

SUDBURY AREA RISK ASSESSMENT

CHAPTER 10.0 DISTRIBUTION OF CHEMICALS OF CONCERN IN THE COMMUNITIES OF INTEREST

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10.0 DISTRIBUTION OF CHEMICALS OF CONCERN IN THE COMMUNITIES OF INTEREST

10.1 Overview of Chemicals of Concern in the Communities of Interest

The following sections summarize soil metal concentrations in all five Communities of Interest examined as part of the HHRA (Copper Cliff, Coniston, Falconbridge, Hanmer, and Sudbury Centre). MOE criteria (Table A/F) used in the selection of COC are provided in Chapter 8 for comparison purposes. It is important to recognize that for the results described in the following sections, the method detection limits (MDLs) for the quantification of arsenic and selenium levels in soil were 5 mg/kg and 1 mg/kg, respectively. For evaluation purposes, any value reported to be below the MDL was replaced with a value equal to half of its respective MDL. Also note that the statistics provided in the tables may differ slightly than the results presented on figures in this chapter. The reason for this is that the statistics provided in tables were calculated using all measured values, which included the original and duplicate samples, whereas the mean concentrations from both sample types were plotted on the maps.

10.1.1 Copper Cliff

A review of the metal concentrations for the six Chemicals of Concern (COC) in Copper Cliff is presented in the following text. In this Community of Interest, a total of 315 soil samples were analyzed from the 0 to 5 cm soil depth, with 290 soil samples analyzed from both the 5 to 10 cm and 10 to 20 cm depths. A summary of the COC concentrations in the soils of this community is provided in Table 10.1.

Arsenic

The minimum As concentration reported at all three soil depths was 2.5 mg/kg; note that this value represents one half of the MDL for As. At the 0 to 5 cm soil depth, the mean As concentration was found to be 17.6 mg/kg. The maximum As concentration for this depth was 72 mg/kg, and the 95th percentile concentration was 44.3 mg/kg. The mean As concentration in the 5 to 10 cm soil depth was 22.2 mg/kg, while the 95th percentile concentration was reported to be 53.55 mg/kg. The maximum concentration at this soil depth was 101 mg/kg. The deepest soil sampled (10 to 20 cm) exhibited a maximum As concentration of 99 mg/kg. The mean concentration at this depth was 23.6 mg/kg, with a 95th percentile concentration of 55.55 mg/kg. Figure 10-1 depicts the As distribution (0 to 5 cm depth) found in the soils of the Copper Cliff community.

Cobalt

The mean Co concentration in the uppermost soil layer was 32.4 mg/kg. The minimum and maximum concentrations for this soil depth were 6 and 110 mg/kg, respectively, with a 95th percentile value of 79.3 mg/kg. The 5 to 10 cm soil depth exhibited a Co range of 3 to 70 mg/kg. The mean and 95th percentile concentrations at this depth were 23.3 mg/kg and 47.1 mg/kg, respectively. The 10 to 20 cm soil depth showed Co concentrations varying from 5 to 46 mg/kg, with a mean concentration of 19.9 mg/kg. The 95th percentile concentration reported was 36.55 mg/kg. Figure 10-2 shows Co levels in soil (0 to 5 cm depth) within the Copper Cliff community.

Copper

The range of Cu concentrations for the 0 to 5 cm soil depth fluctuated from 26 to 5600 mg/kg. The reported mean and 95th percentile concentrations were 1367 mg/kg and 3430 mg/kg, respectively. Copper concentrations in the 5 to 10 cm depth comprised a range of 26 to 2800 mg/kg, with a mean of 778.6 mg/kg. The 95th percentile concentration was 1655 mg/kg at this soil depth. Soil from the 10 to 20 cm depth showed a range of Cu concentrations from 25 to 2000 mg/kg. The mean Cu concentration at this depth was 590.0 mg/kg, whereas the 95th percentile concentration was 1300 mg/kg. Figure 10-3 illustrates Cu concentrations in surface soils (0 to 5 cm depth) in the Copper Cliff community.

Nickel

The range of Ni concentrations in the uppermost soil layer (0 to 5 cm) was 24 to 3700 mg/kg, with an average concentration of 978 mg/kg. In comparison, the 95th percentile concentration for this depth was 2500 mg/kg. The mean Ni concentration at the 5 to 10 cm soil depth was 720 mg/kg. The Ni concentration range at this depth was 40 to 3100 mg/kg, with a 95th percentile concentration of 1755 mg/kg. The 10 to 20 cm soil depth demonstrated Ni concentration values from 27 to 1900 mg/kg. The mean concentration in this lowermost depth was 582 mg/kg, with a 95th percentile concentration of 1200 mg/kg. Nickel concentrations in surface soils across the Copper Cliff community are shown in Figure 10-4.

Lead

Lead concentrations in the upper soil layer ranged from 3 to 410 mg/kg. The mean Pb concentration in the upper 5 cm of soil was 83.0 mg/kg and the 95th percentile concentration was 220 mg/kg. The Pb concentrations at the 5 to 10 cm depth ranged from 7 to 330 mg/kg, with an average concentration of 71.9 mg/kg. The reported 95th percentile concentration was 190 mg/kg at this soil depth. The deepest soil

sampled (10-20 cm) demonstrated an average Pb value of 85.9 mg/kg. The Pb concentrations at this depth varied from 5 to 610 mg/kg, with a 95th percentile concentration reported at 240 mg/kg. Figure 10-5 illustrates Pb levels in soil (0 to 5 cm depth) at sites sampled in the Copper Cliff community.

Selenium

The minimum Se concentration for all three soil sample depths was 0.5 mg/kg; note that this value represents one half of the MDL for Se. The mean Se value for the 0 to 5 cm soil range was 7.5 mg/kg, with a 95th percentile concentration of 19 mg/kg. The maximum Se concentration at this depth was 49 mg/kg. The mean concentration at the 5 to 10 cm soil depth was 3.9 mg/kg, with a 95th percentile concentration of 8 mg/kg. The maximum Se concentration at this depth was 14 mg/kg. The mean Se concentration in the 10 to 20 cm soil depth was 2.8 mg/kg, with a maximum concentration of 11 mg/kg. The 95th percentile concentration reported for this depth was 6 mg/kg. Figure 10-6 shows the Se distribution in soils (0 to 5 cm depth) across the Copper Cliff community.

Table 10.1 Summary of Metal Concentrations in Copper Cliff (mg/kg)

Depth (cm) and number of samples (N)	Statistic	Arsenic	Cobalt	Copper	Nickel	Lead	Selenium
0-5 N= 315	min	2.5	6	26	24	3	0.5
	max	72	110	5600	3700	410	49
	mean	17.6	32.4	1367	978	83.0	7.5
	95th percentile	44.3	79.3	3430	2500	220	19
5-10 N=290	min	2.5	3	26	40	7	0.5
	max	101	70	2800	3100	330	14
	mean	22.2	23.3	779	720	71.9	3.9
	95th percentile	53.6	47.1	1655	1755	190	8
10-20 N=290	min	2.5	5	25	27	5	0.5
	max	99	46	2000	1900	610	11
	mean	23.6	19.9	590	582	85.9	2.8
	95th percentile	55.6	36.55	1300	1200	240	6

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Figure 10-1
Copper Cliff
Distribution of Arsenic
in 2001 Soil Samples

Soil Depth 0-5 cm

Arsenic Concentration (mg/kg)

- < 20 (MOE Table A Guideline)
- 20 - 50
- 50 - 200
- > 200



Scale 1:15,000

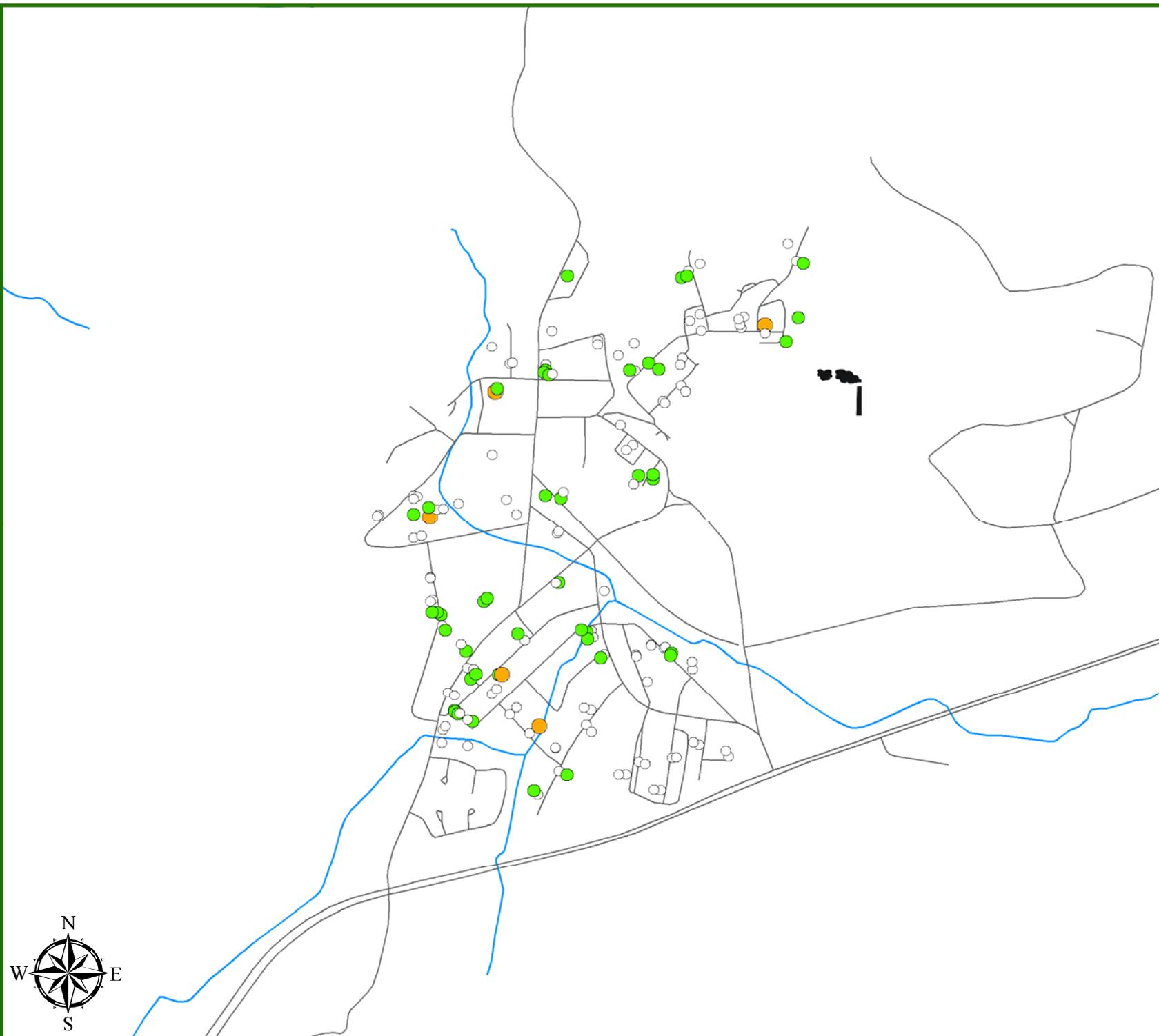
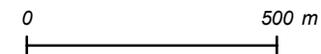


Figure 10-2
Copper Cliff
Distribution of Cobalt
in 2001 Soil Samples

Soil Depth 0-5 cm

Cobalt Concentration (mg/kg)

- < 40 (MOE Table A Guideline)
- 40 - 80
- 80 - 150
- > 150



Scale 1:15,000

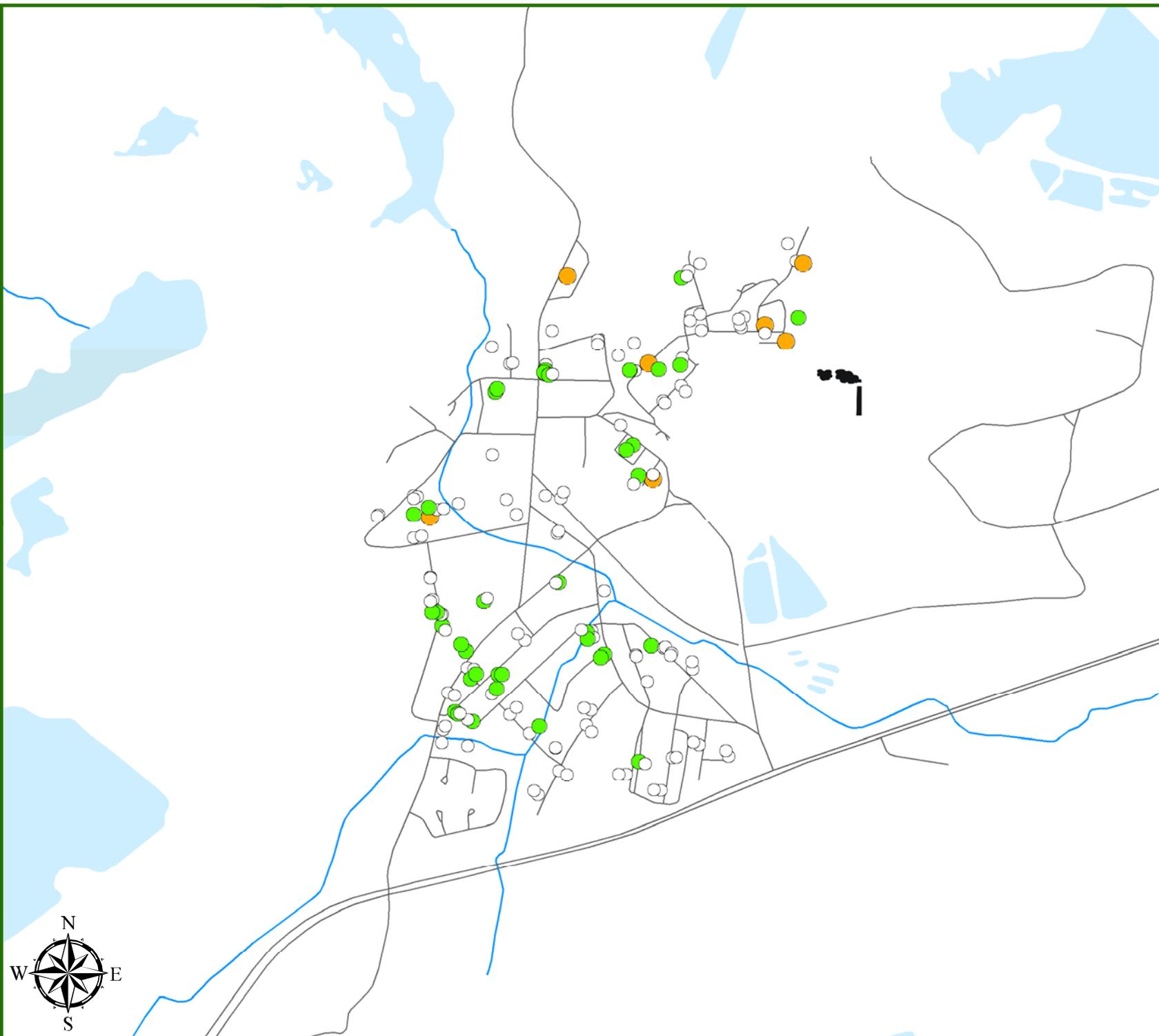
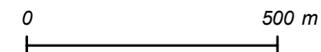


Figure 10-3
Copper Cliff
Distribution of Copper
in 2001 Soil Samples

Soil Depth 0-5 cm

Copper Concentration (mg/kg)

- < 150
- 150 - 300
- 300 - 1000
- 1000 - 2000
- > 2000



(MOE Table A
Guideline is 225 mg/kg)

Scale 1:15,000

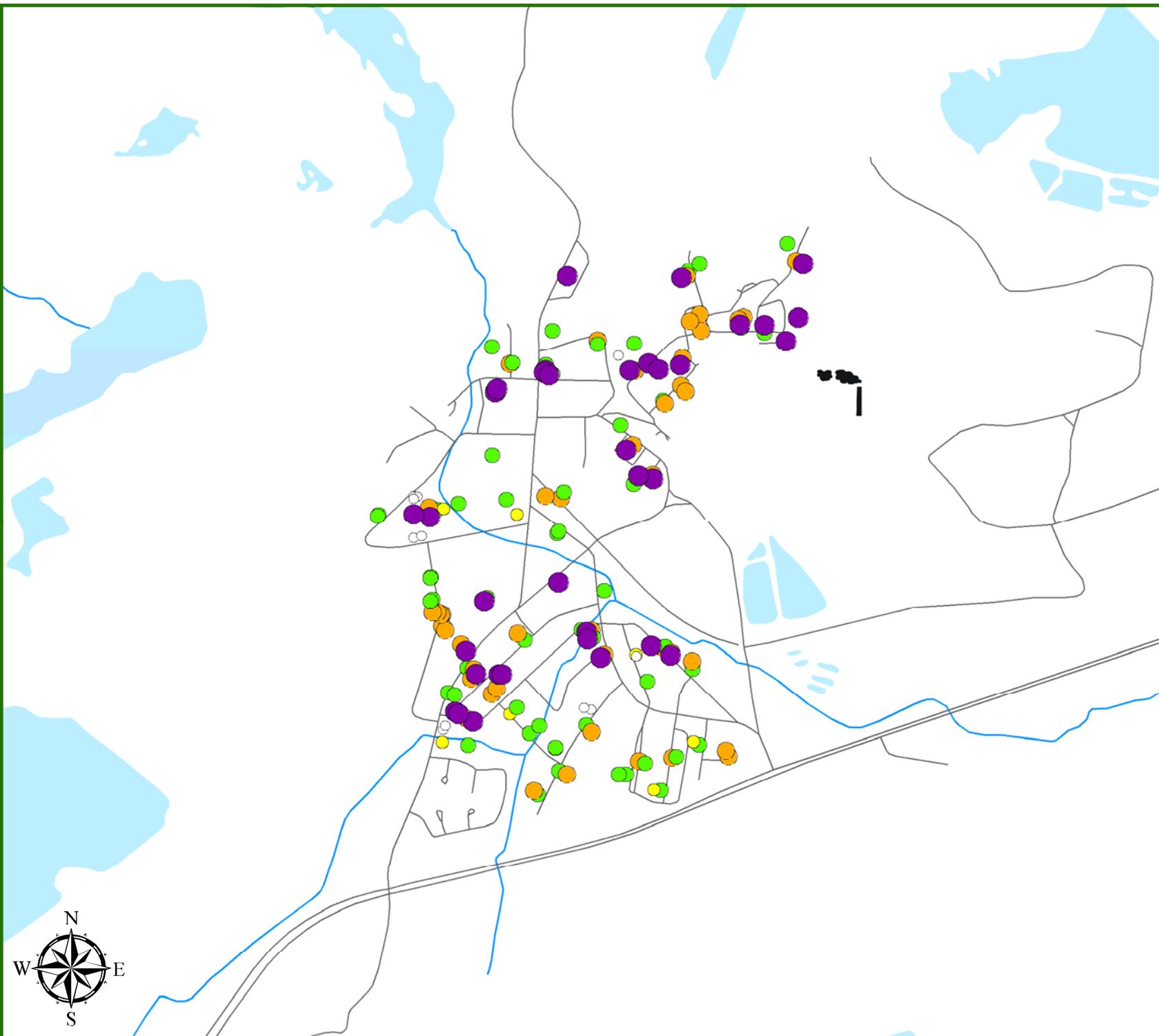
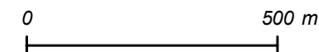


Figure 10-4
Copper Cliff
Distribution of Nickel
in 2001 Soil Samples

Soil Depth 0-5 cm

Nickel Concentration (mg/kg)

- < 150 (MOE Table A Guideline)
- 150 - 300
- 300 - 1000
- 1000 - 2000
- > 2000



Scale 1:15,000

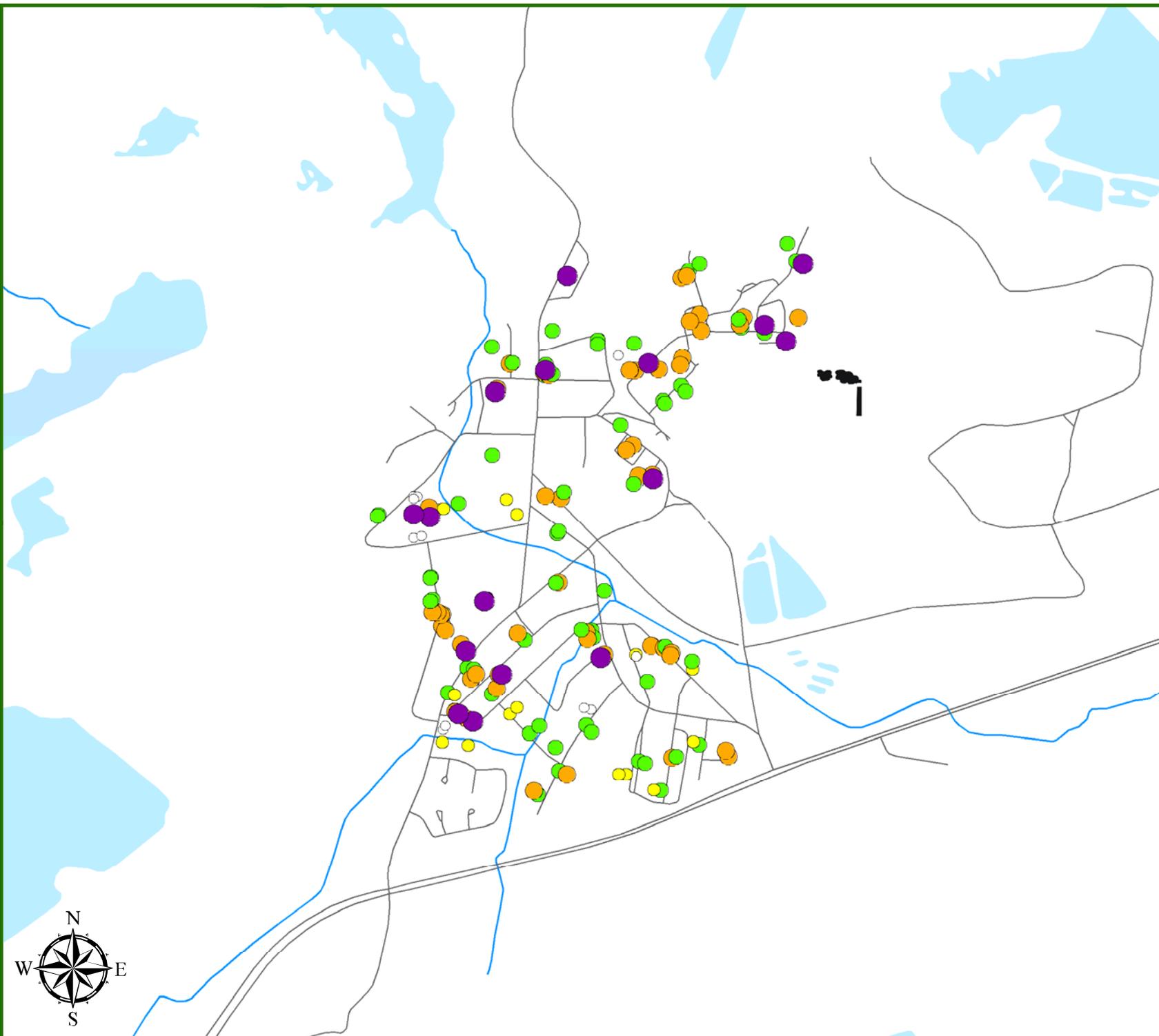


Figure 10-5
Copper Cliff
Distribution of Lead
in 2001 Soil Samples

Soil Depth 0-5 cm

Lead Concentration (mg/kg)

- < 50
- 50 - 100
- 100 - 200
- > 200 (MOE Table A Guideline)



Scale 1:15,000

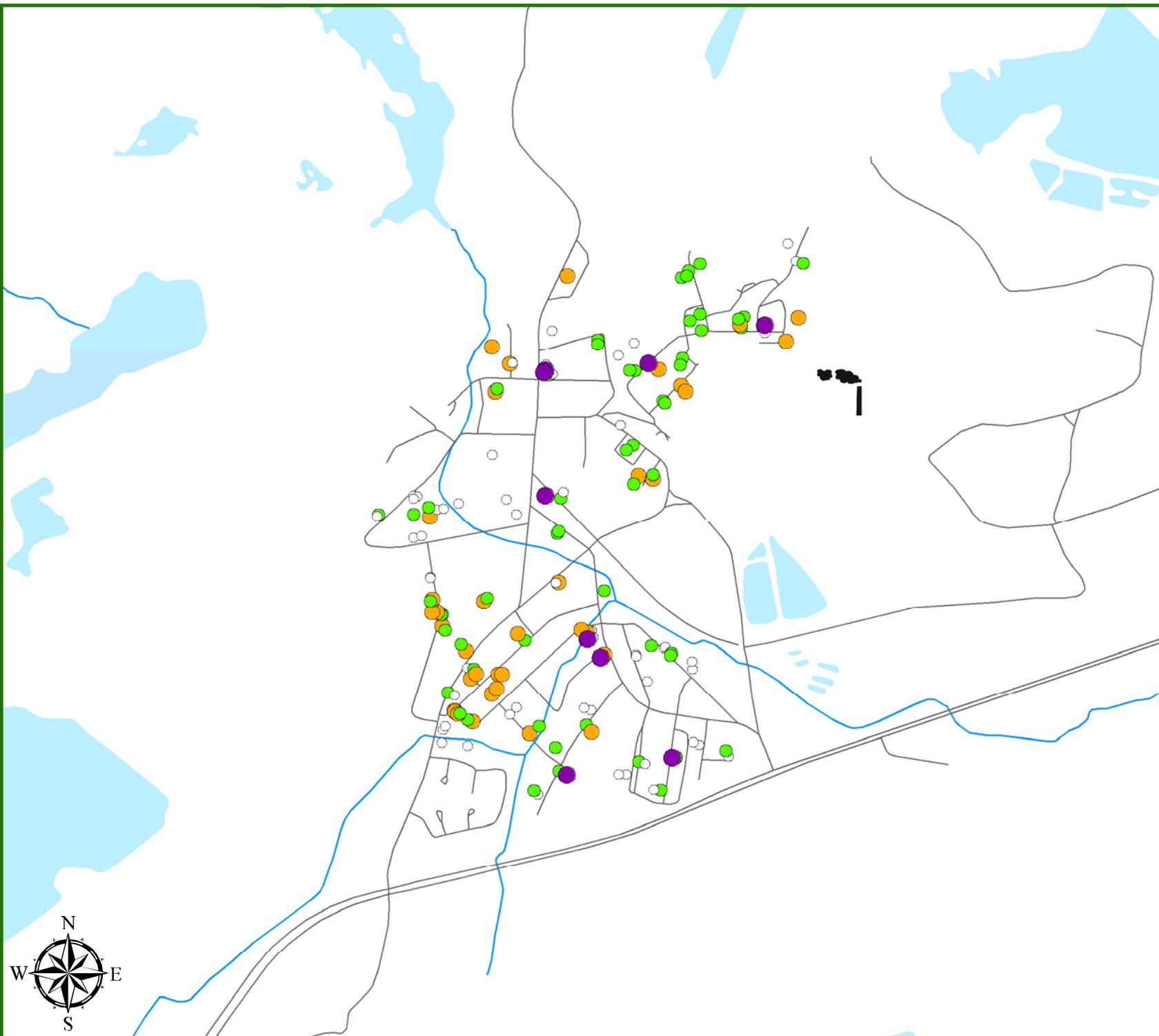
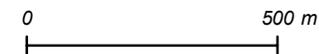


Figure 10-6
Copper Cliff
Distribution of Selenium
in 2001 Soil Samples

Soil Depth 0-5 cm

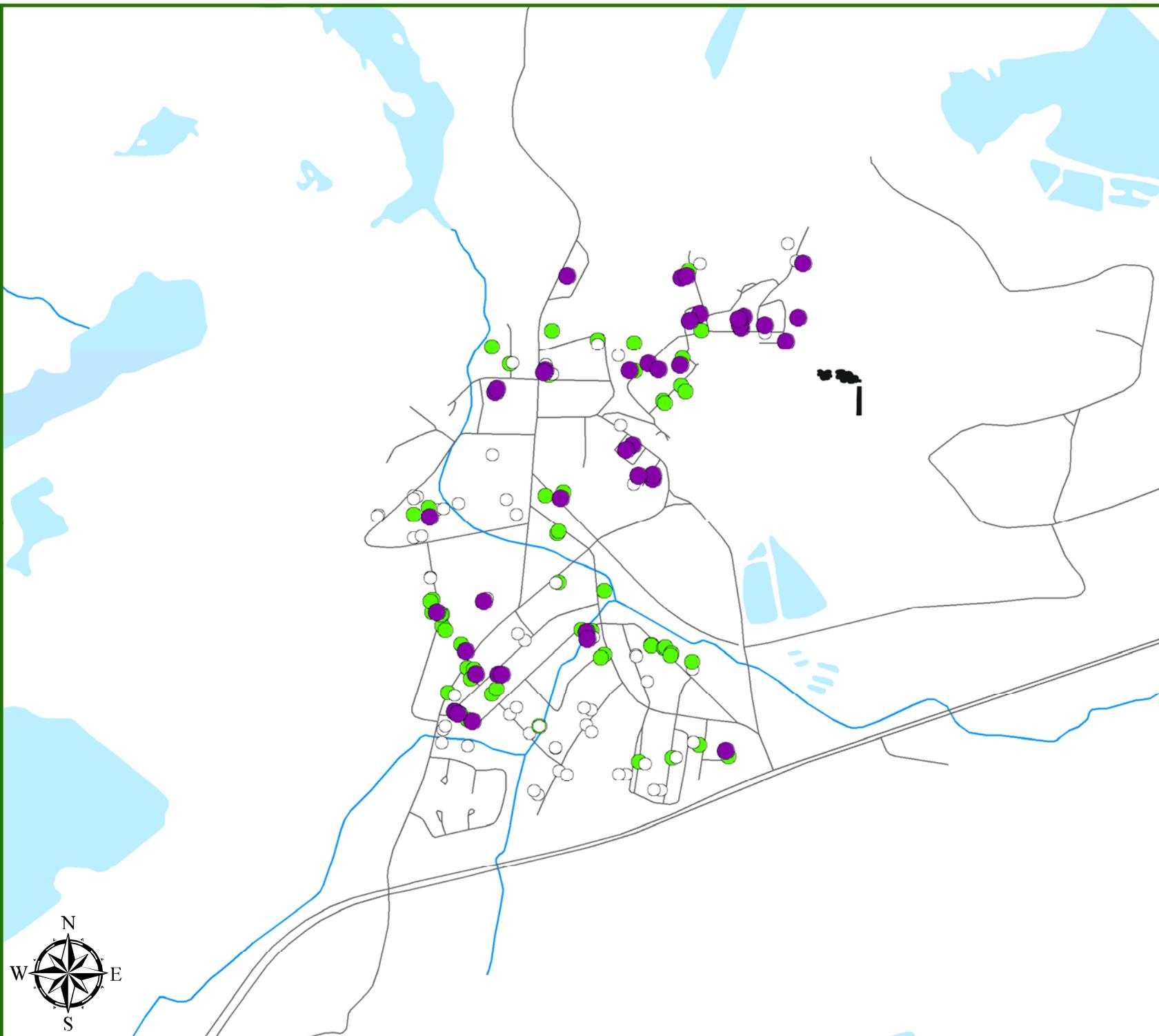
Selenium Concentration (mg/kg)

- < 5
- 5 - 10
- > 10 (MOE Table A Guideline)

Smelter Stack

Scale 1:15,000

0 500 m



10.1.2 Coniston

A review of the metal concentrations for the six COC in Coniston is presented in the following text. In this Community of Interest, a total of 324 soil samples were analyzed from the 0 to 5 cm soil depth, with 304 and 288 soil samples analyzed from the 5 to 10 cm and 10 to 20 cm depths, respectively. A summary of the COC concentrations in the soils of this community is provided in Table 10.2.

Arsenic

The minimum As concentration reported at all three soil sampling depths was 2.5 mg/kg; note that this value represents one half of the MDL for As. The mean As level in the topmost soil layer was 10.3 mg/kg, with a maximum As concentration of 66 mg/kg and a 95th percentile concentration of 33 mg/kg. The maximum As concentration in the 5 to 10 cm soil range was 53 mg/kg. The 95th percentile concentration was 28.85 mg/kg, whereas the mean concentration was 10.6 mg/kg at this depth. The 10 to 20 cm soil layer demonstrated a mean As concentration of 9.9 mg/kg. The maximum As value for this soil depth was 55 mg/kg, with a 95th percentile concentration of 23.65 mg/kg. Figure 10-7 shows the As concentrations in surface soils of the Coniston community.

Cobalt

Cobalt concentrations ranged from 3 to 74 mg/kg in the 0 to 5 cm soil layer. The mean concentration at this depth was 16.0 mg/kg, with the 95th percentile concentration reported as 44.85 mg/kg. The mean Co value in the 5 to 10 cm soil layer was 13.0 mg/kg, with a minimum Co concentration of 3 mg/kg, equivalent to the 0 to 5 cm minimum value. The maximum Co concentration at this depth was 46 mg/kg, and the 95th percentile concentration was 30.85 mg/kg. At the 10 to 20 cm depth, the minimum and maximum Co concentrations were 4 and 43 mg/kg, respectively. The mean concentration in this layer was 11.9 mg/kg, with the 95th percentile concentration reported to be 22 mg/kg. The Co concentration in soils (0 to 5 cm depth) of the Coniston community is illustrated in Figure 10-8.

Copper

Concentrations of Cu in the topmost soil layer (0 to 5 cm) ranged from 8.3 to 1200 mg/kg, with a mean value of 236.2 mg/kg. The 95th percentile concentration in this soil layer was 782.5 mg/kg. The mean Cu concentration measured at the 5 to 10 cm soil depth was 213.6 mg/kg, with the concentration range encompassing 8.2 to 920 mg/kg. The 95th percentile concentration reported for this soil depth was 637 mg/kg. The Cu concentration range at the 10-20 cm depth was 17 to 1100 mg/kg. The mean concentration

in this layer was reported to be 210.5 mg/kg, with a 95th percentile concentration of 506.5 mg/kg. Figure 10-9 illustrates Cu concentrations in surface soil at sites sampled in the Coniston community.

Nickel

The mean Ni content in the 0 to 5 cm soil layer was 320.7 mg/kg, with a 95th percentile concentration of 1100 mg/kg. The Ni concentration range in the topmost soil layer was 16 to 1900 mg/kg. The 5 to 10 cm soil depth demonstrated a mean Ni concentration of 282.4 mg/kg, with a Ni concentration range of 14 to 1200 mg/kg reported. The 95th percentile concentration was 895.5 mg/kg at this depth. The 10 to 20 cm soil range exhibited Ni concentrations from 22 to 1400 mg/kg. The mean concentration at this soil level was 262.4, with a 95th percentile concentration of 653 mg/kg. Figure 10-10 illustrates the Ni distribution in soil (0 to 5 cm depth) across the Coniston community.

Lead

The minimum Pb concentration in the uppermost (0 to 5 cm) and middle (5 to 10 cm) soil layers was reported at 2 mg/kg. In the upper 5 cm of soil the maximum Pb concentration was 400 mg/kg, and had a reported mean of 47.9 mg/kg. The 95th percentile concentration exhibited at this soil depth was 140 mg/kg. The 5 to 10 cm soil depth displayed a mean Pb content of 40.2 mg/kg. The maximum Pb level at this depth was 270 mg/kg, with a 95th percentile concentration of 130 mg/kg. The mean Pb concentration at the 10 to 20 cm soil depth was 43.0 mg/kg. Lead values at this soil level spanned a range of 3 to 280 mg/kg, with a 95th percentile concentration of 146.5 mg/kg. Figure 10-11 shows Pb levels in soil (0 to 5 cm depth) located across the Coniston community.

Selenium

The minimum and 95th percentile Se concentrations at all three soil depths were equivalent at 0.5 mg/kg and 3 mg/kg, respectively. However, the minimum concentration represents one half of the MDL for Se. The mean Se content of the 0 to 5 cm soil depth was 1.1 mg/kg, with a maximum Se concentration of 5 mg/kg. The maximum Se level in the middle soil depth (5 to 10 cm) was 4 mg/kg, and the mean concentration at this level was reported to be 1.0 mg/kg. The deepest soil layer (10 to 20 cm) exhibited a maximum Se level of 9 mg/kg, with a mean Se concentration equal to that of the middle soil layer at 1.0 mg/kg. Figure 10-12 shows concentrations of Se (0 to 5 cm depth) in soils of the Coniston community.

Table 10.2 Summary of Metal Concentrations in Coniston (mg/kg)

Depth (cm) and number of samples (N)	Statistic	Arsenic	Cobalt	Copper	Nickel	Lead	Selenium
0-5 N=324	min	2.5	3	8.3	16	2	0.5
	max	66	74	1200	1900	400	5
	mean	10.3	16.0	236.2	320.7	47.9	1.1
	95th percentile	33	44.85	782.5	1100	140	3
5-10 N=304	min	2.5	3	8.2	14	2	0.5
	max	53	46	920	1200	270	4
	mean	10.6	13.0	213.6	282.4	40.2	1.0
	95th percentile	28.85	30.85	637	895.5	130	3
10-20 N=288	min	2.5	4	17	22	3	0.5
	max	55	43	1100	1400	280	9
	mean	9.9	11.9	210.5	262.4	43.0	1.0
	95th percentile	23.65	22	506.5	653	146.5	3

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Figure 10-7
Coniston
Distribution of Arsenic
in 2001 Soil Samples

Soil Depth 0-5 cm

Arsenic Concentration (mg/kg)

-  < 20 (MOE Table A Guideline)
-  20 - 50
-  50 -200
-  > 200



Scale 1:18,000

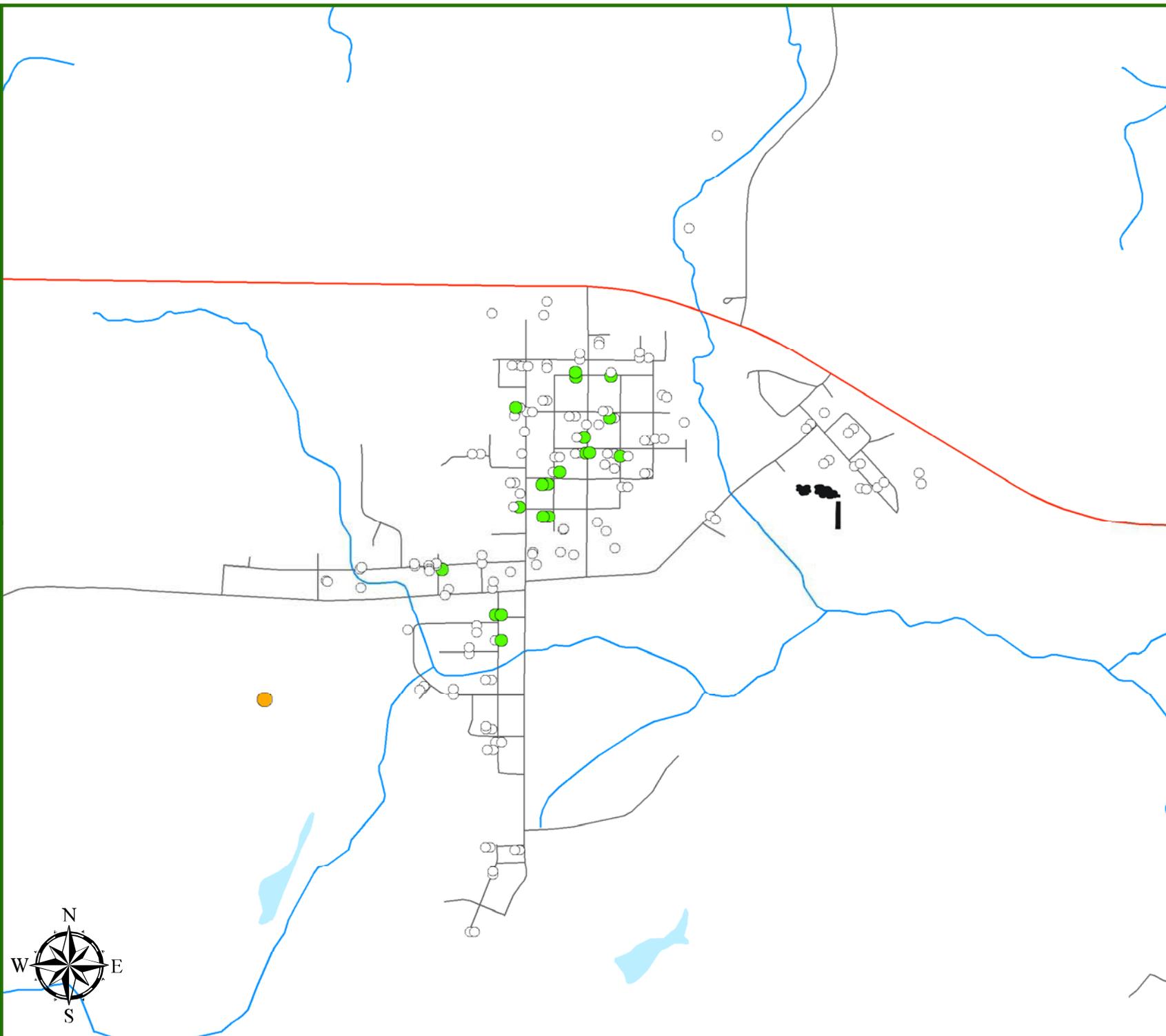
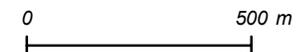
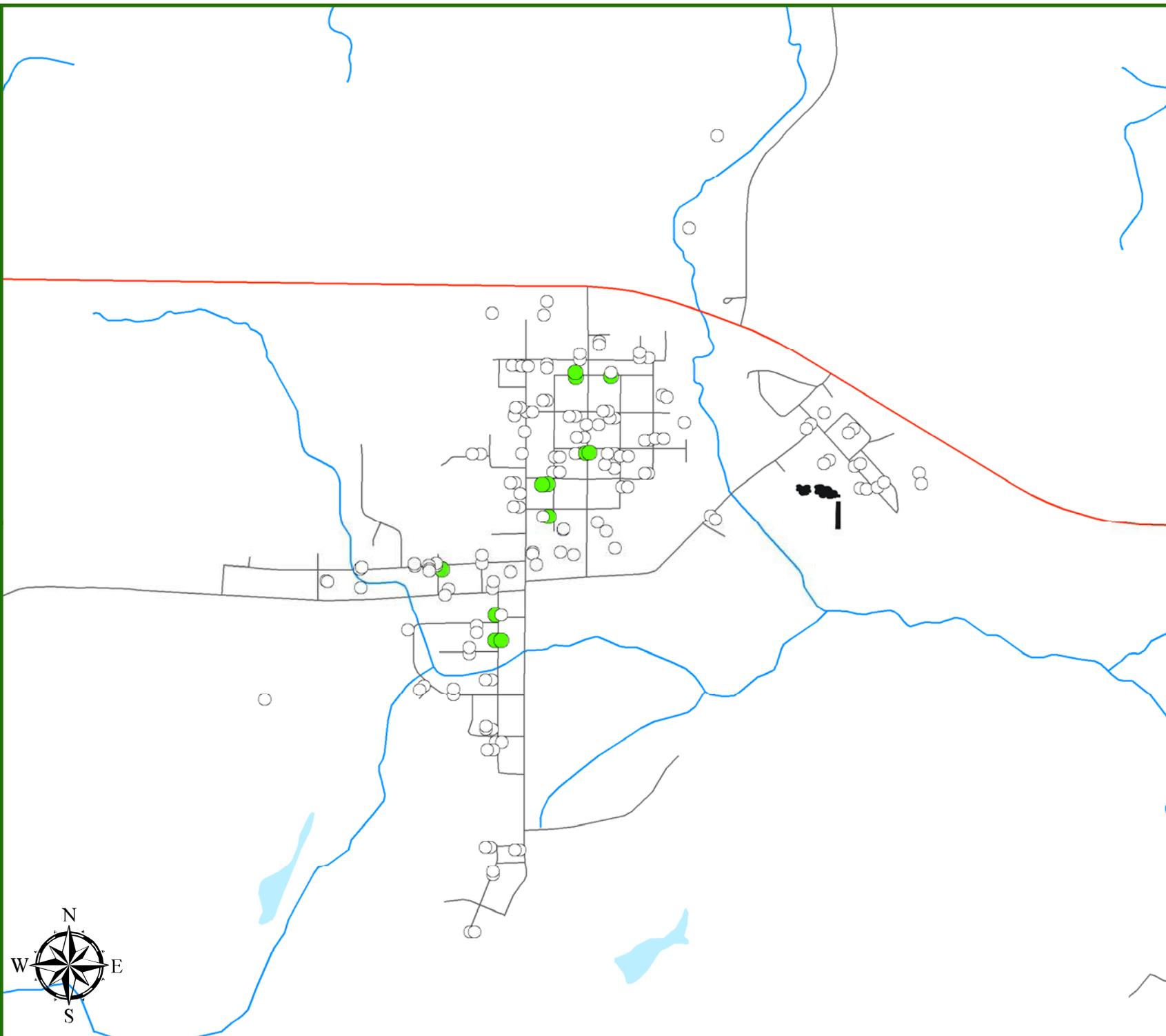


Figure 10-8
Coniston
Distribution of Cobalt
in 2001 Soil Samples

Soil Depth 0-5 cm

Cobalt Concentration (mg/kg)

- < 40 (MOE Table A Guideline)
- 40 - 80
- 80 - 150
- > 150
- Smelter Stack



Scale 1:18,000

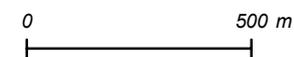


Figure 10-9
Coniston
Distribution of Copper
in 2001 Soil Samples

Soil Depth 0-5 cm

Copper Concentration (mg/kg)

-  < 150
-  150 - 300
-  300 - 1000
-  1000 - 2000
-  > 2000



(MOE Table A
Guideline is 225 mg/kg)

Scale 1:18,000

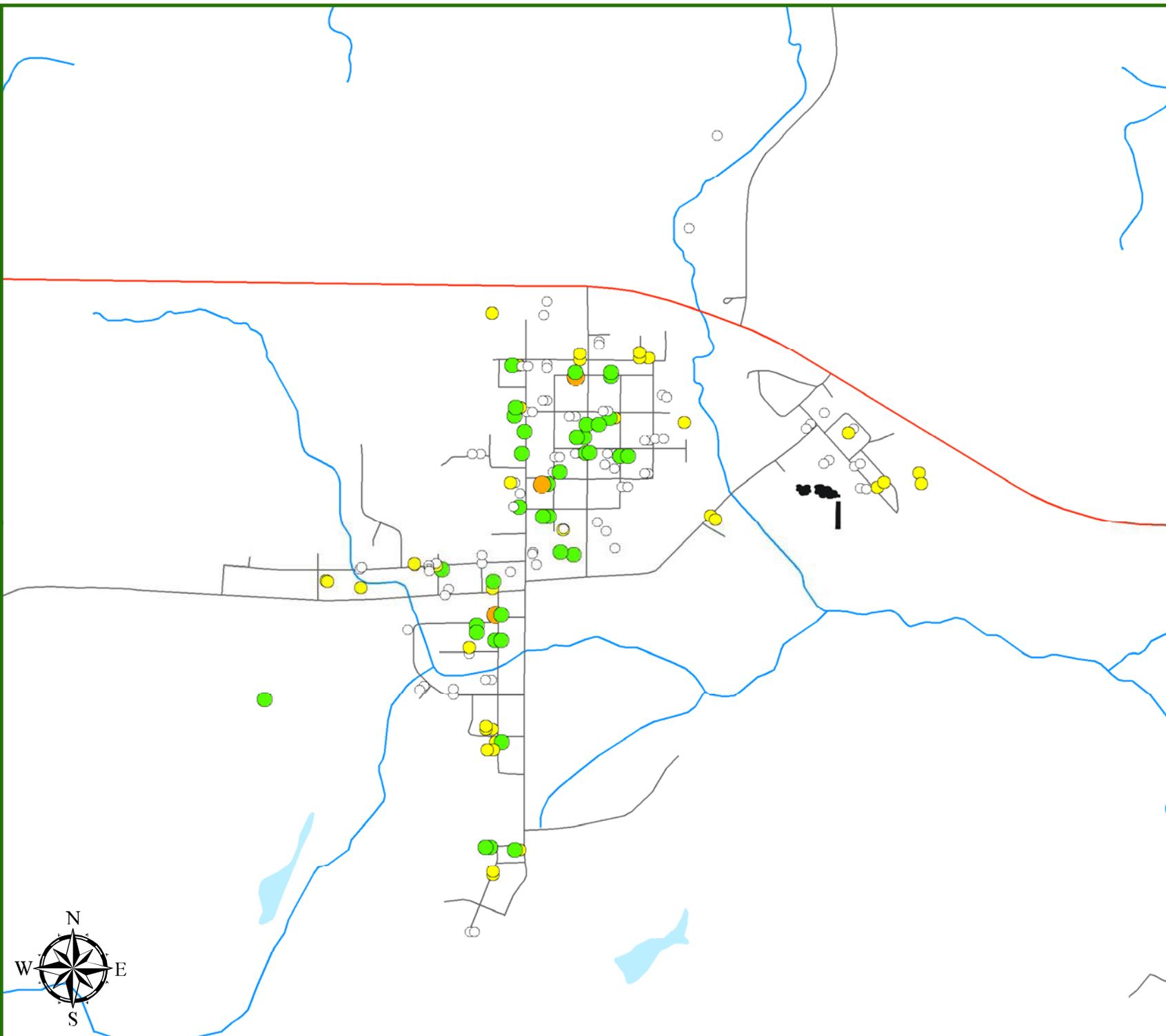
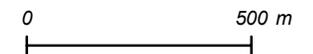
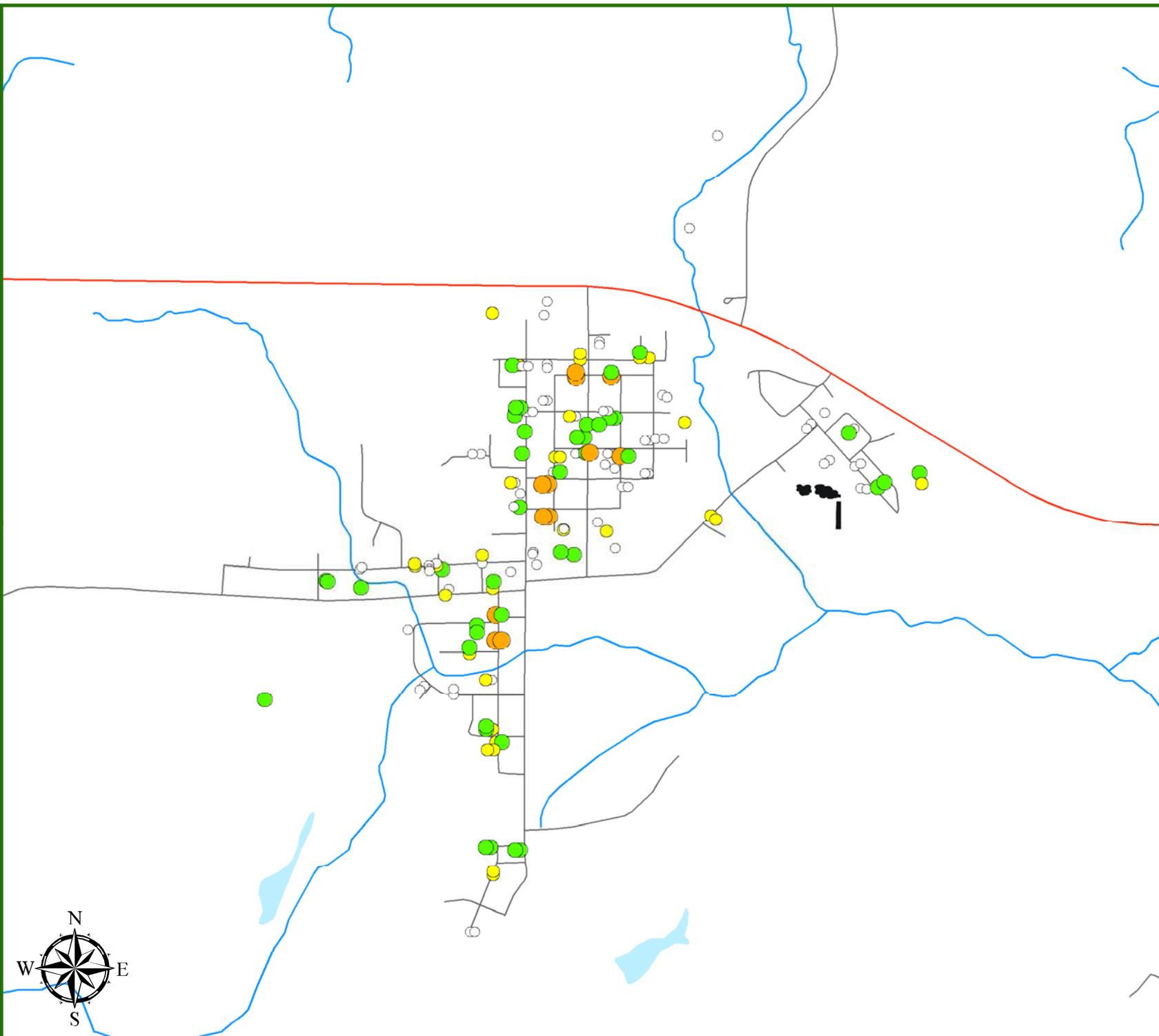


Figure 10-10
Coniston
Distribution of Nickel
in 2001 Soil Samples

Soil Depth 0-5 cm

Nickel Concentration (mg/kg)

-  < 150 (MOE Table A Guideline)
-  150 - 300
-  300 - 1000
-  1000 - 2000
-  > 2000



Scale 1:18,000

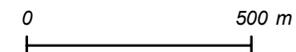


Figure 10-11
Coniston
Distribution of Lead
in 2001 Soil Samples

Soil Depth 0-5 cm

Lead Concentration (mg/kg)

- < 50
- 50 - 100
- 100 - 200
- > 200 (MOE Table A Guideline)



Scale 1:18,000

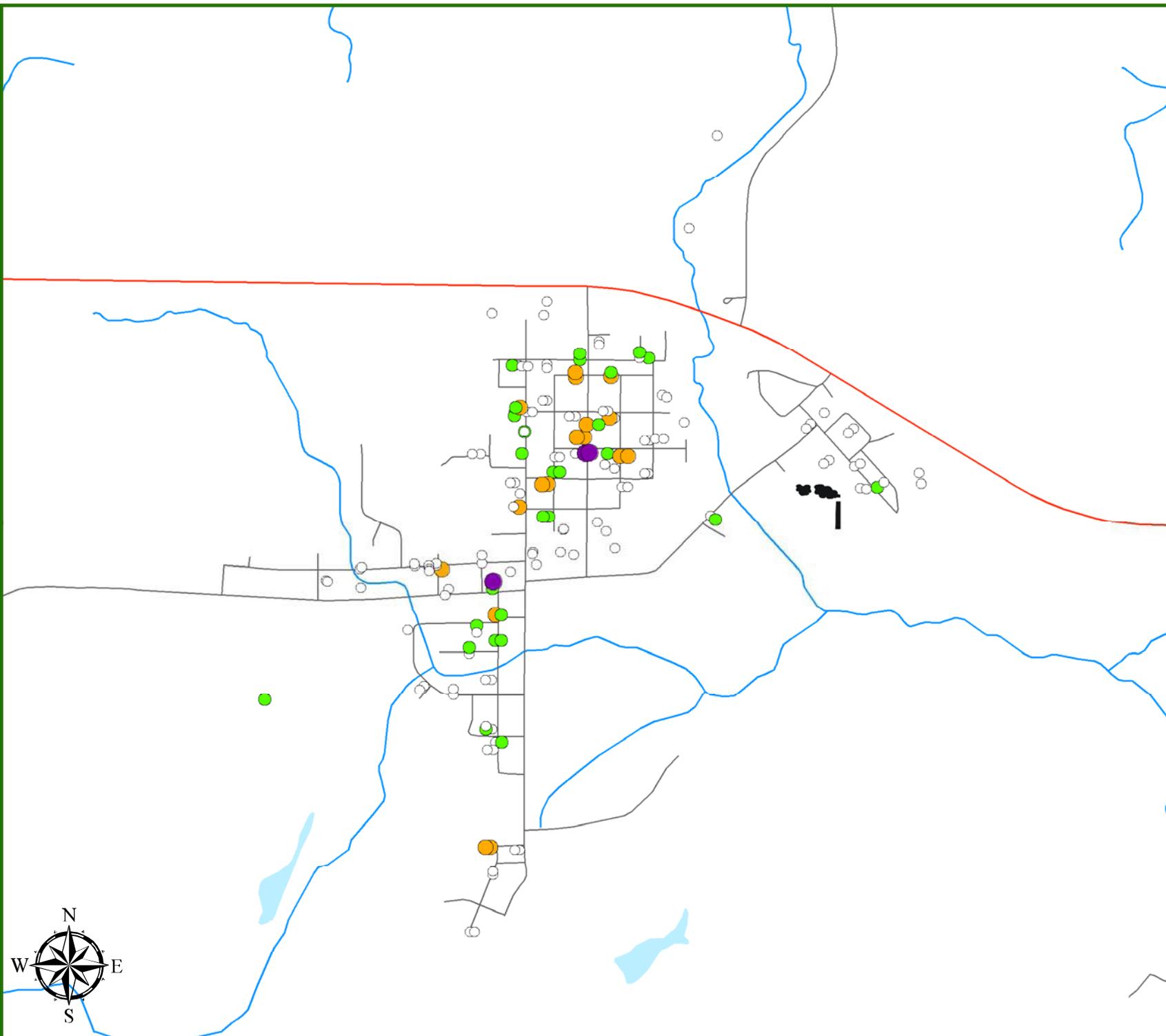
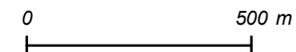
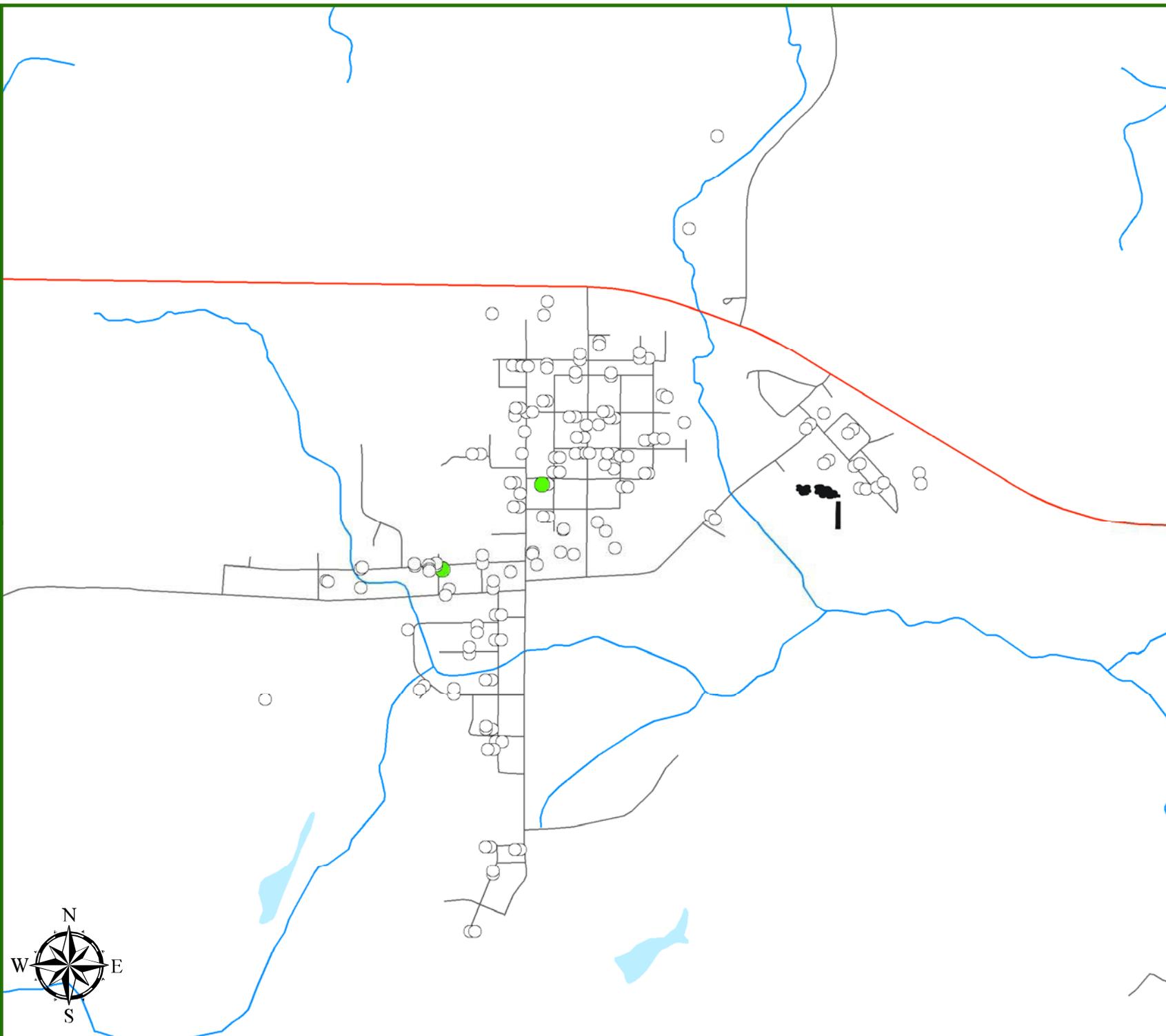


Figure 10-12
Coniston
Distribution of Selenium
in 2001 Soil Samples

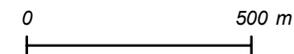
Soil Depth 0-5 cm

Selenium Concentration (mg/kg)

-  < 5
-  5 - 10
-  > 10 (MOE Table A Guideline)



Scale 1:18,000



10.1.3 Falconbridge

A review of the metal concentrations for the six COC in Falconbridge is presented in the following text. In this Community of Interest, a total of 311 soil samples were analyzed from the 0 to 5 cm soil depth, with the exception of lead for which 310 samples were analyzed. In the 5 to 10 cm and 10 to 20 cm depths, 286 and 282 samples were analyzed, respectively. A summary of the COC concentrations in the soils of this community is provided in Table 10.3.

Arsenic

Minimum As levels were equivalent across all three soil depths and had a value of 2.5 mg/kg; note that this value represents one half of the MDL for As. The maximum As concentration in the 0 to 5 cm soil range was 400 mg/kg, with a mean concentration of 65.6 mg/kg. The 95th percentile As concentration at this soil level was 190 mg/kg. The mean As concentration in the middle (5 to 10 cm) soil layer was 95.0 mg/kg, and the 95th percentile concentration was 307.5 mg/kg. The maximum As value at this soil depth was 570 mg/kg. The 10 to 20 cm soil depth demonstrated a mean As concentration of 76.1 mg/kg, with a maximum As concentration of 620 mg/kg. The 95th percentile concentration reported at the deepest soil level sampled was 229.5 mg/kg. Figure 10-13 illustrates As levels in surface soil (0 to 5 cm depth) sampled across the Falconbridge community.

Cobalt

The range of Co concentrations at the shallowest soil depth (0 to 5 cm) was 4 to 190 mg/kg, with an average Co level of 45.0 mg/kg. The 95th percentile concentration observed at this depth was 110 mg/kg. The maximum Co level in the 5 to 10 cm soil depth was 150 mg/kg, with the minimum level reported as 1.9 mg/kg. The mean Co concentration at this depth was 36.3 mg/kg, with a 95th percentile concentration of 95.75 mg/kg. The 10 to 20 cm soil layer exhibited a mean Co concentration of 21.6 mg/kg, and a 95th percentile of 49 mg/kg. The Co concentration range at the lowest soil depth was 2.2 to 110 mg/kg. Figure 10-14 illustrates the distribution of Co concentrations in the surface soils of the Falconbridge community.

Copper

The maximum Cu concentration was 3000 mg/kg at both the 0 to 5 and 5 to 10 cm soil depths; these depths also had identical 95th percentile concentrations of 1800 mg/kg. The minimum Cu concentration in the topmost soil level (0 to 5 cm) was 10 mg/kg, with the mean concentration at this level reported to be 706.9 mg/kg. The mean concentration at the 5 to 10 cm depth was 639.4 mg/kg. The minimum concentration at this depth was identical to that of the deepest soil level (10 to 20 cm) at 9.5 mg/kg. The

mean soil Cu level in the 10 to 20 cm soil depth was and 340.9 mg/kg, and the maximum Cu level at this soil depth was 2000 mg/kg. This depth had a 95th percentile concentration half that of the upper layers at 900 mg/kg. Figure 10-15 illustrates Cu levels in soil (0 to 5 cm depth) at sites sampled in the Falconbridge community.

Nickel

The minimum Ni concentrations in the shallowest and deepest soil depths were equivalent at 17 mg/kg; the maximum soil concentrations at both these depths were 3700 and 2500 mg/kg, respectively. The mean soil Ni concentration at the 0 to 5 cm depth was 751.0 mg/kg, with a 95th percentile concentration of 1950 mg/kg. The 5 to 10 cm soil depth exhibited a concentration range of 22 to 3100 mg/kg. The average and 95th percentile concentrations at this level were 700.0 mg/kg and 1975 mg/kg, respectively. The deepest soil layer (10 to 20 cm) was reported to have a mean concentration of 401.7 mg/kg, and a 95th percentile concentration of 1095 mg/kg. Figure 10-16 shows Ni levels in soil (0 to 5 cm depth) across the Falconbridge community.

Lead

The mean Pb concentration in the 0 to 5 cm soil layer was 72.1 mg/kg, with a Pb concentration range of 2 to 370 mg/kg. The 95th percentile concentration in this uppermost soil layer was 190 mg/kg. The Pb range in the 5 to 10 cm layer of soil was 3.6 to 340 mg/kg. At this depth, the mean and 95th percentile Pb concentrations were 67.2 and 197.5 mg/kg, respectively. The 10 to 20 cm soil layer demonstrated a mean Pb concentration of 44.3 mg/kg, and a 95th percentile of 139.5 mg/kg. The Pb concentration at the 10 to 20 cm depth ranged from 3.1 to 790 mg/kg. Figure 10-17 depicts Pb concentrations (0 to 5 cm depth) measured in the Falconbridge community.

Selenium

The minimum Se concentration reported for all three soil layers was 0.5 mg/kg; note that this value represents one half of the MDL for Se. The average Se level in upper soil layer (0 to 5 cm) was reported to be 2.5 mg/kg, with a maximum of 12 mg/kg. The 95th percentile Se concentration at this soil depth was 6 mg/kg. The maximum Se concentration exhibited by soil at the 5 to 10 cm depth was 11 mg/kg, while the mean and 95th percentile concentrations were 2.6 and 6.75 mg/kg, respectively. The average Se level in the 10 to 20 cm soil depth was 1.9 mg/kg. The maximum concentration of Se being 8 mg/kg at this depth, and the 95th percentile concentration observed as 5 mg/kg. Figure 10-18 shows Se concentrations (0 to 5 cm depth) of soils in the Falconbridge community.

Table 10.3 Summary of Metal Concentrations in Falconbridge (mg/kg)

Depth (cm) and number of samples (N)	Statistic	Arsenic	Cobalt	Copper	Nickel	Lead	Selenium
0-5 N=311	min	2.5	4	10	17	2	0.5
	max	400	190	3000	3700	370	12
	mean	65.6	45.0	706.9	751.0	72.1	2.5
	95th percentile	190	110	1800	1950	190	6
5-10 N=286	min	2.5	1.9	9.5	22	3.6	0.5
	max	570	150	3000	3100	340	11
	mean	95.0	36.3	639.4	700.0	67.2	2.6
	95th percentile	307.5	95.75	1800	1975	197.5	6.75
10-20 N=282	min	2.5	2.2	9.5	17	3.1	0.5
	max	620	110	2000	2500	790	8
	mean	76.1	21.6	340.9	401.7	44.3	1.9
	95th percentile	229.5	49	900	1095	139.5	5

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Figure 10-13
Falconbridge
Distribution of Arsenic
in 2001 Soil Samples

Soil Depth 0-5 cm

Arsenic Concentration (mg/kg)

- < 20 (MOE Table A Guideline)
- 20 - 50
- 50 - 200
- > 200



Scale 1:15,000

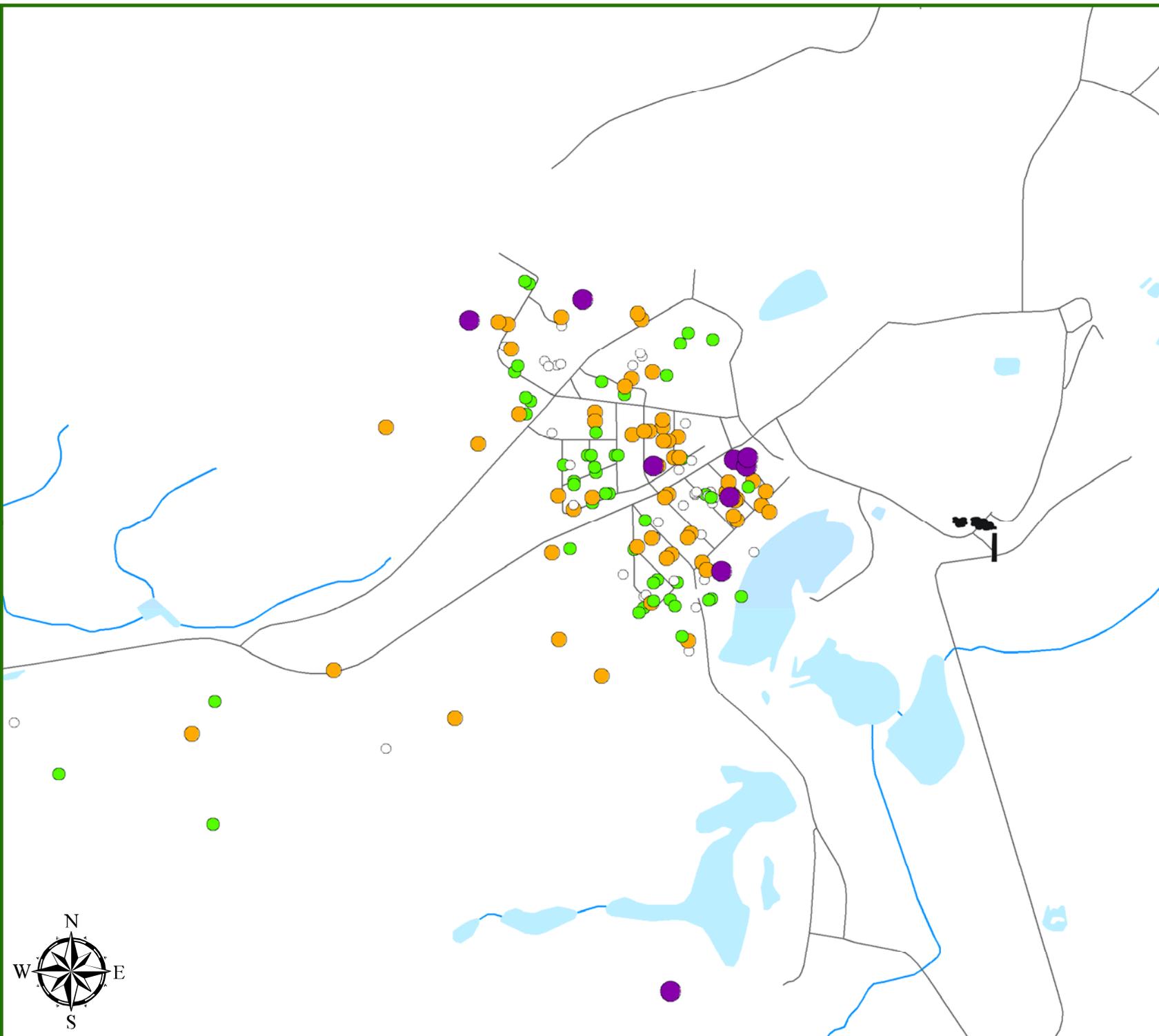
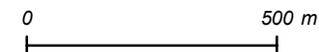


Figure 10-14
Falconbridge
Distribution of Cobalt
in 2001 Soil Samples

Soil Depth 0-5 cm

Cobalt Concentration (mg/kg)

- < 40 (MOE Table A Guideline)
- 40 - 80
- 80 - 150
- > 150



Scale 1:15,000

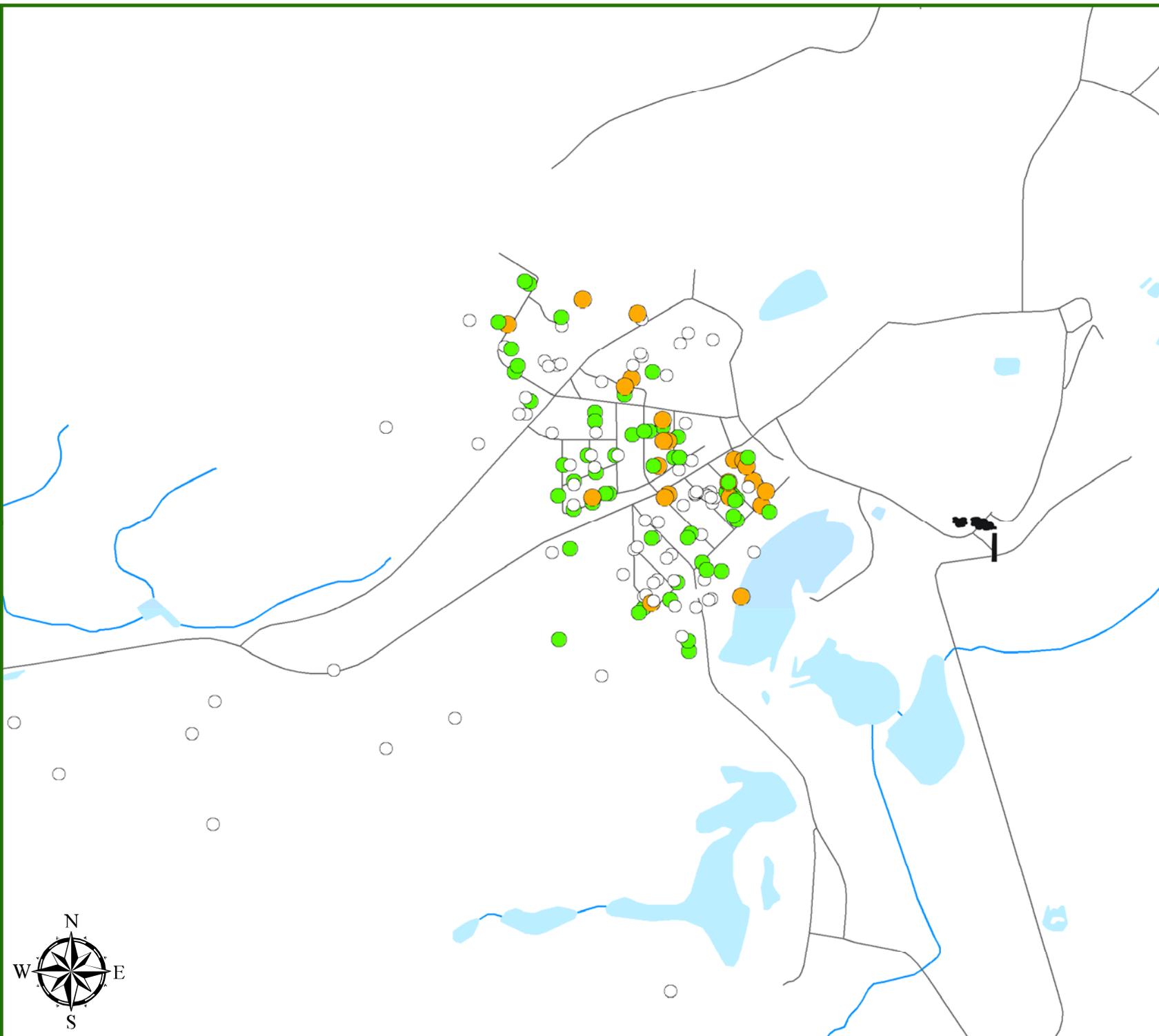
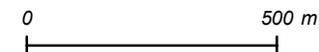


Figure 10-15
Falconbridge
Distribution of Copper
in 2001 Soil Samples

Soil Depth 0-5 cm

Copper Concentration (mg/kg)

-  < 150
-  150 - 300
-  300 - 1000
-  1000 - 2000
-  > 2000



(MOE Table A
Guideline is 225 mg/kg)

Scale 1:15,000

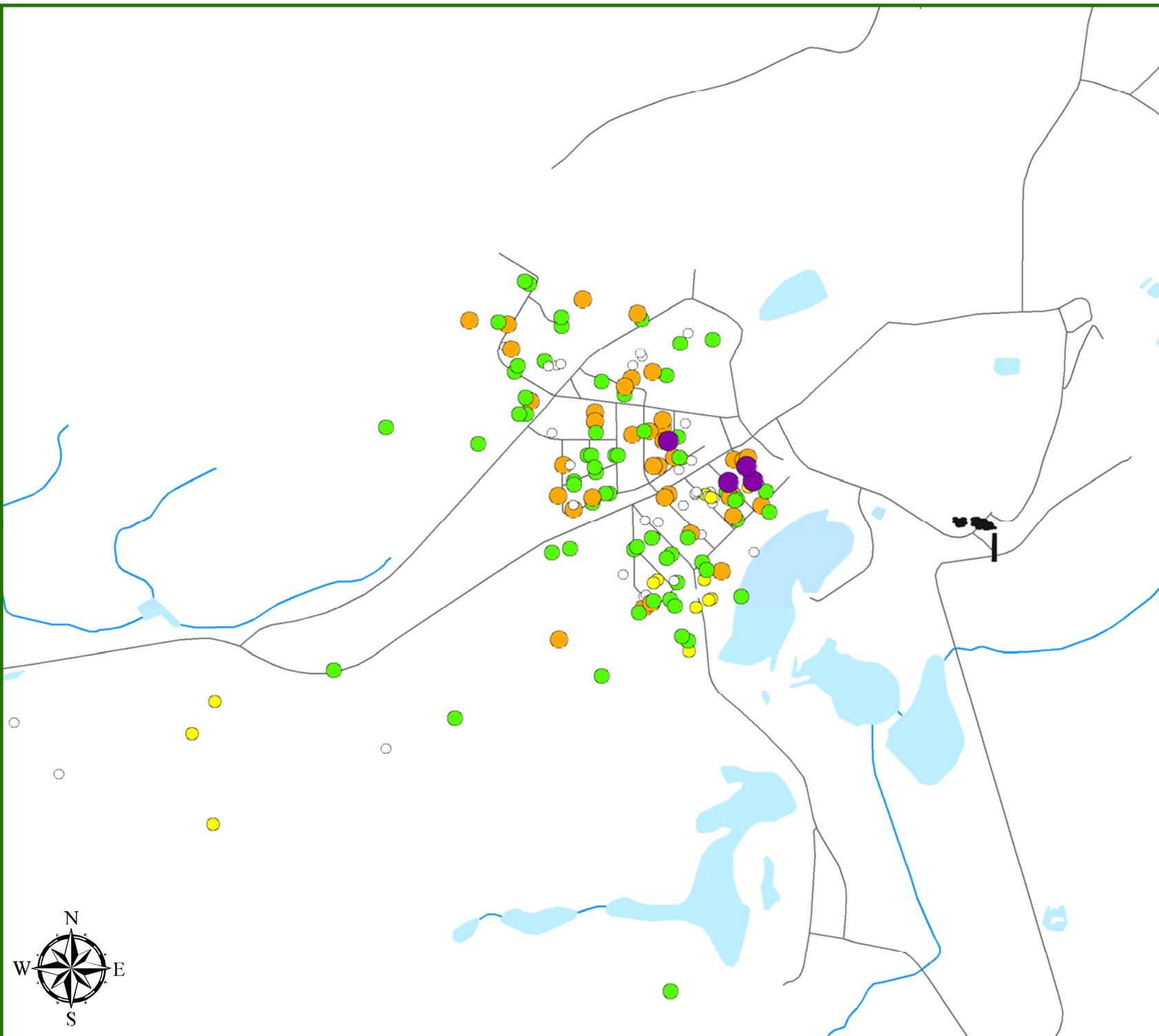
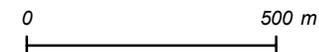
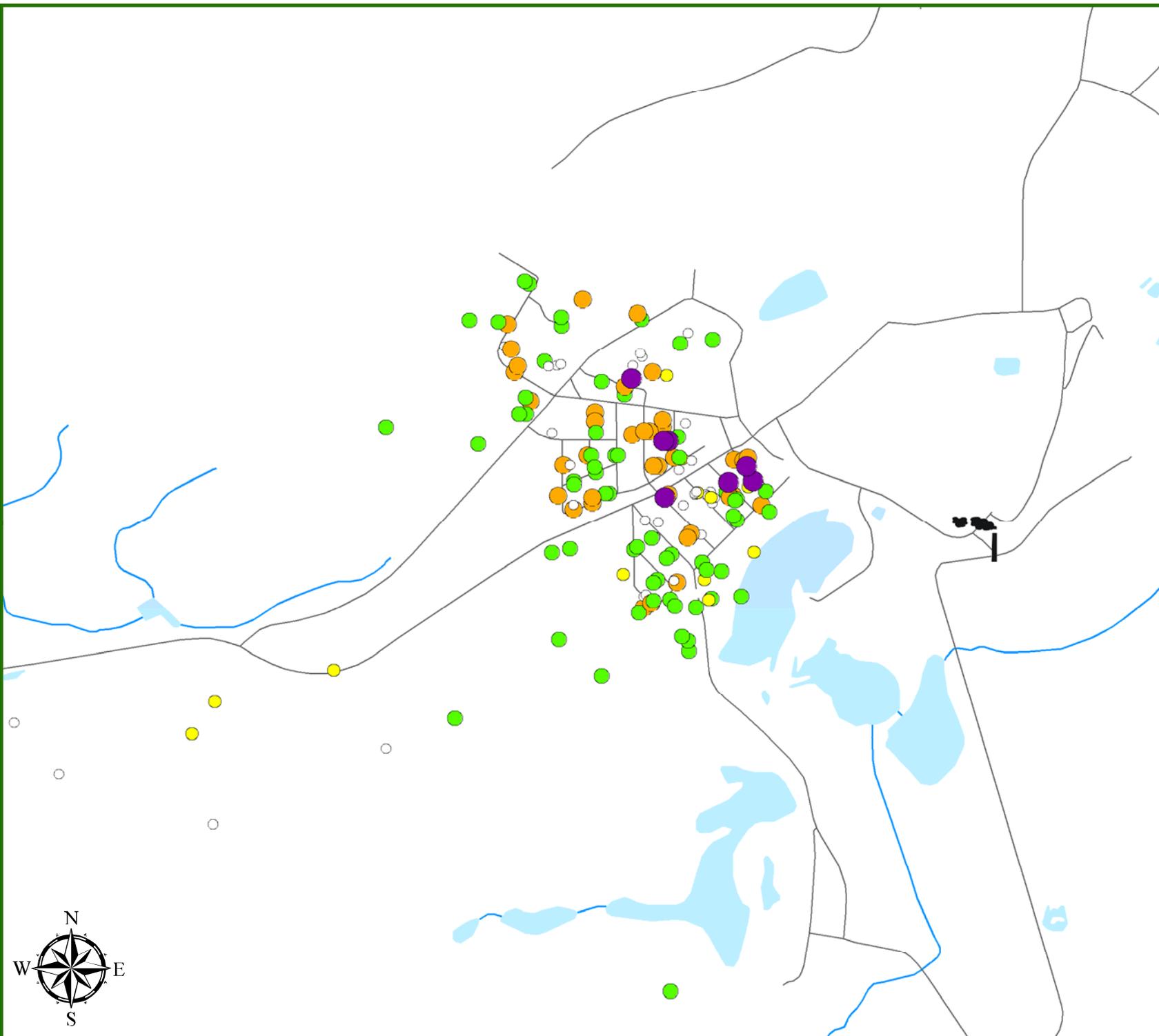


Figure 10-16
Falconbridge
Distribution of Nickel
in 2001 Soil Samples

Soil Depth 0-5 cm

Nickel Concentration (mg/kg)

-  < 150 (MOE Table A Guideline)
-  150 - 300
-  300 - 1000
-  1000 - 2000
-  > 2000



Scale 1:15,000

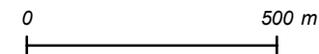


Figure 10-17
Falconbridge
Distribution of Lead
in 2001 Soil Samples

Soil Depth 0-5 cm

Lead Concentration (mg/kg)

- < 50
- 50 - 100
- 100 - 200
- > 200 (MOE Table A Guideline)

 Smelter Stack

Scale 1:15,000

0  500 m

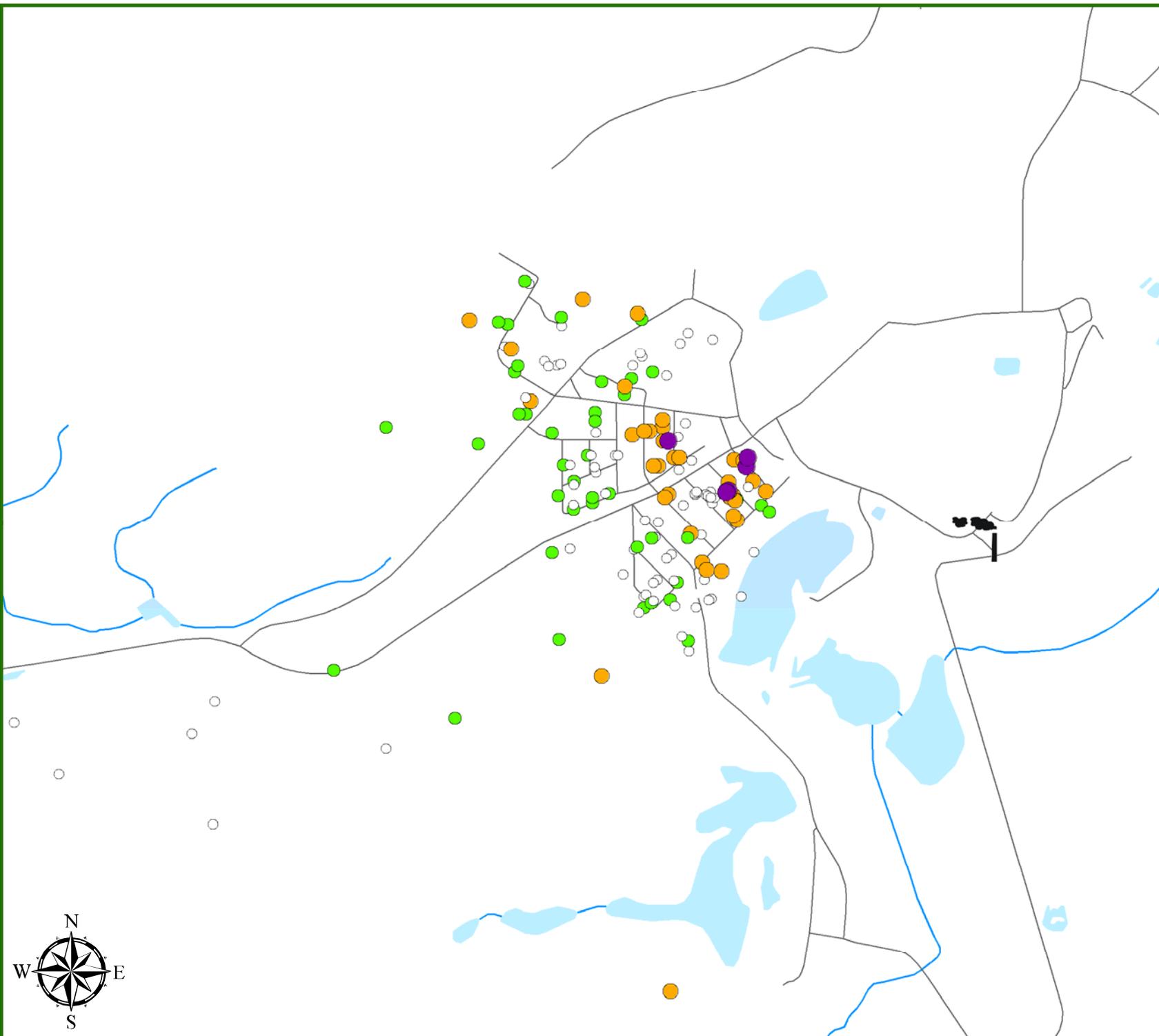


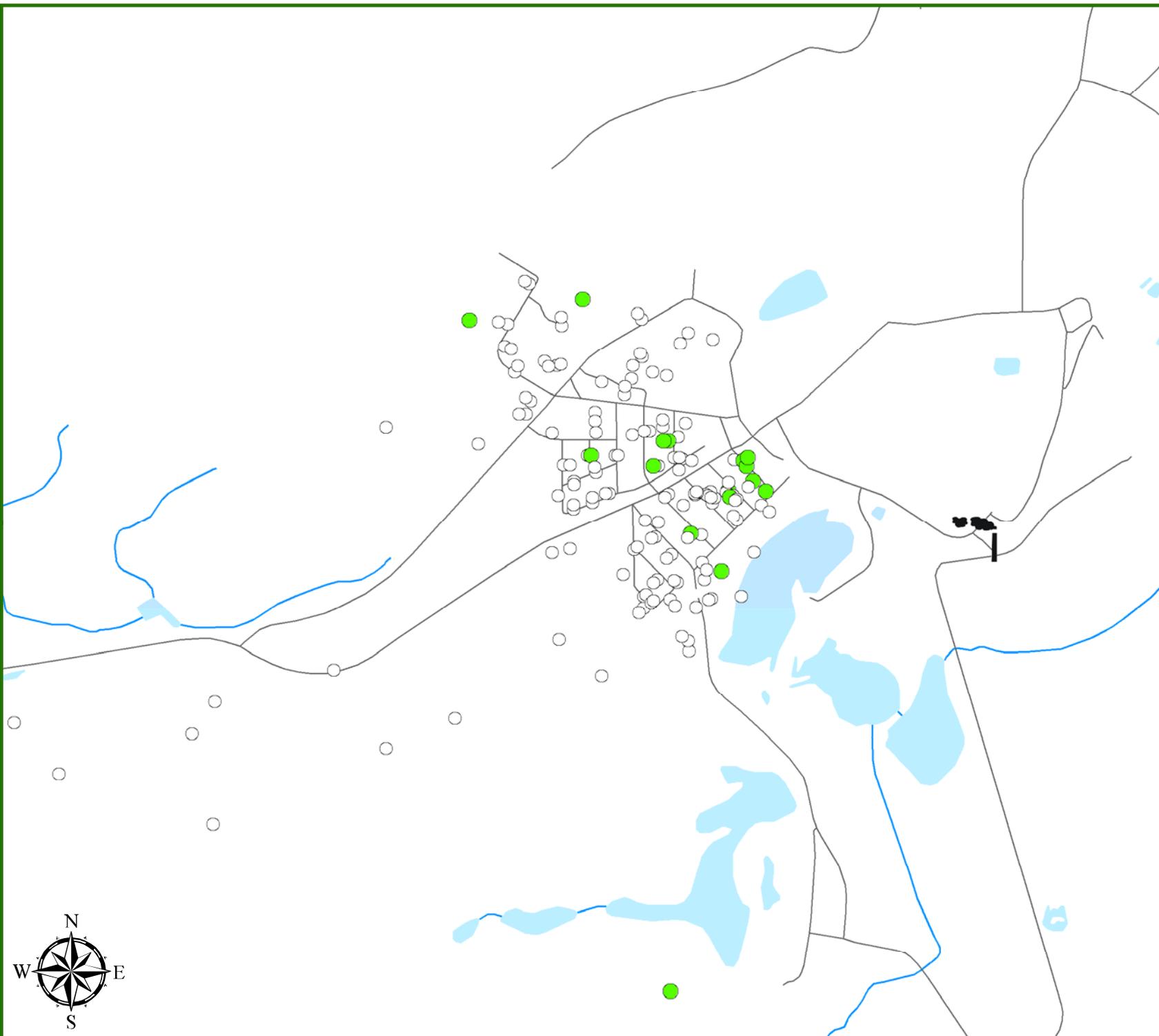
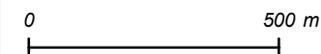
Figure 10-18
Falconbridge
Distribution of Selenium
in 2001 Soil Samples

Soil Depth 0-5 cm

Selenium Concentration (mg/kg)

-  < 5
-  5 - 10
-  > 10 (MOE Table A Guideline)
-  Smelter Stack

Scale 1:15,000



10.1.4 Hanmer

A review of the metal concentrations for the six COC in Hanmer is presented in the following text. In this Community of Interest, a total of 85 soil samples were analyzed from the 0 to 5 cm soil depth, while 30 and 28 samples were analyzed from the 5 to 10 cm and 10 to 20 cm depths, respectively. A summary of the COC concentrations in the soils of this community is provided in Table 10.4.

Arsenic

The minimum As level reported at all three soil depths was 2.5 mg/kg, representing one half of the MDL, with maximum values of 25 mg/kg at the 0 to 5 cm soil depth and 8 mg/kg at both of the deeper soil depths. The mean As concentrations in the three soil depths were: 4.2, 3.2, and 2.8 mg/kg, decreasing correspondingly with soil depth. Similarly, the 95th percentile values decreased with soil depth and were reported to be concentrations of 15, 7, and 4.125 mg/kg. Figure 10-19 shows soil As concentrations in surface soil across the Hanmer community.

Cobalt

The Co concentration range in the 0 to 5 cm soil layer ranged from 4 to 33 mg/kg. The mean Co value at this level was 7.6 mg/kg, while the 95th percentile concentration was 17.8 mg/kg. The Co range in the middle soil layer (5 to 10 cm) was 2 to 6 mg/kg, with a mean value of 4.1 mg/kg. The 95th percentile concentration for the soil in the bottom two soil layers was equivalent at 5 mg/kg. The 10 to 20 cm soil depth demonstrated a mean Co concentration of 4.3 mg/kg, with a total Co range of 3 to 5 mg/kg. Figure 10-20 illustrates Co concentrations (0 to 5 cm depth) found in the Hanmer community soils.

Copper

The mean Cu concentration in the uppermost 5 cm of soil was 54.0 mg/kg. The minimum and maximum concentrations at this soil depth were 13 and 330 mg/kg, respectively, with a 95th percentile concentration value of 198 mg/kg. The 5 to 10 cm soil layer exhibited a Cu range of 11 to 54 mg/kg. The mean and 95th percentile concentrations were 25.0 mg/kg and 36.1 mg/kg respectively at this soil depth. The 10 to 20 cm soil depth range showed Cu concentrations varying from 3.8 to 34 mg/kg, with a mean concentration of 17.4 mg/kg. The 95th percentile concentration reported in the deepest soil layer was 30 mg/kg. Copper concentrations in soil (0 to 5 cm depth) in the Hanmer community are depicted in Figure 10-21.

Nickel

The Ni concentration in the uppermost soil segment (0 to 5 cm) varied from 16 to 297 mg/kg, and had a reported mean of 55.8 mg/kg. The 95th percentile concentration exhibited at this soil level was 217 mg/kg. The 5 to 10 cm soil depth displayed a Ni concentration range from 17 to 50 mg/kg. The mean Ni level at this depth was 34.4, with a 95th percentile concentration of 44.55 mg/kg. The average Ni concentration at the 10 to 20 cm soil depth was 29.4 mg/kg. Nickel at this depth ranged from 14 to 56 mg/kg, with a 95th percentile concentration of 40.95 mg/kg. Figure 10-22 shows the Ni concentrations in soil (0 to 5 cm depth) across the Hanmer community.

Lead

In the top 5 cm of soil a mean Pb level of 14.6 mg/kg was reported, with a 95th percentile concentration of 54.4 mg/kg. The Pb range in this upper soil layer was 2 to 79 mg/kg. The 5 to 10 cm soil layer, with a total Pb range of 5 to 44 mg/kg, exhibited a mean of 10.5 mg/kg. The 95th percentile value for this depth was 29.6 mg/kg. The deepest soil (10 to 20 cm) was observed to have a Pb range of 4 to 19 mg/kg, with an average Pb level of 6.9 mg/kg. The 95th percentile concentration in this soil layer was 10.65 mg/kg. Figure 10-23 depicts levels of Pb in surface soil distributed across the Hanmer community.

Selenium

All three soil levels demonstrated minimum Se values of 0.5 mg/kg; it must be noted that this value represents one half of the MDL for Se. The 5 to 10 and 10 to 20 cm soil depths also exhibited a value of 0.5 mg/kg for mean, maximum, and 95th percentile values. The top soil layer was reported to have a maximum Se concentration of 3 mg/kg, with average and 95th percentile concentrations of 0.7 and 2 mg/kg, respectively. Figure 10-24 illustrates the distribution of soil Se concentrations (0 to 5 cm depth) found in the Hanmer community.

Table 10.4 Summary of Metal Concentrations in Hanmer (mg/kg)

Depth (cm) and number of samples (N)	Statistic	Arsenic	Cobalt	Copper	Nickel	Lead	Selenium
0-5	min	2.5	4	13	16	2	0.5
N=85	max	25	33	330	297	79	3
	mean	4.2	7.6	54.0	55.8	14.6	0.7
	95th percentile	15	17.8	198	217	54.4	2
5-10	min	2.5	2	11	17	5	0.5
N=30	max	8	6	54	50	44	0.5
	mean	3.2	4.1	25.0	34.4	10.5	0.5
	95th percentile	7	5	36.1	44.55	29.6	0.5
10-20	min	2.5	3	3.8	14	4	0.5
N=28	max	8	5	34	56	19	0.5
	mean	2.8	4.3	17.4	29.4	6.9	0.5
	95th percentile	4.125	5	30	40.95	10.65	0.5

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Figure 10-19
Hanmer
Distribution of Arsenic
in 2001 Soil Samples

Soil Depth 0-5 cm

Arsenic Concentration (mg/kg)

- < 20 (MOE Table A Guideline)
- 20 - 50
- 50 -200
- > 200

Scale 1:45,000

0 1 Km

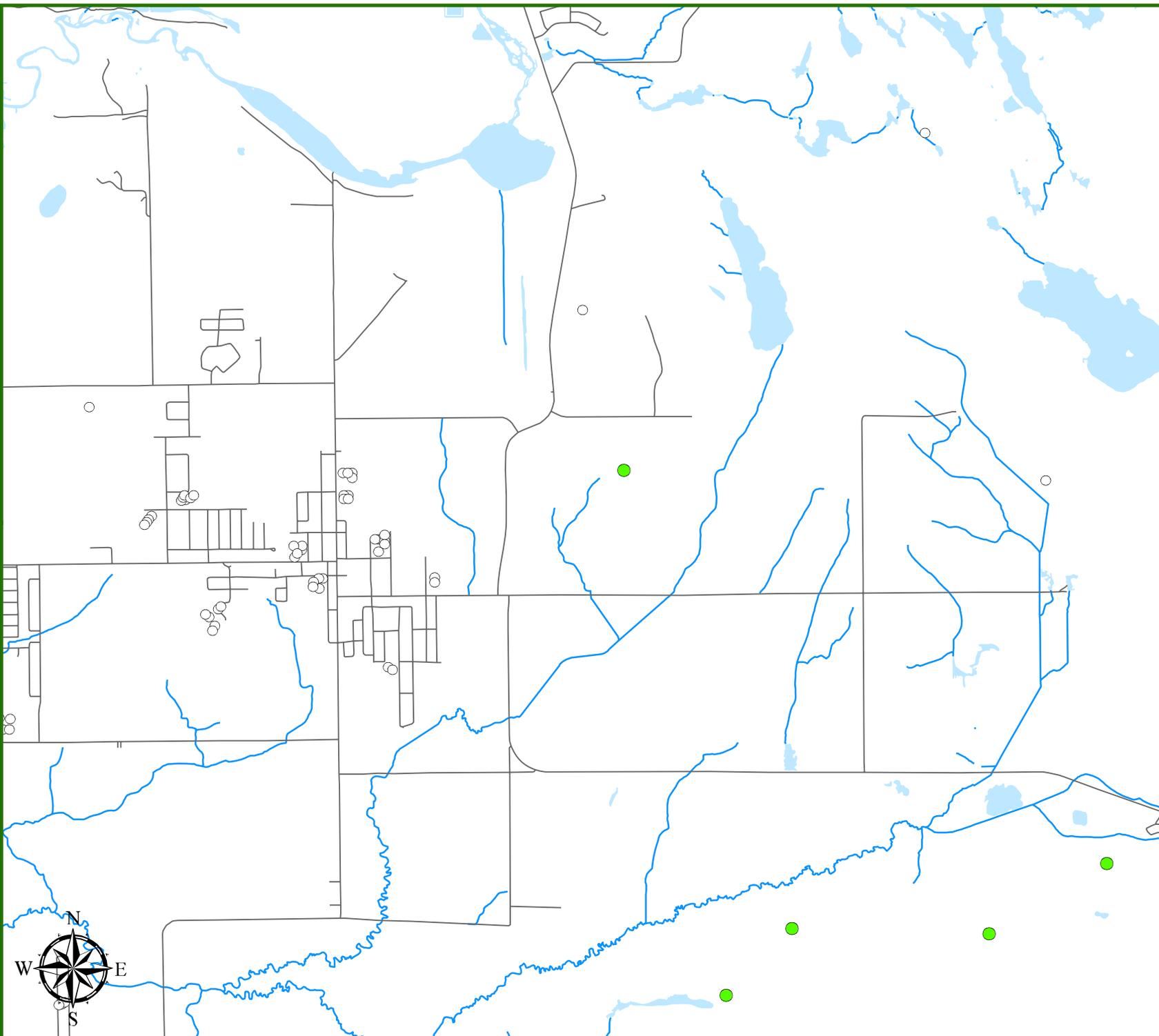


Figure 10-20
Hanmer
Distribution of Cobalt
in 2001 Soil Samples

Soil Depth 0-5 cm

Cobalt Concentration (mg/kg)

- < 40 (MOE Table A Guideline)
- 40 - 80
- 80 - 150
- > 150

Scale 1:45,000

0 1 Km

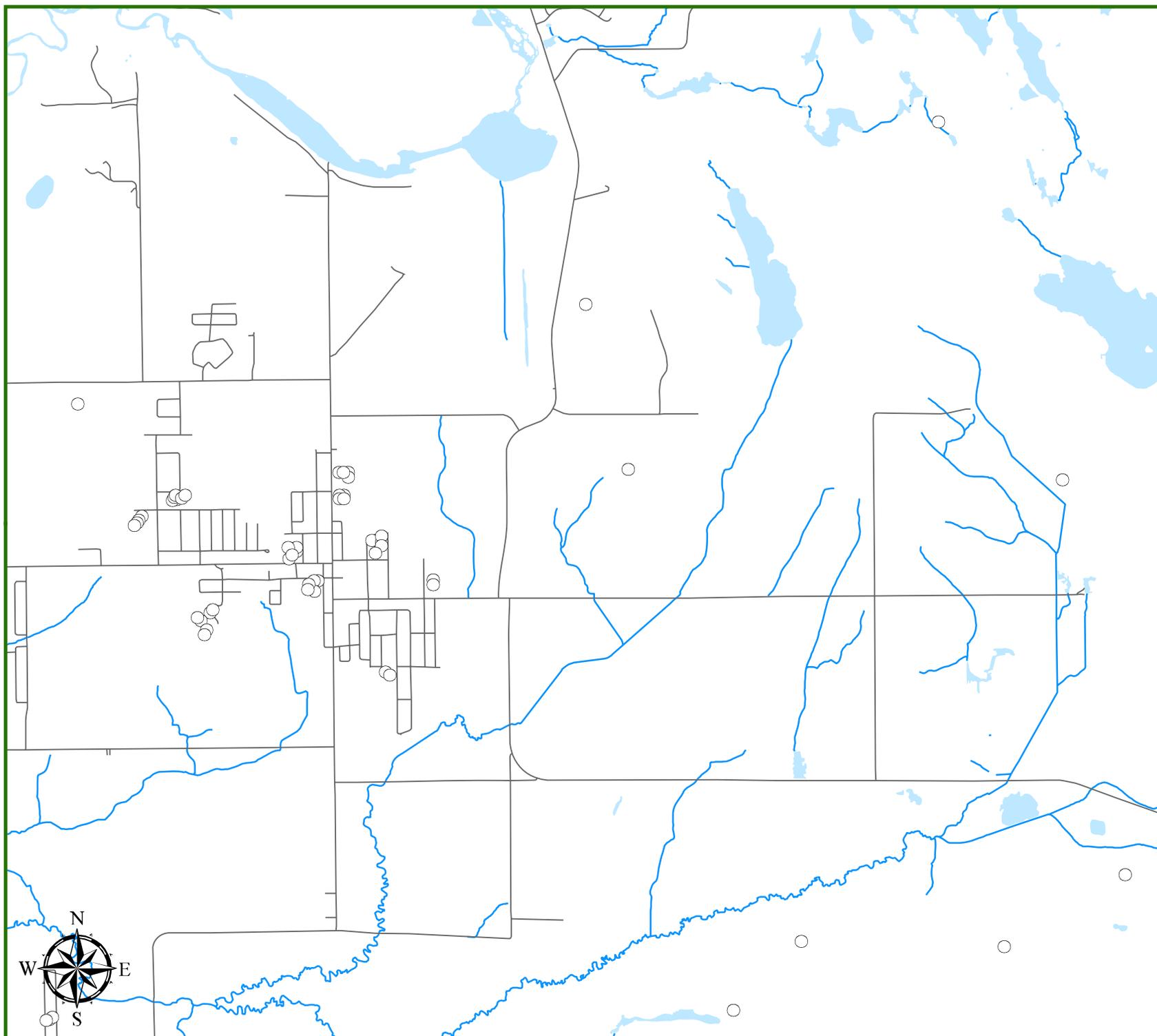


Figure 10-21
Hanmer
Distribution of Copper
in 2001 Soil Samples

Soil Depth 0-5 cm

Copper Concentration (mg/kg)

-  < 150
-  150 - 300
-  300 - 1000
-  1000 - 2000
-  > 2000

(MOE Table A
Guideline is 225 mg/kg)

Scale 1:45,000

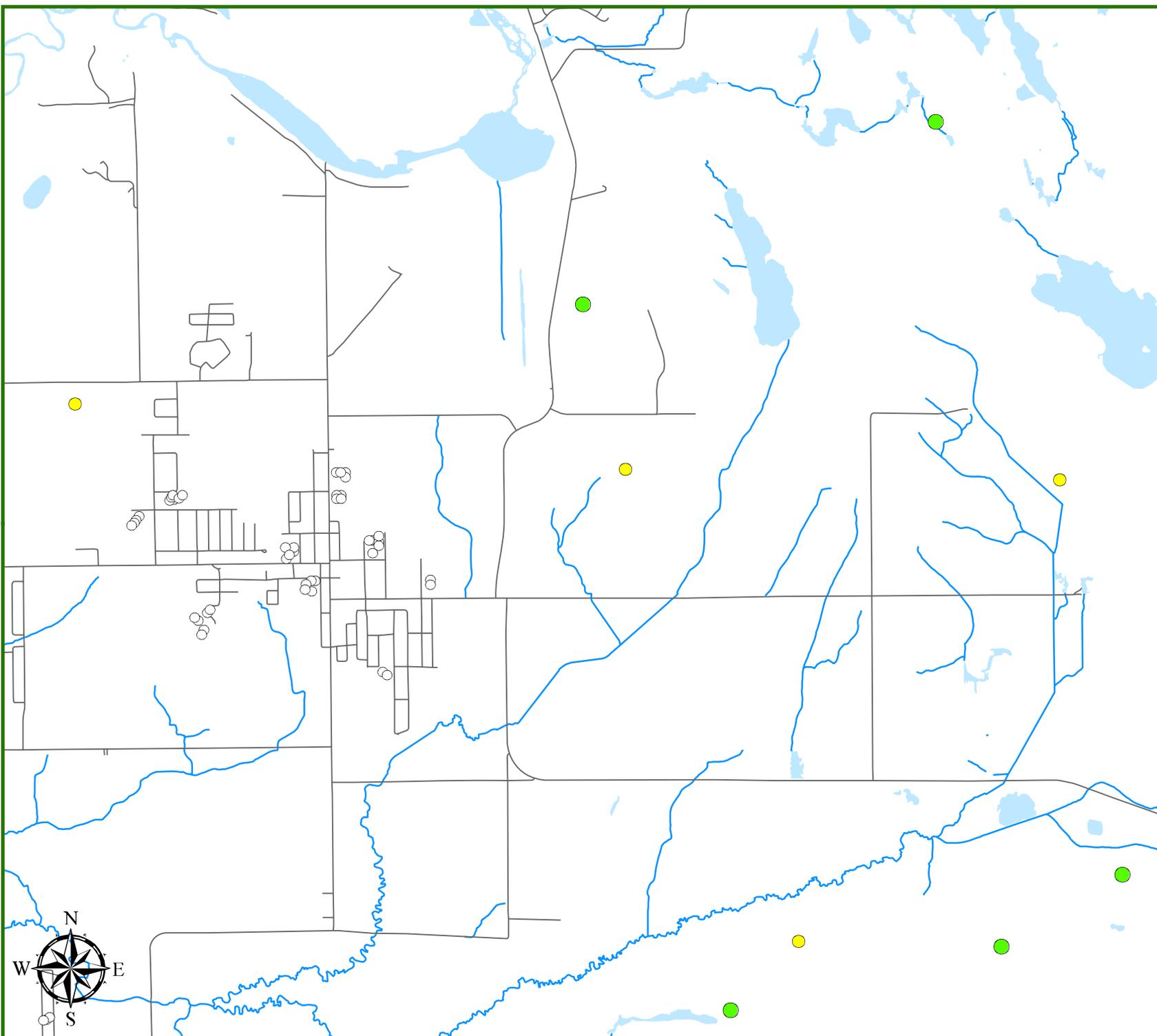


Figure 10-22
Hanmer
Distribution of Nickel
in 2001 Soil Samples

Soil Depth 0-5 cm

Nickel Concentration (mg/kg)

-  < 150 (MOE Table A Guideline)
-  150 - 300
-  300 - 1000
-  1000 - 2000
-  > 2000

Scale 1:45,000

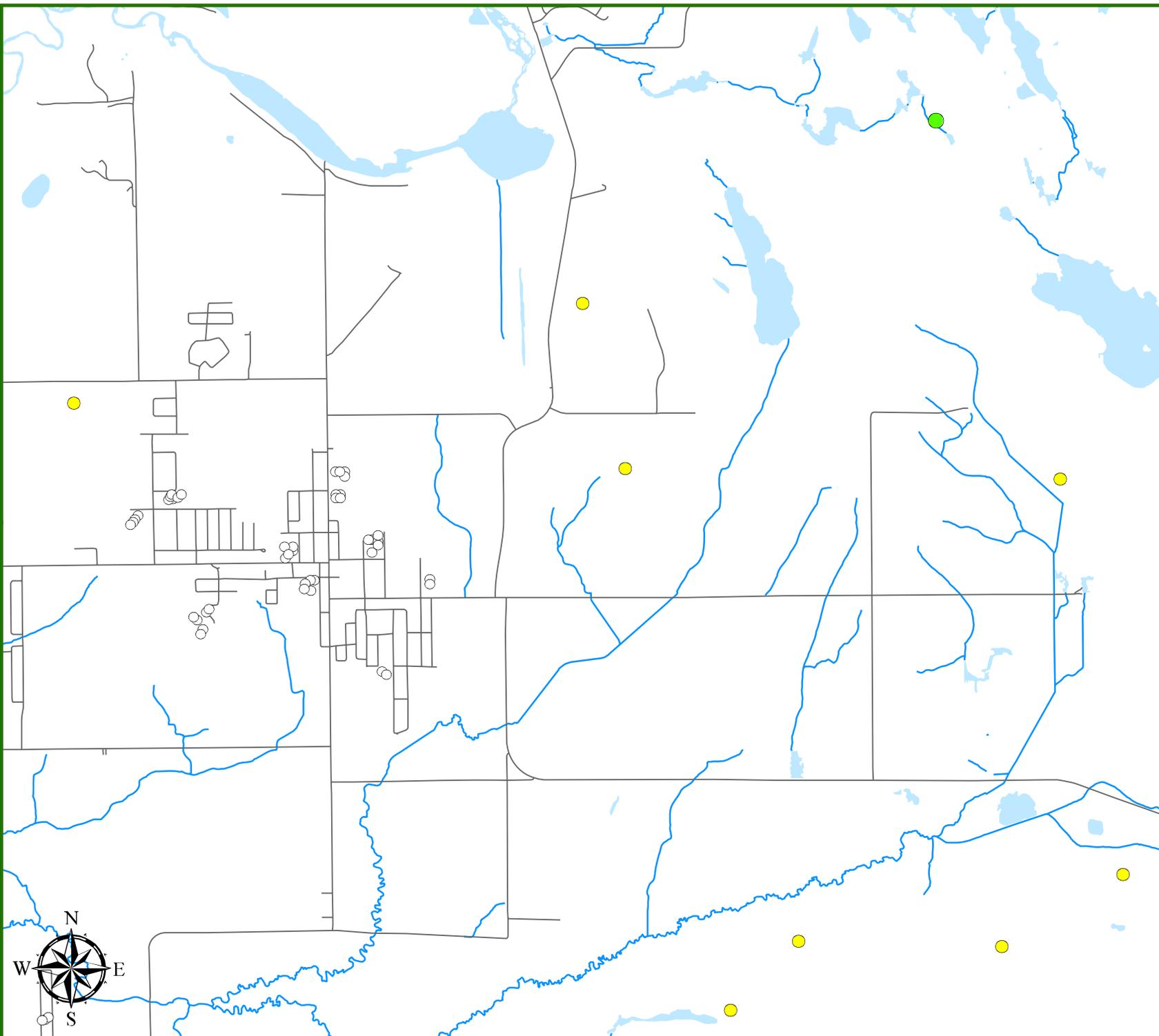


Figure 10-23
Hanmer
Distribution of Lead
in 2001 Soil Samples

Soil Depth 0-5 cm

Lead Concentration (mg/kg)

-  < 50
-  50 - 100
-  100 - 200
-  > 200 (MOE Table A Guideline)

Scale 1:45,000

0  1 Km

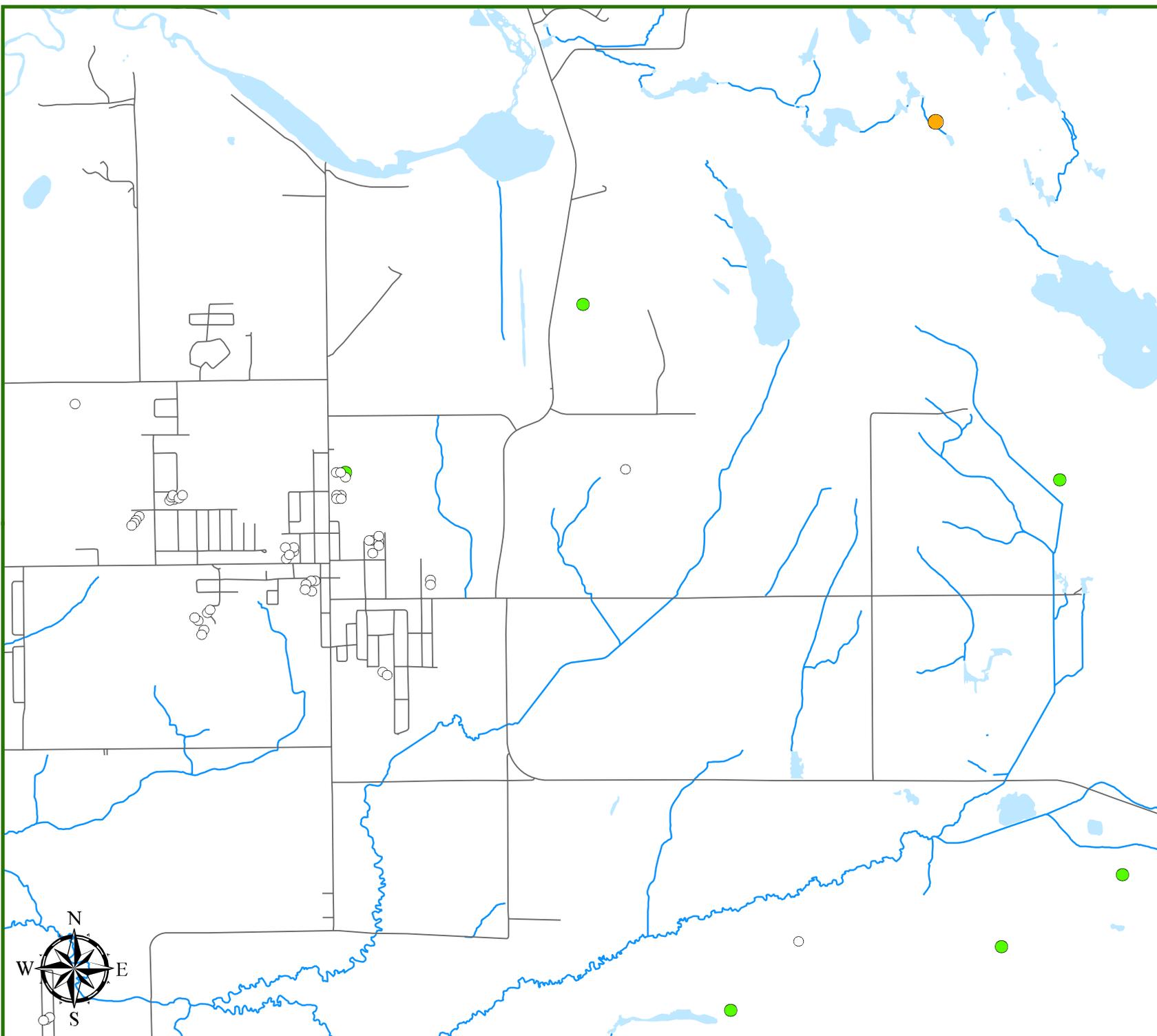


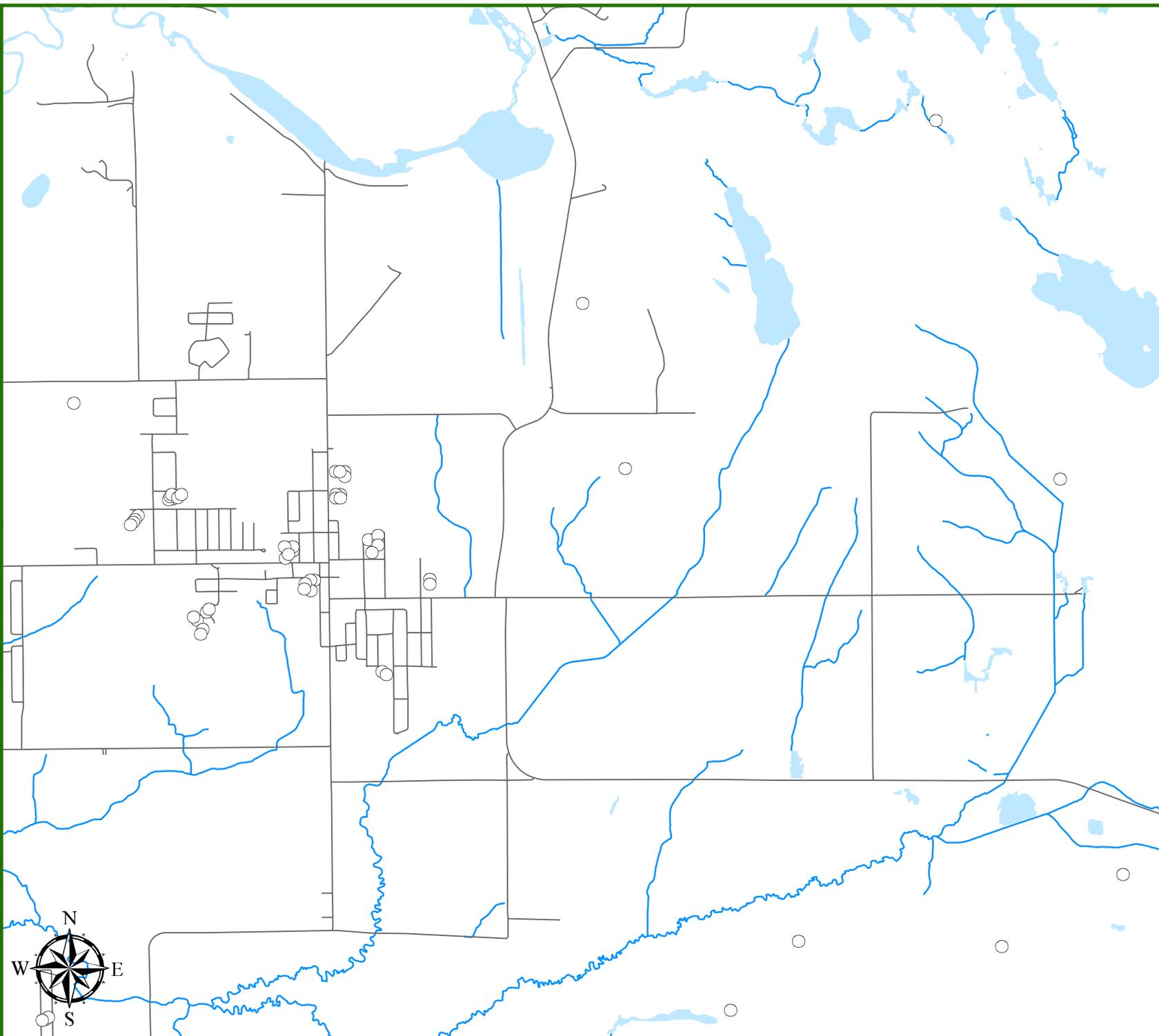
Figure 10-24
Hanmer
Distribution of Selenium
in 2001 Soil Samples

Soil Depth 0-5 cm

Selenium Concentration (mg/kg)

-  < 5
-  5 - 10
-  > 10 (MOE Table A Guideline)

Scale 1:45,000



10.1.5 Sudbury Centre

A review of the metal concentrations for the six COC in the Sudbury Centre is presented in the following text. In this Community of Interest, a total of 1,129 soil samples were analyzed from the 0 to 5 cm soil depth, while 643 and 607 samples were analyzed from the 5 to 10 cm and 10 to 20 cm depths, respectively. A summary of the COC concentrations in the soils of this community is provided in Table 10.5.

Arsenic

Minimum As concentrations detected in the three soil layers sampled were equivalent at 2.5 mg/kg; note that this value represents half of the MDL for As. The mean As concentration in the upper 5 cm of soil sampled was 6.0 mg/kg, with a 95th percentile concentration of 18 mg/kg. The maximum As concentration in this upper soil level was 65 mg/kg. In the middle (5 to 10 cm) soil range, the maximum detected As level was 39 mg/kg. The mean and 95th percentile concentrations at this depth were 6.5 and 17 mg/kg, respectively. The deepest soil layer (10 to 20 cm) contained an average of 5.8 mg/kg As, with a maximum and 95th percentile concentration of 67 and 14.7 mg/kg, respectively. Figure 10-25 depicts the distribution of As concentrations (0 to 5 cm depth) located in the Sudbury Centre community.

Cobalt

The minimum Co content of all three soil depths was equivalent at 3 mg/kg. The upper soil layer (0 to 5 cm) had a reported a mean Co value of 11.2 mg/kg. The maximum and 95th percentile concentrations at this depth were 100 and 28 mg/kg, respectively. A mean concentration of 9.0 mg/kg Co was reported at the 5 to 10 cm soil depth, with a maximum value of 36 mg/kg. The 95th percentile concentration in this soil layer was 17 mg/kg. The 10 to 20 cm soil range contained a maximum Co level of 28 mg/kg, with a 95th percentile concentration of 15 mg/kg and a mean concentration of 8.5 mg/kg. Figure 10-26 shows surface soil Co concentrations found in the Sudbury Centre community.

Copper

The 0 to 5 cm soil depth demonstrated a Cu range of 6.2 to 1800 mg/kg. The average and 95th percentile Cu concentrations were 154.7 and 590 mg/kg, respectively. The middle soil layer (5 to 10 cm) contained a mean Cu value of 121.7 mg/kg, with Cu concentrations ranging from 12 to 1100 mg/kg. The 95th percentile value at this soil depth was 379 mg/kg. The deepest soil layer (10 to 20 cm) had a reported Cu mean concentration of 94.4 mg/kg, while its 95th percentile concentration was 270 mg/kg. Concentrations

of Cu in the 10 to 20 cm layer ranged from 11 to 530 mg/kg. Figure 10-27 illustrates the Cu levels in soil (0 to 5 cm depth) measured in the Sudbury Centre community.

Nickel

Nickel concentrations in the topmost soil layer (0 to 5 cm) varied from 11 to 3284 mg/kg, with a mean value of 171.6 mg/kg. The 95th percentile concentration at this depth was 596 mg/kg. The minimum and maximum values for the 5 to 10 cm soil layer were 18 and 970 mg/kg, respectively. The mean Ni concentration in this layer was 139.5 mg/kg, with a reported 95th percentile value of 429.3 mg/kg. The deepest soil layer sampled (10 to 20 cm) contained a mean Ni level of 114.6 mg/kg, with a Ni concentration range of 15 to 820 mg/kg. The 95th percentile concentration for this soil depth was 300 mg/kg. Nickel levels in soil (0 to 5 cm depth) in the Sudbury Centre community are illustrated in Figure 10-28.

Lead

The reported mean Pb level in the 0 to 5 cm range was 26.4 mg/kg, with a 95th percentile value of 100.6 mg/kg. The Pb concentrations at this soil depth varied from 1 to 320 mg/kg. The minimum Pb value reported at both of the lower soil depths (5 to 10 and 10 to 20 cm) was 2 mg/kg. The mean Pb level in the middle (5 to 10 cm) soil range was 24.8 mg/kg, with maximum and 95th percentile values of 310 and 83.9 mg/kg, respectively. The maximum Pb concentration reported at the lowest soil depth (10 to 20 cm) was 470 mg/kg, while 95th percentile and mean concentrations were 76 and 21.9 mg/kg, respectively. Figure 10-29 shows the distribution of Pb (0 to 5 cm depth) across the Sudbury Centre community.

Selenium

Minimum Se levels reported at all three soil depths were 0.5 mg/kg, however this value represents half of the MDL for Se. Maximum, mean, and 95th percentile Se concentrations in the 0 to 5 cm soil range were 13, 1.1, and 3.64 mg/kg, respectively. The mean Se concentration observed in the middle soil layer (5 to 10 cm) was 0.9 mg/kg. The maximum and 95th percentile Se concentrations at this depth were 5 and 2 mg/kg, respectively. Mean and 95th percentile values in the 10 to 20 cm soil layer were 0.8 and 2 mg/kg, respectively, with Se concentrations peaking at 4 mg/kg. Figure 10-30 illustrates the distribution of Se concentrations in surface soil in the Sudbury Centre community.

Table 10.5 Summary of Metal Concentrations in Sudbury Centre (mg/kg)

Depth (cm) and number of samples (N)	Statistic	Arsenic	Cobalt	Copper	Nickel	Lead	Selenium
0-5	min	2.5	3	6.2	11	1	0.5
N=1129	max	65	100	1800	3284	320	13
	mean	6.0	11.2	154.7	171.6	26.4	1.1
	95th percentile	18	28	590	596	100.6	3.64
5-10	min	2.5	3	12	18	2	0.5
N=643	max	39	36	1100	970	310	5
	mean	6.5	9.0	121.7	139.5	24.8	0.9
	95th percentile	17	17	379	429.3	83.9	2
10-20	min	2.5	3	11	15	2	0.5
N=607	max	67	28	530	820	470	4
	mean	5.8	8.5	94.4	114.6	21.9	0.8
	95th percentile	14.7	15	270	300	76	2

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Figure 10-25
Sudbury Centre
Distribution of Arsenic
in 2001 Soil Samples

Soil Depth 0-5 cm

Arsenic Concentration (mg/kg)

-  < 20 (MOE Table A Guideline)
-  20 - 50
-  50 -200
-  > 200

Scale 1:60,000

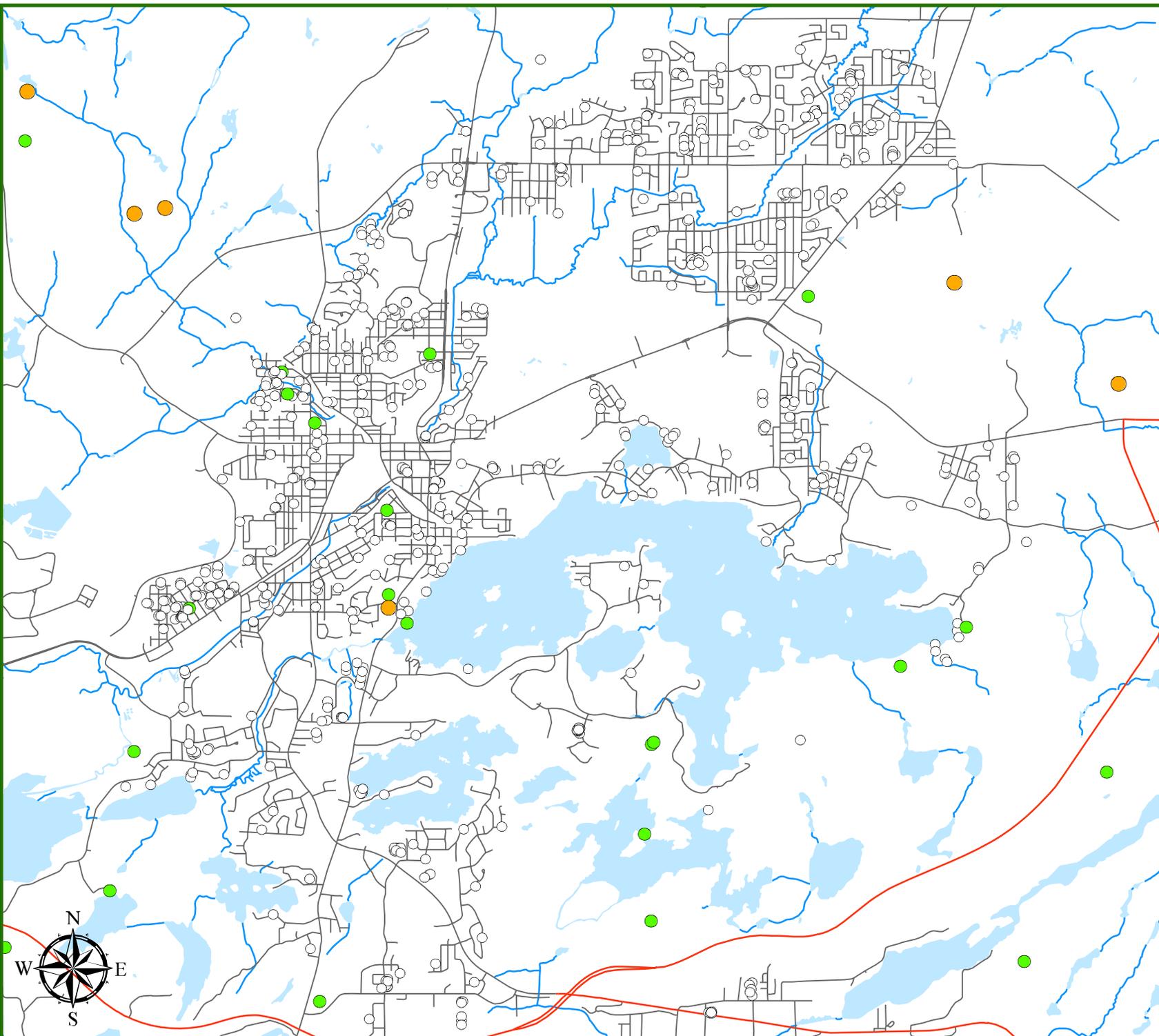
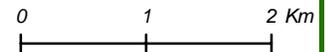


Figure 10-26
Sudbury Centre
Distribution of Cobalt
in 2001 Soil Samples

Soil Depth 0-5 cm

Cobalt Concentration (mg/kg)

-  < 40 (MOE Table A Guideline)
-  40 - 80
-  80 - 150
-  > 150

Scale 1:60,000

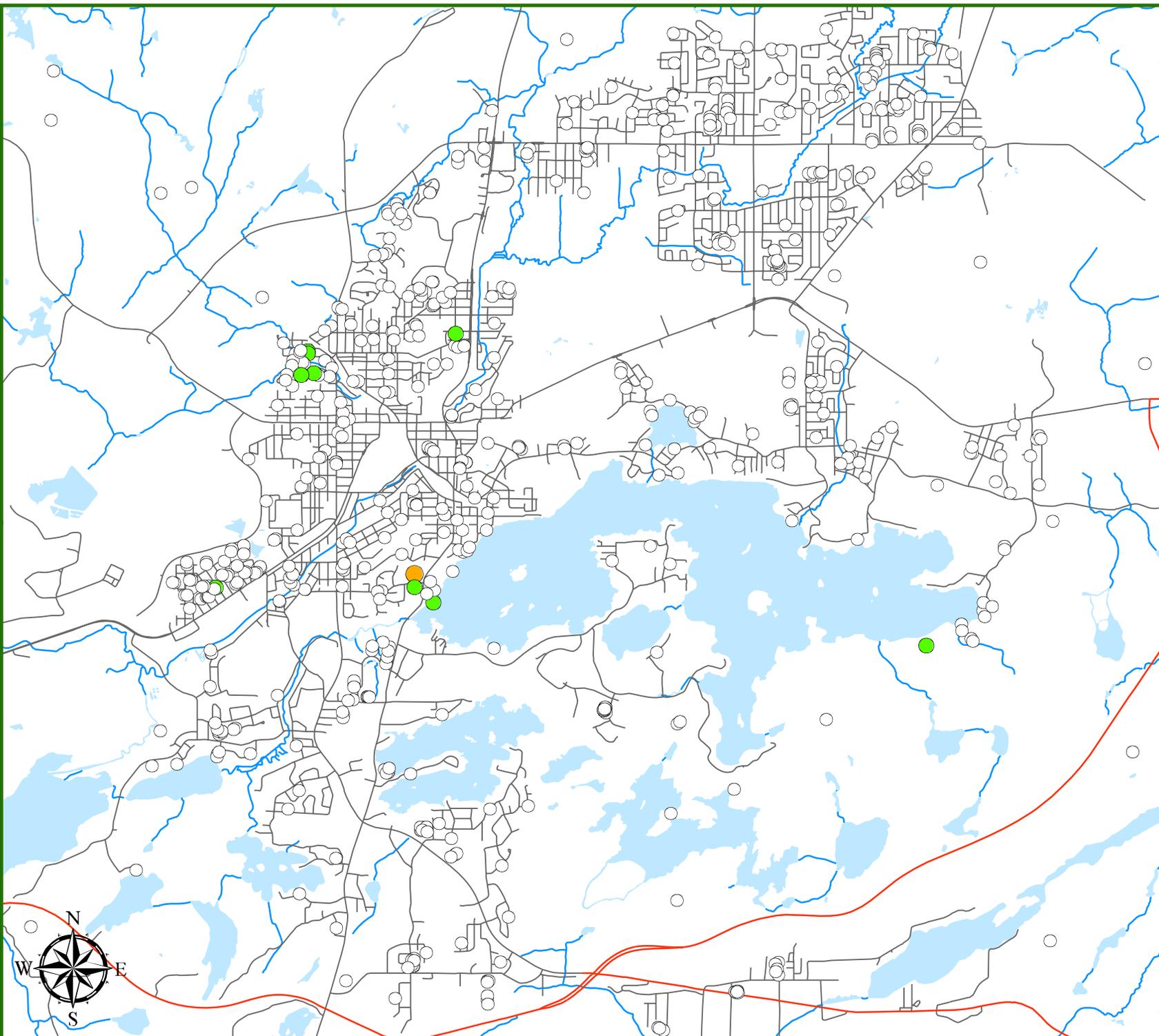
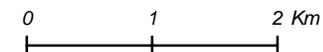


Figure 10-27
Sudbury Centre
Distribution of Copper
in 2001 Soil Samples

Soil Depth 0-5 cm

Copper Concentration (mg/kg)

-  < 150
-  150 - 300
-  300 - 1000
-  1000 - 2000
-  > 2000

(MOE Table A
Guideline is 225 mg/kg)

Scale 1:60,000

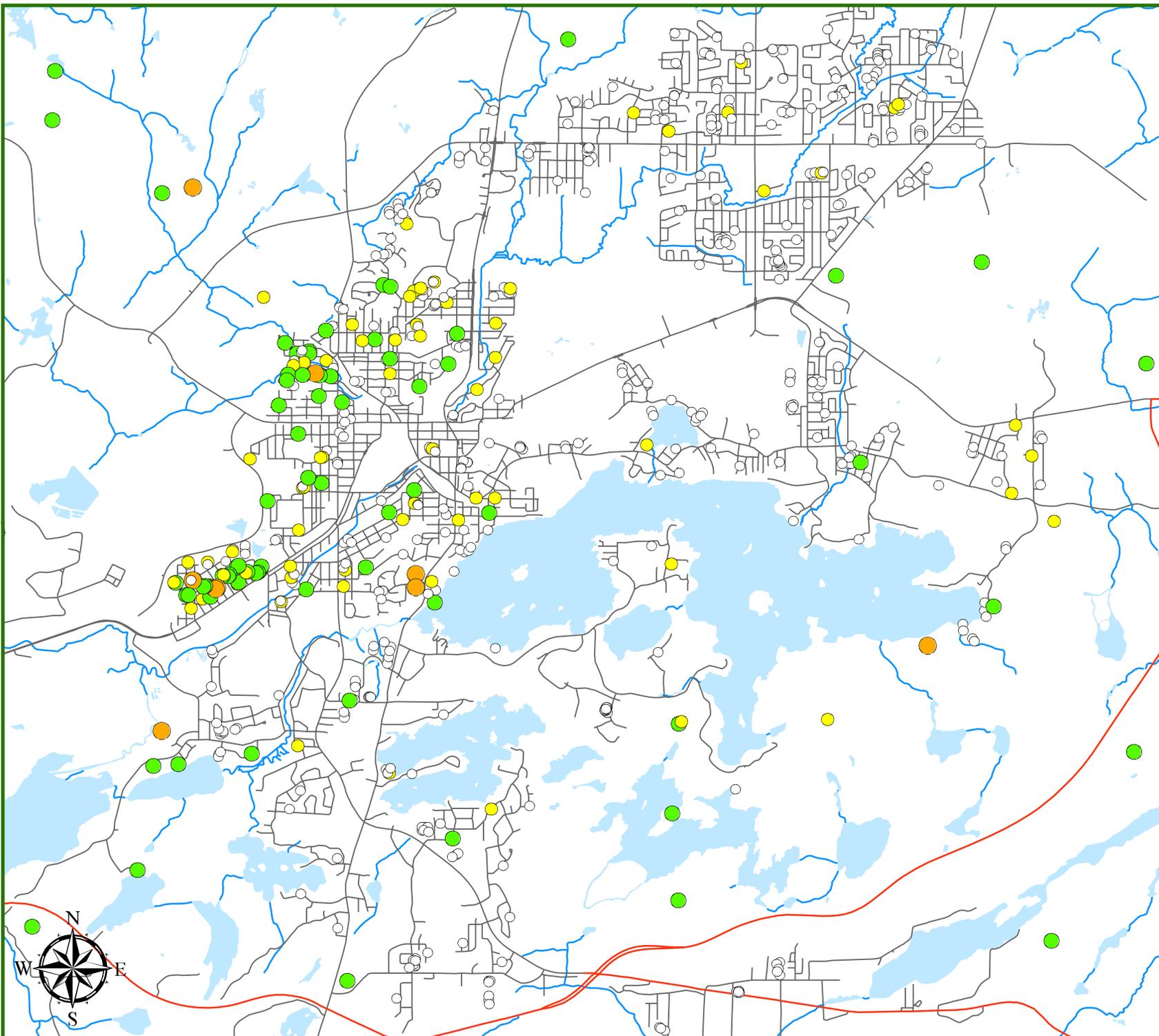
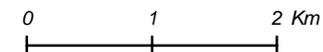


Figure 10-28
Sudbury Centre
Distribution of Nickel
in 2001 Soil Samples

Soil Depth 0-5 cm

Nickel Concentration (mg/kg)

-  < 150 (MOE Table A Guideline)
-  150 - 300
-  300 - 1000
-  1000 - 2000
-  > 2000

Scale 1:60,000

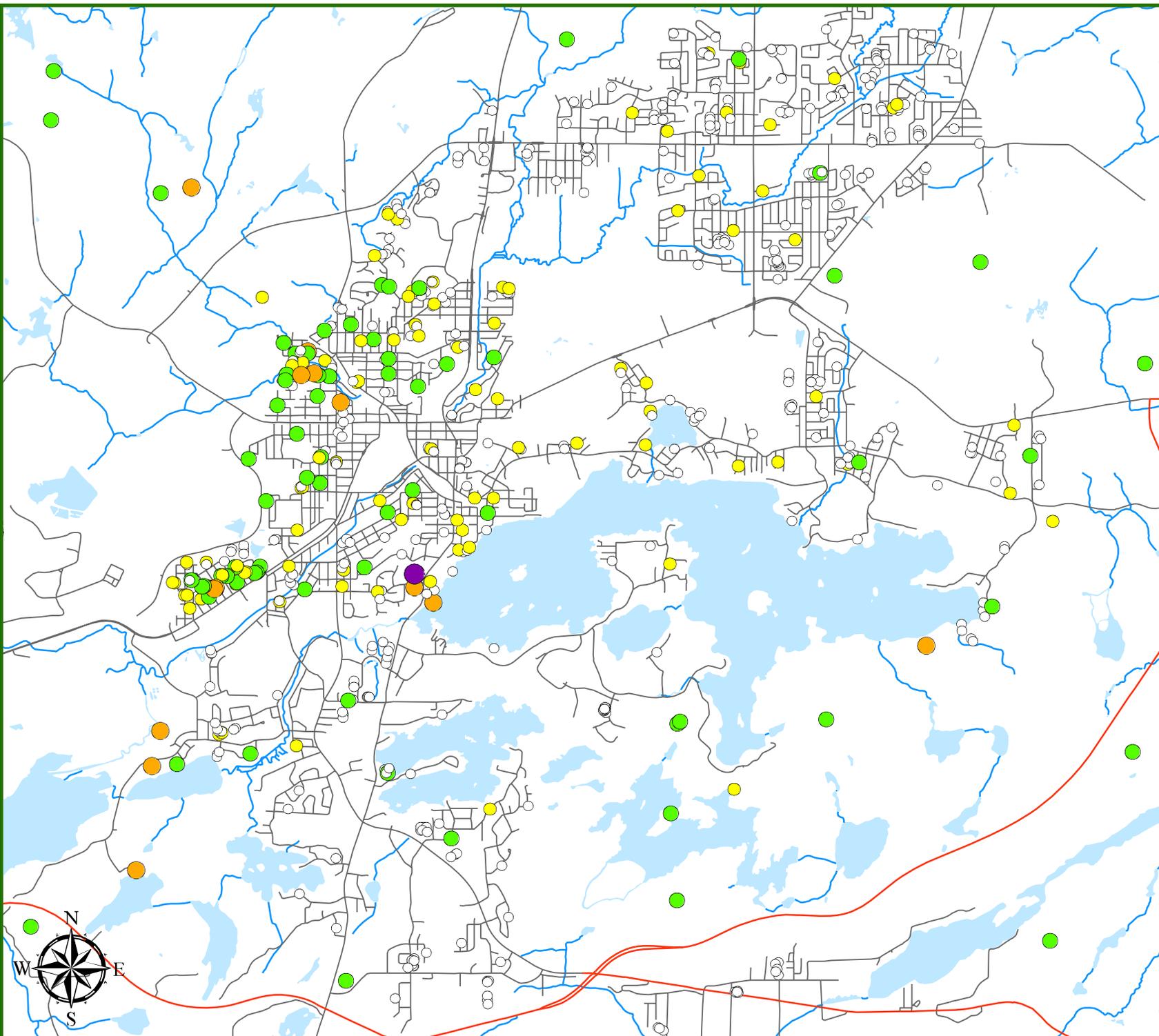
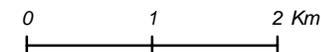


Figure 10-29
Sudbury Centre
Distribution of Lead
in 2001 Soil Samples

Soil Depth 0-5 cm

Lead Concentration (mg/kg)

-  < 50
-  50 - 100
-  100 - 200
-  > 200 (MOE Table A Guideline)

Scale 1:60,000

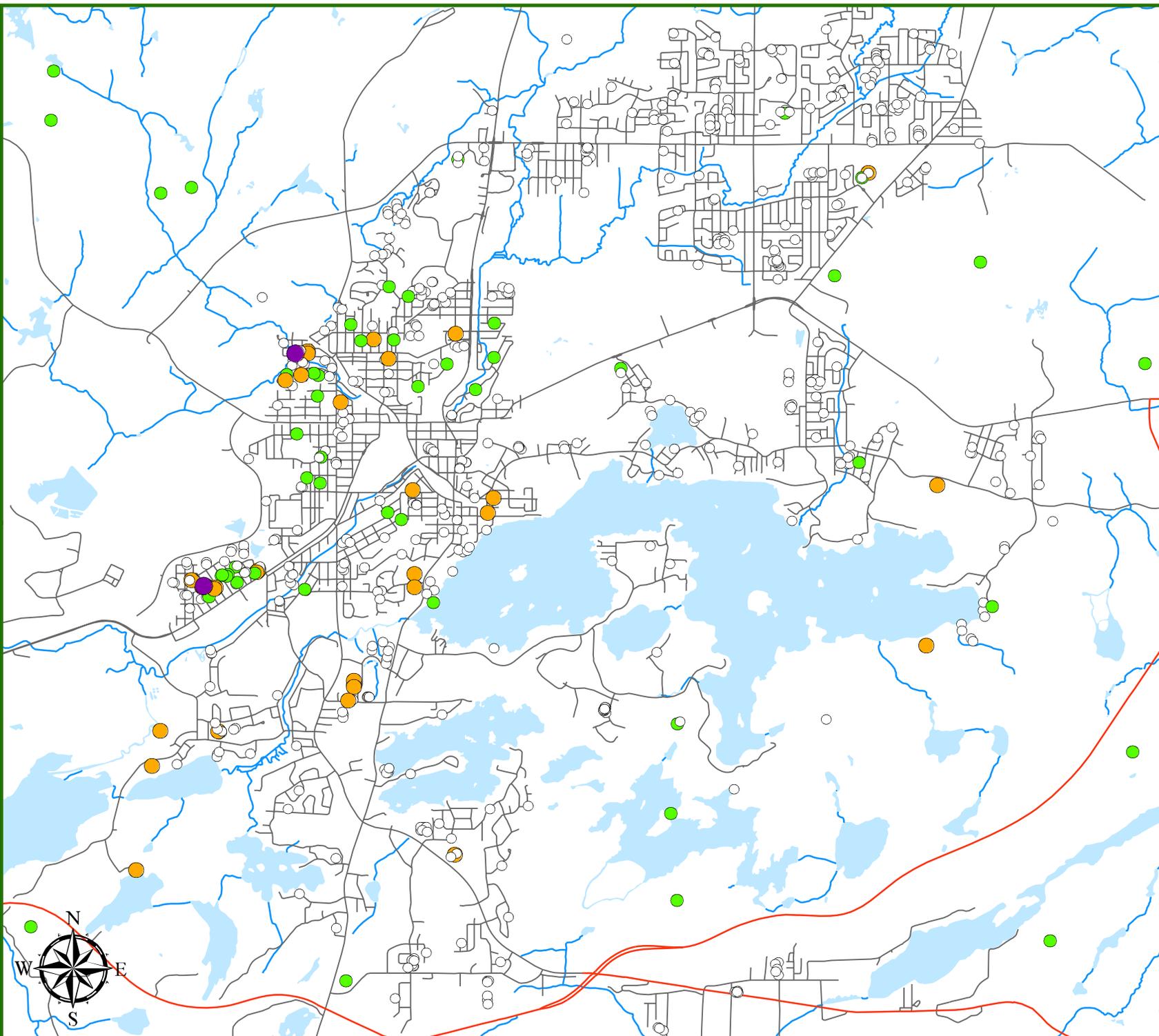
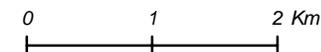


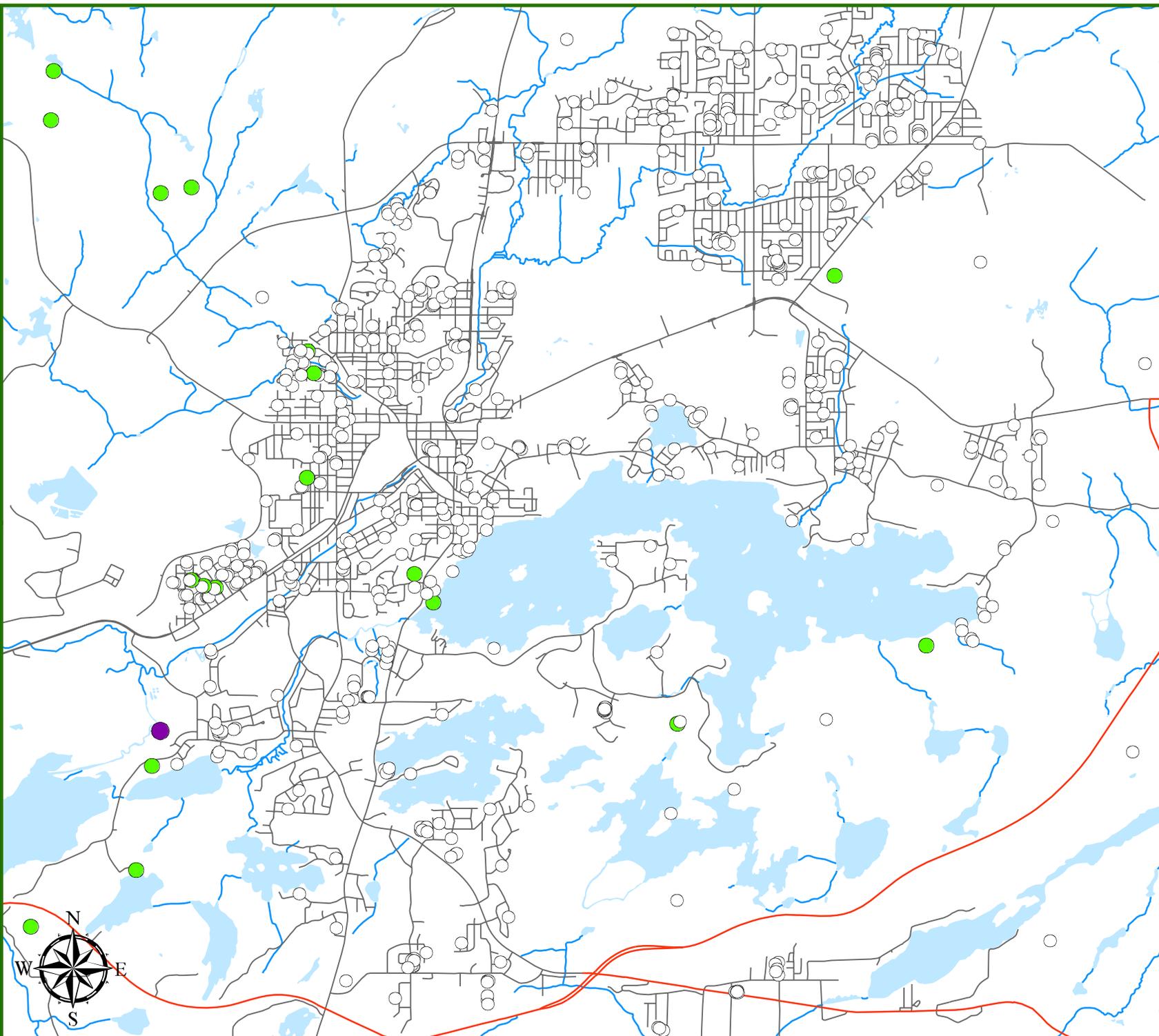
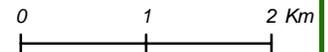
Figure 10-30
Sudbury Centre
Distribution of Selenium
in 2001 Soil Samples

Soil Depth 0-5 cm

Selenium Concentration (mg/kg)

-  < 5
-  5 - 10
-  > 10 (MOE Table A Guideline)

Scale 1:60,000



10.2 Distribution of COC in Communities of Interest by Land Use Type (From MOE Urban Survey)

The Ministry of the Environment (MOE) urban soil survey collected soil samples from different types of land use including residential, schools and parks¹. The purpose of this section is to provide an overview of soil metal concentrations from the different types of land use.

The MOE urban soil survey collected samples throughout the City of Greater Sudbury, but the data have been grouped into six primary communities defined during MOE analysis. These communities are: Copper Cliff, Coniston, Falconbridge, Outer Sudbury, Inner Sudbury and Sudbury Core. The boundaries of the latter three communities do not match up with the Communities of Interest for the purpose of the risk assessment. For consistency, only results from the actual Communities of Interest (*i.e.*, Copper Cliff, Coniston, and Falconbridge) will be presented in this summary.

Data summaries for each community are presented in Tables 10.6 to 10.8 by major land use: residential properties, schools and daycares, and parks. It is important to note that the sample sizes (n values) in Tables 10.6 to 10.8 represent all samples, including duplicates, and not the number of sample locations. In most cases, the sample size will generally be much larger than the number of locations. For details on actual number of sites sampled within a community, refer to the full report (MOE, 2004).

Data from only the surface soils (0 to 5 cm depth) are provided in this summary for ease of presentation to demonstrate trends between communities. Full details of the results for all soil depths are provided in MOE (2004).

10.2.1 Copper Cliff

The majority of sampling sites in the Copper Cliff community were residential, with only one school and a small number of parks. The highest concentrations of nickel (3200 mg/kg), copper (5600 mg/kg) and selenium (49 mg/kg) measured in the MOE study were detected within Copper Cliff. Almost all of the 290 samples within the 0-5 cm depth layer exceeded the Table A criterion for nickel (280 samples) and copper (280 samples) (Table 10.6). In addition, the number of samples that exceeded the generic criteria for arsenic, lead and cobalt were 90, 19 and 190, respectively.

¹ From Ministry of the Environment (MOE). 2004. City of Greater Sudbury 2001 Urban Soil Survey. Ontario Ministry of the Environment Report No. SDB-008-3511-2003.

Table 10.6 Summary concentrations* of select metals (mg/kg) in the surface soils (0-5 cm depth) in Copper Cliff by land use type.

MOE Table A Soil Screening Criteria		As	Co	Cu	Pb	Ni	Se
		20	40	225	200	150	10
Land Use							
Residential (n=266)	min.	2.5	6	65	10	71	0.5
	mean	18	33	1440	91	1017	7.8
	max.	72	100	5600	410	3200	49
Schools and Daycares (n=6)	min.	6	11	250	11	250	1
	mean	22	47	1587	60	1452	5.7
	max.	37	80	2900	100	2500	12
Parks (n=18)	min.	2.5	9	250	13	205	1
	mean	16	32	1274	45	959	5.4
	max.	63	100	4600	130	3649	22

* Concentrations expressed as mg/kg (parts per million) dry weight.

n = number of samples collected

10.2.2 Coniston

The majority of sampling sites in the Coniston community were residential, with only a small number of parks (Table 10.7). At the 0 to 5 cm depth, the maximum nickel and copper concentrations were 1900 and 1200 mg/kg, respectively. Approximately one half (166) of the total number of samples (301) exceeded the Table A criterion for nickel, while 116 samples exceeded the copper criterion. Relatively few samples exceeded the criteria for arsenic (35), lead (6) and cobalt (23).

Table 10.7 Summary concentrations* of select metals (mg/kg) in the surface soils (0-5 cm depth) in Coniston by land use type.

MOE Table A Soil Screening Criteria		As	Co	Cu	Pb	Ni	Se
		20	40	225	200	150	10
Land Use							
Residential (n=287)	min.	2.5	3	14	6	25	0.5
	mean	10	16	246	52	336	1.2
	max.	47	74	1200	400	1900	5
Parks (n=14)	min.	2.5	4	8	2	16	0.5
	mean	7.9	16	211	16	300	0.7
	max.	19	43	620	42	940	2

* Concentrations expressed as mg/kg (parts per million) dry weight.

n = number of samples collected

10.2.3 Falconbridge

The sampling sites in the Falconbridge community included all three land uses, but with relatively fewer school and park sites compared to residential sites. At the 0 to 5 cm depth the maximum nickel and copper concentrations were 3700 and 3000 mg/kg, respectively, with 191 samples that exceeded the Table A criterion for nickel and 178 samples that exceeded the copper criterion (Table 10.8). Arsenic levels in Falconbridge ranged from 2.5 to 300 mg/kg, which represented the highest arsenic values measured within the study area. A total of 184 soil samples exceeded the Table A arsenic criterion. Similarly, the highest levels of cobalt were observed in Falconbridge (maximum of 190 mg/kg) with 135 samples exceeding the soil criterion for cobalt. Very few samples exceeded criteria for lead (9) or selenium (1).

Table 10.8 Summary concentrations* of select metals (mg/kg) in the surface soils (0 to 5 cm depth) in Falconbridge by land use type.

MOE Table A Soil Screening Criteria		As	Co	Cu	Pb	Ni	Se
		20	40	225	200	150	10
Land Use							
Residential (n=199)	min.	2.5	5	31	6	37	0.5
	mean	74	56	874	88	956	2.7
	max.	300	190	3000	370	3700	12
Schools and Daycare (n=3)	min.	2.5	11	46	11	61	0.5
	mean	2.5	12	57	17	97	0.5
	max.	2.5	13	66	21	120	0.5
Parks (n=3)	min.	2.5	8	44	6	68	0.5
	mean	34	34	456	31	601	1.7
	max.	84	130	1800	110	2500	4

* Concentrations expressed as mg/kg (parts per million) dry weight.

n = number of samples collected

10.3 Distribution of COC within a Community

Several geo-statistical approaches were used to examine the spatial distribution of the COC within each of the communities of interest. Visual examination of the COC distribution (*i.e.*, Figures 10-1 to 10-30) revealed no obvious trends. Metal levels did not appear to be elevated in any particular neighbourhood or along a particular street. The lack of a pattern was verified by the geo-statistical analysis. This indicates that the distribution of metals within a community is essentially random. This is not surprising given the fact that topsoil for residential properties has been extensively moved about and imported from different locations for landscaping. Therefore, metal levels at a particular property cannot be predicted with confidence based on neighbouring results. This determination was important for the Human Health Risk

Assessment (HHRA) where it was necessary to select soil exposure point concentrations for the human exposure model (see Volume II). The lack of a predictable pattern also has implications if further soil sampling is required for risk management.

10.4 Soil pH

Soil pH was analyzed on only one out of every ten samples collected during the MOE urban soils survey. Therefore, there is an incomplete database to consider. However, the available data do illustrate some trends.

About 546 soil samples were analyzed for pH in the urban/residential soils collected within the city (MOE, 2004). Of these, only 7 displayed pH <5.0. Therefore, in the most densely populated areas, low soil pH does not appear to be a concern.

These results suggest that the soils of many urban properties have likely been amended, resulting in higher pH compared with soils from the rural or remote locations.