for Gaussian family taken to be 0.5396334 )
```

```
    Null Deviance: 37.03795 on 59 degrees of freedom

Residual Deviance: 30.21947 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Frog body cobalt-sediment

Analysis of Deviance Table

```
Gaussian model

Response: log(Body.Co)

Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                    59   33.22687
     sco  1 6.227784        58   26.99908 15.56568 0.0002244
    Soil  1 4.512888        57   22.48619 11.27948 0.0014149
sco:Soil  1 0.080755        56   22.40544  0.20184 0.6549750
```

Summary

```
Call: glm(formula = log(Body.Co) ~ sco * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
       Min         1Q     Median        3Q      Max
 -2.015374 -0.3804718 0.02706931 0.3436972 1.971788

Coefficients:
                  Value Std. Error     t value
(Intercept) -3.28464557 0.27510876 -11.9394439
        sco  0.08166987 0.02430787   3.3598123
       Soil -0.39282261 0.27510876  -1.4278812
   sco:Soil  0.01092066 0.02430787   0.4492643

(Dispersion Parameter for Gaussian family taken to be 0.4000971 )

    Null Deviance: 33.22687 on 59 degrees of freedom

Residual Deviance: 22.40544 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Frog body arsenic-sediment

Analysis of Deviance Table

Gaussian model

Response: log(Body.As)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			59	3.503884		
sas	1	0.04477574	58	3.459108	0.7364244	0.3944668
Soil	1	0.04957668	57	3.409532	0.8153853	0.3704007
sas:Soil	1	0.00464550	56	3.404886	0.0764044	0.7832482

Summary

```
Call: glm(formula = log(Body.As) ~ sas * Soil, family =
      gaussian, data = frogcoc2, na.action = na.omit)
Deviance Residuals:
       Min         1Q     Median         3Q      Max
 -0.392267 -0.1317711 0.01319809 0.05055046 1.217171
```

Coefficients:

	Value	Std. Error	t value
(Intercept)	-1.217164101	0.1417523	-8.58655605
sas	-0.008094102	0.0367703	-0.22012612
Soil	0.008285591	0.1417523	0.05845119
sas:Soil	-0.010163801	0.0367703	-0.27641337

(Dispersion Parameter for Gaussian family taken to be 0.0608015)

Null Deviance: 3.503884 on 59 degrees of freedom

Residual Deviance: 3.404886 on 56 degrees of freedom

Number of Fisher Scoring Iterations: 1

Tadpole CoCs

Tadpole body nickel-water

Analysis of Deviance Table

Gaussian model

Response: log(bni)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			7	13.98453		
wni	1	0.831170	6	13.15336	0.3309365	0.5959198
soil	1	1.140677	5	12.01268	0.4541692	0.5373004
wni:soil	1	1.966406	4	10.04628	0.7829390	0.4262277

Summary

Call: glm(formula = log(bni) ~ (wni) * soil, family = gaussian, data = tadpoles)

Deviance Residuals:

1	2	3	4	5	6	7	8
0.1661834	-1.922652	1.929646	1.025566	-1.198743	-0.00874148	0.2385175	-0.2297761

Coefficients:

	Value	Std. Error	t value
(Intercept)	2.1622716	0.8990106	2.40516803
wni	-1.8226621	24.4707727	-0.07448323
soil	-0.9985047	0.8990106	-1.11067060
wni:soil	21.6526789	24.4707727	0.88483838

(Dispersion Parameter for Gaussian family taken to be 2.511569)

Null Deviance: 13.98453 on 7 degrees of freedom

Residual Deviance: 10.04628 on 4 degrees of freedom

Number of Fisher Scoring Iterations: 1

Tadpole body nickel-sediment

Analysis of Deviance Table

```
Gaussian model

Response: log(bni)

Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                     7   13.98453
     sni  1 5.747250         6    8.23728 4.137005 0.1117079
    soil  1 1.732281         5    6.50500 1.246936 0.3266856
sni:soil  1 0.948082         4    5.55692 0.682451 0.4551691
```

Summary

```
Call: glm(formula = log(bni) ~ (sni) * soil, family = gaussian, data =
tadpoles)
Deviance Residuals:
          1         2        3         4         5          6         7
8
 -0.8415348 -1.457536 1.303711 0.8736382 0.1217215 0.03161949 0.3342632
-0.3658827

Coefficients:
                  Value Std. Error    t value
(Intercept) -0.52054352 1.32679596 -0.3923312
        sni  0.03074675 0.01896456  1.6212739
       soil -0.21186134 1.32679596 -0.1596789
   sni:soil  0.01566674 0.01896456  0.8261062

(Dispersion Parameter for Gaussian family taken to be 1.38923 )

    Null Deviance: 13.98453 on 7 degrees of freedom

Residual Deviance: 5.556918 on 4 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Tadpole body copper-water

Analysis of Deviance Table

```
Gaussian model

Response: log(bcu)

Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                     7   4.301068
     wcu  1 1.333763         6   2.967305 4.206899 0.1095568
    soil  1 0.676088         5   2.291217 2.132490 0.2179910
wcu:soil  1 1.023050         4   1.268167 3.226861 0.1468615
```

Summary

```
Call: glm(formula = log(bcu) ~ (wcu) * soil, family = gaussian, data =
tadpoles)
Deviance Residuals:
          1          2         3         4          5           6
7
 -0.2251386 -0.7254658 0.7520784 0.3207923 -0.1222663 -0.03079386
0.07142465
           8
 -0.04063079

Coefficients:
                  Value Std. Error    t value
(Intercept)   2.8102658  0.3275818  8.5788224
        wcu -21.0484755 51.8870781 -0.4056593
       soil  -0.7583595  0.3275818 -2.3150236
   wcu:soil  93.2071718 51.8870781  1.7963465

(Dispersion Parameter for Gaussian family taken to be 0.3170418 )

    Null Deviance: 4.301068 on 7 degrees of freedom

Residual Deviance: 1.268167 on 4 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Tadpole body copper-sediment

Analysis of Deviance Table

```
> anova(tadpolebody.coc.cu.2.glm, test="F")
Analysis of Deviance Table

Gaussian model

Response: log(bcu)

Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                     7   4.301068
     scu  1 3.388870         6   0.912198 18.27744 0.0128966
    soil  1 0.017529         5   0.894669  0.09454 0.7738290
scu:soil  1 0.153019         4   0.741651  0.82529 0.4150232
```

Summary

```
Call: glm(formula = log(bcu) ~ (scu) * soil, family = gaussian, data =
tadpoles)
Deviance Residuals:
            1          2         3          4          5        6 7
8
 -0.009253609 -0.3620701 0.5983218 -0.2535416 0.02654351 0.306181 0 -
0.306181

Coefficients:
                  Value Std. Error    t value
(Intercept)  0.78730062  1.3629289  0.5776535
        scu  0.03479620  0.0302737  1.1493871
       soil  1.28161425  1.3629289  0.9403383
   scu:soil -0.02750223  0.0302737 -0.9084529

(Dispersion Parameter for Gaussian family taken to be 0.1854127 )

    Null Deviance: 4.301068 on 7 degrees of freedom

Residual Deviance: 0.7416508 on 4 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Tadpole body cobalt-water

Analysis of Deviance Table

```
Gaussian model

Response: log(bco)

Terms added sequentially (first to last)
        Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                    7   5.912083
     wco  1 0.123829        6   5.788254 0.116909 0.7496207
    soil  1 0.001012        5   5.787242 0.000955 0.9768252
wco:soil  1 1.550464        4   4.236779 1.463814 0.2929341
```

Summary

```
Call: glm(formula = log(bco) ~ (wco) * soil, family = gaussian, data =
tadpoles)
Deviance Residuals:
        1          2        3         4          5             6
7
 -0.904199 -0.9683563 1.387503 0.7071622 -0.2221101 -0.003585166
0.06049968
           8
 -0.05691451

Coefficients:
                   Value  Std. Error    t value
```

```
(Intercept)    0.4863197   0.4791047  1.0150593
        wco  -38.8425925 178.0651008 -0.2181370
       soil   -0.3163042   0.4791047 -0.6601985
   wco:soil  215.4377076 178.0651008  1.2098817
```

(Dispersion Parameter for Gaussian family taken to be 1.059195)

Null Deviance: 5.912083 on 7 degrees of freedom

Residual Deviance: 4.236779 on 4 degrees of freedom

Number of Fisher Scoring Iterations: 1

Tadpole body cobalt-sediment

Analysis of Deviance Table

Gaussian model

Response: log(bco)

Terms added sequentially (first to last)

```
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                     7   5.912083
     sco  1 1.568162         6   4.343921 1.654234 0.2677834
    soil  1 0.401086         5   3.942835 0.423101 0.5508655
sco:soil  1 0.150963         4   3.791873 0.159249 0.7102368
```

Summary

Call: glm(formula = log(bco) ~ (sco) * soil, family = gaussian, data = tadpoles)

Deviance Residuals:

```
         1          2        3         4          5         6
7         8
 -1.146051 -0.6921203 1.122912 0.7799741 -0.0647146 0.1448737 -
0.2897473 0.1448737
```

Coefficients:

```
                  Value Std. Error    t value
(Intercept) -1.73570564   1.766003 -0.9828442
        sco  0.23733017   0.185452  1.2797389
       soil -0.44010415   1.766003 -0.2492092
   sco:soil  0.07400642   0.185452  0.3990596
```

(Dispersion Parameter for Gaussian family taken to be 0.9479682)

Null Deviance: 5.912083 on 7 degrees of freedom

Residual Deviance: 3.791873 on 4 degrees of freedom

Number of Fisher Scoring Iterations: 1

Tadpole body arsenic-water

Analysis of Deviance Table

Gaussian model

Response: log(bas)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			7	2.203354		
was	1	1.033655	6	1.169700	3.813306	0.1225671
soil	1	0.013017	5	1.156683	0.048022	0.8372690
was:soil	1	0.072422	4	1.084261	0.267174	0.6324990

Summary

Call: glm(formula = log(bas) ~ (was) * soil, family = gaussian, data = tadpoles)

Deviance Residuals:

1	2	3	4	5	6	7	8
-0.02470266	-0.02470266	0.7307589	0.04940531	-0.7307589	-0.02997915	0.08993744	-0.05995829

Coefficients:

	Value	Std. Error	t value
(Intercept)	0.1117232	0.3815391	0.2928224
was	460.0511125	288.4164346	1.5950933
soil	0.1292214	0.3815391	0.3386847
was:soil	-149.0792865	288.4164346	-0.5168890

(Dispersion Parameter for Gaussian family taken to be 0.2710652)

Null Deviance: 2.203354 on 7 degrees of freedom

Residual Deviance: 1.084261 on 4 degrees of freedom

Number of Fisher Scoring Iterations: 1

Tadpole body arsenic-sediment

Analysis of Deviance Table

```
Gaussian model

Response: log(bas)

Terms added sequentially (first to last)
         Df   Deviance Resid. Df Resid. Dev   F Value     Pr(F)
    NULL                       7   2.203354
     sas  1 0.03314567         6   2.170209 0.0637467 0.8131126
    soil  1 0.00318841         5   2.167020 0.0061321 0.9413444
sas:soil  1 0.08718609         4   2.079834 0.1676789 0.7031619
```

Summary

```
Call: glm(formula = log(bas) ~ (sas) * soil, family = gaussian, data =
tadpoles)
Deviance Residuals:
          1          2        3          4          5            6
7
 -0.4774291 -0.3831067 1.238889 -0.3561599 -0.0221935 -0.005199422
0.1490501
          8
 -0.1438507

Coefficients:
                 Value Std. Error     t value
(Intercept)  0.6543734  1.0488715  0.62388329
        sas  0.0173485  0.2455625  0.07064799
       soil  0.4333531  1.0488715  0.41316127
   sas:soil -0.1005545  0.2455625 -0.40948617

(Dispersion Parameter for Gaussian family taken to be 0.5199586 )

    Null Deviance: 2.203354 on 7 degrees of freedom

Residual Deviance: 2.079834 on 4 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Tadpole GI Tract nickel-water

Analysis of Deviance Table

Gaussian model

Response: log(gni)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			7	7.127762		
wni	1	0.784780	6	6.342982	1.078923	0.3576009
soil	1	1.589738	5	4.753244	2.185587	0.2133845
wni:soil	1	1.843749	4	2.909495	2.534803	0.1865763

Summary

Call: glm(formula = log(gni) ~ (wni) * soil, family = gaussian, data = tadpoles)

Deviance Residuals:

1	2	3	4	5	6	7	8
0.8259417	-0.6579813	0.02950153	0.4756429	-0.6731049	-0.02785072	0.7599267	-0.7320759

Coefficients:

	Value	Std. Error	t value
(Intercept)	4.587837	0.4838058	9.4828074
wni	-1.439160	13.1690338	-0.1092837
soil	-1.050116	0.4838058	-2.1705322
wni:soil	20.966502	13.1690338	1.5921063

(Dispersion Parameter for Gaussian family taken to be 0.7273738)

Null Deviance: 7.127762 on 7 degrees of freedom

Residual Deviance: 2.909495 on 4 degrees of freedom

Number of Fisher Scoring Iterations: 1

Tadpole GI Tract nickel-sediment

Analysis of Deviance Table

Gaussian model

Response: log(gni)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			7	7.127762		
sni	1	3.971781	6	3.155981	8.989762	0.0400093
soil	1	0.297724	5	2.858257	0.673871	0.4578104
sni:soil	1	1.091010	4	1.767247	2.469402	0.1911790

Summary

Call: glm(formula = log(gni) ~ (sni) * soil, family = gaussian, data = tadpoles)

Deviance Residuals:

1	2	3	4	5	6	7	8
0.1704761	-0.1915913	-0.3086868	0.3627692	-0.03296726	0.07729155	0.8170821	-0.8943736

Coefficients:

	Value	Std. Error	t value
(Intercept)	2.52339815	0.74823102	3.3724853
sni	0.02636732	0.01069484	2.4654240
soil	-0.71325178	0.74823102	-0.9532508
sni:soil	0.01680623	0.01069484	1.5714331

(Dispersion Parameter for Gaussian family taken to be 0.4418116)

Null Deviance: 7.127762 on 7 degrees of freedom

Residual Deviance: 1.767246 on 4 degrees of freedom

Number of Fisher Scoring Iterations: 1

Tadpole GI Tract copper-water

Analysis of Deviance Table

Gaussian model

Response: log(gcu)

```
Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                    7   2.751975
     wcu  1 0.097359        6   2.654616 0.383519 0.5692562
    soil  1 0.095779        5   2.558837 0.377295 0.5722714
wcu:soil  1 1.543407        4   1.015430 6.079817 0.0692637
```

Summary

```
Call: glm(formula = log(gcu) ~ (wcu) * soil, family = gaussian, data =
tadpoles)
Deviance Residuals:
           1          2         3         4          5          6
7          8
 0.001415497 -0.4997972 0.1395631 0.4669179 -0.1080993 -0.2521843
0.5849275 -0.3327432

Coefficients:
                   Value Std. Error    t value
(Intercept)    3.9886220  0.2931274  13.607127
        wcu   54.1863708 46.4297066   1.167063
       soil   -0.6738551  0.2931274  -2.298847
   wcu:soil  114.4830477 46.4297066   2.465728

(Dispersion Parameter for Gaussian family taken to be 0.2538575 )

    Null Deviance: 2.751975 on 7 degrees of freedom

Residual Deviance: 1.01543 on 4 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Tadpole GI Tract copper-sediment

Analysis of Deviance Table

Gaussian model

Response: log(gcu)

```
Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                    7   2.751975
     scu  1 1.317989        6   1.433986 4.251267 0.1082240
    soil  1 0.063744        5   1.370241 0.205612 0.6737390
scu:soil  1 0.130151        4   1.240091 0.419810 0.5523453
```

Summary

```
Call: glm(formula = log(gcu) ~ (scu) * soil, family = gaussian, data =
tadpoles)
Deviance Residuals:
         1          2          3         4          5         6 7
8
 0.1091323 -0.3165638 0.03434411 0.1273192 0.04576829 0.7444743 0 -
0.7444743

Coefficients:
                  Value Std. Error    t value
(Intercept)  1.31958563 1.76238262  0.7487509
        scu  0.06134774 0.03914646  1.5671336
       soil -1.03020318 1.76238262 -0.5845514
   scu:soil  0.02536407 0.03914646  0.6479275

(Dispersion Parameter for Gaussian family taken to be 0.3100227 )

    Null Deviance: 2.751975 on 7 degrees of freedom

Residual Deviance: 1.240091 on 4 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Tadpole GI Tract cobalt-water

Analysis of Deviance Table

Gaussian model

Response: log(aco)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			7	2.717930		
wco	1	0.343853	6	2.374078	1.138732	0.3460449
soil	1	0.017503	5	2.356575	0.057963	0.8215817
wco:soil	1	1.148730	4	1.207845	3.804231	0.1228946

Summary

```
Call: glm(formula = log(aco) ~ (wco) * soil, family = gaussian, data =
tadpoles)
Deviance Residuals:
          1          2          3         4          5           6
7
 0.04577016 -0.5288539 0.02901117 0.5686888 -0.1146162 -0.03308537
0.5583157
          8
 -0.5252303

Coefficients:
                   Value Std. Error     t value
(Intercept)    2.5406893  0.2558104  9.93192519
        wco    3.9473416 95.0750344  0.04151817
       soil   -0.2320178  0.2558104 -0.90699159
   wco:soil  185.4385133 95.0750344  1.95044382

(Dispersion Parameter for Gaussian family taken to be 0.3019612 )

    Null Deviance: 2.71793 on 7 degrees of freedom

Residual Deviance: 1.207845 on 4 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Tadpole GI Tract cobalt-sediment

Analysis of Deviance Table

```
Gaussian model

Response: log(aco)

Terms added sequentially (first to last)
         Df  Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                     7   2.717930
     sco  1 0.8603114        6   1.857619 6.022541 0.0701361
    soil  1 0.4720024        5   1.385617 3.304215 0.1432511
sco:soil  1 0.8142223        4   0.571394 5.699898 0.0753766
```

Summary

```
Call: glm(formula = log(aco) ~ (sco) * soil, family = gaussian, data =
tadpoles)
Deviance Residuals:
           1          2          3         4          5           6
7
 -0.07200703 -0.3343457 -0.1094188 0.6180041 -0.1022326 -0.09135021
0.1827004
           8
 -0.09135021
```

```
Coefficients:
                 Value Std. Error    t value
(Intercept)  0.1433320 0.68553947  0.2090792
        sco  0.2707524 0.07199008  3.7609686
       soil -1.3290376 0.68553947 -1.9386741
   sco:soil  0.1718724 0.07199008  2.3874460

(Dispersion Parameter for Gaussian family taken to be 0.1428486 )

    Null Deviance: 2.71793 on 7 degrees of freedom

Residual Deviance: 0.5713943 on 4 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Tadpole GI Tract arsenic-water

Analysis of Deviance Table

```
Gaussian model

Response: log(gas)

Terms added sequentially (first to last)
         Df  Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                      7   1.210012
     was  1 0.2301973         6   0.979814 1.218311 0.3316256
    soil  1 0.1705500         5   0.809265 0.902630 0.3958764
was:soil  1 0.0534731         4   0.755791 0.283005 0.6229131
```

Summary

```
Call: glm(formula = log(gas) ~ (was) * soil, family = gaussian, data =
tadpoles)
Deviance Residuals:
         1         2        3           4         5           6
7          8
 0.2960977 -0.250446 0.280689 -0.04565163 -0.280689 -0.1784332
0.5352996 -0.3568664

Coefficients:
                    Value  Std. Error    t value
(Intercept)   2.063256302   0.3185467 6.47709242
        was 284.792086922 240.7986579 1.18269798
       soil   0.004086388   0.3185467 0.01282822
   was:soil 128.100537296 240.7986579 0.53198194

(Dispersion Parameter for Gaussian family taken to be 0.1889478 )

    Null Deviance: 1.210012 on 7 degrees of freedom

Residual Deviance: 0.7557914 on 4 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Tadpole GI Tract arsenic-sediment

Analysis of Deviance Table

Gaussian model

Response: log(gas)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			7	1.210012		
sas	1	0.0394308	6	1.170581	0.1771004	0.6955037
soil	1	0.1569209	5	1.013660	0.7047987	0.4484223
sas:soil	1	0.1230746	4	0.890586	0.5527807	0.4984815

Summary

Call: glm(formula = log(gas) ~ (sas) * soil, family = gaussian, data = tadpoles)

Deviance Residuals:

1	2	3	4	5	6	7	8
0.07386182	-0.3340647	0.362799	-0.1985789	0.0959827	-0.01932713	0.5540444	-0.5347173

Coefficients:

	Value	Std. Error	t value
(Intercept)	2.26419471	0.6863501	3.2988916
sas	0.05380065	0.1606888	0.3348127
soil	0.66683783	0.6863501	0.9715709
sas:soil	-0.11947087	0.1606888	-0.7434922

(Dispersion Parameter for Gaussian family taken to be 0.2226464)

Null Deviance: 1.210012 on 7 degrees of freedom

Residual Deviance: 0.8905855 on 4 degrees of freedom

Number of Fisher Scoring Iterations: 1

Meadow Vole CoCs

Meadow Vole liver nickel

Analysis of Deviance Table

Gaussian model

Response: log(Liver.Ni)

```
Terms added sequentially (first to last)
        Df Deviance Resid. Df Resid. Dev  F Value        Pr(F)
   NULL                    22   12.24960
soil.ni  1 5.269922        21    6.97968 15.85579 0.0006783705
```

Summary

```
Call: glm(formula = log(Liver.Ni) ~ soil.ni, family = gaussian, data =
voles)
Deviance Residuals:
        Min         1Q     Median        3Q    Max
 -0.8437134 -0.3882887 -0.2485746 0.4102614 1.4011

Coefficients:
                    Value    Std. Error    t value
(Intercept) -1.9364336239 0.16181191395 -11.967188
    soil.ni  0.0002406445 0.00006043408   3.981933

(Dispersion Parameter for Gaussian family taken to be 0.3323657 )

    Null Deviance: 12.2496 on 22 degrees of freedom

Residual Deviance: 6.979679 on 21 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Meadow Vole liver copper

Analysis of Deviance Table

Gaussian model

Response: log(Liver.Cu)

```
Terms added sequentially (first to last)
        Df    Deviance Resid. Df Resid. Dev    F Value     Pr(F)
   NULL                       22  0.7426750
soil.cu  1 0.001345217        21  0.7413298 0.03810659 0.8471056
```

Summary

```
Call: glm(formula = log(Liver.Cu) ~ soil.cu, family = gaussian, data =
voles)
Deviance Residuals:
        Min          1Q      Median         3Q       Max
 -0.4046461 -0.09808342 0.008063226 0.07800009 0.3749973

Coefficients:
                    Value   Std. Error    t value
(Intercept) 2.66242029805 0.0546867404 48.6849331
    soil.cu 0.00003067839 0.0001571566  0.1952091

(Dispersion Parameter for Gaussian family taken to be 0.0353014 )

    Null Deviance: 0.742675 on 22 degrees of freedom

Residual Deviance: 0.7413298 on 21 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Meadow Vole liver cobalt

Analysis of Deviance Table

```
Gaussian model

Response: log(Liver.Co)

Terms added sequentially (first to last)
        Df Deviance Resid. Df Resid. Dev  F Value         Pr(F)
   NULL                    22   33.16628
soil.co  1 27.53776        21    5.62852 102.7432 1.527877e-009
```

Summary

```
Call: glm(formula = log(Liver.Co) ~ soil.co, family = gaussian, data =
voles)
Deviance Residuals:
       Min         1Q     Median        3Q       Max
 -1.104946 -0.3079641 0.06902448 0.3971613 0.8380305

Coefficients:
                  Value  Std. Error   t value
(Intercept) -2.52114983 0.169886198 -14.84023
    soil.co  0.03987265 0.003933675  10.13623

(Dispersion Parameter for Gaussian family taken to be 0.268025 )

    Null Deviance: 33.16628 on 22 degrees of freedom

Residual Deviance: 5.628525 on 21 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Meadow Vole liver arsenic

Analysis of Deviance Table

```
Gaussian model

Response: log(Liver.As)

Terms added sequentially (first to last)
        Df   Deviance Resid. Df Resid. Dev   F Value     Pr(F)
   NULL                      22   2.354438
soil.as  1 0.09117717        21   2.263261 0.8460008 0.3681315
```

Summary

```
Call: glm(formula = log(Liver.As) ~ soil.as, family = gaussian, data =
voles)
Deviance Residuals:
        Min         1Q     Median        3Q       Max
 -0.6034267 -0.2492534 0.08972051 0.1034244 0.8000955

Coefficients:
                   Value  Std. Error    t value
(Intercept) -1.733613992 0.111450391 -15.555028
    soil.as  0.007830811 0.008513759   0.919783

(Dispersion Parameter for Gaussian family taken to be 0.1077743 )

    Null Deviance: 2.354438 on 22 degrees of freedom

Residual Deviance: 2.263261 on 21 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Meadow Vole body nickel

Analysis of Deviance Table

```
Gaussian model

Response: log(Body.Ni)

Terms added sequentially (first to last)
        Df Deviance Resid. Df Resid. Dev  F Value         Pr(F)
   NULL                    22   34.29704
soil.ni  1 30.39339        21    3.90365 163.5038 2.237444e-011
```

Summary

```
Call: glm(formula = log(Body.Ni) ~ soil.ni, family = gaussian, data =
voles)
Deviance Residuals:
        Min         1Q     Median        3Q       Max
 -0.7411153 -0.3475931 -0.1330335 0.3120024 0.7937361

Coefficients:
                   Value    Std. Error   t value
(Intercept) 0.3410049457 0.12101189599  2.817946
    soil.ni 0.0005779142 0.00004519595 12.786860

(Dispersion Parameter for Gaussian family taken to be 0.185888 )

    Null Deviance: 34.29704 on 22 degrees of freedom

Residual Deviance: 3.903648 on 21 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Meadow Vole body copper

Analysis of Deviance Table

```
Gaussian model

Response: log(Body.Cu)

Terms added sequentially (first to last)
        Df   Deviance Resid. Df Resid. Dev   F Value     Pr(F)
   NULL                      22  0.8189103
soil.cu  1 0.02288304        21  0.7960273 0.6036775 0.4458428
```

Summary

```
Call: glm(formula = log(Body.Cu) ~ soil.cu, family = gaussian, data =
voles)
Deviance Residuals:
        Min         1Q      Median         3Q       Max
 -0.1893493 -0.1119846 -0.04680071 0.05676573 0.6712354

Coefficients:
                   Value   Std. Error    t value
(Intercept) 2.2137808961 0.0566683132 39.0655866
    soil.cu 0.0001265299 0.0001628511  0.7769669

(Dispersion Parameter for Gaussian family taken to be 0.0379061 )

    Null Deviance: 0.8189103 on 22 degrees of freedom

Residual Deviance: 0.7960273 on 21 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Meadow Vole body cobalt

Analysis of Deviance Table

Gaussian model

Response: log(Body.Co)

Terms added sequentially (first to last)

```
        Df Deviance Resid. Df Resid. Dev  F Value         Pr(F)
   NULL                    22   20.21735
soil.co  1 14.69857        21    5.51878 55.93086 2.383906e-007
```

Summary

```
> summary(vole.body.co.glm, corr=F)

Call: glm(formula = log(Body.Co) ~ soil.co, family = gaussian, data =
voles)
Deviance Residuals:
        Min         1Q     Median        3Q       Max
 -0.7475091 -0.3795774 0.04080558 0.2964008 0.9938063

Coefficients:
                  Value  Std. Error    t value
(Intercept) -1.97721785 0.168221785 -11.753637
    soil.co  0.02913052 0.003895136   7.478694

(Dispersion Parameter for Gaussian family taken to be 0.2627989 )

    Null Deviance: 20.21735 on 22 degrees of freedom

Residual Deviance: 5.518777 on 21 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Meadow Vole body arsenic

Analysis of Deviance Table

Gaussian model

Response: log(Body.As)

Terms added sequentially (first to last)

```
        Df Deviance Resid. Df Resid. Dev  F Value      Pr(F)
   NULL                    22   8.923360
soil.as  1 1.245685        21   7.677675 3.407201 0.07905859
```

Summary

```
Call: glm(formula = log(Body.As) ~ soil.as, family = gaussian, data =
voles)
Deviance Residuals:
        Min         1Q     Median        3Q      Max
 -0.7106868 -0.4140045 0.06326478 0.1269429 1.358067

Coefficients:
                  Value Std. Error   t value
(Intercept) -1.80005901 0.20527173 -8.769152
    soil.as  0.02894462 0.01568082  1.845861

(Dispersion Parameter for Gaussian family taken to be 0.3656036 )

    Null Deviance: 8.92336 on 22 degrees of freedom

Residual Deviance: 7.677675 on 21 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Meadow Vole total nickel

Analysis of Deviance Table

```
Gaussian model

Response: log(Total.Ni)

Terms added sequentially (first to last)
        Df Deviance Resid. Df Resid. Dev  F Value         Pr(F)
   NULL                    22   33.94342
soil.ni  1 30.10173        21    3.84169 164.5464 2.108225e-011
```

Summary

```
Call: glm(formula = log(Total.Ni) ~ soil.ni, family = gaussian, data =
voles)
Deviance Residuals:
        Min         1Q     Median        3Q       Max
 -0.7328445 -0.3509855 -0.1194171 0.3234968 0.7791475

Coefficients:
                   Value    Std. Error   t value
(Intercept) 0.3091927527 0.12004774571  2.575581
    soil.ni 0.0005751347 0.00004483585 12.827562

(Dispersion Parameter for Gaussian family taken to be 0.1829377 )

    Null Deviance: 33.94342 on 22 degrees of freedom

Residual Deviance: 3.841692 on 21 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Meadow Vole total copper

Analysis of Deviance Table

Gaussian model

Response: log(Total.Cu)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			22	0.7411618		
soil.cu	1	0.02410999	21	0.7170518	0.7060995	0.4102074

Summary

Call: glm(formula = log(Total.Cu) ~ soil.cu, family = gaussian, data = voles)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-0.173139	-0.1138192	-0.0527983	0.05466542	0.644301

Coefficients:

	Value	Std. Error	t value
(Intercept)	2.2344107330	0.0537838103	41.5442997
soil.cu	0.0001298778	0.0001545618	0.8402972

(Dispersion Parameter for Gaussian family taken to be 0.0341453)

Null Deviance: 0.7411618 on 22 degrees of freedom

Residual Deviance: 0.7170518 on 21 degrees of freedom

Number of Fisher Scoring Iterations: 1

Meadow Vole total cobalt

Analysis of Deviance Table

Gaussian model

Response: log(Total.Co)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			22	20.54436		
soil.co	1	15.08423	21	5.46013	58.01492	1.792659e-007

Summary

```
Call: glm(formula = log(Total.Co) ~ soil.co, family = gaussian, data =
voles)
Deviance Residuals:
        Min         1Q     Median        3Q       Max
 -0.7509013 -0.3788248 0.03966939 0.2931637 0.9823917

Coefficients:
                  Value  Std. Error    t value
(Intercept) -1.99263027 0.167325523 -11.908705
    soil.co  0.02951021 0.003874383   7.616752

(Dispersion Parameter for Gaussian family taken to be 0.2600061 )

    Null Deviance: 20.54436 on 22 degrees of freedom

Residual Deviance: 5.460127 on 21 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Meadow Vole total arsenic

Analysis of Deviance Table

```
Gaussian model

Response: log(Total.As)

Terms added sequentially (first to last)
        Df Deviance Resid. Df Resid. Dev  F Value      Pr(F)
   NULL                    22   8.513289
soil.as  1 1.221492        21   7.291797 3.517833 0.07468422
```

Summary

```
Call: glm(formula = log(Total.As) ~ soil.as, family = gaussian, data =
voles)
Deviance Residuals:
        Min         1Q     Median       3Q      Max
 -0.7041976 -0.4186034 0.05748058 0.122512 1.314273

Coefficients:
                  Value Std. Error   t value
(Intercept) -1.80056023 0.20004678 -9.000696
    soil.as  0.02866216 0.01528169  1.875589

(Dispersion Parameter for Gaussian family taken to be 0.3472284 )

    Null Deviance: 8.513289 on 22 degrees of freedom

Residual Deviance: 7.291797 on 21 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Maple CoCs

Maple total nickel

Analysis of Deviance Table

Gaussian model

Response: log(tni)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			51	96.50908		
sni	1	13.52762	50	82.98146	12.91925	0.0007649
soil	1	0.02264	49	82.95881	0.02163	0.8837013
sni:soil	1	32.69850	48	50.26032	31.22797	0.0000011

Summary

Call: glm(formula = log(tni) ~ sni * soil, family = gaussian, data = maples)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-2.463021	-0.6977228	-0.04537118	0.8144479	1.973239

Coefficients:

	Value	Std. Error	t value
(Intercept)	0.6754997945	0.2558965460	2.639738
sni	0.0008382897	0.0001396834	6.001354
soil	-0.5442031252	0.2558965460	-2.126653
sni:soil	0.0007805789	0.0001396834	5.588199

(Dispersion Parameter for Gaussian family taken to be 1.04709)

Null Deviance: 96.50908 on 51 degrees of freedom

Residual Deviance: 50.26032 on 48 degrees of freedom

Number of Fisher Scoring Iterations: 1

Maple total copper

Analysis of Deviance Table

Gaussian model

Response: log(tcu)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			51	8.732391		
scu	1	0.5723489	50	8.160043	3.632332	0.0626654
soil	1	0.1281526	49	8.031890	0.813302	0.3716489
scu:soil	1	0.4684988	48	7.563391	2.973262	0.0910864

Summary

Call: glm(formula = log(tcu) ~ scu * soil, family = gaussian, data = maples)
Deviance Residuals:

Min	1Q	Median	3Q	Max
-0.8829385	-0.2472396	-0.08495914	0.1428822	0.9881681

Coefficients:

	Value	Std. Error	t value
(Intercept)	2.1693854763	0.1043426042	20.790985
scu	-0.0008393413	0.0004646099	-1.806551
soil	0.1698707662	0.1043426042	1.628010
scu:soil	-0.0008011338	0.0004646099	-1.724315

(Dispersion Parameter for Gaussian family taken to be 0.1575706)

Null Deviance: 8.732392 on 51 degrees of freedom

Residual Deviance: 7.563391 on 48 degrees of freedom

Number of Fisher Scoring Iterations: 1

Maple total cobalt

Analysis of Deviance Table

Gaussian model

Response: log(tco)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			51	46.17362		
sco	1	6.04057	50	40.13305	11.62151	0.0013294
soil	1	0.66551	49	39.46754	1.28038	0.2634499
sco:soil	1	14.51837	48	24.94918	27.93205	0.0000030

Summary

```
Call: glm(formula = log(tco) ~ sco * soil, family = gaussian, data =
maples)
Deviance Residuals:
       Min         1Q     Median        3Q      Max
 -1.540216 -0.6327939 0.04053249 0.5814577 1.258447

Coefficients:
                  Value  Std. Error    t value
(Intercept) -2.58724904 0.196283646 -13.181175
        sco  0.03164174 0.005300308   5.969792
       soil -0.33952569 0.196283646  -1.729771
   sco:soil  0.02801254 0.005300308   5.285078

(Dispersion Parameter for Gaussian family taken to be 0.5197745 )

    Null Deviance: 46.17362 on 51 degrees of freedom

Residual Deviance: 24.94918 on 48 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Maple total arsenic

Analysis of Deviance Table

```
Gaussian model

Response: log(tas)

Terms added sequentially (first to last)
         Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
    NULL                    51   9.535455
     sas  1 2.121788        50   7.413667 13.91109 0.0005064
    soil  1 0.086912        49   7.326755  0.56982 0.4540172
sas:soil  1 0.005556        48   7.321199  0.03642 0.8494473
```

Summary

```
Call: glm(formula = log(tas) ~ sas * soil, family = gaussian, data =
maples)
Deviance Residuals:
        Min            1Q        Median            3Q      Max
 -0.6028537 1.554312e-015 2.331468e-015 2.664535e-015 1.235876

Coefficients:
                   Value Std. Error     t value
(Intercept) -1.552048256 0.12386923 -12.5297323
        sas  0.001914017 0.01002886   0.1908510
       soil -0.057389656 0.12386923  -0.4633084
   sas:soil -0.001914017 0.01002886  -0.1908510

(Dispersion Parameter for Gaussian family taken to be 0.152525 )
```

```
    Null Deviance: 9.535455 on 51 degrees of freedom

Residual Deviance: 7.321199 on 48 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Insect CoCs

Insect total nickel

Analysis of Deviance Table

```
Gaussian model

Response: log(Tis.Ni)

Terms added sequentially (first to last)
                  Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
             NULL                    26   51.00232
          Soil.Ni  1 16.62255        25   34.37977 10.86766 0.0036043
        Soil.Type  1  1.34991        24   33.02986  0.88256 0.3587110
          Habitat  1  0.03077        23   32.99909  0.02012 0.8886255
Soil.Ni:Soil.Type  1  0.19514        22   32.80395  0.12758 0.7246922
  Soil.Ni:Habitat  1  1.74111        21   31.06284  1.13832 0.2987184
Soil.Type:Habitat  1  0.47199        20   30.59085  0.30859 0.5847105
```

Summary

```
Call: glm(formula = log(Tis.Ni) ~ Soil.Ni + Soil.Type + Habitat +
Soil.Ni:Soil.Type + So
il.Ni:
      Habitat + Soil.Type:Habitat, family = gaussian, data = insectcoc,
na.action =
      na.omit)
Deviance Residuals:
       Min         1Q     Median        3Q      Max
 -1.651574 -0.8384224 -0.1827572 0.6130211 2.796567

Coefficients:
                           Value   Std. Error    t value
      (Intercept)  0.21654855932 0.3603439901  0.6009496
          Soil.Ni  0.00057598580 0.0001870418  3.0794497
        Soil.Type -0.30107583713 0.3676179037 -0.8189912
          Habitat  0.15302334039 0.3450051336  0.4435393
Soil.Ni:Soil.Type  0.00006064911 0.0002067228  0.2933837
  Soil.Ni:Habitat -0.00020062557 0.0001847046 -1.0861970
Soil.Type:Habitat -0.16305452125 0.2935250205 -0.5555047

(Dispersion Parameter for Gaussian family taken to be 1.529542 )

    Null Deviance: 51.00232 on 26 degrees of freedom

Residual Deviance: 30.59085 on 20 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Insect total copper

Analysis of Deviance Table

Gaussian model

Response: log(Tis.Cu)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			26	6.201459		
Soil.Cu	1	0.210265	25	5.991195	3.79906	0.0654462
Soil.Type	1	0.338594	24	5.652600	6.11773	0.0224719
Habitat	1	4.367015	23	1.285585	78.90334	0.0000000
Soil.Cu:Soil.Type	1	0.156818	22	1.128767	2.83339	0.1078693
Soil.Cu:Habitat	1	0.017426	21	1.111340	0.31486	0.5809457
Soil.Type:Habitat	1	0.004413	20	1.106928	0.07973	0.7805708

Summary

```
Call: glm(formula = log(Tis.Cu) ~ Soil.Cu + Soil.Type + Habitat +
Soil.Cu:Soil.Type + So
il.Cu:
      Habitat + Soil.Type:Habitat, family = gaussian, data = insectcoc,
na.action =
      na.omit)
Deviance Residuals:
        Min         1Q     Median        3Q       Max
 -0.4173769 -0.1519114 0.02301937 0.1291875 0.3720556
```

Coefficients:

	Value	Std. Error	t value
(Intercept)	3.3486396104	0.0723482174	46.2850327
Soil.Cu	-0.0002759979	0.0002612820	-1.0563218
Soil.Type	-0.1941145724	0.0750797313	-2.5854458
Habitat	-0.4458048747	0.0716807662	-6.2193096
Soil.Cu:Soil.Type	0.0003401150	0.0003113094	1.0925304
Soil.Cu:Habitat	0.0001761034	0.0003005296	0.5859769
Soil.Type:Habitat	-0.0157552327	0.0557988879	-0.2823575

(Dispersion Parameter for Gaussian family taken to be 0.0553464)

Null Deviance: 6.201459 on 26 degrees of freedom

Residual Deviance: 1.106928 on 20 degrees of freedom

Number of Fisher Scoring Iterations: 1

Insect total cobalt

Analysis of Deviance Table

Gaussian model

Response: log(Tis.Co)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			26	21.00611		
Soil.Co	1	5.902634	25	15.10347	10.11718	0.0046980
Soil.Type	1	0.804609	24	14.29886	1.37911	0.2540470
Habitat	1	0.369408	23	13.92946	0.63317	0.4355381
Soil.Co:Soil.Type	1	0.160506	22	13.76895	0.27511	0.6056898
Soil.Co:Habitat	1	1.519042	21	12.24991	2.60366	0.1222853
Soil.Type:Habitat	1	0.581370	20	11.66854	0.99648	0.3300900

Summary

Call: glm(formula = log(Tis.Co) ~ Soil.Co + Soil.Type + Habitat + Soil.Co:Soil.Type + So
il.Co:
    Habitat + Soil.Type:Habitat, family = gaussian, data = insectcoc, na.action =
    na.omit)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-1.297249	-0.4444537	-0.09242807	0.3800423	1.999223

Coefficients:

	Value	Std. Error	t value
(Intercept)	-2.716565301	0.254579719	-10.6707844
Soil.Co	0.025370616	0.008023927	3.1618702
Soil.Type	-0.224709064	0.255192780	-0.8805463
Habitat	0.054432617	0.234640306	0.2319832
Soil.Co:Soil.Type	0.002621732	0.007983243	0.3284044
Soil.Co:Habitat	-0.012126194	0.007020644	-1.7272197
Soil.Type:Habitat	-0.186145784	0.186474711	-0.9982361

(Dispersion Parameter for Gaussian family taken to be 0.5834268)

Null Deviance: 21.00611 on 26 degrees of freedom

Residual Deviance: 11.66854 on 20 degrees of freedom

Number of Fisher Scoring Iterations: 1

Insect total arsenic

Analysis of Deviance Table

Gaussian model

Response: log(Tis.As)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			26	7.906432		
Soil.As	1	0.534468	25	7.371964	2.610096	0.1218512
Soil.Type	1	0.671312	24	6.700652	3.278377	0.0852484
Habitat	1	0.004039	23	6.696613	0.019725	0.8897126
Soil.As:Soil.Type	1	0.071353	22	6.625259	0.348458	0.5615989
Soil.As:Habitat	1	0.828922	21	5.796337	4.048073	0.0578880
Soil.Type:Habitat	1	1.700946	20	4.095391	8.306635	0.0092142

Summary

```
>
Call: glm(formula = log(Tis.As) ~ Soil.As + Soil.Type + Habitat +
Soil.As:Soil.Type + So
il.As:
      Habitat + Soil.Type:Habitat, family = gaussian, data = insectcoc,
na.action =
      na.omit)
Deviance Residuals:
       Min         1Q     Median         3Q       Max
 -1.199553 -0.1803689 0.04261415 0.3163489 0.5403226
```

Coefficients:

	Value	Std. Error	t value
(Intercept)	-1.845681065	0.158445632	-11.64867118
Soil.As	0.022727813	0.010466905	2.17139767
Soil.Type	0.122797582	0.156395253	0.78517461
Habitat	0.008312457	0.156459563	0.05312847
Soil.As:Soil.Type	0.005497872	0.009626695	0.57110692
Soil.As:Habitat	-0.018128216	0.010839346	-1.67244559
Soil.Type:Habitat	-0.314402051	0.109086954	-2.88212330

(Dispersion Parameter for Gaussian family taken to be 0.2047696)

Null Deviance: 7.906432 on 26 degrees of freedom

Residual Deviance: 4.095391 on 20 degrees of freedom

Number of Fisher Scoring Iterations: 1

Earthworm CoCs (2001)

Earthworm total nickel

Analysis of Deviance Table

```
Gaussian model

Response: log(Worm.Ni)

Terms added sequentially (first to last)
                Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
           NULL                    12   25.28068
        Soil.Ni  1 13.96713        11   11.31355 16.01508 0.0071037
           Soil  1  3.02338        10    8.29016  3.46669 0.1119278
        Habitat  1  0.21274         9    8.07742  0.24394 0.6389351
   Soil.Ni:Soil  1  2.65086         8    5.42656  3.03955 0.1318834
Soil.Ni:Habitat  1  0.09076         7    5.33580  0.10406 0.7579529
   Soil:Habitat  1  0.10306         6    5.23274  0.11817 0.7427533
```

Summary

```
Call: glm(formula = log(Worm.Ni) ~ Soil.Ni + Soil + Habitat +
Soil.Ni:Soil + Soil.Ni:Hab
itat +
      Soil:Habitat, family = gaussian, data = wormcoc2)
Deviance Residuals:
       Min         1Q      Median        3Q      Max
 -1.090415 -0.4514002 -0.05869116 0.6041095 1.149106

Coefficients:
                         Value   Std. Error    t value
    (Intercept)  3.16754296726 0.4074029114  7.7749640
        Soil.Ni  0.00094523455 0.0002287932  4.1313922
           Soil -0.12134676792 0.3853014200 -0.3149398
        Habitat  0.18545017867 0.3969765793  0.4671565
   Soil.Ni:Soil -0.00034960804 0.0002247896 -1.5552676
Soil.Ni:Habitat -0.00003659741 0.0001891135 -0.1935208
   Soil:Habitat -0.10068115332 0.2928822839 -0.3437598

(Dispersion Parameter for Gaussian family taken to be 0.8721239 )

    Null Deviance: 25.28068 on 12 degrees of freedom

Residual Deviance: 5.232743 on 6 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Earthworm total copper

Analysis of Deviance Table

Gaussian model

Response: log(Worm.Cu)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			12	5.795328		
Soil.Cu	1	3.692569	11	2.102760	47.47474	0.0004614
Soil	1	0.419475	10	1.683284	5.39312	0.0592613
Habitat	1	0.012971	9	1.670313	0.16677	0.6971738
Soil.Cu:Soil	1	1.102336	8	0.567977	14.17255	0.0093473
Soil.Cu:Habitat	1	0.046958	7	0.521019	0.60373	0.4666758
Soil:Habitat	1	0.054341	6	0.466678	0.69865	0.4352536

Summary

```
Call: glm(formula = log(Worm.Cu) ~ Soil.Cu + Soil + Habitat +
Soil.Cu:Soil + Soil.Cu:Hab
itat +
      Soil:Habitat, family = gaussian, data = wormcoc2)
Deviance Residuals:
        Min         1Q       Median        3Q       Max
 -0.2797186 -0.1104265 -0.001834401 0.1853812 0.2742773
```

Coefficients:

	Value	Std. Error	t value
(Intercept)	2.8890938931	0.1283865668	22.5030855
Soil.Cu	0.0039203756	0.0005341920	7.3388883
Soil	0.0931543339	0.1214753613	0.7668578
Habitat	0.0966871863	0.1234793954	0.7830228
Soil.Cu:Soil	-0.0017739033	0.0005347887	-3.3170169
Soil.Cu:Habitat	-0.0001742173	0.0004372715	-0.3984190
Soil:Habitat	-0.0757285299	0.0906003018	-0.8358530

(Dispersion Parameter for Gaussian family taken to be 0.0777797)

Null Deviance: 5.795328 on 12 degrees of freedom

Residual Deviance: 0.4666779 on 6 degrees of freedom

Number of Fisher Scoring Iterations: 1

Earthworm total cobalt

Analysis of Deviance Table

Gaussian model

Response: log(Worm.Co)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			12	3.696650		
Soil.Co	1	0.692257	11	3.004393	2.635441	0.1556292
Soil	1	1.071261	10	1.933132	4.078319	0.0899646
Habitat	1	0.034128	9	1.899004	0.129925	0.7308594
Soil.Co:Soil	1	0.318534	8	1.580471	1.212666	0.3130092
Soil.Co:Habitat	1	0.004437	7	1.576033	0.016893	0.9008362
Soil:Habitat	1	0.000000	6	1.576033	0.000000	0.9995495

Summary

Call: glm(formula = log(Worm.Co) ~ Soil.Co + Soil + Habitat +
Soil.Co:Soil + Soil.Co:Hab
itat +
Soil:Habitat, family = gaussian, data = wormcoc2)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-0.4797333	-0.2164418	-0.01799155	0.09960441	0.8388248

Coefficients:

	Value	Std. Error	t value
(Intercept)	1.72720934802	0.295458417	5.8458627374
Soil.Co	0.02129754355	0.010007229	2.1282159089
Soil	-0.04622772871	0.282665372	-0.1635422420
Habitat	0.03440602564	0.254371122	0.1352591652
Soil.Co:Soil	-0.01081964362	0.009909097	-1.0918899964
Soil.Co:Habitat	0.00085684506	0.006906025	0.1240721010
Soil:Habitat	-0.00009347493	0.158829353	-0.0005885243

(Dispersion Parameter for Gaussian family taken to be 0.2626722)

Null Deviance: 3.69665 on 12 degrees of freedom

Residual Deviance: 1.576033 on 6 degrees of freedom

Number of Fisher Scoring Iterations: 1

Earthworm total arsenic

Analysis of Deviance Table

Gaussian model

Response: log(Worm.As)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			12	11.08408		
Soil.As	1	0.668836	11	10.41524	1.135108	0.3276725
Soil	1	0.053255	10	10.36199	0.090382	0.7738374
Habitat	1	0.001629	9	10.36036	0.002765	0.9597723
Soil.As:Soil	1	2.168048	8	8.19231	3.679480	0.1035246
Soil.As:Habitat	1	1.235665	7	6.95665	2.097097	0.1977415
Soil:Habitat	1	3.421287	6	3.53536	5.806401	0.0525991

Summary

```
Call: glm(formula = log(Worm.As) ~ Soil.As + Soil + Habitat +
Soil.As:Soil + Soil.As:Hab
itat +
      Soil:Habitat, family = gaussian, data = wormcoc2)
Deviance Residuals:
        Min         1Q     Median        3Q      Max
 -0.9724112 -0.2416857 -0.1177998 0.3782038 1.097361
```

Coefficients:

	Value	Std. Error	t value
(Intercept)	1.62239063	0.38326130	4.233119
Soil.As	0.03334157	0.02556772	1.304050
Soil	0.70304464	0.38758760	1.813899
Habitat	0.79794900	0.38693349	2.062238
Soil.As:Soil	-0.03080566	0.02971506	-1.036702
Soil.As:Habitat	-0.04988680	0.02632259	-1.895209
Soil:Habitat	0.61179073	0.25389221	2.409647

(Dispersion Parameter for Gaussian family taken to be 0.5892267)

Null Deviance: 11.08408 on 12 degrees of freedom

Residual Deviance: 3.53536 on 6 degrees of freedom

Number of Fisher Scoring Iterations: 1

Earthworm CoCs (2002)

Earthworm total nickel

Analysis of Deviance Table

```
Gaussian model

Response: log(worm.Ni)

Terms added sequentially (first to last)
                 Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
           NULL                     29   73.07821
        soil.Ni  1 50.05179         28   23.02642 57.88350 0.0000000
       Soiltype  1  0.14010         27   22.88632  0.16202 0.6905943
soil.Ni:Soiltype  1  0.40415         26   22.48217  0.46739 0.5002368
```

Summary

```
Call: glm(formula = log(worm.Ni) ~ soil.Ni * Soiltype, family =
gaussian, data =
      worms2002field)
Deviance Residuals:
       Min        1Q    Median        3Q      Max
 -1.241969 -0.895578 0.2732858 0.7888163 1.513471

Coefficients:
                        Value   Std. Error      t value
     (Intercept)  3.298759498 0.2150490522  15.33956771
         soil.Ni  0.001369675 0.0001972715   6.94309790
        Soiltype  0.011583903 0.2150490522   0.05386633
soil.Ni:Soiltype -0.000134867 0.0001972715  -0.68366185

(Dispersion Parameter for Gaussian family taken to be 0.8646987 )

    Null Deviance: 73.07821 on 29 degrees of freedom

Residual Deviance: 22.48217 on 26 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Earthworm total copper

Analysis of Deviance Table

```
Gaussian model

Response: log(worm.Cu)

Terms added sequentially (first to last)
                 Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
           NULL                     29   22.63531
        soil.Cu  1 18.56360         28    4.07172 151.1991 0.0000000
       Soiltype  1  0.03535         27    4.03637   0.2879 0.5961363
soil.Cu:Soiltype  1  0.84420         26    3.19217   6.8760 0.0144126
```

Summary

```
Call: glm(formula = log(worm.Cu) ~ soil.Cu * Soiltype, family =
gaussian, data =
      worms2002field)
Deviance Residuals:
        Min         1Q      Median        3Q       Max
 -0.7195105 -0.2272584 0.007647642 0.1990579 0.6732568

Coefficients:
                        Value   Std. Error    t value
     (Intercept)  2.646679382 0.0852704051  31.038663
         soil.Cu  0.005594715 0.0004772809  11.722061
        Soiltype  0.099891423 0.0852704051   1.171466
soil.Cu:Soiltype -0.001251528 0.0004772809  -2.622204

(Dispersion Parameter for Gaussian family taken to be 0.1227758 )

    Null Deviance: 22.63531 on 29 degrees of freedom

Residual Deviance: 3.192171 on 26 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Earthworm total cobalt

Analysis of Deviance Table

```
Gaussian model

Response: log(worm.Co)

Terms added sequentially (first to last)
                 Df Deviance Resid. Df Resid. Dev  F Value      Pr(F)
            NULL                    29   18.59902
         soil.Co  1 12.97872        28    5.62030 92.43026 0.00000000
        Soiltype  1  1.15125        27    4.46905  8.19883 0.00817885
soil.Co:Soiltype  1  0.81822        26    3.65083  5.82710 0.02312161
```

Summary

```
Call: glm(formula = log(worm.Co) ~ soil.Co * Soiltype, family =
gaussian, data =
      worms2002field)
Deviance Residuals:
        Min         1Q     Median        3Q       Max
 -0.8366472 -0.2137601 0.03257847 0.1894898 0.7467972

Coefficients:
                       Value  Std. Error     t value
     (Intercept)  1.08395639 0.100266531  10.8107499
         soil.Co  0.04889228 0.005108497   9.5707755
        Soiltype -0.02890882 0.100266531  -0.2883197
soil.Co:Soiltype -0.01233160 0.005108497  -2.4139395
```

```
(Dispersion Parameter for Gaussian family taken to be 0.1404164 )

    Null Deviance: 18.59902 on 29 degrees of freedom

Residual Deviance: 3.650826 on 26 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Earthworm total arsenic

Analysis of Deviance Table

```
Gaussian model

Response: log(worm.As)

Terms added sequentially (first to last)
                 Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
            NULL                    29   11.95735
         soil.As  1 8.845424        28    3.11192 87.62882 0.0000000
        Soiltype  1 0.100013        27    3.01191  0.99080 0.3287208
soil.As:Soiltype  1 0.387418        26    2.62449  3.83802 0.0609081
```

Summary

```
Call: glm(formula = log(worm.As) ~ soil.As * Soiltype, family =
gaussian, data =
      worms2002field)
Deviance Residuals:
        Min         1Q     Median        3Q      Max
 -0.9131495 -0.2264673 0.07634815 0.1815148 0.486106

Coefficients:
                       Value Std. Error   t value
     (Intercept)  0.51223992 0.10447699  4.902897
         soil.As  0.08637491 0.01464926  5.896196
        Soiltype  0.22194420 0.10447699  2.124336
soil.As:Soiltype -0.02869918 0.01464926 -1.959087

(Dispersion Parameter for Gaussian family taken to be 0.100942 )

    Null Deviance: 11.95735 on 29 degrees of freedom

Residual Deviance: 2.624491 on 26 degrees of freedom

Number of Fisher Scoring Iterations:
```

Frog Surveys

Frogs species richness

Analysis of Deviance Table

```
Poisson model

Response: Total

Terms added sequentially (first to last)
             Df Deviance Resid. Df Resid. Dev   Pr(Chi)
        NULL                    28   18.27808
Ni.Treatment  2 2.626542        26   15.65153 0.2689389
     Habitat  1 0.380598        25   15.27094 0.5372835
    northing  1 0.036771        24   15.23417 0.8479330
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = Total ~ Ni.Treatment + Habitat + northing,
      family = poisson, data = frogs, na.action =
      na.omit)
Deviance Residuals:
      Min         1Q    Median        3Q      Max
 -2.21916 -0.3863429 0.0794092 0.3920697 1.103707

Coefficients:
                       Value    Std. Error    t value
  (Intercept)  1.07321016265 0.31661980583  3.3895863
Ni.Treatment1  0.04114561086 0.13224033698  0.3111427
Ni.Treatment2 -0.12137125382 0.08121132800 -1.4945114
      Habitat  0.04985664044 0.08348215767  0.5972131
     northing  0.00001732164 0.00009024408  0.1919421

(Dispersion Parameter for Poisson family taken to be 1 )

    Null Deviance: 18.27808 on 28 degrees of freedom

Residual Deviance: 15.23417 on 24 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Frogs chorus

Analysis of Deviance Table

Binomial model

Response: chorus

```
Terms added sequentially (first to last)
             Df Deviance Resid. Df Resid. Dev   Pr(Chi)
        NULL                    28   35.92382
Ni.Treatment  2 1.137434        26   34.78639 0.5662513
     Habitat  1 1.683505        25   33.10289 0.1944594
    northing  1 1.229789        24   31.87310 0.2674481
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = chorus ~ Ni.Treatment + Habitat +
      northing, family = binomial, data = frogs,
      na.action = na.omit)
Deviance Residuals:
       Min         1Q    Median        3Q      Max
 -2.127943 -0.7748816 0.6754381 0.8909631 1.061785

Coefficients:
                      Value   Std. Error    t value
  (Intercept)  2.7580925044 1.4920159117  1.8485678
Ni.Treatment1 -0.4465476866 0.6164249550 -0.7244153
Ni.Treatment2 -0.3994403535 0.3215210064 -1.2423461
      Habitat -0.6081982579 0.3803107744 -1.5992139
     northing -0.0004429176 0.0004044674 -1.0950638

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 35.92382 on 28 degrees of freedom

Residual Deviance: 31.8731 on 24 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Frogs peeper

Analysis of Deviance Table

Binomial model

Response: peeper

```
Terms added sequentially (first to last)
             Df Deviance Resid. Df Resid. Dev   Pr(Chi)
        NULL                    28   40.16805
Ni.Treatment  2 1.826839        26   38.34121 0.4011502
     Habitat  1 1.304351        25   37.03686 0.2534199
    northing  1 0.209807        24   36.82705 0.6469184
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = peeper ~ Ni.Treatment + Habitat +
      northing, family = binomial, data = frogs,
      na.action = na.omit)
Deviance Residuals:
       Min        1Q    Median       3Q     Max
 -1.512563 -1.047898 0.7248536 1.132447 1.88624

Coefficients:
                    Value  Std. Error    t value
  (Intercept)  0.15677446 1.186753415  0.1321037
Ni.Treatment1  0.52131265 0.554592534  0.9399922
Ni.Treatment2  0.27064234 0.293010032  0.9236624
      Habitat -0.20479089 0.319598425 -0.6407757
     northing  0.00016272 0.000357497  0.4551647

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 40.16805 on 28 degrees of freedom

Residual Deviance: 36.82705 on 24 degrees of freedom

Number of Fisher Scoring Iterations: 3
```

Frogs toad

Analysis of Deviance Table

Binomial model

Response: toad

```
Terms added sequentially (first to last)
             Df Deviance Resid. Df Resid. Dev   Pr(Chi)
        NULL                    28   26.66220
Ni.Treatment  2 3.771580        26   22.89061 0.1517091
     Habitat  1 2.798394        25   20.09222 0.0943588
    northing  1 3.234875        24   16.85735 0.072085
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = toad ~ Ni.Treatment + Habitat + northing,
      family = binomial, data = frogs, na.action =
      na.omit)
Deviance Residuals:
       Min         1Q    Median        3Q      Max
 -2.001472 0.04884089 0.1861324 0.4306345 1.612157

Coefficients:
                    Value  Std. Error    t value
  (Intercept) -0.74081049 2.401469141 -0.3084822
Ni.Treatment1 -0.49555024 0.902085545 -0.5493384
Ni.Treatment2  0.05231900 0.511321829  0.1023211
      Habitat  0.07687932 0.548664919  0.1401207
     northing  0.00156189 0.001270732  1.2291260

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 26.6622 on 28 degrees of freedom

Residual Deviance: 16.85735 on 24 degrees of freedom

Number of Fisher Scoring Iterations: 6
```

Northern Leopard Frogs

Analysis of Deviance Table

```
Binomial model

Response: NorthernLeopard.times

Terms added sequentially (first to last)
             Df Deviance Resid. Df Resid. Dev   Pr(Chi)
        NULL                    28   37.36278
Ni.Treatment  2 0.944111        26   36.41866 0.6237190
     Habitat  1 0.961466        25   35.45720 0.3268177
    northing  1 1.043505        24   34.41369 0.3070077
```

Summary

```
*** Generalized Linear Model ***

Call: glm(formula = NorthernLeopard.times ~ Ni.Treatment + Habitat +
northing, family =
      binomial, data = frogs)
Deviance Residuals:
       Min         1Q     Median       3Q      Max
 -1.414383 -0.8108009 -0.6856293 1.113938 1.901691

Coefficients:
                      Value   Std. Error     t value
  (Intercept)  0.0255717290 1.2362642127  0.02068468
Ni.Treatment1 -0.1554610012 0.5604059170 -0.27740785
Ni.Treatment2 -0.3164592476 0.3186591502 -0.99309638
      Habitat  0.0391925003 0.3278741771  0.11953518
     northing -0.0003793758 0.0003820196 -0.99307933

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 37.36278 on 28 degrees of freedom

Residual Deviance: 34.41369 on 24 degrees of freedom

Number of Fisher Scoring Iterations: 3
```

Maple Surveys

Maple Class 1 nickel

Analysis of Deviance Table

```
Binomial model

Response: cbind(Class1, 12 - Class1)

Terms added sequentially (first to last)
                    Df Deviance Resid. Df Resid. Dev   Pr(Chi)
               NULL                    47   88.50721
            Soil.Ni  1  0.00002        46   88.50719 0.9964678
          Treatment  2 10.52045        44   77.98674 0.0051941
Site %in% Treatment  3  2.69436        41   75.29238 0.4411858
```

Summary

```
Call: glm(formula = cbind(Class1, 12 - Class1) ~ Soil.Ni +
      Treatment/Site, family = binomial, data =
      maplefield)
Deviance Residuals:
       Min        1Q     Median        3Q      Max
 -1.611509 -1.317888 -0.4843716 0.6797541 2.897939

Coefficients:
                               Value    Std. Error
          (Intercept) -3.58718971619 0.76291447990
              Soil.Ni  0.00001025922 0.00005598588
           Treatment1  0.77789487481 1.10532639158
           Treatment2  0.70185131729 0.39798159450
 TreatmentControlSite  0.44378852756 0.35874640449
    TreatmentHighSite  0.30982777200 0.33622672083
TreatmentModerateSite -0.00035783252 0.13174695410
                           t value
          (Intercept) -4.701955213
              Soil.Ni  0.183246564
           Treatment1  0.703769385
           Treatment2  1.763527075
 TreatmentControlSite  1.237053590
    TreatmentHighSite  0.921484679
TreatmentModerateSite -0.002716059

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 88.50721 on 47 degrees of freedom

Residual Deviance: 75.29238 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Maple Class 1 copper

Analysis of Deviance Table

Binomial model

Response: cbind(Class1, 12 - Class1)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	Pr(Chi)
NULL			47	88.50721	
Soil.Cu	1	0.00647	46	88.50074	0.9359037
Treatment	2	10.35210	44	78.14864	0.0056503
Site %in% Treatment	3	2.87717	41	75.27147	0.4109542

Summary

Call: glm(formula = cbind(Class1, 12 - Class1) ~ Soil.Cu + Treatment/Site, family = binomial, data = maplefield)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-1.610764	-1.327016	-0.4845782	0.6811315	2.898207

Coefficients:

	Value	Std. Error
(Intercept)	-3.6063751903	0.7474403839
Soil.Cu	0.0001038172	0.0004457128
Treatment1	0.7483962639	1.0858614179
Treatment2	0.7109839432	0.3922400189
TreatmentControlSite	0.4427880011	0.3587404816
TreatmentHighSite	0.3187522983	0.3235782474
TreatmentModerateSite	-0.0013030199	0.1318557597

	t value
(Intercept)	-4.824967005
Soil.Cu	0.232923890
Treatment1	0.689218948
Treatment2	1.812624692
TreatmentControlSite	1.234285016
TreatmentHighSite	0.985085682
TreatmentModerateSite	-0.009882161

(Dispersion Parameter for Binomial family taken to be 1)

Null Deviance: 88.50721 on 47 degrees of freedom

Residual Deviance: 75.27147 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 4

Maple Class 1 cobalt

Analysis of Deviance Table

Binomial model

Response: cbind(Class1, 12 - Class1)

```
Terms added sequentially (first to last)
                    Df Deviance Resid. Df Resid. Dev   Pr(Chi)
               NULL                    47   88.50721
            Soil.Co  1  0.00005        46   88.50716 0.9942546
          Treatment  2 10.84542        44   77.66174 0.0044152
Site %in% Treatment  3  2.33740        41   75.32434 0.5053942
```

Summary

```
Call: glm(formula = cbind(Class1, 12 - Class1) ~ Soil.Co +
      Treatment/Site, family = binomial, data =
      maplefield)
Deviance Residuals:
       Min       1Q     Median        3Q      Max
 -1.606846 -1.29007 -0.4842686 0.6853327 2.867552

Coefficients:
                              Value  Std. Error
          (Intercept) -3.5200839628 0.843177172
              Soil.Co  0.0002006771 0.004836877
           Treatment1  0.8771665911 1.215841854
           Treatment2  0.6702863888 0.424607764
 TreatmentControlSite  0.4439412140 0.358863400
    TreatmentHighSite  0.2743386064 0.374564752
TreatmentModerateSite -0.0003341695 0.131927864
                           t value
          (Intercept) -4.174785655
              Soil.Co  0.041488980
           Treatment1  0.721447932
           Treatment2  1.578601349
 TreatmentControlSite  1.237075762
    TreatmentHighSite  0.732419709
TreatmentModerateSite -0.002532971

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 88.50721 on 47 degrees of freedom

Residual Deviance: 75.32434 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Maple Class 1 arsenic

Analysis of Deviance Table

```
Binomial model

Response: cbind(Class1, 12 - Class1)

Terms added sequentially (first to last)
                    Df Deviance Resid. Df Resid. Dev   Pr(Chi)
               NULL                    47   88.50721
            Soil.As  1  0.00109        46   88.50612 0.9736641
          Treatment  2 10.69909        44   77.80703 0.0047503
Site %in% Treatment  3  2.55016        41   75.25687 0.4662943
```

Summary

```
Call: glm(formula = cbind(Class1, 12 - Class1) ~ Soil.As +
      Treatment/Site, family = binomial, data =
      maplefield)
Deviance Residuals:
       Min        1Q     Median        3Q      Max
 -1.607976 -1.332705 -0.4853693 0.6847417 2.880072

Coefficients:
                              Value Std. Error
          (Intercept) -3.695550883 0.96329312
              Soil.As  0.003613532 0.01381515
           Treatment1  0.623107371 1.38929054
           Treatment2  0.745870069 0.46499233
 TreatmentControlSite  0.439101483 0.35878011
    TreatmentHighSite  0.361470032 0.44003892
TreatmentModerateSite -0.000508565 0.13164488
                            t value
          (Intercept) -3.836372135
              Soil.As  0.261563062
           Treatment1  0.448507602
           Treatment2  1.604048122
 TreatmentControlSite  1.223873549
    TreatmentHighSite  0.821450135
TreatmentModerateSite -0.003863158

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 88.50721 on 47 degrees of freedom

Residual Deviance: 75.25687 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Maple Class 2 nickel

Analysis of Deviance Table

```
Binomial model

Response: cbind(Class2, 12 - Class2)

Terms added sequentially (first to last)
                    Df Deviance Resid. Df Resid. Dev   Pr(Chi)
               NULL                    47   77.05013
            Soil.Ni  1 1.066111        46   75.98402 0.3018256
          Treatment  2 2.501430        44   73.48259 0.2863001
Site %in% Treatment  3 0.050914        41   73.43168 0.9969908
```

Summary

```
Call: glm(formula = cbind(Class2, 12 - Class2) ~ Soil.Ni +
      Treatment/Site, family = binomial, data =
      maplefield)
Deviance Residuals:
       Min         1Q    Median       3Q      Max
 -2.424267 -0.5866061 0.1021748 1.019605 2.656264

Coefficients:
                              Value    Std. Error
          (Intercept)  1.2669248803 0.37403829008
              Soil.Ni  0.0000139462 0.00003498299
           Treatment1 -0.0810277332 0.52482496204
           Treatment2 -0.1275143322 0.20553862414
 TreatmentControlSite -0.0182981631 0.13320428253
    TreatmentHighSite -0.0300294067 0.19201778799
TreatmentModerateSite  0.0077768688 0.09090887124
                          t value
          (Intercept)  3.38715290
              Soil.Ni  0.39865652
           Treatment1 -0.15439001
           Treatment2 -0.62039110
 TreatmentControlSite -0.13736918
    TreatmentHighSite -0.15638867
TreatmentModerateSite  0.08554576

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 77.05013 on 47 degrees of freedom

Residual Deviance: 73.43168 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Maple Class 2 copper

<u>Analysis of Deviance Table</u>

```
Binomial model

Response: cbind(Class2, 12 - Class2)

Terms added sequentially (first to last)
                    Df Deviance Resid. Df Resid. Dev   Pr(Chi)
               NULL                    47   77.05013
            Soil.Cu  1 0.917184        46   76.13295 0.3382154
          Treatment  2 2.497716        44   73.63523 0.2868322
Site %in% Treatment  3 0.112925        41   73.52231 0.9902425
```

<u>Summary</u>

```
Call: glm(formula = cbind(Class2, 12 - Class2) ~ Soil.Cu +
      Treatment/Site, family = binomial, data =
      maplefield)
Deviance Residuals:
       Min         1Q    Median        3Q      Max
 -2.424577 -0.5805153 0.1003074 0.9913185 2.659555

Coefficients:
                             Value   Std. Error
          (Intercept)  1.31183523931 0.3599106654
              Soil.Cu  0.00007232542 0.0002760097
           Treatment1 -0.01572769526 0.5048761465
           Treatment2 -0.14808553397 0.2004575262
 TreatmentControlSite -0.01863101097 0.1332457493
    TreatmentHighSite -0.05330382021 0.1826401209
TreatmentModerateSite  0.00735536427 0.0909737952
                          t value
          (Intercept)  3.64489126
              Soil.Cu  0.26203942
           Treatment1 -0.03115159
           Treatment2 -0.73873771
 TreatmentControlSite -0.13982443
    TreatmentHighSite -0.29185165
TreatmentModerateSite  0.08085146

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 77.05013 on 47 degrees of freedom

Residual Deviance: 73.52231 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Maple Class 2 cobalt

Analysis of Deviance Table

Binomial model

Response: cbind(Class2, 12 - Class2)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	Pr(Chi)
NULL			47	77.05013	
Soil.Co	1	1.149568	46	75.90056	0.2836396
Treatment	2	2.642475	44	73.25809	0.2668050
Site %in% Treatment	3	0.037153	41	73.22094	0.9981165

Summary

```
Call: glm(formula = cbind(Class2, 12 - Class2) ~ Soil.Co +
      Treatment/Site, family = binomial, data =
      maplefield)
Deviance Residuals:
      Min         1Q     Median       3Q      Max
 -2.42455 -0.5887882 0.09828464 1.040012 2.642925
```

Coefficients:

	Value	Std. Error	t value
(Intercept)	1.158097599	0.436657330	2.65218861
Soil.Co	0.001852924	0.003054924	0.60653687
Treatment1	-0.237561222	0.615670108	-0.38585798
Treatment2	-0.081058432	0.225799494	-0.35898412
TreatmentControlSite	-0.020973583	0.133276109	-0.15736941
TreatmentHighSite	0.021364450	0.218325908	0.09785577
TreatmentModerateSite	0.005209124	0.091129445	0.05716181

(Dispersion Parameter for Binomial family taken to be 1)

Null Deviance: 77.05013 on 47 degrees of freedom

Residual Deviance: 73.22094 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 4

Maple Class 2 arsenic

Analysis of Deviance Table

Binomial model

Response: cbind(Class2, 12 - Class2)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	Pr(Chi)
NULL			47	77.05013	
Soil.As	1	0.920359	46	76.12977	0.3373808
Treatment	2	2.504651	44	73.62512	0.2858392
Site %in% Treatment	3	0.070546	41	73.55457	0.9951207

Summary

```
Call: glm(formula = cbind(Class2, 12 - Class2) ~ Soil.As +
      Treatment/Site, family = binomial, data =
      maplefield)
Deviance Residuals:
       Min         1Q    Median        3Q      Max
 -2.425125 -0.5811216 0.1093924 0.9758435 2.658538
```

Coefficients:

	Value	Std. Error	t value
(Intercept)	1.298300372	0.501097743	2.59091243
Soil.As	0.001609146	0.008425704	0.19098061
Treatment1	-0.031621321	0.701541785	-0.04507404
Treatment2	-0.144694059	0.245614041	-0.58911151
TreatmentControlSite	-0.019582806	0.133573269	-0.14660722
TreatmentHighSite	-0.047386794	0.244662881	-0.19368199
TreatmentModerateSite	0.008041526	0.090938124	0.08842854

(Dispersion Parameter for Binomial family taken to be 1)

Null Deviance: 77.05013 on 47 degrees of freedom

Residual Deviance: 73.55457 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 4

Maple Class 3 nickel

Analysis of Deviance Table

Binomial model

Response: cbind(Class3, 12 - Class3)

```
Terms added sequentially (first to last)
                    Df Deviance Resid. Df Resid. Dev   Pr(Chi)
               NULL                    47   110.6488
            Soil.Ni  1 1.004424        46   109.6444 0.3162425
          Treatment  2 0.880640        44   108.7637 0.6438303
Site %in% Treatment  3 0.541840        41   108.2219 0.9096078
```

Summary

```
Call: glm(formula = cbind(Class3, 12 - Class3) ~ Soil.Ni +
      Treatment/Site, family = binomial, data =
      maplefield)
Deviance Residuals:
      Min        1Q     Median        3Q      Max
 -2.20638 -1.867341 -0.2736426 0.9205342 2.987112

Coefficients:
                               Value    Std. Error
          (Intercept) -1.52254856702 0.42781887269
              Soil.Ni -0.00002137691 0.00004229217
           Treatment1  0.03101321824 0.59230936822
           Treatment2 -0.12095153515 0.24086779739
 TreatmentControlSite -0.05923074295 0.14171117034
    TreatmentHighSite -0.13394376936 0.22263128019
TreatmentModerateSite -0.01251792852 0.11514838079
                          t value
          (Intercept) -3.55886256
              Soil.Ni -0.50545791
           Treatment1  0.05235983
           Treatment2 -0.50214905
 TreatmentControlSite -0.41796806
    TreatmentHighSite -0.60163949
TreatmentModerateSite -0.10871129

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 110.6488 on 47 degrees of freedom

Residual Deviance: 108.2219 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Maple Class 3 copper

Analysis of Deviance Table

```
Binomial model

Response: cbind(Class3, 12 - Class3)

Terms added sequentially (first to last)
                    Df  Deviance Resid. Df Resid. Dev   Pr(Chi)
               NULL                     47   110.6488
            Soil.Cu  1 0.9338241        46   109.7150 0.3338712
          Treatment  2 0.9378827        44   108.7771 0.6256643
Site %in% Treatment  3 0.4272648        41   108.3498 0.9345544
```

Summary

```
Call: glm(formula = cbind(Class3, 12 - Class3) ~ Soil.Cu +
      Treatment/Site, family = binomial, data =
      maplefield)
Deviance Residuals:
       Min        1Q     Median        3Q      Max
 -2.206027 -1.868188 -0.2901861 0.9218003 3.001774

Coefficients:
                              Value   Std. Error
          (Intercept) -1.5805570056 0.4100839302
              Soil.Cu -0.0001195568 0.0003321969
           Treatment1 -0.0530904076 0.5667407887
           Treatment2 -0.0945096216 0.2346753201
 TreatmentControlSite -0.0586248885 0.1417697757
    TreatmentHighSite -0.1042612060 0.2116025036
TreatmentModerateSite -0.0117636619 0.1152336111
                         t value
          (Intercept) -3.8542281
              Soil.Cu -0.3598973
           Treatment1 -0.0936767
           Treatment2 -0.4027250
 TreatmentControlSite -0.4135218
    TreatmentHighSite -0.4927220
TreatmentModerateSite -0.1020853

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 110.6488 on 47 degrees of freedom

Residual Deviance: 108.3498 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Maple Class 3 cobalt

Analysis of Deviance Table

Binomial model

Response: cbind(Class3, 12 - Class3)

```
Terms added sequentially (first to last)
                    Df Deviance Resid. Df Resid. Dev   Pr(Chi)
               NULL                     47   110.6488
            Soil.Co  1 1.113134         46   109.5357 0.2914018
          Treatment  2 0.778756         44   108.7569 0.6774783
Site %in% Treatment  3 0.690000         41   108.0669 0.8755534
```

Summary

```
Call: glm(formula = cbind(Class3, 12 - Class3) ~ Soil.Co +
      Treatment/Site, family = binomial, data =
      maplefield)
Deviance Residuals:
       Min        1Q    Median        3Q      Max
 -2.206148 -1.859328 -0.258511 0.9194232 2.969629

Coefficients:
                              Value  Std. Error
          (Intercept) -1.415325942 0.505776376
              Soil.Co -0.002362354 0.003703623
           Treatment1  0.184352217 0.706676737
           Treatment2 -0.165511721 0.265585207
 TreatmentControlSite -0.055918256 0.141808548
    TreatmentHighSite -0.183251001 0.254345478
TreatmentModerateSite -0.009415929 0.115519423
                           t value
          (Intercept) -2.79832355
              Soil.Co -0.63784945
           Treatment1  0.26087206
           Treatment2 -0.62319631
 TreatmentControlSite -0.39432218
    TreatmentHighSite -0.72048067
TreatmentModerateSite -0.08150949

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 110.6488 on 47 degrees of freedom

Residual Deviance: 108.0669 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Maple Class 3 arsenic

Analysis of Deviance Table

```
Binomial model

Response: cbind(Class3, 12 - Class3)

Terms added sequentially (first to last)
                    Df Deviance Resid. Df Resid. Dev   Pr(Chi)
               NULL                    47   110.6488
            Soil.As  1 0.854875        46   109.7939 0.3551769
          Treatment  2 1.018813        44   108.7751 0.6008521
Site %in% Treatment  3 0.384475        41   108.3906 0.9434306
```

Summary

```
Call: glm(formula = cbind(Class3, 12 - Class3) ~ Soil.As +
      Treatment/Site, family = binomial, data =
      maplefield)
Deviance Residuals:
      Min        1Q    Median        3Q      Max
 -2.20534 -1.866727 -0.302689 0.9274213 3.004008

Coefficients:
                              Value Std. Error
          (Intercept) -1.5387550371 0.57765158
              Soil.As -0.0030151068 0.01009525
           Treatment1  0.0007829646 0.80143433
           Treatment2 -0.1084826702 0.28680048
 TreatmentControlSite -0.0566982440 0.14220982
    TreatmentHighSite -0.1234513331 0.28138839
TreatmentModerateSite -0.0128594776 0.11524373
                            t value
          (Intercept) -2.6638117037
              Soil.As -0.2986658549
           Treatment1  0.0009769542
           Treatment2 -0.3782513533
 TreatmentControlSite -0.3986943011
    TreatmentHighSite -0.4387221993
TreatmentModerateSite -0.1115850486

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 110.6488 on 47 degrees of freedom

Residual Deviance: 108.3906 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Maple Galls nickel

Analysis of Deviance Table

Binomial model

Response: cbind(Galls, 12 - Galls)

```
Terms added sequentially (first to last)
                    Df Deviance Resid. Df Resid. Dev   Pr(Chi)
               NULL                    47   405.9353
            Soil.Ni  1 4.015127        46   401.9202 0.0450938
          Treatment  2 3.081771        44   398.8384 0.2141914
Site %in% Treatment  3 9.089527        41   389.7489 0.0281240
```

Summary

```
Call: glm(formula = cbind(Galls, 12 - Galls) ~ Soil.Ni +
      Treatment/Site, family = binomial, data =
      maplefield)
Deviance Residuals:
       Min        1Q     Median       3Q      Max
 -3.691703 -2.805716 -0.8737137 2.020153 6.085489

Coefficients:
                                Value    Std. Error
          (Intercept)  0.04529371018 0.31243981503
              Soil.Ni -0.00007414338 0.00003064655
           Treatment1  1.05144913211 0.43484139767
           Treatment2  0.10139666639 0.17438344069
 TreatmentControlSite  0.12970477218 0.11312238614
    TreatmentHighSite -0.30744359253 0.15794372918
TreatmentModerateSite -0.16371580821 0.08254997877
                          t value
          (Intercept)  0.1449678
              Soil.Ni -2.4193060
           Treatment1  2.4180061
           Treatment2  0.5814581
 TreatmentControlSite  1.1465880
    TreatmentHighSite -1.9465388
TreatmentModerateSite -1.9832326

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 405.9353 on 47 degrees of freedom

Residual Deviance: 389.7489 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Maple Galls copper

Analysis of Deviance Table

```
Binomial model

Response: cbind(Galls, 12 - Galls)

Terms added sequentially (first to last)
                    Df Deviance Resid. Df Resid. Dev   Pr(Chi)
               NULL                    47   405.9353
            Soil.Cu  1 3.561252        46   402.3740 0.0591431
          Treatment  2 3.025255        44   399.3488 0.2203303
Site %in% Treatment  3 7.707149        41   391.6416 0.0524681
```

Summary

```
Call: glm(formula = cbind(Galls, 12 - Galls) ~ Soil.Cu +
      Treatment/Site, family = binomial, data =
      maplefield)
Deviance Residuals:
       Min        1Q     Median       3Q      Max
 -3.605377 -2.804347 -0.8662909 2.048654 5.922309

Coefficients:
                              Value   Std. Error
          (Intercept) -0.0928636829 0.2982988052
              Soil.Cu -0.0004823135 0.0002390558
           Treatment1  0.8530076450 0.4145490532
           Treatment2  0.1639389190 0.1693579459
 TreatmentControlSite  0.1327232640 0.1131780513
    TreatmentHighSite -0.2324944599 0.1487242031
TreatmentModerateSite -0.1601897651 0.0825735741
                        t value
          (Intercept) -0.3113109
              Soil.Cu -2.0175766
           Treatment1  2.0576760
           Treatment2  0.9680025
 TreatmentControlSite  1.1726944
    TreatmentHighSite -1.5632591
TreatmentModerateSite -1.9399640

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 405.9353 on 47 degrees of freedom

Residual Deviance: 391.6416 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Maple Galls cobalt

Analysis of Deviance Table

Binomial model

Response: cbind(Galls, 12 - Galls)

```
Terms added sequentially (first to last)
                    Df Deviance Resid. Df Resid. Dev   Pr(Chi)
               NULL                    47   405.9353
            Soil.Co  1  3.46285        46   402.4724 0.0627619
          Treatment  2  3.20086        44   399.2716 0.2018096
Site %in% Treatment  3 10.05474        41   389.2168 0.0181065
```

Summary

```
Call: glm(formula = cbind(Galls, 12 - Galls) ~ Soil.Co +
      Treatment/Site, family = binomial, data =
      maplefield)
Deviance Residuals:
       Min        1Q    Median       3Q     Max
 -3.710825 -2.808553 -0.862028 2.021455 6.12567

Coefficients:
                            Value  Std. Error
          (Intercept)  0.25088135 0.369312802
              Soil.Co -0.00674699 0.002677467
           Treatment1  1.34076576 0.517665305
           Treatment2  0.02080567 0.192484222
 TreatmentControlSite  0.13842091 0.113164538
    TreatmentHighSite -0.40052667 0.182342679
TreatmentModerateSite -0.15575865 0.082813372
                         t value
          (Intercept)  0.6793194
              Soil.Co -2.5199150
           Treatment1  2.5900244
           Treatment2  0.1080903
 TreatmentControlSite  1.2231827
    TreatmentHighSite -2.1965602
TreatmentModerateSite -1.8808394

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 405.9353 on 47 degrees of freedom

Residual Deviance: 389.2168 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Maple Galls arsenic

Analysis of Deviance Table

Binomial model

Response: cbind(Galls, 12 - Galls)

```
Terms added sequentially (first to last)
                    Df Deviance Resid. Df Resid. Dev   Pr(Chi)
               NULL                    47   405.9353
            Soil.As  1 1.669320        46   404.2660 0.1963496
          Treatment  2 3.134821        44   401.1312 0.2085846
Site %in% Treatment  3 6.469844        41   394.6613 0.0908594
```

Summary

```
Call: glm(formula = cbind(Galls, 12 - Galls) ~ Soil.As +
      Treatment/Site, family = binomial, data =
      maplefield)
Deviance Residuals:
       Min        1Q     Median       3Q      Max
 -3.654769 -2.804363 -0.8708462 2.068777 5.600508

Coefficients:
                             Value  Std. Error
          (Intercept) -0.149147179 0.415207670
              Soil.As -0.007666957 0.007127571
           Treatment1  0.750919812 0.578439026
           Treatment2  0.203327118 0.205930230
 TreatmentControlSite  0.135594357 0.113464956
    TreatmentHighSite -0.206100623 0.199820104
TreatmentModerateSite -0.165330723 0.082558434
                         t value
          (Intercept) -0.3592110
              Soil.As -1.0756760
           Treatment1  1.2981832
           Treatment2  0.9873593
 TreatmentControlSite  1.1950329
    TreatmentHighSite -1.0314309
TreatmentModerateSite -2.0025903

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 405.9353 on 47 degrees of freedom

Residual Deviance: 394.6613 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Greenhouse Maple Trials

Greenhouse Class 1 nickel

Analysis of Deviance Table

Binomial model

Response: cbind(Class1, Leaf.Number - Class1)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	Pr(Chi)
NULL			47	91.13456	
Soil.Ni	1	0.35441	46	90.78015	0.5516253
Seed	1	0.63912	45	90.14103	0.4240311
Soil	1	18.81750	44	71.32354	0.0000144
Soil.Ni:Seed	1	1.08048	43	70.24306	0.2985907
Soil.Ni:Soil	1	1.67045	42	68.57261	0.1961977
Seed:Soil	1	0.08728	41	68.48533	0.7676642

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = cbind(Class1, Leaf.Number - Class1) ~
      Soil.Ni * Seed * Soil - Soil.Ni:Seed:Soil,
      family = binomial, data = greenhouse)
Deviance Residuals:
       Min         1Q     Median        3Q      Max
 -2.560737 -0.7515813 0.07433779 0.7584347 2.421681

Coefficients:
                      Value    Std. Error    t value
 (Intercept)  0.99500173947 0.15284956986  6.5096797
     Soil.Ni -0.00007218339 0.00008699587 -0.8297335
        Seed -0.03087257217 0.14986383987 -0.2060041
        Soil -0.57221597789 0.15285999380 -3.7433992
Soil.Ni:Seed  0.00008545422 0.00008500544  1.0052793
Soil.Ni:Soil  0.00011334553 0.00008697090  1.3032581
   Seed:Soil  0.02966552491 0.10026094265  0.2958832

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 91.13456 on 47 degrees of freedom

Residual Deviance: 68.48533 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 3
```

Greenhouse Class 2 nickel

Analysis of Deviance Table

```
Binomial model

Response: cbind(Class2, Leaf.Number - Class2)

Terms added sequentially (first to last)
             Df Deviance Resid. Df Resid. Dev   Pr(Chi)
        NULL                    47   78.28822
     Soil.Ni  1 1.867593        46   76.42063 0.1717510
        Seed  1 0.211550        45   76.20908 0.6455552
        Soil  1 0.910638        44   75.29844 0.3399452
Soil.Ni:Seed  1 0.146222        43   75.15222 0.7021722
Soil.Ni:Soil  1 1.045351        42   74.10687 0.3065803
   Seed:Soil  1 0.337214        41   73.76965 0.5614416
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = cbind(Class2, Leaf.Number - Class2) ~
      Soil.Ni * Seed * Soil - Soil.Ni:Seed:Soil,
      family = binomial, data = greenhouse)
Deviance Residuals:
       Min        1Q      Median        3Q      Max
 -2.004054 -1.584018 -0.04848664 0.6149271 2.319232

Coefficients:
                      Value   Std. Error    t value
 (Intercept) -1.89641521332 0.1904214062 -9.9590443
     Soil.Ni  0.00012815812 0.0001066983  1.2011259
        Seed -0.11103434395 0.1902836864 -0.5835200
        Soil -0.02638496312 0.1905488795 -0.1384682
Soil.Ni:Seed  0.00003224073 0.0001054379  0.3057792
Soil.Ni:Soil  0.00010645251 0.0001068869  0.9959363
   Seed:Soil  0.07192745185 0.1239983167  0.5800680

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 78.28822 on 47 degrees of freedom

Residual Deviance: 73.76965 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Greenhouse Class 3 nickel

Analysis of Deviance Table

Binomial model

Response: cbind(Class3, Leaf.Number - Class3)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	Pr(Chi)
NULL			47	92.56318	
Soil.Ni	1	4.41983	46	88.14335	0.0355235
Seed	1	1.92523	45	86.21812	0.1652816
Soil	1	20.71100	44	65.50712	0.0000053
Soil.Ni:Seed	1	4.00255	43	61.50457	0.0454315
Soil.Ni:Soil	1	5.24417	42	56.26040	0.0220204
Seed:Soil	1	1.03963	41	55.22077	0.3079080

Summary

*** Generalized Linear Model ***

```
Call: glm(formula = cbind(Class3, Leaf.Number - Class3) ~
      Soil.Ni * Seed * Soil - Soil.Ni:Seed:Soil,
      family = binomial, data = greenhouse)
```

Deviance Residuals:

Min	1Q	Median	3Q	Max
-1.766065	-1.031719	-0.6900174	0.5054071	2.059378

Coefficients:

	Value	Std. Error	t value
(Intercept)	-2.1150602997	0.2603690146	-8.1233180
Soil.Ni	-0.0001802278	0.0001572318	-1.1462554
Seed	0.1772371249	0.2378004677	0.7453187
Soil	1.0958659995	0.2611878799	4.1957000
Soil.Ni:Seed	-0.0003022085	0.0001497087	-2.0186427
Soil.Ni:Soil	-0.0003769537	0.0001528899	-2.4655241
Seed:Soil	-0.1821143858	0.1795692577	-1.0141735

(Dispersion Parameter for Binomial family taken to be 1)

Null Deviance: 92.56318 on 47 degrees of freedom

Residual Deviance: 55.22077 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 4

Greenhouse germination success nickel

Analysis of Deviance Table

Binomial model

Response: cbind(Germ.succ, 5 - Germ.succ)

```
Terms added sequentially (first to last)
             Df Deviance Resid. Df Resid. Dev   Pr(Chi)
        NULL                    47   58.67285
     Soil.Ni  1 0.000867        46   58.67199 0.9765060
        Seed  1 8.096308        45   50.57568 0.0044356
        Soil  1 1.529039        44   49.04664 0.2162568
Soil.Ni:Seed  1 5.140708        43   43.90593 0.0233711
Soil.Ni:Soil  1 1.526655        42   42.37928 0.2166152
   Seed:Soil  1 0.497148        41   41.88213 0.4807558
```

Summary

```
*** Generalized Linear Model ***

Call: glm(formula = cbind(Germ.succ, 5 - Germ.succ) ~ Soil.Ni *
      Seed * Soil - Soil.Ni:Seed:Soil, family =
      binomial, data = greenhouse)
Deviance Residuals:
       Min         1Q       Median       3Q      Max
 -1.655085 -0.6393188 0.0008352028 0.677591 2.403927

Coefficients:
                      Value   Std. Error    t value
 (Intercept)  0.70737484749 0.2185820671  3.2361980
     Soil.Ni -0.00004024424 0.0001226125 -0.3282229
        Seed -0.77248298920 0.2188289534 -3.5300767
        Soil  0.39578627581 0.2174286540  1.8203041
Soil.Ni:Seed  0.00028508997 0.0001229037  2.3196209
Soil.Ni:Soil -0.00015904847 0.0001225442 -1.2978869
   Seed:Soil -0.10061155258 0.1430561241 -0.7033013

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 58.67285 on 47 degrees of freedom

Residual Deviance: 41.88213 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 3
```

Greenhouse leaf number nickel

Analysis of Deviance Table

```
Poisson model

Response: Leaf.Number

Terms added sequentially (first to last)
             Df Deviance Resid. Df Resid. Dev   Pr(Chi)
        NULL                    47   10.58211
     Soil.Ni  1 0.020544        46   10.56157 0.8860295
        Seed  1 0.232263        45   10.32931 0.6298509
        Soil  1 1.399859        44    8.92945 0.2367471
Soil.Ni:Seed  1 0.039000        43    8.89045 0.8434492
Soil.Ni:Soil  1 0.037368        42    8.85308 0.8467177
   Seed:Soil  1 0.135615        41    8.71746 0.712679
```

Summary

```
*** Generalized Linear Model ***

Call: glm(formula = Leaf.Number ~ Soil.Ni * Seed * Soil -
      Soil.Ni:Seed:Soil, family = poisson, data =
      greenhouse)
Deviance Residuals:
       Min         1Q      Median        3Q       Max
 -1.445229 -0.2868142 -0.06977573 0.3091611 0.8387084

Coefficients:
                     Value    Std. Error    t value
 (Intercept) 2.376641e+000 0.06506507297 36.5271445
     Soil.Ni 4.911064e-006 0.00003825426  0.1283795
        Seed 1.095088e-002 0.06502893498  0.1684000
        Soil 4.240361e-002 0.06506473115  0.6517141
Soil.Ni:Seed 7.425271e-006 0.00003820019  0.1943779
Soil.Ni:Soil 7.272017e-006 0.00003824779  0.1901291
   Seed:Soil 1.616091e-002 0.04388554748  0.3682513

(Dispersion Parameter for Poisson family taken to be 1 )

    Null Deviance: 10.58211 on 47 degrees of freedom

Residual Deviance: 8.717464 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 3
```

Greenhouse maple height nickel

Analysis of Deviance Table

```
Gaussian model

Response: (Plant.Ht/100)

Terms added sequentially (first to last)
              Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
        NULL                     47   33.18468
     Soil.Ni  1 0.610651         46   32.57403  1.21475 0.2768217
        Seed  1 1.646502         45   30.92753  3.27533 0.0776632
        Soil  1 7.184269         44   23.74326 14.29144 0.0004999
Soil.Ni:Seed  1 2.702179         43   21.04108  5.37536 0.0254875
Soil.Ni:Soil  1 0.002969         42   21.03811  0.00591 0.9391141
   Seed:Soil  1 0.427519         41   20.61059  0.85045 0.3618204
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = (Plant.Ht/100) ~ Soil.Ni * Seed * Soil -
      Soil.Ni:Seed:Soil, family = gaussian, data =
      greenhouse)
Deviance Residuals:
       Min         1Q       Median        3Q      Max
 -2.042808 -0.3415079 -0.005297619 0.3238442 1.678562

Coefficients:
                      Value    Std. Error     t value
 (Intercept)  3.267560e+000 0.15146139924  21.5735464
     Soil.Ni  9.845238e-005 0.00008932706   1.1021563
        Seed -7.367063e-002 0.15146139924  -0.4863987
        Soil  3.954563e-001 0.15146139924   2.6109382
Soil.Ni:Seed  2.071032e-004 0.00008932706   2.3184819
Soil.Ni:Soil -6.865079e-006 0.00008932706  -0.0768533
   Seed:Soil -9.437500e-002 0.10233700345  -0.9221982

(Dispersion Parameter for Gaussian family taken to be 0.5026974 )

    Null Deviance: 33.18468 on 47 degrees of freedom

Residual Deviance: 20.61059 on 41 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Earthworm Surveys

Earthworm species richness nickel

Analysis of Deviance Table

```
Poisson model

Response: richness

Terms added sequentially (first to last)
                Df Deviance Resid. Df Resid. Dev   Pr(Chi)
           NULL                    37   16.32284
        Soil.Ni  1 0.224288        36   16.09855 0.6357919
        Landuse  1 0.024109        35   16.07444 0.8766074
           soil  1 0.148029        34   15.92641 0.7004258
Soil.Ni:Landuse  1 0.620414        33   15.30600 0.4308936
   Soil.Ni:soil  1 1.126843        32   14.17915 0.2884498
   Landuse:soil  1 1.570367        31   12.60879 0.2101537
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = richness ~ Soil.Ni * Landuse * soil -
      Soil.Ni:Landuse:soil, family = poisson, data =
      worms.out, na.action = na.omit)
Deviance Residuals:
       Min         1Q      Median        3Q       Max
 -1.459273 -0.2929181 -0.08565688 0.3776948 0.9612676

Coefficients:
                         Value    Std. Error
    (Intercept)  0.65342548511 0.20588472692
        Soil.Ni -0.00005810865 0.00011055629
        Landuse -0.17585083437 0.20367006384
           soil -0.25641026527 0.18348603085
Soil.Ni:Landuse  0.00006496450 0.00009450097
   Soil.Ni:soil  0.00012366228 0.00010633233
   Landuse:soil -0.18023083147 0.14918901829
                   t value
    (Intercept)  3.1737443
        Soil.Ni -0.5256024
        Landuse -0.8634103
           soil -1.3974375
Soil.Ni:Landuse  0.6874480
   Soil.Ni:soil  1.1629791
   Landuse:soil -1.2080704

(Dispersion Parameter for Poisson family taken to be 1 )

    Null Deviance: 16.32284 on 37 degrees of freedom

Residual Deviance: 12.60879 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Earthworm species richness copper

Analysis of Deviance Table

```
> anova(worm.rich.cu.glm, test="Chi")
Analysis of Deviance Table

Poisson model

Response: richness

Terms added sequentially (first to last)
                Df Deviance Resid. Df Resid. Dev   Pr(Chi)
           NULL                    37   16.32284
        Soil.Cu  1 0.258718        36   16.06412 0.6110019
        Landuse  1 0.025330        35   16.03879 0.8735465
           soil  1 0.135856        34   15.90293 0.7124358
Soil.Cu:Landuse  1 0.776247        33   15.12668 0.3782914
   Soil.Cu:soil  1 1.203869        32   13.92282 0.2725497
   Landuse:soil  1 1.478766        31   12.44405 0.2239677
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = richness ~ Soil.Cu * Landuse * soil -
      Soil.Cu:Landuse:soil, family = poisson, data =
      worms.out, na.action = na.omit)
Deviance Residuals:
       Min         1Q      Median        3Q      Max
 -1.437572 -0.3015496 -0.09157822 0.4422295 1.006455

Coefficients:
                        Value   Std. Error    t value
    (Intercept)  0.6497729172 0.2209127588  2.9413100
        Soil.Cu -0.0004389160 0.0008706888 -0.5041020
        Landuse -0.2098935670 0.2165615714 -0.9692097
           soil -0.2811396475 0.1952653765 -1.4397824
Soil.Cu:Landuse  0.0005378229 0.0007419272  0.7248998
   Soil.Cu:soil  0.0009308380 0.0008506579  1.0942565
   Landuse:soil -0.1826122147 0.1568203549 -1.1644676

(Dispersion Parameter for Poisson family taken to be 1 )

    Null Deviance: 16.32284 on 37 degrees of freedom

Residual Deviance: 12.44405 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Earthworm species richness cobalt

Analysis of Deviance Table

```
Poisson model

Response: richness

Terms added sequentially (first to last)
                Df Deviance Resid. Df Resid. Dev   Pr(Chi)
           NULL                    37   16.32284
        Soil.Co  1 0.053653        36   16.26918 0.8168239
        Landuse  1 0.039917        35   16.22927 0.8416439
           soil  1 0.190123        34   16.03914 0.6628139
Soil.Co:Landuse  1 0.336152        33   15.70299 0.5620588
   Soil.Co:soil  1 0.996129        32   14.70686 0.3182490
   Landuse:soil  1 1.396573        31   13.31029 0.2372982
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = richness ~ Soil.Co * Landuse * soil -
      Soil.Co:Landuse:soil, family = poisson, data =
      worms.out, na.action = na.omit)
Deviance Residuals:
       Min         1Q      Median        3Q      Max
 -1.488859 -0.2361761 -0.08842452 0.4705401 1.068936

Coefficients:
                       Value  Std. Error    t value
    (Intercept)  0.721055379 0.266313774  2.7075407
        Soil.Co -0.004933775 0.008844587 -0.5578299
        Landuse -0.178292775 0.237143983 -0.7518334
           soil -0.326932171 0.240363518 -1.3601572
Soil.Co:Landuse  0.003449156 0.006298295  0.5476333
   Soil.Co:soil  0.009013870 0.008619388  1.0457668
   Landuse:soil -0.165662595 0.144661873 -1.1451711

(Dispersion Parameter for Poisson family taken to be 1 )

    Null Deviance: 16.32284 on 37 degrees of freedom

Residual Deviance: 13.31029 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Earthworm species richness arsenic

<u>Analysis of Deviance Table</u>

```
Poisson model

Response: richness

Terms added sequentially (first to last)
                Df Deviance Resid. Df Resid. Dev   Pr(Chi)
           NULL                    37   16.32284
        Soil.As  1 0.445726        36   15.87711 0.5043715
        Landuse  1 0.000909        35   15.87620 0.9759434
           soil  1 0.105554        34   15.77065 0.7452641
Soil.As:Landuse  1 0.633666        33   15.13698 0.4260139
   Soil.As:soil  1 1.556471        32   13.58051 0.2121826
   Landuse:soil  1 1.564548        31   12.01596 0.2110006
```

<u>Summary</u>

```
      *** Generalized Linear Model ***

Call: glm(formula = richness ~ Soil.As * Landuse * soil -
      Soil.As:Landuse:soil, family = poisson, data =
      worms.out, na.action = na.omit)
Deviance Residuals:
       Min         1Q      Median       3Q       Max
 -1.495106 -0.2950409 -0.07147665 0.317372 0.9853135

Coefficients:
                       Value Std. Error    t value
    (Intercept)  0.712067884 0.23175820  3.0724603
        Soil.As -0.013593341 0.01524252 -0.8918043
        Landuse -0.145715636 0.23299813 -0.6253940
           soil -0.364869210 0.22517953 -1.6203480
Soil.As:Landuse  0.002588975 0.01525376  0.1697271
   Soil.As:soil  0.024830993 0.01702121  1.4588267
   Landuse:soil -0.192553647 0.16105081 -1.1956081

(Dispersion Parameter for Poisson family taken to be 1 )

    Null Deviance: 16.32284 on 37 degrees of freedom

Residual Deviance: 12.01596 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Earthworm total weight nickel

Analysis of Deviance Table

Gaussian model

Response: log(Total.wt + 0.01)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			37	107.3553		
Soil.Ni	1	0.84607	36	106.5092	0.349448	0.5587116
Landuse	1	8.05520	35	98.4540	3.326994	0.0778049
soil	1	0.36748	34	98.0866	0.151777	0.6995066
Soil.Ni:Landuse	1	1.37350	33	96.7131	0.567289	0.4570206
Soil.Ni:soil	1	0.80248	32	95.9106	0.331443	0.5689666
Landuse:soil	1	20.85446	31	75.0561	8.613401	0.0062336

Summary

*** Generalized Linear Model ***

Call: glm(formula = log(Total.wt + 0.01) ~ Soil.Ni * Landuse * soil - Soil.Ni:Landuse:soil, family = gaussian, data = worms.out, na.action = na.omit)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-3.311298	-0.8109506	0.1057033	0.9140656	3.142517

Coefficients:

	Value	Std. Error	t value
(Intercept)	0.43754091416	0.3925505320	1.1146104
Soil.Ni	0.00035371034	0.0002203187	1.6054486
Landuse	-0.77290731928	0.3831330342	-2.0173341
soil	-0.17291635926	0.3721085326	-0.4646933
Soil.Ni:Landuse	0.00005888363	0.0001942935	0.3030653
Soil.Ni:soil	-0.00012209003	0.0002258333	-0.5406201
Landuse:soil	-0.83410374673	0.2842056761	-2.9348596

(Dispersion Parameter for Gaussian family taken to be 2.421165)

Null Deviance: 107.3553 on 37 degrees of freedom

Residual Deviance: 75.05612 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 1

Earthworm total weight copper

<u>Analysis of Deviance Table</u>

Gaussian model

Response: log(Total.wt + 0.01)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			37	107.3553		
Soil.Cu	1	0.38629	36	106.9690	0.160067	0.6918381
Landuse	1	7.64734	35	99.3217	3.168860	0.0848595
soil	1	0.30483	34	99.0169	0.126312	0.7246942
Soil.Cu:Landuse	1	1.56837	33	97.4485	0.649892	0.4262927
Soil.Cu:soil	1	0.29012	32	97.1584	0.120217	0.7311421
Landuse:soil	1	22.34677	31	74.8116	9.259926	0.0047410

<u>Summary</u>

*** Generalized Linear Model ***

Call: glm(formula = log(Total.wt + 0.01) ~ Soil.Cu * Landuse * soil - Soil.Cu:Landuse:soil, family = gaussian, data = worms.out, na.action = na.omit)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-3.238383	-0.7399465	0.1753767	0.8922781	3.111463

Coefficients:

	Value	Std. Error	t value
(Intercept)	0.3713072254	0.413526640	0.8979040
Soil.Cu	0.0028010919	0.001718374	1.6300828
Landuse	-0.8005506877	0.399130800	-2.0057352
soil	-0.1755356881	0.392776710	-0.4469096
Soil.Cu:Landuse	0.0006206154	0.001513709	0.4099964
Soil.Cu:soil	-0.0010604952	0.001804651	-0.5876457
Landuse:soil	-0.8918751270	0.293089527	-3.0430126

(Dispersion Parameter for Gaussian family taken to be 2.413278)

Null Deviance: 107.3553 on 37 degrees of freedom

Residual Deviance: 74.8116 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 1

Earthworm total weight cobalt

Analysis of Deviance Table

Gaussian model

Response: log(Total.wt + 0.01)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			37	107.3553		
Soil.Co	1	1.20702	36	106.1483	0.515390	0.4781905
Landuse	1	8.15168	35	97.9966	3.480717	0.0715759
soil	1	0.38476	34	97.6118	0.164290	0.6880210
Soil.Co:Landuse	1	0.85227	33	96.7596	0.363915	0.5507285
Soil.Co:soil	1	2.77464	32	93.9849	1.184756	0.2847800
Landuse:soil	1	21.38432	31	72.6006	9.130967	0.0050047

Summary

*** Generalized Linear Model ***

Call: glm(formula = log(Total.wt + 0.01) ~ Soil.Co * Landuse *
soil - Soil.Co:Landuse:soil, family = gaussian,
data = worms.out, na.action = na.omit)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-3.223574	-0.7262561	-0.01770751	0.843744	3.09115

Coefficients:

	Value	Std. Error	t value
(Intercept)	0.039305376	0.50990096	0.07708433
Soil.Co	0.033408888	0.01725737	1.93591960
Landuse	-0.871268328	0.44396451	-1.96247294
soil	0.136273971	0.49177872	0.27710424
Soil.Co:Landuse	0.006780273	0.01277385	0.53079344
Soil.Co:soil	-0.018986699	0.01763996	-1.07634605
Landuse:soil	-0.834324493	0.27610648	-3.02174903

(Dispersion Parameter for Gaussian family taken to be 2.341955)

Null Deviance: 107.3553 on 37 degrees of freedom

Residual Deviance: 72.60061 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 1

Earthworm total weight arsenic

Analysis of Deviance Table

Gaussian model

Response: log(Total.wt + 0.01)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			37	107.3553		
Soil.As	1	0.12623	36	107.2291	0.052251	0.8206933
Landuse	1	7.07158	35	100.1575	2.927265	0.0970857
soil	1	0.18469	34	99.9728	0.076451	0.7840010
Soil.As:Landuse	1	1.97484	33	97.9980	0.817482	0.3728905
Soil.As:soil	1	1.03770	32	96.9603	0.429552	0.5170437
Landuse:soil	1	22.07161	31	74.8887	9.136492	0.0049931

Summary

*** Generalized Linear Model ***

```
Call: glm(formula = log(Total.wt + 0.01) ~ Soil.As * Landuse *
      soil - Soil.As:Landuse:soil, family = gaussian,
      data = worms.out, na.action = na.omit)
```

Deviance Residuals:

Min	1Q	Median	3Q	Max
-3.239289	-0.678482	-0.01870981	0.8580707	3.152218

Coefficients:

	Value	Std. Error	t value
(Intercept)	0.307587188	0.44828674	0.6861394
Soil.As	0.048122558	0.03007936	1.5998533
Landuse	-0.787713486	0.45699890	-1.7236660
soil	-0.259596015	0.45768980	-0.5671877
Soil.As:Landuse	-0.001315567	0.03356733	-0.0391919
Soil.As:soil	-0.007710289	0.03667215	-0.2102492
Landuse:soil	-0.915474929	0.30287032	-3.0226631

(Dispersion Parameter for Gaussian family taken to be 2.415764)

Null Deviance: 107.3553 on 37 degrees of freedom

Residual Deviance: 74.88867 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 1

Earthworm total count nickel

Analysis of Deviance Table

Poisson model

Response: Total.count

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	Pr(Chi)
NULL			37	347.9348	
Soil.Ni	1	5.09665	36	342.8382	0.0239721
Landuse	1	1.88846	35	340.9497	0.1693759
soil	1	16.73617	34	324.2135	0.0000430
Soil.Ni:Landuse	1	0.51582	33	323.6977	0.4726321
Soil.Ni:soil	1	0.65925	32	323.0385	0.4168258
Landuse:soil	1	36.65929	31	286.3792	0.0000000

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = Total.count ~ Soil.Ni * Landuse * soil -
      Soil.Ni:Landuse:soil, family = poisson, data =
      worms.out, na.action = na.omit)
Deviance Residuals:
       Min      1Q     Median       3Q     Max
 -5.361291 -2.5871 -0.9398875 2.221578 5.59197
```

Coefficients:

	Value	Std. Error	t value
(Intercept)	2.46180314591	0.09305585468	26.4551129
Soil.Ni	0.00017271624	0.00003964430	4.3566479
Landuse	-0.38974057848	0.09280034430	-4.1997751
soil	-0.39569476537	0.07667521311	-5.1606608
Soil.Ni:Landuse	0.00011660325	0.00003677029	3.1711266
Soil.Ni:soil	0.00003069657	0.00003269062	0.9390024
Landuse:soil	-0.34243803687	0.06346680795	-5.3955453

(Dispersion Parameter for Poisson family taken to be 1)

Null Deviance: 347.9348 on 37 degrees of freedom

Residual Deviance: 286.3792 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 4

Earthworm total count copper

Analysis of Deviance Table

Poisson model

Response: Total.count

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	Pr(Chi)
NULL			37	347.9348	
Soil.Cu	1	3.67700	36	344.2578	0.0551679
Landuse	1	1.64208	35	342.6157	0.2000402
soil	1	16.38132	34	326.2344	0.0000518
Soil.Cu:Landuse	1	0.86094	33	325.3735	0.3534756
Soil.Cu:soil	1	1.05281	32	324.3207	0.3048606
Landuse:soil	1	45.34252	31	278.9782	0.0000000

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = Total.count ~ Soil.Cu * Landuse * soil -
      Soil.Cu:Landuse:soil, family = poisson, data =
      worms.out, na.action = na.omit)
Deviance Residuals:
       Min        1Q     Median       3Q      Max
 -5.354864 -2.482415 -0.7029819 2.136434 5.634935
```

Coefficients:

	Value	Std. Error	t value
(Intercept)	2.351617951	0.1112523150	21.1376990
Soil.Cu	0.001546807	0.0003345924	4.6229584
Landuse	-0.506370377	0.1106491089	-4.5763620
soil	-0.469010306	0.0890878206	-5.2645839
Soil.Cu:Landuse	0.001181128	0.0003121355	3.7840244
Soil.Cu:soil	0.000156255	0.0002619325	0.5965468
Landuse:soil	-0.429821356	0.0768416112	-5.5936016

(Dispersion Parameter for Poisson family taken to be 1)

Null Deviance: 347.9348 on 37 degrees of freedom

Residual Deviance: 278.9782 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 4

Earthworm total count cobalt

Analysis of Deviance Table

Poisson model

Response: Total.count

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	Pr(Chi)
NULL			37	347.9348	
Soil.Co	1	6.29674	36	341.6381	0.0120960
Landuse	1	1.96384	35	339.6742	0.1611030
soil	1	17.33920	34	322.3351	0.0000313
Soil.Co:Landuse	1	0.98933	33	321.3457	0.3199054
Soil.Co:soil	1	0.01963	32	321.3261	0.8885722
Landuse:soil	1	39.19208	31	282.1340	0.0000000

Summary

*** Generalized Linear Model ***

Call: glm(formula = Total.count ~ Soil.Co * Landuse * soil - Soil.Co:Landuse:soil, family = poisson, data = worms.out, na.action = na.omit)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-5.31264	-2.582807	-0.8591329	2.153249	5.386794

Coefficients:

	Value	Std. Error	t value
(Intercept)	2.3107688522	0.121221517	19.0623654
Soil.Co	0.0136389755	0.003106754	4.3901045
Landuse	-0.5089741957	0.116917745	-4.3532673
soil	-0.3885946652	0.094108819	-4.1292056
Soil.Co:Landuse	0.0095588525	0.002635954	3.6263347
Soil.Co:soil	0.0003594912	0.002590238	0.1387869
Landuse:soil	-0.3624697498	0.067000975	-5.4099176

(Dispersion Parameter for Poisson family taken to be 1)

Null Deviance: 347.9348 on 37 degrees of freedom

Residual Deviance: 282.134 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 4

Earthworm total count arsenic

Analysis of Deviance Table

Poisson model

Response: Total.count

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	Pr(Chi)
NULL			37	347.9348	
Soil.As	1	0.43023	36	347.5046	0.5118779
Landuse	1	1.52029	35	345.9843	0.2175759
soil	1	14.02480	34	331.9595	0.0001804
Soil.As:Landuse	1	0.20563	33	331.7539	0.6502149
Soil.As:soil	1	5.49026	32	326.2636	0.0191227
Landuse:soil	1	45.41894	31	280.8447	0.0000000

Summary

*** Generalized Linear Model ***

Call: glm(formula = Total.count ~ Soil.As * Landuse * soil -
Soil.As:Landuse:soil, family = poisson, data =
worms.out, na.action = na.omit)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-5.624236	-2.589814	-1.024721	2.044393	6.055986

Coefficients:

	Value	Std. Error	t value
(Intercept)	2.433201438	0.106791375	22.784625
Soil.As	0.015831665	0.005189250	3.050858
Landuse	-0.409730203	0.106633516	-3.842415
soil	-0.597063436	0.097421383	-6.128669
Soil.As:Landuse	0.006561093	0.005310267	1.235549
Soil.As:soil	0.018987981	0.005317644	3.570750
Landuse:soil	-0.423127011	0.073470517	-5.759140

(Dispersion Parameter for Poisson family taken to be 1)

Null Deviance: 347.9348 on 37 degrees of freedom

Residual Deviance: 280.8447 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 4

Earthworm Lumbricus terrestris nickel

Analysis of Deviance Table

```
Binomial model

Response: luts

Terms added sequentially (first to last)
                Df Deviance Resid. Df Resid. Dev   Pr(Chi)
           NULL                    37   47.39777
        Soil.Ni  1  0.32364        36   47.07413 0.5694295
        Landuse  1  3.85992        35   43.21421 0.0494528
           soil  1  4.66290        34   38.55131 0.0308211
Soil.Ni:Landuse  1  1.97475        33   36.57656 0.1599444
   Soil.Ni:soil  1  1.62509        32   34.95147 0.2023836
   Landuse:soil  1 12.32102        31   22.63046 0.0004479
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = luts ~ Soil.Ni * Landuse * soil - Soil.Ni:
      Landuse:soil, family = binomial, data =
      worms.out, na.action = na.omit)
Deviance Residuals:
       Min        1Q        Median        3Q      Max
 -1.482304 -0.636628 -0.0003707721 0.0534921 1.880175

Coefficients:
                        Value  Std. Error
    (Intercept) -0.2625308606 374.2914731
        Soil.Ni  0.0007073579   0.1446765
        Landuse  0.4846608262 374.3023189
           soil -8.2218663233 311.9850236
Soil.Ni:Landuse -0.0190827284   0.1470944
   Soil.Ni:soil  0.0199077049   0.0265809
   Landuse:soil -8.7491564886 311.9717088
                      t value
    (Intercept) -0.0007014075
        Soil.Ni  0.0048892396
        Landuse  0.0012948379
           soil -0.0263534006
Soil.Ni:Landuse -0.1297311790
   Soil.Ni:soil  0.7489476890
   Landuse:soil -0.0280447112

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 47.39777 on 37 degrees of freedom

Residual Deviance: 22.63046 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 10
```

Earthworm Lumbricus terrestris copper

Analysis of Deviance Table

Binomial model

Response: luts

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	Pr(Chi)
NULL			37	47.39777	
Soil.Cu	1	0.49731	36	46.90046	0.4806857
Landuse	1	3.81538	35	43.08508	0.0507841
soil	1	4.78442	34	38.30066	0.0287183
Soil.Cu:Landuse	1	1.62783	33	36.67284	0.2020040
Soil.Cu:soil	1	1.94101	32	34.73183	0.1635590
Landuse:soil	1	12.29717	31	22.43465	0.0004536

Summary

*** Generalized Linear Model ***

Call: glm(formula = luts ~ Soil.Cu * Landuse * soil - Soil.Cu:
Landuse:soil, family = binomial, data =
worms.out, na.action = na.omit)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-1.482593	-0.5582659	-0.00384526	0.04355858	1.967684

Coefficients:

	Value	Std. Error	t value
(Intercept)	0.46720620	98.7292823	0.004732195
Soil.Cu	0.00327887	0.2629644	0.012468872
Landuse	3.06597752	98.7540231	0.031046609
soil	-10.47086635	79.6805169	-0.131410623
Soil.Cu:Landuse	-0.13782317	0.3247345	-0.424418027
Soil.Cu:soil	0.14342027	0.2127028	0.674275529
Landuse:soil	-8.92654934	78.9955949	-0.113000596

(Dispersion Parameter for Binomial family taken to be 1)

Null Deviance: 47.39777 on 37 degrees of freedom

Residual Deviance: 22.43465 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 10

Earthworm Lumbricus terrestris cobalt

Analysis of Deviance Table

Binomial model

Response: luts

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	Pr(Chi)
NULL			37	47.39777	
Soil.Co	1	0.06816	36	47.32961	0.7940386
Landuse	1	4.06220	35	43.26741	0.0438533
soil	1	4.44952	34	38.81789	0.0349110
Soil.Co:Landuse	1	1.61993	33	37.19796	0.2031015
Soil.Co:soil	1	0.44543	32	36.75253	0.5045152
Landuse:soil	1	14.18177	31	22.57076	0.0001660

Summary

*** Generalized Linear Model ***

Call: glm(formula = luts ~ Soil.Co * Landuse * soil - Soil.Co:
Landuse:soil, family = binomial, data =
worms.out, na.action = na.omit)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-1.482304	-0.6116644	-0.00001513492	0.08619987	1.857577

Coefficients:

	Value	Std. Error	t value
(Intercept)	-1.6781054	8375.493164	-0.000200359
Soil.Co	0.1964769	176.326751	0.001114277
Landuse	16.1643170	8375.483408	0.001929956
soil	-34.5393869	5378.117554	-0.006422208
Soil.Co:Landuse	-1.9739695	176.334800	-0.011194441
Soil.Co:soil	2.1530585	2.255111	0.954746195
Landuse:soil	-18.4869175	5378.001204	-0.003437507

(Dispersion Parameter for Binomial family taken to be 1)

Null Deviance: 47.39777 on 37 degrees of freedom

Residual Deviance: 22.57076 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 10

Earthworm Lumbricus terrestris arsenic

Analysis of Deviance Table

Binomial model

Response: luts

```
Terms added sequentially (first to last)
                Df Deviance Resid. Df Resid. Dev   Pr(Chi)
           NULL                    37   47.39777
        Soil.As  1  2.53064        36   44.86713 0.1116552
        Landuse  1  2.81143        35   42.05570 0.0935949
           soil  1  5.00755        34   37.04816 0.0252371
Soil.As:Landuse  1 12.17728        33   24.87088 0.0004838
   Soil.As:soil  1  2.01924        32   22.85164 0.1553167
   Landuse:soil  1  0.36887        31   22.48276 0.5436192
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = luts ~ Soil.As * Landuse * soil - Soil.As:
      Landuse:soil, family = binomial, data =
      worms.out, na.action = na.omit)
Deviance Residuals:
       Min         1Q        Median         3Q
 -1.482304 -0.6002182 -0.0005517823 0.07871844
      Max
 1.898834

Coefficients:
                     Value  Std. Error      t value
    (Intercept) -34.525448 5667.458398 -0.006091875
        Soil.As   1.534294  224.461343  0.006835448
        Landuse -18.032483 5667.021364 -0.003182004
           soil -56.493277 4456.340862 -0.012677055
Soil.As:Landuse  -4.075830  224.377671 -0.018165041
   Soil.As:soil   5.653968    6.128663  0.922545099
   Landuse:soil -41.013523 4455.784835 -0.009204557

(Dispersion Parameter for Binomial family taken to be 1 )

    Null Deviance: 47.39777 on 37 degrees of freedom

Residual Deviance: 22.48276 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 10
```

Earthworm Lumbricus rubellus count nickel

Analysis of Deviance Table

Poisson model

Response: LURB.count

```
Terms added sequentially (first to last)
                Df Deviance Resid. Df Resid. Dev   Pr(Chi)
           NULL                    37   370.7236
        Soil.Ni  1 27.50925        36   343.2144 0.0000002
        Landuse  1  0.02147        35   343.1929 0.8835043
           soil  1 47.09774        34   296.0952 0.0000000
Soil.Ni:Landuse  1  0.70421        33   295.3910 0.4013736
   Soil.Ni:soil  1  0.00095        32   295.3900 0.9753818
   Landuse:soil  1 11.45188        31   283.9381 0.0007142
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = LURB.count ~ Soil.Ni * Landuse * soil -
      Soil.Ni:Landuse:soil, family = poisson, data =
      worms.out, na.action = na.omit)
Deviance Residuals:
       Min        1Q     Median       3Q      Max
 -4.773715 -2.012984 -0.8618739 1.056807 6.620539

Coefficients:
                         Value    Std. Error
    (Intercept)  1.96924752380 0.10818214830
        Soil.Ni  0.00029356952 0.00004436033
        Landuse -0.18046713929 0.10841921025
           soil -0.44293688777 0.09348951137
Soil.Ni:Landuse  0.00005672440 0.00004231823
   Soil.Ni:soil -0.00001289997 0.00003834951
   Landuse:soil -0.23145406870 0.07263096501
                    t value
    (Intercept)  18.2030728
        Soil.Ni   6.6178392
        Landuse  -1.6645310
           soil  -4.7378244
Soil.Ni:Landuse   1.3404247
   Soil.Ni:soil  -0.3363789
   Landuse:soil  -3.1867134

(Dispersion Parameter for Poisson family taken to be 1 )

    Null Deviance: 370.7236 on 37 degrees of freedom

Residual Deviance: 283.9381 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Earthworm Lumbricus rubellus count copper

Analysis of Deviance Table

Poisson model

Response: LURB.count

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	Pr(Chi)
NULL			37	370.7236	
Soil.Cu	1	23.80643	36	346.9172	0.0000011
Landuse	1	0.06550	35	346.8517	0.7980059
soil	1	47.37768	34	299.4740	0.0000000
Soil.Cu:Landuse	1	0.82850	33	298.6455	0.3627071
Soil.Cu:soil	1	0.00032	32	298.6452	0.9856746
Landuse:soil	1	18.58323	31	280.0620	0.0000163

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = LURB.count ~ Soil.Cu * Landuse * soil -
      Soil.Cu:Landuse:soil, family = poisson, data =
      worms.out, na.action = na.omit)
Deviance Residuals:
       Min       1Q     Median       3Q      Max
 -4.923805 -2.17024 -0.9690848 1.115648 6.709246
```

Coefficients:

	Value	Std. Error	t value
(Intercept)	1.8465551063	0.1274818305	14.4848493
Soil.Cu	0.0024911535	0.0003751377	6.6406368
Landuse	-0.2847946945	0.1273952169	-2.2355211
soil	-0.4978262062	0.1065207648	-4.6735133
Soil.Cu:Landuse	0.0007258085	0.0003578545	2.0282220
Soil.Cu:soil	-0.0002232597	0.0003105799	-0.7188478
Landuse:soil	-0.3341216295	0.0874722650	-3.8197437

(Dispersion Parameter for Poisson family taken to be 1)

Null Deviance: 370.7236 on 37 degrees of freedom

Residual Deviance: 280.062 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 4

Earthworm Lumbricus rubellus count cobalt

Analysis of Deviance Table

```
> anova(worm.lurb.ct.co.glm,test="Chi")
Analysis of Deviance Table

Poisson model

Response: LURB.count

Terms added sequentially (first to last)
                Df Deviance Resid. Df Resid. Dev   Pr(Chi)
           NULL                    37   370.7236
        Soil.Co  1 24.86527        36   345.8584 0.0000006
        Landuse  1  0.04865        35   345.8097 0.8254341
           soil  1 46.35885        34   299.4509 0.0000000
Soil.Co:Landuse  1  0.05664        33   299.3942 0.8118880
   Soil.Co:soil  1  0.36023        32   299.0340 0.5483758
   Landuse:soil  1 14.25724        31   284.7768 0.0001594
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = LURB.count ~ Soil.Co * Landuse * soil -
      Soil.Co:Landuse:soil, family = poisson, data =
      worms.out, na.action = na.omit)
Deviance Residuals:
       Min        1Q    Median       3Q      Max
 -4.916483 -2.147466 -1.025635 1.208998 6.797012

Coefficients:
                       Value  Std. Error     t value
    (Intercept)  1.738215341 0.142686063  12.1820961
        Soil.Co  0.022190190 0.003498750   6.3423188
        Landuse -0.319248171 0.139884512  -2.2822267
           soil -0.420450189 0.114534351  -3.6709527
Soil.Co:Landuse  0.006721230 0.003099045   2.1688067
   Soil.Co:soil -0.002812274 0.002961257  -0.9496894
   Landuse:soil -0.271143491 0.079067717  -3.4292566

(Dispersion Parameter for Poisson family taken to be 1 )

    Null Deviance: 370.7236 on 37 degrees of freedom

Residual Deviance: 284.7768 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Earthworm Lumbricus rubellus count arsenic

Analysis of Deviance Table

Poisson model

Response: LURB.count

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	Pr(Chi)
NULL			37	370.7236	
Soil.As	1	13.30688	36	357.4168	0.0002644
Landuse	1	0.02318	35	357.3936	0.8789786
soil	1	40.17218	34	317.2214	0.0000000
Soil.As:Landuse	1	2.42677	33	314.7946	0.1192783
Soil.As:soil	1	4.69500	32	310.0996	0.0302504
Landuse:soil	1	22.04040	31	288.0592	0.0000027

Summary

*** Generalized Linear Model ***

Call: glm(formula = LURB.count ~ Soil.As * Landuse * soil - Soil.As:Landuse:soil, family = poisson, data = worms.out, na.action = na.omit)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-4.899209	-2.173178	-0.8491521	0.974395	6.796909

Coefficients:

	Value	Std. Error	t value
(Intercept)	1.871716090	0.130147525	14.3814959
Soil.As	0.034808778	0.005911981	5.8878370
Landuse	-0.219365851	0.128963076	-1.7009974
soil	-0.703031495	0.122151144	-5.7554229
Soil.As:Landuse	-0.004204855	0.006355274	-0.6616324
Soil.As:soil	0.017447079	0.006274288	2.7807265
Landuse:soil	-0.359038827	0.086611702	-4.1453847

(Dispersion Parameter for Poisson family taken to be 1)

Null Deviance: 370.7236 on 37 degrees of freedom

Residual Deviance: 288.0592 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 4

Earthworm Lumbricus rubellus weight nickel

Analysis of Deviance Table

Gaussian model

Response: LURB.wt

```
Terms added sequentially (first to last)
                Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
           NULL                   37   278.6663
        Soil.Ni  1 49.62583       36   229.0405 7.754126 0.0090542
        Landuse  1  0.41383       35   228.6267 0.064661 0.8009544
           soil  1  8.78527       34   219.8414 1.372714 0.2502726
Soil.Ni:Landuse  1  1.22293       33   218.6185 0.191085 0.6650451
   Soil.Ni:soil  1 20.13111       32   198.4873 3.145522 0.0859608
   Landuse:soil  1  0.08965       31   198.3977 0.014008 0.9065512
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = LURB.wt ~ Soil.Ni * Landuse * soil -
      Soil.Ni:Landuse:soil, family = gaussian, data
       = worms.out, na.action = na.omit)
Deviance Residuals:
       Min        1Q     Median        3Q     Max
 -4.269736 -1.299024 -0.6254046 0.6630059 7.51131

Coefficients:
                        Value   Std. Error    t value
    (Intercept)  1.1745789001 0.6382206319  1.8403963
        Soil.Ni  0.0012107837 0.0003582008  3.3801810
        Landuse -0.1829060183 0.6229093767 -0.2936318
           soil  0.1958574360 0.6049854056  0.3237391
Soil.Ni:Landuse  0.0001030457 0.0003158883  0.3262094
   Soil.Ni:soil -0.0006506275 0.0003671667 -1.7720220
   Landuse:soil -0.0546875954 0.4620702595 -0.1183534

(Dispersion Parameter for Gaussian family taken to be 6.399926 )

    Null Deviance: 278.6663 on 37 degrees of freedom

Residual Deviance: 198.3977 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Earthworm Lumbricus rubellus weight copper

Analysis of Deviance Table

Gaussian model

Response: LURB.wt

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			37	278.6663		
Soil.Cu	1	45.79201	36	232.8743	7.034052	0.0124920
Landuse	1	0.21980	35	232.6545	0.033764	0.8554068
soil	1	9.40133	34	223.2532	1.444126	0.2385732
Soil.Cu:Landuse	1	1.19128	33	222.0619	0.182990	0.6717730
Soil.Cu:soil	1	18.73838	32	203.3235	2.878378	0.0997972
Landuse:soil	1	1.51204	31	201.8115	0.232263	0.6332360

Summary

*** Generalized Linear Model ***

```
Call: glm(formula = LURB.wt ~ Soil.Cu * Landuse * soil -
      Soil.Cu:Landuse:soil, family = gaussian, data
       = worms.out, na.action = na.omit)
Deviance Residuals:
       Min        1Q     Median        3Q      Max
 -4.445011 -1.303339 -0.4630275 0.8143718 8.272267
```

Coefficients:

	Value	Std. Error	t value
(Intercept)	1.008904821	0.679191007	1.4854508
Soil.Cu	0.009313515	0.002822319	3.2999511
Landuse	-0.209451168	0.655546761	-0.3195061
soil	0.202835167	0.645110577	0.3144192
Soil.Cu:Landuse	0.001231565	0.002486170	0.4953663
Soil.Cu:soil	-0.005126379	0.002964023	-1.7295340
Landuse:soil	-0.231995113	0.481380766	-0.4819368

(Dispersion Parameter for Gaussian family taken to be 6.510047)

Null Deviance: 278.6663 on 37 degrees of freedom

Residual Deviance: 201.8115 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 1

Earthworm Lumbricus rubellus weight cobalt

Analysis of Deviance Table

Gaussian model

Response: LURB.wt

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			37	278.6663		
Soil.Co	1	46.34001	36	232.3263	7.675726	0.0093732
Landuse	1	0.28852	35	232.0378	0.047790	0.8283867
soil	1	7.92675	34	224.1110	1.312981	0.2606244
Soil.Co:Landuse	1	0.23509	33	223.8759	0.038940	0.8448553
Soil.Co:soil	1	36.60466	32	187.2713	6.063170	0.0195630
Landuse:soil	1	0.11761	31	187.1537	0.019482	0.8898973

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = LURB.wt ~ Soil.Co * Landuse * soil -
      Soil.Co:Landuse:soil, family = gaussian, data
       = worms.out, na.action = na.omit)
Deviance Residuals:
       Min        1Q     Median        3Q      Max
 -4.523126 -1.111521 -0.4389305 0.6919681 6.876921
```

Coefficients:

	Value	Std. Error	t value
(Intercept)	0.008262749	0.81868127	0.01009275
Soil.Co	0.105191155	0.02770791	3.79643092
Landuse	-0.424283056	0.71281572	-0.59522124
soil	1.118801766	0.78958476	1.41694955
Soil.Co:Landuse	0.014431812	0.02050929	0.70367187
Soil.Co:soil	-0.069722716	0.02832217	-2.46177144
Landuse:soil	-0.061875484	0.44330806	-0.13957672

(Dispersion Parameter for Gaussian family taken to be 6.037215)

Null Deviance: 278.6663 on 37 degrees of freedom

Residual Deviance: 187.1537 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 1

Earthworm Lumbricus rubellus weight arsenic

Analysis of Deviance Table

Gaussian model

Response: LURB.wt

```
Terms added sequentially (first to last)
                Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
           NULL                    37   278.6663
        Soil.As  1 40.04036        36   238.6259 5.837567 0.0217692
        Landuse  1  2.24073        35   236.3852 0.326680 0.5717418
           soil  1  9.87287        34   226.5123 1.439387 0.2393279
Soil.As:Landuse  1  5.46081        33   221.0515 0.796143 0.3791232
   Soil.As:soil  1  6.72643        32   214.3251 0.980660 0.3297030
   Landuse:soil  1  1.69347        31   212.6316 0.246895 0.6227756
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = LURB.wt ~ Soil.As * Landuse * soil -
      Soil.As:Landuse:soil, family = gaussian, data
       = worms.out, na.action = na.omit)
Deviance Residuals:
       Min        1Q     Median        3Q      Max
 -4.484544 -1.214431 -0.4802224 0.5688118 9.329618

Coefficients:
                       Value Std. Error     t value
    (Intercept)  0.877917943 0.75537350  1.16223026
        Soil.As  0.152447625 0.05068441  3.00778137
        Landuse -0.253581267 0.77005371 -0.32930335
           soil -0.022245634 0.77121789 -0.02884481
Soil.As:Landuse -0.004422907 0.05656173 -0.07819611
   Soil.As:soil -0.056094897 0.06179342 -0.90778102
   Landuse:soil -0.253582199 0.51034348 -0.49688535

(Dispersion Parameter for Gaussian family taken to be 6.859085 )

    Null Deviance: 278.6663 on 37 degrees of freedom

Residual Deviance: 212.6316 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Earthworm Aporrectodea tuberculata count nickel

Analysis of Deviance Table

Poisson model

Response: APTB.count

```
Terms added sequentially (first to last)
                Df Deviance Resid. Df Resid. Dev   Pr(Chi)
           NULL                    37   166.0901
        Soil.Ni  1 15.00282        36   151.0873 0.0001074
        Landuse  1  1.20516        35   149.8821 0.2722932
           soil  1  5.00439        34   144.8777 0.0252832
Soil.Ni:Landuse  1 27.75911        33   117.1186 0.0000001
   Soil.Ni:soil  1  4.56566        32   112.5530 0.0326191
   Landuse:soil  1  9.08727        31   103.4657 0.0025739
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = APTB.count ~ Soil.Ni * Landuse * soil -
      Soil.Ni:Landuse:soil, family = poisson, data =
      worms.out, na.action = na.omit)
Deviance Residuals:
       Min        1Q     Median       3Q     Max
 -3.365151 -1.194421 -0.7363685 1.072608 2.93531

Coefficients:
                        Value   Std. Error   t value
    (Intercept)  1.0268082133 0.2475045962  4.148643
        Soil.Ni -0.0006490874 0.0001720572 -3.772509
        Landuse -0.3882188116 0.2478514968 -1.566336
           soil -0.9120356478 0.2326242537 -3.920639
Soil.Ni:Landuse  0.0004206007 0.0001493324  2.816539
   Soil.Ni:soil  0.0005946028 0.0001692095  3.514005
   Landuse:soil -0.5366781441 0.2143999128 -2.503164

(Dispersion Parameter for Poisson family taken to be 1 )

    Null Deviance: 166.0901 on 37 degrees of freedom

Residual Deviance: 103.4657 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Earthworm Aporrectodea tuberculata count copper

Analysis of Deviance Table

Poisson model

Response: APTB.count

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	Pr(Chi)
NULL			37	166.0901	
Soil.Cu	1	13.96174	36	152.1283	0.0001866
Landuse	1	0.88782	35	151.2405	0.3460688
soil	1	4.50944	34	146.7311	0.0337082
Soil.Cu:Landuse	1	31.11359	33	115.6175	0.0000000
Soil.Cu:soil	1	2.64411	32	112.9734	0.1039341
Landuse:soil	1	7.45712	31	105.5163	0.0063186

Summary

*** Generalized Linear Model ***

```
Call: glm(formula = APTB.count ~ Soil.Cu * Landuse * soil -
      Soil.Cu:Landuse:soil, family = poisson, data =
      worms.out, na.action = na.omit)
```

Deviance Residuals:

Min	1Q	Median	3Q	Max
-3.321627	-1.156456	-0.5663756	1.171883	2.911838

Coefficients:

	Value	Std. Error	t value
(Intercept)	1.085168070	0.281791543	3.850960
Soil.Cu	-0.004901397	0.001500577	-3.266342
Landuse	-0.509947313	0.277975828	-1.834502
soil	-1.004486282	0.258916408	-3.879578
Soil.Cu:Landuse	0.003193047	0.001190471	2.682171
Soil.Cu:soil	0.004451319	0.001544524	2.882001
Landuse:soil	-0.502921005	0.221005394	-2.275605

(Dispersion Parameter for Poisson family taken to be 1)

Null Deviance: 166.0901 on 37 degrees of freedom

Residual Deviance: 105.5163 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 4

Earthworm Aporrectodea tuberculata count cobalt

Analysis of Deviance Table

Poisson model

Response: APTB.count

```
Terms added sequentially (first to last)
                Df Deviance Resid. Df Resid. Dev   Pr(Chi)
           NULL                    37   166.0901
        Soil.Co  1  8.50709        36   157.5830 0.0035377
        Landuse  1  0.72507        35   156.8579 0.3944871
           soil  1  5.50732        34   151.3506 0.0189371
Soil.Co:Landuse  1 22.38308        33   128.9675 0.0000022
   Soil.Co:soil  1  6.22485        32   122.7427 0.0125969
   Landuse:soil  1  7.03253        31   115.7101 0.0080042
```

Summary

```
*** Generalized Linear Model ***

Call: glm(formula = APTB.count ~ Soil.Co * Landuse * soil -
      Soil.Co:Landuse:soil, family = poisson, data =
      worms.out, na.action = na.omit)
Deviance Residuals:
       Min        1Q    Median        3Q      Max
 -3.203249 -1.174193 -1.015147 0.7443475 4.150488

Coefficients:
                      Value  Std. Error   t value
    (Intercept)  1.64396545 0.320170446  5.134657
        Soil.Co -0.04950326 0.013375460 -3.701051
        Landuse -0.47614848 0.280997938 -1.694491
           soil -1.35888125 0.307128420 -4.424472
Soil.Co:Landuse  0.02197582 0.009038872  2.431257
   Soil.Co:soil  0.04658973 0.013522823  3.445267
   Landuse:soil -0.42698549 0.182262241 -2.342699

(Dispersion Parameter for Poisson family taken to be 1 )

    Null Deviance: 166.0901 on 37 degrees of freedom

Residual Deviance: 115.7101 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Earthworm Aporrectodea tuberculata count arsenic

Analysis of Deviance Table

Poisson model

Response: APTB.count

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	Pr(Chi)
NULL			37	166.0901	
Soil.As	1	11.01556	36	155.0745	0.0009035
Landuse	1	1.90619	35	153.1683	0.1673871
soil	1	3.84293	34	149.3254	0.0499562
Soil.As:Landuse	1	22.60529	33	126.7201	0.0000020
Soil.As:soil	1	9.75263	32	116.9675	0.0017907
Landuse:soil	1	7.68696	31	109.2805	0.0055621

Summary

*** Generalized Linear Model ***

```
Call: glm(formula = APTB.count ~ Soil.As * Landuse * soil -
      Soil.As:Landuse:soil, family = poisson, data =
      worms.out, na.action = na.omit)
Deviance Residuals:
       Min        1Q     Median        3Q      Max
 -3.257033 -1.326192 -0.9143932 0.6719298 3.878604
```

Coefficients:

	Value	Std. Error	t value
(Intercept)	1.29635953	0.27485831	4.716465
Soil.As	-0.09805173	0.02472622	-3.965497
Landuse	-0.46888135	0.27365820	-1.713383
soil	-1.14732202	0.27342136	-4.196168
Soil.As:Landuse	0.04812842	0.02121790	2.268293
Soil.As:soil	0.08757088	0.02357771	3.714139
Landuse:soil	-0.49607366	0.21465516	-2.311026

(Dispersion Parameter for Poisson family taken to be 1)

Null Deviance: 166.0901 on 37 degrees of freedom

Residual Deviance: 109.2805 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 4

Earthworm Aporrectodea tuberculata weight nickel

Analysis of Deviance Table

Gaussian model

Response: APTB.wt

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			37	10.33656		
Soil.Ni	1	1.078576	36	9.25799	4.345935	0.0454264
Landuse	1	0.082636	35	9.17535	0.332966	0.5680849
soil	1	0.171435	34	9.00391	0.690770	0.4122587
Soil.Ni:Landuse	1	0.062517	33	8.94140	0.251901	0.6192861
Soil.Ni:soil	1	0.954905	32	7.98649	3.847625	0.0588507
Landuse:soil	1	0.292903	31	7.69359	1.180201	0.2856906

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = APTB.wt ~ Soil.Ni * Landuse * soil -
      Soil.Ni:Landuse:soil, family = gaussian, data
       = worms.out, na.action = na.omit)
Deviance Residuals:
        Min         1Q      Median         3Q      Max
 -0.6504978 -0.2800484 -0.09231993 0.1933697 1.229502

Coefficients:
                         Value    Std. Error
    (Intercept)  4.502584e-001 0.12568025592
        Soil.Ni -1.708645e-004 0.00007053795
        Landuse  9.460551e-003 0.12266511917
           soil -2.580025e-001 0.11913547885
Soil.Ni:Landuse -2.100601e-006 0.00006220565
   Soil.Ni:soil  1.427540e-004 0.00007230354
   Landuse:soil -9.885126e-002 0.09099221423
                     t value
    (Intercept)  3.58257080
        Soil.Ni -2.42230609
        Landuse  0.07712503
           soil -2.16562286
Soil.Ni:Landuse -0.03376866
   Soil.Ni:soil  1.97437065
   Landuse:soil -1.08637052

(Dispersion Parameter for Gaussian family taken to be 0.2481803 )

    Null Deviance: 10.33656 on 37 degrees of freedom

Residual Deviance: 7.69359 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Earthworm Aporrectodea tuberculata weight copper

Analysis of Deviance Table

Gaussian model

Response: APTB.wt

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			37	10.33656		
Soil.Cu	1	1.005604	36	9.33096	3.898864	0.0572843
Landuse	1	0.068631	35	9.26233	0.266092	0.6096253
soil	1	0.161936	34	9.10039	0.627847	0.4341684
Soil.Cu:Landuse	1	0.134072	33	8.96632	0.519817	0.4763223
Soil.Cu:soil	1	0.758876	32	8.20744	2.942265	0.0962706
Landuse:soil	1	0.211855	31	7.99559	0.821392	0.3717645

Summary

*** Generalized Linear Model ***

```
Call: glm(formula = APTB.wt ~ Soil.Cu * Landuse * soil -
      Soil.Cu:Landuse:soil, family = gaussian, data
       = worms.out, na.action = na.omit)
Deviance Residuals:
        Min         1Q      Median       3Q      Max
 -0.5705641 -0.2946707 -0.06161528 0.107651 1.313167
```

Coefficients:

	Value	Std. Error	t value
(Intercept)	0.4442060431	0.1351898929	3.2857933
Soil.Cu	-0.0011790528	0.0005617699	-2.0988183
Landuse	-0.0266267356	0.1304836130	-0.2040619
soil	-0.2568577896	0.1284063377	-2.0003513
Soil.Cu:Landuse	0.0000897628	0.0004948610	0.1813899
Soil.Cu:soil	0.0009662545	0.0005899753	1.6377879
Landuse:soil	-0.0868392803	0.0958166607	-0.9063067

(Dispersion Parameter for Gaussian family taken to be 0.2579222)

Null Deviance: 10.33656 on 37 degrees of freedom

Residual Deviance: 7.995588 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 1

Earthworm Aporrectodea tuberculata weight cobalt

Analysis of Deviance Table

Gaussian model

Response: APTB.wt

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			37	10.33656		
Soil.Co	1	0.7148261	36	9.62174	2.698954	0.1105207
Landuse	1	0.0600099	35	9.56173	0.226578	0.6374103
soil	1	0.2197725	34	9.34195	0.829791	0.3693623
Soil.Co:Landuse	1	0.0524060	33	9.28955	0.197868	0.6595376
Soil.Co:soil	1	0.7553951	32	8.53415	2.852130	0.1012888
Landuse:soil	1	0.3237103	31	8.21044	1.222227	0.2774306

Summary

*** Generalized Linear Model ***

```
Call: glm(formula = APTB.wt ~ Soil.Co * Landuse * soil -
      Soil.Co:Landuse:soil, family = gaussian, data
       = worms.out, na.action = na.omit)
```

Deviance Residuals:

Min	1Q	Median	3Q	Max
-0.5930534	-0.2884434	-0.1041961	0.1920011	1.322885

Coefficients:

	Value	Std. Error	t value
(Intercept)	0.5468825761	0.171474265	3.18929827
Soil.Co	-0.0119679202	0.005803471	-2.06220040
Landuse	-0.0030515271	0.149300536	-0.02043882
soil	-0.3450642766	0.165379949	-2.08649403
Soil.Co:Landuse	0.0003363638	0.004295708	0.07830229
Soil.Co:soil	0.0100445320	0.005932130	1.69324205
Landuse:soil	-0.1026515674	0.092851670	-1.10554358

(Dispersion Parameter for Gaussian family taken to be 0.264853)

Null Deviance: 10.33656 on 37 degrees of freedom

Residual Deviance: 8.210442 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 1

Earthworm Aporrectodea tuberculata weight arsenic

Analysis of Deviance Table

Gaussian model

Response: APTB.wt

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			37	10.33656		
Soil.As	1	0.9565264	36	9.38004	3.749951	0.0619710
Landuse	1	0.1900527	35	9.18998	0.745080	0.3946678
soil	1	0.1400788	34	9.04990	0.549163	0.4642369
Soil.As:Landuse	1	0.2076606	33	8.84224	0.814109	0.3738656
Soil.As:soil	1	0.6777602	32	8.16448	2.657081	0.1132104
Landuse:soil	1	0.2570961	31	7.90739	1.007916	0.323175

Summary

*** Generalized Linear Model ***

Call: glm(formula = APTB.wt ~ Soil.As * Landuse * soil - Soil.As:Landuse:soil, family = gaussian, data = worms.out, na.action = na.omit)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-0.6492216	-0.2539824	-0.09289828	0.185567	1.291263

Coefficients:

	Value	Std. Error	t value
(Intercept)	0.486251942	0.145668052	3.3380823
Soil.As	-0.022202290	0.009774104	-2.2715422
Landuse	0.025825821	0.148499018	0.1739124
soil	-0.309988381	0.148723522	-2.0843265
Soil.As:Landuse	-0.001593929	0.010907500	-0.1461315
Soil.As:soil	0.020953625	0.011916393	1.7583866
Landuse:soil	-0.098804618	0.098415871	-1.0039500

(Dispersion Parameter for Gaussian family taken to be 0.255077)

Null Deviance: 10.33656 on 37 degrees of freedom

Residual Deviance: 7.907387 on 31 degrees of freedom

Number of Fisher Scoring Iterations: 1

Leaf Litter

Leaf litter dry weight nickel

Analysis of Deviance Table

```
Gaussian model

Response: log(Leaf.dry)

Terms added sequentially (first to last)
            Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
       NULL                   314   146.7993
total.basal  1 22.66176       313   124.1375 73.46733 0.0000000
         Ni  1 28.24700       312    95.8905 91.57416 0.0000000
       Soil  1  0.21697       311    95.6736  0.70339 0.4022920
    Ni:Soil  1  0.05085       310    95.6227  0.16486 0.6850031
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(Leaf.dry) ~ total.basal + Ni * Soil,
      family = gaussian, data = leaflitter)
Deviance Residuals:
       Min         1Q    Median        3Q      Max
 -1.540876 -0.3525443 0.0341882 0.3860753 1.584425

Coefficients:
                     Value    Std. Error     t value
(Intercept)  4.235787e+000 0.08902556035  47.5794512
total.basal -7.172787e-005 0.00000934879  -7.6724226
         Ni  4.329332e-005 0.00001842261   2.3500103
       Soil -3.997220e-002 0.04296277028  -0.9303915
    Ni:Soil  7.404029e-006 0.00001823533   0.4060267

(Dispersion Parameter for Gaussian family taken to be 0.3084603 )

    Null Deviance: 146.7993 on 314 degrees of freedom

Residual Deviance: 95.62271 on 310 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Leaf litter dry weight copper

Analysis of Deviance Table

```
Gaussian model

Response: log(Leaf.dry)

Terms added sequentially (first to last)
            Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
       NULL                   314   146.7993
total.basal  1 22.66176       313   124.1375 73.17016 0.0000000
         Cu  1 27.43133       312    96.7062 88.57013 0.0000000
       Soil  1  0.18729       311    96.5189  0.60470 0.4373815
    Cu:Soil  1  0.50785       310    96.0111  1.63975 0.2013171
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(Leaf.dry) ~ total.basal + Cu * Soil,
      family = gaussian, data = leaflitter)
Deviance Residuals:
       Min         1Q     Median        3Q      Max
 -1.558525 -0.3657909 0.02735659 0.3783805 1.573715

Coefficients:
                     Value    Std. Error    t value
(Intercept)  4.27479623179 8.814464e-002  48.497517
total.basal -0.00007523465 9.214032e-006  -8.165226
         Cu  0.00019712267 1.746522e-004   1.128659
       Soil -0.05815938459 4.511198e-002  -1.289223
    Cu:Soil  0.00022260480 1.738384e-004   1.280527

(Dispersion Parameter for Gaussian family taken to be 0.3097131 )

    Null Deviance: 146.7993 on 314 degrees of freedom

Residual Deviance: 96.01106 on 310 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Leaf litter dry weight cobalt

Analysis of Deviance Table

Gaussian model

Response: log(Leaf.dry)

```
Terms added sequentially (first to last)
            Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
       NULL                   314   146.7993
total.basal  1 22.66176       313   124.1375 73.50115 0.0000000
         Co  1 27.63546       312    96.5021 89.63286 0.0000000
       Soil  1  0.27154       311    96.2305  0.88072 0.3487354
    Co:Soil  1  0.65181       310    95.5787  2.11407 0.1469619
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(Leaf.dry) ~ total.basal + Co * Soil,
      family = gaussian, data = leaflitter)
Deviance Residuals:
       Min         1Q    Median        3Q      Max
 -1.538858 -0.3643857 0.0235546 0.3656493 1.573816

Coefficients:
                     Value    Std. Error    t value
(Intercept)  4.21731949483 9.239105e-002  45.646408
total.basal -0.00007020329 9.391396e-006  -7.475277
         Co  0.00212341544 1.126685e-003   1.884658
       Soil -0.06982638800 4.577956e-002  -1.525274
    Co:Soil  0.00161457393 1.110447e-003   1.453986

(Dispersion Parameter for Gaussian family taken to be 0.3083184 )

    Null Deviance: 146.7993 on 314 degrees of freedom

Residual Deviance: 95.57871 on 310 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Leaf litter dry weight arsenic

<u>Analysis of Deviance Table</u>

Gaussian model

Response: log(Leaf.dry)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			314	146.7993		
total.basal	1	22.66176	313	124.1375	74.20954	0.0000000
As	1	27.99782	312	96.1397	91.68333	0.0000000
Soil	1	0.39170	311	95.7480	1.28270	0.2582730
As:Soil	1	1.08167	310	94.6663	3.54210	0.0607663

<u>Summary</u>

*** Generalized Linear Model ***

Call: glm(formula = log(Leaf.dry) ~ total.basal + As * Soil,
family = gaussian, data = leaflitter)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-1.528349	-0.3649211	0.02430355	0.3694002	1.571896

Coefficients:

	Value	Std. Error	t value
(Intercept)	4.21956583796	9.199115e-002	45.869260
total.basal	-0.00007164943	9.227026e-006	-7.765170
As	0.00410726298	2.812026e-003	1.460607
Soil	-0.09666276531	4.854216e-002	-1.991316
As:Soil	0.00524465264	2.786676e-003	1.882046

(Dispersion Parameter for Gaussian family taken to be 0.3053753)

Null Deviance: 146.7993 on 314 degrees of freedom

Residual Deviance: 94.66633 on 310 degrees of freedom

Number of Fisher Scoring Iterations: 1

Leaf twig nickel

Analysis of Deviance Table

```
Gaussian model

Response: log(Twig)

Terms added sequentially (first to last)
            Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
       NULL                   314   128.1405
total.basal  1 0.169544       313   127.9710 0.421961 0.5164410
         Ni  1 0.000196       312   127.9708 0.000488 0.9823858
       Soil  1 2.951832       311   125.0189 7.346526 0.0070935
    Ni:Soil  1 0.461023       310   124.5579 1.147394 0.2849286
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(Twig) ~ total.basal + Ni * Soil,
      family = gaussian, data = leaflitter)
Deviance Residuals:
       Min         1Q     Median        3Q      Max
 -1.813116 -0.4001815 0.01772242 0.4481232 1.475079

Coefficients:
                     Value    Std. Error     t value
(Intercept)  3.765281e+000 0.10160611830  37.0576211
total.basal  4.997365e-006 0.00001066991   0.4683607
         Ni  3.117071e-005 0.00002102598   1.4824855
       Soil -1.023713e-001 0.04903401115  -2.0877614
    Ni:Soil -2.229333e-005 0.00002081223  -1.0711648

(Dispersion Parameter for Gaussian family taken to be 0.4017997 )

    Null Deviance: 128.1405 on 314 degrees of freedom

Residual Deviance: 124.5579 on 310 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Leaf twig copper

Analysis of Deviance Table

Gaussian model

Response: log(Twig)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			314	128.1405		
total.basal	1	0.169544	313	127.9710	0.423164	0.5158441
Cu	1	0.000291	312	127.9707	0.000725	0.9785296
Soil	1	2.895261	311	125.0754	7.226275	0.0075727
Cu:Soil	1	0.871622	310	124.2038	2.175480	0.1412406

Summary

*** Generalized Linear Model ***

Call: glm(formula = log(Twig) ~ total.basal + Cu * Soil,
family = gaussian, data = leaflitter)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-1.807037	-0.3900632	0.02712868	0.4528311	1.468217

Coefficients:

	Value	Std. Error	t value
(Intercept)	3.760844e+000	0.10025422982	37.5130670
total.basal	3.944674e-006	0.00001047988	0.3764044
Cu	3.602902e-004	0.00019864644	1.8137258
Soil	-8.600574e-002	0.05130960720	-1.6762113
Cu:Soil	-2.916286e-004	0.00019772088	-1.4749509

(Dispersion Parameter for Gaussian family taken to be 0.4006574)

Null Deviance: 128.1405 on 314 degrees of freedom

Residual Deviance: 124.2038 on 310 degrees of freedom

Number of Fisher Scoring Iterations: 1

Leaf twig cobalt

Analysis of Deviance Table

Gaussian model

Response: log(Twig)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			314	128.1405		
total.basal	1	0.169544	313	127.9710	0.423174	0.5158394
Co	1	0.005800	312	127.9652	0.014477	0.9043059
Soil	1	3.158031	311	124.8071	7.882298	0.0053085
Co:Soil	1	0.606117	310	124.2010	1.512840	0.2196388

Summary

*** Generalized Linear Model ***

```
Call: glm(formula = log(Twig) ~ total.basal + Co * Soil,
      family = gaussian, data = leaflitter)
```

Deviance Residuals:

Min	1Q	Median	3Q	Max
-1.829869	-0.3942751	0.02448483	0.4443856	1.492603

Coefficients:

	Value	Std. Error	t value
(Intercept)	3.738937e+000	0.10532025123	35.5006428
total.basal	6.067526e-006	0.00001070563	0.5667604
Co	2.262257e-003	0.00128435306	1.7613980
Soil	-9.709300e-002	0.05218595267	-1.8605198
Co:Soil	-1.556956e-003	0.00126584285	-1.2299758

(Dispersion Parameter for Gaussian family taken to be 0.4006484)

Null Deviance: 128.1405 on 314 degrees of freedom

Residual Deviance: 124.201 on 310 degrees of freedom

Number of Fisher Scoring Iterations: 1

Leaf twig arsenic

Analysis of Deviance Table

Gaussian model

Response: log(Twig)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			314	128.1405		
total.basal	1	0.169544	313	127.9710	0.421118	0.5168600
As	1	0.001557	312	127.9694	0.003867	0.9504558
Soil	1	2.949970	311	125.0194	7.327224	0.0071682
As:Soil	1	0.212171	310	124.8073	0.526997	0.4684198

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(Twig) ~ total.basal + As * Soil,
      family = gaussian, data = leaflitter)
Deviance Residuals:
       Min         1Q     Median        3Q      Max
 -1.842136 -0.4062792 0.02954206 0.4577271 1.518002

Coefficients:
                     Value    Std. Error     t value
(Intercept)  3.762870e+000 0.10562535748  35.6246825
total.basal  3.969928e-006 0.00001059458   0.3747129
         As  3.935931e-003 0.00322880206   1.2190067
       Soil -1.024594e-001 0.05573670199  -1.8382761
    As:Soil -2.322805e-003 0.00319969502  -0.7259456

(Dispersion Parameter for Gaussian family taken to be 0.4026041 )

    Null Deviance: 128.1405 on 314 degrees of freedom

Residual Deviance: 124.8073 on 310 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Leaf fruit nickel

Analysis of Deviance Table

```
Gaussian model

Response: log(Fruit)

Terms added sequentially (first to last)
            Df Deviance Resid. Df Resid. Dev  F Value     Pr(F)
       NULL                   313   697.3700
total.basal  1 30.53665       312   666.8333 16.50788 0.0000615
         Ni  1 82.97325       311   583.8601 44.85469 0.0000000
       Soil  1  4.25538       310   579.6047  2.30043 0.1303609
    Ni:Soil  1  8.00937       309   571.5953  4.32980 0.0382740
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(Fruit) ~ total.basal + Ni * Soil,
      family = gaussian, data = leaflitter, na.action
       = na.omit)
Deviance Residuals:
       Min         1Q    Median        3Q      Max
 -6.994905 -0.8691004 0.0415107 0.9149207 3.072118

Coefficients:
                     Value    Std. Error    t value
(Intercept)  0.87270246216 0.21805900891  4.0021390
total.basal -0.00006481923 0.00002289911 -2.8306444
         Ni  0.00018314525 0.00004512673  4.0584651
       Soil -0.06279245232 0.10521460990 -0.5968035
    Ni:Soil -0.00009293109 0.00004466084 -2.0808180

(Dispersion Parameter for Gaussian family taken to be 1.849823 )

    Null Deviance: 697.37 on 313 degrees of freedom

Residual Deviance: 571.5953 on 309 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Leaf fruit copper

Analysis of Deviance Table

Gaussian model

Response: log(Fruit)

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	F Value	Pr(F)
NULL			313	697.3700		
total.basal	1	30.53665	312	666.8333	16.22571	0.0000708
Cu	1	75.63052	311	591.2028	40.18643	0.0000000
Soil	1	3.36333	310	587.8394	1.78711	0.1822616
Cu:Soil	1	6.30401	309	581.5354	3.34965	0.0681824

Summary

*** Generalized Linear Model ***

```
Call: glm(formula = log(Fruit) ~ total.basal + Cu * Soil,
      family = gaussian, data = leaflitter, na.action
       = na.omit)
```

Deviance Residuals:

Min	1Q	Median	3Q	Max
-6.98029	-0.8517531	0.02345379	0.9161808	3.22859

Coefficients:

	Value	Std. Error	t value
(Intercept)	0.94944886698	0.21733072040	4.3686823
total.basal	-0.00007531938	0.00002271745	-3.3154856
Cu	0.00149847304	0.00043061294	3.4798607
Soil	-0.03521204140	0.11121327034	-0.3166173
Cu:Soil	-0.00078437506	0.00042857222	-1.8302051

(Dispersion Parameter for Gaussian family taken to be 1.881992)

Null Deviance: 697.37 on 313 degrees of freedom

Residual Deviance: 581.5354 on 309 degrees of freedom

Number of Fisher Scoring Iterations: 1

Leaf fruit cobalt

Analysis of Deviance Table

```
Gaussian model

Response: log(Fruit)

Terms added sequentially (first to last)
            Df Deviance Resid. Df Resid. Dev  F Value      Pr(F)
       NULL                   313   697.3700
total.basal  1 30.53665       312   666.8333 16.62710 0.00005793
         Co  1 88.33266       311   578.5006 48.09683 0.00000000
       Soil  1  5.87662       310   572.6240  3.19980 0.07462666
    Co:Soil  1  5.12734       309   567.4967  2.79182 0.09575922
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(Fruit) ~ total.basal + Co * Soil,
      family = gaussian, data = leaflitter, na.action
       = na.omit)
Deviance Residuals:
      Min         1Q     Median        3Q      Max
 -6.96715 -0.8512163 0.05335447 0.9364994 3.156566

Coefficients:
                    Value    Std. Error    t value
(Intercept)  0.7608943938 0.22555220960  3.3734735
total.basal -0.0000598233 0.00002292752 -2.6092356
         Co  0.0114283661 0.00275074243  4.1546478
       Soil -0.0844181935 0.11173617469 -0.7555135
    Co:Soil -0.0045290361 0.00271058064 -1.6708730

(Dispersion Parameter for Gaussian family taken to be 1.836559 )

    Null Deviance: 697.37 on 313 degrees of freedom

Residual Deviance: 567.4967 on 309 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

Leaf fruit arsenic

Analysis of Deviance Table

```
Gaussian model

Response: log(Fruit)

Terms added sequentially (first to last)
            Df Deviance Resid. Df Resid. Dev  F Value      Pr(F)
       NULL                   313   697.3700
total.basal  1 30.53665       312   666.8333 16.72770 0.00005509
         As  1 88.13086       311   578.7024 48.27727 0.00000000
       Soil  1  6.64835       310   572.0541  3.64190 0.05726899
    As:Soil  1  7.97011       309   564.0840  4.36595 0.03748160
```

Summary

```
      *** Generalized Linear Model ***

Call: glm(formula = log(Fruit) ~ total.basal + As * Soil,
      family = gaussian, data = leaflitter, na.action
       = na.omit)
Deviance Residuals:
       Min         1Q     Median        3Q      Max
 -6.885055 -0.8352496 0.06401349 0.9270241 3.021352

Coefficients:
                     Value    Std. Error    t value
(Intercept)  0.72642884669 0.22496071879  3.2291364
total.basal -0.00006501302 0.00002256481 -2.8811685
         As  0.03098056605 0.00687701745  4.5049422
       Soil -0.04910134839 0.11868878264 -0.4136983
    As:Soil -0.01423840873 0.00681431188 -2.0894859

(Dispersion Parameter for Gaussian family taken to be 1.825514 )

    Null Deviance: 697.37 on 313 degrees of freedom

Residual Deviance: 564.084 on 309 degrees of freedom

Number of Fisher Scoring Iterations: 1
```

DETERMINATION OF
TOXICITY REFERENCE VALUES (TRVs)

DETERMINATION OF TOXICITY REFERENCE VALUES FOR NICKEL, COPPER, COBALT, AND ARSENIC FOR ENVIRONMENTAL RISK ASSESSMENT – PORT COLBORNE

1.1 Methodology

For significant effects, such as mortality of 50% (LC_{50}) of the test population, these were converted to TRVs by approximating the concentration that would affect 10% of the population assuming a linear dose-response relationship. The relationship (see Efroymson *et al*. 1997a; Efroymson *et al*. 1997b) for estimating the TRV from a 50% mortality concentration (*i.e.*, LC_{50}) is as follows:

$$EC_{20,est} = \frac{LC_{50}}{5} \quad (1)$$

where

LC_{50}	=	Lowest concentration at which 50% mortality has been observed.
TRV	=	Threshold response value or EC_{20} (concentration at which less severe effect to 20% of the population is estimated)

For mammals and birds, the methods of Sample *et al.* 1996 were used to estimate Lowest Observed Adverse Effect Levels (LOAELs) as follows:

$$LOAEL_w = LOAEL_t \left(\frac{BW_t}{BW_w} \right)^{(1-f)} \quad (2)$$

where,

$LOAEL_w$	=	lowest observed adverse effects level for wildlife species
$LOAEL_t$	=	lowest observed adverse effects level for test species
BW_w	=	body weight for wildlife species
BW_t	=	body weight for test species
f	=	scaling factor (0.94 for mammals; 1.2 for birds; Sample and Arenal, 1999)

1.2 Nickel

Earthworms

The speciation of nickel can be seen to have a major impact on the toxicity of nickel to earthworms. Substantially higher toxicities have been observed for nickel chloride, nickel sulphate and other soluble nickel forms than for metallic nickel and nickel oxide. Endpoint data available for nickel species relevant to the current study area are summarized in Table 1.

Speciation of samples of natural soils (excludes road bed and rail bed samples) from the east side of Port Colborne by X-Ray Absorption Spectroscopy (XAS) and by Scanning Electron Microscopy (SEM) indicated that the nickel in soil is almost entirely (i.e., greater than 99%) oxidic and metallic forms of nickel. Other nickel containing substances were not quantified in the speciation analyses of those samples applicable to the natural environment.

Table 1: Selected Chronic Endpoints for Nickel Exposure to Earthworms

Chemical Form	Concentration	Duration	Endpoint	Reference
Nickel	1200 - 12000 mg/kg	8 weeks	NOEC, weight & mortality	Hartenstein, 1981
Nickel oxide	40,000 mg/kg	8 weeks	NOEC, weight	Malecki *et al.*, 1982
	40,000 mg/kg	8 weeks	LOEC cocoons	
Nickel sulphate	500 mg/kg	8 weeks	LOEC, weight & cocoons	
Nickel acetate	100 – 200 mg/kg	140 days	NOEC, LOEC & cocoon	Malecki *et al.*, 1982
Nickel (soluble forms)	250 mg/kg (lowest concentration)	42 days	LOEC, cocoon	Neuhauser *et al.*, 1984, in Efroymson *et al.*, 1997b
Nickelous nitrate	757 mg/kg	14 days	LOEC, LC_{50}, mortality	Neuhauser *et al.*, 1985
	500 mg/kg	8 weeks	LOEC, weight, progeny	Malecki *et al.*, 1982.
Nickelous chloride	150 mg/kg	12 weeks	NOEC, survival	Ma, 1982
	1,000 mg/kg	12 weeks	LOEC, survival	
	2000-2500 mg/kg	6 weeks	LC_{50}, mortality	
	200 mg/kg	8 weeks	LOEC, weight, progeny count	Malecki *et al.*, 1982
	300 mg/kg	4 weeks	EC_{50}, progeny count	Scott-Fordsmand, 1998
	684 mg/kg	4 weeks	EC_{50}, mortality	

Chronic toxicity to earthworms for nickel oxide was evaluated by Malecki *et al.* (1982). That study established a No Observed Effects Concentration (NOEC) of 40,000 mg/kg nickel oxide based on weight and a Lowest Observed Effects Concentration (LOEC) of 40,000 nickel oxide for reproduction. Hartenstein (1981) observed no effects at 1200 to 12,000 mg/kg nickel, based on weight and mortality.

As shown in Table 1, much lower effects levels can be seen for other nickel species. Since the data are limited for nickel, excluding nickel salts that are not prevalent in soils in the study area, the NOEC for nickel and nickel oxide of 12,000 mg/kg based on weight was selected. For nickel chloride, Malecki *et al*. recorded a LOEC for reproduction at 25% of the LOEC for weight. The NOEC was reduced by this factor to derive a NOEC concentration for reproduction of 3000 mg/kg, based on nickel as nickel oxide. The results for nickel oxide indicate that this TRV is very conservative for application to soils containing oxidic nickel. This value is considered appropriate for application to soils in the current study for soils in which the dominant forms of nickel are metallic nickel and/or nickel oxide. This TRV value is also considered conservative because of the addition of an uncertainty factor of 4 to the NOEC.

Frogs

The review of nickel toxicity to frogs and toads shown in Table 2 reveals widely varying tolerance to nickel for different species. The review shows that the Fowlers Toad is far more tolerant to nickel than most other species tested including all frogs tested.

The lowest chronic LC_{50} identified (see Table 2) was for frogs measured for nickel chloride exposure of *Gastrophryne carolinensis* (Eastern narrow-mouth toad) embryos at 0.05 mg/l (Birge, 1978; Birge, *et al*., 1979; Birge and Black, 1980). The LC_{10} measured for the eastern narrow-mouthed toad (Birge *et al*., 2000) was 0.004 mg/l, with the lowest LC_{10} equal to 0.002 mg/l for the leopard frog (Birge *et al*., 2000).

For Fowler's toad, an LC_{50} of 11.03 mg/l was measured and an LC_{10} of 0.41 mg/l, two orders of magnitude above the LC_{10} for the eastern narrow-mouth toad.

In order to better understand the applicability of the results of the toxicity review, background surface water quality for nickel were reviewed. Table 3 provides a summary of surface water quality data reported by the Ontario Ministry of the Environment (MOE, 2004; 1999).

Surface water for nickel from 35 rivers with drinking water treatment plant intakes was tabulated (MOE 2004) along with water quality data from six tributaries to Lake Ontario (MOE 1999).

For nickel, 10 values were listed in the MOE reports as having concentrations less than the detection. For the purposes of computing statistics, these values were set to one half of the detection limit.

Table 2 Chronic Endpoints for Nickel Exposure to Frogs and Toads

Chemical Form	Test Species	Concentration	Duration	Endpoint	Reference
Nickel	*G. carolinensis* embryo (Eastern narrow-mouthed toad)	0.05 mg/l	7 days	LC_{50}	Birge, *et al*., 1979
Nickelous chloride	*G. carolinensis* embryo Eastern narrow-mouthed toad	0.05 mg/l	7 days	LC_{50}	Birge, 1978
	Clawed toad embryo	2.5 µmol/L (0.32 mg/l)	96 hour	EC_{50}, growth	Sunderman, 1992
		365 µmol/L	96 hour	LC_{50}	
		5.6 µmol/L (0.73 mg/l)	96 hour	LOEC, growth	
Nickel sulfate	Egyptian toad, adult female	73 mg/kg BW	96 hour	LD_{50}	Daabees et al., 1991, in Eisler, 1998b
		120 mg/kg BW	24 hour	LD_{50}	
Sulfuric acid, nickel (2+) salt	Common Indian toad tadpole	25.32 mg/l	96 hour	LC_{50}	Khangarot and Ray, 1987
Nickel chloride	Fowler's toad, embryo/ tadpole	11.03 mg/l	Fertilization through day 4 after hatching	LC_{50}	Birge & Black, 1980
	Narrow-mouthed toad, embryo/ tadpole	0.05 mg/l	Fertilization through day 4 after hatching	LC_{50}	
	Narrow-mouthed toad, embryo	0.05 mg/l	7 days	LC_{50}	US EPA, 1980, in Eisler, 1998b
Unspecified	*B. fowleri* (Fowler's Toad)	14.3 mg/l	Unspecified	LC_{50}	Birge *et al*., 2000
	G. carolinensis (Eastern narrow-mouth toad)	0.05 mg/l	Unspecified	LC_{50}	Birge *et al*., 2000
	R. pipiens (Leopard frog)	0.06 mg/l	Unspecified	LC_{50}	Birge *et al*., 2000
	B. fowleri (Fowler's Toad)	0.41 mg/l	Unspecified	LC_{10}	Birge *et al*., 2000
	G. carolinensis (Eastern narrow-mouth toad)	0.004 mg/l	Unspecified	LC_{10}	Birge *et al*., 2000
	R. pipiens (Leopard frog)	0.002 mg/l	Unspecified	LC_{10}	Birge *et al*., 2000

Table 3 Summary of Background Concentrations of Nickel in Surface Water

Parameter	Value
Number of Rivers	41
Number of Samples	385
Average	0.0027 mg/l
Standard Deviation	0.0076 mg/l
Upper Confidence Limit on the Mean (95%)	0.0035 mg/l
95^{th} Percentile Concentration	0.0059 mg/l
98^{th} Percentile Concentration	0.0288 mg/l
Maximum Measured Concentration	0.084 mg/l

The LC_{10} values measured for the eastern narrow-mouth toad and the leopard frog are well within the range of background surface water concentrations in rivers in southern Ontario. Although less than the maximum background concentration measured, the lowest LC_{50} is greater than the 98^{th} percentile of the background surface water data and is thus considered reasonable for use in this assessment for frogs in the Port Colborne area.

For this study, the EC_{20} has been estimated from the lowest LC_{50} of 0.05 mg/l using equation (1):

$$EC_{20,est} = \frac{LC_{50}}{5} = \frac{0.05 mg/L}{5} = 0.01\, mg/L$$

The LC_{10} of 0.4 mg/l has been used as the TRV specific to Fowler's toad.

Birds

Endpoint data available for nickel species relevant to the current study area are summarized in Table 4.

Table 4 Selected Chronic Endpoints for Nickel Exposure to Birds

Chemical Form	Test Species	Duration	Concentration	Endpoint	Reference
Unspecified form	Mallard	90 days	12.5 mg/kg	LOEC & nickel accumulation in kidneys	Eastin & O'Shea, 1981; Outridge & Scheuhammer, 1993, in Eisler, 1998b
	Coturnix quail	4 generations	0.074 mg/kg	NOEC	National Academy of Sciences, 1975, in Eisler, 1998b
	Day-old Plymouth Rock chickens	3 weeks	300 mg/kg	LOEC & reduced growth rate, elevated Ni concentrations in kidneys	Ling & Leach, 1979; Outridge & Scheuhammer, 1993, in Eisler, 1998b
Nickel sulfate or nickel acetate	Broiler chicks	4 weeks	500 mg/kg	NOEC	National Academy of Sciences, 1975; Nielsen, 1977; Weber & Reid, 1968, in Eisler, 1998b
		4 weeks	700 mg/kg	LOEC & decreased growth in body weight	
Nickel sulfate	Mallard	90 days	774 mg/kg	NOEC & mortality	Cain and Pafford, 1981
		90 days	1,069 mg/kg	LOEC, Reduced growth & mortality	Sample *et al*., 1996

A dose of 1069 mg/kg Ni as nickel sulphate in diet of mallards reduced growth and resulted in 70% mortality, including all of the males. Because the study was conducted over 90 days, Sample *et al.* (1996) considered this the LOEC. Two of the chicks in the 774 mg/kg group died; however, no significant differences in weight were observed in this group (Cain and Pafford, 1981). Sample *et al.* considered this a NOEC and derived a NOAEL of 77 mg Ni/kg-day. This value has been selected as the TRV for birds in the current study because of its duration and the establishment of a NOEC fairly close to the LOEC, generally consistent with other study results.

Although absolute bioavailabilities may vary substantially between birds and mammals, since the relative bioavailability is proportionate to water solubility, a substantial difference between relative bioavailability in mammals and birds is not expected.

Fishelson, *et al.* (1994) measured levels of various metals in animals inhabiting the Acre Valley of Israel. This area is the most densely populated and urbanized site of Israel, as well as the most industrialized containing petrochemical refineries, metal smelters and other small-scale enterprises. One of the metals that was measured in both birds and mammals was nickel (Table 5). Relatively similar concentrations of nickel were observed in both the birds and mammals studied. This indicates that uptake of nickel is similar for mammalian species and birds.

Table 5 Concentrations of Nickel Ions in Tissues of Birds and Mammals.

	Concentrations (mg/kg wet weight)		
Animal	**Brain**	**Heart**	**Liver**
Spur Winged Plover (*Hoplopterus spinosus*) (n=4)	3.9	4.2	3.4
Little Egret (*Egretta garzeta*) (n=6)	3.6	3.9	3.4
Glossy Ibis (*Plegadis falcinellus*) (n=4)	4.9	4.9	4.2
Cattle Egret (*Bubulcus ibis*) (n=6)	3.1	4.2	4.7
House Mouse (*Mus musculus*) (n=4)	3.9	3.1	3.1
Black Rat (*Rattus rattus*) (n=3)	4.4	4.4	4.4

Source:
Based on Fishelson *et al.*, 1994

In the study area, the dominant forms of nickel have much lower solubilities than the nickel sulphate used in the Cain and Pafford (1981) study. Based on the results of the *in vivo* bioavailability testing, most of the nickel in soils will have a bioavailability much less than that of the nickel sulphate on which the TRV is based. An adjustment for relative bioavailability of nickel compounds in the soil compared to nickel sulphate, is considered appropriate for nickel in soil consumed by birds. An uncertainty factor of 2 to account for differences between birds and mammals is recommended.

Red Tailed Hawks

The NOAEL for Red Tailed Hawks has been estimated from the applicable NOAEL for the test species, mallards, of 77 mg/kg-day using equation (A4-2):

$$NOAEL_w = 77\ mg/kg-day\left(\frac{0.782kg}{1.13kg}\right)^{1-1.2} = 83\ mg/kg-day$$

$NOAEL_t$	=	NOAEL for mallards (30 mg/kg-day)
BW_t	=	Body weight of mallards (0.782 kg)
BW_w	=	Body weight of Red Tailed Hawks (1.13 kg)
f	=	1.2

American Woodcocks

$$NOAEL_w = 77\ mg/kg - day\left(\frac{0.782kg}{0.2kg}\right)^{1-1.2} = 59\ mg/kg - day$$

$NOAEL_t$	=	NOAEL for mallards (77 mg/kg-day)
BW_t	=	Body weight of mallards (0.782 kg)
BW_w	=	Body weight of American Woodcocks (0.2 kg)
f	=	1.2

American Robins

$$NOAEL_w = 77\ mg/kg - day\left(\frac{0.782kg}{0.082kg}\right)^{1-1.2} = 49\ mg/kg - day$$

$NOAEL_t$	=	NOAEL for mallards (77 mg/kg-day)
BW_t	=	Body weight of mallards (0.782 kg)
BW_w	=	Body weight of American Robins (0.082 kg)
f	=	1.2

Red-Eyed Vireos

$$NOAEL_w = 77\ mg/kg - day\left(\frac{0.782kg}{0.0203kg}\right)^{1-1.2} = 37\ mg/kg - day$$

$NOAEL_t$	=	NOAEL for mallards (30 mg/kg-day)
BW_t	=	Body weight of mallards (0.782 kg)
BW_w	=	Body weight of Red-Eyed Vireos (0.0203 kg)
f	=	1.2

Mammals

In a two year feeding study in rats conducted be Ambrose, *et al*. (1976), decreased body weight and organ weights were observed in Wistar rats exposed to nickel in food. Nickel was administered in the diets as nickel sulfate hexahydrate. Doses used were 0, 100, 1,000 and 2,500 mg/kg nickel. Body weights in the high dose rats were significantly decreased compared with controls. Body weight was also reduced at 1000 mg/kg. The NOEC from this study was 100 mg/kg and the LOEC was 1000 mg/kg.

A three-generation reproduction study in rats was undertaken by Ambrose *et al.* (1976) with dietary nickel concentrations of 0, 250, 500 and 1,000 mg/kg. They report a LOEC of 1,000 mg/kg. Sample *et al.* (1996) calculated from these results a LOAEL of 80 mg/kg-day and a NOAEL of 40 mg/kg-day.

More recent one and two generation rat studies (Springborn 2000a and 2000b) resulted in a LOAEL from the 1 generation study of 30 mg/kg-day based on increased mortality of unborn pups and a NOAEL from the 2 generation study of 10 mg/kg-day for reproductive effects. This dose rate is less than that resulting from the Ambrose *et al.* (1976) work.

The LOAEL of 30 mg/kg-day from Springborn (2000a) was adjusted for each mammal evaluated in this assessment using equation (A4-2).

Endpoint data available for nickel species relevant to the current study area are summarized in Table 6.

Table 6 Selected Chronic Endpoints for Nickel Exposure to Mammals

Chemical Form	Test Species	Duration	Concentration	Endpoint	Reference
Unspecified form	Guinea Pig	4 months	2.5 mg/l (drinking water)	NOEC (no accumulation in hair)	Scheiner et al., 1976, in Eisler, 1998b
	Monkeys	24 weeks	up to 1000 mg/kg (diet)	NOEC	US EPA, 1980; Nielsen, 1977, in Eisler, 1998b
	Rat	Lifetime	5 mg/l (drinking water)	NOEC	Schroeder & Mitchener, 1971; Schroeder et al., 1974, in Eisler, 1998b
	Rat	3 generations	5 mg/l (drinking water) + 0.31 mg/kg (diet)	LOEC & significant increase in mortality of young rats in all generations	Schroeder & Mitchener, 1971, in Eisler, 1998b

Table 6 Selected Chronic Endpoints for Nickel Exposure to Mammals (cont'd)

Chemical Form	Test Species	Duration	Concentration	Endpoint	Reference
Elemental Nickel	Domestic Dog	200 days	12 mg/kg BW daily (oral)	NOEC	USEPA, 1980, in Eisler, 1998b
	Rat	55 days	0.08 mg/kg (diet)	NOEC	National Academy of Sciences, 1975, in Eisler, 1998b
	Rat	16 months	250 mg/kg (diet)	NOEC (normal growth)	Ling and Leach, 1979, in Eisler, 1998b
	Rat (juveniles)	13 days	1000 mg (diet)	LOEC & altered blood chemistry, diminished food intake, reduced growth	Schnegg & Kirchgessner, 1976, in Eisler, 1998b
Elemental nickel and inorganic nickel salts	Domestic Cat	up to 200 days	12-25 mg Ni/kg BW daily (oral)	NOEC	National Academy of Sciences, 1975; Sunderman, 1970; US EPA, 1980, in Eisler, 1998b
Nickel acetate	Rat Weanlings	6 weeks	100 mg/kg (diet)	NOEC	Whanger, 1973, in Eisler, 1998b
			500 mg/kg (diet)	LOEC & depressed growth, low hematocrit and hemoglobin, low enzyme activities	
	Rat (male) (OSU Brown)	6 weeks	5 mg/kg-day	NOAEL (hemato., body weight.)	Whanger 1973 in ATSDR 1997
			25 mg/kg-day	LOAEL (less serious effects –hemato.)	
	Domestic Mouse	4 weeks	1,100 mg/kg (diet)	LOEC & food consumption and growth reduced; decreases in various enzyme activities	Weber and Reid, 1969; Ling and Leach, 1979, in Eisler, 1998b
Nickel carbonate or catalysts	Rat	8 weeks	1000 mg/kg (diet)	NOEC (normal growth)	US EPA, 1980, in Eisler, 1998b
Nickel chloride	Rat	4 months	Dietary equivalent of 1 mg Ni/kg BW daily	LOEC & decreased thyroid iodine uptake	USPHS, 1977, in Eisler, 1998b
	Rat	4 months	225 mg/l (drinking water)	LOEC & depressed growth rate, lower serum triglyceride and cholesterol concentrations	Nielsen, 1977; Clary, 1975, in Eisler, 1998b

Table 6 Selected Chronic Endpoints for Nickel Exposure to Mammals (cont'd)

Chemical Form	Test Species	Duration	Concentration	Endpoint	Reference
Nickel chloride or nickel sulfate	Domestic Mouse	2 years	Equivalent to >1.4 mg Ni/kg BW daily (diet)	LOEC & decreased liver weight	USPHS, 1993, in Eisler, 1998b
	Rat	2 years	Dietary equivalent of >1.4 mg Ni/kg BW daily	LOEC & decreased liver weight	USPHS, 1993, in Eisler, 1998b
Nickel chloride	Rat (Sprague-Dawley)	91 days	1.2 mg/kg-day	NOAEL (resp., hemato., hepatic, renal, body weight, neuro.) LOAEL (serious effects – 2/60 deaths)	American Biogenics Corp. 1988 in ATSDR 1997
			8.6 mg/kg-day	NOAEL (gastro., derm., ocular.) LOAEL (less serious effects – cardio., hemato., hepatic, renal.) LOAEL (serious effects – resp., Body weight, neuro)	
	Rat	30 weeks (F) 24 weeks (M)	7 mg/kg-day	LOAEL (serious effects – 1/31 pregnant rat deaths)	RTI 1988a in ATSDR 1997
	Rat	30 weeks (F) 24 weeks (M)	53 mg/kg-day (F)	NOAEL (cardio., hepatic, renal) LOAEL (less serious effects – resp., body weight) LOAEL (serious effects – develop.)	RTI 1988a in ATSDR 1997
			31 mg/kg-day (F)	NOAEL (resp., body weight, develop.)	
			20 mg/kg-day (M)	LOAEL (less serious effects – endocr.)	
			4 mg/kg-day (M)	NOAEL (endocr.)	
	Rat	27-30 weeks (F) 21-24 weeks (M)	50 mg/kg-day	LOAEL (less serious effects – hepatic, renal)	RTI 1988b in ATSDR 1997
			28 mg/kg-day	NOAEL (hepatic, renal)	
			20 mg/kg-day	LOAEL (less serious effects – resp., endocr.)	
			4 mg/kg-day	NOAEL (resp., endocr.)	

Table 6 Selected Chronic Endpoints for Nickel Exposure to Mammals (cont'd)

Chemical Form	Test Species	Duration	Concentration	Endpoint	Reference
Nickel chloride (cont'd)	Rat (Long-Evans)	11 weeks	31.6 mg/kg-day 6.8 mg/kg-day 1.3 mg/kg-day	NOAEL (body weight.) LOAEL (less serious effects –endocr.) NOAEL (endocr.) LOAEL (serious effects –reprod.)	Smith et al. 1993.
	Rat (Wistar)	28 days	1.5 mg/kg-day 0.75 mg/kg-day 0.38 mg/kg-day	LOAEL (less serious effects –hepatic, renal) NOAEL (hepatic, renal) LOAEL (less serious effects –hemato.) NOAEL (hemato.) LOAEL (serious effects – body wt.)	Weischer et al. 1980 in ATSDR 1997
	Mouse (F) (BALB/c)	10-11 weeks	20.3 mg/kg-day	LOAEL (less serious effects – immuno/lymphor.)	Ilback et al. 1994 in ATSDR 1997
	Mouse	Gestational day 8-12	90.6 mg/kg-day	NOEC	Seidenberg et al., 1986 in ATSDR 1997
	Mouse (CD-1)	Gestational day 2-17	80 mg/kg-day 160 mg/kg-day	NOEC LOAEL (serious effects – reprod.)	Berman and Rehnberg 1983 in ATSDR 1997

Table 6 Selected Chronic Endpoints for Nickel Exposure to Mammals (cont'd)

Chemical Form	Test Species	Duration	Concentration	Endpoint	Reference
Nickel sulfate	Domestic Dog	2 years	25 mg Ni/kg BW (diet)	NOEC	USPHS, 1993, in Eisler, 1998b
			63 mg Ni/kg BW (diet)	LOEC & emphysema, pneumonia, low hematocrit, increased liver and kidney weight, 40% decrease in body weight gain	
	Dog (Beagle)	2 years	62.5 mg/kg-day 25 mg/kg-day	NOAEL (cardio, musc/skel, renal, endocr, derm., immuno/lymphor, neuro.) LOAEL (serious effects – resp.) LOAEL (less serious effects – gastro, hemato, hepatic, body wt.) NOAEL (resp, gastro, hemato, hepatic, body wt.)	Ambrose et al., 1976
	Domestic Mouse	180 days	Equivalent to 108 mg Ni/kg BW daily (diet)	LOEC & renal tubular damage at the corticomedullary junction	USPHS, 1993, in Eisler, 1998b
	Domestic Mouse	6 months	150 mg/l (drinking water)	No deaths	USPHS, 1993, in Eisler, 1998b
	Mouse (F) (B6C3F1)	180 days	150 mg/kg-day	LOAEL (less serious effects-hepatic) LOAEL (serious effects- body weight)	Dieter et al., 1988 in ATSDR 1997
			108 mg/kg-day	NOAEL (hepatic) LOAEL (less serious effects – renal, body weight) LOAEL (serious effects – decr. Bone marrow cellularity)	
			44 mg/kg-day	NOAEL (less serious effects – renal, body weight) LOAEL (less serious effects – decr. thymus weight)	
	Rat (Wistar)	3 or 6 months	7.6 mg/kg-day	NOAEL (body wt.) LOAEL (less serious effects – renal)	Vyskocil et al., 1994b in ATSDR 1997

Table 6 Selected Chronic Endpoints for Nickel Exposure to Mammals (cont'd)

Chemical Form	Test Species	Duration	Concentration	Endpoint	Reference
	Rat (F) (Wistar)	24 weeks	22.5 mg/kg-day	LOAEL (serious effects – reprod.)	Ambrose et al. 1976
	Rat (F) (Wistar)	2 years	187.5 mg/kg-day 75 mg/kg-day 7.5 mg/kg-day	NOAEL (Resp., cardio, gastro, hemato, musc/skel., renal, endocr, derm., immuno/lymphor., neuro.) LOAEL (serious effects – body wt.) LOAEL (less serious effects hepatic, body wt.) NOAEL (hepatic, body wt.)	Ambrose et al. 1976
Nickel sulfate hexahydrate	Domestic Dog	2 years	1000 mg/kg (diet)	NOEC	Ambrose et al., 1976
	Domestic Dog		2500 mg/kg (diet)	LOEC & adversely affected growth and blood chemistry, liver and kidney enlargement, lung lesions, bone marrow hyperplasia	
	Rat	3 generations	250 mg/kg (diet)	LOEC & higher incidence of stillborns and fetal mortalities in first generation	Ambrose et al., 1976; USPHS, 1993; US EPA, 1985, in Eisler, 1998b
	Rat	2 years	100 mg/kg	NOEC	Ambrose *et al*., 1976
	Rat		1,000 mg/kg	LOEC & reduced body weight	
	Rat	3 generations (approximately 17 weeks)	1,000 mg/kg	LOEC & body weight	
	Rat	1 generation	30 mg/kg-day	LOEC, reproductive	Springborn, 2000a
	Rat	2 generation	10 mg/kg-day	NOEC, reproductive	Springborn, 2000b

In this study, the form of nickel is primarily nickel oxide which is less bioavailable than the nickel sulphate hexahydrate used in the Ambrose, *et al.* (1976) and Springborn (2000a and 2000b) studies. Bioavailability testing with rats has led to the development of an estimate of relative bioavailability of nickel in Port Colborne soils compared to nickel sulphate hexahydrate used in the Ambrose study. An adjustment for bioavailability of nickel in soil ingested by mammals equal to the relative bioavailability developed through *in vivo* testing, is considered appropriate.

Meadow Vole

$$LOAEL_w = 30\,mg/kg-day\left(\frac{0.35\,kg}{0.048\,kg}\right)^{1-0.94} = 34\,mg/kg-day$$

$LOAEL_t$ = 30 mg/kg-day, based on increases in unborn rat pups (Springborn 2000a, 2000b)
BW_t = body weight rat (0.35 kg) (Sample *et al.*, 1996)
BW_w = body weight meadow vole (0.048 kg)

Raccoon

$$LOAEL_w = 30\,mg/kg-day\left(\frac{0.35\,kg}{4.0\,kg}\right)^{1-0.94} = 26\,mg/kg-day$$

$LOAEL_t$ = 30 mg/kg-day, based on increases in unborn rat pups (Springborn 2000a, 2000b)
BW_t = body weight rat (0.35 kg) (Sample *et al.*, 1996)
BW_w = body weight raccoon (4.0 kg)

Shrew

$$LOAEL_w = 30\,mg/kg-day\left(\frac{0.35\,kg}{0.00533\,kg}\right)^{1-0.94} = 39\,mg/kg-day$$

$LOAEL_t$ = 30 mg/kg-day, based on increases in unborn rat pups (Springborn 2000a, 2000b)
BW_t = body weight rat (0.35 kg) (Sample *et al.*, 1996)
BW_w = body weight shrew (0.00533 kg)

Red Fox

$$LOAEL_w = 30\, mg/kg - day\left(\frac{0.35\, kg}{5.2\, kg}\right)^{1-0.94} = 26\, mg/kg - day$$

$LOAEL_t$ = 30 mg/kg-day, based on increases in unborn rat pups (Springborn 2000a, 2000b)
BW_t = body weight rat (0.35 kg) (Sample *et al.*, 1996)
BW_w = body weight red fox (5.2 kg)

White tailed deer

$$LOAEL_w = 30\, mg/kg - day\left(\frac{0.35\, kg}{56.5\, kg}\right)^{1-0.94} = 22\, mg/kg - day$$

$LOAEL_t$ = 30 mg/kg-day, based on increases in unborn rat pups (Springborn 2000a, 2000b)
BW_t = body weight rat (0.35 kg) (Sample *et al.*, 1996)
BW_w = body weight white tailed deer (56.5 kg)

1.3 Copper

Earthworms

Studies of toxicity of copper on earthworms have shown increased availability and toxicity under more acidic conditions. Toxicity has also been shown to vary for different types of soils and species of earthworms. Efroymson *et al.* (1997b) reviewed 24 measurement endpoints and adopted a benchmark of 50 mg/kg (the lowest LOEC). Confidence in the benchmark is moderate. The benchmark is based on a 20% reduction in growth, reproduction or activity. The derivation of this benchmark was reviewed and the benchmark was adopted and is considered conservative for this study. Selected chronic endpoints are summarized in Table 7.

Table 7 Lowest Chronic Endpoints for Copper Exposure to Earthworms

Chemical Form	Test Species	Concentration	Duration	Endpoint	Reference
Copper chloride	*Apporectodea calinginosa*	68 mg/kg	-	LOEC, cocoons	Ma, 1998, in Efroymson *et al.*,1997b
	Allolobophora chlorotica	51 mg/kg (sandy loam)		LOEC, cocoons	Ma, 1988
	Lumbricus rubellus	63 mg/kg (sandy loam)	6 week	LOEC, cocoons	Ma, 1984
		13 mg/kg (sandy loam)	6 week	NOEC, cocoons	
	Eisenia andrei	32 mg/kg	84 days	NOEC, growth	van Gestel *et al.*, 1991, in Efroymson *et al.*,1997b
		100 mg/kg		LOEC, growth	
	Lumbricus rubellus	122 mg/kg (sandy loam)	-	LOEC, cocoon	Ma, 1998, in Efroymson *et al.*,1997b
	Lumbricus rubellus	54 mg/kg (loamy sand)	42 days	NOEC, cocoon	Ma, 1984, in Efroymson *et al.*,1997b
		131 mg/kg (loamy sand)		LOEC, cocoon	
	Lumbricus rubellus	150 mg/kg (sandy loam)	84 days	NOEC, survival	Ma, 1982, in Efroymson *et al.*,1997b
		1,000 mg/kg (sandy loam)		LOEC, survival	
	Eisenia fetida	120 mg/kg	21 days	NOEC, cocoon	Van Gestel *et al.*, 1989, in Efroymson *et al.*,1997b
		180 mg/kg		LOEC, cocoon	
Copper sulfate	*Lumbricus rubellus*	83 (loamy sand)	18 days	NOEC, cocoon	Ma, 1984, in Efroymson *et al.*,1997b
		148 (loamy sand)		LOEC, cocoon	
	Octolasium cyaneum	180 mg/kg	14 days	LOEC, survival LC_{50}	Streit & Jaggy, 1983, in Efroymson *et al.*,1997b
	Octolasium cyaneum	850 mg/kg	14 days	LOEC, survival LC_{50}	Streit & Jaggy, 1983, in Sample *et al.*,1997
	Lumbricus rubellus	148 mg/kg (loamy sand)	18 days	NOEC, cocoon	Ma, 1984, in Efroymson *et al.*,1997b
	Aporrectodea calingnosa	50 mg/kg	12 weeks	NOEC, coccons	Khalil et al, 1996
		100 mg/kg	12 week	LOEC, cocoons	
	Octolasium cyaneum	2,500 mg/kg	43 days	LOEC, LC_{50}	Streit and Jaggy, 1983, in Efroymson *et al.*, 1997b
	Octolasium cyaneum	850 mg/kg	14 days	LOEC, survival LC_{50}	

Table 7 Lowest Chronic Endpoints for Copper Exposure to Earthworms (cont'd)

Chemical Form	Test Species	Concentration	Duration	Endpoint	Reference
Copper nitrate	*Eisenia fetida*	53.3 mg/kg	8 week	LOEC, cocoons	Spurgeon *et al*., 1994
	Eisenia fetida	601 mg/kg		EC_{50}, growth	Spurgeon and Hopkin, 1995, in Efroymson *et al.*,1997b
	Eisenia fetida	643 mg/kg	14 days	LOEC, survival LC_{50}	Neuhauser *et al*., 1985
$C_4H_6CuO_4$	*Eisenia fetida*	300 mg/kg	56 days	NOEC	Malecki et al., 1982, in Sample et al., 1997
	Eisenia fetida	500 mg/kg	140 days	NOEC	Malecki et al., 1982, in Sample et al., 1997
	Eisenia fetida	1000 mg/kg	140 days	LOEC, cocoons	
Copper	*Eisenia fetida*	2,000 mg/kg	6 weeks	Reduced growth weight & cocoons	Neuhauser *et al*., 1984, in Efroymson *et al.*,1997b
	Dendrobaena rubida	100 mg/kg	120 days	LOEC, cocoons	Bengtsson *et al*., 1991, in Efroymson *et al.*,1997b
		278 mg/kg (loamy sand)		LOEC, cocoon	
	Dendrobaena rubida	100 mg/kg	120 days	NOEC, cocoons	Bengtsson *et al*., 1986, in Efroymson *et al.*,1997b
		500 mg/kg		LOEC, cocoon	
	Eisenia fetida	1,000 mg/kg	42 days	NOEC, cocoon	Neuhauser *et al*., 1984, in Efroymson *et al.*,1997b
		2,000 mg/kg		LOEC, cocoon	
	Allolobophora calinginosa	110 mg/kg	60 days	LOEC, cocoon	Van Rhee, 1975, in Efroymson *et al.*,1997b
	Eisenia fetida	1100-11000 mg/kg	8 weeks	NOEC, weight	Hartenstein, 1981
		22000 mg/kg	8 weeks	NOEC, mortality	
Unspecified	Three species	40 – 238 mg/kg	Unknown	NOEC, growth, survival, reproduction	Denneman & van Straalen, 1991, in Eisler, 1998a
Copper oxide	*Eisenia fetida*	40,000 mg/kg	8 weeks	LOEC, weight	Malecki *et al*., 1982
		20,000 mg/kg	8 weeks	LOEC, progeny	

Frogs and Toads

A large diversity in LC_{50}s have been recorded for toxicity of embryos and tadpoles to copper. Selected data including the lowest chronic values identified are summarized on Table 8.

Table 8 Lowest Chronic Endpoints Identified for Copper Exposure to Frogs and Toads

Chemical Form	Test Species	Concentration	Duration	Endpoint	Reference
Copper sulphate	*Rana pipiens* adult (northern leopard frog)	6.368 mg/l	72 hours	LC_{50}	Kaplan & Yoh 1961
	Bufo fowleri embryo (Fowler's Toad)	2.696 mg/l	7 days	LC_{50}	Birge & Black 1979
	Gastrophryne carolinensis embryo (eastern narrow-mouthed toad)	0.04 mg/l	7 days	LC_{50}	Birge 1978; Birge & Black 1979; Birge *et al*., 1979
	Hyla chysocelis embryo (southern grey treefrog)	0.04 mg/l	7 days	LC_{50}	Birge & Black 1979
	Rana hexadactyla tadpole (six-toed frog)	0.039 mg/l	96 hour	LC_{50}	Khangarot *et al*., 1985b
Not specified	*R. catesbeiana* (Bullfrog)	0.02 mg/l	Not specified	LC_{50}	Birge *et al*., 2000
	G. carolinensis Eastern narrow-mouth toad)	0.02 mg/l	Not specified	LC_{50}	Birge *et al*., 2000
	R. palustris (Pickerel frog)	0.02 mg/l	Not specified	LC_{50}	Birge *et al*., 2000
	P. crucifer (Spring peeper)	0.05 mg/l	Not specified	LC_{50}	Birge *et al*., 2000
	R. pipiens (Leopard frog)	0.05 mg/l	Not specified	LC_{50}	Birge *et al*., 2000
	B. fowleri (Fowler's Toad)	27 mg/l	Not specified	LC_{50}	Birge *et al*., 2000
	R. catesbeiana (Bullfrog)	0.002 mg/l	Not specified	LC_{10}	Birge *et al*., 2000
	G. carolinensis Eastern narrow-mouth toad)	0.003 mg/l	Not specified	LC_{10}	Birge *et al*., 2000
	R. palustris (Pickerel frog)	0.001 mg/l	Not specified	LC_{10}	Birge *et al*., 2000
	P. crucifer (Spring peeper)	0.002 mg/l	Not specified	LC_{10}	Birge *et al*., 2000
	R. pipiens (Leopard frog)	0.004 mg/l	Not specified	LC_{10}	Birge *et al*., 2000
	B. fowleri (Fowler's Toad)	6.12 mg/l	Not specified	LC_{10}	Birge *et al*., 2000
	R. pipiens embryo (Northern leopard frog)	0.05 mg/l	8 days	LC_{50}	Birge & Black, 1979

Values of 0.04 and 0.039 mg/l, representing the lowest LC_{50}s, have been obtained in 7 and 4 day tests conducted by Birge *et al.* (1979) and Khangarot *et al.* (1985b), respectively. LC_{10}s of 0.001 to 0.004 mg/l were reported for 5 species of frogs and toads (Birge *et al.* 2000).

Birge and Black (1979) obtained LC_{50}s for Fowlers Toad embryos. The lower LC_{50} from their studies was 2.696 mg/l, 2 orders of magnitude higher than for other tadpoles and embryos. Birge *et al.* (2000) report an LC_{10} of 6.12 mg/l for Fowlers Toad.

In order to better understand the applicability of the results of the toxicity review, background surface water quality for nickel were reviewed. Table 9 provides a summary of surface water quality data reported by the Ontario Ministry of the Environment (MOE, 2004; 1999).

Table 9 Summary of Background Concentrations of Copper in Surface Water

Parameter	Value
Number of Rivers	41
Number of Samples	369
Average	0.0061 mg/l
Standard Deviation	0.0148 mg/l
Upper Confidence Limit on the Mean (95%)	0.0077 mg/l
95th Percentile Concentration	0.0207 mg/l
98th Percentile Concentration	0.0748 mg/l
Maximum Measured Concentration	0.109 mg/l

Surface water for copper from 35 rivers with drinking water treatment plant intakes was tabulated (MOE 2004) along with water quality data from six tributaries to Lake Ontario (MOE 1999).

For copper, 2 values were listed in the MOE reports as having concentrations less than the detection. For the purposes of computing statistics, these values were set to one half of the detection limit.

The LC_{10} values are less than the average of background surface water concentrations in rivers in southern Ontario. Although less than the maximum background concentration measured, the lowest LC_{50}s are greater than the 95th percentile of the background surface water data and are thus considered reasonable for use in this assessment for frogs in the Port Colborne area.

For this study, the EC_{20} has been estimated from the lowest LC_{50} of 0.040 mg/l using equation (A4-1):

$$EC_{20,est} = \frac{LC_{50}}{5} = \frac{0.04\,mg/L}{5} = 0.008\,mg/L$$

The EC_{20} for Fowler's Toad has been estimated from the applicable LC_{50} of 26.96 mg/l using equation (A4-1). The $EC_{20,est}$ is very similar to the LC_{10} value and both have thus been selected for use in this assessment:

$$EC_{20,est} = \frac{LC_{50}}{5} = \frac{26.96\,mg/L}{5} = 5\,mg/L$$

$$LC_{10} = 6\,mg/L$$

Birds

In a study of day old chicks (Mehring *et al.*, 1960), no effects on growth were seen at 570 mg/kg copper in feed. At 749 mg/kg in feed, growth was reduced by over 30% and there was 15% mortality. Because the study was conducted over 10 weeks, Sample *et al.* (1996) considered this a LOAEL and the 570 mg/kg dose a NOAEL. The NOAEL was selected for use in the current study. The results of this study are consistent with studies conducted by Arthur *et al.* (1958) who observed no adverse effects on chicks fed 500 mg/kg copper in the diet for 8 weeks. Sample, et al (1996) derived a NOAEL of 47 mg/kg-day from the Mehring *et al.* study. The Mehring study was compared to other studies shown in Table 10 and was selected because of it's duration, endpoint and robustness. The appropriateness of the copper species was also considered. The value based on Mehring *et al.* (1996) was selected for use as the TRV in this assessment.

Table 10 Lowest Chronic Endpoints for Copper Exposure to Birds

Chemical Form	Test Species	Concentration	Dose	Duration	Endpoint	Reference
Copper	Chick	500 mg/kg		8 weeks	NOEC	Arthur *et al.*, 1958
Copper carbonate	Chicken	60 mg/kg		Unspecified	LOEC, slight symptoms of copper poisoning	Pullar, 1940, in Sample et al., 1997
	Mallard		29 mg/kg-day (of copper carbonate)	Unspecified	NOAEL	Pullar, 1940, in Sample et al., 1997
	Mallard		55 mg/kg-day (of copper carbonate)		LOAEL	
Copper oxide	Chick	570 mg/kg	47 mg/kg-day	10 weeks	NOAEL	Mehring *et al.*, 1960; Sample *et al.*, 1996
	Chick	749 mg/kg	61.7 mg/kg-day	10 weeks	LOAEL, reduced growth & mortality	
Copper sulfate	Chick	1000 mg/kg		5 weeks	LOEC, reduced growth	Hill, 1979b
	Duckling	1500 mg/kg		15 days	LOEC, polymyopathic lesions	van Vleet et al., 1981
Copper sulfate pentahydrate	Chick	500 mg/kg		5 weeks	LOEC, reduced growth	Hill, 1979a
Unspecified	Chick	8 mg/kg		4-6 weeks	NOEC	Carlton & Henderson, 1963, 1964, in Eisler, 1998a
	Chick	200 mg/kg		25 days	NOEC	National Academy of Sciences, 1977, in Eisler, 1998a
	Chick	350 mg/kg		25 days	LOEC, reduced growth	
	Chick	250 mg/kg		4 weeks	LOEC, gizzard erosion	Poupoulis & Jensen, 1976, in Eisler, 1998a
	Turkey poult	60 mg/kg		24 weeks	NOEC	Kashani et al., 1986, in Eisler, 1998a
	Turkey poult	120 mg/kg		24 weeks	LOEC, reduced growth in first 8 weeks	
	Turkey poult	800 mg/kg		Unspecified	LOEC, reduced growth	Supplee, 1964, in Eisler, 1998a
	Turkey poult	500 mg/kg		24 weeks	LOEC, reduced growth, increased gizzard histopathology	Kashani et al., 1986, in Eisler, 1998a

Table 10 Lowest Chronic Endpoints for Copper Exposure to Birds (cont'd)

Chemical Form	Test Species	Concentration	Dose	Duration	Endpoint	Reference
Unspecified (cont'd)	Chick	324 mg/kg		Unspecified	LOEC, reduced growth rate	Mayo et al., 1956, in Sample et al., 1997
	Turkey poult	676 mg/kg		21 days	NOEC	Vohra & Kratzer, 1968, in Sample et al., 1997
	Turkey poult	1620 mg/kg		21 days	LOEC	Vohra & Kratzer, 1968, in Sample et al., 1997

Red-Tailed Hawks

The NOAEL for Red-Tailed Hawks has been estimated from the derived NOAEL of 47 mg/kg-day using equation (A4-2):

$$NOAEL_w = 47\ mg/kg-day\left(\frac{1kg}{1.13kg}\right)^{1-1.2} = 48\ mg/kg-day$$

$NOAEL_t$ = NOAEL for day-old chicks (47 mg/kg-day)
BW_t = Body weight of day-old chicks (1kg)
BW_w = Body weight of Red-Tailed Hawks (1.13kg)
f = 1.2

American Woodcock

The NOAEL for American Woodcocks has been estimated from the derived NOAEL of 47 mg/kg-day using equation (A4-2):

$$NOAEL_w = 47\ mg/kg-day\left(\frac{1kg}{0.2kg}\right)^{1-1.2} = 34\ mg/kg-day$$

$NOAEL_t$ = NOAEL for day-old chicks (47 mg/kg-day)
BW_t = Body weight of day-old chicks (1kg)
BW_w = Body weight of American Woodcocks (0.2 kg)
f = 1.2

American Robin

The NOAEL for American Robins has been estimated from the derived NOAEL of 47 mg/kg-day using equation (A4-2):

$$NOAEL_w = 47\ mg/kg-day\left(\frac{1kg}{0.082kg}\right)^{1-1.2} = 29\ mg/kg-day$$

$NOAEL_t$	=	NOAEL for day-old chicks (47 mg/kg-day)
BW_t	=	Body weight of day-old chicks (1kg)
BW_w	=	Body weight of American Robins (0.082 kg)
f	=	1.2

Red-Eyed Vireo

The LOAEL for Red-Eyed Vireos has been estimated from the derived NOAEL of 47 mg/kg-day using equation (A4-2):

$$NOAEL_w = 47\ mg/kg-day\left(\frac{1kg}{0.0203kg}\right)^{1-1.2} = 22\ mg/kg-day$$

$NOAEL_t$	=	NOAEL for day-old chicks (47 mg/kg-day)
BW_t	=	Body weight of day-old chicks (1kg)
BW_w	=	Body weight of Red-Eyed Vireos (0.0203 kg)
f	=	1.2

Mammals

Numerous studies of copper toxicity to mammals have been conducted, as illustrated by the selected studies summarized in Table 11.

Table 11 Chronic Endpoints for Copper Exposure to Mammals

Chemical Form	Test Species	Concentration	Dose	Duration	Effect	Reference
Copper sulphate	Mink	110.5 mg/kg	15 mg/kg-day		NOAEL	Aulerich *et al.*, 1982; Sample *et al.*, 1996
		160.5 mg/kg	22 mg/kg-day		LOAEL	
		-	13 mg/kg-day 3 mg/kg-day	50 weeks	NOAEL LOAEL (serious effects – increased mortality)	Aulerich *et al.*, 1982; ATSDR, 1990
		-	110.5 mg/day	357 days	NOAEL	Bleavins and Aulerich, 1981
Copper Sulphate	Rat	4000 mg/kg	133 mg/kg-day		Increased Mortality	Boyden et al, 1988 in ATSDR, 1990
		-	100 mg/kg-day	1-2 weeks	NOAEL - renal	Haywood, 1980 in ATSDR, 1990
		2000 mg/kg	100 mg/kg-day	1-2 weeks	LOAEL (less serious effects - hepatic)	Haywood and Comerford, 1980 in ATSDR, 1990
		-	61 mg/kg-day	15 days	NOAEL	NTP 1990a in ATSDR, 1990
		-	35 mg/kg-day 508 mg/kg-day	14 days	LOAEL (less serious effects - gastro) NOAEL - hepatic	NTP 1990a in ATSDR, 1990
		-	228 mg/kg-day	13 weeks	NOAEL	NTP 1990a in ATSDR, 1990
		2000 mg/kg	100 mg/kg-day	3-15 weeks	LOAEL (less serious effects – hepatic, renal)	Haywood 1980 in ATSDR, 1990
		-	100 mg/kg-day	1-15 weeks	LOAEL (less serious effects - hepatic)	Haywood and Comerford, 1980 in ATSDR, 1990
		-	89 mg/kg-day 144 mg/kg-day	4 weeks	NOAEL LOAEL (less serious effects - other)	Boyden et al., 1938 in ATSDR, 1990
		-	150 mg/kg-day 300 mg/kg-day	18 weeks	LOAEL (less serious effects – hepatic, other) LOAEL (serious effects –hepatic, other)	Haywood and Loughran, 1985 in ATSDR, 1990
		-	100 mg/kg-day	20 days	LOAEL (serious effects - hepatic)	Rena and Kumar, 1980 in ATSDR, 1990
		-	40 mg/kg-day	30 days	LOAEL (less serious effects – hemato, hepatic, other)	Kumar and Kumar, 1987 in ATSDR, 1990

Table 11 Chronic Endpoints for Copper Exposure to Mammals (cont'd)

Chemical Form	Test Species	Concentration	Dose	Duration	Effect	Reference
		1000 mg/kg 1000 mg/kg 500 mg/kg	14 mg/kg-day 55 mg/kg-day 14 mg/kg-day 14 mg/kg-day 113 mg/kg-day	13 weeks	NOAEL – gastro NOAEL – hemato NOAEL – hepatic LOAEL (less serious effects – renal) NOAEL –other	NTP 1990a in ATSDR, 1990
		-	12.5 mg/kg-day	30 days	NOAEL – neuro	Murthy et al., 1981 in ATSDR, 1990
		-	175 mg/kg-day	11 months	LOAEL (less serious effects – neuro)	DeVries et al., 1986 in ATSDR, 1990
Copper Sulphate	Mouse	-	39 mg/kg-day	14 days	NOAEL – gastro, hepatic	NTP 1990a in ATSDR, 1990
		-	67 mg/kg-day	14 days	LOAEL (less serious effects – gastro	NTP 1990a in ATSDR, 1990
		-	39 mg/kg-day	14 days	NOAEL	NTP 1990a in ATSDR, 1990
		-	71 mg/kg-day 1734 mg/kg-day	13 weeks	NOAEL – gastro NOAEL – hepatic, renal	NTP 1990b in ATSDR, 1990
		-	78 mg/kg-day 104 mg/kg-day 155 mg/kg-day	1 month + 0-19 gestational days	NOAEL – developmental LOAEL (serious effects – mortality) LOAEL (serious effects – developmental malformations)	Lecyk et al., 1980 in ATSDR, 1990
Copper Sulphate	Pig	-	8.8 mg/kg-day 14.6 mg/kg-day	54 days	NOAEL – hemato, other LOAEL (less serious effects – hemato, other)	Kline et al., 1971 in ATSDR, 1990
		238 mg/kg	-	9 months	LOAEL, mortality	Higgins, 1981, in Eisler, 1998a
Copper Sulphate	Sheep	-	7.5 mg/kg-day	83 days	LOAEL, severe morphological changes	Gopinath & Howell, 1975, in Eisler, 1998a
Copper acetate	Rat	398 mg/kg	7.9 mg/kg-day 7.9 mg/kg-day	90 days	LOAEL (less serious effects – hepatic) NOAEL – other	Epstein et al., 1982 in ATSDR, 1990
		-	130 mg/kg-day	18 weeks	NOAEL – musc/skel LOAEL (less serious effects – decreased testes, body weight)	Llewellyn, 1985 in ATSDR, 1990

Table 11 Chronic Endpoints for Copper Exposure to Mammals (cont'd)

Chemical Form	Test Species	Concentration	Dose	Duration	Effect	Reference
Copper Carbonate	Rat	-	10 mg/kg-day	20 week	LOAEL (less serious effects – cardio and hemato)	Liu and Medeiros, 1986 in ATSDR, 1990
Copper Carbonate	Pig	-	36 mg/kg-day	49 days	LOAEL (less serious effects – hemato and hepatic)	Suttle and Mills, 1966a in ATSDR, 1990
		-	36 mg/kg-day	48 days	LOAEL (less serious effects – hemato and hepatic)	Suttle and Mills, 1966a in ATSDR, 1990
Copper gluconate	Mouse	-	4.2 mg/kg-day	850 days	LOAEL (serious effects – decr. survival)	Massie and Aiello, 1984 in ATSDR, 1990
		-	42.5 mg/kg-day	Lifetime	LOAEL, mortality	ATSDR, 1990, in Eisler, 1998a
Copper hydroxide	Pig	-	36 mg/kg-day	49 days	LOAEL (less serious effects – hemato and hepatic)	Suttle and Mills, 1966a in ATSDR, 1990
		-	36 mg/kg-day	48 days	LOAEL (less serious effects – hemato and hepatic)	Suttle and Mills, 1966a in ATSDR, 1990
Unspecified	Rat	-	150 mg/kg-day	2-15 weeks	LOAEL (less serious effects - renal)	Haywood 1985b in ATSDR, 1990
		-	150 mg/kg-day 300 mg/kg-day	2-15 weeks	LOAEL (less serious effects – hepatic, renal, other) LOAEL (serious effects – hepatic, other)	Haywood 1985 in ATSDR, 1990
		-	250 mg/kg-day 300 mg/kg-day	2-15 weeks	NOAEL LOAEL (serious effects – death in weanling rats)	Haywood, 1985 in ATSDR, 1990
		-	150 mg/kg-day	2-15 weeks	LOAEL (less serious effects - renal)	Haywood et al., 1985b in ATSDR, 1990
		-	150 mg/kg-day	2-14 weeks	LOAEL (less serious effects – hepatic, renal)	Haywood et al., 1985a in ATSDR, 1990
Unspecified	Horse	800 mg/kg	-	6 months	NOAEL	Bremner, 1979, in Eisler, 1998a
Unspecified	Mouse	-	4.2 mg/kg-day	850 days	LOAEL, reduced growth, survival	ATSDR, 1990, in Eisler, 1998a
	Mouse	640 mg/l (drinking water)	-	850 days	LOAEL, mortality	ATSDR, 1990, in Eisler, 1998a

Table 11 Chronic Endpoints for Copper Exposure to Mammals (cont'd)

Chemical Form	Test Species	Concentration	Dose	Duration	Effect	Reference
Unspecified	Sheep	-	0.67 mg/kg-day	Unspecified	NOAEL	Bires & Vrzgula, 1990, in Eisler, 1998a
		-	10.7 mg/kg-day		LOAEL, mortality	
Unspecified	Merino Sheep	-	5.1 mg/kg-day	28 weeks	LOAEL, mortality	Howell et al., 1991, in Eisler, 1998a
Unspecified	Lamb	37.3 mg/kg	-	11 weeks	LOEL, elevated plasma aspartate aminotransferase	Buckley & Tait, 1981, in Eisler, 1998a
Unspecified	Ram	-	15 mg/kg-day	50 days	LOAEL, decreased sperm motility, increased abnormalities	Gamcik et al., 1990, in Eisler, 1998a
Unspecified	Sheep	-	20 mg/kg-day	9 weeks	LOAEL, hemolysis	Aaseth & Norseth, 1986, in Eisler, 1998a
Unspecified	Lamb	-	80 mg/kg-day	6 weeks	LOAEL, brain histopathology	Doherty et al., 1969, in Eisler, 1998a
Unspecified	Rat	-	7.9 mg/kg-day	90 days	LOEL, increased serum glutamic oxaloacetic transaminase enzyme activity	ATSDR, 1990, in Eisler, 1998a
	Rat	-	10 mg/kg-day	20 weeks	LOAEL, increased blood pressure, hemoglobin	ATSDR, 1990, in Eisler, 1998a
	Rat	-	40 mg/kg-day	30 days	LOAEL, anemia	ATSDR, 1990, in Eisler, 1998a
	Rat	-	130 mg/kg-day	18 weeks	LOAEL, decreased growth, testes weight	ATSDR, 1990, in Eisler, 1998a
	Rat	-	144 mg/kg-day	4 weeks	LOAEL, decreased body weight gain	ATSDR, 1990, in Eisler, 1998a
	Rat	0.25 mg/l (drinking water)	-	119 days	LOEL, elevated serum copper	Petering et al., 1977, in Eisler, 1998a
	Rat	150 mg/l (drinking water)	-	15 to 30 days	NOAEL (liver microsomes)	Moffitt & Murphy, 1973, in Eisler, 1998a
	Rat	398 mg/l (drinking water)	-	15 to 30 days	LOAEL, liver histopathology	Moffitt & Murphy, 1973; ATSDR, 1990, in Eisler, 1998a

Table 11 Chronic Endpoints for Copper Exposure to Mammals (cont'd)

Chemical Form	Test Species	Concentration	Dose	Duration	Effect	Reference
Unspecified	Common Shrew	-	2.13 mg/shrew	12 weeks	NOAEL	Dodds-Smith et al., 1992a, 1992b, in Eisler, 1998a
Unspecified	Pig	<150 mg/kg	-	9 months	NOAEL	Higgins, 1981, in Eisler, 1998a
		700 mg/kg	-	Several months	LOAEL, mortality	Aaseth & Norseth, 1986, in Eisler, 1998a

A 50 week chronic duration study of minks was conducted by Aulerich *et al.* (1982). Females were mated and litter masses and number of kits were within the normal range for all groups. A higher mortality of kits was noted with 100 mg/kg and 200 mg/kg copper supplement groups from birth to 4 weeks. No increase in mortality of kits was observed for the 50 mg/kg supplement group. The authors concluded that the supplement adversely affected lactation. A NOAEL and a LOAEL can be calculated from the results of this study. The 50 mg/kg supplement group received 60.5 mg/kg body weight dietary copper in addition to the supplement for a total intake of 110.5 kg. From this, a dose of 10 mg/kg-day was estimated as the NOAEL.

The NOAEL of 10 mg/kg-day was considered appropriate to the assessment of wildlife in this study because of the study duration and assessment of reproduction. This value was compared to other NOAELs and LOAELs developed based on studies of other mammal species and was adopted as reasonable and conservative. Species specific values were derived using equation (A4-2).

Meadow Vole

$$NOAEL_w = 10\ mg/kg-day\left(\frac{1.05kg}{0.048kg}\right)^{1-0.94} = 12\ mg/kg-day$$

$NOAEL_t$ = NOAEL (10 mg/kg-day) from Bleavins and Aulerich (1981) for reproductive effects
BW_t = body weight mink (1.05 kg)
BW_w = body weight meadow vole (0.048 kg)

Raccoon

$$NOAEL_w = 10\, mg/kg-day\left(\frac{1.05\, kg}{4.0\, kg}\right)^{1-0.94} = 9.2\, mg/kg-day$$

$NOAEL_t$	=	NOAEL (10 mg/kg-day) from Bleavins and Aulerich (1981) for reproductive effects
BW_t	=	body weight mink (1.05 kg)
BW_w	=	body weight raccoon (4.0 kg)

Shrew

$$NOAEL_w = 10\, mg/kg-day\left(\frac{1.05\, kg}{0.00533\, kg}\right)^{1-0.94} = 14\, mg/kg-day$$

$NOAEL_t$	=	NOAEL (10 mg/kg-day) from Bleavins and Aulerich (1981) for reproductive effects
BW_t	=	body weight mink (1.05 kg)
BW_w	=	body weight shrew (0.00533 kg)

Red Fox

$$NOAEL_w = 10\, mg/kg-day\left(\frac{1.05\, kg}{5.2\, kg}\right)^{1-0.94} = 9.1\, mg/kg-day$$

$NOAEL_t$	=	NOAEL (10 mg/kg-day) from Bleavins and Aulerich (1981) for reproductive effects
BW_t	=	body weight mink (1.05 kg)
BW_w	=	body weight red fox (5.2 kg)

White tailed deer

$$NOAEL_w = 10\, mg/kg-day\left(\frac{1.05\, kg}{56.5\, kg}\right)^{1-0.94} = 7.9\, mg/kg-day$$

$NOAEL_t$	=	NOAEL (10 mg/kg-day) from Bleavins and Aulerich (1981) for reproductive effects
BW_t	=	body weight mink (1.05 kg)
BW_w	=	body weight white tailed deer (56.5 kg)

1.4 Cobalt

Earthworms

In an 8 week study on *Eisenia fetida* conducted by Hartenstein *et al.* (1981) using natural soil, a No Observed Effects Concentration (NOEC) of 300 to 3000 mg/kg cobalt (dry weight) was reported based on measurement of earthworm weight. A NOEC concentration of 30,000 mg/kg cobalt was reported based on mortality.

In a 7 week study conducted by Fischer and Molnar (1997) using natural soil, a 77% mortality was reported for earthworms exposed to 80 mmol $CoCl_2$/kg soil (4700 µg Co/kg soil). An endpoint measurement could not be obtained from the results of this study.

A TRV of 3,000 mg/kg cobalt in soil was selected for use in this study based on the NOEC reported by Hartenstein *et al.* (1981).

Table 12 Chronic Endpoints for Cobalt Exposure to Earthworms

Chemical Form	Test Species	Concentration	Duration	Endpoint	Reference
Cobalt	*Eisenia fetida*	300 – 3,000 mg/kg	8 weeks	NOEC, weight	Hartenstein, *et al.*, 1981
		30,000	8 weeks	NOEC, mortality	
Cobalt chloride	*Eisenia fetida*	4,700µg Co/kg soil	7 weeks	-	Fischer and Molnar, 1997

Frogs

A vast difference in toxicity effects values have been measured for cobalt as shown in Table 13. The eastern narrow-mouthed toad can be seen to be significantly more sensitive to cobalt than other species tested.

Table 13 Chronic Endpoints for Cobalt Exposure to Frogs

Chemical Form	Test Species	Concentration	Duration	Endpoint	Reference
Cobalt chloride	*Rana hexadactyla* tadpole	17.59 mg/l	96 hour	LC_{50}	Khangarot, *et al.*, 1985a
	Xenopus laevis clawed toad embryo	1,300 mg/l	96 hour	LC_{50}	Sunderman, 1992
		3.2 mg/l	96 hour	EC_{50}, growth	
		5.5 mg/l	96 hour	LOEC, growth	
Cobalt	*Gastrophryne carolinensis* Eastern narrow-mouthed toad embryo	0.05 mg/l	7 days	LC_{50}	Birge *et al.*, 1979
Cobalt nitrate	*Gastrophryne carolinensis* Eastern narrow-mouthed toad embryo	0.05 mg/l	7 days	LC_{50}	Birge, 1978
Not Specified	*B. fowleri* (Fowler's Toad)	4.04 mg/l	Not Specified	LC_{50}	Birge *et al.*, 2000
	G. carolinensis (Eastern narrow-mouth toad)	0.05 mg/l	Not Specified	LC_{50}	Birge *et al.*, 2000
	R. catesbeiana (Bull frog)	1.23 mg/l	Not Specified	LC_{50}	Birge *et al.*, 2000
	R. pipiens (Northern leopard frog)	0.05 mg/l	Not Specified	LC_{50}	Birge *et al.*, 2000
	B. fowleri (Fowler's Toad)	0.23 mg/l	Not Specified	LC_{10}	Birge *et al.*, 2000
	G. carolinensis (Eastern narrow-mouth toad)	0.03 mg/l	Not Specified	LC_{10}	Birge *et al.*, 2000
	R. catesbeiana (Bull frog)	0.12 mg/l	Not Specified	LC_{10}	Birge *et al.*, 2000
	R. pipiens (Northern leopard frog)	0.01 mg/l	Not Specified	LC_{10}	Birge *et al.*, 2000

The chronic LC_{50}s of 0.05 mg/l measured by Birge *et al.* (1979) and Birge (1978) are orders of magnitude lower than the 96 hour LC_{50}s measured by Sunderman (1992) and Khangarot *et al.* (1985).

The 7 day LC_{50} for the eastern narrow-mouthed toad was selected as a conservative value for this sensitive species for use in this study. The TRV was derived from this value using equation (A4-1):

$$EC_{20,est} = \frac{LC_{50}}{5} = \frac{50\,mg/L}{5} = 10\,\mu g/L$$

For the Fowler's toad, the LC_{10} of 0.2 mg/l was chosen as an appropriate TRV.

Birds

A number of studies shown in Table 14 were reviewed by US EPA (2003). In this review, the Diaz et al. (1994a) study, overall scored the highest in ranking the quality of the study for use as a TRV and was thus selected for use in this assessment.

Table 14 Chronic Endpoints for Cobalt Exposure to Birds

Chemical	Test Species	Concentration	Duration	Endpoint	Reference
Cobalt	Chick	4.10 mg/kg-day	3 weeks	NOAEL (growth)	Ling et al., 1979, in US EPA, 2003
		8.20 mg/kg-day	3 weeks	LOAEL, reduced growth	
Cobalt carbonate	Chick	25.2 mg/kg-day	2 weeks	NOAEL (growth)	Berg & Martinson, 1972, in US EPA, 2003
Cobalt chloride	Chick	3.89 mg/kg-day	5 weeks	NOAEL (growth)	Hill, 1979a
		7.80 mg/kg-day	5 weeks	LOAEL, reduced growth	
	Chick	17.0 mg/kg-day	2 weeks	NOAEL (mortality)	Hill, 1979b
		17.0 mg/kg-day	2 weeks	LOAEL, reduced growth	
Cobalt chloride hexahydrate	Broiler chick	116 mg/kg	14 days	LOEC, reduced weight gain and mortality	Diaz *et al*., 1994a
	Duckling	15.0 mg/kg-day	15 days	NOAEL (mortality)	van Vleet *et al*., 1981
		15.3 mg/kg-day	15 days	LOAEL, skeleton and muscle lesions	
	Meat-type day-old chick	500 mg/kg	42 days	LOEC, increased hemoglobin content, correlated with increased pulmonary hypertension	Diaz *et al*., 1994b
	White Plymouth Rock chick	50 mg/kg	35 days	NOEC	Hill, 1974
		100 mg/kg	35 days	LOEC, reduced growth	
	Duckling	14.8 mg/kg-day	8 days	NOAEL (growth)	Paulov, 1971
		148 mg/kg-day	8 days	LOAEL, reduced growth	
	Chick	21.5 mg/kg-day	14 days	LOAEL, reduced growth	Brown & Southern, 1985, in US EPA, 2003
	Chick	22.3 mg/kg-day	15 days	LOAEL, reduced growth	Southern & Baker, 1981, in US EPA, 2003

The study authors recorded feed intake rates for this group at 377.8 g/chick and initial and final body weights of 39.1 and 253.2 g, respectively. The LOAEL was selected and divided by an uncertainty factor of 10 for use of a sub-chronic study (rather than chronic). The TRV_t (i.e. test species TRV) was then estimated from the dose rate calculated as follows:

$$TRV_t = \frac{C_{feed} \times IR_{feed}}{BW \times UF}$$

$$TRV_t = \frac{(116\, mg\ Co / kg) \times (0.3778\, kg / 14\, days)}{(39.1g + 253.2g)/2 \times 10} \times 1000\, g / kg = 2.1\, mg / kg - day$$

The TRV_t of 2.1 mg/kg-day was applied to birds in this study. No other suitable studies were identified on which to base a TRV for birds.

Since the TRV_t for birds is based on soluble cobalt chloride, an adjustment for relative bioavailability of cobalt in Port Colborne soils compared to the cobalt chloride is considered appropriate. Bioaccessibilities for cobalt have been developed through *in vitro* testing of Port Colborne soils. The bioaccessibilities estimated for cobalt are considered applicable to wildlife in this study to account for differences in solubility and hence absorption. For birds, an uncertainty factor of 2 to account for differences between birds and mammals is used.

Red-Tailed Hawk

The TRV_w for Red-Tailed Hawks has been estimated from the derived TRV_t of 2.1 mg/kg-day using equation (A4-2):

$$TRV_w = 2.1\, mg / kg - day \left(\frac{0.146kg}{1.13kg} \right)^{1-1.2} = 3.2\, mg / kg - day$$

TRV_w	=	TRV for wildlife species
TRV_t	=	TRV for day-old chicks (2.1 mg/kg-day)
BW_t	=	Body weight of day-old chicks (0.146kg)
BW_w	=	Body weight of Red-Tailed Hawks (1.13kg)
F	=	1.2

American Woodcock

The TRV_w for American Woodcocks has been estimated from the derived TRV_t of 2.1 mg/kg-day using equation (A4-2):

$$TRV_w = 2.1\, mg/kg - day \left(\frac{0.146kg}{0.2kg} \right)^{1-1.2} = 2.2\, mg/kg - day$$

TRV_w	=	TRV for wildlife species
TRV_t	=	TRV for day-old chicks (2.1 mg/kg-day)
BW_t	=	Body weight of day-old chicks (0.146 kg)
BW_w	=	Body weight of American Woodcocks (0.2 kg)
f	=	1.2

American Robin

The TRV_w for American Robins has been estimated from the derived TRV_t of 2.1 mg/kg-day using equation (A4-2):

$$LOAEL_w = 2.1\, mg/kg - day \left(\frac{0.146kg}{0.082kg} \right)^{1-1.2} = 1.9\, mg/kg - day$$

TRV_w	=	TRV for wildlife species
TRV_t	=	TRV for day-old chicks (2.1 mg/kg-day)
BW_t	=	Body weight of day-old chicks (0.146 kg)
BW_w	=	Body weight of American Robins (0.082 kg)
f	=	1.2

Red-Eyed Vireo

The TRV_w for Red-Eyed Vireos has been estimated from the derived TRV_t of 2.1 mg/kg-day using equation (A4-2):

$$TRV_w = 2.1\, mg/kg - day \left(\frac{0.146kg}{0.0203kg} \right)^{1-1.2} = 1.4\, mg/kg - day$$

TRV_w	=	TRV for wildlife species
TRV_t	=	TRV for day-old chicks (2.1 mg/kg-day)
BW_t	=	Body weight of day-old chicks (1kg)
BW_w	=	Body weight of Red-Eyed Vireos (0.0203 kg)
f	=	1.2

Mammals

Intermediate duration studies of developmental and reproductive effects are summarized in Table 15. Longer duration studies were not identified. Based on a review of these chronic effects levels and data for more serious effects and shorter term exposures, the LOAEL of 13.25 mg Co/kg-day was selected as the measurement endpoint for this study. Species specific TRVs were estimated using equation (A4-2).

Table 15 Selected NOEL and LOAEL Endpoints for Cobalt Exposure to Mammals

Chemical Form	Test Species	Duration	Dose	Endpoint	Reference
Cobalt	Norway rat	98 days	13.25 mg Co/kg-day (ATSDR, 1992)	LOAEL for histological changes	Mollenhauer, *et al.*, 1985; ATSDR 1992
Cobalt chloride	Norway rat		5 mg Co/kg-day	NOAEL	Nation, *et al.*, 1983; ATSDR 1992
			20 mg Co/kg-day	LOAEL for decreased weight of testes	
Cobalt chloride	Rat		161.1 mg Co/kg-day	LOAEL (less serious effects – hemato.)	Domingo and Lobet, 1984 in ATSDR 1992
		Gestational Day 6-15	24.8 mg Co/kg-day	NOAEL	Paternian *et al.*, 1988 in ATSDR 1992
		150 days (5d/wk)	10 mg Co/kg-day	LOAEL (less serious effects – hemato., hepatic, renal) NOAEL (Other)	Murdock 1959 in ATSDR 1992
		7 months (6d/wk)	0.05 mg Co/kg-day	NOAEL (hemato, immunological, neuro)	Krasovskii and Fridlyand 1971 in ATSDR 1992
			0.5 mg Co/kg-day	LOAEL (less serious effects – hemato, immuno., neuro)	
			2.5 mg Co/kg-day	NOAEL (hepatic) LOAEL (serious effects – neuro)	

Table 15 Selected NOEL and LOAEL Endpoints for Cobalt Exposure to Mammals (cont'd)

Chemical Form	Test Species	Duration	Dose	Endpoint	Reference
		6 weeks (7d/wk)	2.5 mg Co/kg-day	NOAEL (hemato)	Stanley et al., 1947 in ATSDR 1992
			9.9 mg Co/kg-day	LOAEL (less serious effects – hemato)	
		4 months	18 mg Co/kg-day	NOAEL (resp, cardio, gastro, hepatic) LOAEL (less serious effects – renal, hemato)	Holly, 1955 in ATSDR 1992
		3 months	30.2 mg Co/kg-day	NOAEL (gastro, musc/skel, hepatic, renal, other) LOAEL (less serious effects – resp, cardio, , hemato)	Domingo *et al.,* 1984
		69 days	5 mg Co/kg-day	NOAEL (neuro)	Nation *et al*., 1983
			20 mg Co/kg-day	LOAEL (less serious effects – neuro)	
		57 days	20 mg Co/kg-day	LOAEL (less serious effects – neuro)	Bourg *et al*., 1985 in ASTDR 1992
		Gestational day 14 to Lactation Day 21	5.4 mg Co/kg-day	LOAEL (serious effects – develop.)	Domingo *et al*., 1984
		98 days	13.25 mg Co/kg-day	LOAEL (serious effects – reprod.)	Mollenhauer *et al*., 1985
		69 days	5 mg Co/kg-day	NOAEL (reprod.)	Nation *et al*., 1983
			20 mg Co/kg-day	LOAEL (serious effects – reprod.)	
Cobalt chloride	Mouse	Gestational Day 8-12	81.7 mg Co/kg-day	NOAEL	Seidenberg 1986 in ATSDR 1992
		13 weeks	5.7 mg Co/kg-day	LOAEL (less serious effects – reprod.)	Pedigo *et al*., 1988 in ATSDR 1992
Cobalt chloride	Dog	4 weeks (7d/wk)	5 mg Co/kg-day	LOAEL (less serious effects – hemato)	Brewer 1940 in ATSDR 1992
Cobalt (II) chloride	Wistar rat		12 mg Co/kg-day	LOAEL for decreased number of litters, survival	Domingo *et al*., 1984

Table 15 Selected NOEL and LOAEL Endpoints for Cobalt Exposure to Mammals (cont'd)

Chemical Form	Test Species	Duration	Dose	Endpoint	Reference
Cobalt sulfate	Guinea pig		20 mg Co/kg-day	LOAEL (serious effects – cardiomyopathy) NOAEL (other)	Mohiuddin et al, 1970
		5 weeks	20 mg Co/kg-day	Death	Mohiuddin et al, 1970
Cobalt sulfate	Rat		110 mg Co/kg-day	NOAEL	FDRL 1984a in ATSDR 1992
			209 mg Co/kg-day	LOAEL (less serious effects)	
		8 weeks	26 mg Co/kg-day	LOAEL (serious effects - cardio)	Grice *et al*., 1969 in ATSDR 1992
		8 weeks	4.2 mg Co/kg-day	LOAEL (less serious effects - other)	Clyne *et al*., 1988 in ATSDR 1992
Cobalt fluoride	Rat		176.6 mg Co/kg-day	LOAEL (serious effects – Cardio., renal)	Speijers *et al*., 1992 in ATSDR 1992
			109.6 mg Co/kg-day	LOAEL (serious effects – otherl) NOAEL (cardio.)	
			68.2 mg Co/kg-day	LOAEL (serious effects – hepatic)	
			42.6 mg Co/kg-day	NOAEL (hepatic) LOAEL (less serious effects – renal)	
Cobalt Oxide	Rat		794.5 mg Co/kg-day	LOAEL (serious effects – Cardio.)	Speijers *et al*., 1992 in ATSDR 1992
			157.3 mg Co/kg-day	LOAEL (serious effects – hepatic, renal, other)	
			149 mg Co/kg-day	LOAEL (less serious effects)	FDRL 1984b in ATSDR 1992

An adjustment for relative bioavailability of cobalt ingested in soils is applicable to mammals in this study since the TRV is based on cobalt in food. The *in vitro* bioaccessibility estimates for cobalt are recommended for this purpose.

Meadow Vole

$$LOAEL_w = 13.25\, mg/kg-day\left(\frac{0.35\, kg}{0.048\, kg}\right)^{1-0.94} = 14\, mg/kg-day$$

$LOAEL_t$	=	LOAEL for rats (13.25 mg Co/kg-day) Rats exposed to cobalt for 98 days displayed histological changes. Mollenhauer, *et al.*, 1985; ATSDR 1992
BW_t	=	body weight rat (0.35 kg) (Sample *et al.*, 1996)
BW_w	=	body weight meadow vole (0.048 kg)

Raccoon

$$LOAEL_w = 13.25\, mg/kg-day\left(\frac{0.35\, kg}{4.0\, kg}\right)^{1-0.94} = 10\, mg/kg-day$$

$LOAEL_t$	=	LOAEL for rats (13.25 mg Co/kg-day) Rats exposed to cobalt for 98 days displayed histological changes. Mollenhauer, *et al.*, 1985; ATSDR 1992
BW_t	=	body weight rat (0.35 kg) (Sample *et al.*, 1996)
BW_w	=	body weight raccoon (4.0 kg)

Shrew

$$LOAEL_w = 13.25\, mg/kg-day\left(\frac{0.35\, kg}{0.00533\, kg}\right)^{1-0.94} = 15\, mg/kg-day$$

$LOAEL_t$	=	LOAEL for rats (13.25 mg Co/kg-day) Rats exposed to cobalt for 98 days displayed histological changes. Mollenhauer, *et al.*, 1985; ATSDR 1992
BW_t	=	body weight rat (0.35 kg) (Sample *et al.*, 1996)
BW_w	=	body weight shrew (0.00533 kg)

Red Fox

$$LOAEL_w = 13.25\, mg/kg-day\left(\frac{0.35\, kg}{5.2\, kg}\right)^{1-0.94} = 10\, mg/kg-day$$

$LOAEL_t$	=	LOAEL for rats (13.25 mg Co/kg-day) Rats exposed to cobalt for 98 days displayed histological changes. Mollenhauer, *et al.*, 1985; ATSDR 1992
BW_t	=	body weight rat (0.35 kg) (Sample *et al.*, 1996)
BW_w	=	body weight red fox (5.2 kg)

White tailed deer

$$LOAEL_w = 13.25\, mg/kg-day\left(\frac{0.35\,kg}{56.5\,kg}\right)^{1-0.94} = 8.8\, mg/kg-day$$

$LOAEL_t$	=	LOAEL for rats (13.25 mg Co/kg-day) Rats exposed to cobalt for 98 days displayed histological changes. Mollenhauer, *et al.*, 1985; ATSDR 1992
BW_t	=	body weight rat (0.35 kg) (Sample *et al.*, 1996)
BW_w	=	body weight white-tailed deer (56.5 kg)

1.5 Arsenic

Earthworms

Fischer and Koszorus (1992) observed about a 50% decrease in number of cocoons per worm at 50 mg/kg potassium arsenate in soil for *Eisenia fetida*. In the same study, about a 20% decline in earthworm mass was observed at 50 mg/kg potassium arsenate in soil. No other applicable studies were identified. Sample, *et al*. (1996) recommend a benchmark of 60 mg/kg arsenic in soil based on these data. For the current study, an EC_{20} of 50 mg/kg potassium arsenate (21 mg/kg arsenic) was selected.

Table 16 Chronic Endpoints for Arsenic Exposure to Earthworms

Chemical Form	Test Species	Concentration	Duration	Endpoint	Reference
Potassium arsenate	*Eisenia fetida*	50 mg/kg (21 mg/kg arsenic)	5 weeks	EC_{20}, weight & cocoons	Fischer and Koszorus, 1992

Frogs

Chronic endpoints for arsenic exposures to frogs are shown in Table 17. A broad diversity of toxicity for different species is evident. The data available for adult frogs indicates a much greater tolerance to arsenic for adults.

Table 17 Chronic Endpoints for Arsenic Exposure to Frogs

Chemical Form	Test Species	Concentration	Duration	Endpoint	Reference
Sodium arsenite	*Limnodynastes peroni* tadpole	34.6 mg/l	96 hour	LC_{50}	Johnson 1976 as cited in Sparling et al, 2000
	Rana pipiens tadpole	5 mg/l	22 days	24% mortality	Birge & Just 1973
	Rana pipiens adult	25 mg/l	25 days	NOEC	
	Gastrophryne carolinensis Eastern narrow-mouthed toad embryo	0.04 mg/l	7 days	LC_{50}	Birge 1987; Birge *et al.*, 1979
As (III)	*Rana hexadactyla* frog	0.37 mg/l	24 hour	LC_{50}	AQUIRE, 1996, in Sample et al., 1997
	Rana hexadactyla frog	0.25 mg/l	96 hour	LC_{50}	AQUIRE, 1996, in Sample et al., 1997
Arsenic trioxide	*Rana hexadactyla* tadpole	0.249 mg/l	96 hour	LC_{50}	Khangarot, *et al.*, 1985a
Iron methanoarsenate	*Bufo bufo japonicus* toad	>40 mg/l	48 hour	LC_{50}	Hashimoto & Nishiuchi, 1981
Not Specified	*B. fowleri* Fowler's Toad	7.87 mg/l*	Not specified	LC_{50}	Birge *et al.*, 2000
Not Specified	*G. carolinensis* Eastern narrow-mouth toad)	0.04 mg/l	Not specified	LC_{50}	Birge *et al.*, 2000
Not Specified	*R. catesbeiana* (Bullfrog)	0.26 mg/l	Not specified	LC_{50}	Birge *et al.*, 2000
Not Specified	*R. palustris* (Leopard frog)	0.14 mg/l	Not specified	LC_{50}	Birge *et al.*, 2000
Not Specified	*R. pipiens* (Leopard frog)	0.11 mg/l	Not specified	LC_{50}	Birge *et al.*, 2000
Not Specified	*P. crucifer* (Spring peeper)	0.11 mg/l	Not specified	LC_{50}	Birge *et al.*, 2000
Not Specified	*B. fowleri* Fowler's Toad	54.9 mg/l	Not specified	LC_{10}	Birge *et al.*, 2000
Not Specified	*G. carolinensis* Eastern narrow-mouth toad)	0.01 mg/l	Not specified	LC_{10}	Birge *et al.*, 2000
Not Specified	*R. catesbeiana* (Bullfrog)	0.03 mg/l	Not specified	LC_{10}	Birge *et al.*, 2000
Not Specified	*R. palustris* (Leopard frog)	0.01 mg/l	Not specified	LC_{10}	Birge *et al.*, 2000
Not Specified	*R. pipiens* (Leopard frog)	0.01 mg/l	Not specified	LC_{10}	Birge *et al.*, 2000
Not Specified	*P. crucifer* (Spring peeper)	0.01 mg/l	Not specified	LC_{10}	Birge *et al.*, 2000

* Value was not considered further due to suspected discrepancy in source.

In soils and sediments, arsenic is commonly found in one of three oxidation states: +5 (arsenate, As(V)), +3 (arsenite, As(III)), and as 0 (metalloid, As(0)) (Cullen and Reimer, 1989; CCME, 2001). Arsenate is the dominant arsenic species, typically greater than 95%, in oxic soil and sediment zones and is present as an anion ($H_xAsO_4^{x-3}$) in pH range of 4-8 (Cullen and Reimer, 1989; LaForce *et al*, 2000; Pongratz, 1998). Arsenate is also the dominant form of arsenic found in oxic surface waters (CCME, 2001; Cullen and Reimer, 1989; Bright *et al*, 1994; Azcue and Nriagu, 1994).

Most of the arsenic toxicity data for frogs are for trivalent forms that may not be applicable to arsenic found in the aquatic environment. A 48-hour LC_{50} was estimated as greater than 40 mg/l for iron methanoarsenate, indicating that toxicity values for frogs based on trivalent arsenic are likely conservative. The lowest LC_{50} of 0.04 mg/l for the Eastern narrow-mouthed toad exposed to trivalent arsenic was selected. This is considered highly conservative because of the oxidation state of the arsenic and because the Eastern narrow-mouthed toad is known to be particularly sensitive to metals (*e.g.* nickel, copper).

The minimum LC_{10} from all of the consulted studies was 0.01 mg/l, which was selected as a TRV for all frogs but Fowler's Toad since this value is similar to an estimated EC_{20} that would be derived from the LC_{50}. For the Fowler's Toad, its own $LC_{10}$of 50 mg/l, was chosen as an appropriate TRV.

Birds

Studies identifying chronic and subchronic NOELs or LOELs for birds are summarized in Table 18.

Table 18 Selected NOEL and LOAEL Endpoints for Arsenic Exposure to Birds

Chemical Form	Test Species	Concentration	Dose	Duration	Endpoint	Reference
Arsenic	Mallard duck	30 mg/kg	-	9 weeks	LOEL; behavioral changes	Whitworth, 1991
		300 mg/kg	-	9 weeks	LOEL; behavioral changes	
		100 mg/kg	-	9 weeks	NOEL	
Sodium arsenite (51.35% As^{+3})	Mallard duck	100 mg/kg	5.14 mg/kg-day	128 days	NOAEL based on mortality	USFWS, 1964
		250 mg/kg	12.84 mg/kg-day	128 days	LOAEL (12% mortality)	
Paris green; copper acetoarsenite (44.34% As^{+3})	Brown-headed cowbird (males)	25 mg/kg (11.09 mg As/kg)	2.46 mg/kg-day	7 months	NOAEL based on mortality	USFWS, 1969
		75 mg/kg (33.26 mg As/kg)	7.38 mg/kg-day	7 months	LOAEL (20% mortality)	

Paris green was not considered directly applicable to this study; therefore, sodium arsenite was selected as the most representative compound. The LOAEL is based on a severe effect of 12% mortality, so the NOAEL of 100 mg/kg sodium arsenite for mallard ducks (USFWS 1964) was used to derive a TRV of 5.14 mg/kg-day based on a body weight of 1 kg and a feed ingestion rate of 100 g/d (Sample et al, 1996). The concentration of 100 mg/kg was also a NOEL for behavioural changes (Whitworth 1991), and is thus considered sufficiently protective for use in this study.

For arsenic in soils, *in vitro* bioaccessibility testing has been validated through mammal studies for relative bioavailability of arsenic. This testing is considered applicable to birds in this study, with the addition of an uncertainty factor of 2 to account for differences between birds and mammals.

Red-Tailed Hawk

The NOAEL for Red-Tailed Hawks has been estimated from the derived NOAEL of 5.14 mg/kg-day using equation (A4-2):

$$NOAEL_w = 5.14\, mg/kg-day\left(\frac{1kg}{1.13kg}\right)^{1-1.2} = 5.3\, mg/kg-day$$

$NOAEL_t$	=	NOAEL for mallards (5.14 mg/kg-day)
BW_t	=	Body weight of mallards (1 kg)
BW_w	=	Body weight of Red-Tailed Hawks (1.13 kg)
f	=	1.2

American Woodcock

The NOAEL for American Woodcocks has been estimated from the derived NOAEL of 5.14 mg/kg-day using equation (A4-2):

$$NOAEL_w = 5.14\, mg/kg-day\left(\frac{1kg}{0.2kg}\right)^{1-1.2} = 3.7\, mg/kg-day$$

$NOAEL_t$	=	NOAEL for mallards (5.14 mg/kg-day)
BW_t	=	Body weight of mallards (1kg)
BW_w	=	Body weight of American Woodcocks (0.2 kg)
f	=	1.2

American Robin

The NOAEL for American Robins has been estimated from the derived NOAEL of 5.14 mg/kg-day using equation (A4-2):

$$NOAEL_w = 5.14\ mg/kg-day\left(\frac{1kg}{0.082kg}\right)^{1-1.2} = 3.1\ mg/kg-day$$

$NOAEL_t$	=	NOAEL for mallards (5.14 mg/kg-day)
BW_t	=	Body weight of mallards (1kg)
BW_w	=	Body weight of American Robins (0.082 kg)
f	=	1.2

Red-Eyed Vireo

The NOAEL for Red-Eyed Vireos has been estimated from the derived NOAEL of 5.14 mg/kg-day using equation (A4-2):

$$NOAEL_w = 5.14\ mg/kg-day\left(\frac{1kg}{0.0203kg}\right)^{1-1.2} = 2.4\ mg/kg-day$$

$NOAEL_t$	=	NOAEL for mallards (5.14 mg/kg-day)
BW_t	=	Body weight of mallards (1kg)
BW_w	=	Body weight of Red-Eyed Vireos (0.0203 kg)
f	=	1.2

Mammals

Eisler 1988 reports malformations and deaths in wildlife as chronic doses of 1 to 10 mg As/kg body weight, or dietary intakes of 5 to 50 mg As/kg feed. They also report that rats and mice metabolize arsenic differently from other animals and thus should not be used for extrapolating to other species. Studies that identified NOAELs or LOAELs in mammals are summarized in Table 19.

Table 19 NOAEL and LOAEL Studies of Arsenic Exposure to Mammals

Chemical Form	Test Species	Concentration	Dose	Duration	Endpoint	Reference
sodium arsenite	Dog	125 mg As/kg food	3.0 mg As/kg-day	2 years	reduced survival	Byron *et al.* 1967
		50 mg As/kg food	1.2 mg As/kg-day	2 years	NOAEL	
		-	4 mg/kg-day (58 days) +8 mg/kg (125 days)		LOAEL; liver enzyme changes	Neiger and Osweiler, 1989
As (III)	Dog	-	0.8 mg/kg-day	26 weeks	LOAEL; mild increase in serum ALT/AST	Neiger & Osweiler, 1989
		-	1 mg/kg-day	2 years	NOAEL; gastrointestinal, hematological, hepatic, body weight	Byron et al., 1967
		-	2.4 mg/kg-day	2 years	LOAEL; bleeding in gut, anemia, hemosiderin deposits, weight loss	Byron et al., 1967
As (V)	Dog	-	1 mg/kg-day	2 years	NOAEL; hematological, hepatic, body weight	Byron et al., 1967
		-	2.4 mg/kg-day	2 years	LOAEL; anemia, hepatic macrophage pigmentation, decreased weight gain	Byron et al., 1967

Table 19 NOAEL and LOAEL Studies of Arsenic Exposure to Mammals (cont'd)

Chemical Form	Test Species	Concentration	Dose	Duration	Endpoint	Reference
sodium arsenite	Rat	125 mg As/kg food	10 mg As/kg	2 years	Frank Effects Level (FEL)	Byron *et al.* 1967
		62.5 mg As/kg food	5 mg As/kg	2 years	NOAEL	
		5 mg As/L	0.65 mg/kg-day	Lifetime	NOAEL	Schroeder *et al.*, 1968
Unspecified	Rat	-	11 mg/kg-day	4 weeks	LOAEL; decreased vasoreactivity	Bekemeier & Hirschelmann, 1989, in ATDSR, 2000
As (III)	Rat	-	2 mg/kg-day	2 years	NOAEL; body weight	Byron et al., 1967, in ATSDR, 2000
		-	4 mg/kg-day	2 years	LOAEL; reduced body weight gain	Byron et al., 1967, in ATSDR, 2000
		-	2 mg/kg-day	14 days pre-mating through gestation day 19	NOAEL; hepatic	Holson et al., 2000, in ATSDR, 2000
		-	4 mg/kg-day	14 days pre-mating through gestation day 19	LOAEL; increased liver weight	Holson et al., 2000, in ATSDR, 2000
As (V)	Rat	-	4.7 mg/kg-day	6 weeks	LOAEL; increase in relative kidney weight	Brown et al., 1976, in ATSDR, 2000
		-	3 mg/kg-day	6 weeks	NOAEL; hepatic	Fowler et al., 1977, in ATSDR, 2000
		-	6 mg/kg-day	6 weeks	LOAEL; ultrastructural changes in hepatocytes	Fowler et al., 1977, in ATSDR, 2000
		-	2 mg/kg-day	2 years	LOAEL; decreased body weight gain in females	Byron et al., 1967, in ATSDR, 2000
		-	7 mg/kg-day	27 months	LOAEL; decreased body weight gain	Kroes et al., 1974, in ATSDR, 2000

Table 19 NOAEL and LOAEL Studies of Arsenic Exposure to Mammals (cont'd)

Chemical Form	Test Species	Concentration	Dose	Duration	Endpoint	Reference
As (V) as lead arsenate	Rat	-	7 mg/kg-day	27 months	NOAEL; hematological, hepatic, body weight	Kroes et al., 1974, in ATSDR, 2000
		-	30 mg/kg-day	27 months	LOAEL; anemia, enlarged bile duct, decreased body weight gain	Kroes et al., 1974, in ATSDR, 2000
sodium arsenite	Mouse	75.8 mg As/L	18.95 mg As/kg	Lifetime	LOAEL; mild hyperkeratosis/ epidermal hyperplasia	Baroni et al, 1963
		5 mg As/L + 0.46 mg As/kg food	0.44 mg As/kg	Lifetime	LOAEL; slight decr. in median life span; no effect of growth	Schroeder and Balassa, 1967
		0.5 mg As/L	0.125 mg As/kg	3 weeks	LOAEL; immunosuppressive effects	Blakely et al, 1980
Soluble arsenite	Mouse	5 mg As/L + 0.06 mg As/kg food	1.26 mg As/kg	3 generations	LOAEL; incr. in male to female ratio; decr. in litter size	Schroeder and Mitchener 1971
As (V)	Mouse	-	5 mg/kg-day	6 weeks	NOAEL; hepatic & body weight	Fowler & Woods, 1979, in ATSDR, 2000
		-	10 mg/kg-day	6 weeks	LOAEL; ultrastructural changes in hepatocytes, decreased body weight gain	Fowler & Woods, 1979, in ATSDR, 2000
		-	25 mg/kg-day	14 weeks	NOAEL; hepatic, renal	Kirkvliet et al., 1980, in ATSDR, 2000
		-	25 mg/kg-day	14 weeks	NOAEL; immunological/ lymphoreticular	Kirkvliet et al., 1980, in ATSDR, 2000
As (V)	Monkey (Rhesus)	-	3 mg/kg-day	1 year	LOAEL; mortality	Heywood & Sortwell, 1979, in ATSDR, 2000

For species not closely related to mice and rats, including raccoons, red foxes and white-tailed deer, the two year toxicity study conducted by Byron *et al*. (1967) provide the best chronic data to evaluate effects to mammals. This study presents a NOAEL of 1.2 mg As/kg and reduced survival at 3.0 mg As/kg. For meadow voles, The data available for mice and rats were considered appropriate.

The 3 generation study by Schroeder and Mitchener (1971) provides a chronic LOAEL of 5 mg As/L from which a dose rate of 1.26 mg As/kg-day has been estimated (Sample *et al*., 1996). Since the NOAEL developed for dogs is almost identical to the LOAEL developed from the 3 generation mice study, the latter was determined to be applicable for all mammals in this study. Sample *et al*. (1996) also report lethal doses in rodents similar to those observed in other mammals and concluded that the LOAEL of 1.26 mg As/kg-day selected in the current study is considered appropriate for assessing all mammals. Species specific values were estimated using equation(A4-2).

Since the LOAEL is based on arsenic in water, a conversion for relative bioavailability equal to the results of the *in vitro* bioaccessibility testing is considered appropriate.

Meadow Vole

$$LOAEL_w \quad = \quad 1.26\, mg/kg-day\left(\frac{0.03\, kg}{0.048\, kg}\right)^{1-0.94} \quad = \quad 1.2\, mg/kg-day$$

$LOAEL_t$	=	LOAEL for mice (1.26 mg As/kg-day) Mice exposed to As+3 displayed declining litter sizes with each successive generation, and the study considered exposure over 3 generations. Schroeder and Mitchener (1971)
BW_t	=	body weight mouse (0.03 kg) (US EPA 1985; Sample *et al.*, 1996)
BW_w	=	body weight meadow vole (0.048 kg)

Raccoon

$$LOAEL_w = 1.26\ mg/kg-day\left(\frac{0.03\ kg}{4.0\ kg}\right)^{1-0.94} = 0.94\ mg/kg-day$$

$LOAEL_t$	=	LOAEL for mice (1.26 mg As/kg-day) Mice exposed to As+3 displayed declining litter sizes with each successive generation, and the study considered exposure over 3 generations. Schroeder and Mitchener (1971)
BW_t	=	body weight mouse (0.03 kg) (US EPA 1985; Sample *et al.*, 1996)
BW_w	=	body weight raccoon (4.0 kg)

Shrew

$$LOAEL_w = 1.26\ mg/kg-day\left(\frac{0.03\ kg}{0.00533\ kg}\right)^{1-0.94} = 1.4\ mg/kg-day$$

$LOAEL_t$	=	LOAEL for mice (1.26 mg As/kg-day) Mice exposed to As+3 displayed declining litter sizes with each successive generation, and the study considered exposure over 3 generations. Schroeder and Mitchener (1971)
BW_t	=	body weight mouse (0.03 kg) (US EPA 1985; Sample *et al.*, 1996)
BW_w	=	body weight shrew (0.00533 kg)

Red Fox

$$LOAEL_w = 1.26\ mg/kg-day\left(\frac{0.03\ kg}{5.2\ kg}\right)^{1-0.94} = 0.92\ mg/kg-day$$

$LOAEL_t$	=	LOAEL for mice (1.26 mg As/kg-day) Mice exposed to As+3 displayed declining litter sizes with each successive generation, and the study considered exposure over 3 generations. Schroeder and Mitchener (1971)
BW_t	=	body weight mouse (0.03 kg) (US EPA 1985; Sample *et al.*, 1996)
BW_w	=	body weight red fox (5.2 kg)

White tailed deer

$$LOAEL_w = 1.26\ mg/kg-day\left(\frac{0.03\ kg}{56.5\ kg}\right)^{1-0.94} = 0.80\ mg/kg-day$$

$LOAEL_t$	=	LOAEL for mice (1.26 mg As/kg-day) Mice exposed to As+3 displayed declining litter sizes with each successive generation, and the study considered exposure over 3 generations. Schroeder and Mitchener (1971)
BW_t	=	body weight mouse (0.03 kg) (US EPA 1985; Sample *et al.*, 1996)
BW_w	=	body weight white tailed deer (56.5 kg)

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EXPOSURE PARAMETERS FOR RISK CALCULATIONS

ECOLOGICAL RISK ASSESSMENT – NATURAL ENVIRONMENT

PORT COLBORNE COMMUNITY BASED RISK ASSESSMENT

Meadow Vole

Parameter	Definition	Expected Value	Source
Water Exposure			
C	CoC concentration in the water source (mg/l)	Section 6	Field data.
FR	Fraction of total water ingested from the contaminated water source (unitless)	1	Assumed on the basis of a very small (0.03-0.08 ha; Ostfeld *et al*. 1988) home range relative to the size of the contaminated area.
NIR	Normalized water ingestion rate (fraction of body weight consumed as water per unit time, g/g-d).	0.21	Ernst (1968).
n	Number of contaminated water sources	1	Assumed on the basis of a very small home range relative to the size of the contaminated areas.
Diet Exposure			
C_k	CoC concentration in the k^{th} type of food (mg/kg)	Section 6	Field data for field arthropods and goldenrod, data from unamended fields for oats.
FR	Fraction of food group that is contaminated (unitless)	1	Assumed on the basis of a very small home range relative to the size of the contaminated areas.
DF_k	Fraction of total diet accounted for by the k^{th} food group (unitless).	Goldenrods (56%) Oats (29%) Oat Seed (13%) Arthropods (2%)	Diet composition to resemble that of Lindroth and Batzli (1984) for Illinois Blue Grass habitat, recalculated excluding roots and fungi.
NIR	Fraction of body weight (wet) consumed as food (wet) per day (g/g-d).	0.35	From Ognev (1950) in Russia.
m	Number of contaminated food types	4	Diet compositions from Lindroth and Batzli (1984) for Illinois Blue Grass habitat.
Soil Exposure			
C	CoC concentration in soil in the foraging area (mg/kg dw)	Section 6	Field data.
FS	Fraction of soil in diet (g/g dry weight)	0.024	Assumed as per US EPA (1993).
IR	Food ingestion rate on a dry weight basis (kg/day)	8.876	Calculated using: (0.048kg) x (0.35 g/g-d) x (1-mc (%)) Values for body weight and food ingestion taken from US EPA (1993). Moisture content (mc) was derived from field samples.
FR	Fraction of total soil intake from the contaminated area (unitless)	1	Assumed on the basis of a very small home range relative to the size of the contaminated area.
BW	Body weight (kg)	0.048	Assumed on the basis of Ontario data in US EPA (1993).

Meadow Vole

Parameter	Definition	Expected Value	Source
m	Number of contaminated foraging areas	1	Assumed on the basis of a very small home range relative to the size of the contaminated area.
Air Exposure			
C	CoC concentration in air (mg/m^3)	Section 6	Field data.
IR	Inhalation rate (m^3/d)	0.048	Estimated by taking average of male and female rates as presented in US EPA (1993).
FR	Fraction of total air intake from contaminated area.	1	Assumed on the basis of a very small home range relative to the size of the contaminated areas.
BW	Body Weight (kg)	0.048	Assumed on the basis of Ontario data in US EPA (1993).
m	Number of contaminated areas	1	Assumed on the basis of a very small home range relative to the size of the contaminated area.

White-tailed Deer

Parameter	Definition	Expected Value	Source
Water Exposure			
C	CoC concentration in the water source (mg/l)	Section 6	Field data.
FR	Fraction of total water ingested from the contaminated water source (unitless)	1	Assumed on the basis of the home range (0.6 to 5.2km^2 - Marchinton and Hirth 1984) relative to the size of the contaminated area.
NIR	Normalized water ingestion rate (fraction of body weight consumed as water per unit time, g/g-d).	0.066	Estimated using [3-17] and [3-18] in US EPA (1993).
n	Number of contaminated water sources	1	Assumed on the basis of the home range relative to the size of the contaminated areas.
Diet Exposure			
C_k	CoC concentration in the kth type of food (mg/kg)	Section 6	Field data for maple leaves and goldenrods, data from unamended fields for oats and unamended fields and farm fields for corn.
FR	Fraction of food group that is contaminated (unitless)	1	Assumed on the basis of the home range relative to the size of the contaminated areas.
DF_k	Fraction of total diet accounted for by the kth food group (unitless).	Corn Seeds (26%) Oat Seeds (25%) Maple Leaves (17%) Goldenrod (16%)	Diet is varied, depending on the abundance of food available at a particular season (Sample and Suter 1994).
NIR	Fraction of body weight consumed as food per day (g/g-d).	0.031	Based on rate of 1.74 kg/d (Mautz *et al*. 1976) and a mean body weight of 56.5 kg (Smith 1991).
m	Number of contaminated food types	4	
Soil Exposure			
C	CoC concentration in soil in the foraging area (mg/kg dry weight)	Section 6	Field data.
FS	Fraction of soil in diet (g/g dry weight)	0.02	Assumed as per guidance in Sample *et al*. (1996).
IR	Food ingestion rate on a dry weight basis (kg/d)	1.89	Estimated using [3-7] in US EPA (1993).
FR	Fraction of total soil intake from the contaminated area (unitless)	0.85	Assumed on the basis of the home range relative to the size of the contaminated areas, and on the number of days (51.7) where snow cover exceeds 1 cm in an average year (MSC 2002).
BW	Body weight (kg)	56.5	Smith (1991).

White-tailed Deer

Parameter	Definition	Expected Value	Source
m	Number of contaminated foraging areas	1	Assumed on the basis of the home range relative to the size of the contaminated area.
Air Exposure			
C	CoC concentration in air (mg/m^3)	Section 6	Field data.
IR	Inhalation rate (m^3/d)	13.76	Estimated on the basis of body weight, using Sample *et al*. (1997).
FR	Fraction of total air intake from the contaminated area.	1	Assumed on the basis of the home range relative to the size of the contaminated areas.
BW	Body weight (kg)	56.5	Smith (1991).
m	Number of contaminated areas	1	Assumed on the basis of the home range relative to the size of the contaminated areas.

American Robin

Parameter	Definition	Expected Value	Source
Water Exposure			
C	CoC concentration in the water source (mg/l)	Section 6	Field data.
FR	Fraction of total water ingested from the contaminated water source (unitless)	0.67	Assumed on the basis of a small breeding territory (200-1300m^2; Environment Canada 1989a) relative to the size of the contaminated areas, and to the migration habits of the species (8/12 exposure, based on departure from study area in November and return in March; US EPA 1993).
NIR	Normalized water ingestion rate (fraction of body weight consumed as water per unit time, g/g-d).	0.14	Estimated by US EPA (1993) for an adult.
n	Number of contaminated water sources	1	Assumed on the basis of a small breeding territory relative to the size of the contaminated areas.
Diet Exposure			
C_k	CoC concentration in the k^{th} type of food (mg/kg)	Section 6	Field data for grapes, earthworms and arthropods.
FR	Fraction of food group that is contaminated (unitless)	0.67	Assumed on the basis of a small home range relative to the size of the contaminated areas, and migration habits.
DF_k	Fraction of total diet accounted for by the k^{th} food group (unitless).	Grapes (56%) Earthworms (10%) Arthropods (34%)	Diet composition to resemble that of Wheelwright (1986) for eastern US robins, averaged over spring, summer and fall. Invertebrate proportions estimated using fledgling diet for New York state (US EPA 1993).
NIR	Fraction of body weight consumed as food per day (g/g-d).	1.22	Based on consumption of 1.4kg of food every two weeks (Environment Canada 1989a).
m	Number of contaminated food types	3	
Soil Exposure			
C	CoC concentration in soil in the contaminated foraging area (mg/kg dry weight)	Section 6	Field data.
FS	Fraction of soil in diet (g/g dry weight)	0.02	Based on US EPA (1993).
IR	Food ingestion rate on a dry weight basis (kg/day)	0.01685	Calculated using: (0.082kg) x (1.22 g/g-d) x (1-mc (%)) Values for body weight and food ingestion taken from Wheelwright (1986) and Environment Canada (1989a), respectively. Moisture content (mc) was derived from field samples.
FR	Fraction of total food intake from the contaminated foraging area (unitless)	0.67	Assumed on the basis of a very small home range relative to the size of the contaminated areas, and migration habits.

American Robin

Parameter	Definition	Expected Value	Source
BW	Body weight (kg)	0.082	For an average adult, based on Wheelwright (1986).
m	Total number of foraging areas	1	Assumed on the basis of a small home range relative to the size of the contaminated areas.
Air Exposure			
C	CoC concentration in air (mg/m^3)	Section 6	Field data.
IR	Inhalation rate (m^3/d)	0.304	Estimated using [3-19] in US EPA (1993) for an adult.
FR	Fraction of total air intake from contaminated area.	0.67	Assumed on the basis of a small home range relative to the size of the contaminated areas, and migration habits.
BW	Body weight (kg)	0.082	For an average adult, based on Wheelwright (1986).
m	Number of contaminated areas	1	Assumed on the basis of a small home range relative to the size of the contaminated areas.

American Woodcock

Parameter	Definition	Expected Value	Source
Water Exposure			
C	CoC concentration in the water source (mg/l)	Section 6	Field data.
FR	Fraction of total water ingested from the contaminated water source (unitless)	0.58	Assumed on the basis of a small breeding territory (7-98 ha; Gregg 1984) relative to the size of the contaminated areas, and to the migration habits of the species (7/12 exposure, based on departure from study area in November and return in April; US EPA 1993).
NIR	Normalized water ingestion rate (fraction of body weight consumed as water per unit time, g/g-d).	0.10	Estimated by US EPA (1993) for an adult male.
n	Number of contaminated water sources	1	Assumed on the basis of a small territory relative to the size of the contaminated areas.
Diet Exposure			
C_k	CoC concentration in the k^{th} type of food (mg/kg)	Section 6	Field data for earthworms and arthropods.
FR	Fraction of food group that is contaminated (unitless)	0.58	Assumed on the basis of a very small home range relative to the size of the contaminated areas, and migration habits.
DF_k	Fraction of total diet accounted for by the k^{th} food group (unitless).	Earthworms (76%), Arthropods (24%)	Based on US EPA (1993).
NIR	Fraction of body weight consumed as food per day (g/g d).	0.77	From Stickel *et al*. (1965)
m	Number of contaminated food types	2	
Soil Exposure			
C	CoC concentration in soil in the contaminated foraging area (mg/kg dw)	Section 6	Field data.
FS	Fraction of soil in diet (g/g dry weight)	0.104	Based on US EPA (1993).
IR	Food ingestion rate on a dry weight basis (kg/day)	0.0204	Calculated using: (0.20kg) x (0.77 g/g-d) x (1-mc (%)) Values for body weight and food ingestion taken from Nelson and Martin (1953) and Stickel *et al*. (1965), respectively. Moisture content (mc) was be derived from field samples.
FR	Fraction of total soil intake from the contaminated foraging area (unitless)	0.58	Assumed on the basis of a small territory relative to the size of the contaminated areas and migration habits.
BW	Body weight (kg)	0.20	Nelson and Martin (1953), average adult.
m	Number of contaminated foraging areas	1	Assumed on the basis of a small territory relative to the size of the contaminated areas.

American Woodcock

Parameter	Definition	Expected Value	Source
Air Exposure			
C	CoC concentration in air (mg/m^3)	Section 6	Field data.
IR	Inhalation rate (m^3/d)	0.296	Estimated by US EPA (1993) for an average adult.
FR	Fraction of total air intake from contaminated area.	0.58	Assumed on the basis of a small territory relative to the size of the contaminated areas and migration habits.
BW	Body weight (kg)	0.20	Nelson and Martin (1953), average adult.
m	Number of contaminated areas	1	Assumed on the basis of a small territory relative to the size of the contaminated areas.

Red-eyed Vireo

Parameter	Definition	Expected Value	Source
Water Exposure			
C	CoC concentration in the water source (mg/l)	Section 6	Field data.
FR	Fraction of total water ingested from the contaminated water source (unitless)	0.33	Assumed on the basis of a very small breeding territory (0.69 ha; US EPA 1993) relative to the size of the contaminated areas, and on migration habits (existing in Canada from June to August (4/12 of year)).
NIR	Normalized water ingestion rate (fraction of body weight consumed as water per unit time, g/g-d).	0.21	Estimated by US EPA (1993).
n	Number of contaminated water sources	1	Assumed on the basis of a very small breeding territory relative to the size of the contaminated areas.
Diet Exposure			
C_k	CoC concentration in the k^{th} type of food (mg/l or mg/kg)	Section 6	Field data for arthropods.
FR	Fraction of food group that is contaminated (unitless)	0.33	Assumed on the basis of a very small breeding territory relative to the size of the contaminated areas, and migration habits.
DF_k	Fraction of total diet accounted for by the k^{th} food group (unitless).	Arthropods (85%), Wild Grapes (15%)	Diet composition to resemble Chapin (1925).
NIR	Fraction of body weight consumed as food per day (g/g-d).	0.845	Estimated based on US EPA (1993).
m	Number of contaminated food types	2	
Soil Exposure			
C	CoC concentration in soil in the contaminated foraging area (mg/kg dw)	Section 6	Field data.
FS	Fraction of soil in diet (g/g dry weight)	0.02	Based on US EPA (1993).
IR	Food ingestion rate on a dry weight basis (kg/day)	0.0051	Calculated using: (0.0203kg) x (0.845 g/g-d) x (1-mc (%)) Values for body weight and food ingestion taken from Cimprich *et al*. (2000) and US EPA (1993), respectively. Moisture content (mc) will be derived from field samples.
FR	Fraction of total soil intake from the contaminated foraging area (unitless)	0.33	Assumed on the basis of a very small breeding territory relative to the size of the contaminated areas, and migration habits.
BW	Body weight (kg)	0.0203	Based on mean mass of migrating adult males and adult females in North Carolina (Cimprich *et al*. 2000).
m	Number of contaminated foraging areas	1	Assumed on the basis of a very small territory relative to the size of the contaminated areas

Red-eyed Vireo

Parameter	Definition	Expected Value	Source
Air Exposure			
C	CoC concentration in air (mg/m^3)	Section 6	Field data.
IR	Inhalation rate (m^3/d)	0.1	Estimated using equation [3-19] in U.S. EPA (1993)
FR	Fraction of total air intake from the contaminated area.	0.33	Assumed on the basis of a very small breeding territory relative to the size of the contaminated areas, and migration habits.
m	Number of contaminated areas	1	Assumed on the basis of a very small breeding territory relative to the size of the contaminated areas.

Raccoon

Parameter	Definition	Expected Value	Source
Water Exposure			
C	CoC concentration in the water source (mg/l)	Section 6	Field data.
FR	Fraction of total water ingested from the contaminated water source (unitless)	1	Assumed on the basis of a small (1-4 km^2; Environment Canada 1989b) home range relative to the size of the contaminated areas.
NIR	Normalized water ingestion rate (fraction of body weight consumed as water per unit time, g/g-d).	0.082	Estimated by US EPA (1993) for adult male.
n	Number of contaminated water sources	1	Assumed on the basis of a very small home range relative to the size of the contaminated areas.
Diet Exposure			
C_k	CoC concentration in the k^{th} type of food (mg/kg)	Section 6	Field data for grapes, earthworms, arthropods, voles and green frogs, data from farm fields and unamended fields for corn, data from unamended fields for oats.
FR_k	Fraction of food group that is contaminated (unitless)	1	Assumed on the basis of a small home range relative to the size of the contaminated areas.
DF_k	Fraction of total diet accounted for by the k^{th} food group (unitless).	Grapes (25.3%), Earthworms (5.3%), Arthropods (45.0%), Green Frogs (7.4%), Meadow Voles (4.6%), Corn (6.2%), Oats (6.2%)	Estimated based on full year data presented in US EPA (1993).
NIR	Fraction of body weight consumed as food per day (g/g-d).	0.054	Estimated based on US EPA (1993).
m	Number of contaminated food types	7	
Soil Exposure			
C	CoC concentration in soil in the contaminated foraging area (mg/kg dw)	Section 6	Field data.
FS	Fraction of soil in diet (g/g dry weight)	0.094	Assumed as per guidance in US EPA (1993).
IR	Food ingestion rate on a dry weight basis (kg/day)	0.21	Estimated using [3-7] in US EPA (1993) for a specimen weighing 4 kg.
FR	Fraction of total soil intake from the k^{th} foraging area (unitless)	0.85	Assumed on the basis of a very small home range relative to the size of the contaminated areas, and on the number of days (51.7) where snow cover exceeds 1 cm in an average year (MSC 2002).

Raccoon

Parameter	Definition	Expected Value	Source
BW	Body weight (kg)	4.0	Environment Canada (1989b).
m	Total number of foraging areas	1	Assumed on the basis of a small home range relative to the size of the contaminated areas
Air Exposure			
C	CoC concentration in air (mg/m^3)	Section 6	Field data.
IR	Inhalation rate (m^3/d)	2.32	Estimated by US EPA (1993)
FR	Fraction of total air intake from contaminated area.	1	Assumed on the basis of a small home range relative to the size of the contaminated areas.
BW	Body weight (kg)	4.0	Environment Canada (1989b).
m	Number of contaminated areas	1	Assumed on the basis of a small home range relative to the size of the contaminated areas.

Red Fox

Parameter	Definition	Expected Value	Source
Water Exposure			
C	CoC concentration in the water source (mg/l)	Section 6	Field data.
FR	Fraction of total water ingested from the contaminated water source (unitless)	1	Assumed on the basis of a small (4-8 km^2) home range relative to the size of the contaminated areas.
NIR	Normalized water ingestion rate (fraction of body weight consumed as water per unit time, g/g-d)	0.085	Estimated by US EPA (1993).
n	Number of contaminated water sources	1	Assumed on the basis of a small home range relative to the size of the contaminated areas.
Diet Exposure			
C_k	CoC concentration in the k^{th} type of food (mg/kg)	Section 6	Field data. Birds are based on average exposure of American Robin, American Woodcock and Red-eyed Vireo (Section 6).
FR_k	Fraction of food group that is contaminated (unitless)	1	Assumed on the basis of a small home range relative to the size of the contaminated areas.
DF_k	Fraction of total diet accounted for by the k^{th} food group (unitless)	Meadow Vole (61.6%), Grapes (13.1%), Arthropods (3.8%), Birds (16.5%), Frogs (5%)	Based on US EPA (1993).
NIR_k	Fraction of body weight consumed as food per day (g/g-d).	0.069	Sargeant (1978).
m	Number of contaminated food types	2	
Soil Exposure			
C	CoC concentration in soil in the contaminated foraging area (mg/kg dw)	Section 6	Field data.
FS	Fraction of soil in diet (g/g dry weight)	0.028	Assumed as per guidance in US EPA (1993).
IR	Food ingestion rate on a dry weight basis (kg/day)	0.266	Estimated using [3-7] in US EPA (1993) for a specimen weighing 5.2 kg.
FR	Fraction of total soil intake from the contaminated foraging area (unitless)	1	Assumed on the basis of a small home range relative to the size of the contaminated areas.
BW	Body weight (kg)	5.2	Average weight (Environment Canada 1993).

Red Fox

Parameter	Definition	Expected Value	Source
m	Number of contaminated foraging areas	1	Assumed on the basis of a small home range relative to the size of the contaminated areas, and on the number of days (51.7) where snow cover exceeds 1 cm in an average year (MSC 2002).
Air Exposure			
C	CoC concentration in air (mg/m^3)	Section 6	Field data.
IR	Inhalation rate (m^3/d)	1.9	Estimated by US EPA (1993).
FR	Fraction of total air intake from the contaminated area.	1	Assumed on the basis of a small home range relative to the size of the contaminated areas.
BW	Body weight (kg)	5.2	Average weight (Environment Canada 1993).
m	Number of contaminated areas	1	Assumed on the basis of a small home range relative to the size of the contaminated areas.

Red-tailed Hawk

Parameter	Definition	Expected Value	Source
Water Exposure			
C	CoC concentration in the water source (mg/l)	Section 6	Field data.
FR	Fraction of total water ingested from the contaminated water source (unitless)	1	Assumed on the basis of a small (3-7 km^2; US EPA 1993) home range relative to the size of the contaminated areas, and no migration.
NIR	Normalized water ingestion rate (fraction of body weight consumed as water per unit time, g/g-d).	0.057	Estimated by US EPA (1993).
n	Number of contaminated water sources	1	Assumed on the basis of a small home range relative to the size of the contaminated areas.
Diet Exposure			
C_k	CoC concentration in the k^{th} type of food (mg/kg)	Section 6	Based on calculations (see Section 6) and meadow vole field data.
FR_k	Fraction of food group that is contaminated (unitless)	1	Assumed on the basis of a small home range relative to the size of the contaminated areas.
DF_k	Fraction of total diet accounted for by the k^{th} food group (unitless).	Meadow Vole (74%), Birds (average; 26%)	Diet composition to resemble that in U.S. EPA (1993). Average CoC value for three bird species (Red-eyed Vireo, American Robin and American Woodcock) will be used.
NIR	Fraction of body weight consumed as food per day (g/g-d).	0.096	Craighead and Craighead (1956), annual average.
m	Number of contaminated food types	4	Diet compositions from US EPA (1993).
Soil Exposure			
C	CoC concentration in soil in the contaminated foraging area (mg/kg dw)	Section 6	Field data.
FS	Fraction of soil in diet (g/g dry weight)	0.02	Assumed as per guidance in US EPA (1993).
IR	Food ingestion rate on a dry weight basis (kg/day)	0.063	Estimated using [3-3] in US EPA (1993).
FR	Fraction of total food intake from the contaminated foraging area (unitless)	1.0	Assumed on the basis of a small home range relative to the size of the contaminated areas.
BW	Body weight (kg)	1.13	Average adult in Craighead and Craighead (1956).
m	Number of contaminated foraging areas	1	Assumed on the basis of a small home range relative to the size of the contaminated areas.

Red-tailed Hawk

Parameter	Definition	Expected Value	Source
Air Exposure			
C	CoC concentration in air (mg/m^3)	Section 6	Field data.
IR	Inhalation rate (m^3/d)	0.45	Estimated by US EPA (1993).
FR	Fraction of total air intake from the contaminated area.	1	Assumed on the basis of a small home range relative to the size of the contaminated areas.
BW	Body weight (kg)	1.13	Average adult in Craighead and Craighead (1956).
m	Number of contaminated areas	1	Assumed on the basis of a small home range relative to the size of the contaminated areas.

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EXAMPLE CALCULATIONS

EXAMPLE CALCULATIONS

To illustrate the use of equations found in Chapter 6, here we present a real example of how we calculated nickel exposure for the American Robin in one scenario (woodlots on organic soils) and calculated its risk due to nickel.

Firstly, Equation 6-1 states that a robin's overall potential average daily dose (ADD) is the sum of a robin's dose due to each of water exposure, diet exposure, soil exposure and air exposure.

$$ADD_{tot} = ADD_{water} + ADD_{diet} + ADD_{soil}$$

For water exposure, Equation 6-2 was used.

$$ADD_{water} = (C \bullet FR) \bullet NIR$$

From Table 6-17 and Volume III (Tab 5),

ADD_{water} = 0.178 mg/l * 0.67 * 0.13 kg/kg d = **0.02 mg/kg d**

For diet exposure, Equation 6-3 was used.

$$ADD_{diet} = \sum (C_k \bullet FR \bullet DF_k \bullet NIR)$$

From Tables 6-17 and 6-18, and Volume III (Tab 5),

ADD_{diet} = (Earthworms) 180 mg/kg * 0.67 * 0.10 * (0.0169 kg/d / 0.082 kg)
\+
(Arthropods) 12.4 mg/kg * 0.67 * 0.34 * (0.0169 kg/d / 0.082 kg)
\+
(Grapes) 1.6 mg/kg * 0.67 * 0.56 * (0.0169 kg/d / 0.082 kg) = **3.2 mg/kg d**

For soil exposure, Equation 6-4 was used.

$$ADD_{soil} = \frac{(C \bullet FS \bullet IR \bullet FR)}{BW}$$

From Table 6-18 and Volume III (Tab 5),

$$ADD_{soil} = \frac{15200 \text{ mg/kg} * 0.021 \text{ kg/kg dw} * 0.0169 \text{ kg/d} * 0.67}{0.082 \text{ kg}} = \mathbf{44.08 \text{ mg/kg d}}$$

Of this, 6.4% is considered to be bioavailable, giving the corrected ADD_{soil} of **2.82 mg/kg d**.

The total potential average daily dose equals

$$ADD_{pot} = 0.02 \text{ mg/kg d} + 3.2 \text{ mg/kg d} + 2.82 \text{ mg/kg d} = \mathbf{6.04 \text{ mg/kg d}}$$

Comparing this average daily dose with the American Robin's Toxicity Reference Value for nickel (Chapter 7), the following risk is calculated, using Equation 8-1.

$$\text{Risk} = \frac{6.04 \text{ mg/kg d}}{49 \text{ mg/kg d}} = \mathbf{0.12}$$

Since the Risk < 1, we do not calculate a soil nickel concentration at which robins will not be at risk. The American Robin population in the Port Colborne area is deemed to be not at risk by nickel concentrations existing in the Study Area.

American Robin
Total Risk

Scenario	CoC	ADD (mg/kg d)	TRV (mg/kg d)	Risk
Woodlot on clay soils	Nickel	3.59	49	0.07
	Copper	3.03	32	0.09
	Cobalt	0.16	1.9	0.08
	Arsenic	0.09	3.1	0.03
Woodlot on organic soils	Nickel	6.04	49	0.12
	Copper	5.72	32	0.18
	Cobalt	0.38	1.9	0.2
	Arsenic	0.35	3.1	0.11
Field on clay soils	Nickel	3.47	49	0.07
	Copper	4.32	32	0.14
	Cobalt	0.21	1.9	0.11
	Arsenic	0.16	3.1	0.05
Field on organic soils	Nickel	3.59	49	0.07
	Copper	3.79	32	0.12
	Cobalt	0.18	1.9	0.09
	Arsenic	0.18	3.1	0.06

American Robin
ADD Water

CoC	Concentration (mg/l)	Total Fraction	NIR (kg/kg d)		ADD (mg/kg d)
Nickel	0.178	0.67	0.13		0.02
Copper	0.018	0.67	0.13		0
Cobalt	0.006	0.67	0.13		0
Arsenic	0.005	0.67	0.13		0

American Robin
ADD Diet

Scenario	CoC	Food	Concentration (mg/kg)	Food Fraction	Total Fraction	Ingestion Rate (kg/d)	Body Weight (kg)		ADD (mg/kg d)
Woodlot on clay soils	Nickel	grapes	1.6	0.56	0.67	0.0169	0.082		3.2
		earthworms	180	0.1					
		arthropods	12.4	0.34					
	Copper	grapes	12	0.56	0.67	0.0169	0.082		3
		earthworms	52	0.1					
		arthropods	29.6	0.34					
	Cobalt	grapes	0.03	0.56	0.67	0.0169	0.082		0.16
		earthworms	10.1	0.1					
		arthropods	0.46	0.34					
	Arsenic	grapes	0.1	0.56	0.67	0.0169	0.082		0.08
		earthworms	4.2	0.1					
		arthropods	0.3	0.34					
Woodlot on organic soils	Nickel	grapes	1.6	0.56	0.67	0.0169	0.082		3.2
		earthworms	180	0.1					
		arthropods	12.4	0.34					
	Copper	grapes	12	0.56	0.67	0.0169	0.082		5.1
		earthworms	52	0.1					
		arthropods	72.6	0.34					
	Cobalt	grapes	0.03	0.56	0.67	0.0169	0.082		0.33
		earthworms	21.9	0.1					
		arthropods	0.46	0.34					
	Arsenic	grapes	0.1	0.56	0.67	0.0169	0.082		0.17
		earthworms	8.9	0.1					
		arthropods	0.8	0.34					
Field on clay soils	Nickel	grapes	1.6	0.56	0.67	0.0169	0.082		3.2
		earthworms	180	0.1					
		arthropods	12.4	0.34					
	Copper	grapes	12	0.56	0.67	0.0169	0.082		4.3
		earthworms	52	0.1					
		arthropods	57	0.34					
	Cobalt	grapes	0.03	0.56	0.67	0.0169	0.082		0.21
		earthworms	13.7	0.1					
		arthropods	0.46	0.34					
	Arsenic	grapes	0.1	0.56	0.67	0.0169	0.082		0.15
		earthworms	9.6	0.1					
		arthropods	0.3	0.34					
Field on organic soils	Nickel	grapes	1.6	0.56	0.67	0.0169	0.082		3.2
		earthworms	180	0.1					
		arthropods	12.4	0.34					
	Copper	grapes	12	0.56	0.67	0.0169	0.082		3.7
		earthworms	52	0.1					
		arthropods	44.6	0.34					
	Cobalt	grapes	0.03	0.56	0.67	0.0169	0.082		0.17
		earthworms	10.6	0.1					
		arthropods	0.46	0.34					
	Arsenic	grapes	0.1	0.56	0.67	0.0169	0.082		0.14
		earthworms	8.2	0.1					
		arthropods	0.5	0.34					

American Robin
ADD Soil

Scenario	CoC	Concentration (mg/kg)	Soil Fraction (kg/kg dw)	Ingestion Rate (kg/d)	Food Fraction	Body Weight (kg)	ADD (mg/kg d)	Bioaccessible Ratio	Bioaccessible ADD (mg/kg d)
Woodlot on clay soils	Nickel	1630	0.021	0.0169	0.67	0.082	4.73	0.078	0.37
	Copper	180	0.021	0.0169	0.67	0.082	0.5	0.058	0.03
	Cobalt	33	0.021	0.0169	0.67	0.082	0.1	0.043	0
	Arsenic	12	0.021	0.0169	0.67	0.082	0.03	0.27	0.01
Woodlot on organic soils	Nickel	15200	0.021	0.0169	0.67	0.082	44.08	0.064	2.82
	Copper	2020	0.021	0.0169	0.67	0.082	5.86	0.105	0.62
	Cobalt	219	0.021	0.0169	0.67	0.082	0.64	0.083	0.05
	Arsenic	83	0.021	0.0169	0.67	0.082	0.24	0.74	0.18
Field on clay soils	Nickel	1090	0.021	0.0169	0.67	0.082	3.16	0.078	0.25
	Copper	140	0.021	0.0169	0.67	0.082	0.41	0.058	0.02
	Cobalt	27	0.021	0.0169	0.67	0.082	0.08	0.043	0
	Arsenic	8	0.021	0.0169	0.67	0.082	0.02	0.27	0.01
Field on organic soils	Nickel	2020	0.021	0.0169	0.67	0.082	5.86	0.064	0.37
	Copper	308	0.021	0.0169	0.67	0.082	0.89	0.105	0.09
	Cobalt	37	0.021	0.0169	0.67	0.082	0.11	0.083	0.01
	Arsenic	20	0.021	0.0169	0.67	0.082	0.06	0.74	0.04

American Woodcock
Total Risk

Scenario	CoC	ADD (mg/kg/d)	TRV (mg/kg/d)	Risk
Woodlot on clay soils	Nickel	9.08	59	0.15
	Copper	2.86	39	0.07
	Cobalt	0.47	2.2	0.21
	Arsenic	0.21	3.7	0.06
Woodlot on organic soils	Nickel	14.29	59	0.24
	Copper	4.7	39	0.12
	Cobalt	1.1	2.2	0.5
	Arsenic	0.79	3.7	0.21
Field on clay soils	Nickel	8.82	59	0.15
	Copper	3.15	39	0.08
	Cobalt	0.63	2.2	0.29
	Arsenic	0.45	3.7	0.12
Field on organic soils	Nickel	9.1	59	0.15
	Copper	3.2	39	0.08
	Cobalt	0.5	2.2	0.23
	Arsenic	0.47	3.7	0.13

American Woodcock
ADD Diet

Scenario	CoC	Food	Concentration (mg/kg)	Food Fraction	Total Fraction	Ingestion Rate (kg/d)	Body Weight (kg)	ADD (mg/kg d)
Woodlot on clay soils	Nickel	earthworms	180	0.76	0.58	0.0204	0.2	8.3
		arthropods	12.5	0.24				
	Copper	earthworms	52	0.76	0.58	0.0204	0.2	2.8
		arthropods	29.6	0.24				
	Cobalt	earthworms	10.1	0.76	0.58	0.0204	0.2	0.46
		arthropods	0.46	0.24				
	Arsenic	earthworms	4.2	0.76	0.58	0.0204	0.2	0.19
		arthropods	0.3	0.24				
Woodlot on organic soils	Nickel	earthworms	180	0.76	0.58	0.0204	0.2	8.3
		arthropods	12.5	0.24				
	Copper	earthworms	52	0.76	0.58	0.0204	0.2	3.4
		arthropods	72.6	0.24				
	Cobalt	earthworms	21.9	0.76	0.58	0.0204	0.2	0.99
		arthropods	0.46	0.24				
	Arsenic	earthworms	8.9	0.76	0.58	0.0204	0.2	0.41
		arthropods	0.8	0.24				
Field on clay soils	Nickel	earthworms	180	0.76	0.58	0.0204	0.2	8.3
		arthropods	12.5	0.24				
	Copper	earthworms	52	0.76	0.58	0.0204	0.2	3.1
		arthropods	57	0.24				
	Cobalt	earthworms	13.7	0.76	0.58	0.0204	0.2	0.62
		arthropods	0.46	0.24				
	Arsenic	earthworms	9.6	0.76	0.58	0.0204	0.2	0.44
		arthropods	0.3	0.24				
Field on organic soils	Nickel	earthworms	180	0.76	0.58	0.0204	0.2	8.3
		arthropods	12.5	0.24				
	Copper	earthworms	52	0.76	0.58	0.0204	0.2	3
		arthropods	44.6	0.24				
	Cobalt	earthworms	10.6	0.76	0.58	0.0204	0.2	0.48
		arthropods	0.46	0.24				
	Arsenic	earthworms	8.2	0.76	0.58	0.0204	0.2	0.38
		arthropods	0.5	0.24				

American Woodcock
ADD Soil

Scenario	CoC	Concentration (mg/kg)	Soil Fraction (kg/kg dw)	Ingestion Rate (kg/d)	Food Fraction	Body Weight (kg)	ADD (mg/kg d)	Bioaccessible Ratio	Bioaccessible ADD (mg/kg d)
Woodlot on clay soils	Nickel	1630	0.104	0.0204	0.58	0.2	10.03	0.078	0.78
	Copper	180	0.104	0.0204	0.58	0.2	1.11	0.058	0.06
	Cobalt	33	0.104	0.0204	0.58	0.2	0.2	0.043	0.01
	Arsenic	12	0.104	0.0204	0.58	0.2	0.07	0.27	0.02
Woodlot on organic soils	Nickel	15200	0.104	0.0204	0.58	0.2	93.52	0.064	5.99
	Copper	2020	0.104	0.0204	0.58	0.2	12.43	0.105	1.3
	Cobalt	219	0.104	0.0204	0.58	0.2	1.35	0.083	0.11
	Arsenic	83	0.104	0.0204	0.58	0.2	0.51	0.74	0.38
Field on clay soils	Nickel	1090	0.104	0.0204	0.58	0.2	6.71	0.078	0.52
	Copper	140	0.104	0.0204	0.58	0.2	0.86	0.058	0.05
	Cobalt	27	0.104	0.0204	0.58	0.2	0.17	0.043	0.01
	Arsenic	8	0.104	0.0204	0.58	0.2	0.05	0.27	0.01
Field on organic soils	Nickel	2020	0.104	0.0204	0.58	0.2	12.43	0.064	0.8
	Copper	308	0.104	0.0204	0.58	0.2	1.9	0.105	0.2
	Cobalt	37	0.104	0.0204	0.58	0.2	0.23	0.083	0.02
	Arsenic	20	0.104	0.0204	0.58	0.2	0.12	0.74	0.09

Earthworm
Total Risk

Aqueous Extraction

Scenario	CoC	Soil Concentration (ppm)	Extracted Proportion	Extracted Soil Concentration (ppm)	TRV (ppm)	Risk
Woodlot on clay soils	Nickel	1630	0.007	11.41	3000	0.004
	Copper	180	0.016	2.88	50	0.058
	Cobalt	33	0.01	0.33	3000	0
	Arsenic	12	1	12	21	0.571
Woodlot on organic soils	Nickel	15200	0.003	45.6	3000	0.015
	Copper	2020	0.003	6.06	50	0.121
	Cobalt	219	0.017	3.723	3000	0.001
	Arsenic	83	1	83	21	3.952
Field on clay soils	Nickel	1090	0.007	7.63	3000	0.003
	Copper	140	0.016	2.24	50	0.045
	Cobalt	27	0.01	0.27	3000	0
	Arsenic	8	1	8	21	0.381
Field on organic soils	Nickel	2020	0.003	6.06	3000	0.002
	Copper	308	0.003	0.924	50	0.018
	Cobalt	37	0.017	0.629	3000	0
	Arsenic	20	1	20	21	0.952

Earthworm
Total Risk

Acid Ammonium Oxalate Extraction

Scenario	CoC	Soil Concentration (ppm)	Extracted Proportion	Extracted Soil Concentration (ppm)	TRV (ppm)	Risk
Woodlot on clay soils	Nickel	1630	0.33	537.9	3000	0.179
	Copper	180	1	180	50	3.6
	Cobalt	33	0.165	5.445	3000	0.002
	Arsenic	12	1	12	21	0.571
Woodlot on organic soils	Nickel	15200	0.392	5958.4	3000	1.986
	Copper	2020	0.804	1624.08	50	32.482
	Cobalt	219	0.61	133.59	3000	0.045
	Arsenic	83	1	83	21	3.952
Field on clay soils	Nickel	1090	0.33	359.7	3000	0.12
	Copper	140	1	140	50	2.8
	Cobalt	27	0.165	4.455	3000	0.001
	Arsenic	8	1	8	21	0.381
Field on organic soils	Nickel	2020	0.392	791.84	3000	0.264
	Copper	308	0.804	247.632	50	4.953
	Cobalt	37	0.61	22.57	3000	0.008
	Arsenic	20	1	20	21	0.952

Meadow Vole
Total Risk

Scenario	CoC	ADD (mg/kg/d)	TRV (mg/kg/d)	Risk
Field on clay soils	Nickel	6.1	34	0.18
	Copper	0.13	12	0.01
	Cobalt	0.01	14	0
	Arsenic	0.02	1.2	0.02
Field on organic soils	Nickel	0.59	34	0.02
	Copper	0.17	12	0.01
	Cobalt	0.02	14	0
	Arsenic	0.04	1.2	0.03

Meadow Vole
ADD Water

CoC	Concentration (mg/l)	Total Fraction	NIR (kg/kg d)		ADD (mg/kg d)
Nickel	0.178	1	0.13		0.02
Copper	0.018	1	0.13		0
Cobalt	0.006	1	0.13		0
Arsenic	0.005	1	0.13		0

Raccoon
Total Risk

Scenario	CoC	ADD (mg/kg/d)	TRV (mg/kg/d)	Risk
Woodlot on clay soils	Nickel	1.36	26	0.05
	Copper	1.13	9.2	0.12
	Cobalt	0.04	10	0
	Arsenic	0.03	0.94	0.03
Woodlot on organic soils	Nickel	3.29	26	0.13
	Copper	2.53	9.2	0.28
	Cobalt	0.11	10	0.01
	Arsenic	0.19	0.94	0.2
Field on clay soils	Nickel	1.26	26	0.05
	Copper	1.73	9.2	0.19
	Cobalt	0.05	10	0.01
	Arsenic	0.05	0.94	0.05
Field on organic soils	Nickel	1.37	26	0.05
	Copper	1.51	9.2	0.16
	Cobalt	0.05	10	0.01
	Arsenic	0.07	0.94	0.07

Raccoon
ADD Water

CoC	Concentration (mg/l)	Total Fraction	NIR (kg/kg d)		ADD (mg/kg d)
Nickel	0.178	1	0.34		0.06
Copper	0.018	1	0.34		0.01
Cobalt	0.006	1	0.34		0
Arsenic	0.005	1	0.34		0

Red-eyed Vireo
Total Risk

Scenario	CoC	ADD (mg/kg/d)	TRV (mg/kg/d)	Risk
Woodlot on clay soils	Nickel	1.25	37	0.03
	Copper	2.47	24	0.1
	Cobalt	0.04	11	0
	Arsenic	0.03	2.4	0.01
Woodlot on organic soils	Nickel	2.65	37	0.07
	Copper	6.37	24	0.27
	Cobalt	0.07	11	0.01
	Arsenic	0.17	2.4	0.07
Field on clay soils	Nickel	1.18	37	0.03
	Copper	4.74	24	0.2
	Cobalt	0.04	11	0
	Arsenic	0.02	2.4	0.01
Field on organic soils	Nickel	1.25	37	0.03
	Copper	3.75	24	0.16
	Cobalt	0.04	11	0
	Arsenic	0.06	2.4	0.03

Red Fox
Total Risk

Scenario	CoC	ADD (mg/kg/d)	TRV (mg/kg/d)	Risk
Woodlot on clay soils	Nickel	0.735	26	0.03
	Copper	0.582	9.1	0.06
	Cobalt	0.041	10	0
	Arsenic	0.02	0.92	0.02
Woodlot on organic soils	Nickel	1.355	26	0.05
	Copper	0.812	9.1	0.09
	Cobalt	0.051	10	0.01
	Arsenic	0.06	0.92	0.07
Field on clay soils	Nickel	0.705	26	0.03
	Copper	0.632	9.1	0.07
	Cobalt	0.041	10	0
	Arsenic	0.02	0.92	0.02
Field on organic soils	Nickel	0.735	26	0.03
	Copper	0.622	9.1	0.07
	Cobalt	0.041	10	0
	Arsenic	0.03	0.92	0.03

Red Fox
ADD Water

CoC	Concentration (mg/l)	Total Fraction	NIR (kg/kg d)		ADD (mg/kg d)
Nickel	0.178	1	0.084		0.015
Copper	0.018	1	0.084		0.002
Cobalt	0.006	1	0.084		0.001
Arsenic	0.005	1	0.084		0

Scenario	CoC	Food	Concentration (mg/kg)	Bioaccumulation Factor	Prey Body Weight (kg)	Food Fraction	Total Fraction	Ingestion Rate (kg/d)	Body Weight (kg)	ADD (mg/kg d)
Woodlot on clay soils	Nickel	voles	18.6			0.616	1	0.266	5.2	0.63
		grapes	1.6			0.131				
		arthropods	12.5			0.038				
		American Robin	0.00029438	0.001	0.082	0.055				
		American Woodcock	0.001816		0.2	0.055				
		Red-eyed Vireo	0.000025375		0.0203	0.055				
		frogs	4			0.05				
	Copper	voles	11			0.616	1	0.266	5.2	0.57
		grapes	12			0.131				
		arthropods	29.6			0.038				
		American Robin	0.12423	0.5	0.082	0.055				
		American Woodcock	0.286		0.2	0.055				
		Red-eyed Vireo	0.0250705		0.0203	0.055				
		frogs	33.4			0.05				
	Cobalt	voles	1.3			0.616	1	0.266	5.2	0.04
		grapes	0.03			0.131				
		arthropods	0.46			0.038				
		American Robin	0.02624	2	0.082	0.055				
		American Woodcock	0.188		0.2	0.055				
		Red-eyed Vireo	0.001624		0.0203	0.055				
		frogs	0.41			0.05				
	Arsenic	voles	0.6			0.616	1	0.266	5.2	0.02
		grapes	0.1			0.131				
		arthropods	0.3			0.038				
		American Robin	0.0061254	0.83	0.082	0.055				
		American Woodcock	0.03486		0.2	0.055				
		Red-eyed Vireo	0.00050547		0.0203	0.055				
		frogs	0.5			0.05				
Woodlot on organic soils	Nickel	voles	18.6			0.616	1	0.266	5.2	0.63
		grapes	1.6			0.131				
		arthropods	12.5			0.038				
		American Robin	0.00049528	0.001	0.082	0.055				
		American Woodcock	0.002858		0.2	0.055				
		Red-eyed Vireo	0.000053795		0.0203	0.055				
		frogs	4			0.05				
	Copper	voles	11			0.616	1	0.266	5.2	0.66
		grapes	12			0.131				
		arthropods	72.6			0.038				
		American Robin	0.23452	0.5	0.082	0.055				
		American Woodcock	0.47		0.2	0.055				

		Red-eyed Vireo	0.0646555		0.0203	0.055				
		frogs	33.4			0.05				
	Cobalt	voles	1.3			0.616	1	0.266	5.2	0.04
		grapes	0.03			0.131				
		arthropods	0.46			0.038				
		American Robin	0.06232	2	0.082	0.055				
		American Woodcock	0.44		0.2	0.055				
		Red-eyed Vireo	0.002842		0.0203	0.055				
		frogs	0.41			0.05				
	Arsenic	voles	0.6			0.616	1	0.266	5.2	0.02
		grapes	0.1			0.131				
		arthropods	0.8			0.038				
		American Robin	0.023821	0.83	0.082	0.055				
		American Woodcock	0.13114		0.2	0.055				
		Red-eyed Vireo	0.00286433		0.0203	0.055				
		frogs	0.5			0.05				
Field on clay soils	Nickel	voles	18.6			0.616	1	0.266	5.2	0.63
		grapes	1.6			0.131				
		arthropods	12.5			0.038				
		American Robin	0.00028454	0.001	0.082	0.055				
		American Woodcock	0.001764		0.2	0.055				
		Red-eyed Vireo	0.000023954		0.0203	0.055				
		frogs	4			0.05				
	Copper	voles	11			0.616	1	0.266	5.2	0.62
		grapes	12			0.131				
		arthropods	57			0.038				
		American Robin	0.17712	0.5	0.082	0.055				
		American Woodcock	0.315		0.2	0.055				
		Red-eyed Vireo	0.048111		0.0203	0.055				
		frogs	33.4			0.05				
	Cobalt	voles	1.3			0.616	1	0.266	5.2	0.04
		grapes	0.03			0.131				
		arthropods	0.46			0.038				
		American Robin	0.03444	2	0.082	0.055				
		American Woodcock	0.252		0.2	0.055				
		Red-eyed Vireo	0.001624		0.0203	0.055				
		frogs	0.41			0.05				
	Arsenic	voles	0.6			0.616	1	0.266	5.2	0.02
		grapes	0.1			0.131				
		arthropods	0.3			0.038				
		American Robin	0.0108896	0.83	0.082	0.055				
		American Woodcock	0.0747		0.2	0.055				
		Red-eyed Vireo	0.00033698		0.0203	0.055				

		frogs	0.5			0.05				
Field on organic soils	Nickel	voles	18.6			0.616	1	0.266	5.2	0.63
		grapes	1.6			0.131				
		arthropods	12.5			0.038				
		American Robin	0.00029438	0.001	0.082	0.055				
		American Woodcock	0.00182		0.2	0.055				
		Red-eyed Vireo	0.000025375		0.0203	0.055				
		frogs	4			0.05				
	Copper	voles	11			0.616	1	0.266	5.2	0.6
		grapes	12			0.131				
		arthropods	44.6			0.038				
		American Robin	0.15539	0.5	0.082	0.055				
		American Woodcock	0.32		0.2	0.055				
		Red-eyed Vireo	0.0380625		0.0203	0.055				
		frogs	33.4			0.05				
	Cobalt	voles	1.3			0.616	1	0.266	5.2	0.04
		grapes	0.03			0.131				
		arthropods	0.46			0.038				
		American Robin	0.02952	2	0.082	0.055				
		American Woodcock	0.2		0.2	0.055				
		Red-eyed Vireo	0.001624		0.0203	0.055				
		frogs	0.41			0.05				
	Arsenic	voles	0.6			0.616	1	0.266	5.2	0.02
		grapes	0.1			0.131				
		arthropods	0.5			0.038				
		American Robin	0.0122508	0.83	0.082	0.055				
		American Woodcock	0.07802		0.2	0.055				
		Red-eyed Vireo	0.00101094		0.0203	0.055				
		frogs	0.5			0.05				

Red Fox
ADD Soil

Scenario	**CoC**	**Concentration (mg/kg)**	**Soil Fraction (kg/kg dw)**	**Ingestion Rate (kg/d)**	**Food Fraction**	**Body Weight (kg)**		**ADD (mg/kg d)**	**Bioaccessible Ratio**	**Bioaccessible ADD (mg/kg d)**
Woodlot on clay soils	Nickel	1630	0.028	0.27	1	5.2		2.37	0.039	0.09
	Copper	180	0.028	0.27	1	5.2		0.26	0.029	0.01
	Cobalt	33	0.028	0.27	1	5.2		0.05	0.0215	0
	Arsenic	12	0.028	0.27	1	5.2		0.02	0.135	0
Woodlot on organic soils	Nickel	15200	0.028	0.27	1	5.2		22.1	0.032	0.71
	Copper	2020	0.028	0.27	1	5.2		2.94	0.0525	0.15
	Cobalt	219	0.028	0.27	1	5.2		0.32	0.0415	0.01
	Arsenic	83	0.028	0.27	1	5.2		0.12	0.37	0.04
Field on clay soils	Nickel	1090	0.028	0.27	1	5.2		1.58	0.039	0.06
	Copper	140	0.028	0.27	1	5.2		0.2	0.029	0.01
	Cobalt	27	0.028	0.27	1	5.2		0.04	0.0215	0
	Arsenic	8	0.028	0.27	1	5.2		0.01	0.135	0
Field on organic soils	Nickel	2020	0.028	0.27	1	5.2		2.94	0.032	0.09
	Copper	308	0.028	0.27	1	5.2		0.45	0.0525	0.02
	Cobalt	37	0.028	0.27	1	5.2		0.05	0.0415	0
	Arsenic	20	0.028	0.27	1	5.2		0.03	0.37	0.01

Red-tailed Hawk
Total Risk

Scenario	CoC	ADD (mg/kg/d)	TRV (mg/kg/d)	Risk
Woodlot on clay soils	Nickel	0.5	83	0.01
	Copper	0.261	55	0
	Cobalt	0.03	3.2	0.01
	Arsenic	0.01	5.3	0
Woodlot on organic soils	Nickel	1.01	83	0.01
	Copper	0.381	55	0.01
	Cobalt	0.04	3.2	0.01
	Arsenic	0.05	5.3	0.01
Field on clay soils	Nickel	0.47	83	0.01
	Copper	0.251	55	0
	Cobalt	0.03	3.2	0.01
	Arsenic	0.01	5.3	0
Field on organic soils	Nickel	0.5	83	0.01
	Copper	0.271	55	0
	Cobalt	0.03	3.2	0.01
	Arsenic	0.02	5.3	0

Red-tailed Hawk
ADD Water

CoC	Concentration (mg/l)	Fraction	NIR (kg/kg d)		ADD (mg/kg d)
Nickel	0.178	1	0.057		0.01
Copper	0.018	1	0.057		0.001
Cobalt	0.006	1	0.057		0
Arsenic	0.005	1	0.057		0

Scenario	CoC	Food	Concentration (mg/kg)	Bioaccumulation Factor	Prey Body Weight (kg)	Food Fraction	Total Fraction	Ingestion Rate (kg/d)	Body Weight (kg)	ADD (mg/kg d)
Woodlot on clay soils	Nickel	voles	18.6			0.74	1	0.034	1.13	0.41
		robin	0.00029438	0.001	0.082	0.086666667				
		woodcock	0.001816		0.2	0.086666667				
		vireo	0.000025375		0.0203	0.086666667				
	Copper	voles	11			0.74	1	0.034	1.13	0.25
		robin	0.12423	0.5	0.082	0.086666667				
		woodcock	0.286		0.2	0.086666667				
		vireo	0.0250705		0.0203	0.086666667				
	Cobalt	voles	1.3			0.74	1	0.034	1.13	0.03
		robin	0.02624	2	0.082	0.086666667				
		woodcock	0.188		0.2	0.086666667				
		vireo	0.001624		0.0203	0.086666667				
	Arsenic	voles	0.6			0.74	1	0.034	1.13	0.01
		robin	0.0061254	0.83	0.082	0.086666667				
		woodcock	0.03486		0.2	0.086666667				
		vireo	0.00050547		0.0203	0.086666667				
Woodlot on organic soils	Nickel	voles	18.6			0.74	1	0.034	1.13	0.41
		robin	0.00049528	0.001	0.082	0.086666667				
		woodcock	0.002858		0.2	0.086666667				
		vireo	0.000053795		0.0203	0.086666667				
	Copper	voles	11			0.74	1	0.034	1.13	0.25
		robin	0.23452	0.5	0.082	0.086666667				
		woodcock	0.47		0.2	0.086666667				
		vireo	0.0646555		0.0203	0.086666667				
	Cobalt	voles	1.3			0.74	1	0.034	1.13	0.03
		robin	0.06232	2	0.082	0.086666667				
		woodcock	0.44		0.2	0.086666667				
		vireo	0.002842		0.0203	0.086666667				
	Arsenic	voles	0.6			0.74	1	0.034	1.13	0.01
		robin	0.023821	0.83	0.082	0.086666667				
		woodcock	0.13114		0.2	0.086666667				
		vireo	0.00286433		0.0203	0.086666667				
Field on clay soils	Nickel	voles	18.6			0.74	1	0.034	1.13	0.41
		robin	0.00028454	0.001	0.082	0.086666667				
		woodcock	0.001764		0.2	0.086666667				
		vireo	0.000023954		0.0203	0.086666667				
	Copper	voles	11			0.74	1	0.034	1.13	0.25
		robin	0.17712	0.5	0.082	0.086666667				
		woodcock	0.315		0.2	0.086666667				
		vireo	0.048111		0.0203	0.086666667				
	Cobalt	voles	1.3			0.74	1	0.034	1.13	0.03
		robin	0.03444	2	0.082	0.086666667				
		woodcock	0.252		0.2	0.086666667				

		vireo	0.001624		0.0203	0.086666667				
	Arsenic	voles	0.6			0.74	1	0.034	1.13	0.01
		robin	0.0108896	0.83	0.082	0.086666667				
		woodcock	0.0747		0.2	0.086666667				
		vireo	0.00033698		0.0203	0.086666667				
Field on organic soils	Nickel	voles	18.6			0.74	1	0.034	1.13	0.41
		robin	0.00029438	0.001	0.082	0.086666667				
		woodcock	0.00182		0.2	0.086666667				
		vireo	0.000025375		0.0203	0.086666667				
	Copper	voles	11			0.74	1	0.034	1.13	0.25
		robin	0.15539	0.5	0.082	0.086666667				
		woodcock	0.32		0.2	0.086666667				
		vireo	0.0380625		0.0203	0.086666667				
	Cobalt	voles	1.3			0.74	1	0.034	1.13	0.03
		robin	0.02952	2	0.082	0.086666667				
		woodcock	0.2		0.2	0.086666667				
		vireo	0.001624		0.0203	0.086666667				
	Arsenic	voles	0.6			0.74	1	0.034	1.13	0.01
		robin	0.0122508	0.83	0.082	0.086666667				
		woodcock	0.07802		0.2	0.086666667				
		vireo	0.00101094		0.0203	0.086666667				

Red-tailed Hawk
ADD Soil

Scenario	CoC	Concentration (mg/kg)	Soil Fraction (kg/kg dw)	Ingestion Rate (kg/d)	Food Fraction	Body Weight (kg)		ADD (mg/kg d)	Bioaccessible Ratio	Bioaccessible ADD (mg/kg d)
Woodlot on clay soils	Nickel	1630	0.02	0.034	1	1.13		0.98	0.078	0.08
	Copper	180	0.02	0.034	1	1.13		0.11	0.058	0.01
	Cobalt	33	0.02	0.034	1	1.13		0.02	0.043	0
	Arsenic	12	0.02	0.034	1	1.13		0.01	0.27	0
Woodlot on organic soils	Nickel	15200	0.02	0.034	1	1.13		9.15	0.064	0.59
	Copper	2020	0.02	0.034	1	1.13		1.22	0.105	0.13
	Cobalt	219	0.02	0.034	1	1.13		0.13	0.083	0.01
	Arsenic	83	0.02	0.034	1	1.13		0.05	0.74	0.04
Field on clay soils	Nickel	1090	0.02	0.034	1	1.13		0.66	0.078	0.05
	Copper	140	0.02	0.034	1	1.13		0.08	0.058	0
	Cobalt	27	0.02	0.034	1	1.13		0.02	0.043	0
	Arsenic	8	0.02	0.034	1	1.13		0	0.27	0
Field on organic soils	Nickel	2020	0.02	0.034	1	1.13		1.22	0.064	0.08
	Copper	308	0.02	0.034	1	1.13		0.19	0.105	0.02
	Cobalt	37	0.02	0.034	1	1.13		0.02	0.083	0
	Arsenic	20	0.02	0.034	1	1.13		0.01	0.74	0.01
				0.03379						

Tadpole
Total Risk

Scenario	CoC	Water Concentration (mg/l)	TRV - EC20 (mg/l)	Risk (EC20)	TRV - LC10 (mg/l)	Risk (LC10)
Overall	Nickel	0.178	0.01	17.8	-	-
	Copper	0.018	0.008	2.25	-	-
	Cobalt	0.006	0.01	0	0.01	0.6
	Arsenic	0.005	0.008	0.625	0.01	0.5
Fowler's Toad	Nickel	0.019	-	-	0.4	0.0475
	Copper	0.003	5	0	6	0.0005
	Cobalt	0.001	-	-	0.2	0.005
	Arsenic	0.006	-	-	50	0.00012

White-tailed Deer
Total Risk

CoC	ADD (mg/kg/d)	TRV (mg/kg/d)	Risk
Nickel	0.691	22	0.03
Copper	0.211	7.9	0.03
Cobalt	0.01	8.8	0
Arsenic	0.01	0.8	0.01

White-tailed Deer
ADD Water

CoC	Concentration (mg/l)	Fraction	NIR (kg/kg d)		ADD (mg/kg d)
Nickel	0.178	1	0.064		0.011
Copper	0.018	1	0.064		0.001
Cobalt	0.006	1	0.064		0
Arsenic	0.005	1	0.064		0

White-tailed Deer
ADD Diet

CoC	**Food**	**Concentration (mg/kg)**	**Food Fraction**	**Total Fraction**	**Ingestion Rate (kg/d)**	**Body Weight (kg)**	**ADD (mg/kg d)**
Nickel	corn	2.7	0.26	1	1.89	74.8	0.63
	oat seeds	62.3	0.25				
	maple leaves	12.3	0.33				
	goldenrods	29.6	0.16				
Copper	corn	3.2	0.26	1	1.89	74.8	0.2
	oat seeds	6.7	0.25				
	maple leaves	10.5	0.33				
	goldenrods	12.4	0.16				
Cobalt	corn	0.3	0.26	1	1.89	74.8	0.01
	oat seeds	0.2	0.25				
	maple leaves	0.4	0.33				
	goldenrods	1.4	0.16				
Arsenic	corn	0.2	0.26	1	1.89	74.8	0.01
	oat seeds	0.1	0.25				
	maple leaves	0.4	0.33				
	goldenrods	0.3	0.16				

White-tailed Deer
ADD Soil

CoC	Concentration (mg/kg)	Soil Fraction (kg/kg dw)	Ingestion Rate (kg/d)	Food Fraction	Body Weight (kg)		ADD (mg/kg d)	Bioaccessible Ratio	Bioavailable ADD (mg/kg d)
Nickel	2650	0.02	1.89	1	74.8		1.34	0.036	0.05
Copper	350	0.02	1.89	1	74.8		0.18	0.04075	0.01
Cobalt	47	0.02	1.89	1	74.8		0.02	0.0315	0
Arsenic	18	0.02	1.89	1	74.8		0.01	0.2525	0

SOIL DATA USED TO CALCULATE UCLMS

Soil Data Used To Calculate UCLMS

Source	Sample	As	Co	Cu	Ni	Pb	Habitat	Soil
JWEL Earthworm 2002	CS-H-10	2.1	8	36	203	13	f	clay
JWEL Earthworm 2002	CS-H-11	2.8	7	30	147	14	f	clay
JWEL Earthworm 2002	CS-H-12	2.2	11	29	125	17	f	clay
JWEL Earthworm 2002	CS-H-13	2.7	8	35	186	13	f	clay
JWEL Earthworm 2002	CS-H-25	8.8	14	104	434.5	30	f	clay
JWEL Earthworm 2002	CS-H-4	8	40	367	2460	28	f	clay
JWEL Earthworm 2002	CS-H-5	12.4	36	346	2000	27	f	clay
JWEL Earthworm 2002	CS-H-7	3.2	12	66	364	14	f	clay
JWEL Earthworm 2002	CS-H-8	5.3	13	71	410	22	f	clay
JWEL Earthworm 2002	CS-H-9	5.2	13	58	355	22	f	clay
JWEL Earthworm 2002	OS-H-1	20.2	23	257	1350	29	f	org
JWEL Earthworm 2002	OS-H-2	13.4	26	371	1550	28	f	org
JWEL Earthworm 2002	OS-H-24	3	3	16	84	16	f	org
JWEL Earthworm 2002	OS-H-26	21.6	39	345	1770	44	f	org
JWEL Earthworm 2002	OS-H-27	14.5	16	169	935	16	f	org
JWEL Earthworm 2002	OS-H-28	21.6	34	300	2000	34	f	org
JWEL Earthworm 2002	OS-H-29	9.3	12	102	802	29	f	org
JWEL Earthworm 2002	OS-H-3	26.7	46	453	2900	49	f	org
JWEL Earthworm 2002	OS-H-30	19.9	8	47	151	13	f	org
JWEL Earthworm 2002	OS-H-6	28.5	77	577	3820	55	f	org
JWEL Earthworm 2002	RS-H-1	129	340	3620	21100	241	w	org
JWEL Earthworm 2002	RS-H-2	109	181	2520	13800	213	w	org
JWEL Earthworm 2002	RS-H-3	81.4	190	2020	12600	174	w	org
JWEL Earthworm 2002	RS-H-4	23.7	43	414	2550	51	w	org
JWEL Earthworm 2002	RS-H-5	38.7	50	550	3530	50	w	org
JWEL Earthworm 2002	SS-H-1	21	41	308	2070	49	w	clay
JWEL Earthworm 2002	SS-H-2	21.7	41	321	2430	56	w	clay
JWEL Earthworm 2002	SS-H-3	21.6	32	252	1550	47	f	clay
JWEL Field Insect Soils	I-H-2	18	54	484	3790	40	f	clay
JWEL Field Insect Soils	I-H-3	21	29	333	1860	25	f	org
JWEL Field Insect Soils	I-H-4	14	44	313	2600	61	f	clay
JWEL Field Insect Soils	I-H-5	21	73	566	4310	46	f	clay
JWEL Field Insect Soils	I-M-2	4	6	37	145	81	f	clay
JWEL Field Insect Soils	I-M-3	4	12	76	421	34	f	clay
JWEL Field Insect Soils	I-M-4	3	9	37	156	21	f	clay
JWEL Field Insect Soils	I-M-5	14	9	45	119	12	f	org
JWEL Field Insect Soils	Mean of I-H-1 and IH-Soil	7	14	107	623	81	f	clay
JWEL Field Insect Soils	Mean of I-M-1 and IM-Soil	5	11	41	230	24	f	clay
JWEL Leaf Litter Study Soils	1	29.9	70	436	4130	83	w	clay
JWEL Leaf Litter Study Soils	2	14	40	252	2025	76	w	clay
JWEL Leaf Litter Study Soils	3	8.2	17	106	780	40.5	w	clay
JWEL Leaf Litter Study Soils	6	6.9	18	95	709	47	w	clay
JWEL Leaf Litter Study Soils	7	15.4	28	125	1070	55	w	clay
JWEL Leaf Litter Study Soils	8	8.2	12	125	288	47.75	w	clay
JWEL Leaf Litter Study Soils	9	7.4	23	176	1505	66.5	w	clay
JWEL Leaf Litter Study Soils	10	7.7	16	73	550	35	w	clay
JWEL Leaf Litter Study Soils	16	92.5	211	1453	12900	188.75	w	org
JWEL Leaf Litter Study Soils	17	127.5	311	2755	22700	209	w	org
JWEL Leaf Litter Study Soils	18	99.8	248	2270	18250	178.5	w	org
JWEL Leaf Litter Study Soils	19	45.1	78	680	4745	100.5	w	org
JWEL Leaf Litter Study Soils	20	5.4	16.5	80	430.75	36.5	w	org

Soil Data Used To Calculate UCLMS

Source	Sample	As	Co	Cu	Ni	Pb	Habitat	Soil
JWEL surface soil	ss12-1	5.1	19	70	493	34	f	clay
JWEL surface soil	ss2-1	4.4	8	44	289	26	f	clay
JWEL surface soil	ss4-1	7.1	20	105	778	32	w	clay
JWEL surface soil	ss6-1	0.5	8	44	321	222	f	clay
JWEL test pits	TP-J	24	116	712	5920	67	f	clay
JWEL test pits	TP-K	8	23	126	1040	32	f	clay
JWEL test pits	TP-L	10.5	25	160	1350	39	f	clay
JWEL test pits	TP-M	6.3	16	81	344	28	f	clay
JWEL test pits	TP-R	23.9	33	379	2000	41	f	org
JWEL test pits	TP-S	16.9	27	220	1600	22	f	org
JWEL test pits	TP-X1	7.1	15	55	405	21	f	clay
JWEL Trees - High Woodlots	A1	27.4	93	827	5400	85	w	org
JWEL Trees - High Woodlots	A2	97.3	356	2910	24500	259	w	org
JWEL Trees - High Woodlots	A3	137	427	3930	33000	292	w	org
JWEL Trees - High Woodlots	A4	82.9	224	1870	14200	231	w	org
JWEL Trees - High Woodlots	A5	78.1	249	2100	18900	211	w	org
JWEL Trees - High Woodlots	E1	4	9	52	303	70	w	clay
JWEL Trees - High Woodlots	G1	10.2	21	126	1020	35	w	clay
JWEL Trees - Moderate Woodlots	B1	5.9	19	92	627	36	w	clay
JWEL Trees - Moderate Woodlots	B2	11.8	52	241	1750	61	w	clay
JWEL Trees - Moderate Woodlots	B3	12.3	57	275	2110	73	w	clay
JWEL Trees - Moderate Woodlots	B4	6.4	17	92	572	36	w	clay
JWEL Trees - Moderate Woodlots	B5	8.5	22	108	747	39	w	clay
JWEL Trees - Moderate Woodlots	D1	4.4	14	59	320	31	w	clay
JWEL Trees - Moderate Woodlots	D2	5.3	17	80	476	37	w	clay
JWEL Trees - Moderate Woodlots	D3	5.6	18	111	700	44	w	clay
JWEL Trees - Moderate Woodlots	F1	2.8	7	31	126	30	w	clay
MOE 2000 (1998)	11	7.6	25.5	125	980	32	f	org
MOE 2000 (1998)	12	3.9	14	30	78	19	f	clay
MOE 2000 (1998)	14	3.8	17.5	69	585	29	f	org
MOE 2000 (1998)	15	8	42.5	165	1400	48	f	clay
MOE 2000 (1998)	16	3	11	51	310	26	f	clay
MOE 2000 (1998)	20	2.8	12	29	130	27	f	clay
MOE 2000 (1998)	43	5.7	13	63	580	24	f	clay
MOE 2000 (1998)	49	4	8.5	34	130	50	f	clay
MOE 2000 (1998)	50	3.3	9.7	38	145	27	f	clay
MOE 2000 (1998)	51	10.7	51.5	275	2750	54	f	clay
MOE 2000 (1998)	61	4.1	9.6	35	190	30	f	clay
MOE 2000 (1998)	62	4.4	13	56	345	101	f	clay
MOE 2000 (1998)	64	10	9.1	33	115	25	f	clay
MOE 2000 (1998)	65	4.2	9.3	35	195	62	f	clay
MOE 2000 (1998)	150		74.5	355	3900	380	f	clay
MOE 2000 (1998)	151		29	160	1500	62	w	clay
MOE 2000 (1999)	184	9	33	170	1250	37.5	f	org
MOE 2000 (1999)	185	1.9	5	19	120	19	w	clay
MOE 2000 (1999)	186	3.2	11	63	320	37.5	w	clay
MOE 2000 (1999)	188	4.9	21	81	550	47.5	w	clay
MOE 2000 (1999)	190	5.1	18	70	490	44.5	f	clay
MOE 2000 (1999)	191	4.3	14	48	285	29.5	f	clay
MOE 2000 (1999)	192	4.6	14	57	430	30	f	clay
MOE 2000 (1999)	193	4.2	10	44	265	30.5	f	clay
MOE 2000 (1999)	194	5.3	17	66	535	39	w	clay

Soil Data Used To Calculate UCLMS								
Source	Sample	As	Co	Cu	Ni	Pb	Habitat	Soil
MOE 2000 (1999)	195	5.3	16	32	195	33.5	w	clay
MOE 2000 (1999)	199	3.7	10	39	180	29	f	clay
MOE 2000 (1999)	200	5.3	17	89	525	57.5	w	clay
MOE 2000 (1999)	201	4.1	14	50	305	40.5	f	clay
MOE 2000 (1999)	209	5.6	15	33	165	33.5	f	clay
MOE 2000 (1999)	210	4.6	11	48	340	32	f	clay
MOE 2000 (1999)	211	4.1	8	42	160	44.5	f	clay
MOE 2000 (1999)	212	5.3	16	41	215	34.5	f	clay
MOE 2000 (1999)	213	4.1	14	52	330	51	w	clay
MOE 2000 (1999)	229	4.2	19	83	515	59	f	clay
MOE 2000 (1999)	230	9.4	24	105	735	46.5	w	clay
MOE Humberstone	1	4.95	21.5	99	600	31	f	clay
MOE Humberstone	2	5.65	21.5	99	665	31	f	clay
MOE Humberstone	3	8	21.5	97	680	35	f	clay
MOE Humberstone	4	9.9	23	100	775	37	f	clay
MOE Humberstone	5	11	23.5	110	855	38	f	clay
MOE Humberstone	6	5.05	21.5	93	580	28	f	clay
MOE Humberstone	7	4.25	16.5	71	460	35	f	clay
MOE Humberstone	8	6.1	21	91.5	640	38	f	clay
MOE Humberstone	9	8.75	22	97.5	735	36	f	clay
MOE Humberstone	10	11.3	23.5	110	835	110	f	clay
MOE Humberstone	11	5.55	17.5	90	575	33	f	clay
MOE Humberstone	12	3.35	15.5	67.5	420	26	f	clay
MOE Humberstone	13	4.35	19	83	580	30	f	clay
MOE Humberstone	14	5.55	20	90	585	34	f	clay
MOE Humberstone	15	8.35	23.5	105	795	33	f	clay
MOE Humberstone	16	8.05	21	90	630	41	f	clay
MOE Humberstone	17	2.85	24	76	480	30	f	clay
MOE Humberstone	18	4	27	92.5	610	45	f	clay
MOE Humberstone	19	5.35	36	130	910	59	f	clay
MOE Humberstone	20	8.75	28	120	780	40	f	clay
MOE Humberstone	21	5	17.5	78.5	640	28	f	clay
MOE Humberstone	22	7.5	24	103	720	43	f	clay
MOE Humberstone	23	2.95	20	70	340	31	f	clay
MOE Humberstone	24	4.1	25.5	104	615	42	f	clay
MOE Humberstone	25	5.35	23	106	630	46	f	clay
MOE Humberstone	26	10.7	41	170	1150	60	f	clay
MOE Humberstone	27	9.85	23.5	97.5	690	39	f	clay
MOE school	12St.Joseph-baseball		12	38	160	27	f	clay
MOE school	12St.Joseph-swings		4	16	96	10	f	clay
MOE school	1St.Therese-central soccer		38	150	1250	48	f	clay
MOE school	1St.Therese-east open		37	185	1450	53	f	clay
MOE school	1St.Therese-east soccer		30	130	1045	37	f	clay
MOE school	1St.Therese-north open		30	140	1350	45	f	clay
MOE school	1St.Therese-play set		12	57	270	31	f	clay
MOE school	7Humberstone-central soccer		29	135	1050	44	f	clay

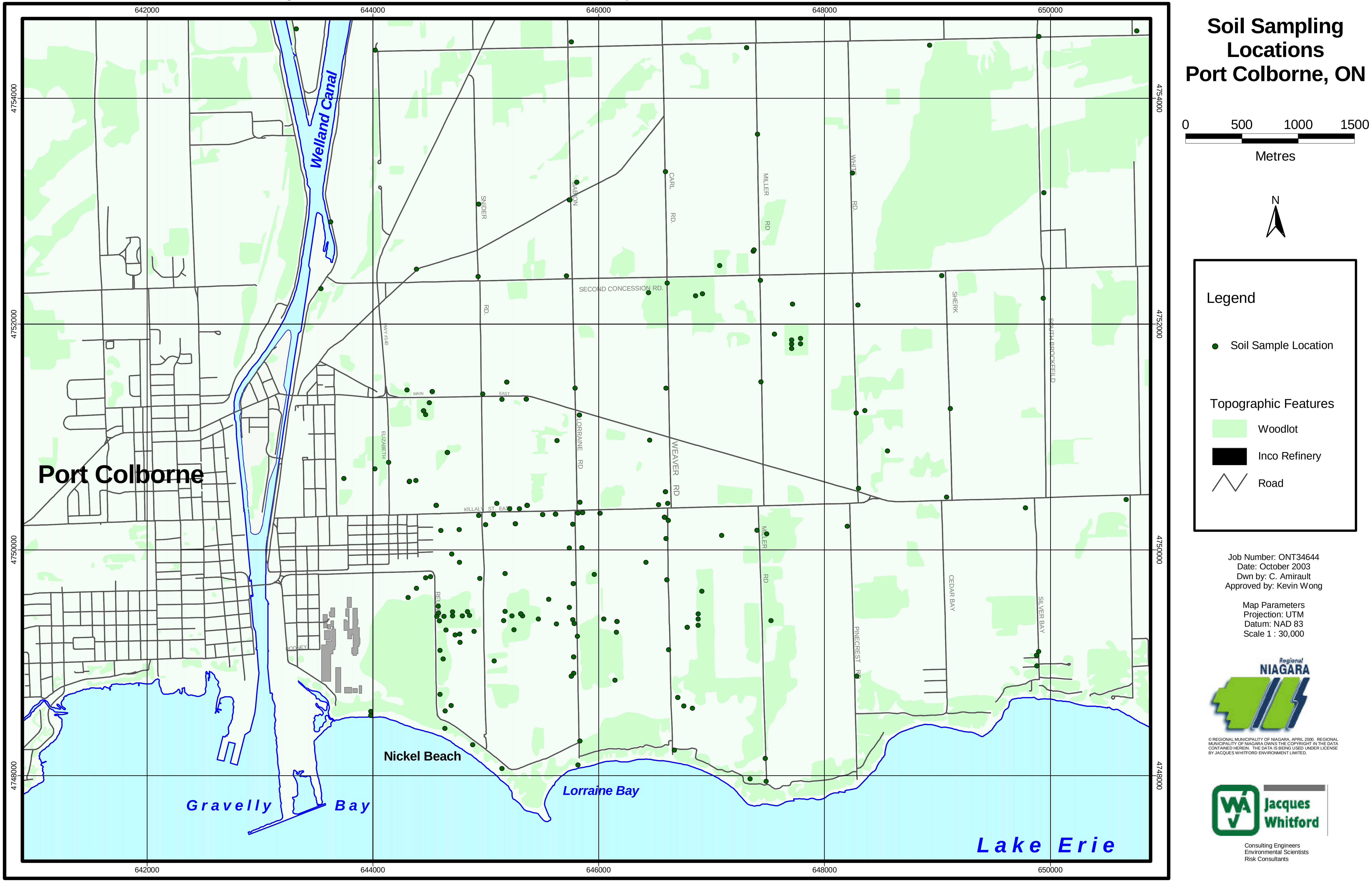
Soil Data Used To Calculate UCLMS

Source	Sample	As	Co	Cu	Ni	Pb	Habitat	Soil
MOE school	7Humberstone-east soccer		22	105	755	33	f	clay
MOE school	7Humberstone-north soccer		21	103	720	30	f	clay
MOE school	7Humberstone-play set		22	106	795	37	f	clay
MOE school (supplemental from Humberstone report)	12St.Joseph-max	5.6					f	clay
MOE school (supplemental from Humberstone report)	1St.Therese-max	9.8					f	clay
MOE school (supplemental from Humberstone report)	7Humberstone-max	9.6					f	clay
MOE St.Therese	1	7.6	30	170	1400	49	f	clay
MOE St.Therese	2	9	32	190	1500	46	f	clay
MOE St.Therese	3	8.1	26	140	1000	42	f	clay
MOE St.Therese	4	8.4	29	170	1300	46	f	clay
MOE St.Therese	5	7.8	30	150	1200	44	f	clay
MOE St.Therese	6	8.1	30	130	1000	45	f	clay
MOE St.Therese	7	7.3	31	160	1300	50	f	clay
MOE St.Therese	8	7.2	31	150	1200	45	f	clay
MOE St.Therese	9	8.1	34	190	1400	50	f	clay
MOE St.Therese	10	8.3	31	170	1300	48	f	clay
MOE St.Therese	11	7.6	36	160	1300	48	f	clay
MOE St.Therese	12	6.4	27	120	1000	41	f	clay
MOE St.Therese	13	6.8	34	160	1300	47	f	clay
MOE St.Therese	14	6.7	35	160	1300	50	f	clay
MOE St.Therese	15	8.7	30	140	1200	42	f	clay
MOE St.Therese	16	8.1	25	120	1100	38	f	clay
MOE St.Therese	17	6.5	29	140	1100	47	f	clay
MOE St.Therese	18	5.8	24	79	580	41	f	clay
MOE St.Therese	19	9	30	160	1300	49	f	clay
MOE St.Therese	20	7.2	27	120	1100	44	f	clay
MOE St.Therese	21	11	40	210	1900	47	f	clay
MOE St.Therese	22	8.9	31	170	1500	46	f	clay
MOE St.Therese	23	7.3	27	140	1300	41	f	clay
MOE St.Therese	24	8.8	35	160	1600	55	f	clay
MOE woodlot	W1S1	11	16	79	690	38	f	clay
MOE woodlot	W1S2	16	39	180	1900	63	f	clay
MOE woodlot	W1S3	12	56	320	4650	82	w	clay
MOE woodlot	W1S4A	14	43	230	2300	73	w	clay
MOE woodlot	W1S4B	16	36	210	2150	68	w	clay
MOE woodlot	W1S4C	9.4	38	230	2350	81	w	clay
MOE woodlot	W1S5	14	24	145	1200	59	w	clay
MOE woodlot	W1S6	9.2	14	58	390	60	f	clay
MOE woodlot	W1S7	11	19	73	570	40	f	clay
MOE woodlot	W2S1	6.4	18	84	630	30	f	clay
MOE woodlot	W2S2	20	85	445	5000	82	f	clay
MOE woodlot	W2S3	15	42	225	2550	55	w	clay
MOE woodlot	W2S4A	13	50	225	2500	60	w	clay
MOE woodlot	W2S4B	12	65	270	3100	70	w	clay
MOE woodlot	W2S4C	11	37	160	1700	67	w	clay
MOE woodlot	W2S5	16	22	120	980	51	w	clay
MOE woodlot	W2S6	8.8	14	63	405	60	f	clay

Soil Data Used To Calculate UCLMS

Source	Sample	As	Co	Cu	Ni	Pb	Habitat	Soil
MOE woodlot	W2S7	6.8	20	76	600	39	f	clay
MOE woodlot	W3S1	18	31	270	2000	33	f	org
MOE woodlot	W3S2	27	63	455	3900	61	f	org
MOE woodlot	W3S3	31	79	540	4100	82	w	org
MOE woodlot	W3S4A	14	24	135	1040	45	w	org
MOE woodlot	W3S4B	14	29	190	1500	49	w	org
MOE woodlot	W3S4C	22	58	405	3100	83	w	org
MOE woodlot	W3S5	21	42	255	1950	70	w	org
MOE woodlot	W3S6	13	29	210	1600	42	f	org
MOE woodlot	W3S7	12	38	185	1800	52	f	org
Legend								
f=field habitat								
w=woodlot habitat								

Ecological Risk Assessment - Natural Environment - Community Based Risk Assessment, Port Colborne, ON



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CALCULATIONS OF CoCs CONCENTRATIONS
FOR COMPOSITE TISSUE SAMPLES

Calculation Formulas

A. Total Frog CoC Concentrations

Formula: Nickel Example

*=(Liver Weight *(1-Liver Moisture Content)*Liver Nickel Content +GI Weight*(1-GI Moisture Content)*GI Nickel Content + Body Weight *(1- Body Moisture Content) *Body Nickel Content)/(Liver Weight *(1-Liver Moisture Content)+ GI Weight *(1-GI Moisture Content)+ Body Weight *(1-Body Moisture Content))*

B. Total Tadpole CoC Concentrations

Formula: Copper Example

=(GI Weight(1-GI Moisture Content)*GI Copper Content + Body Weight *(1- Body Moisture Content) *Body Copper Content)/(GI Weight *(1-GI Moisture Content)+ Body Weight *(1-Body Moisture Content))*

C. Total Vole CoC Concentrations

Formula: Cobalt Example

=(Liver Weight(1-Liver Moisture Content)*Liver Cobalt Content + Body Weight *(1- Body Moisture Content) *Body Cobalt Content)/(Liver Weight *(1-Liver Moisture Content)+ Body Weight *(1-Body Moisture Content))*

D. Field Composite CoC Concentrations

Formula: Arsenic Example

*=(((100-Composite Moisture Content)*Composite Weight/100)*Composite Arsenic Content +((100-Grasshopper Moisture Content)*Grasshopper Weight/100)*Grasshopper Arsenic Content)/(((100-Composite Moisture Content)*Composite Weight/100)+((100-Grasshopper Moisture Content)*Grasshopper Weight/100))*

E. Woodlot Composite CoC Concentrations

Formula: Nickel Example

*=(((100-Composite Moisture Content)*Composite Weight/100)*Composite Nickel Content +((100-Spider Moisture Content)*Spider Weight/100)*Spider Nickel Content)/(((100-Composite Moisture Content)*Composite Weight/100)+((100-Spider Moisture Content)*Spider Weight/100))*

Total Frog CoC Concentrations

Sample	Liver_wt	Liver_mc	Liver_Ni	Liver_Cu	Liver_Co	Liver_As	GI_wt	GI_mc	GI_Ni	GI_Cu	GI_Co	GI_As	Body_wt	Body_mc	Body_Ni	Body_Cu	Body_Co	Body_As	Total_Ni	Total_Cu	Total_Co	Total_As
H-1-E	0.336	0.7614	0.93	194.000	0.38	0.5	2.872	0.8131	101.00	30.90	8.19	2.4	17.527	0.78	0.83	15.95	0.10	0.25	12.85	20.94	1.07	0.5
H-1-A	0.638	0.7614	0.82	247.000	0.67	0.7	2.712	0.8131	76.90	106.00	2.77	3.0	24.086		0.92	20.30	0.10	0.25	7.38	33.38	0.34	0.5
H-1-B	3.426	0.7614	0.51	399.000	0.41	0.8	18.451	0.8131	27.20	26.50	1.15	1.0	72.196		2.12	25.80	0.18	0.25	6.35	41.06	0.36	0.4
H-1-C	0.546	0.7614	1.80	179.000	0.59	0.2	3.512	0.8131	1.04	10.40	0.26	4.1	21.295		0.94	9.00	0.11	0.30	0.97	13.22	0.14	0.8
H-1-D	2.881	0.7614	0.45	229.000	0.43	0.4	2.793	0.8131	6.77	43.30	0.80	0.7	52.417		0.79	7.92	0.16	0.30	1.02	21.30	0.20	0.3
H-2-A	0.122	0.7614	0.63	734.000	1.06	1.3	0.622	0.8131	5.28	12.60	0.45	0.6	8.241		6.15	225.00	0.26	0.30	6.02	219.96	0.28	0.3
H-2-B	0.202	0.7614	0.94	415.000	0.76	0.8	1.201	0.8131	4.17	15.80	0.38	0.3	9.947		0.69	15.53	0.17	0.30	1.02	23.38	0.20	0.3
H-2-C	0.168	0.7614	0.90	497.000	1.00	0.9	1.248	0.8131	2.24	11.30	0.48	0.3	9.076		0.49	7.89	0.22	0.25	0.68	16.88	0.26	0.3
H-2-D	0.170	0.7614	0.40	399.000	1.34	0.8	0.499	0.8131	2.13	9.87	0.35	0.6	9.060		0.36	14.10	0.27	0.20	0.44	21.25	0.29	0.2
H-2-I	1.515	0.7614	0.39	180.000	1.21	0.8	5.154	0.8131	7.24	26.20	0.79	0.7	45.974		0.33	6.08	0.14	0.25	0.91	13.27	0.23	0.3
H-3-A	1.278	0.7614	0.31	203.000	0.78	0.2	3.977	0.8131	7.66	8.47	0.44	0.3	49.105		0.76	19.60	0.13	0.20	1.18	23.62	0.17	0.2
H-3-B	0.466	0.7614	0.15	224.000	0.40	0.3	1.400	0.8131	51.10	17.10	1.29	0.3	16.518		0.13	7.02	0.11	0.25	3.45	13.70	0.20	0.3
H-3-C	0.479	0.7614	0.13	207.000	0.32	0.3	1.194	0.8131	4.62	9.75	0.26	0.3	15.918		0.36	7.34	0.10	0.25	0.60	13.42	0.11	0.3
H-3-D	0.973	0.7614	0.37	208.000	0.27	0.2	2.423	0.8131	31.80	236.00	1.24	0.3	26.096		0.13	4.23	0.09	0.25	2.37	27.92	0.17	0.2
H-3-E	0.422	0.7614	0.15	191.000	0.36	0.3	1.529	0.8131	23.20	20.60	0.79	0.3	15.004		0.36	13.90	0.07	0.30	2.12	19.26	0.13	0.3
H-4-A	0.249	0.7614	0.25	197.000	0.51	0.5	0.987	0.8131	2.45	12.70	0.21	0.3	13.200	0.78	0.41	22.30	0.07	0.25	0.53	25.03	0.09	0.3
H-4-B	0.183	0.7614	0.30	261.000	0.54	0.6	0.945	0.8131	17.70	47.90	0.69	0.4	7.700	0.87	0.95	76.80	0.09	0.40	3.35	79.21	0.19	0.4
H-4-C	0.807	0.7614	0.64	374.000	0.95	0.3	1.245	0.8131	9.83	10.70	0.57	0.3	38.900	0.81	0.52	10.90	0.19	0.30	0.80	19.84	0.22	0.3
H-4-D	0.229	0.7614	0.28	317.000	0.45	0.6	1.189	0.8131	1.98	9.12	0.22	0.3	13.000	0.86	2.19	36.10	0.26	0.35	2.12	40.56	0.26	0.3
H-4-E	0.141	0.7614	0.50	297.000	0.67	1.0	0.708	0.8131	40.00	21.50	1.16	0.4	7.300	0.82	0.78	41.50	0.10	0.30	4.28	45.52	0.21	0.3
H-5-A	0.509	0.7614	0.65	179.000	1.11	1.1	2.852	0.8131	36.30	73.20	1.90	0.7	15.400	0.79	3.59	24.37	0.26	0.25	7.98	35.89	0.51	0.3
H-5-B	0.319	0.7614	0.20	181.000	0.53	1.4	1.754	0.8131	35.30	81.90	2.52	1.0	10.800	0.85	0.67	11.10	0.10	0.35	6.26	28.96	0.51	0.5
H-5-C	0.308	0.7614	0.20	133.000	0.57	1.2	1.692	0.8131	108.00	47.20	5.29	2.4	10.600	0.83	1.47	15.90	0.21	0.30	16.80	24.34	0.96	0.6
H-5-D	0.266	0.7614	0.20	52.500	0.64	1.9	1.861	0.8131	40.50	37.80	2.79	1.5	9.600	0.80	0.52	14.30	0.07	0.25	6.48	18.85	0.49	0.5
H-5-E	0.219	0.7614	0.35	157.000	1.56	0.7	1.251	0.8131	26.80	43.70	2.14	1.1	7.300	0.85	0.54	40.70	0.15	0.35	4.98	45.61	0.54	0.5
M-1-A	0.765	0.7614	0.55	34.400	0.40	0.7	1.432	0.8131	33.70	62.70	4.34	1.8	9.500	0.74	1.10	13.30	0.26	0.20	4.07	19.18	0.65	0.4
M-1-B	1.744	0.7614	0.10	91.550	0.21	3.7	4.960	0.8131	42.80	58.20	6.24	4.6	40.400	0.78	2.27	19.25	0.42	0.65	5.79	25.61	0.93	1.1
M-1-C	0.191	0.7614	1.07	85.000	1.79	0.9	0.395	0.8131	3.94	8.52	0.63	0.8	4.900	0.76	0.69	10.40	0.10	0.20	0.89	12.91	0.19	0.3
M-1-D	0.126	0.7614	0.68	0.405	0.07	1.4	0.542	0.8131	65.60	46.70	7.59	4.2	5.600	0.79	0.87	6.40	0.21	0.25	5.84	9.36	0.78	0.6
M-1-E	0.159	0.7614	0.75	0.450	0.08	1.5	0.993	0.8131	15.90	15.60	2.66	3.7	4.500	0.77	0.76	5.66	0.20	1.00	2.98	6.96	0.56	1.4
M-2-A	0.667	0.7614	0.20	139.000	0.73	0.7	1.571	0.8131	1.05	26.70	0.19	0.3	36.100	0.83	0.15	4.11	0.06	0.30	0.19	8.35	0.08	0.3
M-2-B	0.549	0.7614	0.47	110.000	0.45	0.6	1.853	0.8131	0.69	13.00	0.12	0.3	41.400	0.82	0.13	4.13	0.09	0.25	0.15	6.22	0.09	0.3
M-2-C	0.669	0.7614	0.10	95.100	0.33	1.4	4.596	0.8131	12.60	69.70	1.53	1.0	23.300	0.81	0.13	3.61	0.08	0.25	2.12	16.89	0.31	0.4
M-2-D	0.553	0.7614	0.36	62.900	0.33	0.6	2.512	0.8131	1.35	68.30	0.19	0.3	48.500	0.82	0.13	4.97	0.09	0.25	0.19	8.87	0.10	0.3
M-2-E	0.691	0.7614	0.27	45.400	0.75	0.4	1.821	0.8131	10.40	27.50	1.06	0.6	63.800	0.80	0.13	4.57	0.12	0.25	0.39	5.68	0.15	0.3
M-4-A	0.230	0.7614	0.30	49.000	1.60	0.6	1.177	0.8131	3.39	78.70	0.65	0.6	7.700	0.80	0.60	13.30	0.17	0.25	0.93	22.46	0.27	0.3
M-4-B	0.327	0.7614	0.68	72.200	0.73	0.9	0.877	0.8131	5.47	13.10	0.68	0.4	10.100	0.83	0.15	4.51	0.11	0.30	0.63	8.00	0.18	0.3
M-4-D	0.395	0.7614	2.16	28.000	0.55	0.3	2.036	0.8131	4.88	59.30	1.45	0.3	12.600	0.83	0.30	5.60	0.12	0.30	1.04	14.34	0.33	0.3
M-4-E	0.254	0.7614	0.64	73.400	0.72	1.2	1.700	0.8131	22.60	66.90	4.55	1.4	9.000	0.86	0.58	5.27	0.25	0.35	4.76	19.43	1.08	0.6
M-4-I	0.250	0.7614	0.30	39.300	1.02	0.6	0.815	0.8131	9.35	71.70	1.74	0.9	9.000	0.84	0.59	12.00	0.14	0.30	1.41	18.64	0.32	0.4
M-5-A	0.504	0.7614	0.28	333.000	0.95	0.7	2.867	0.8131	0.71	12.20	0.30	0.8	43.800	0.84	0.15	2.78	0.05	0.30	0.19	8.50	0.08	0.3
M-5-B	0.644	0.7614	0.64	477.000	1.08	0.6	2.456	0.8131	1.10	16.75	0.41	0.3	47.300	0.79	0.13	3.36	0.13	0.25	0.17	10.68	0.16	0.3
M-5-C	0.587	0.7614	0.40	425.000	0.88	0.2	2.349	0.8131	1.61	32.30	1.04	0.3	35.800	0.80	0.13	3.45	0.07	0.25	0.21	12.63	0.14	0.2
M-5-D	0.745	0.7614	0.27	141.000	0.50	0.3	4.616	0.8131	16.20	47.30	0.88	0.7	42.000	0.78	0.13	7.95	0.08	0.25	1.49	13.62	0.15	0.3
M-6-A	2.073	0.7614	0.10	159.500	0.43	0.9	7.260	0.8131	8.36	42.20	1.83	0.9	101.000	0.81	0.37	7.23	0.07	0.25	0.87	13.01	0.19	0.3
M-6-B	0.914	0.7614	0.34	137.000	0.56	0.2	5.893	0.8131	2.36	35.00	0.16	0.3	48.500	0.78	0.36	5.08	0.06	0.25	0.54	10.27	0.08	0.2
M-6-C	0.449	0.7614	0.35	86.300	0.54	0.8	1.926	0.8131	84.20	178.00	8.63	2.6	14.000	0.80	1.46	9.61	0.16	0.25	10.50	30.59	1.10	0.5
M-6-D	0.356	0.7614	0.18	136.000	0.33	0.4	1.327	0.8131	7.68	27.90	0.46	0.3	10.100	0.80	0.13	5.22	0.04	0.25	0.93	12.36	0.09	0.3
M-6-E	0.158	0.7614	0.50	0.300	0.05	1.0	0.459	0.8131	0.64	12.20	0.12	0.6	6.100	0.72	0.10	3.56	0.02	0.20	0.13	3.89	0.03	0.2

Total Frog CoC Concentrations

Sample	Liver_wt	Liver_mc	Liver_Ni	Liver_Cu	Liver_Co	Liver_As	GI_wt	GI_mc	GI_Ni	GI_Cu	GI_Co	GI_As	Body_wt	Body_mc	Body_Ni	Body_Cu	Body_Co	Body_As	Total_Ni	Total_Cu	Total_Co	Total_As
C-1-B	1.070	0.7614	0.10	186.000	0.48	0.6	3.370	0.8131	8.58	13.80	3.63	3.8	24.700	0.80	0.13	5.15	0.06	0.25	1.04	14.01	0.46	0.6
C-1-C	3.202	0.7614	0.17	8.660	0.43	1.3	8.740	0.8131	47.80	35.90	17.50	3.1	71.000	0.78	0.13	6.10	0.08	0.25	4.45	8.91	1.68	0.6
C-1-D	0.683	0.7614	0.10	250.000	0.79	0.4	5.054	0.8131	12.70	35.90	6.37	3.5	23.500	0.80	0.13	9.44	0.03	0.25	2.17	20.49	1.09	0.8
C-1-E	1.122	0.7614	0.11	106.050	0.42	0.6	2.984	0.8131	1.85	8.51	1.20	0.7	25.800	0.81	0.13	8.51	0.07	0.25	0.29	13.07	0.20	0.3
C-1-F	0.469	0.7614	0.13	178.000	0.53	0.3	3.750	0.8131	3.95	19.40	2.19	2.5	18.400	0.81	0.15	13.60	0.07	0.30	0.77	18.81	0.42	0.7
C-3-A	1.859	0.7614	0.08	54.400	0.50	0.6	5.531	0.8131	13.60	32.90	5.42	3.3	45.900	0.79	0.13	7.34	0.06	0.25	1.38	11.59	0.57	0.5
C-3-B	0.395	0.7614	0.18	85.600	0.46	0.4	2.533	0.8131	1.92	31.30	0.48	0.3	13.900	0.80	0.13	9.26	0.03	0.25	0.38	14.53	0.11	0.3
C-3-C	0.328	0.7614	0.23	83.100	0.73	1.1	2.210	0.8131	3.60	72.70	1.31	0.8	12.800	0.82	0.15	12.10	0.06	0.30	0.66	23.04	0.26	0.4
C-3-D	0.381	0.7614	0.18	103.000	0.48	0.4	1.627	0.8131	2.44	65.50	1.01	0.6	11.100	0.81	0.15	6.91	0.05	0.30	0.43	17.51	0.18	0.3
C-3-F	0.167	0.7614	0.38	94.900	2.43	0.8	0.882	0.8131	3.33	17.70	1.38	0.4	7.700	0.84	0.15	11.70	0.38	0.30	0.52	14.70	0.55	0.3
C-4-A	0.303	0.7614	0.20	143.000	0.26	0.4	1.949	0.8131	0.58	32.70	0.26	0.2	16.000	0.82	0.42	10.90	0.04	0.30	0.43	16.17	0.07	0.3
C-4-B	0.517	0.7614	0.13	48.000	0.21	0.3	2.138	0.8131	0.50	6.21	0.08	0.3	15.200	0.82	0.15	7.55	0.02	0.30	0.19	8.92	0.03	0.3
C-4-C	0.197	0.7614	1.00	135.000	0.29	0.8	1.342	0.8131	3.22	29.00	0.73	0.8	6.500	0.82	0.64	21.63	0.04	0.30	1.09	26.52	0.16	0.4
C-4-D	0.159	0.7614	1.31	28.800	0.48	1.0	0.659	0.8131	7.53	15.40	1.09	1.2	5.300	0.79	0.38	19.80	0.05	0.25	1.10	19.64	0.16	0.4
C-4-E	0.160	0.7614	0.50	62.000	0.56	2.3	0.806	0.8131	1.57	21.80	0.63	0.5	4.000	0.82	0.38	34.60	0.05	0.30	0.58	33.63	0.17	0.4
C-5-A	0.379	0.7614	0.18	168.000	0.92	0.8	2.105	0.8131	4.02	27.50	1.03	0.6	15.300	0.82	0.34	14.80	0.12	0.30	0.78	20.62	0.25	0.4
C-5-B	0.900	0.7614	0.08	49.100	0.30	1.0	2.253	0.8131	0.30	7.47	0.12	0.3	34.000	0.77	0.13	5.37	0.03	0.25	0.13	6.59	0.04	0.3
C-5-C	0.513	0.7614	0.32	70.700	0.32	0.3	1.787	0.8131	1.09	12.00	0.74	0.2	11.900	0.82	0.15	4.74	0.02	0.30	0.28	8.78	0.12	0.3
C-5-D	0.257	0.7614	0.25	224.000	0.50	0.5	1.145	0.8131	0.96	119.00	0.75	0.3	11.500	0.80	0.13	6.69	0.04	0.25	0.20	21.20	0.11	0.3
C-5-E	0.165	0.7614	0.50	250.000	0.65	1.0	0.653	0.8131	4.11	24.30	1.52	0.5	5.300	0.84	0.42	13.70	0.10	0.35	0.87	24.20	0.29	0.4
C-6-A	0.334	0.7614	0.20	177.000	0.33	0.4	1.276	0.8131	0.82	46.50	0.50	0.3	8.300	0.78	0.13	5.71	0.05	0.25	0.21	16.61	0.11	0.3
C-6-B	0.478	0.7614	0.13	170.000	0.39	0.3	2.316	0.8131	3.75	25.70	2.25	1.0	12.900	0.79	0.13	4.35	0.03	0.25	0.61	12.99	0.33	0.3
C-6-C	0.291	0.7614	0.23	208.000	0.35	0.5	1.048	0.8131	3.38	16.70	0.89	0.3	9.500	0.81	0.15	5.52	0.04	0.30	0.46	13.37	0.13	0.3
C-6-D	0.354	0.7614	0.23	32.800	0.31	0.5	1.242	0.8131	4.18	17.30	4.05	1.9	8.700	0.80	0.13	4.41	0.04	0.25	0.59	7.03	0.50	0.4
C-6-E	0.307	0.7614	0.20	96.800	0.47	0.4	1.168	0.8131	4.46	19.10	2.43	1.6	6.600	0.82	0.15	5.00	0.13	0.30	0.79	11.63	0.49	0.5

Total Tadpole CoC Concentrations

Sample	GI_wt	GI_mc	GI_Ni	GI_Cu	GI_Co	GI_As	Body_wt	Body_mc	Body_Ni	Body_Cu	Body_Co	Body_As	Total_Ni	Total_Cu	Total_Co	Total_As
T-H-1	13.567	86.3	335.0	88.5	16.60	11.4	27.729	87.3	14.10	20.10	0.89	1.3	118.70	42.40	6.01	4.6
T-H-2	15.142	86.3	133.0	59.4	9.26	6.6	77.421	87.3	3.14	14.80	0.83	1.3	24.18	22.03	2.19	2.2
T-H-3	2.062	86.3	189.0	101.0	15.60	14.2	2.351	87.3	104.00	52.80	8.28	6.9	143.47	75.18	11.68	10.3
T-M-1	2.250	86.3	236.0	128.0	24.00	8.1	4.830	87.3	33.30	28.90	3.60	1.4	97.21	60.14	10.03	3.5
T-M-2	7.940	86.3	43.7	32.3	6.78	8.1	16.334	87.3	2.05	4.06	0.63	1.6	15.57	13.22	2.63	3.7
T-M-3	11.125	86.3	218.0	98.4	36.30	15.1	12.991	87.3	21.30	14.50	4.03	2.3	111.47	52.96	18.82	8.2
T-C-1	3.450	86.3	79.5	102.0	19.70	20.4	6.590	87.3	4.40	11.40	1.40	1.9	30.01	42.29	7.64	8.2
T-C-2	4.590	86.3	16.7	22.2	6.18	6.8	8.450	87.3	2.57	7.86	1.16	1.4	7.51	12.87	2.91	3.3

Total Vole CoC Concentrations

Sample	Liver_wt	Liver_mc	Liver_Ni	Liver_Cu	Liver_Co	Liver_As	Body_wt	Body_mc	Body_Ni	Body_Cu	Body_Co	Body_As	Total_Ni	Total_Cu	Total_Co	Total_As
V-H-2-1-	1.190	69.8	0.58	15.0	0.76	0.2	25.8	67.7	8.56	8.05	0.70	0.15	8.20	8.37	0.70	0.2
V-H-2-2-	2.622	69.8	0.67	14.9	1.06	0.3	46.7	71.4	20.53	10.30	1.29	0.97	19.50	10.54	1.27	0.9
V-H-2-3-	1.062	69.8	0.22	16.9	1.00	0.2	19.1	65.5	8.66	9.28	0.99	0.15	8.18	9.71	0.99	0.2
V-H-2-4-	2.987	69.8	0.28	10.6	1.60	0.2	48.4	72.7	27.80	13.43	1.80	1.07	26.26	13.27	1.79	1.0
V-H-2-5-	1.107	69.8	0.24	14.9	1.11	0.2	20.1	69.4	8.57	8.91	0.80	0.15	8.13	9.23	0.81	0.2
V-H-5-1-	1.346	69.8	1.08	15.5	1.11	0.2	33.3	67.3	13.70	9.48	0.84	0.15	13.19	9.73	0.85	0.2
V-H-5-2	0.661	69.8	0.45	14.7	0.65	0.3	20.8	66.1	23.80	8.80	0.57	0.15	23.04	8.99	0.57	0.2
V-H-5-3	0.908	69.8	0.48	11.7	2.07	0.2	26.6	71.2	22.60	12.20	1.90	0.83	21.88	12.18	1.90	0.8
V-H-5-4	0.477	69.8	0.18	20.1	0.49	0.4	16.4	69.7	12.30	10.40	0.58	0.15	11.96	10.67	0.58	0.2
V-H-5-5	1.068	69.8	0.27	12.8	2.27	0.3	22.4	68.7	13.00	8.37	1.06	0.53	12.41	8.57	1.12	0.5
V-M-1-1-	0.902	69.8	0.25	20.9	0.29	0.2	31.5	68.4	3.33	9.39	0.22	0.15	3.24	9.71	0.22	0.2
V-C-1-1-	1.149	69.8	0.23	16.1	0.10	0.2	35.5	73.0	0.97	8.39	0.14	0.20	0.95	8.62	0.14	0.2
V-C-1-2-	0.928	69.8	0.10	9.6	0.09	0.2	27.7	69.6	1.14	8.00	0.11	0.20	1.11	8.05	0.11	0.2
V-C-1-3-	0.892	69.8	0.10	12.5	0.18	0.2	27.1	71.3	1.81	8.78	0.17	0.20	1.75	8.89	0.17	0.2
V-C-1-4-	0.920	69.8	0.59	14.0	0.11	0.2	45.5	69.6	1.59	9.79	0.18	0.15	1.57	9.87	0.18	0.2
V-C-1-5-	1.552	69.8	0.16	18.7	0.13	0.1	31.0	68.2	1.05	8.20	0.13	0.15	1.00	8.71	0.13	0.1
V-C-1-7	0.829	69.8	0.10	14.1	0.11	0.2	29.9	68.6	0.89	8.00	0.20	0.15	0.87	8.17	0.19	0.2
V-C-2-1-	0.886	69.8	0.10	12.9	0.10	0.2	30.1	73.0	0.68	8.22	0.19	0.15	0.66	8.34	0.19	0.2
V-C-3-1-	1.470	69.8	0.08	15.4	0.10	0.2	30.6	72.5	2.07	17.93	0.36	0.20	1.98	17.82	0.35	0.2
V-C-3-2-	1.148	69.8	0.21	13.4	0.09	0.2	20.0	73.0	1.69	9.87	0.19	0.20	1.61	10.05	0.18	0.2
V-C-3-3-	0.768	69.8	0.10	15.6	0.11	0.2	19.6	72.6	1.62	8.98	0.19	0.20	1.56	9.22	0.19	0.2
V-C-3-4-	1.213	69.8	0.08	13.1	0.05	0.2	20.4	73.6	2.79	8.58	0.07	0.20	2.65	8.82	0.07	0.2
V-C-3-9-	0.424	69.8	0.20	14.1	0.16	0.4	18.3	73.4	1.24	8.10	0.26	0.20	1.22	8.23	0.26	0.2

Field Composite CoC Concentrations

Site	Grass_Ni	Grass_Cu	Grass_Co	Grass_As	Grass_weight	Grass_mc	Composite_Ni	Composite_Cu	Composite_Co	Composite_As	Composite_weight	Composite_mc	Total_Ni	Total_Cu	Total_Co	Total_As
I-H-1	21.67	80.20	0.598	0.2	2.191	64.9	1.15	32.70	0.040	0.5	4.400	47.6	6.28	44.58	0.180	0.4
I-H-2	26.75	50.90	0.839	0.2	0.809	61.6	10.30	34.00	0.394	0.3	3.650	24.6	11.97	35.71	0.439	0.3
I-H-3	18.75	73.70	0.222	0.2	2.210	68.8	16.70	30.20	0.355	0.6	10.030	64.1	17.03	37.19	0.334	0.5
I-H-4	22.05	36.85	0.819	0.2	0.861	62.5	5.88	47.90	0.154	0.1	13.640	46.7	6.57	47.43	0.182	0.1
I-H-5	20.76	43.80	1.116	0.2	2.264	68.5	22.30	37.70	1.230	0.3	10.080	62.5	22.05	38.67	1.212	0.3
I-C-1	3.88	19.22	0.053	0.1	0.596	50.6	2.19	220.00	0.333	1.0	2.066	25.1	2.46	187.90	0.288	0.9
I-C-2	1.47	36.85	0.058	0.2	3.000		0.34	49.50	0.101	0.2	12.562	53.6	0.54	47.31	0.094	0.2
I-C-3	1.52	50.60	0.117	0.2	4.210	64.5	0.29	56.40	0.060	0.1	12.803	54.3	0.54	55.22	0.071	0.1
I-C-4	2.10	63.90	0.123	0.2	4.410	63.2	0.24	58.10	0.028	0.1	10.150	45.0	0.66	59.41	0.049	0.1
I-C-5	1.58	57.25	0.135	0.2	2.400		0.44	45.90	0.078	0.1	4.786	38.4	0.72	48.72	0.092	0.1
I-M-1							3.12	45.80	0.092	0.2	7.510	77.1	3.12	45.80	0.092	0.2
I-M-2							1.48	52.80	0.063	0.2	3.170	46.3	1.48	52.80	0.063	0.2
I-M-3							27.10	48.20	0.734	0.2	8.400	69.0	27.10	48.20	0.734	0.2
I-M-4							8.39	57.00	0.210	0.2	5.450	55.0	8.39	57.00	0.210	0.2
I-M-5							1.03	41.20	0.067	0.2	26.090	65.1	1.03	41.20	0.067	0.2

Woodlot Composite CoC Concentrations

Site	Spider_Ni	Spider_Cu	Spider_Co	Spider_As	Spider_weight	Spider_mc	Composite_Ni	Composite_Cu	Composite_Co	Composite_As	Composite_weight	Composite_mc	Total_Ni	Total_Cu	Total_Co	Total_As
H1	18.50	88.90	0.646	0.7	2.175	68.0	25.70	30.70	2.020	1.0	0.76	64.5	20.52	72.61	1.031	0.8
H2	7.34	86.90	0.401	0.9	2.679	67.9	4.18	16.80	0.182	0.2	2.40	43.8	5.41	44.09	0.267	0.5
H3	3.40	65.60	0.171	0.5	3.820	69.7	7.84	14.70	0.148	0.2	6.39	56.2	6.54	29.60	0.155	0.3
H4	5.73	59.80	0.189	0.4	2.560	67.9	4.50	19.50	0.137	0.2	3.44	46.9	4.88	32.00	0.153	0.3
H5	3.36	53.10	0.143	0.5	4.130	66.0	33.30	43.50	1.220	1.2	1.72	72.6	10.89	50.68	0.414	0.7
M1							11.90	25.30	0.184	0.2	2.66	66.8	11.90	25.30	0.184	0.2
M2							4.52	22.00	0.227	0.2	3.58	78.6	4.52	22.00	0.227	0.2
M3							3.97	27.90	0.136	0.2	3.04	68.0	3.97	27.90	0.136	0.2
M4							8.15	26.10	0.184	0.2	4.18	65.3	8.15	26.10	0.184	0.2
M5							4.78	22.80	0.293	0.2	1.87	60.4	4.78	22.80	0.293	0.2
C1	1.88	45.10	0.025	0.5	0.490	65.2	0.78	32.50	0.078	0.2	1.84	68.3	1.03	35.35	0.066	0.2
C2	0.61	47.40	0.135	1.7	0.716	65.2	0.60	17.40	0.064	0.3	1.54	49.0	0.60	24.63	0.081	0.6
C3	0.62	60.50	0.042	0.5	5.557	65.2	0.81	14.70	0.057	0.2	2.80	59.7	0.69	43.62	0.048	0.4
C4	2.66	53.30	0.181	0.4	0.405	65.2	2.88	19.30	0.108	0.1	1.27	57.8	2.83	26.38	0.123	0.2
C5	1.07	44.40	0.038	1.0	7.155	65.2	0.51	10.30	0.026	0.2	2.75	51.1	0.87	32.44	0.034	0.7

SOIL COCs MAPPING

Methods Used for Mapping CoC Isolines

1. INTRODUCTION

The location of all soil sampling sites in the Community Based Risk Assessment (CBRA) were mapped in the field on a hardcopy map for verification purposes. Universal Transverse Mercator (UTM) coordinates were inputted into the database and appended to other information such as chemical analytical results.

2. COC ISOLINE MAPPING AND DATA INTERPOLATION

To illustrate the spatial distribution of soil contamination in the study area, isoline maps were created for selected elements using Surfer TM and ArcView TM computer mapping programs. Maps were created for the CoCs (arsenic, cobalt, copper, nickel).

These two software packages were used to generate isoline maps. The data analysis and creation of the concentration isolines were produced using Surfer TM (Version 8.0 for Windows 95/NT, by Golden Software Inc.). The output from Surfer TM was then imported into ArcView TM GIS (Version 3.3, by Environmental Systems Research Institute Inc.) and combined with base maps and air photos to produce the final maps.

These maps are statistically derived approximations of the spatial distribution based on measurements at discrete sampling points. Soil concentrations are only known with certainty at those sites for which soil was actually sampled and chemically analysed. The isolines produced by the program are significantly affected by the spatial distribution of the sampling sites, the density of the sampling sites, and the program options used to generate the isolines.

The accuracy of the isolines diminishes at the edges of the map and in large areas where there are no or very few soil sample sites. Since soil sampling was not uniform across the landscape, generated isolines can only approximate the soil conditions where no soil samples were obtained. The isolines may have a higher uncertainty on the west side of the canal where there are significantly less sampling points.

Mapping of the soil CoC isolines used a conservative approach. Where single sites with significantly elevated concentrations of some elements were surrounded by sites with much lower concentrations, the local maxima were used to generate the isoline. Surfer TM 's Kriging options allow for data interpretation and interpolation of data that are not of even densities or distribution.

In situations where soil sampling locations are highly clustered into a small area (eg Rodney Street Community) relative to the other areas of the landscape, the algorithm averages out a value for this very small area. This proved very difficult in integrating the observations and data from the residential area directly to the west of the Inco refinery into the rest of the study area. This small residential community area accounts for less than 5 percent of the total study area but had a very high sampling density.

Mathematical measures to customize the interpolation software were taken to ensure that this variance in the soil sampling density and distribution did not distort the spatial detail of the whole study area where soil samples were collected.

3. KRIGING AND DATA INTERPOLATION METHODS

Kriging is a geostatistical method of spatial data interpolation that can be used to visually portray the distrubution and patterning of chemical distributions in an area. In 1963, G. Matheron named Kriging after D.G. Krige, a South African mining engineer, who used the technique to more accurately predict the extent of gold deposits in unsampled areas. Kriging is an interpolation method that optimally predicts data values by using data taken at known discrete nearby locations. Interpolation is the estimation of values between two or more known values. In regard to GIS software, interpolation is a process where the software adds an estimation of a parameter or gradation based on the values of the surrounding discrete points. The software can then map the isolines (gradients) between the discrete sampling points in two or three dimensions. Kriging uses a set of linear regression routines, which minimize estimation variance from a predefined covariance model. Kriging is based on the assumption that the parameter being interpolated at a site is a *regionalized* and not a *localized* variable. A regionalized variable varies in a continuous manner spatially so that data values from points nearer each other are more correlated. Data values from widely separated points are statistically independent in Kriging.

A Kriging model can estimate of the concentrations of chemical parameters and an associated variance can be predicted at each node of a grid. Additional sampling locations can be added to a data set and the reduction in Kriging variance can be estimated at each location.

For the CBRA, surface soil CoC data was kriged in two-dimension, using the custom Kriging options in the Surfer Software.

In theory, ordinary Kriging estimates the unknown value between two or more points by using a weighted linear combination or sum of squares analysis between all data points to the point of estimation. Surfer uses variograms to calculate the weight of each possible unknown point based on the data available. The challenge with the Port Colborne data set was that there were clusters of relatively higher concentrations of CoCs in some areas that would be distorted or ignored by the basic Kriging software simply because the software would examine these datapoints and the lower points around them and eliminate them as outliers. In the theory, this is called the **sill effect**. These datapoints had to be portrayed effectively. In technical terms, the model had to be developed to maximize the **nugget effect** of the Kriging model.

The nugget effect is the high variance between a pairset of datapoints with an extremely small separation distance. Normally, the software will examine many pairsets of points and will eliminate points with very high variance on the assumption that several factors, such as sampling error and short scale variability, may cause sample values separated by extremely small distances to be quite dissimilar.

For the modeling of the CBRA chemical isoline maps this nugget effect was maximized to allow for the most conservative distribution pattern and to show up as many pockets of higher or lower points as possible.

The Kriging module comes with two (2) options, spherical and exponential.

1. **Spherical Option**

$$\tilde{g}(h)=\begin{cases}C_o+C_1\left(1.5\frac{h}{a}-0.5\left(\frac{h}{a}\right)^3\right) & if\,|h|\le a\\ C_o+C_1 & if\,|h|>0\end{cases} \quad \textbf{(1)}$$

Where,

$\tilde{g}(h)$	=	variogram weighting at distance h
C_0	=	nugget affect (see definitions section)
C_1	=	data point value
h	=	distance (see definitions section)
a	=	range (see definitions section)

2. **Exponential Option**

$$\tilde{g}(h)=\begin{cases}0 & if\,|h|=0\\ C_o+C_1\left(1-\exp\left(\frac{-3|h|}{a}\right)\right) & if\,|h|>0\end{cases} \quad \textbf{(2)}$$

To maximize the nugget effect, (C_0) has to be the dominant factor in the variogram at close distances. Thus there had to be developed a customized variogram examining the data where distance (h) approaches zero. For larger ranges where distance is large, the exponential model could be used. Thus the model applied to Port Colborne mapping uses an exponential function where distance (h) is small between pair sets and a more spheroid model where distance is much greater than zero. This customized option is shown below.

3. **Customized Option**

$$\tilde{g}(h)=\begin{cases}C_o+C_1\left(1.5\frac{h}{a}-0.5\left(\frac{h}{a}\right)^3\right) & if\,|h|=0\\ C_o+C_1\left(1-\exp\left(\frac{-3|h|}{a}\right)\right) & if\,|h|>0\end{cases} \quad \textbf{(3)}$$

In the above equation, as distance (h) is minimized the variogram weights the closest points higher and the points further away on a decreasing weight; therefore, local maximums are maintained in the kriged model.

4. DEFINITIONS

4.1 Nugget effect (C_0):

Modeling used for the CBRA CoC isoline maps maximized this nugget effect to allow for the most conservative distribution pattern. Though the value of the variogram for h = 0 is strictly 0, several factors, such as sampling error and short scale variability, may cause sample values separated by extremely small distances to be quite dissimilar. This causes a discontinuity at the origin of the variogram in the exponential model. The vertical jump from the value of 0 at the origin to the value of the variogram at extremely small separation distances is called the nugget effect.

4.2 Range (a) :

As the distance between two pairs increase, the variogram of those two pairs also increases. Eventually, the increase of the distance cannot cause the variogram increase. The distance which causes the variogram to reach a plateau is called range (a). (See Figure 1)

4.3 Sill Effect (C0 + C1) :

The maximum variogram value which is the plateau of Figure B1.

4.4 Distance (h):

The distance between estimated location and observed location.

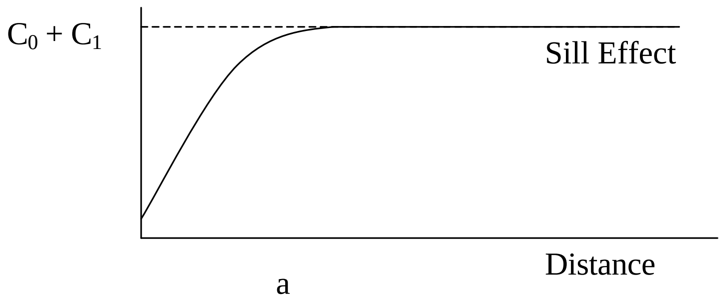

Figure B1. An example of an exponential variogram model`

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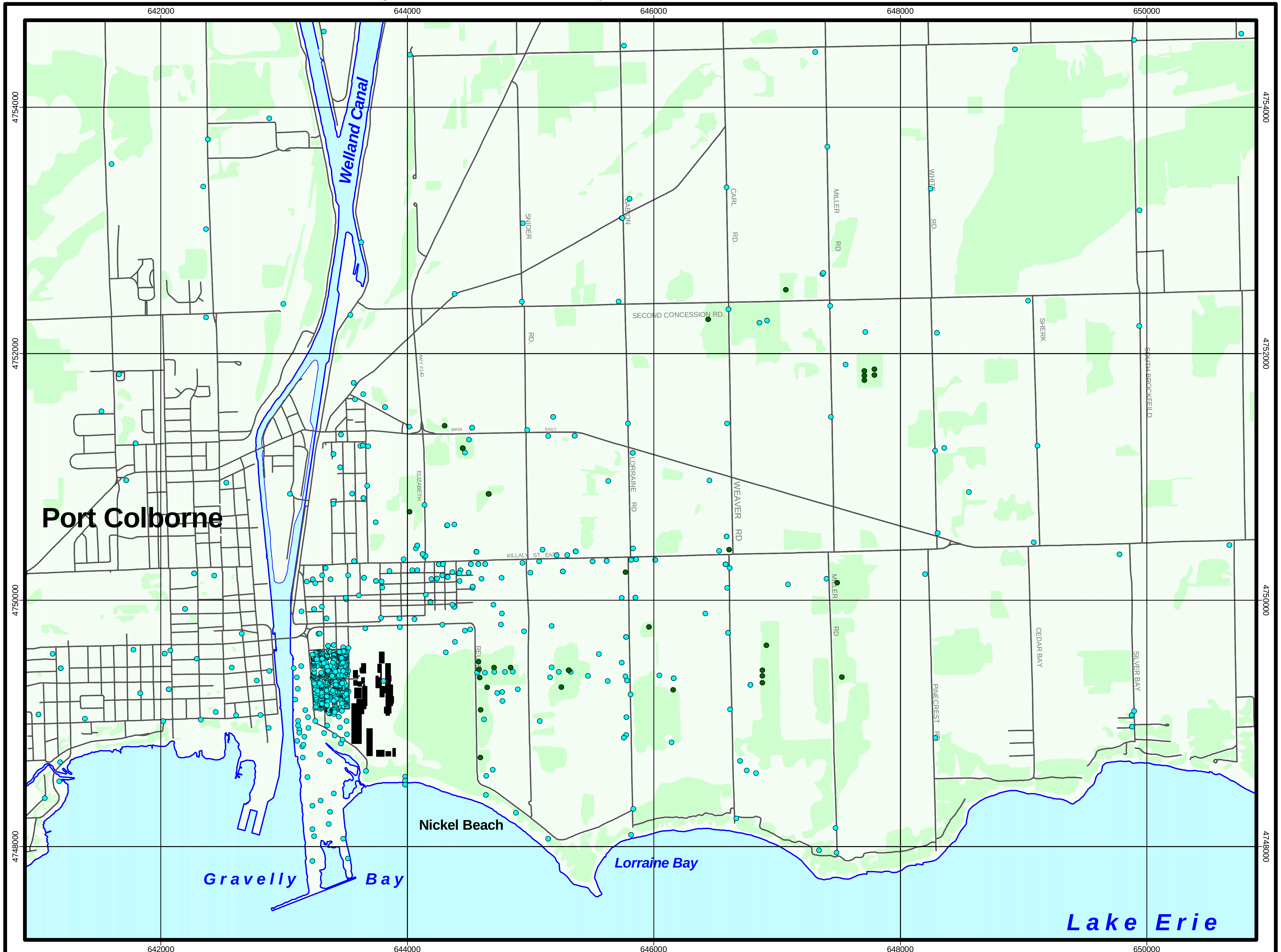


Soil Sampling Locations Port Colborne, ON

0 500 1000 1500

Metres

N

Legend

Sampling Locations

- Woodlot
- Open Space

Topographic Features

- Woodlot
- Inco Refinery
- Road

Job Number: ONT34644
Date: October 2003
Dwn by: C. Amirault
Approved by: Kevin Wong

Map Parameters
Projection: UTM
Datum: NAD 83
Scale 1 : 30,000

Regional NIAGARA

Jacques Whitford
Consulting Engineers
Environmental Scientists
Risk Consultants

../AV_Projects/HHRA_Report_Figures.APR

DASSESSING PREDICTORS FOR TISSUE COCs

1.0 ASSESSING PREDICTORS FOR TISSUE COCS

A tool used to evaluate the relationships between CoC concentrations in tissue and in physical media was the Generalised Linear Model (often abbreviated as *glm*). This method is akin to linear regression, but allows both linear and non-linear relationships to be examined, using normally and non-normally distributed data. A significant result from the *glm* analysis does not necessarily indicate that variables are closely correlated, but instead suggests that a predictor has a significant influence on the response. For example, higher tissue nickel concentrations may be positively related to higher soil nickel concentrations, but the error may be high, suggesting that other variables also have an influence on the response. Further technical information regarding the use and applications of the *glm* are provided in McCullagh and Neldar (1989) and Volume II (Tab 18).

For the Exposure Assessment, response variables in the *glm*s were tissue CoC concentrations fitted against habitat (woodlot/field), soil type (clay/organic) and the relevant media CoC concentrations (e.g., nickel for nickel) to determine if relationships existed between tissue CoC concentrations and these predictors. For example, earthworm tissue copper concentrations were fit against habitat, soil type and soil copper concentrations to determine if there was a relationship between earthworm tissue and soil copper concentrations. Also, first-order interactions between the predictors were included in the model and tested for significance to determine, for example, if the relationship between tissue and soil nickel concentrations was influenced by soil type. For any of the responses, it may be that CoC uptake differed between soil types.

Generalised Linear Models estimate the coefficients for the predictor effects and predictor interactions on the response variable. For each *glm*, the likelihood that each coefficient could be obtained in the absence of a true predictor effect is also provided in the model's output and used to evaluate whether it is likely the predictor effect actually exists, where the estimated $p<0.05$. These values are provided for each *glm*, as are ANOVA tables showing the contribution of each predictor to the model. Relevant output is provided in the following sections and in Volume III (Tab 3).

Plots presented here are meant to clarify for the reader how the environment (predictors) is influencing the concentration of CoCs in tissue, showing general trends in the data. The lines, which were created using locally weighted regression (loess, with spans of 0.9), are not meant to reflect any specific relationship other than general trends in the data. Further discussion for the rationale for this statistical approach and a summary of these results is presented in the main body of the report, in Section 6.4.2.

1.1 Amphibian Tissues

Amphibian tissue sampled for this ERA consisted of tadpoles (with separate chemical analyses performed on gastrointestinal tracts and carcass remainder) and adult frogs (with separate chemical analyses performed on livers, gastrointestinal tracts and carcass remainder). Statistical analyses using *glm* indicate that water CoC concentrations found at tadpole sample sites did not significantly contribute to models of tadpole GI tract or carcass CoC concentrations (Volume III, Tab 3). However, relationships between sediment and tadpole tissue nickel concentrations were found. Concentrations of nickel in sediment is a significant predictor of GI tract nickel concentrations (Table 1), with increased sediment nickel concentrations relating to increased nickel concentrations in the GI tract (Figure 1; Volume III, Tab 3). No other *glm* presented significant evidence of a relationship between CoC concentrations of tadpole tissue and sediment (Volume III, Tab 3), although the sparseness of the data and its high variability restrict our ability to draw conclusions.

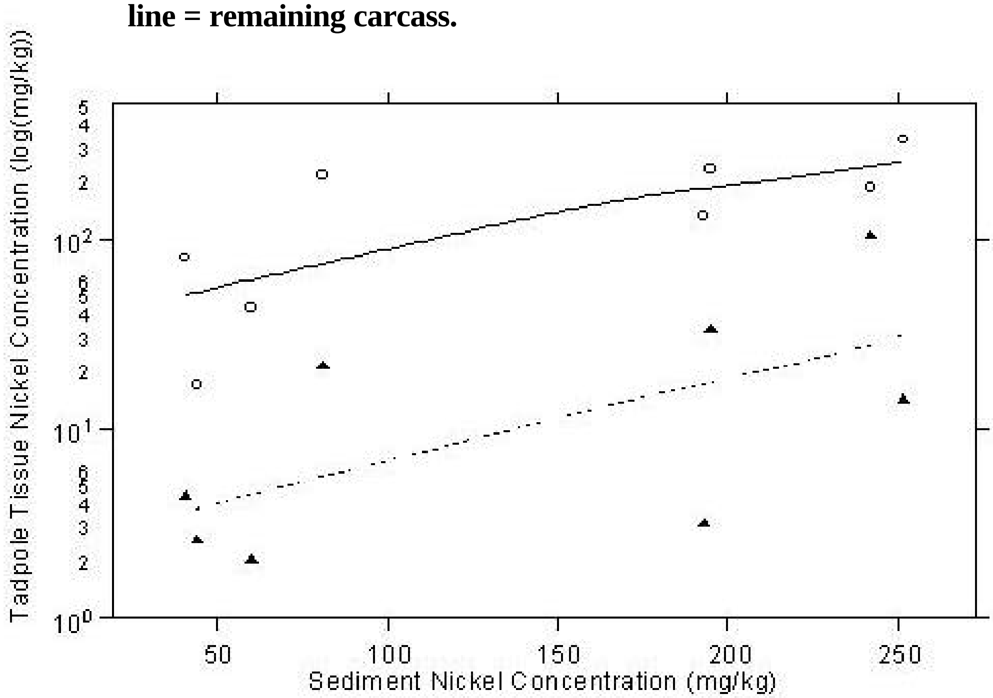
Table 1 Analysis of Deviance Table. The response variable is nickel concentration in tadpole tissue, log-transformed.

		Tadpole GI Tract Ni Concentration[1]	
Term	**df**	**Dev**	***p***
Null	7	7.128	
Sediment Nickel Concentration	1	3.972	**0.04**
Soil Type	1	0.298	0.46
Sediment Nickel Concentration: Soil Type (Interaction)	1	1.091	0.19
Residual	4	1.767	

Notes

1 The models were fit as Gaussian. Bold type indicates an estimated p-value of ≤ 0.05. Further information on Analysis of Deviance is found in Volume II, Tab 18.

Figure 1 **Relationship between sediment nickel concentration and tadpole tissue nickel concentration (log-linear). Circles & solid line = GI tract, triangles & dotted line = remaining carcass.**



The relationships between CoC concentrations in water and sediment and adult frog tissues were analysed using *glm*. Certain CoC concentrations in water appeared to be significant predictors of respective tissue CoC concentrations. Water cobalt concentrations significantly contributed to the models of GI tract and carcass cobalt concentrations (Table 2, Figure 2), but no such contribution was made to the model of liver cobalt concentrations (Volume III, Tab 3). Copper concentrations in water contributed significantly to carcass copper concentrations (Table 2, Figure 3), but not to models of the other tissues. Water nickel concentrations do not appear to significantly predict tissue nickel concentrations, but an interaction between water nickel and soil type was noted (Table 2, Figure 4); this interaction indicates that the relationship between water and tissue CoC concentrations differed between soil types. Additionally, background soil type also had an influence on tissue CoC concentrations, with frogs sampled in areas surrounded by clay soil generally having higher concentrations of nickel, cobalt and arsenic than areas sampled with organic soil.

Sediment CoC concentrations were good predictors of tissue CoC concentrations, as noted in Tables 3 and 4 (see Figures 7 to 16). Interactions between sediment CoC concentrations and soil type were noted for nickel, cobalt and arsenic (Tables 3 and 4). The relationship between sediment nickel concentrations and those in frog liver, GI tracts and remaining carcasses differed between clay soils and organic (Figures 8 to 10). This was noted for arsenic and cobalt also (Figures 13, 15 and 16).

Table 2 Analysis of deviance table. The response variables are concentrations of nickel, copper, cobalt and arsenic in frog tissue, log-transformed.

		Frog GI Tract Cobalt Concentration		**Frog Carcass Nickel Concentration**		**Frog Carcass Copper Concentration**		**Frog Carcass Cobalt Concentration**	
Term	**df**	**Dev**	***p***	**Dev**	***p***	**Dev**	***p***	**Dev**	***p***
Null	59	80.15		60.66		37.04		33.23	
Water CoC[1] Concentration	1	8.60	**0.01**	1.14	0.24	3.00	**0.03**	2.94	**0.01**
Soil Type	1	<0.01	0.95	8.19	**<0.01**	0.03	0.81	4.66	**<0.01**
Water CoC[1] Concentration: Soil Type (Interaction)	1	0.16	0.72	6.03	**<0.01**	1.92	0.07	0.51	0.29
Residual	56	71.38		45.31		32.08		25.12	

Notes

1 Relevant CoC for the model (e.g., water nickel for frog nickel).

2 The models were fit as Gaussian. Bold type indicates an estimated p-value of ≤ 0.05. Further information on Analysis of Deviance is found in Volume II, Tab 18.

Table 3 **Analysis of deviance table. The response variables are concentrations of nickel, copper, cobalt and arsenic in frog tissue, log-transformed.**

		Frog Liver Nickel Concentration		Frog GI Tract Nickel Concentration		Frog GI Tract Cobalt Concentration		Frog GI Tract Arsenic Concentration	
Term	**df**	**Dev**	***p***	**Dev**	***p***	**Dev**	***p***	**Dev**	***p***
Null	59	34.90		127.41		80.15		54.54	
Sediment CoC[1] Concentration	1	1.95	**0.05**	28.95	**<0.01**	0.88	0.40	6.53	**<0.01**
Soil Type	1	4.60	**<0.01**	2.54	0.19	<0.01	0.94	4.25	**0.02**
Sediment CoC[1] Concentration: Soil Type (Interaction)	1	2.20	**0.03**	16.50	**<0.01**	10.21	**<0.01**	3.32	**0.04**
Residual	56	26.15		79.42		69.06		41.44	

Notes

1 Relevant CoC for the model (e.g., sediment nickel for frog nickel).

2 The models were fit as Gaussian. Bold type indicates an estimated p-value of ≤ 0.05. Further information on Analysis of Deviance is found in Volume II, Tab 18.

Table 4 **Analysis of deviance table. The response variables are concentrations of nickel, copper, cobalt and arsenic in frog tissue, log-transformed.**

		Frog Carcass Nickel Concentration		Frog Carcass Copper Concentration		Frog Carcass Cobalt Concentration	
Term	**df**	**Dev**	***p***	**Dev**	***P***	**Dev**	***p***
Null	59	60.66		37.04		33.23	
Sediment CoC[1] Concentration	1	17.27	**<0.01**	5.91	**<0.01**	6.23	**<0.01**
Soil Type	1	9.29	**<0.01**	0.02	0.84	4.51	**<0.01**
Sediment CoC[1] Concentration: Soil Type (Interaction)	1	8.40	**<0.01**	0.89	0.20	0.08	0.65
Residual	56	25.71		30.22		22.41	

Notes

1 Relevant CoC for the model (e.g., sediment nickel for frog nickel).

2 The models were fit as Gaussian. Bold type indicates an estimated p-value of ≤ 0.05. Further information on Analysis of Deviance is found in Volume II, Tab 18.

Figure 2 **Relationship between water nickel concentration and frog tissue nickel concentration (log-linear). Circles & solid line = liver, triangles & dotted line = GI tract, squares & dashed line = remaining carcass.**

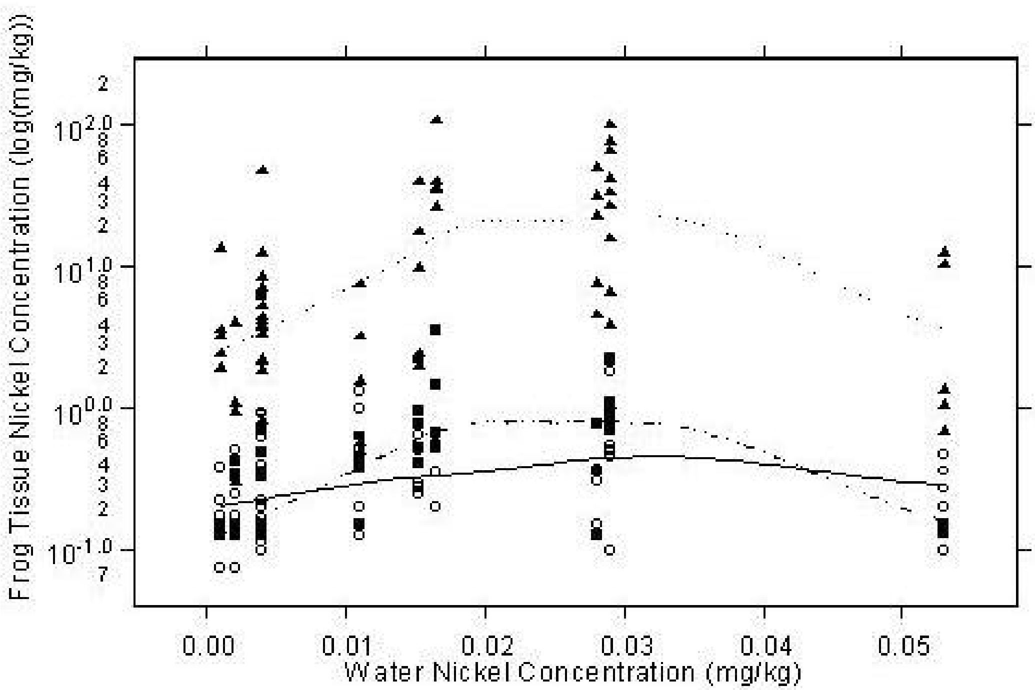


Figure 3 **Relationship between water nickel concentration and frog carcass tissue nickel concentration (log-linear). Circles & solid line = clay soil, triangles & dotted line = organic soil.**

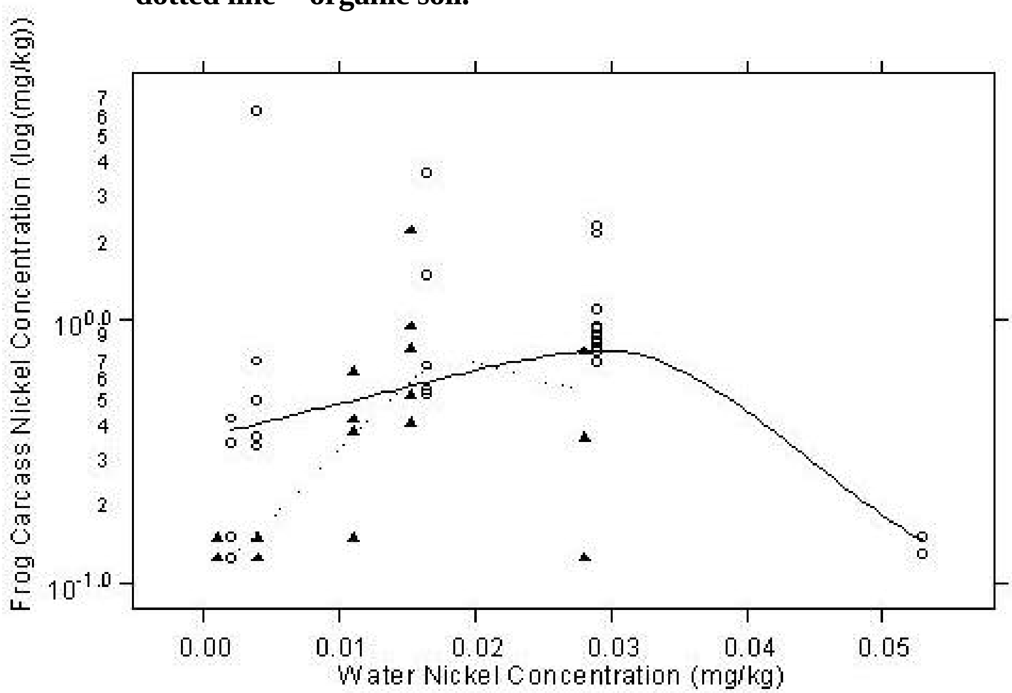


Figure 4 **Relationship between water copper concentration and frog tissue copper concentration (log-linear). Circles & solid line = liver, triangles & dotted line = GI tract, squares & dashed line = remaining carcass.**

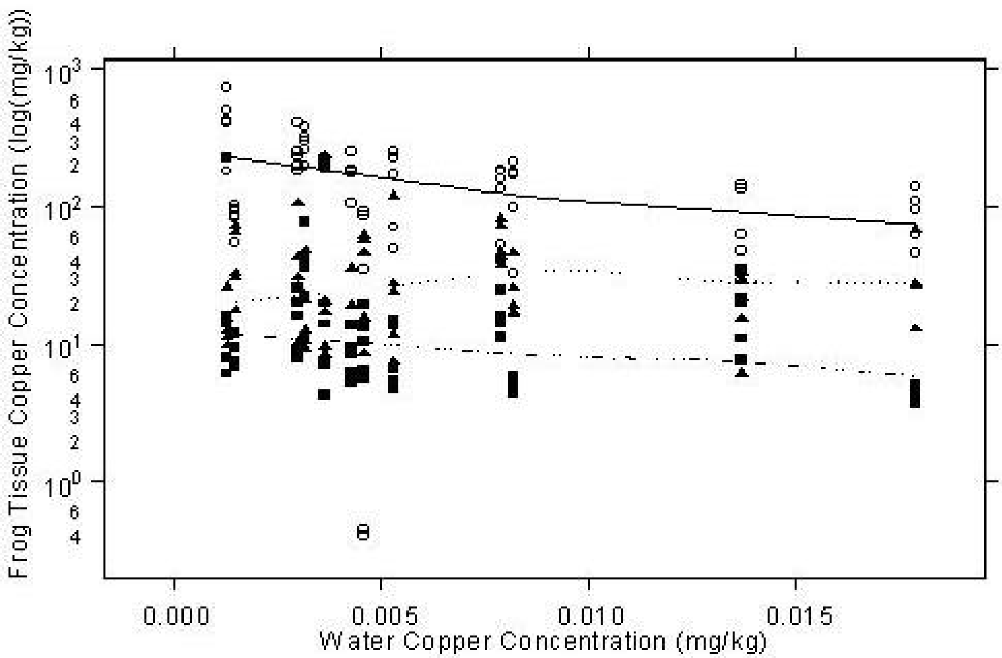


Figure 5 **Relationship between water cobalt concentration and frog tissue cobalt concentration (log-linear). Circles & solid line = liver, triangles & dotted line = GI tract, squares & dashed line = remaining carcass.**

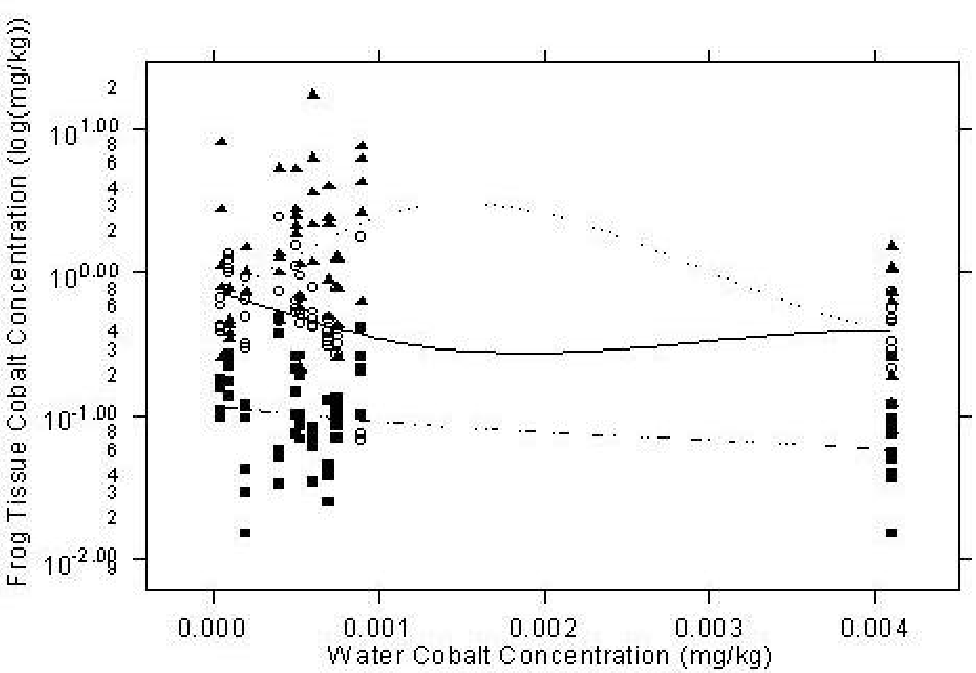


Figure 6 **Relationship between water cobalt concentration and frog carcass tissue cobalt concentration (log-linear). Circles & solid line = clay soil, triangles & dotted line = organic soil.**

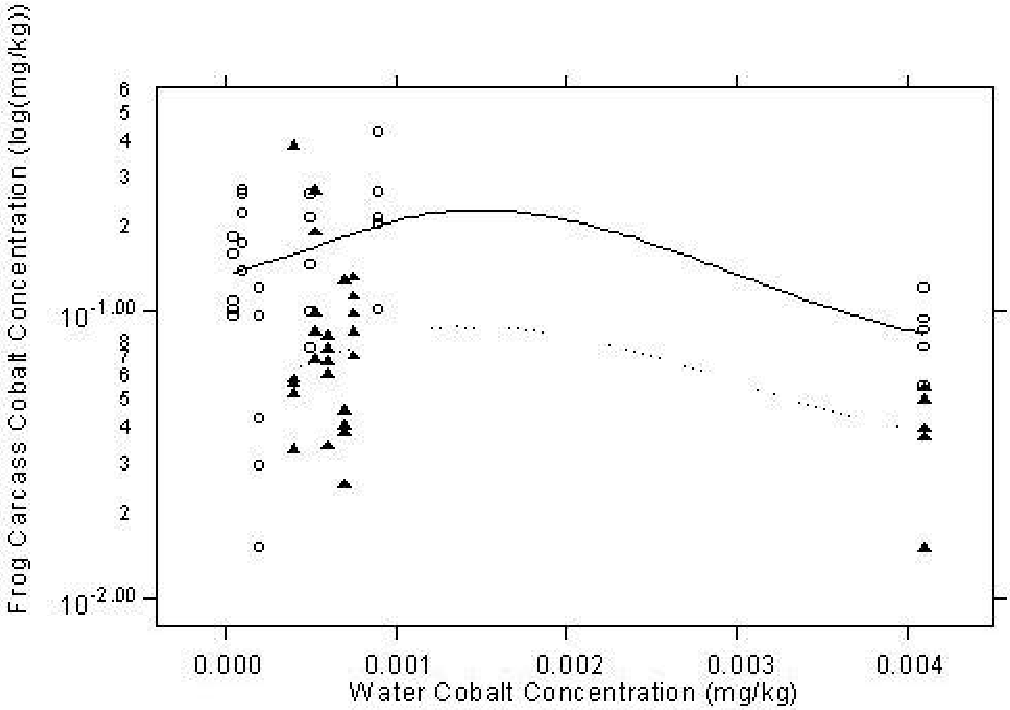


Figure 7 **Relationship between sediment nickel concentration and frog tissue nickel concentration (log-linear). Circles & solid line = liver, triangles & dotted line = GI tract, squares & dashed line = remaining carcass.**

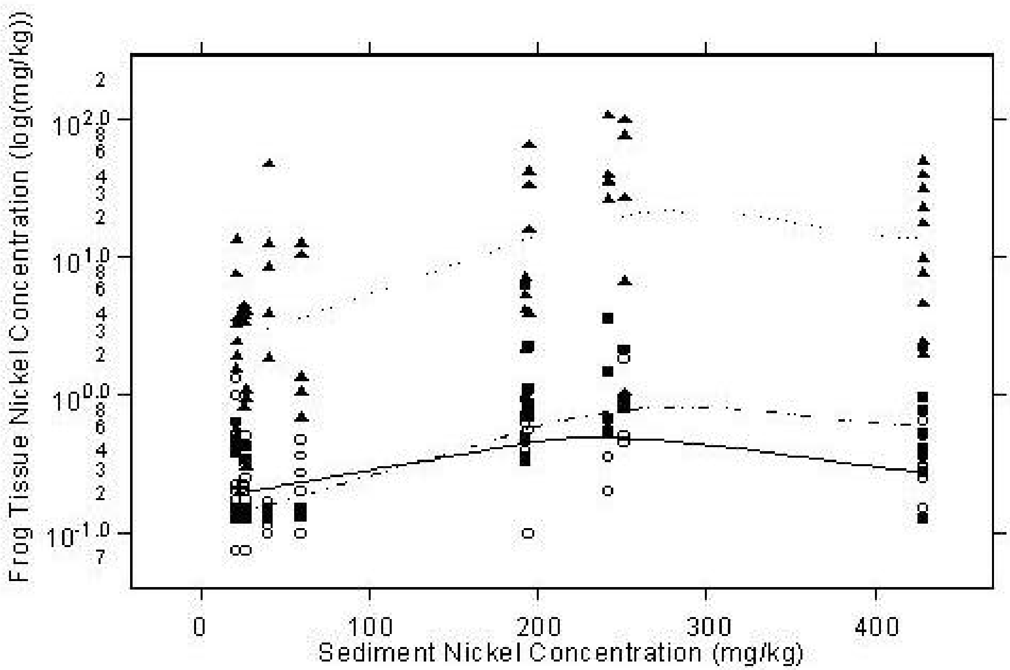


Figure 8 **Relationship between sediment nickel concentration and frog liver tissue nickel concentration (log-linear). Circles & solid line = clay soil, triangles & dotted line = organic soil.**

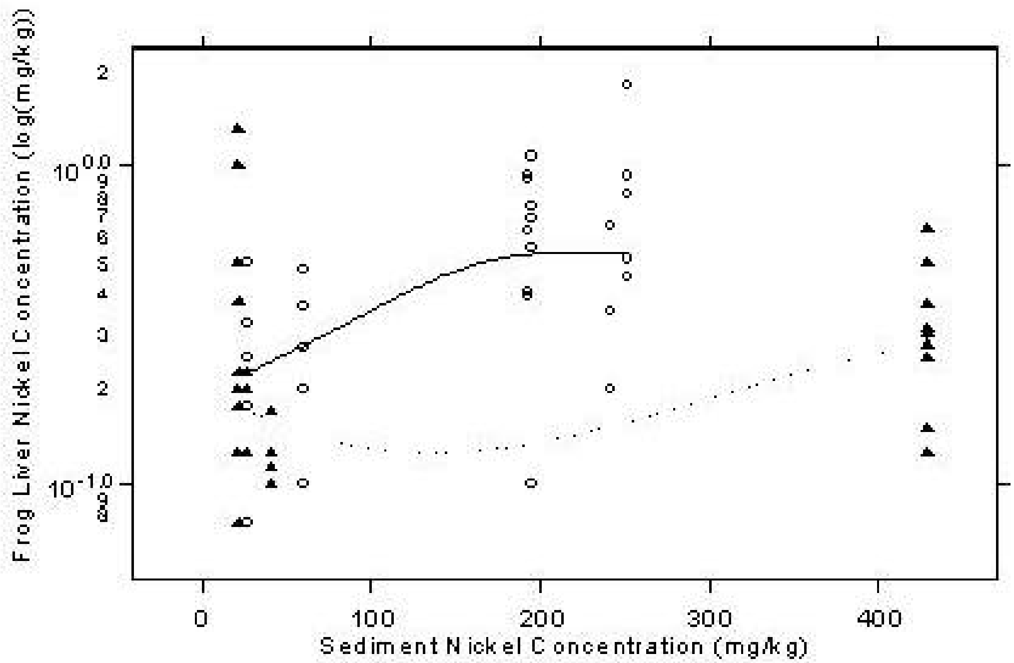


Figure 9 **Relationship between sediment nickel concentration and frog GI tract nickel concentration (log-linear). Circles & solid line = clay soil, triangles & dotted line = organic soil.**

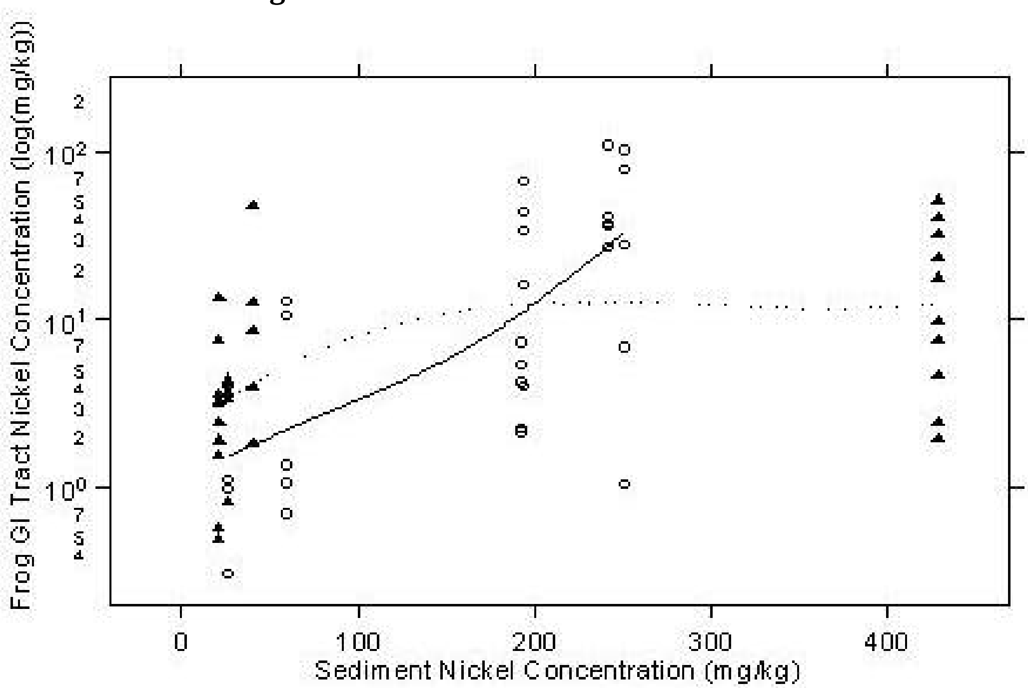


Figure 10 **Relationship between sediment nickel concentration and frog carcass tissue nickel concentration (log-linear). Circles & solid line = clay soil, triangles & dotted line = organic soil.**

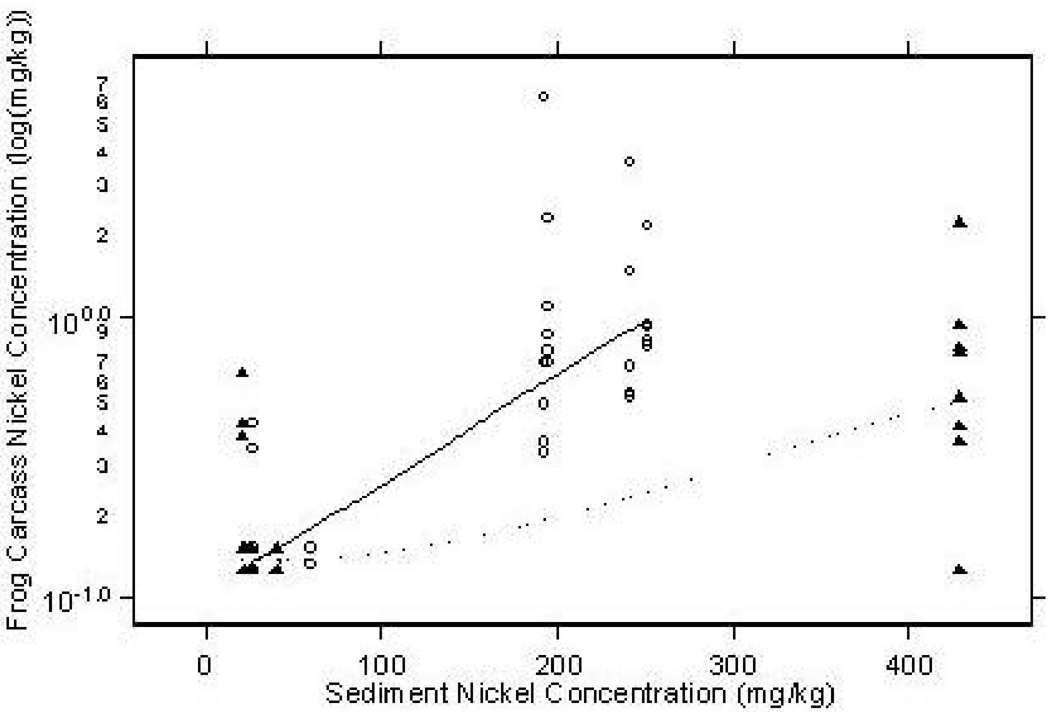


Figure 11 **Relationship between sediment copper concentration and frog tissue copper concentration (log-linear). Circles & solid line = liver, triangles & dotted line = GI tract, squares & dashed line = remaining carcass.**

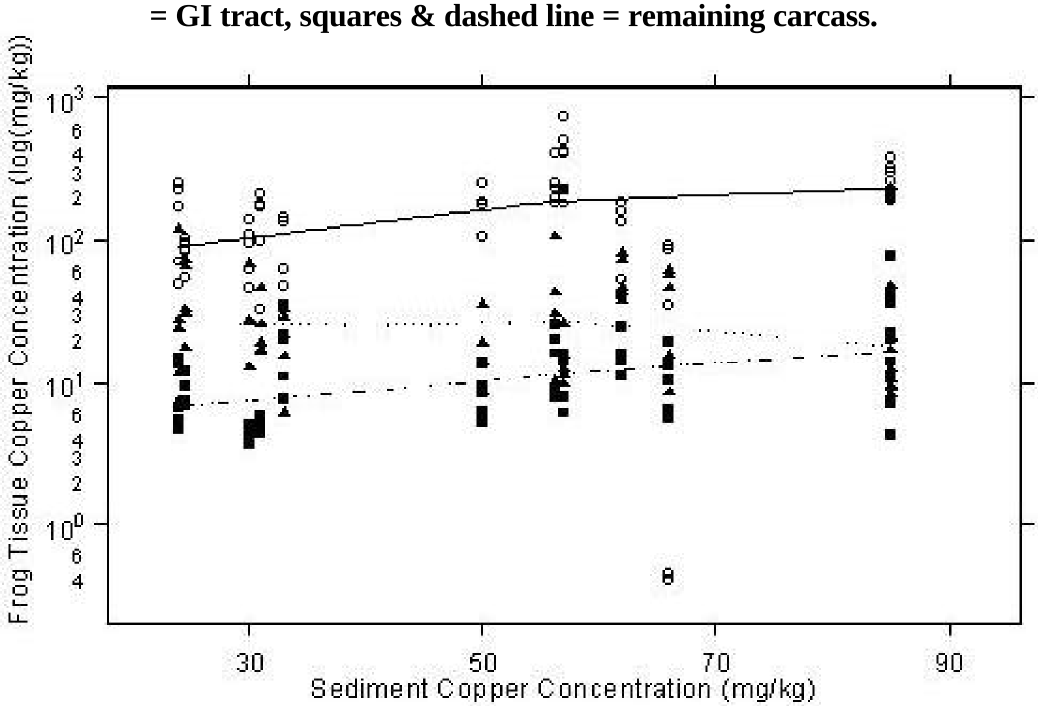


Figure 12 **Relationship between sediment cobalt concentration and frog tissue cobalt concentration (log-linear). Circles & solid line = liver, triangles & dotted line = GI tract, squares & dashed line = remaining carcass.**

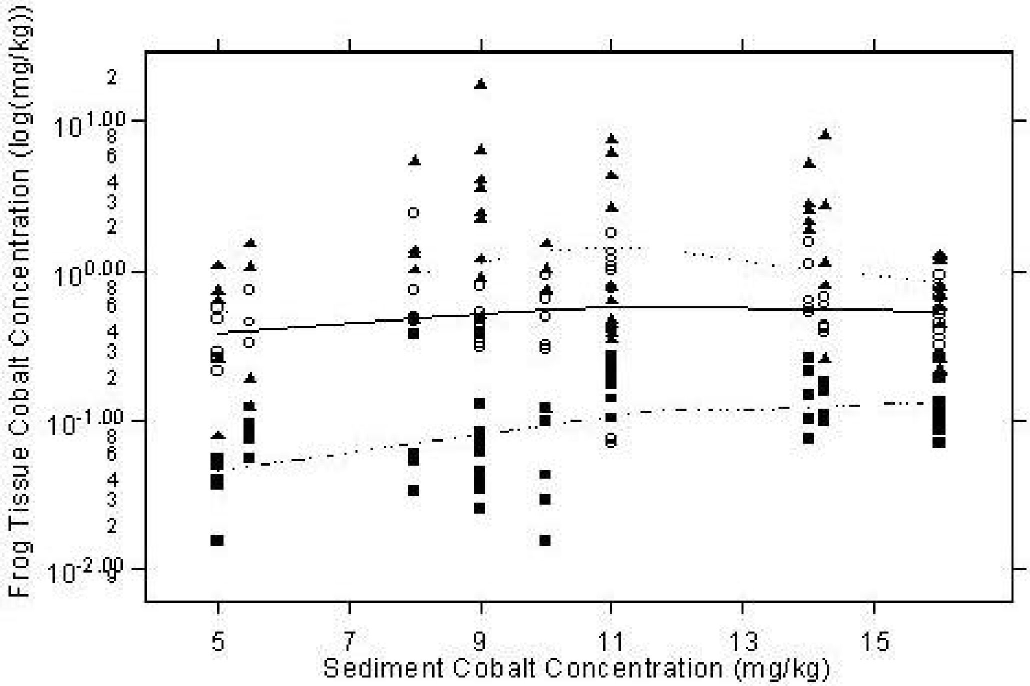


Figure 13 **Relationship between sediment cobalt concentration and frog GI tract cobalt concentration (log-linear). Circles & solid line = clay soil, triangles & dotted line = organic soil.**

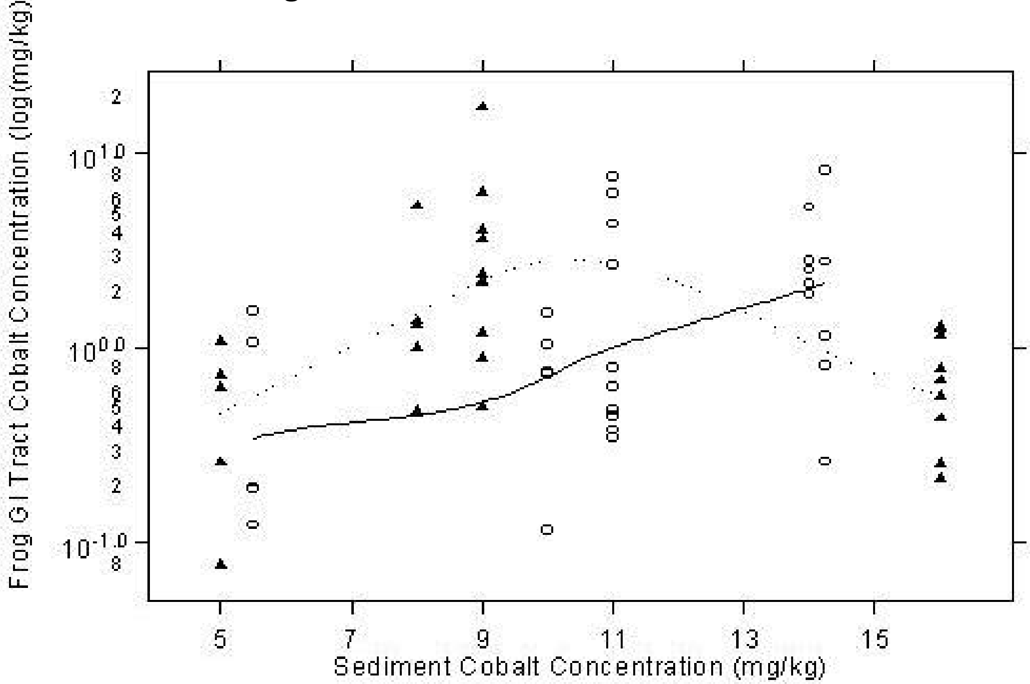


Figure 14 **Relationship between sediment arsenic concentration and frog tissue arsenic concentration (log-linear). Circles & solid line = liver, triangles & dotted line = GI tract, squares & dashed line = remaining carcass.**

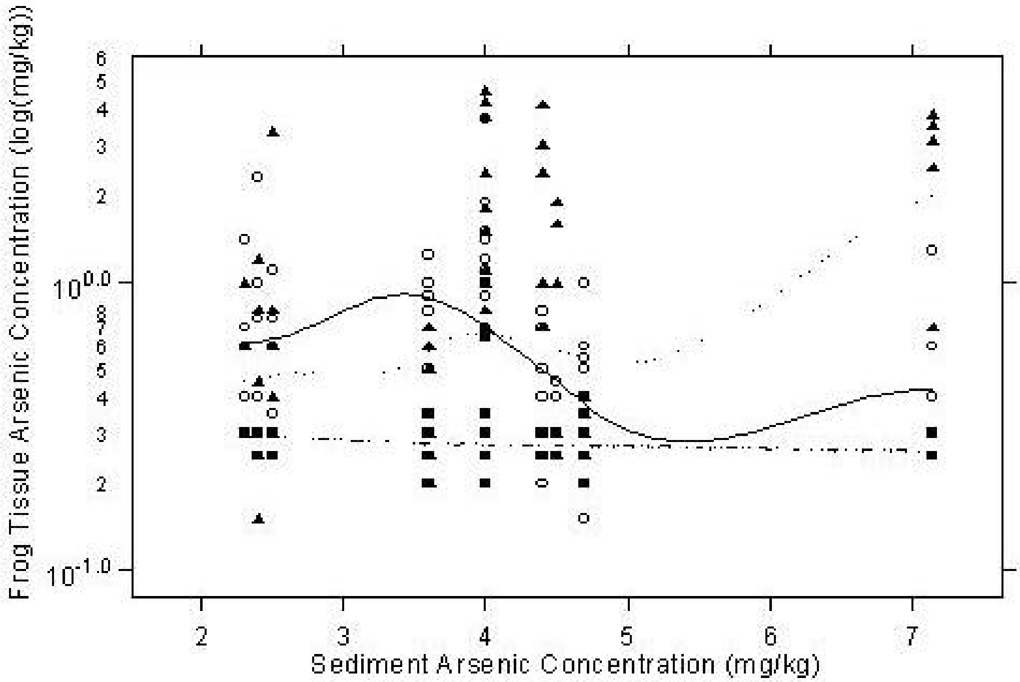


Figure 15 **Relationship between sediment arsenic concentration and frog liver arsenic concentration (log-linear). Circles & solid line = clay soil, triangles & dotted line = organic soil.**

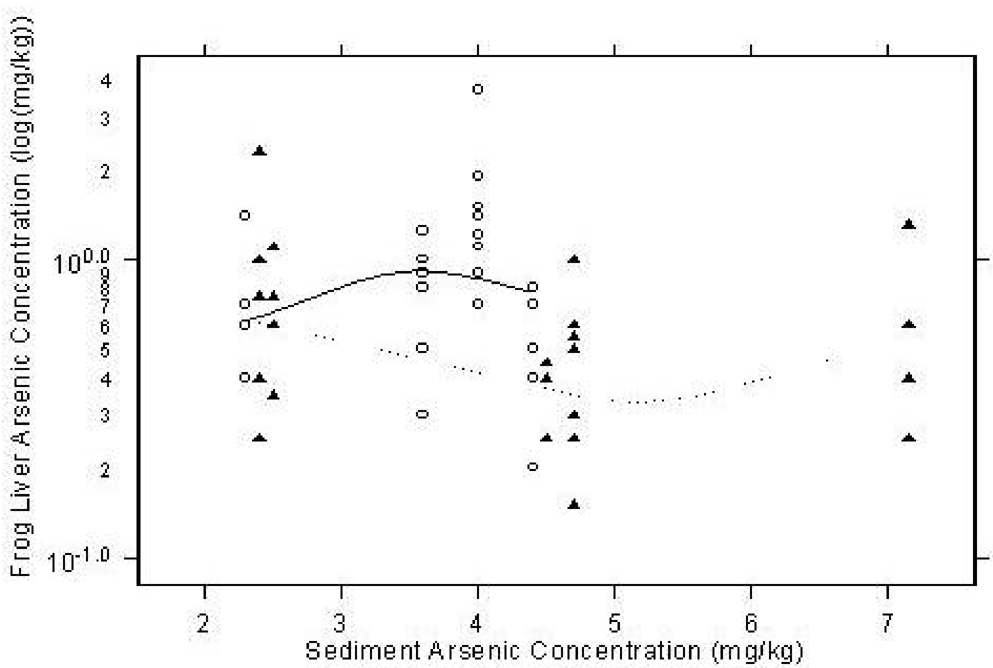
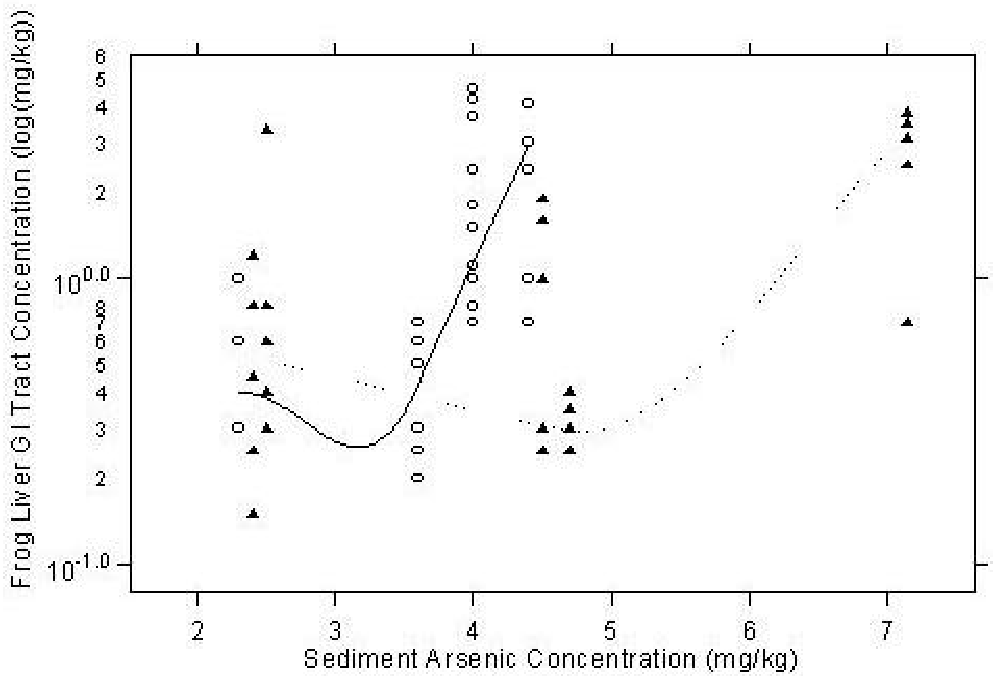


Figure 16 **Relationship between sediment arsenic concentration and frog GI tract arsenic concentration (log-linear). Circles & solid line = clay soil, triangles & dotted line = organic soil.**



1.2 Maple Tissues

To assess uptake of CoCs in maples, CoC concentrations in soil at each sample station were used as predictors to statistically assess relationships between these CoC concentrations and those found in maple leaf tissue. Figures 17 to 20 present the relationships between soil CoC concentrations and maple leaf CoC concentrations. Concentrations of nickel and cobalt in maple leaves were found to be influenced by concentrations of these CoCs in soils (Table 5), with each showing positive relationships between soil and leaf CoC concentrations (Figures 17 and 19). Although soil type did not significantly contribute to the models as a predictor, the interaction between soil type and CoC concentration was found to be significant for both cobalt and nickel (Table 5, Figures 17 and 19); the highest cobalt and nickel concentrations in maple leaves were achieved at lower soil concentrations on clay soils than on organic soils (Figures 17 and 19). This indicates that proportionally more cobalt and nickel may be available for maple uptake in clay soils than in organic soils, but more sampling may need to be done to clarify this relationship.

Table 5 Analysis of deviance table. The response variables are concentrations of nickel, copper, cobalt and arsenic in maple leaf tissue, log-transformed[1].

		Maple Leaf Ni Concentration		Maple Leaf Cu Concentration		Maple Leaf Co Concentration		Maple Leaf As Concentration	
Term	**df**	**Dev**	***p***	**Dev**	***p***	**Dev**	***p***	**Dev**	***p***
Null	51	96.51		8.73		46.17		9.54	
Soil CoC[2] Concentration	1	13.53	**<0.01**	0.57	0.06	6.04	**<0.01**	2.12	**<0.01**
Soil Type	1	0.02	0.88	0.13	0.37	0.67	0.26	0.09	0.45
Soil CoC[2] Concentration: Soil Type (Interaction)	1	32.70	**<0.01**	0.47	0.09	14.52	**<0.01**	0.01	0.85
Residual	48	50.26		7.56		24.95		7.32	

Notes

1 The models were fit as Gaussian. Bold type indicates an estimated p-value of ≤ 0.05. Further information on Analysis of Deviance is found in Volume II, Tab 18.

2 Relevant CoC for the model (e.g., soil nickel for maple leaf nickel)

A significant positive link between soil arsenic concentrations and maple leaf arsenic concentrations was found (Table 5). However, the majority of the arsenic concentrations were below the EQL and the relationship was driven by only three points (Figure 20; Volume III, Tab 3), which weakens any conclusions from these results. No significant influence of soil copper concentrations on concentrations in maple leaf tissue was noted.

Figure 17 **Relationship between soil nickel concentration and maple leaf tissue nickel concentration (log-linear). Circles & solid line = clay soil, triangles & dotted line = organic soil.**

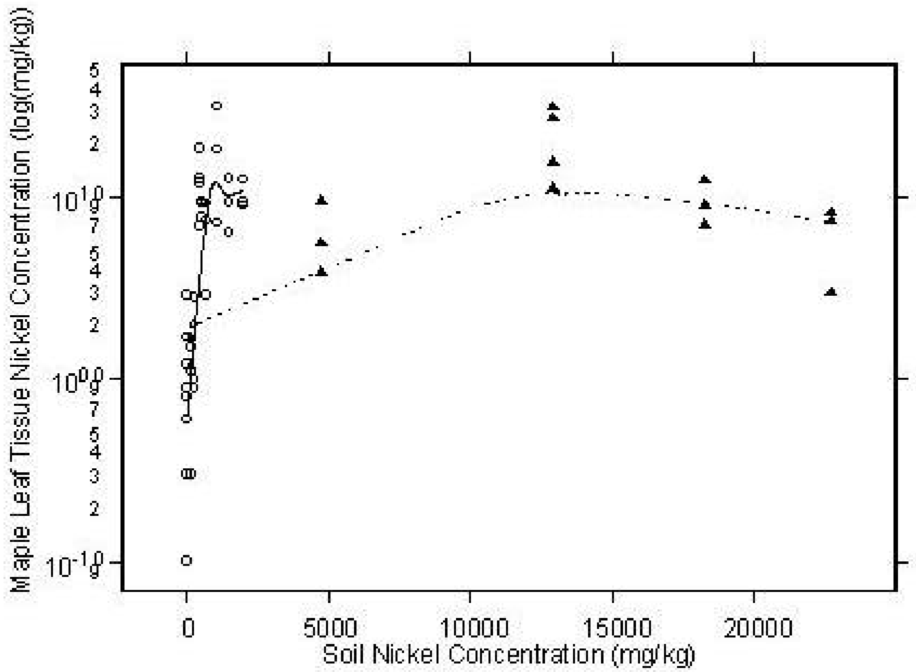


Figure 18 **Relationship between soil copper concentration and maple leaf tissue copper concentration (log-linear). Circles & solid line = clay soil, triangles & dotted line = organic soil.**

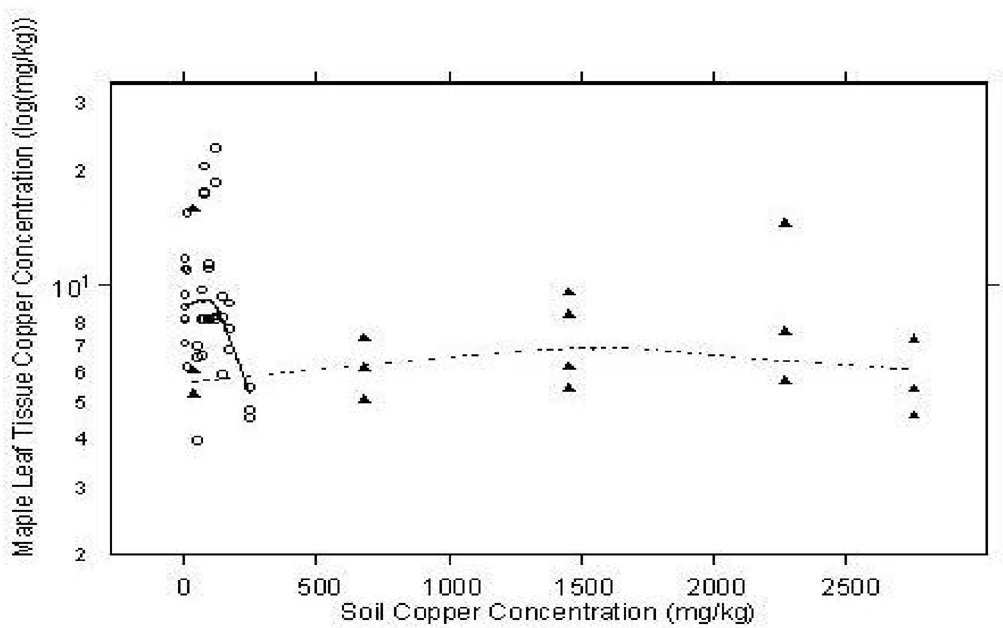


Figure 19 **Relationship between soil cobalt concentration and maple leaf tissue cobalt concentration (log-log). Circles & solid line = clay soil, triangles & dotted line = organic soil.**

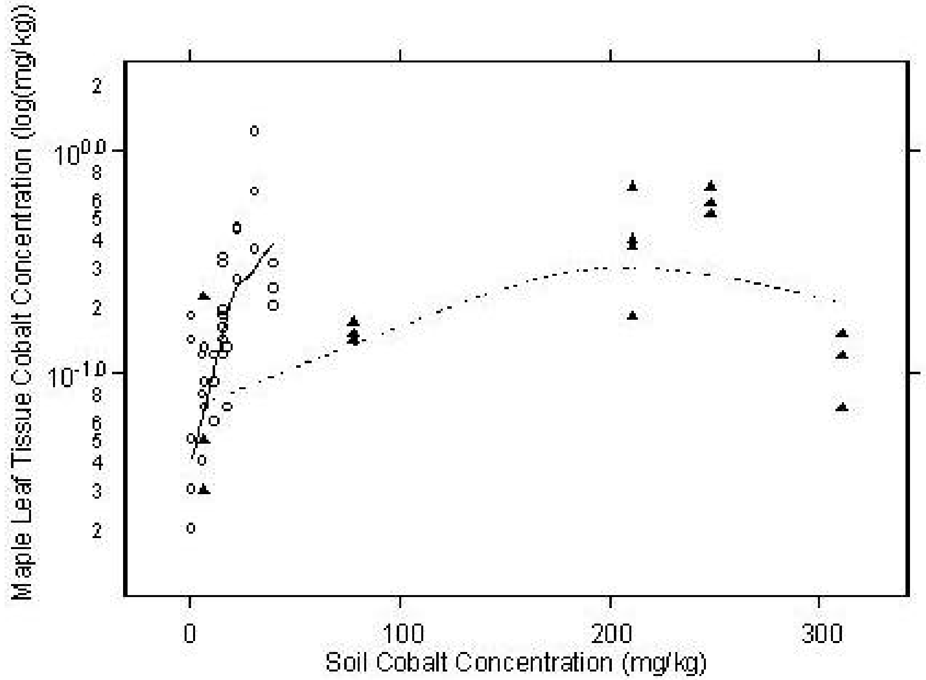
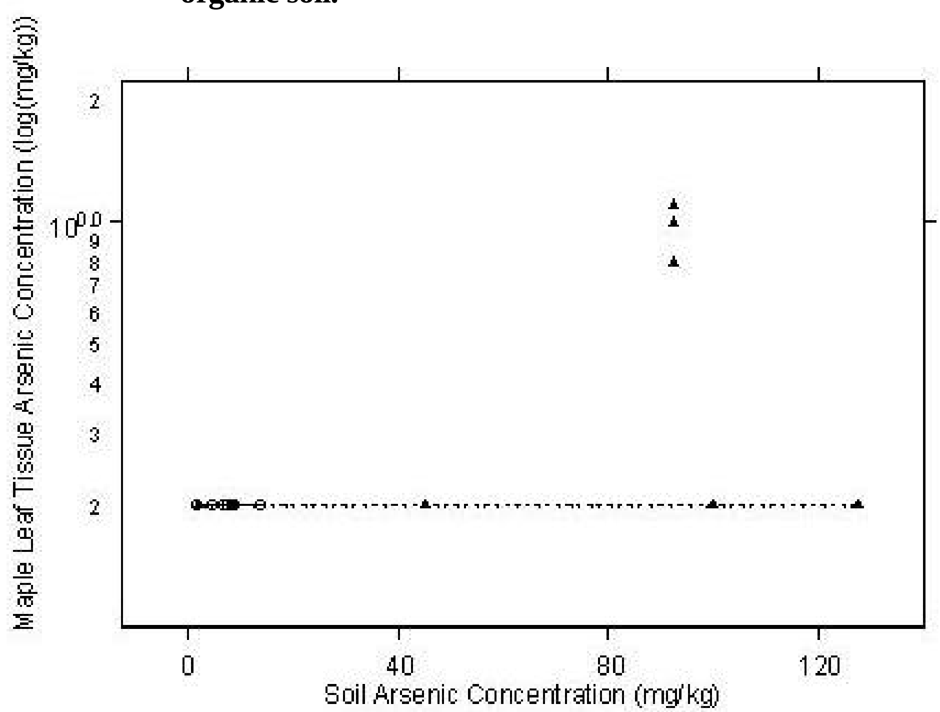


Figure 20 **Relationship between soil arsenic concentration and maple leaf tissue arsenic concentration (log-log). Circles & solid line = clay soil, triangles & dotted line = organic soil.**



1.3 Earthworm Tissue

For earthworm CoC data collected in 2001, the influence of soil CoC concentrations, soil type and habitat were examined statistically using *glm*. Despite the differences seen between habitats in Chapter 6, habitat does not appear to be a significant predictor (Table 6), and soil type appears to be an influence only on copper uptake (Table 6): whole earthworms on clay soils had greater copper concentrations at lower soil copper concentrations than worms on organic soils (Figure 22). Only nickel and copper in earthworms were apparently influenced by concentrations in soil (Table 6, Figures 21 and 22). Nickel uptake appears to decrease once soil nickel concentrations reach approximately 1000 mg/kg, as seen on the log-linear plot presented in Figure 21. Although earthworm arsenic concentration did not appear to be related to soil arsenic concentration, there was an interaction noted between habitat and soil type for arsenic concentrations in worms (Table 6). Sample size was small but the data indicate that earthworms in woodlots on organic soil may have higher arsenic concentrations than worms on clay soils or in fields (Figure 24).

Table 6 Analysis of deviance table. The response variables are concentrations of nickel, copper, cobalt and arsenic in whole earthworms sampled in 2001, log-transformed[2].

		Earthworm Ni Concentration		**Earthworm Cu Concentration**		**Earthworm Co Concentration**		**Earthworm As Concentration**	
Term	**Df**	**Dev**	***P***	**Dev**	***p***	**Dev**	***p***	**Dev**	***p***
Null	12	25.28		5.8		3.7		11.08	
Soil CoC[1] Concentration	1	13.97	**<0.01**	3.69	**<0.01**	0.69	0.16	0.67	0.33
Soil Type	1	3.02	0.11	0.42	0.06	1.07	0.09	0.05	0.77
Habitat	1	0.21	0.64	0.01	0.7	0.03	0.73	<0.01	0.96
Soil CoC[1] Concentration: Soil Type (Interaction)	1	2.65	0.13	1.10	**<0.01**	0.32	0.31	2.17	0.10
Soil CoC[1] Concentration: Habitat (Interaction)	1	0.09	0.76	0.05	0.47	<0.01	0.90	1.24	0.20
Soil Type: Habitat (Interaction)	1	0.10	0.74	0.05	0.44	<0.01	1.00	3.42	**0.05**
Residual	6	5.23		0.47		1.58		3.54	

Notes

1 Relevant CoC for the model (e.g., soil nickel for earthworm nickel).

2 The models were fit as Gaussian. Bold type indicates an estimated p-value of ≤ 0.05. Further information on Analysis of Deviance is found in Volume II, Tab 18.

Figure 21 **Relationship between soil nickel concentration and whole earthworm nickel concentration (log-linear), based on samples from 2001.**

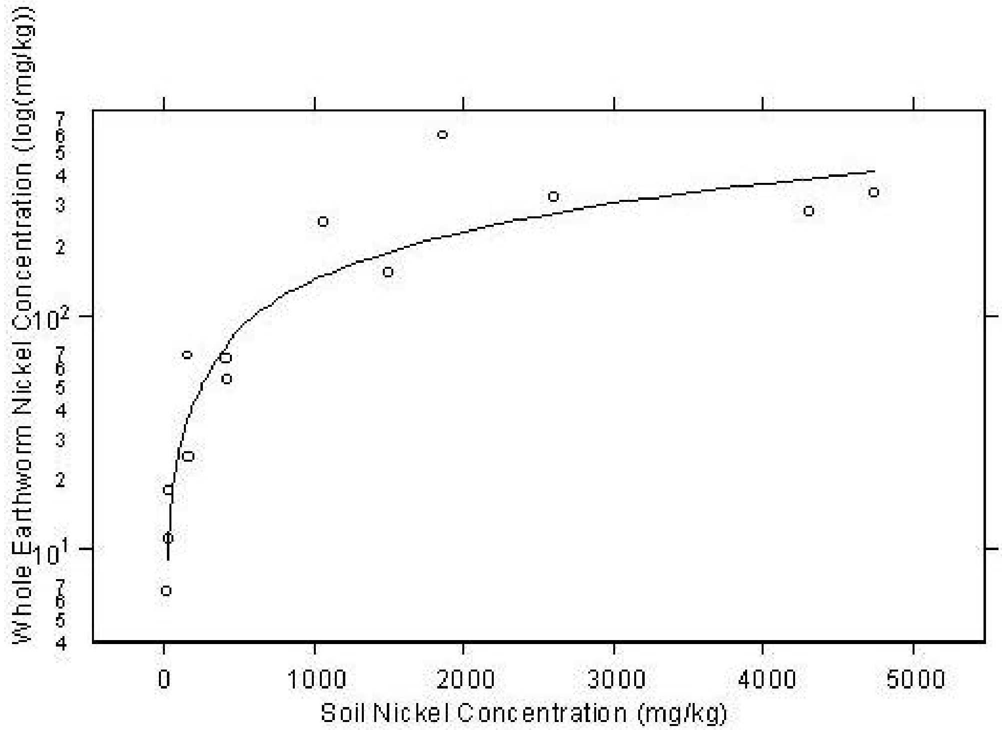


Figure 22 **Relationship between soil copper concentration and whole earthworm tissue copper concentration (log-linear), based on samples from 2001. Circles & solid line = clay soil, triangles & dotted line = organic soil.**

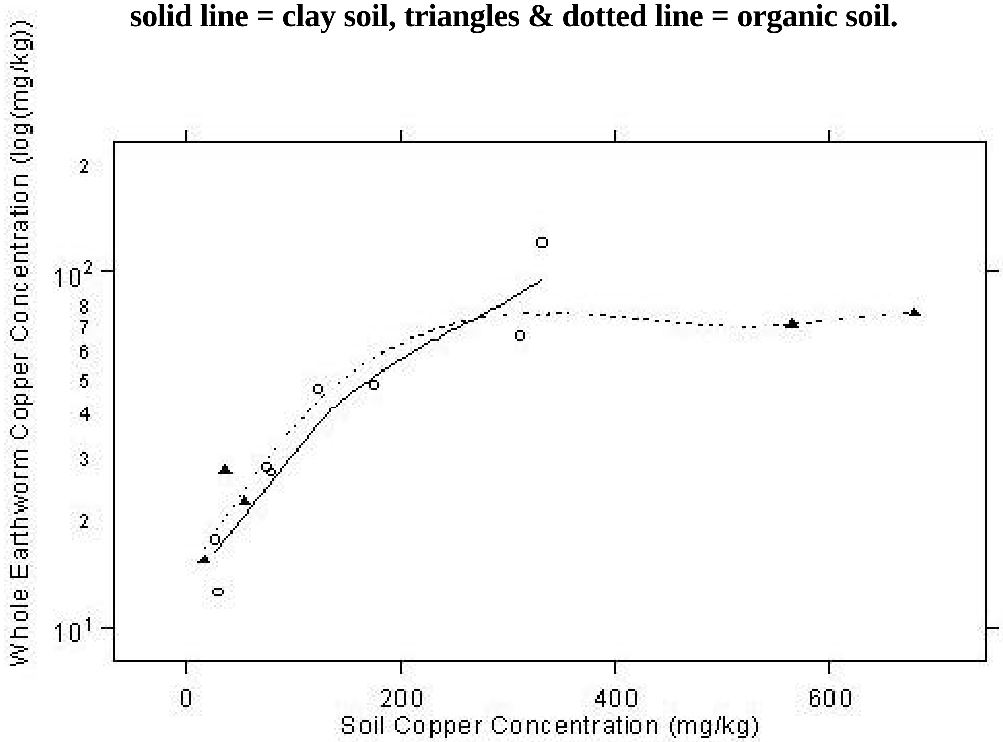


Figure 23 **Relationship between soil cobalt concentration and whole earthworm tissue cobalt concentration (log-linear), based on samples from 2001.**

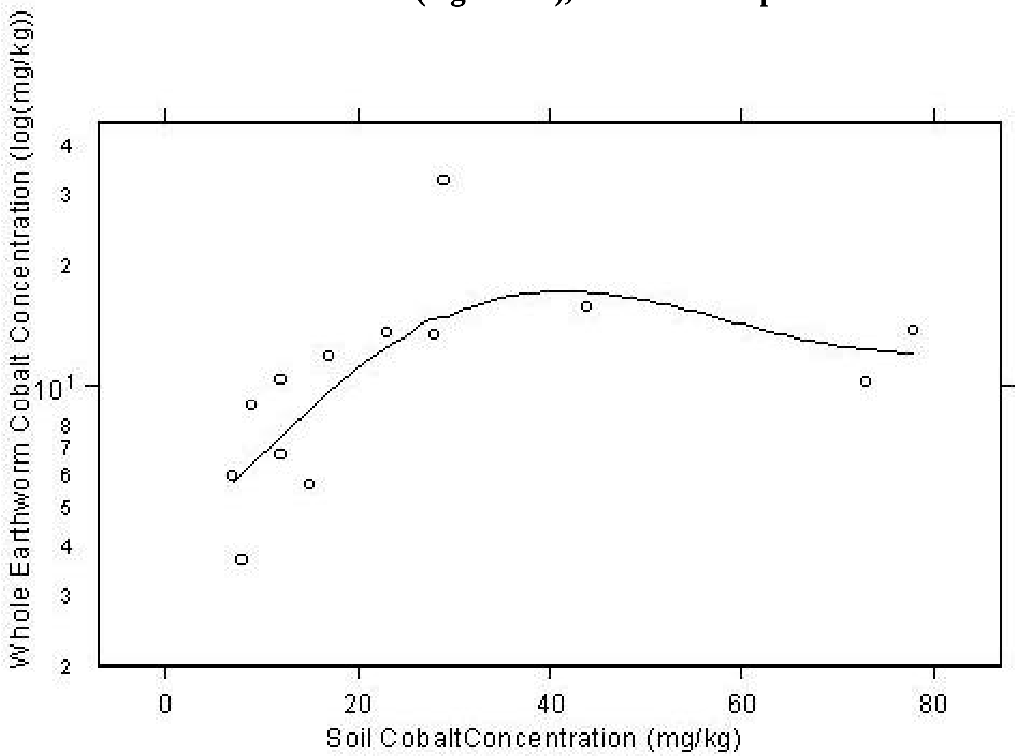
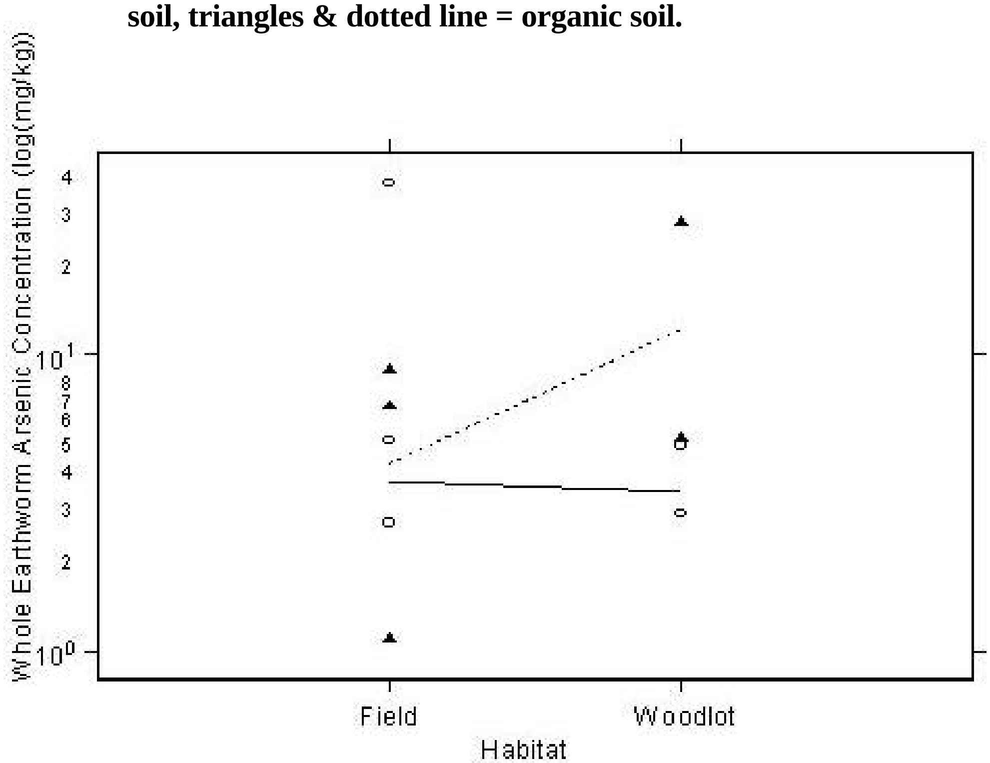


Figure 24 **Relationship between habitat and whole earthworm tissue arsenic concentration (log), based on samples from 2001. Circles & solid line = clay soil, triangles & dotted line = organic soil.**



The influence of soil type on tissue CoC concentrations in whole earthworms is difficult to explain, and further investigation with an increase in sample size was deemed appropriate. Earthworms were sampled at 30 sites in field habitats across the Primary Study Area, Secondary Study Area and Reference Area during June 2002 (Volume II, Tab 10). On average, 21 earthworms were sampled from each site and submitted to PSC for chemical analyses, accompanied by separate soil samples collected at each sample site. Section 6.4.3.4 presents a summary of the 2002 earthworm data on organic and clay soils.

An examination of the relationship between soil and whole earthworm CoC concentrations revealed a difference between the 2001 and 2002 sampling seasons. Contrary to the 2001 results, statistically significant relationships between whole earthworm and soil CoC concentrations were found for all CoCs (Table 7, Figures 25 to 28). Additionally, soil type had an apparent influence on both copper and cobalt worm concentrations, as shown in Figures 26 and 27. As seen in the 2001 data for copper, earthworms in clay soils had higher concentrations of copper and cobalt than earthworms sampled from organic soils with the same soil CoC concentrations (Figures 26 and 27). Although overall higher concentrations of CoCs were found in worms sampled from organic soils, these were collected from sites with markedly higher soil CoC concentrations (Section 6.4.3.4). Since the sampling was restricted to field habitats in 2002, these relationships pertain to this habitat type only. However, habitat was not an important predictor based on the 2001 data, so it is likely these relationships hold true for woodlot habitat also.

Table 7 Analysis of deviance table. The response variables are concentrations of nickel, copper, cobalt and arsenic in whole earthworms sampled in 2002, log-transformed[2].

		Earthworm Ni Concentration		Earthworm Cu Concentration		Earthworm Co Concentration		Earthworm As Concentration	
Term	**df**	**Dev**	***p***	**Dev**	***p***	**Dev**	***p***	**Dev**	***p***
Null	29	73.08		22.64		18.60		11.96	
Soil CoC[1] Concentration	1	50.05	**<0.01**	18.56	**<0.01**	12.98	**<0.01**	8.85	**<0.01**
Soil Type	1	0.14	0.69	0.04	0.60	1.15	**0.01**	0.10	0.33
Soil CoC[1] Concentration: Soil Type (Interaction)	1	0.40	0.50	0.84	**0.01**	0.82	**0.02**	0.39	0.06
Residual	26	22.48		3.19		3.65		2.62	

Notes

1 Relevant CoC for the model (e.g., soil nickel for earthworm nickel).

2 The models were fit as Gaussian. Bold type indicates an estimated p-value of ≤ 0.05. Further information on Analysis of Deviance is found in Volume II, Tab 18.

Figure 25 **Relationship between soil nickel concentration and whole earthworm tissue nickel concentration (log-linear), based on samples from 2002. Circles & solid line = clay soil, triangles & dotted line = organic soil.**

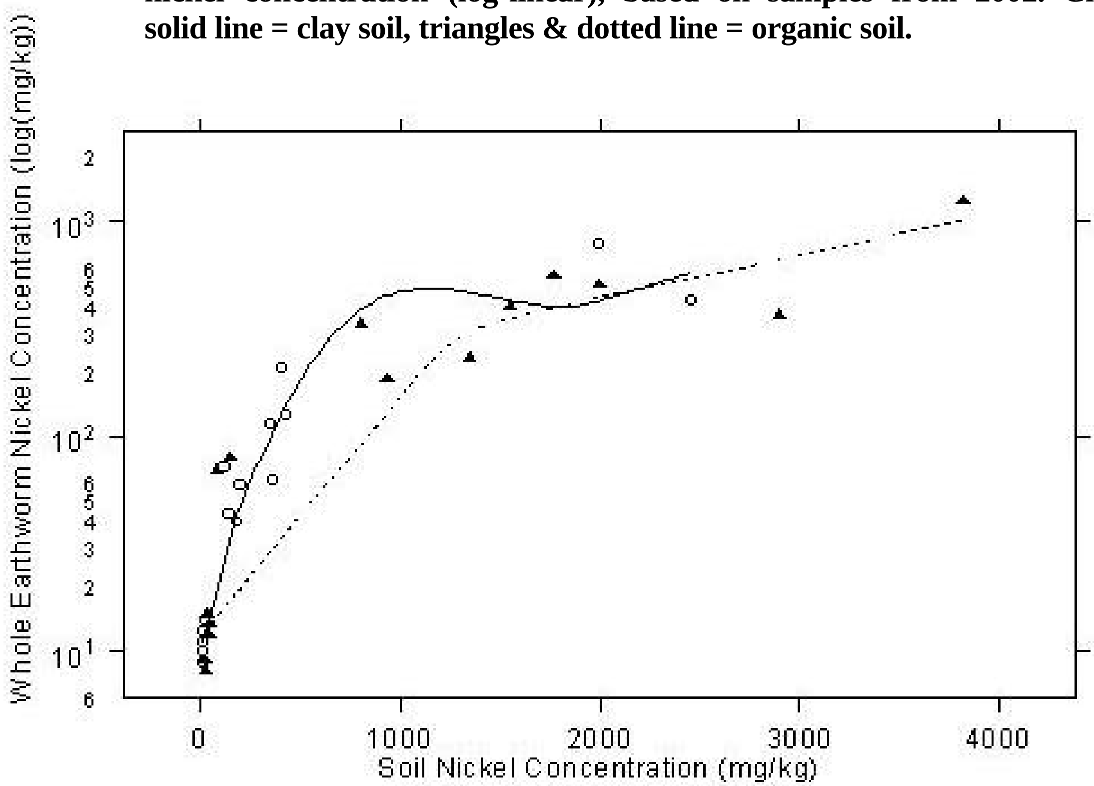


Figure 26 **Relationship between soil copper concentration and whole earthworm tissue copper concentration (log-linear), based on samples from 2002. Circles & solid line = clay soil, triangles & dotted line = organic soil.**

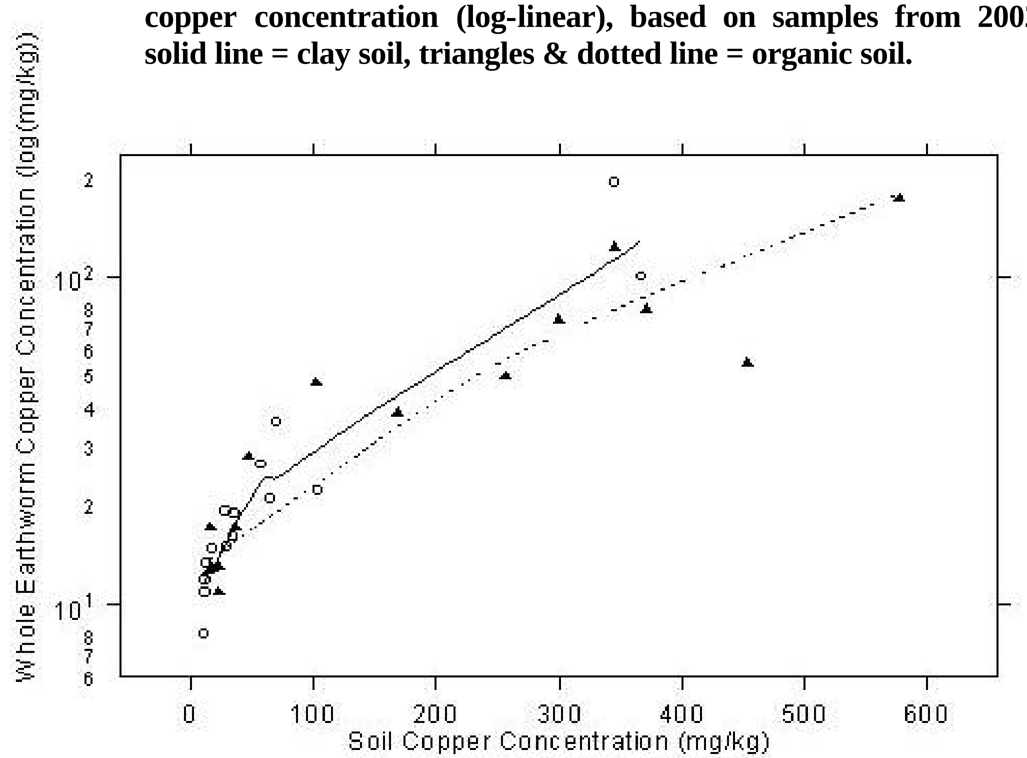


Figure 27 **Relationship between soil cobalt concentration and whole earthworm tissue cobalt concentration (log-linear), based on samples from 2002. Circles & solid line = clay soil, triangles & dotted line = organic soil.**

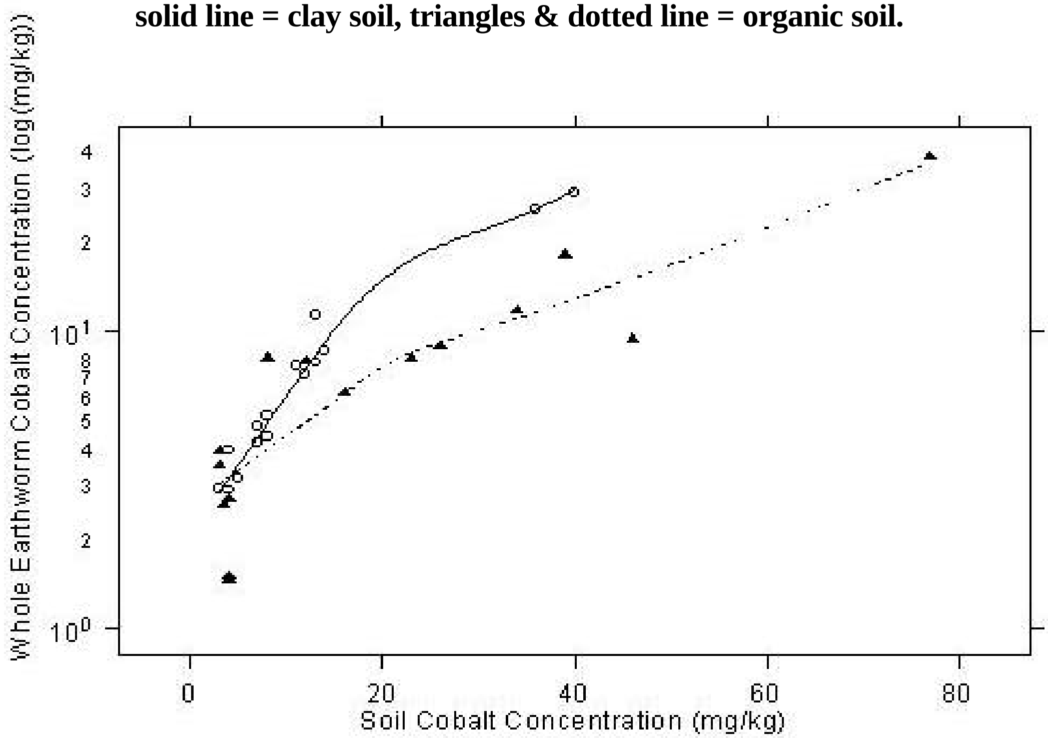
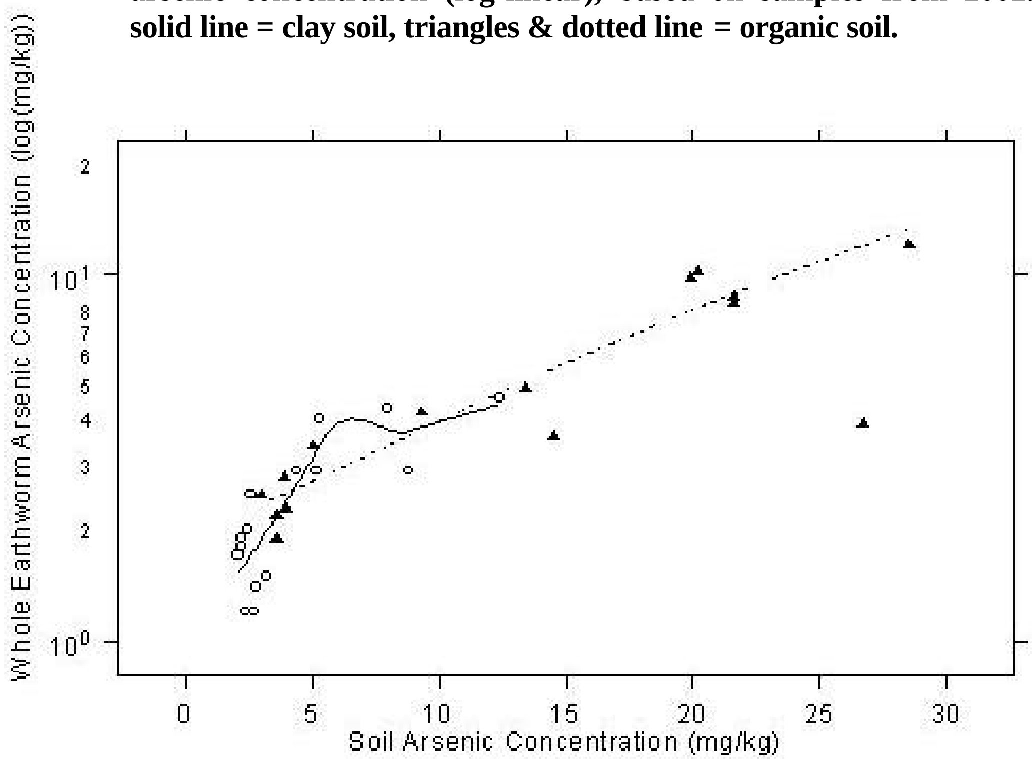


Figure 28 **Relationship between soil arsenic concentration and whole earthworm tissue arsenic concentration (log-linear), based on samples from 2002. Circles & solid line = clay soil, triangles & dotted line = organic soil.**



1.4 Arthropod Tissue

Arthropods (insects and spiders) were sampled from both fields and woodlots in the Primary and Secondary Study Areas and at sites in the Reference Study Area. Certain groups of arthropods were initially sorted from the samples (spiders from woodlot samples, grasshoppers from field samples) and submitted separately for chemical analyses. Chemical analysis of grasshopper tissue proved to be problematic, especially in the homogenisation stage of the process, but by subsequently analysing all parts of each grasshopper sample, the average for each sample counters problems with homogenisation. The remainders of the samples were also submitted for chemical analyses and a composite value for each site was determined through weighted averaging based on sample mass.

The relationships between soil CoC concentrations and arthropod tissue CoC concentrations were examined using *glm* (Table 8). Figures 29 to 32 plot arthropod tissue CoC concentrations against CoC concentrations found in soil. Soil concentrations influence tissue concentrations for nickel and cobalt (Figure 29 and 31), but there is no influence of soil type or habitat (Table 8). However, arthropod copper concentrations appear to be influenced by soil type and habitat, as shown in Figure 33, where arthropods in woodlots have lower copper concentrations than arthropods in fields, and lower copper concentrations in areas with organic soil than in areas with clay soil. Arthropod arsenic concentrations were not linked to soil arsenic concentrations, but an interaction between habitat and soil type was noted (Table 8). Whereas there was no difference between woodlots with respect to arthropod arsenic concentrations, organic fields hosted arthropods with higher arsenic concentrations than those found in clay fields (Figure 6-51).

Table 8 Analysis of deviance table. The response variables are concentrations of nickel, copper, cobalt and arsenic in arthropod tissue, log-transformed. The models were fit as Gaussian. Bold type indicates a p-value of £ 0.05.

		Arthropod Ni Concentration		Arthropod Cu Concentration		Arthropod Co Concentration		Arthropod As Concentration	
Term	**Df**	**Dev**	***p***	**Dev**	***p***	**Dev**	***p***	**Dev**	***p***
Null	26	51.00		6.20		21.01		7.91	
Soil CoC[1] Concentration	1	16.62	**<0.01**	0.21	0.07	5.90	**<0.01**	0.53	0.12
Soil Type	1	1.35	0.36	0.34	**0.02**	0.80	0.25	0.67	0.09
Habitat	1	0.03	0.89	4.37	**<0.01**	0.37	0.44	<0.01	0.89
Soil CoC[1] Concentration: Soil Type (Interaction)	1	0.20	0.72	0.16	0.11	0.16	0.61	0.07	0.56
Soil CoC[1] Concentration: Habitat (Interaction)	1	1.74	0.30	0.02	0.58	1.52	0.12	0.83	0.06
Soil Type: Habitat (Interaction)	1	0.47	0.58	<0.01	0.78	0.58	0.33	1.70	**<0.01**
Residual	20	30.59		1.11		11.67		4.10	

1 Relevant CoC for the model (e.g., soil nickel for tissue nickel, soil copper for tissue copper) Further information on Analysis of Deviance is found in Volume II, Tab 18.

Figure 29 **Relationship between soil nickel concentration and arthropod tissue nickel concentration (log-linear).**

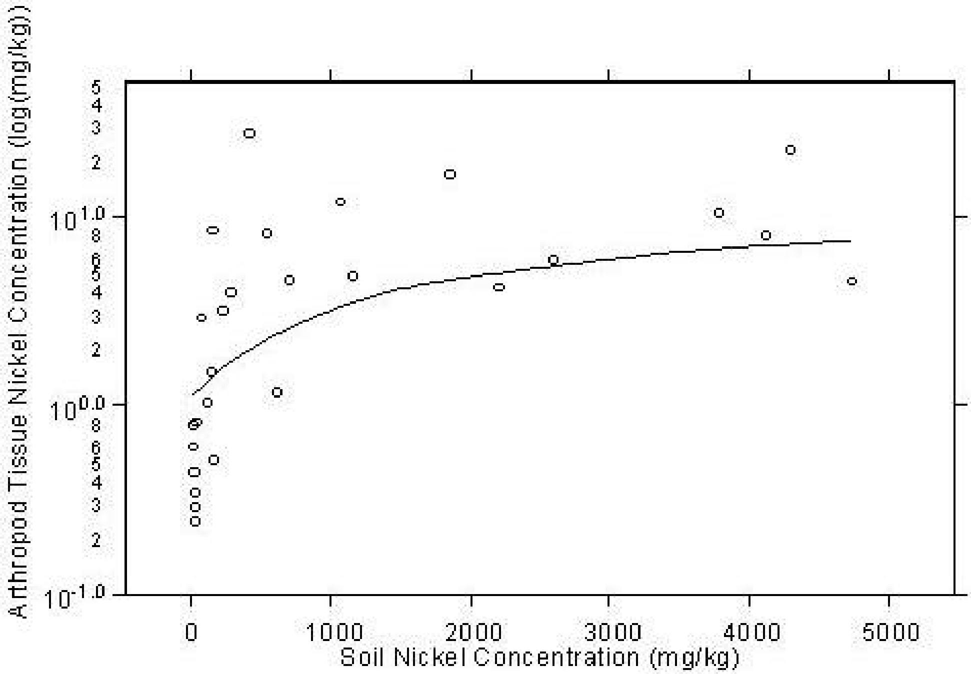


Figure 30 **Relationship between soil copper concentration and arthropod tissue copper concentration (log-linear).**

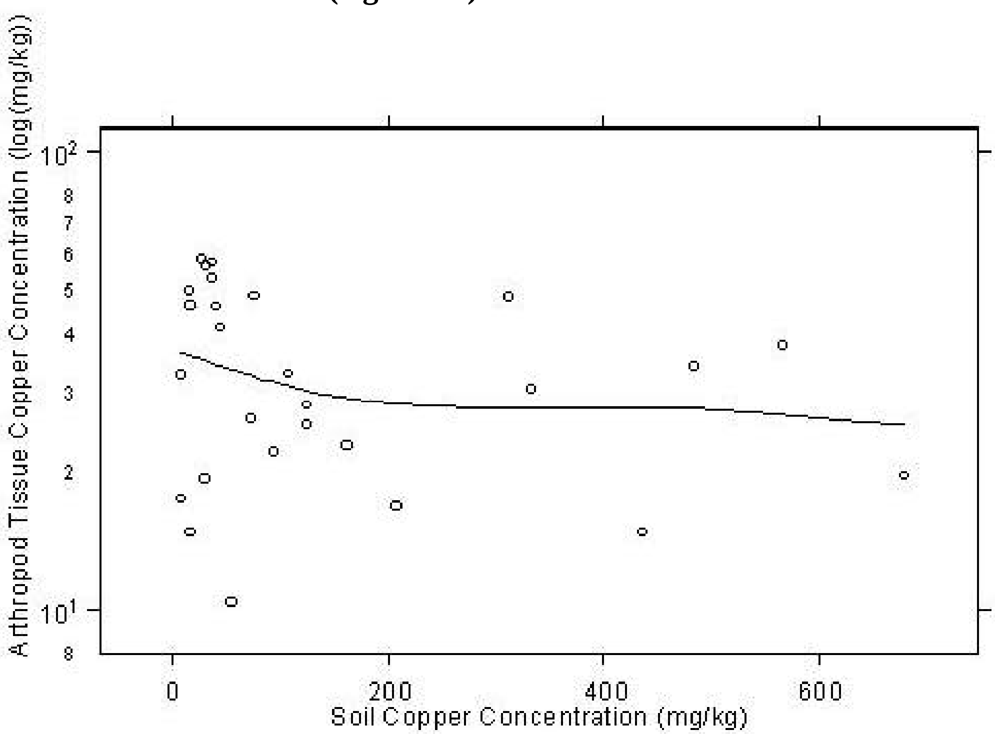


Figure 31 **Relationship between soil cobalt concentration and arthropod tissue cobalt concentration (log-linear).**

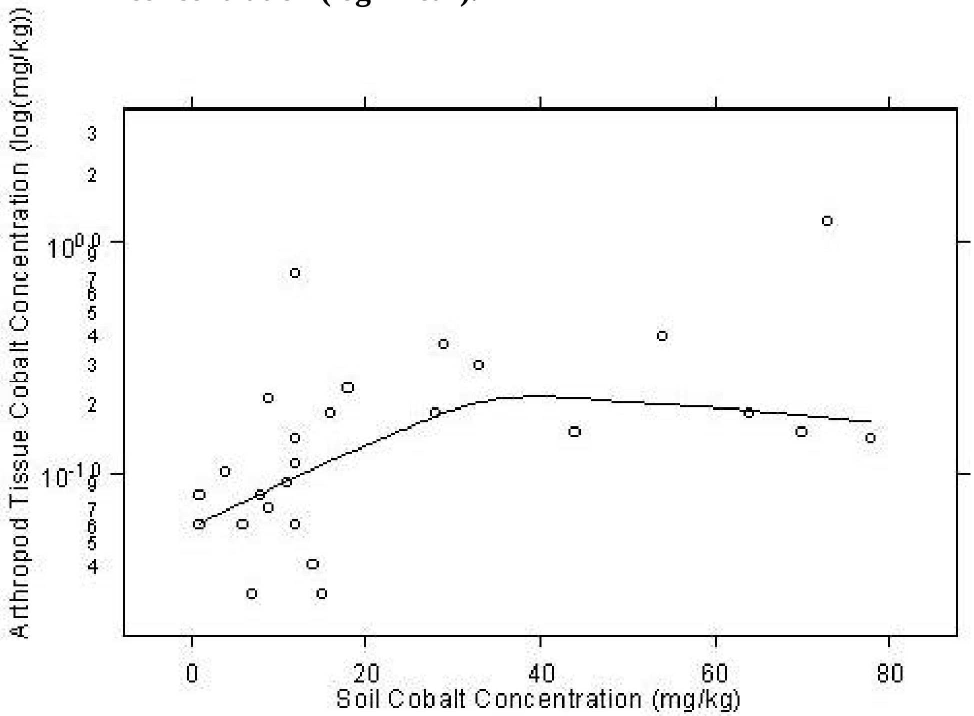


Figure 32 **Relationship between soil arsenic concentration and arthropod tissue arsenic concentration (log-linear). Circles & solid line = fields, triangles & dotted line = woodlots.**

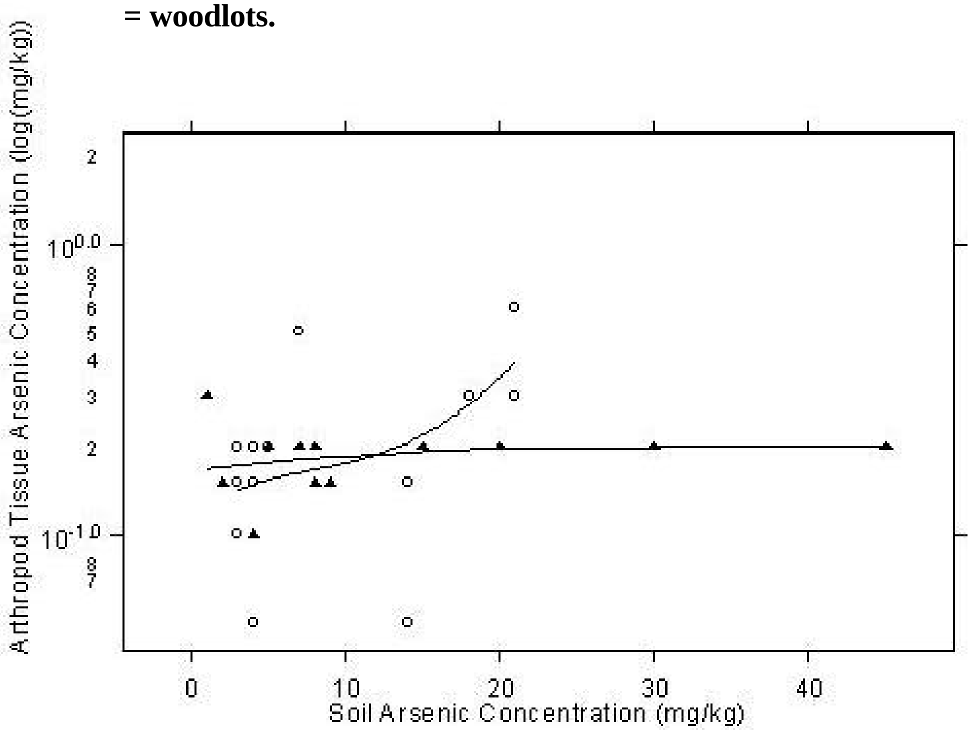


Figure 33 **Interaction between soil type and habitat for arthropod tissue copper concentration (log). Circles & solid line = field, triangles & dotted line = woodlot.**

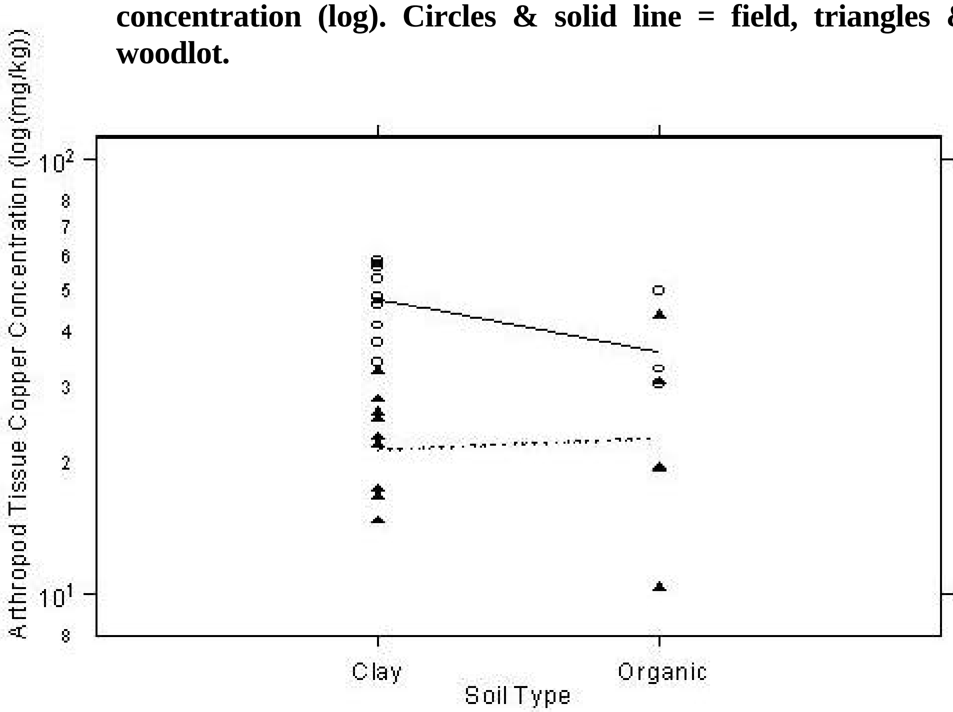
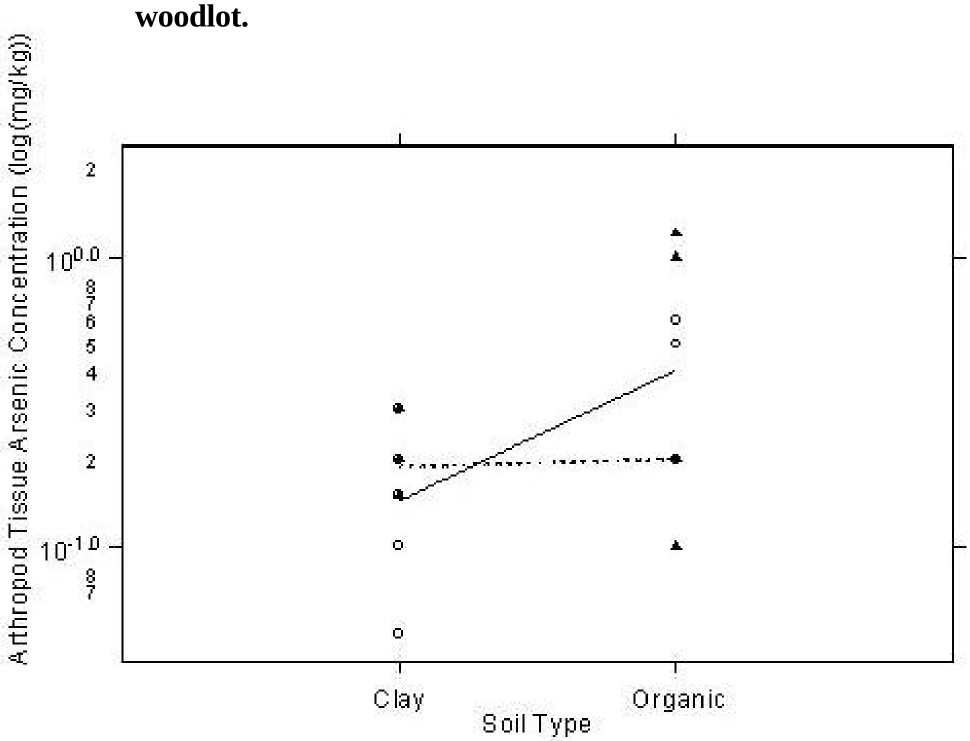


Figure 34 **Interaction between soil type and habitat for arthropod tissue arsenic concentration (log). Circles & solid line = field, triangles & dotted line = woodlot.**



1.5 Meadow Vole Tissue

Meadow Voles were sampled in the Primary and Reference Study Areas, and two tissue samples were analysed for each vole: liver tissue and the remaining carcass. Although attempts were made to sample voles in the Secondary Study Area, only one vole was captured; CoC concentrations from this vole were included in the *glm* analysis.

Figures 35 to 38 plot tissue CoC concentrations against CoC concentrations found in soil. Meadow Voles were only sampled in field habitat, so the influence of habitat type on CoC uptake was not assessed. Similarly, the influence of soil type on CoC uptake was not assessed; despite sampling in fields on organic soils and clay soils, voles were only captured in fields on clay soils.

Of the four CoCs, nickel and cobalt concentrations in soil significantly contributed to those CoC concentrations in vole tissue (Table 9). As soil nickel concentration increased, nickel concentrations in both liver tissue and remaining carcasses increased, as shown on the log-linear plot in Figure 35. Cobalt concentrations in soil and both liver and remaining carcasses were influenced also, although the relationship differs; the greatest accumulation of cobalt in vole tissues occurs at soil CoC concentrations exceeding 20 mg/kg (Figure 37). Despite the plots, tissue copper and arsenic concentrations were not influenced by CoC concentrations in soil (Volume III, Tab 3).

Table 9 Analysis of deviance table. The response variables are concentrations of nickel, copper, cobalt and arsenic in Meadow Vole tissue, log-transformed.

		Vole Liver Ni Concentration		Vole Carcass Ni Concentration		Vole Liver Co Concentration		Vole Carcass Co Concentration	
Term	**df**	**Dev**	***p***	**Dev**	***p***	**Dev**	***p***	**Dev**	***p***
Null	22	12.25		34.30		33.17		20.22	
Soil CoC[1] Concentration	1	5.27	**<0.01**	30.39	**<0.01**	27.54	**<0.01**	14.70	**<0.01**
Residual	21	6.98		3.91		5.63		5.52	

Notes

1 Relevant CoC for the model (e.g., soil nickel for tissue nickel).

2 The models were fit as Gaussian. Bold type indicates an estimated p-value of ≤ 0.05. Further information on Analysis of Deviance is found in Volume II, Tab 18.

Figure 35 **Relationship between soil nickel concentration and Meadow Vole tissue nickel concentration (log-linear). Circles & solid line = liver, triangles & dotted line = remaining carcass.**

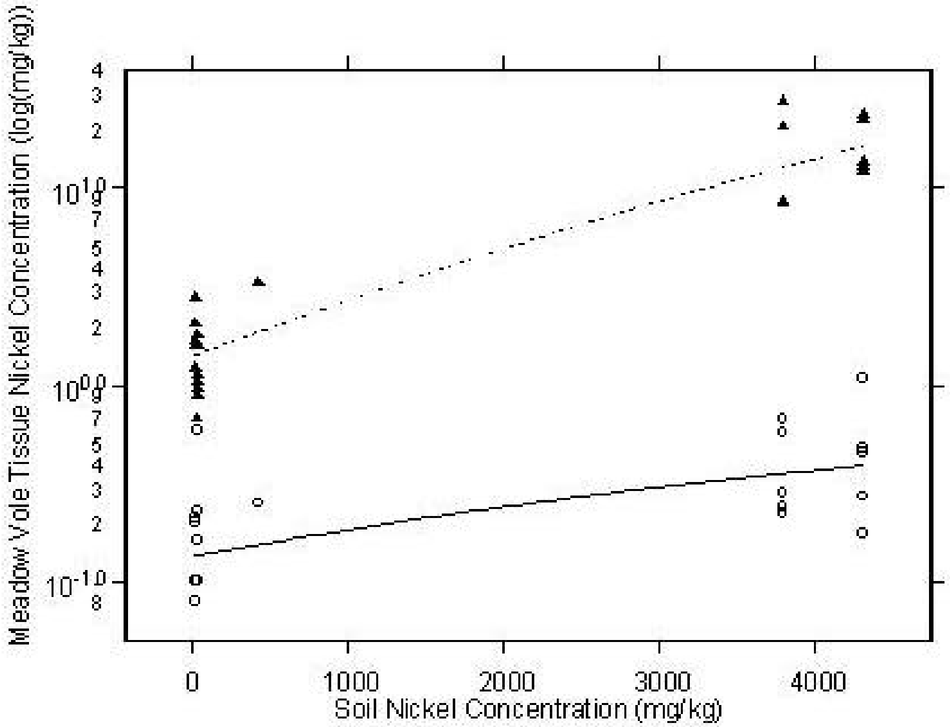


Figure 36 **Relationship between soil copper concentration and Meadow Vole tissue copper concentration (log-linear). Circles & solid line = liver, triangles & dotted line = remaining carcass.**

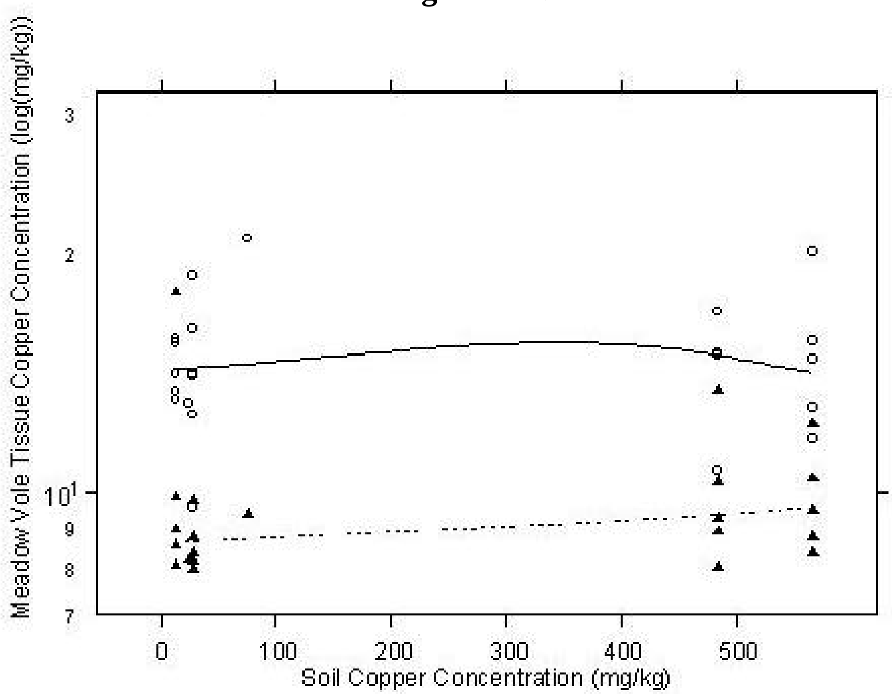


Figure 37 **Relationship between soil cobalt concentration and Meadow Vole tissue cobalt concentration (log-linear). Circles & solid line = liver, triangles & dotted line = remaining carcass.**

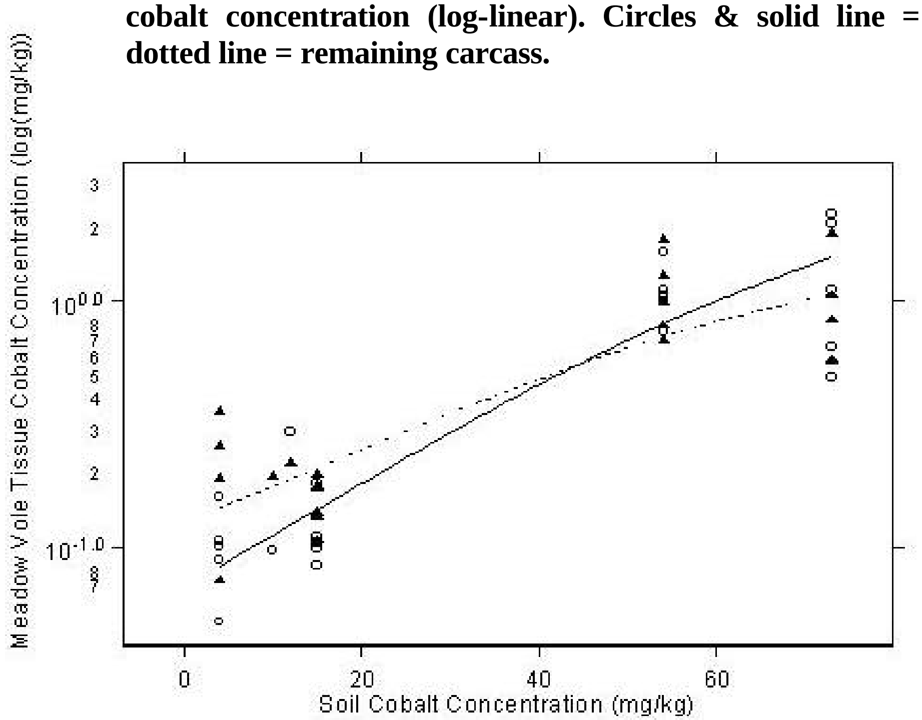
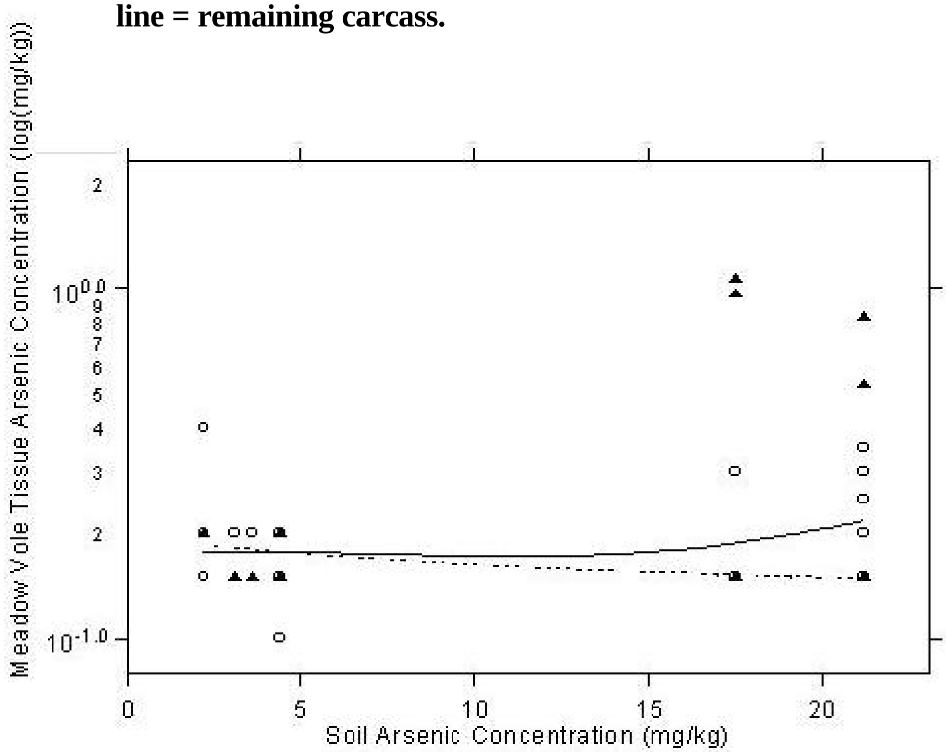


Figure 38 **Relationship between soil arsenic concentration and Meadow Vole tissue arsenic concentration (log-log). Circles & solid line = liver, triangles & dotted line = remaining carcass.**



PUBLIC NOTICES

N O T I C E

PORT COLBORNE COMMUNITY BASED RISK ASSESSMENT
FINAL "CALL" FOR PUBLIC INPUT / COMMENT ON EXISTING REPORTS

ECOLOGICAL RISK ASSESSMENT - CROPS STUDIES
AND
ECOLOGICAL RISK ASSESSMENT - NATURAL ENVIRONMENT

In 2003, reports on two of the main studies related to the **Community Based Risk Assessment** (CBRA) were released for both public and technical review. Specifically,

- Ecological Risk Assessment, "Natural Environment", and,
- Ecological Risk Assessment, "Crop Studies"

Both study reports were prepared by **Jacques Whitford Environmental Limited on behalf of Inco.**

The purpose of the studies was to determine the concentrations of **Chemicals of Concern** that present an unacceptable risk to the **"Natural Environment"** and to **"Crops"**. The studies have been the subject of public open houses and meetings of the CBRA during the past year.

Both reports have been available in the Port Colborne Public Library since their release in July 2003.

The Public Liaison Committee of the CBRA, through public involvement, has set a **final date for submission of "comments"** from the public related to both of these reports, as follows;

FINAL DATE for Submission of Comments on Existing ERA Reports:

Wednesday, June 16, 2004

Any person wishing to submit comments, or seeking additional information about the reports, may do so through the office of:

Charles V. Miller
Manager of Strategic Projects
City of Port Colborne
66 Charlotte Street
Port Colborne, Ontario
L3K 3C8
(905) 835-2900 (Ext. 303)

PORT COLBORNE

HERE IS YOUR INVITATION

COME MEET PORT COLBORNE'S CONSULTANTS AND HEAR ABOUT HOW INCO PLANS TO ADDRESS THE CONTAMINATION & COMMUNITY ISSUES

IT'S BEGUN!

- Come hear details on how Inco is proposing to deal with the contamination
- Hear how the CBRA (Community Based Risk Assessment) will be used
- Talk with our consultants about how this proces will affect your property
- Understand how the CBRA proces will address community health, and the health of our plants, gardens and animals.
- Also hear about the Ministry of Environment's new soils data for the general area and local schools
- Help our consultants gather local information to ensure that the CBRA benefits our community

Mayor Badawey, Council and the Members of the Public Liaison Committee urge all citizens of Port Colborne to come to an all-day drop-in centre.

Meeting Location: **Knights of Columbus Hall**
61 Nickel Street
Port Colborne

Meeting Date: **Thursday, September 28, 2000**
Drop-in Centre Hours: **9:00 a.m. - 7:00 p.m.**

Should you be unable to attend and would like to express your comments on a confidential basis, please contact Chuck Miller at 835-2900 ext. 203 or our Consultant, Rob Watters at 1-800-361-2325 ext. 323.

We need the community's support to make a difference.

We look forward to hearing from you.

The Tribune Sat Sept 23/00

PORT COLBORNE

Here is your invitation!

COME MEET PORT COLBORNE'S CONSULTANTS AND HEAR ABOUT HOW INCO PLANS TO ADDRESS THE CONTAMINATION & COMMUNITY ISSUES.

It's Begun!

- Come hear details on how INCO is proposing to deal with the contamination
- Hear how the CBRA (Community-Based Risk Assessment) will be used
- Talk with our consultants about how this process will affect your property
- Understand how the CBRA process will address community health, and the health of our plants, gardens and animals

Also, hear about the Ministry of Environment's new soils data for the general area and local schools.

- Help our consultants gather local information to ensure that the CBRA benefits our community.

Mayor Badawey, Council and the Members of the Public Liaison Committee urge all citizens of Port Colborne to come to the all-day Drop-In centre Thursday, Sept. 28 in the Knight of Columbus Hall on Nickel Street, from 9 a.m to 7 p.m.

Meet consultants & members of your Public Liaison Committee at the all-day Drop-in Centre

Knights of Columbus Hall
61 Nickel Street
Port Colborne
Thursday, Sept. 28, 2000
9:00 a.m. - 7:00 p.m.

Should you be unable to attend and would like to express your comments on a confidential basis, please contact Chuck Miller at 835-2900 ext. 203 or our Consultant, Rob Watters at 1-800-361-2325 Ext. 323.

WE NEED THE COMMUNITY'S SUPPORT TO MAKE A DIFFERENCE.

WE LOOK FORWARD TO HEARING FROM YOU.

The Leader Wed Sept 27/2000

The Leader Wed Sept 27/2000

Share your thoughts on soil contamination with PLC, consultants at all day drop-in centre tomorrow

Members of the city's public liaison committee and their consultants from Beak International as well as Inco consultants Jacques Whitford will be in the Knights of Columbis Hall on Nickel Street all day Thursday, Sept. 28 to hear public opinion on issues pertaining to soil contaminated with nickel, cobalt, copper and others. There's an ad on page 8 with details, names and numbers.

PORT COLBORNE

HERE'S ANOTHER INVITATION

To Another "OPEN HOUSE" dealing with the INCO contamination Issue ...

This time with both INCO's Consultant (Jacques Whitford) & Port Colborne's Consultant (Beak Environmental)

This is very important...

- Inco, through its consultant, Jacques Whitford, has submitted for review the "Scope of Work" for the Community Based Risk Assessment.
- Currently, your Public Liaison Committee is reviewing the "Scope" to determine if it is adequate ... into other words ... does it address all issues important to this City.
- The Public Liaison Committee needs to hear your comments on the "Scope of Work" ... and ... invite you to an "open house" to:
  - Understand the details of what Inco is proposing
  - Discuss the "Scope" with both Inco consultants and the Community consultant
  - Understand and learn how to participate in the review process for the "Scope of Work" and the "Community Based Risk Assessment"
- All input received through the "open house" will form part of the review at the Public Liaison Committee.

Mayor Badawey, Council and the Members of the Public Liaison Committee urge all citizens of Port Colborne to come to an all-day drop-in centre.

Meeting Location:	***Knights of Columbus Hall*** ***61 Nickel Street, Port Colborne***
Meeting Date:	***Thursday, October 26th, 2000***
Drop-in centre Hours:	***9:00 a.m. - 6:00 p.m.***

Should you be unable to attend and would like to express your comments on a confidential basis, please contact Chuck Miller at 835-2900, ext. 203 or our Consultant, Rob Watters at 1-800-361-2325, ext. 323

We need the community's support to make a difference.
We look forward to hearing from you.

The Tribune (In Port) Wed Oct 25/00

PORT COLBORNE

NOTICE OF MEETING

PUBLIC LIAISON COMMITTEE
for the
COMMUNITY BASED RISK ASSESSMENT
for Soils Contminated with Nickel, Copper and Cobalt in the Port Colborne Area

SIXTH MEETING OF THE COMMITTEE

Thurs., Sept. 7, 2000 at 7:00 p.m
Council Chambers, City Hall

AGENDA

1. **Approval of Agenda**
2. **Approval of Minutes**
   - Meeting of Thursday, August 24, 2000
3. **Delegations**
4. **Presentation of "Scope of Work" for C.B.R.A. (INCO)**
   - Jacques Whitford Environmental (Eric Veska)
5. **Testing of Woodlots**
   - MOE (Bob Slattery)
   - Beak Consulting (J. Bishop)
6. **Testing of Garden Vegetables**
   - Jacques Whitford Environmental (Eric Veska)
7. **Public Forums to co**nsider the "Scope of Work"
   - Setting a schedule of meetings for public input.
   - Beak Consulting (J. Bishop)
8. **Next Meeting**
   - Thursday, September 14, 2000
   - Presentation of MOE/Health Unit...Report on Potential Health Risks (Audrey Wagenaar; MOE)
9. **Adjournment**

Persons wishing to be "delegates" to the Committee should register, in advance, with the Committee Secretary: Martha Toscher at 835-2900 ext. 219.

PORT COLBORNE

PUBLIC LIAISON COMMITTEE
FOR THE
COMMUNITY BASED RISK ASSESSMENT

for Soils Contaminated with Nickel, Copper and Cobalt in the Port Colborne Area

The Port Colborne Public Liaison Committee (PLC) has been asked by Jacques Whitford Environmental (Inco's consultant) to coordinate the collection of locally-grown product (fruits and vegetables) as part of a "food basket" study related to the Community BAsed Risk Assessment. Generally, the consultant is looking to test produce which is garden grown from the area with elevated levels of nickel, copper and cobalt in surface soils.

Gardeners willing to donate produce are asked to contact the PLC via the City of Port Colborne at 905-835-2901, ext. 219. Donors will be contacted directly by the Consultant.

The Tribune Tues. Sept 5/00

The Tribune Tues Nov 28/2000

Berkhout wants residents off polluted property

DOUG TODD
THE LEADER

It's our responsibility to do something for those people, local developer says, offering a month's free rent to family

In an emotional plea to Inco, local developer Jack Berkhout called on the nickel giant to provide temporary housing until the possible health effects posed by a contaminated Rodney Street property can be determined.

"Is there anything we can do for the people living on Rodney Street? My heat bleeds for them!" thundered Berkhout at Thursday's PLC meeting, after reading that the Edwards family is living on property where 14,000 ppm of nickel, 70 times higher than what is acceptable for residential properties in this province, can be found.

Arsenic tops out at 85 ppm, more than three times the acceptable level. A list of the other metals found on the property reads like the elemental table.

Berkhout and the PLC wanted to know why no one has taken any action to address Rodney Street.

"It's our responsibility to do something for those people," continued Berkhout who called Rodney Street a "time bomb." He felt Inco should buy every home on the street.

Ministry of Environment toxicologist Dave McLaughlin stood to respond to Berkhout. He said the MOE views Rodney Street as a separate issue of the ongoing CBRA process on soil contamination and are dealing with it "as fast as we can." The MOE called Rodney Street a "dumping ground scenario" a month ago yet it has increased its area of testing on the east side to encompass eight blocks.

McLaughlin said the MOE was working with the city and the health department to develop a plan by February because it will take some time to complete analysis of the tested properties.

That reassurance didn't sit well with several people at Thursday's public liaison committee meeting.

"Are you willing to take action? To take the steps necessary if remediation has to take place," Ward 2 Councillor Yvon Doucet asked Bjorn Christianson of the Niagara Region Public Health Department.

Christianson confirmed his department would take steps "to protect the health of the communi-

Berkhout called it "baloney" that the public has to wait until February for an official reaction to the situation. "It's absolutely ridiculous. This is serious. I can't wait until February. What's going on? There are lives at risk here!"

Killaly Street resident Ruth Kramer said she couldn't understand how the health department could issue an information sheet exclaiming that locally contaminated soil poses no adverse health affect to humans yet warn some Rodney Street residents to not let their children play in the soil.

Rodney Street resident Craig Edwards told the meeting he didn't want to keep his wife and two sons on the property too much longer. He couldn't understand why the problem has only come to light recently.

"I saw you guys out there five years ago. Why didn't you tell me?" asked Edwards of the MOE.

A plan to build houses behind his property fell through in the early 1990s when it was determined the land was too contaminated.

"Why didn't someone knock at my door then?" asked Edwards.

Continued on page 4

Inco says it's open to dialogue on clean-up

DOUG TODD
THE LEADER

It was another long evening of boredom and excitement peppered with moments of high emotion and drama.

It was another entertaining Thursday night Public Liaison Committee meeting.

With more than 30 people in attendance, the night began, as it does at almost every meeting, with an adjustment and clarification of minutes from the past meeting.

Inco made it clear landowners with contaminated property cannot demand what form of remediation is used to clean their contaminated land. However, Inco's Dr. Bruce Conard said the nickel giant was open to "dialogue" on the subject.

Beak International, the PLC's consultant, then gave a presentation on its concerns with the current scope of work prepared by Inco and its consultant, Jacques Whitford Environmental.

Speaking on behalf of Beak, Dr. Rob Watters ...

into the ongoing process.

"This community, when it has a statement to make, stands up and makes it," said Watters, reiterating the four major concerns of the public — human health, property values, liability and protection of the environment.

He said the heavy air of skepticism in the community is welcomed and helps "power the process."

"While we can't force Inco to dig and dump (contaminated soil), we can force them to make the community safe," he said. When asked why Beak had not publicly acknowledged a 1998 ecological study Beak had done for Inco, both Watters and PLC chair Harry Wells said that fact had been shared with the committee before they were hired.

Talk then turned to groundwater, more testing and the food basket tests started in late summer with the collection of vegetables from over 40 properties.

City planner Chuck Miller said the city receives as many as three

The Leader Wed Nov 29/2000

PORT COLBORNE

NOTICE OF MEETING

PUBLIC LIAISON COMMITTEE
for the
COMMUNITY BASED RISK ASSESSMENT
for Soils Contaminated with Nickel, Copper and Cobalt in the Port Colborne Area

TWELFTH MEETING OF COMMITTEE
Thursday, November 23rd, 2000 – 7:00 p.m.
Council Chambers, City Hall

AGENDA

1. Approval of Agenda
2. Approval of Minutes
   - Meeting of Thursday, November 9th, 2000
   - Meeting of Thursday, November 16th, 2000
3. Delegations
4. Technical Scope of Work
   - Jacques Whitford
   - Beak International
6. Adjournment

Copies of the Technical Scope of Work can be obtained at City Hall during regular office hours or can be viewed on the City's website at www.portcolborne.com

Further information can be obtained by calling Martha Toscher, Committee Secretary at 835-2901 ext. 219.

Persons wishing to be "delegates" to the Committee should register, in advance with the Committee Secretary: Martha Toscher at 835-2900 ext. 219

The Tribune Wed Nov 22/2000

New Health study in Port possible

TRIBUNE STAFF/
PORT COLBORNE

The Tribune Wed Nov 22/2000

A new health study could be conducted on residents in the Rodney Street area and area surrounding the Inco plant, says the region's medical officer of health.

"It depends on what the science tells us," says Dr. Robin Williams.

Williams says once soil samples from the Ministry of Environment are analyzed, the regional health department can determine what its next steps are.

The ministry has 1,500 soil samples collected from the Rodney Street area and areas adjacent to Inco's plant in Port Colborne.

Those samples have been fast tracked for analysis, says Williams, adding the regional health unit met with the Ministry of Environment and Ministry of Health earlier this week about the issue.

Residents of Rodney Street learned some of their properties contained high levels of lead, zinc and arsenic, metals not seen in other areas of the city. The environment ministry isn't sure of the source of the metals, and has stated they could be from Inco, or the former Canada Furnace and Algoma Steel plants, which were located along the east pier of the Welland Canal.

"The Rodney Street area has brought up new issues and new substances that we have to look at very carefully," says Williams.

A new health study would depend on what exactly is in the soil in the area and the extent to which the contamination has spread.

Mayor seeks tests

Sat Nov 25 2000 By DAVE JOHNSON
TRIBUNE STAFF
PORT COLBORNE

Mayor Vance Badawey has asked for immediately testing of residents in the Rodney Street area, after hearing about concerns raised Thursday night.

"A Ministry of Environment official said he was concerned about the corridor last week and thought there were some health concerns in the area," said Badawey Friday.

The mayor was reacting to concerns raised during the Public Liaison Committee meeting held this past Thursday night in council chambers at Port Colborne City Hall.

The liaison committee is looking into soil contamination across the city, from nickel, copper and cobalt released by Inco into the air during its past operations.

Rodney Street residents have seen some soil test results come in with very high numbers of nickel, copper and cobalt, but have also seen high levels of other metals and chemicals, such as arsenic.

Badawey spoke with Bjorn Christensen of the regional health department, on Friday morning and asked him what the department was going to do about the area.

The mayor said if things like blood and urine samples need to be done, then they should be done immediately.

"It seems it's now my Friday morning routine to make a call to a ministry after a Thursday night liaison committee meeting."

Last week, Badawey called the Ministry of Environment and asked them to speed up soil sample analysis from the Rodney Street area.

"I expect them (the health department) to take immediate action and won't accept anything less."

During the Community Based Risk Assessment process, red flags, such as the one for Rodney Street, will pop up and have to be taken care of immediately, Badawey said.

SEE RELATED STORIES/ A4

PORT COLBORNE

NOTICE OF MEETING

PUBLIC LIAISON COMMITTEE
for the
COMMUNITY BASED RISK ASSESSMENT
for Soils Contaminated with Nickel, Copper and Cobalt in the Port Colborne Area

TENTH MEETING OF COMMITTEE
Thursday, November 9th, 2000 – 7:00 p.m.
Council Chambers, City Hall

AGENDA

1. Approval of Agenda
2. Approval of Minutes
   - Meeting of Thursday, October 26, 2000
3. Delegations
4. Scope of Work to be Tabled
   - Eric Veska, JWEL
5. Presentation of CBRA Process
   - Dr. Bruce Conard, Inco
6. Adjournment

PLEASE NOTE: The Technical Sub-Committee meeting originally scheduled for November 9th, 2000 has been cancelled.

Persons wishing to be "delegates" to the Committee should register, in advance, with the Committee Secretary; Martha Toscher at 835-2900 ext. 219.

The Tribune Wed Nov 8/2000

NOTICE OF MEETING

PUBLIC LIAISON COMMITTEE
for the
COMMUNITY BASED RISK ASSESSMENT
for Soils Contaminated with Nickel, Copper and Cobalt in the Port Colborne Area

PORT COLBORNE

TENTH MEETING OF COMMITTEE
Thursday, November 9, 2000 - 7 p.m.
Council Chambers, City Hall

AGENDA

1. **Approval of Agenda**
2. **Approval of Minutes**
   - Meeting of Thursday, October 26, 2000
3. **Delegations**
4. **Scope of Work to be Tabled**
   - Eric Veska, JWEL
5. **Presentation of CBRA Process**
   - Dr. Bruce Conard, INCO
6. **Adjournment**

PLEASE NOTE: The Technical Sub-Committee meeting originally scheduled for November 9, 2000 has been cancelled.

Persons wishing to be delegates to the Committee should register, in advance, with Committee Secretary Martha Toscher at 835-2900 ext. 219.

The Leader Wed Nov 8/00

NOTICE OF MEETING

PUBLIC LIAISON COMMITTEE
for the
COMMUNITY BASED RISK ASSESSMENT
for Soils Contaminated with Nickel, Copper and Cobalt
in the Port Colborne Area

PORT COLBORNE

EIGHTH MEETING OF COMMITTEE
Thursday, October 19, 2000 - 7 p.m.
Council Chambers, City Hall

AGENDA

1. **Approval of Agenda**
2. **Approval of Minutes**
   - Meeting of Thursday, September 14, 2000
   - Report from Technical Sub-Committee Meeting of October 12, 2000 - Beak Consulting
   - Report from Technical Sub-Committee Meeting of October 19, 2000 - Beak Consulting
3. **Delegations**
4. **Review of Health Study /Health Related Issues**
   - Bjorn Christiansen, Regional Niagara Health Unit
5. **Presentation of Scope of Work**
   - Jacques Whitford Environmental Limited (Eric Veska)
6. **Adjournment**

Please be advised the Technical Sub-Committee will also meet on October 19, 2000 beginning at 2 p.m. in Committee Room 3 at City Hall. Members of the public are welcome to attend. The main topic of discussion is the Scope of Work as presented by Jacques Whitford Environmental Ltd.

Persons wishing to be "delegates" to the Committee should register, in advance, with Committee Secretary Martha Toscher at 835-2900 ext. 219.

The Leader Wed Oct 18/00

PORT COLBORNE

NOTICE OF MEETING

PUBLIC LIAISON COMMITTEE
for the
COMMUNITY BASED RISK ASSESSMENT
for Soils Contaminated with Nickel, Copper and Cobalt in the Port Colborne Area

EIGHTH MEETING OF COMMITTEE
Thursday, October 19, 2000 at 7:00 p.m
Council Chambers, City Hall

AGENDA

1. **Approval of Agenda**
2. **Approval of Minutes**
   - Meeting of Thursday, July 14, 2000
   - Report from Technical Sub-Committee Meeting of October 12, 2000 - Beak Consulting
   - Report from Technical Sub-Committee Meeting of October 19, 2000 - Beak Consulting
3. **Delegations**
4. **Review of Health Study/Health Related Issues**
   - Bjorn Christiansen, Regional Niagara Health Unit
5. **Presentation of Scope of Work**
   - Jacques Whitford Environmental Limited (Eric Veska)
6. **Adjournment**

Please be advised the Technical Sub-Committee will also meet on October 19th, 2000 beginning at 2:00 p.m. Committee Room 3 at City Hall. Members of the public are welcome to attend. The main topic of discussion is the Scope of Work as presented by Jacques Whitford Environmental Ltd.

Persons wishing to be "delegates" to the Committee should register, in advance, with the Committee Secretary: Martha Toscher at 835-2900 ext. 219.

The Tribune Wed Oct 18/00

NOTICE OF MEETING

PUBLIC LIAISON COMMITTEE

for the

COMMUNITY BASED RISK ASSESSMENT

for Soils Contaminated with Nickel, Copper and Cobalt in the Port Colborne Area

PORT COLBORNE

13TH MEETING OF COMMITTEE
Thursday, November 30, 2000 - 7 p.m.
Council Chambers, City Hall

AGENDA

1. **Approval of Agenda**
2. **Approval of Minutes**
   - Meeting of Thursday, November 23, 2000
3. **Delegations**
4. **Technical Scope of Work**
   - Jacques Whitford & Beak International
5. **Adjournment**

Copies of the Technical Scope of Work may be obtained at City Hall during regular business hours <u>or</u> may be viewed on the City's website at **www.portcolborne.com**

Further information may be obtained by calling Martha Toscher, Committee Secretary, at 835-2900 ext. 219.

Persons wishing to be delegates to the Committee should register in advance with Committee Secretary Martha Toscher.

The Leader Wed Nov29/2000

PORT COLBORNE

NOTICE OF MEETING

PUBLIC LIAISON COMMITTEE

for the

COMMUNITY BASED RISK ASSESSMENT

for Soils Contaminated in the Port Colborne Area

THIRTEENTH MEETING OF COMMITTEE

Thursday, November 30th, 2000 – 7:00 p.m.
Council Chambers, City Hall

AGENDA

1. Approval of Agenda
2. Approval of Minutes
   - Meeting of Thursday, November 23rd, 2000
3. Delegations
4. Technical Scope of Work
   - Jacques Whitford
   - Beak International
6. Adjournment

Copies of the Technical Scope of Work can be obtained at City Hall during regular office hours or can be viewed on the City's website at www.portcolborne.com

Further information can be obtained by calling Martha Toscher, Committee Secretary at 835-2901 ext. 219.

Persons wishing to be "delegates" to the Committee should register, in advance with the Committee Secretary, Martha Toscher at 835-2900 ext. 219

In Port Wed Nov 29/2000

Inco process not binding, company official says

Residents not locked into Community Based Risk Assessment

By Dave Johnson
InPort Staff/PORT COLBORNE

Residents aren't being forced into the Community Based Risk Assessment process, an Inco official said last week during a Public Liaison Committee meeting.

Dave Reed was responding to a concern raised by committee members during its meeting held last Thursday in council chambers.

The liaison committee is studying the issue of soil contaminated by metals like nickel, copper and cobalt through Inco's refining process throughout the years.

"If we do the Community Based Risk Assessment process, we're not locking people into it, people can still go another route?" asked Paul Dayboll, liaison committee member.

Reed said people could choose to go one-on-one with Inco in an attempt to have their lands cleaned of nickel, copper and cobalt contamination.

The issue of the Community Based Risk Assessment process and whether it was fair or not, was raised by members of the Kramer family, who live on Killaly Street East.

The family asked liaison committee chair Harry Wells to read a letter they submitted to the Minister of Environment, Erie-Lincoln MPP Tim Hudak, Welland-Thorold MPP Peter Kormos and the committee itself.

"It is our understanding that there are three distinct and separate approaches for site restoration of contaminated properties: the background approach; the generic approach and the site specific risk assessment approach," said the Kramers' letter.

The letter said Inco has chosen to go through with a Community Based Risk Assessment process and that it deviates from ministry guidelines relating to clean-up.

It also stated the Community Based Risk Assessment process has not been accepted, endorsed or approved by the Ministry of Environment.

"Due to the intensity, complexities and far ranging effects this heavy metal contamination has and will have on this community as long as this situation exists, we do not accept a deviation approach from established guidelines as one that this community should be saddled with and forced to endorse as the sole method, mechanism or avenue that Inco will base their clean-up commitments upon," said the Kramer letter.

The family also stated they wanted their land, the property belonging to one of their sons, and the Humberstone School, cleaned up under the site specific process, not under the Community Based Risk Assessment process.

Wells asked the family for some clarification and whether they were stating that they didn't want to be part of the Community Based Risk Assessment process.

"That is our intent," said Neale Kramer.

He said the family feels left out of the current process and were at the meeting to let the committee know their feelings.

In Port Wed Nov29/2000

NOTICE OF MEETING

PUBLIC LIAISON COMMITTEE

for the

COMMUNITY BASED RISK ASSESSMENT

for Soils Contaminated in the Port Colborne Area

PORT COLBORNE

15TH MEETING OF COMMITTEE

Thursday, January 25th, 2001 - 7 p.m.

Council Chambers, City Hall

AGENDA

1. **Approval of Agenda**
2. **Approval of Minutes**
   - Meeting of Thursday, December 21, 2000 (PLC)
   - Technical Sub-Committee Meetings
3. **Delegations**
4. **Woodlot Report**
   - Ministry of Environment
5. **Update from the Technical Sub-Committee**
   - Jacques Whitford / Beak
6. **Protocol & Procedures; Tech. Sub-Committee & PLC**
   - Beak
7. **School Board Studies** ***(Yet to be confirmed)***
   - Ministry of Environment / Health Unit
8. **Adjournment**

Persons wishing to be delegates to the Committee should register in advance with Committee Secretary Martha Toscher at 835-2900 ext. 219

The Leader Wed Jan 24/01

PORT COLBORNE

NOTICE OF MEETING

PUBLIC LIAISON COMMITTEE
for the
COMMUNITY BASED RISK ASSESSMENT
for Soils Contaminated in the Port Colborne Area

EIGHTEENTH MEETING OF COMMITTEE

Thursday, April 12, 2001 – 7:00 p.m.
Council Chambers, City Hall

AGENDA

1. Approval of Agenda
2. Approval of Minutes
   - *Meeting of Thursday, March 29, 2001 (PLC)*
   - *Technical Sub-Committee Meeting, Thursday, April 5, 2001*
3. Delegations
4. Report -
   Ecological Risk Assessment, Natural Environment
   Jacques Whitford Environment Ltd. (R. Huizer)
5. Matters related to the Ecological Risk Assessment;
   - "Protocol" for surface water collection
   - "Protocol" for frog inventory
   - master schedule for biological survey
6. Human Health Risk Assessment (C.B.R.A)
   - survey/questionnaire
   - sample population for "survey"
7. Other Matters
8. Upcoming Schedule
9. Adjournment

Persons wishing to be "delegates" to the Committee should register, in advance with Martha Toscher at 835-2900 ext. 219.

IN PORT ~~MARCH~~ April 11/01

...the forum began. "It's a whole facade, quite frankly, to make it look as if the company [Inco] is concerned, to make it look as if democracy is actually working," Connett told reporters.

"This won't be easy, but you have no alternative but to fight," Connett said to cheers and applause. "Passive people get poisoned, angry people get organized."

He said he is not impressed with provincial Ministry of Environment and their role in the Inco soil contamination issue.

"I think it's very clear, based upon my conversations with people, that ministry officials have not done what they should have done, which makes me suspicious."

One of the environmental duo's key themes was the need for the community to work together. Network and get the message of the Inco situation out to the the world they advised. "The good news is a threatened community is a strengthened community," Connett said.

Connett has given more than 1,700 presentations in 49 states, five provinces and 44 other countries. He has researched waste management for 16 years, co-authored six papers on dioxin presented around the world and received numerous awards for community service.

He formed a non-profit video production company, Grass Roots and Global Video, to share his international experiences with people seeking environmental justice and sustainability. He's produced 31 tapes on waste management and 10 on dioxin.

For the past five years, he has been trying to stop countries from putting flu...

NOTICE OF MEETING

PUBLIC LIAISON COMMITTEE

for the

COMMUNITY BASED RISK ASSESSMENT

for Soils Contaminated in the Port Colborne Area

PORT COLBORNE

18TH MEETING OF COMMITTEE
Thursday, April 12th, 2001 - 7 p.m.
Council Chambers, City Hall

AGENDA

1. **Approval of Agenda**
2. **Approval of Minutes**
   - Meeting of Thursday, March 29, 2001 (PLC)
   - Technical Sub-Committee Meeting, Thursday, April 5
3. **Delegations**
4. **Report**
   - Ecological Risk Assessment, Natural Environment Jacques Whitford Environmental Ltd. (R. Huizer)
5. **Matters related to the Ecological Risk Assessment**
   - Protocol for surface water collection
   - Protocol for frog inventory
   - Master schedule for biological survey
6. **Human Health Risk Assessment (CBRA)**
   - Survey/questionnaire
   - Sample population for survey
7. **Other matters**
8. **Upcoming Schedule**
9. **Adjournment**

Everyone's invited to PLC open house

Rob Watters
BEAK - CBRA

The public liaison committee (PLC) will sponsor an open "town hall" meeting to discuss the Community-Based Risk Assessment (CBRA) on Thursday, May 3 at St. Therese's School on Killaly Street East in Port Colborne.

The meeting will involve a brief presentation by the PLC and a question-answer period, during which citizens can ask questions of the PLC and its environmental consultants, Beak International Inc., about the CBRA.

There is no question that soils and other components of the environment in Port Colborne are contaminated. The significant difference between Port Colborne and their communities with widespread contamination is the following:

1. Inco acknowledges responsibility for the airborne contamination
2. There is a process underway (the CBRA) that is addressing the contamination,
3. Key parties are working cooperatively to address the contamination (namely the City of Port Colborne, Ontario Ministry of Environment, Inco, Environment Canada, Regional Health Department and others), and
4. The community of Port Colborne, through the PLC and its consultants, has a significant opportunity to input to the CBRA.

The overall objective of the CBRA is to ensure that the process of addressing the contamination results in protection of human health and the natural environment. This means the CBRA will ensure the levels of contaminants after cleanup must be safe for people who live and work in Port Colborne.

The community has already provided much to the CBRA process. Through open houses and public meetings, the PLC and community have significantly expanded the original scope of the CBRA, as follows:

1. The list of potential chemicals-of-concern has expanded beyond just nickel, copper and cobalt,
2. There will be a community-wide human health study,
3.There will be a property valuation study, to address potential problems with the value of properties due to contamination,
4. The role of the community is significantly enhanced, with community input a requirement and expectation, and,
5. There is general acceptance that all work will adhere to strict scientific principles and protocols.

The regular PLC meetings address specific study components of the CBRA. Since the CBRA is scientifically based, each of the studies must follow strict protocols and procedures. Most of the PLC meetings are technical.

The town hall (or update) PLC meetings are introduced as a forum for the community to receive regular updates and to ask general questions of the PLC and Beak. The meetings will be held regularly at various locations within the community.

There will be regular notices for these meetings.

The CBRA process involves the entire community of Port Colborne. The PLC wants to ensure that the entire community is aware of the CBRA and has an opportunity to input.

Please join us at St. Therese's School on May 3 at 7 p.m.

We look forward to seeing you.

The Leader Wed April 25/01

NOTICE OF MEETING

PUBLIC LIAISON COMMITTEE
for the
COMMUNITY BASED RISK ASSESSMENT
for Soils Contaminated in the Port Colborne Area

PORT COLBORNE

21st MEETING OF COMMITTEE
Thursday, June 28th, 2001 - 7 p.m.
Council Chambers, City Hall

AGENDA

1. **Approval of Agenda**
2. **Approval of Minutes**
   - Meeting of Wednesday, May 30, 2001 (PLC)
3. **Delegations**
4. **Chemicals of Concern**
5. **Human Health Risk Assessment**
6. **Ecological Risk Assessment**
7. **General Protocols**
8. **Rodney Street Area**
9. **Health Assessment Programs**
10. **Other Matters**
11. **Adjournment**

Persons wishing to be delegates to the Committee should register in advance with Martha Toscher at 835-2900 ext.219

The Leader Wed June 27/01

PORT COLBORNE

NOTICE OF MEETING

PUBLIC LIAISON COMMITTEE
for the
COMMUNITY BASED RISK ASSESSMENT
for Soils Contaminated in the Port Colborne Area

MEETING OF COMMITTEE

Thursday, June 28th, 2001 – 7:00 p.m.
Council Chambers, City Hall

AGENDA

1. Approval of Agenda
2. Approval of Minutes
   - *Meeting of Wednesday, May 30th, 2001 (PLC)*
3. Delegations
4. Chemicals of Concern
5. Human Health Risk Assessment
6. Ecological Risk Assessment
7. General Protocols
8. Rodney Street Area
9. Health Assessment Programs
10. Other Matters
11. Adjournment

Persons wishing to be "delegates" to the Committee should register, in advance with the Committee Secretary; Martha Toscher at 835-2900 ext. 219.

Tribune
Wed June 27/01

NOTICE OF MEETING

PUBLIC LIAISON COMMITTEE
for the
COMMUNITY BASED RISK ASSESSMENT
for Soils Contaminated in the Port Colborne Area

PORT COLBORNE

24th MEETING OF COMMITTEE
Thursday, Oct. 25th, 2001 - 7 p.m.
Council Chambers, City Hall

AGENDA

1. **Approval of Agenda**
2. **Approval of Minutes**
   - Meeting of Thursday, June 28, 2001 (PLC)
   - Meeting of Thursday, July 19, 2001 (PLC)
   - Meeting of Thursday, September 27, 2001 (PLC)
3. **Delegations**
4. **Status of the Community Health Assessment Project (CHAP) & Short Term Schedule (Beak)**
5. **Update of Community Based Risk Assessment (CBRA) Activities (JWEL)**
   - **Activities for Human Health Risk Assessment (HHRA)**
   - **Activities for Ecological Risk Assessment (ERA) (Natural Environment)**
   - **Activities for ERA (Crops)**
   - **Overall Master Schedule**
6. **Other Matters**
7. **Next Meeting**
8. **Adjournment**

Persons wishing to be delegates to the Committee should register in advance with Martha Toscher at 835-2900 ext.219

The Leader Wed Oct 24/01

PORT COLBORNE

PUBLIC LIAISON COMMITTEE
for the
COMMUNITY BASED RISK ASSESSMENT
for Soils contaminated in the Port Colborne Area

MEETING OF COMMITTEE
Thursday, October 25th, 2001 - 7:00 p.m.
Council Chambers, City Hall

AGENDA

1. **Approval of Agenda**
2. **Approval of Minutes**
   - Meeting of Thursday, June 28th, 2001 (PLC)
   - Meeting of Thursday, July 19th, 2001 (PLC)
   - Meeting of Thursday, September 27th, 2001 (PLC)
3. **Delegations**
4. **Status of the Community Health Assessment Project (CHAP) & Short Term Schedule** - Beak
5. **Update of Community Based Risk Assessment (CBRA) Activities - JWEL**
   - Activities for Human Health Risk Assessment (HHRA)
   - Activities for Ecological Risk Assessment (ERA) - (Natural Environment)
   - Activities for ERA - (Crops)
   - Overall Master Schedule
6. **Other Matters**
7. **Next Meeting**
8. **Adjournment**

IN PORT WED OCT 24/01

Persons wishing to be "delegates" to the Committee should register in advance with the Committee Secretary; Martha Toscher at 835-2900 ext. 219.

OPEN HOUSE
ON CBRA UPDATE

Want to know what has been happening this summer with the Port Colborne Community Based Risk Assessment? (CBRA)

Why were water wells sampled?

Why were frogs collected and birds surveyed?

Why were samples of garden vegetables collected?

Why were air monitors operating this summer?

Come hear from the technical consultants to INCO (JWEL) and the PLC/City of Port Colborne (BEAK)

Knights of Columbus Hall, 61 Nickel Street
Wednesday, Nov. 21, 2001
Noon to 8 pm

The Leader Wed Nov 14/01

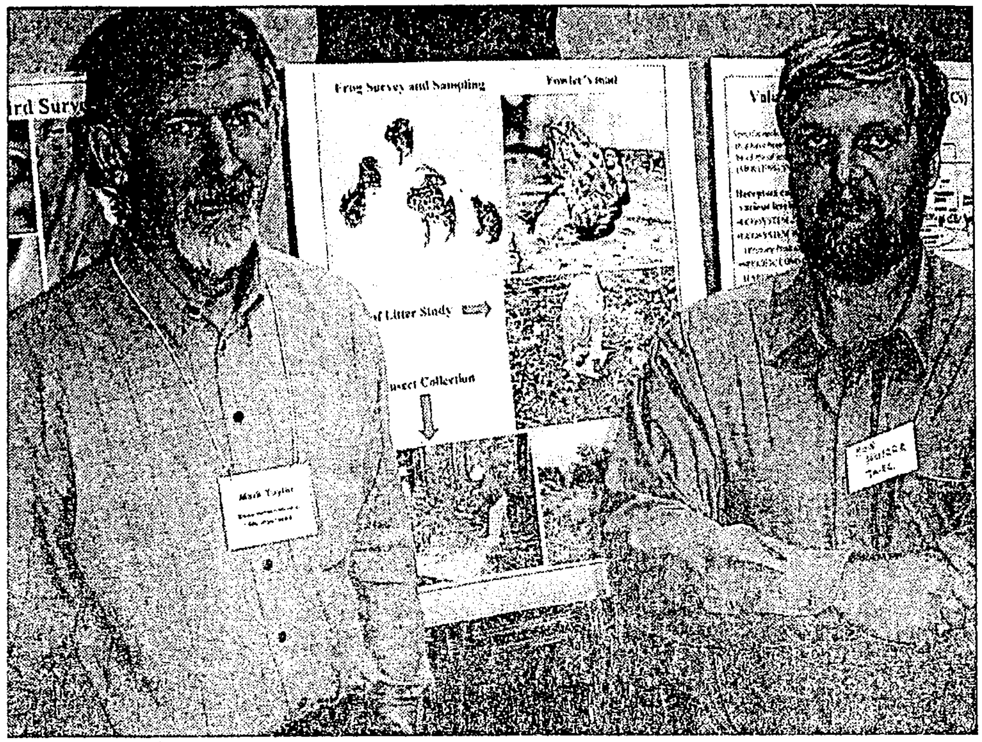
PORT COLBORNE

OPEN HOUSE ON CBRA UPDATE

- Want to know what has been happening this summer with the Port Colborne Based Risk Assessment (CBRA)?
- Why were water wells sampled? Why were frogs collected and birds surveyed? Why were samples of garden vegetables collected? Why were air monitors operating this summer?
- Come hear from technical consultants to INCO (JWEL) and the PLC/City of Port Colborne (BEAK)

PLACE: Knights of Columbus Hall, 61 Nickel St.
DATE: November 21, 2001
TIME: 12:00 p.m. to 8:00 p.m.

The Tribune Wed Nov 14/01



It's not easy being green

Biologists Mark Taylor of Beak International and Ron Huizer of Jacques Whitford were among members of the teams at the Beak-JW open house last Thursday in the Knights of Columbus Hall on Nickel Street. About 12 people attended. Beak is the environmental consulting firm working for the city's Public Liaison Committee in the Community-Based Risk Assessment. Jacques Whitford is the environmental consulting firm working for Inco. Scientists specializing in land, water and air issues from each firm work side by side to ensure QAQC (quality assurance quality control) in every test conducted. Environmental studies are a part of the CBRA big picture which will determine the effects of soil-metal contamination on area ecology as well as human health. The open house was the latest CBRA update for residents on the progress of greenhouse and field experiments, garden produce analysis, air quality monitoring tests, soil test-pitting, and tree sampling. The big job for biologists Taylor and Huizer is the Ecological Risk Assessment, which includes testing earthworms, surveying birds and studying amphibians. They made a remarkable find last summer when they discovered the Fowler's Toad, a rare species in these parts, alive and well and breeding in the Nickel Beach area. A summary finding also indicates earthworms live in soils with 10,000 parts per million of nickel with no observable adverse effect

CBRA consultants show & tell

Lead consultant Eric Veska of Jacques Whitford and his team of scientists joined their counterparts from Beak International last week at an open house to update residents on the progress of the Community-Based Risk Assessment. On easels that filled the perimeter of the Knights of Columbus Hall, JW produced 32 large format photo-posters of maps, pie charts, flow charts, and graphs to illustrate work to date and work in progress. A slice of a 150-year-old tree trunk illustrated effects of Inco emis-sions. A video demonstration showed the dust stirred up as a tractor ploughed and disked back and forth across a field. Air monitoring was criticized last year because the soil was so wet, farm operations generated little dust if any. This hot dry summer was much better for dust and better for testing.

The CBRA includes a Human Health Risk Assessment, an Ecological Risk Assessment for the natural environment, an ERA for greenhouse and field experiments— and all the protocols for testing everything. The project also includes all the testing and reports done by the Ministry of Environment to determine the acceptable level, or number per million, of metal contamination in soil. There will also be a socio-econom-ic study to determine the impact of contamination on property values.

The next big thing will be the determination of the Chemicals of Concern, the subject of more than a year of debate between Beak and its client, the PLC, and JW and its client, Inco. The draft report on COCs was presented to Beak and the PLC last Friday.

The CBRA process has been underway almost two years, and JW's Veska said at the open house almost everything is on track and running to schedule. There are still con-cerns among residents, he said, which is why such drop-in centres are held, so people can come individually to speak one-on-one with the consultants doing the work. Port Colborne's CBRA is the first such major undertaking of its kind, Veska said, in which the public is the most significant component, driving the entire project

IN Port Dec 12/01

PUBLIC LIAISON COMMITTEE for the COMMUNITY BASED RISK ASSESSMENT

for Soils Contaminated in the Port Colborne Area

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MEETING OF COMMITTEE

Thursday, December 13th, 2001
7:00 pm
Council Chambers, City Hall

AGENDA

1. Approval of Agenda
2. Approval of Minutes
   • Meeting of Thursday, November 22, 2001 (PLC)
3. Delegations
4. Updates
   - MOE Rodney Community HHRA
     - PLC Response to EBR
   - Community Based Risk Assessment (CBRA)
     - HHRA Update Technical Sub-Committee
     - Chemicals of Concern (Presentation by JWEL)
     - ERA Update (JWEL & Beak)
   - Socio-Economic Assessment (Presentation by Deloitte-Touche)
   - Community Health Assessment (CHAP) (Ventana)
   - Data Release Procedures
5. Comments/Concerns from Residents
   - East Side Community Health Study
6. Other Matters
7. Schedule Update
8. Next Meeting
9. Adjournment

Persons wishing to be "delegates" to the Committee should register in advance with Martha Toscher at 835-2900 ext. 319.

NOTICE OF MEETING

PUBLIC LIAISON COMMITTEE
for the
COMMUNITY BASED RISK ASSESSMENT
for Soils Contaminated in the Port Colborne Area

PORT COLBORNE

27th MEETING OF COMMITTEE
Thursday, January 17th, 2002 - 7 p.m.
Council Chambers, City Hall

AGENDA

1. **Approval of Agenda**
2. **Approval of Minutes**
   - Meeting of Thursday, November 22, 2001 (PLC)
   - Meeting of Thursday, December 13, 2001 (PLC)
3. **Delegations**
4. **Updates**
   - **MOE Rodney Community HHRA**
   - **Community Based Risk Assessment (CBRA)**
     - **HHRA Update**
     - **ERA Update**
   - **Socio-Economic Assessment**
5. **Community Health Assessment (CHAP)**
   - **Approval of plan to move forward (Recommendation from TSC)**
6. **Other Matters**
7. **Schedule Update**
8. **Next Meeting**
9. **Adjournment**

Persons wishing to be delegates to the Committee should register in advance with Martha Toscher at 835-2900 ext.319

The Leader Wed Jan 16/02

NOTICE OF MEETING

PUBLIC LIAISON COMMITTEE
for the
COMMUNITY BASED RISK ASSESSMENT
for Soils Contaminated in the Port Colborne Area

PORT COLBORNE

27th MEETING OF COMMITTEE
Thursday, January 17th, 2002 - 7 p.m.
Council Chambers, City Hall

AGENDA

1. **Approval of Agenda**
2. **Approval of Minutes**
   - Meeting of Thursday, November 22, 2001 (PLC)
   - Meeting of Thursday, December 13, 2001 (PLC)
3. **Delegations**
4. **Updates**
   - **MOE Rodney Community HHRA**
   - **Community Based Risk Assessment (CBRA)**
     - **HHRA Update**
     - **ERA Update**
   - **Socio-Economic Assessment**
5. **Community Health Assessment (CHAP)**
   - **Approval of plan to move forward (Recommendation from TSC)**
6. **Other Matters**
7. **Schedule Update**
8. **Next Meeting**
9. **Adjournment**

Persons wishing to be delegates to the Committee should register in advance with Martha Toscher at 835-2900 ext.319

The Leader Wed Jan 16/02

PUBLIC LIAISON COMMITTEE & BEAK

WORKSHOP

CHEMICALS OF CONCERN FOR THE COMMUNITY BASED RISK ASSESSMENT

- **What are the chemicals of concern? (COCs)**
- **How was the current list determined?**

Workshop Date: **Thursday, February 28th 2002 7:00 p.m.**

Location: **Knights of Columbus Hall 61 Nickel Street Port Colborne**

We hope to see you there!

PUBLIC LIAISON COMMITTEE for the COMMUNITY BASED RISK ASSESSMENT for Soils Contaminated in the Port Colborne Area

MEETING OF COMMITTEE
Thursday, February 21st, 2002 - 7:00 p.m.
Council Chambers, City Hall

AGENDA

1. Approval of Agenda
2. Approval of Minutes
   - Meeting of Thursday, January 17th, 2002 (PLC)
3. Delegations
4. Updates
   - Community Based Risk Assessment (CBRA)
     - HHRA Update
     - ERA Update
     - Chemicals of Concern Update
     - Socio-Economic Assessment (Property Valuation Study)
     - Community Health Assessment Project (CHAP)
   - Schedule Update (CBRA)
5. Federal Lands Environmental Site Assessment
6. Other Matters
7. Next Meetings
8 Adjournment

Persons wishing to be "delegates" to the Committee should register, in advance, with Martha Toscher at 835-2900 ext 319.

IN PORT Feb 20/02

NOTICE OF MEETING

PUBLIC LIAISON COMMITTEE
for the
COMMUNITY BASED RISK ASSESSMENT
for Soils Contaminated in the Port Colborne Area

PORT COLBORNE

28th MEETING OF COMMITTEE
Thursday, February 21st, 2002 - 7 p.m.
Council Chambers, City Hall

AGENDA

1. **Approval of Agenda**
2. **Approval of Minutes**
   - Meeting of Thursday, January 17, 2002 (PLC)
3. **Delegations**
4. **Updates**
   Community Based Risk Assessment (CBRA)
   - **HHRA Update**
   - **ERA Update**
   - **Chemicals of Concern Update**
   - **Socio-Economic Assessment (Property Valuation Study)**
   - **Community Health Assessment Project (CHAP)**
   - **Schedule Update (CBRA)**
5. **Federal Lands Environmental Site Assessment**
6. **Other Matters**
7. **Next Meetings**
8. **Adjournment**

Persons wishing to be delegates to the Committee should register in advance with Martha Toscher at 835-2900 ext.319

Leader

TECHNICAL SUBCOMMITTEE
of the
PUBLIC LIAISON COMMITTEE
for the
COMMUNITY BASED RISK ASSESSMENT
for Soils Contaminated in the Port Colborne Area

The "Technical Subcommittee: (TSC) of the Public Liaison committee will meet this **Thursday (April 4, 2002) in Committee room three on the third floor, City Hall.** Meetings of the TSC are open to the public as "observers" only.

The report scheduled to be considered at the meeting is:

2:00 p.m. The TSC will review a "protocol" prepared by Jacques Whitford Environment Limited, related to the Ecological Risk Assessment, and dealing with:
-Crop Studies Data Interpretation

This message is in the interest of keeping you informed....

YOUR PUBLIC LIAISON COMMITTEE

Tribune Wed April 3 /02

NOTICE OF MEETING

PUBLIC LIAISON COMMITTEE
for the
COMMUNITY BASED RISK ASSESSMENT
for Soils Contaminated in the Port Colborne Area

PORT COLBORNE

30th MEETING OF COMMITTEE
Thursday, April 25, 2002 - 7 p.m.
Council Chambers, City Hall

AGENDA

1. **Approval of Agenda**
2. **Approval of Minutes**
   - Meeting of Thursday, February 21, 2002 (PLC)
   - Meeting of Thursday, March 21, 2001 (PLC)
3. **Delegations**
4. **Updates on CBRA Activities (Beak)**
5. **General Question and Answer Session**
6. **Next Meeting**
8. **Adjournment**

Persons wishing to be delegates to the Committee should register in advance with Martha Toscher at 835-2900 ext.319

PLC NOTICE OF MEETING

PORT COLBORNE

TECHNICAL SUB-COMMITTEE
of the
PUBLIC LIAISON COMMITTEE
for the
COMMUNITY BASED RISK ASSESSMENT

The "Technical Sub-Committee" (TSC) of the Public Liaison Committee will meet this **Thursday, (April 25, 2002)** in **Committee Room Three at City Hall**. Meetings of the TSC are open to the public as "observers" only. However, members of the public can provide comment or questions respecting the agenda items by submitting them in writing to Martha Toscher at City Hall in advance of the meeting(s).

The report scheduled to be considered is:

2 p.m. The TSC will review the **"revised Scope of Work"** for the **"Property Valuation Study"** as prepared by Deloitte and Touche.

This message is in the interest of keeping you informed ...

YOUR PUBLIC LIAISON COMMITTEE

Comments or questions may be submitted to:

Martha Toscher
City of Port Colbone
66 Charlotte Street
Port Colborne, Ontario L3K 3C8
Ph: (905-835-2900 ext. 319
Fax: (905) 835-2969
marthatoscher@portcolborne.com

The Leader April 24/02

NOTICE OF MEETING

TECHNICAL SUB COMMITTEE COMMUNITY BASED RISK ASSESSMENT

PORT COLBORNE

On Thursday July 11, 2002 the Technical Subcommittee of the Public Liaison Committee will meet in Committee Room Three at City Hall, 66 Charlotte Street, to discuss certain matters relating to the Community Based Risk Assessment.

The public is welcome to attend the meeting(s) as observers. The public can make submissions respecting the agenda items by submitting same in advance to Martha Toscher at City Hall (see below). The reports related to the agenda items can be reviewed by contacting Mrs. Toscher.

The agenda for Thursday July 11, 2002 is:

2:00 p.m.

1). Review of Final Draft of the "Data Analysis and Interpretation Protocol" for the "Human Health Risk Assessment".
2). Review of Final Draft of the "Data Analysis and Interpretation Protocol" for the "Ecological Risk Assessment" for the Natural Environment.
3). Review of Final Draft of the "Data Analysis and Interpretation Protocol" for the "Ecological Risk Assessment" for Crops.
4). Review of comments received on the "Indoor Dust Sampling Protocol".
5). Development of "parameters" for participants in the TSC and PLC; presentations at conferences/seminars etc.

7:00 p.m.

1). Review of Protocol "A" related to the Community Health Assessment Project; "Self Reported Health Assessment of the Port colborne Community".
2). Review of Protocol "B" related to the Community Health Assessment Project; "A Comprehensive Assessment of the Current Health Status of a Stratified Random Sample of Residents of Port Colborne".
3). Review of Protocol "C" related to the Community Health Assessment Project; "A Comparison of Hospitalization Patterns in Port Colborne to the General Population of Ontario".

Martha Toscher
Secretary to the PLC
66 Charlotte Street
Port Colborne, Ont.
905-835-2900 (Ext. 319)

Tribune July 10/02

NOTICE OF MEETING

PORT COLBORNE

TECHNICAL SUB COMMITTEE

COMMUNITY BASED RISK ASSESSMENT

On Thursday, July 11, 2002 the Technical Subcommittee of the Public Liaison Committee will meet in Committee Room Three at City Hall, 66 Charlotte St., to discuss certain matters relating to the Community Based Risk Assessment.

The public is welcome to attend the meeting(s) as observers. The public can make submissions respecting the agenda items by submitting same in advance to Martha Toscher at City Hall (see below). The reports related to the agenda items can be reviewed by contacting Mrs. Toscher.

The agenda for Thursday, July 11 is:

2 pm

1. Review of Final Draft of the "Data Analysis and Interpretation Protocol" for the "Human Health Risk Assessment".
2. Review of Final Draft of the "Data Analysis and Interpretation Protocol" for the "Ecological Risk Assessment" for the Natural Environment.
3. Review of Final Draft of the "Data Analysis and Interpretation Protocol" for the "Ecological Risk Assessment" for Crops.
4. Review of comments received on the "Indoor Dust Sampling Protocol"
5. Development of "parameters" for participants in the TSC and PLC; presentations at conferences/seminars etc.

7 pm

1. Review of Protocol "A" related to the Community Health Assessment Project; "Self Reported Health Assessment of the Port Colborne Community".
2. Review of Protocol "B" related to the Community Health Assessment Project; "A Comprehensive Assessment of the Current Health Status of a Stratified Random Sample of Residents of Port Colborne".
3. Review of Protocol "C" related to the Community Health Assessment Project; "A Comparison of Hospitalization Patterns in Port Colborne to the General Population of Ontario".

Martha Toscher
Secretary to the PLC
66 Charlotte St., Port Colborne, ON
(905) 835-2900 (ext. 319)

The Leader July 10/02

Meetings on soil contamination

InPort Staff/PORT COLBORNE

A Technical Subcommittee meeting will be held Thursday August 8, to discuss a number of topics

The meeting will be held in third floor committee room of city hall at 2 p.m. and residents are welcome to attend and observe the meeting.

Topics to be discussed include:

"Data Analysis and Interpretation Protocol" for the "Ecological Risk Assessment" for the Natural Environment; Review of the "Protocol" relating to the "Renovation" Study and discussion of the "relationship" between the HHRA and the CHAP studies (Jacques Whitford Environmental Ltd. and Ventana).

A Public Liaison Committee meeting will be held at 7 p.m. that night.

IN Port July 24/02

Soil issue meetings tonight, Thursday

TRIBUNE STAFF

PORT COLBORNE

Public meetings today and Thursday will discuss issues related to the soil contamination.

Today's meeting 4 - 9 p.m. in the council chambers of city hall will see Jacques Whitford Environmental Ltd. present data analysis and protocols for the Human Health Risk Assessment and Ecological Risk Assessment for Crops.

On Thursday, a technical sub-committee meeting will be held in the third floor committee room of city hall at 2 p.m. It will review of data analysis and interpretation protocol for the Ecological Risk Assessment for the Natural Environment and the protocol for a renovation study.

The Public Liaison Committee will meet Thursday in the council chambers at 7 p.m. It will review and approve protocols, including indoor dust sampling; local supermarket food basket analysis and one for estimation of oral bioavailability of nickel in Port Colborne Soils.

"NOTICE OF MEETING"
TECHNICAL SUBCOMMITTEE COMMUNITY BASED RISK ASSESSMENT

On Thursday, August 8, 2002 at 2:00 p.m. the Technical Subcommittee of the Public Liaison Committee will meet in Committee Room Three at City Hall, 66 Charlotte Street, to discuss certain matters relating to the Community based Risk Assessment.

The public is welcome to attend the meeting as observers. The public can make submissions respecting the agenda items by submitting same in advance to Martha Toscher at City Hall (see below). The reports related to the agenda can be reviewed by contacting Mrs. Toscher.

The agenda for Thursday, August 8, 2002 (2:00 p.m.) is:

1. Review of the Final Draft of the "Data Analysis and Interpretation Protocol" for the "Ecological Risk Assessment" for the natural Environment.

   &

2. Review of the "Protocol" relating to the "Renovation" Study.

Martha Toscher
Secretary to the Public Liaison Committee
City Hall, 66 Charlotte Street
Port Colborne, Ontario
905-835-2900 ext. 319

Public Liaison Committee for the Community Based Risk Assessment

for Soils Contaminated in the Port Colborne Area

"NOTICE" OF MEETING OF THE COMMITTEE
Thursday, August 8, 2002 - 7:00 p.m.
Council Chambers, City Hall

AGENDA

1. **Approval of Agenda**
2. **Approval of Minutes**
3. **Delegations**
4. **"Review" of "Protocois" referred from the "TSC":**
   -"Indoor Dust Sampling Protocol"
   -"Local Supermarket Food Basket Analysis Protocol"
   -"Protocol for the Estimation of Oral Bioavailability of Nickel in Port Colborne Soils"
5. **Updates of CBRA Activities**
6. **General Question and Answer Session**
7. **Next Meeting**

Persons wishing to be "delegates" to the Committee should register, in advance, with Martha Toscher at 835-2900, ext. 319

Tribune Aug 7/02

Public Liaison Committee

for the

Community Based Risk Assessment

for Soils Contaminated in the Port Colborne Area

Notice of "Public Forum"
Wednesday August 7, 2002

This Wednesday from 4:00p.m. to 9:00p.m. a public forum/open house will be held in the Council Chambers at City Hall to discuss certain "Protocols" related to the Community Based Risk Assessment. Specifically two protocols, prepared by Jacques Whitford Environmental Limited, will be reviewed;

1. The "Data Analysis and Interpretation Protocol" for the "Ecological Risk Assessment " for the natural Environment

   &

2. The "Data Analysis and Interpretation Protocol" for the "Ecological Risk Assessment" for Crops.

This will be an "open house" format with a formal presentation at 7:00p.m. Anyone interested in the Community Based Risk Assessment is urged to attend.

Information respecting the "Public Form", and the "Protocols" to be discussed, may be obtained from:

Martha Toscher
Secretary to the Public Liaison Committee
City Hall, 66 Charlotte Street
Port Colborne, Ontario
905-835-2900 ext. 319

Tribune Aug 7/02

PORT COLBORNE

NOTICE OF MEETING

TECHNICAL SUBCOMMITTEE

of the

PUBLIC LIAISON COMMITTEE

for the

COMMUNITY BASED RISK ASSESSMENT

At **6:00 p.m.** on **Thursday October 24, 2002** the Technical Subcommittee of the Public Liaison Committee will meet in **Committee Room Three at City Hall, 66 Charlotte Street** to discuss certain matters relating to the Community Based Risk Assessment.

The public is welcome to attend the meeting as observers. **The public can make submissions respecting the agenda items by submitting same in advance to Martha Toscher at City Hall (see below).** The reports related to the agenda items can be reviewed by contacting Martha Toscher.

The topics scheduled to be considered this Thursday are as follows:

6:00 p.m.

- **Data Analysis and Interpretation Protocol for the ERA Natural Environment,** as prepared by Jacques Whitford Environmental
- **Indoor Dust Sampling Protocol** – "Implementation"
- **CBRA Schedule**

Martha Toscher
City of Port Colborne
66 Charlotte Street,
Port Colborne, Ontario L3K 3C8
Phone: (905) 835-2900 ext. 319
Fax: (905) 835-2969
marthatoscher@portcolborne.com

The Tribune Wed Oct 23/02

NOTICE OF MEETING

PORT COLBORNE

TECHNICAL SUB COMMITTEE
of the
PUBLIC LIAISON COMMITTEE
for the
COMMUNITY BASED RISK ASSESSMENT

At **6pm** on **Thursday, October 24, 2002** the Technical Subcommittee of the Public Liaison Committee will meet in **Committee Room Three** at **City Hall, 66 Charlotte St** to discuss certain matters relating to the Community Based Risk Assessment.

The public is welcome to attend the meeting as observers. **The public can make submissions respecting the agenda items by submitting same in advance to Martha Toscher at City Hall (see below).** The reports related to the agenda items can be reviewed by contacting Martha Toscher.

The topics scheduled to be discussed this Thursday are as follows:

6 pm Data Analysis and Interpretation Protocol for the ERA Natural Environment, as prepared by Jacques Whitford Environmmental

Indoor Dust Sampling Protocol - "Implementation"

CBRA Schedule

Martha Toscher
City of Port Colborne
66 Charlotte St., Port Colborne, ON
(905) 835-2900 (ext. 319) Fax: 905-835-2969
marthatoscher@portcolborne.com

Wed Oct 23/02 The Leader.

IN PORT NOV 20/02

PORT COLBORNE

Port Colborne
Community Based Risk Assessment
Ecological Risk Assessment - Natural Environment
Human Health Risk Assessment - Renovation Study
Open House/Presentation Session

- Jacques Whitford Environment Limited (JWEL) will hold an Open House and Presentation Session on "Approach to Data Interpretation and Analysis - Ecological Risk Assessment for the Natural Environment" as part of the Port Colborne Community Based Risk Assessment
- JWEL will also present an "Indoor Dust Sampling - Renovation Study Protocol" as part of the Human Health Risk Assessment (HHRA)
- The purpose of the Open House/Presentation Session is to give the residents of Port Colborne an opportunity to provide input into the HHRA/ERA Studies.
- The documents related to the Presentations can be reviewed by contacting Martha Toscher at City Hall.

The session will be held at:

City Hall Council Chambers
on Tuesday, November 26th, 2002

The session will be in two parts:

5:00 p.m. - 6:00 p.m. Open House
7:00 p.m. - Presentation, Question & Answer Session

For further information, please contact:

Eric Veska
Jacques Whitford Environment Ltd.
(416) 495-8614
eveska@jacqueswhitford.com

Martha Toscher
City of Port Colborne
(905) 835-2901 ext. 319
marthatoscher@portcolborne.com

OPEN HOUSE/PRESENTATION SESSION

PORT COLBORNE

COMMUNITY BASED RISK ASSESSMENT
ECOLOGICAL RISK ASSESSMENT - NATURAL ENVIRONMENT
HUMAN HEALTH RISK ASSESSMENT - RENOVATION STUDY

Jacques Whitford Environment Limited (JWEL) will hold an Open House and Presentation Session on "Approach to Data Interpretation and Analysis - Ecological Risk Assessment for the Natural Environment" as part of the Port Colborne's Community Based Risk Assessment.

JWEL will also present an "Indoor Dust Sampling - Renovation Study Protocol" as part of the Human Health Risk Assessment (HHRA).

The purpose of the Open House/Presentation Session is to give the residents of Port Colborne an opportunity to provide input into the HHRA/ERA Studies.

The documents related to the Presentations can be reviewed by contacting Martha Toscher at City Hall.

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5 - 6 pm ~ Open House

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City of Port Colborne
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marthatoscher@portcolborne.com

The Leader Nov 20/02

PORT COLBORNE

Port Colborne
Community Based Risk Assessment
Ecological Risk Assessment - Natural Environment
Human Health Risk Assessment - Renovation Study
Open House/Presentation Session

- Jacques Whitford Environment Limited (JWEL) will hold an Open House and Presentation Session on "Approach to Data Interpretation and Analysis - Ecological Risk Assessment for the Natural Environment" as part of the Port Colborne Community Based Risk Assessment
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Martha Toscher
City of Port Colborne
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marthatoscher@portcolborne.com

Tribune Nov 23/02

NOTICE OF MEETING

PORT COLBORNE

PUBLIC LIAISON COMMITTEE

for the

COMMUNITY BASED RISK ASSESSMENT

for Soils Contaminated in the Port Colborne Area

MEETING OF COMMITTEE

Thursday, December 5, 2002 --- 7 pm

Council Chambers, City Hall

AGENDA

1. Approval of Agenda
2. Approval of Minutes
   - Special Meeting of the PLC August 15, 2002
   - PLC Meeting of September 26, 2002
   - PLC Meeting of October 17, 2002
3. Delegations
4. Updates of CBRA Activities
5. Final Review of:
   - Data Analysis & Interpretation Protocol, Human Health Risk Assessment
   - Data Analysis & Interpretation Protocol, Environmental Risk Assessment, Crops
   - Data Analysis & Interpretation Protocol, Environmental Risk Assessment, Natural Environment
   - Human Health Risk Assessment, Indoor Dust Sampling - Renovation Study Protocol
6. General Question and Answer Session
7. Next Meeting

Persons wishing to be "delegates" to the Committee should register, in advance, with Martha Toscher at 835-2900 ext.319.

The Leader
Wed Dec 4/02

NOTICE OF MEETING

PUBLIC LIAISON COMMITTEE

for the

COMMUNITY BASED RISK ASSESSMENT

for Soils contaminated in the Port Colborne Area

Thursday, December 5th, 2002 - 7:00 p.m.
Council Chambers, City Hall

AGENDA

1 **Approval of Agenda**

2 **Approval of Minutes**
- **Special Meeting of the PLC August 15th, 2002**
- **PLC Meeting of September 26th, 2002**
- **PLC Meeting of October 17, 2002**

3 **Delegations**

4 **Updates of CBRA Activities**

5 **Final Review of:**
- **Data Analysis & Interpretation Protocol, Human Health Risk Assessment**
- **Data Analysis & Interpretation Protocol, Environmental Risk Assessment, Crops**
- **Data Analysis & Interpretation Protocol, Environmental Risk Assessment, Natural Environment**
- **Human Health Risk Assessment, Indoor Dust Sampling - Renovation Study Protocol**

6 **General Question and Answer Session**

7 **Next Meeting**

8 **Adjournment**

Persons wishing to be "delegates" to the Committee should register, in advance, with Martha Toscher at 835-2900 ext. 319

INPORT WED DEC 4/02

INVITATION

PORT COLBORNE

AN INVITATION TO A PUBLIC MEETING TO DISCUSS THE "TIMING", "PRESENTATION" AND "FORMAT" FOR REVIEWING THE FINAL "CBRA" REPORTS

The "Major" reports related to the Community Based Risk Assessment are nearly complete at the Consultant/Scientific Level. These reports are large and complex. Your Public Liaison committee (PLC) has now received a "Draft" schedule for making these reports available to the public. The PLC and its consultant (Stantec Environmental) will be holding a "Public Meeting" to review that schedule and to receive public input on how best to facilitate public review of the documents and reports as follows:

Location: **Council Chambers**
City Hall
66 Charlotte St.

Date: **Wednesday, July 2, 2003 - 7pm**

A copy of the Draft "Schedule" will be available at the meeting, or can be obtained through:

Chuck Miller

City Hall, 66 Charlotte St., Port Colborne ON L3K 3C8
Phone: 905-835-2900 ext. 303
email: chuckmiller@portcolborne.com

The Leader July 2/03

PORT COLBORNE
COMMUNITY BASED RISK ASSESSMENT
ECOLOGICAL RISK ASSESSMENT
- NATURAL ENVIRONMENT

OPEN HOUSE/ PRESENTATION SESSION

- Jacques Whitford Environment Limited (JWEL) will hold an Open House and Presentation Session on the recently released **Ecological Risk Assessment Report** related to the **Natural Environment**; which forms part of the Community Based Risk Assessment. This is the first of three main studies for the CBRA to be released.
- The purpose of the Open House/Presentation Session is to "introduce" the report and it's findings. There will be additional open houses and drop-ins related to the report over the next few months.
- An "executive summary" of the report can be obtained from Chuck Miller at City Hall, or, by attending the open house.

THE SESSION WILL BE HELD AT:

CITY HALL COUNCIL CHAMBERS
ON THURSDAY JULY 31, 2003

THE SESSION WILL BE IN TWO PARTS:

4:00 P.M. - 6:00 P.M. • OPEN HOUSE

7:00 P.M. • PRESENTATION, QUESTION & ANSWER SESSION

For further information, please contact:

Charles V. Miller
Manager of Strategic Projects
City of Port Colborne
(905) 835-2900 (ext. 303)
chuck miller@portcolborne.com

Tribune July 30/03

PORT COLBORNE
COMMUNITY BASED RISK ASSESSMENT
ECOLOGICAL RISK ASSESSMENT - NATURAL ENVIRONMENT

OPEN HOUSE/ PRESENTATION SESSION

- Jacques Whitford Environment Limited (JWEL) will hold an Open House and Presentation Session on the recently released **Ecological Risk Assessment Report** related to the **Natural Environment**, which forms part of the Community Based Risk Assessment. This is the first of three main studies for the CBRA to be released.
- The purpose of the Open House/Presentation Session is to "introduce" the report and it's findings. There will be additional open houses and drop-ins related to the report over the next few months.
- An "executive summary" of the report can be obtained from Chuck Miller at City Hall, or, by attending the open house.

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For further information, please contact:

Charles V. Miller
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chuck miller@portcolborne.com

Tribune July 31/03

OPEN HOUSE/PRESENTATION SESSION

PORT COLBORNE
COMMUNITY BASED RISK ASSESSMENT
ECOLOGICAL RISK ASSESSMENT
NATURAL ENVIRONMENT

• Jacques Whitford Environment Limited (JWEL) will hold an Open House and Presentation Session on the recently released Ecological Risk Assessment Report related to the Natural Environment; which forms part of the Community Based Risk Assessment. This is the first of three main studies for the CBRA to be released.

• The purpose of the Open House/Presentation Session is to "introduce" the report and it's findings. There will be additional open houses and drop-ins related to the report over the next few months.

• An "executive summary" of the report can be obtained from Charles Miller at City Hall, or, by attending the open house.

The session will be held at:

City Hall Council Cambers
on Thursday, July 31, 2003

The session will be in two parts:

4pm - 6pm Open House
7pm presentation, Question & Answer Session

For further information, please contact:

Charles V. Miller, Manager of Strategic Projects
City of Port Colborne 905-835-2900 ext 303
chuckmiller@portcolborne.com

The Leader July 30/03

PORT COLBORNE
COMMUNITY BASED RISK ASSESSMENT
ECOLOGICAL RISK ASSESSMENT - NATURAL ENVIRONMENT
OPEN HOUSE/PRESENTATION SESSION/INVITATION
FOR PUBLIC INPUT

- Next Thursday, representatives from Stantec Consulting (Consultants to the Public Liaison Committee) will hold an **Open House and Presentation Session** dealing with the **Ecological Risk Assessment Report** related to the **Natural Environment**; which forms part of the Community Based Risk Assessment. This report was the subject of a previous "Open House" (in late July) which introduced the report and its findings.
- Since the July "Open House", the **Natural Environment** Report has undergone considerable review. The upcoming "Open House/Presentation Session" (hosted by Stantec) will provide summary of that review.
- At the meeting, interested members of the public are invited to provide comment/input respecting the report.
- **Following the "Open House/Presentation"** relating to the **Natural Environment** Report, the Public Liaison Committee and Stantec will provide an **"Update"** and **"Question and Answer"** session respecting the overall **CBRA process.** Potential **"Update"** topics include the overall **CBRA Schedule, Lead as a Potential Chemical of Concern,** and, the **Integration Report.**
- The **Natural Environment** Report can be reviewed, and, an "executive summary" can be obtained by contacting Chuck Miller at City Hall, or, by attending the open house.

The session will be held at:

City Hall Council Chambers
on Thursday, October 23, 2003

The session will be in two parts:

5:00 p.m. - 7:00 p.m.	**- Open House**
7:00 p.m.	**- Presentation, Public Comment/Input** **- CBRA Update**

For further information, please contact:

Charles V. Miller
Manager of Strategic Projects
City of Port Colborne
(905) 835-2900 (ext. 303)
chuckmiller@portcolborne.com

Or

Martha Toscher
City of Port Colborne
Municipal Offices
(905) 835-2900 (ext. 319)
marthatoscher@portcolborne.com

Tribune Oct 22/03