Ministry of the Environment

PHYTOTOXICOLOGY TECHNICAL MEMORANDUM

Phytotoxicology 2001 Investigation: Re-sampling of Soil at Humberstone School, and Arsenic in Soil at all Schools - Port Colborne

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Background

On February 25, 2001, the Ecological Standards and Toxicology Section (Phytotoxicology) received a request from the Niagara District Office to conduct an investigation into soil contamination of the playing field of Humberstone Public School in Port Colborne. The playing field at this school, and all schools in Port Colborne, had been sampled in April 2000 and the results reported in MOE Phytotoxicology report SDB-031-3511-2000.

This particular request was precipitated by the results of a separate Phytotoxicology investigation which examined the role of woodlots in intercepting atmospheric particulates containing nickel and other metals that had been emitted by the International Nickel Company (INCO) refinery during the 66 years that it operated in Port Colborne. This investigation concluded that where a woodlot is adjacent to an open field the soil metal concentrations in the woodlot can be two to five times higher then in the adjacent open field. Furthermore, the highest soil metal levels occur at the field/woodlot edge on the side of the woodlot facing INCO. Details of this investigation are contained in MOE Phytotoxicology report SDB-012-3511-2001.

Because the eastern side of the playing field at Humberstone Public school is adjacent to the INCO side of a woodlot, there was a concern raised about the applicability of soil data previously collected for this playing field; specifically that the April 2000 results for the Humberstone playing field may have understated the degree of soil metal contamination. These earlier data were for samples collected from the three soccer fields and an area around the playground equipment, but no samples were collected adjacent to the fence next to the woodlot.

Due to the urgency of resolving whether there were high metal concentrations along the eastern side of the playing field near the edge of the woodlot, an investigation was initiated even though the ground was frozen and partially snow-covered.

Investigation Procedures

The investigation was conducted on February 27, 2001 by Phytotoxicology scientists Bill Gizyn (author) and Bob Emerson. Upon arriving at the school, the principal was informed of the purpose of the visit and consulted about the property lines defining the playing field. The field was measured and a sampling scheme that would systematically assess the whole field, including the eastern edge nearest the woodlot, was developed.

The main part of the field was very close to a square at approximately 190 metres on each side. The perimeter of the field was staked at 45 metre intervals. Markers were dropped a distance of five metres from the edges at these intervals. Then the intersections of the lines between the markers on opposite sides of the field was likewise marked. This produced a grid that contained 25 potential sampling sites. Finally, because the playing field extended south beyond the main part of the field, two additional sites were added on the eastern side of the school building by extending two of the grid lines, bringing the total number of sample sites to 27. Figure 1 is a schematic representation of the sampling site locations in relation to the school building and the woodlot.

A each sampling location a tube-type soil sampler was used to remove cylindrical cores of soil to depth of five centimetres. Five cores were collected at each site and composited to form a single sample. Duplicate samples were collected at each site. For the first duplicate, one core was collected at the site marker and the remaining four were collected at a distance of five metres to the north, south, east and west. For the second duplicate, the first core was also collected at the site marker and the remaining four at a distance of five metres to the NE, SE, SW and NW of the marker. Because of the frozen soil conditions, the sampler had to be driven to the five centimetre depth with a hammer. Each duplicate sample containing five cores was placed in a labelled polyethylene bag. A total of 54 samples were collected (duplicates at 27 sites) and delivered to the Phytotoxicology processing laboratory.

At the processing lab the samples were air dried and sieved to remove roots and stones larger than two millimetres. Each sieved sample was ground to a powder in an agate mortar to pass through a 355 micron sieve, collected in a glass jar, and forwarded to the MOE Laboratory Services Branch for analysis. All sampling, processing, and analytical protocols were consistent with those used in all prior Phytotoxicology investigations in Port Colborne.

Results

The results of the soil analyses for all samples are listed in Table 1. This table also reports the maximum and minimum concentrations of each chemical quantified by the analysis. The data are compared to the MOE effects-based Table A and background-based Table F guidelines as published in the *Guideline for Use at Contaminated Sites in Ontario* (see Appendix A). The OTR_{98} guidelines for rural parkland soil are substituted where there are no Table F guidelines (see Appendix C). Soil concentrations in Table 1 exceeding background (Table F guidelines) are in bold font, whereas concentrations exceeding the effects-based Table A guidelines are bolded and underlined.

To show how certain chemical elements were distributed over the playing field, a contouring application was used to interpolate concentration gradients. The application used was Surfer 7.0 (Golden Software). Six elements were plotted in this manner; nickel, copper, cobalt, arsenic, selenium, and zinc. These elements have previously been ascribed to INCO emissions. Although only these six elements were mapped, the results for all 20 elements are summarized in Table 1.

The results of the soil contaminant contouring mapping procedure across the Humberstone playing field are illustrated in Figures 2 through 7. The input data consisted of the average metal concentrations for the duplicate samples from all 27 sample sites.

Discussion

The chemical analysis included a total of 20 chemical elements. The concentrations of twelve of these were exclusively below background levels. These were iron, aluminum, magnesium, manganese, barium, lead, vanadium, chromium, arsenic, molybdenum, beryllium, and cadmium. This suggests either there are no anthropogenic sources that contributed to these elements to the soil, or the deposition was insufficient to bring the soil concentrations above background.

Three elements, calcium, strontium, and antimony, are elevated above background at two or three of the 26 sample sites. A plausible explanation for the elevated calcium in two samples is the possibility that one or more of the sample cores included a spot where playing field lines had been applied. These lines are draw by applying lime dust to the field, and lime is a calcium based compound. The marginally elevated strontium levels are environmentally inconsequential because they are not related to INCO's emissions and are consistent with the occasional spuriously elevated levels encountered in other Phytotoxicology investigations in soil samples not affected by a known pollution source. Soil antimony levels at three sites were marginally above background (maximum 1.9 µg/g) but well below the effects-based guideline of 13 µg/g.

The remaining five elements are present in concentrations that exceeded background levels either at several sample sites (zinc, selenium) or at most sample sites (cobalt, copper, and nickel). Nickel is the only chemical that exceeding the effects-based Table A criterion of 200 µg/g, and this occurred at every sample site in the Humberstone field.

Emissions from the INCO refinery contained copper, cobalt, and nickel, and probably zinc and selenium. Humberstone school is downwind of INCO in a high deposition zone. Consequently, the enrichment of soil concentrations of these metals over the playing field at Humberstone school is attributed to INCO emissions.

The soil metal concentrations determined in this investigation are entirely consistent with the April 2000 soil investigation. The range of soil nickel concentrations in the Humberstone playing field in February 2001 was 310 µg/g to 1,200 µg/g, compared to 720 µg/g to 1,050 µg/g in April 2000. In February 2001 many more samples were collected from more parts of the Humberstone property, and so a greater variability in soil metal levels would be expected.

A review of the contaminant contour maps shows that there is a clear pattern of higher soil metal levels towards the east side of the playing field, which supports the observations made in the Phytotoxicology woodlot investigation. This pattern would likely be even clearer if not for the relatively lower concentrations at Site 25 compared to the other sites along the eastern side of the field (the exception is zinc, which was highest at Site 25. It should be noted that Site 25 was in the immediate vicinity of the baseball backstop and the high traffic, and possibly soil disturbance or amendments, could have influenced the metal concentration in the top five centimetres of soil. The presence of the baseball backstop at Site 25 could account for the higher zinc concentrations, as it is common to find elevated zinc concentrations in soil near galvanized fences, such as the type used for the backstop.

Another observation apparent from the contour maps is that five of the six metals tended to be higher near Site 26. In fact, this one site contained the highest concentrations of these five metals (zinc is the exception).

Given that this investigation has re-affirmed that the playing field at this school has been impacted by deposition of metals ascribed to INCO emissions, it remains to interpret the risk to students using the playing field. The Table A affects based criterion of 200 µg/g nickel relates to potential toxicity to plants growing in nickel-contaminated soil. The 1997 MOE/Health Department human health risk assessment of soil nickel contamination in Port Colborne concluded that a lifetime of exposure to concentrations below 9,750 µg/g should not pose a health risk (SDB-EA054.94-3540-1997). Subsequently, the March 2001 MOE human health risk assessment conducted for the Rodney St. community in Port Colborne recommended a soil nickel intervention level of 10,000 µg/g, which is intended to protect toddlers (up to 5 years old) from potential adverse health effects of continuous exposure to nickel in soil (MOE report SDB-010-3511-2001). This level should not pose a health concern for children (greater than 5 years old), teens, or adults. The average soil nickel level of the Humberstone field is about 1/15th of the intervention level, and the maximum concentration, which occurred only in the southeast corner, is about 1/8th of the intervention level. In addition to being considerably lower than the MOE intervention level, there are two additional safety factors for students at Humberstone school; the first is that they are children not toddlers, and the second is that their exposure to nickel-contaminated soil is periodic and of short duration, unlike the continuous exposure assumed in the risk assessment. The soil nickel concentrations in this playing field, even at the eastern edge, should not pose a health risk to Humberstone students.

The March 2001 MOE risk assessment determined no undo risk and therefore did not set intervention levels for other soil contaminants in the Rodney St. community. Since the soil levels at Humberstone school are far lower than in the Rodney St. community there is no health risk to Humberstone students from exposure to the other metals in school soil.

Arsenic in Soil at all Port Colborne Schools

The April 2000 MOE study of soil metal levels at Port Colborne schools did not include arsenic, because arsenic has not been identified as a soil contaminant in Port Colborne at the community level. However, some parents of children attending these schools had strong objection to this omission and the MOE committed to retrieving the archived soil samples and re-submitting them for arsenic analysis. The results of these analyses are summarized in Table 2. In addition to arsenic, Table 2 also includes antimony and selenium data, as these three elements are generated at the same time by the same analytical instrument.

Not all the arsenic data from the schools is provided in Table 2. Because none of the soil arsenic levels exceeded background (in fact the average arsenic concentration was less than 1/3 the Table F guideline) only the maximum soil arsenic concentration encountered at each school is listed in Table 2. The highest soil arsenic level found at Humberstone school based on the April 2000 sampling was 9.6 µg/g, about ½ of the 17 µg/g Table F background-based guideline. Soil at St. Theresa had the highest soil arsenic level of any school in Port Colborne, and this was 9.8 µg/g which is only marginally higher than Humberstone, and still well within normal Ontario background concentrations. All samples collected from Humberstone school in February 2001 were analysed for arsenic, and the highest soil arsenic concentration detected in this most recent and extensive sampling was 10.0 µg/g.

Also included in Table 2 is the soil arsenic concentration predicted by the regression equation determined from the 1999 MOE Port Colborne soil investigation. All soil samples collected for the 1999 study were analyzed for arsenic. The relationship between nickel in soil and arsenic in soil is statistically highly significant, which strongly suggests arsenic was co-emitted along with nickel from the INCO stack. This relationship implies that if the soil nickel level is known then the soil arsenic level can be predicted with considerable confidence. For example, the predicted soil arsenic level at Humberstone school is 10.7 µg/g, whereas the actual soil arsenic level is 9.6 µg/g. The regression formula at the bottom of Table 2 can be used to predict the soil arsenic level anywhere in Port Colborne where the nickel level is known. Even though large quantities of nickel were emitted by INCO, by comparison only a very small amount of arsenic was emitted. In addition, arsenic tends to be more mobile in soil that nickel, and so proportionately more arsenic would have been leached from the soil over time. Regardless of the rate of arsenic emissions from INCO or the soil arsenic leaching rate, the levels of arsenic currently in soil in playgrounds of Port Colborne schools is well within normal Ontario background concentrations.

Soil antimony concentrations at Steele Street School and soil selenium levels at St. Theresa and Humberstone schools marginally exceeded their Table F background-based guidelines, but both were substantially below the Table A effects-based criteria.

Conclusions

This investigation reaffirmed that INCO emissions have impacted the playing field at Humberstone Public School resulting in soil concentrations of nickel, copper, cobalt, and selenium that are consistently higher than background. It also demonstrated that woodlots can influence deposition patterns resulting in higher deposition to soil in open areas close to the windward edge of the woodlot.

Based on the recent human health risk assessment conducted for the Rodney St. community in Port Colborne the soil metal levels at Humberstone school should not be a health risk to the students. There is no restriction to the normal use of the playing fields at Humberstone Public School.

The re-analyses of archived soil samples clearly illustrated that the soil arsenic concentrations at Port Colborne schools are well within normal Ontario background levels.

Table 1: Chemical Concentrations (µg/g) in Surface Soil (0-5 cm) at Humberstone Public School, February 2001.

Site-Rep	Iron	Calcium	Aluminum	Magnesium	Nickel	Manganese	Zinc	Barium	Copper	Lead
1-a	16000	8600	13000	3300	**650**	420	78	86	**100**	31
1-b	12000	10000	8800	2700	**550**	480	72	70	**98**	30
2-a	16000	8500	15000	3600	**660**	350	90	98	**100**	30
2-b	16000	8300	15000	3400	**670**	360	87	100	**98**	31
3-a	20000	6900	18000	4400	**660**	370	94	110	**94**	36
3-b	23000	7000	20000	5000	**700**	400	100	120	**100**	33
4-a	27000	6100	21000	5300	**810**	580	110	130	**100**	38
4-b	24000	6500	20000	5100	**740**	430	100	120	**100**	35
5-a	28000	6600	24000	5900	**880**	430	120	130	**110**	37
5-b	27000	6700	23000	5800	**830**	440	120	130	**110**	39
6-a	16000	16000	12000	7300	**600**	500	94	83	**97**	30
6-b	14000	11000	11000	4100	**560**	520	81	81	**89**	26
7-a	11000	47000	8900	4800	**460**	300	100	130	74	40
7-b	11000	9400	9900	3100	**460**	340	100	81	68	30
8-a	16000	8000	14000	3600	**650**	320	110	89	**98**	33
8-b	16000	7900	13000	3700	**630**	400	100	89	85	43
9-a	23000	5800	19000	4800	**760**	380	120	120	**100**	36
9-b	21000	6200	18000	4400	**710**	390	120	110	**95**	36
10-a	26000	7700	22000	5700	**810**	360	140	130	**110**	32
10-b	29000	7600	25000	6200	**860**	430	140	140	**110**	35
11-a	18000	8400	15000	4000	**630**	320	90	95	**91**	31
11-b	16000	14000	14000	5200	**520**	350	110	94	89	34
12-a	9800	8600	8300	2400	**460**	290	92	67	72	27
12-b	9700	**99000**	9000	3400	**380**	330	68	90	63	25
13-a	13000	7500	11000	3000	**570**	260	82	81	82	27
13-b	13000	8200	11000	3200	**590**	250	94	79	84	33
14-a	13000	**87000**	12000	8300	**420**	330	77	130	70	34
14-b	21000	8300	20000	4700	**750**	550	110	120	**110**	33
15-a	24000	8000	20000	5200	**750**	350	130	120	**100**	32
15-b	26000	7800	23000	5600	**840**	440	140	130	**110**	33
16-a	26000	7200	23000	5900	**690**	480	120	130	**100**	44
16-b	24000	11000	19000	5900	**570**	430	110	130	80	38
17-a	7500	10000	3800	2100	**500**	550	65	40	75	29
17-b	5700	11000	2800	2100	**460**	380	64	32	77	30
18-a	7100	12000	4200	2100	**620**	330	88	46	**89**	47
18-b	8300	11000	5500	2200	**600**	420	97	55	**96**	43
19-a	13000	12000	11000	3600	**950**	390	160	94	**130**	60
19-b	12000	12000	9900	3400	**870**	330	150	96	**130**	57
20-a	27000	11000	26000	6400	**830**	480	**170**	160	**120**	42
20-b	23000	10000	23000	5800	**730**	380	150	140	**120**	38
21-a	13000	6200	9500	3400	**630**	240	60	57	72	27
21-b	15000	7300	12000	4100	**650**	330	77	72	85	28
22-a	20000	50000	16000	14000	**660**	390	90	170	**95**	39
22-b	23000	14000	17000	6900	**780**	400	99	140	**110**	47
23-a	6100	15000	3000	2900	**370**	710	130	75	77	28
23-b	8800	44000	5900	12000	**310**	900	88	82	63	33
24-a	14000	14000	10000	5500	**680**	550	120	110	**110**	46
24-b	7500	15000	5200	3000	**550**	580	110	82	**98**	38
25-a	20000	10000	18000	4500	**730**	380	**580**	110	**120**	51
25-b	16000	12000	14000	4000	**530**	330	**410**	87	**91**	41
26-a	22000	13000	20000	5200	**1100**	570	**210**	140	**180**	69
26-b	29000	11000	25000	6400	**1200**	840	**190**	190	**160**	50
27-a	25000	32000	19000	11000	**670**	460	94	150	**100**	43
27-b	25000	15000	19000	9800	**710**	460	93	130	**95**	35
Max	29000	99000	26000	14000	1200	900	580	190	180	69
Min	5700	5800	2800	2100	310	240	60	32	63	25
Table F	35000*	55000*	30000*	20000*	43	2200	160	210	85	120
Table A	NG	NG	NG	NG	200	NG	800	1000	300	200

NG = no guideline / criterion   <T = a measurable trace amount   <W = below analytical detection   * OTR$_{98}$ substituted

Table 1: Chemical Concentrations (µ/g) in Surface Soil (0-5 cm) at Humberstone Public School, February 2001

Site-Rep	Strontium	Vanadium	Cobalt	Chromium	Arsenic	Selenium	Molybdenum	Beryllium	Cadmium	Antimony
1-a	23	28	22	18	5.4	1.9	0.8<T	0.6<T	0.6<T	0.6<T
1-b	25	19	21	14	4.5	1.6	1.0<T	0.5<W	0.5<T	0.5<T
2-a	26	30	21	20	5.6	**2.1**	0.7<T	0.7<T	0.6<T	0.3<T
2-b	23	28	22	19	5.7	1.7	0.7<T	0.7<T	0.8<T	0.3<T
3-a	22	35	21	23	7.4	1.6	0.7<T	0.9<T	0.4<T	0.4<T
3-b	24	40	**22**	27	8.6	1.7	0.6<T	0.9<T	0.6<T	0.3<T
4-a	19	43	**25**	29	11	**2.1**	0.5<W	1.0<T	0.7<T	0.4<T
4-b	20	40	21	26	8.8	1.8	0.5<W	1.0<T	0.7<T	0.3<T
5-a	21	46	**24**	31	11	**2.1**	0.5<W	1.1<T	0.3<T	0.3<T
5-b	21	45	**23**	31	11	**2.4**	0.5<W	1.1<T	0.5<T	0.3<T
6-a	28	25	**22**	17	5.2	1.6	0.6<T	0.6<T	0.6<T	0.3<T
6-b	26	24	21	16	4.9	1.5	1.1<T	0.5<W	0.4<T	0.2<W
7-a	29	19	16	14	4.2	1.4	1.1<T	0.5<W	0.5<T	**1.9**
7-b	28	21	17	15	4.3	1.5	0.9<T	0.5<W	0.5<T	1.0
8-a	23	27	21	20	5.7	1.5	1.1<T	0.6<T	0.7<T	0.2<W
8-b	21	28	21	20	6.5	1.7	1.0<T	0.6<T	0.6<T	0.5<T
9-a	18	39	**22**	27	9.0	1.8	0.5<W	0.9<T	0.5<T	0.4<T
9-b	18	37	**22**	26	8.5	1.8	0.5<W	0.8<T	0.4<T	0.3<T
10-a	23	42	**22**	30	9.6	**2.4**	0.5<W	1.1<T	0.8<T	0.3<T
10-b	23	47	**25**	33	13	**2.6**	0.7<T	1.2<T	0.6<T	0.4<T
11-a	27	30	18	20	5.7	1.8	1.3<T	0.6<T	0.2<W	0.4<T
11-b	33	28	17	20	5.4	1.4	1.2<T	0.6<T	0.4<T	0.4<T
12-a	21	17	16	12	3.1	1.7	1.3<T	0.5<W	0.7<T	0.3<T
12-b	39	17	15	11	3.6	1.0	0.5<W	0.5<W	0.5<T	**1.6<T**
13-a	19	23	19	16	4.5	1.5	1.0<T	0.5<W	0.5<T	0.3<T
13-b	21	23	19	16	4.2	**2.0**	1.4<T	0.5<W	0.5<T	0.3<T
14-a	39	24	15	18	4.4	1.3	0.8<T	0.5<W	0.6<T	**1.6<T**
14-b	23	38	**25**	25	6.7	1.9	1.1<T	0.9<T	0.7<T	0.4<T
15-a	23	39	**22**	27	7.7	**2.0**	0.5<W	0.9<T	0.5<T	0.5<T
15-b	24	44	**25**	30	9.0	**2.2**	0.8<T	1.0<T	0.4<T	0.4<T
16-a	27	45	**23**	27	8.4	1.4	0.5<W	0.9<T	0.6<T	0.3<T
16-b	32	40	19	24	7.7	1.2	0.5<W	0.8<T	0.3<T	0.3<T
17-a	21	10	**26**	10	3.2	1.9	1.3<T	0.5<W	0.4<T	0.3<T
17-b	21	8.0	**22**	9.0	2.5	1.6	1.4<T	0.5<W	0.4<T	0.2<W
18-a	25	11	**28**	11	3.7	**2.0**	1.3<T	0.5<W	0.5<T	0.3<T
18-b	25	14	**26**	12	4.3	**2.0**	1.0<T	0.5<W	0.4<T	0.3<T
19-a	25	24	**38**	20	5.6	**2.8**	0.9<T	0.5<W	0.7<T	0.5<T
19-b	24	22	**34**	20	5.1	**2.8**	1.2<T	0.5<W	0.7<T	0.6<T
20-a	32	48	**30**	32	10	**2.3**	0.5<W	1.1<T	0.8<T	0.4<T
20-b	29	43	**26**	28	7.5	**2.2**	0.5<W	1.0<T	0.6<T	0.4<T
21-a	18	24	16	14	5.4	1.1	0.5<W	0.5<W	0.2<W	0.2<W
21-b	20	27	19	17	4.6	1.1	0.5<W	0.5<W	0.4<T	0.2<W
22-a	56	35	**22**	22	6.8	1.3	0.5<W	0.7<T	0.2<W	0.3<T
22-b	35	36	**26**	25	8.2	1.6	0.8<T	0.8<T	0.4<T	0.3<T
23-a	**130**	9.0	**23**	9.0	2.6	1.9	1.5<T	0.5<W	0.5<T	0.3<T
23-b	**80**	16	17	12	3.3	1.3	1.4<T	0.5<W	0.4<T	0.5<T
24-a	**110**	24	**26**	16	5.2	**2.1**	0.8<T	0.5<W	0.7<T	0.3<T
24-b	**140**	15	**25**	11	3.0	**2.2**	1.5<T	0.5<W	0.4<T	0.5<T
25-a	26	33	**27**	25	5.7	**2.0**	0.6<T	0.8<T	0.8<T	0.4<T
25-b	26	29	19	19	5.0	1.6	0.8<T	0.6<T	0.7<T	0.4<T
26-a	35	39	**39**	27	8.4	**2.8**	0.5<W	0.9<T	0.8<T	0.5<T
26-b	30	48	**43**	32	13	**2.6**	1.0<T	1.1<T	0.8<T	0.4<T
27-a	54	41	**24**	27	9.7	1.8	0.6<T	0.9<T	0.2<W	0.3<T
27-b	39	44	**23**	28	10	1.5	0.6<T	0.9<T	0.3<T	0.3<T
Max	140	48	43	33	13	2.8	1.5	1.2<T	0.8<T	1.9
Min	18	8	15	9	2.5	1.0	0.5	0.5<W	0.2<W	0.2<W
Table F	78	91	21	71	17	1.9	2.5	1.2	1.0	1.0
Table A	NG	250	50	1000	25	10	40	1.2	12	13

NG = no guideline / criterion   <T = a measurable trace amount   <W = below analytical detection

Table 2: Arsenic, antimony, and selenium levels in the Port Colborne school soil samples collected April 2000 and re-analyzed January 2001. The concentrations are µg/g, dry weight, highest level found on the schoolyards.

School	Predicted Arsenic Level[1]	Actual Arsenic Level[4]	Antimony	Selenium
St. Therese Catholic School	12.8	9.8	0.7<T	**2.5**
St. John Bosco Catholic School	5.8	6.7	0.3<T	1.3
St. Patrick Catholic School	5.6	7.0	0.4<T	0.4<T
Lakeshore Catholic High School	6.9	6.5	0.3<T	0.6<T
C.M. Thompson Public School	5.6	5.0	0.5<T	0.5<T
Dewitt Carter Public School	8.3	8.7	0.4<T	1.0
Humberstone Public School	10.7	9.6	0.6<T	**2.0**
Oakwood Public School and Day Care	6.2	5.0	0.8<T	0.7<T
Steele Street Public School	6.3	6.3	**2.5**	0.5<T
Port Colborne High School	5.5	4.3	0.2<W	0.3<T
McKay Public School	6.0	6.1	0.3<T	0.6<T
Ecole St. Joseph	6.1	5.6	0.2<T	0.5<T
Port Colborne Regional Daycare	5.3	2.3	0.2<W	0.2<W
Lorraine Beach	5.3	0.8<T	0.2<W	0.2<T
Lakeshore Rd Beach	5.2	0.8<T	0.2<W	0.2<W
Nickel Beach	6.5	4.6	0.2<W	0.4<T
Table F (background)[2]	17		1	1.9
Table A (effects)[3]	20		13	10

1 - **µg/g arsenic** in soil = (0.00521 X **µg/g nickel** in soil) + 5.218879, as stated in MOE Port Colborne school report (SDB-031-3511-2000).

2 - see Appendix A and B.

3 - residential and parkland landuse, see Appendix A.

4 - only the maximum soil arsenic level found on the schools is listed in this table.

T - measurable trace concentration, interpret with caution.

W - analytical detection limit

Figure 1: Soil Sampling Sites at Humberstone Public School, February 2001.

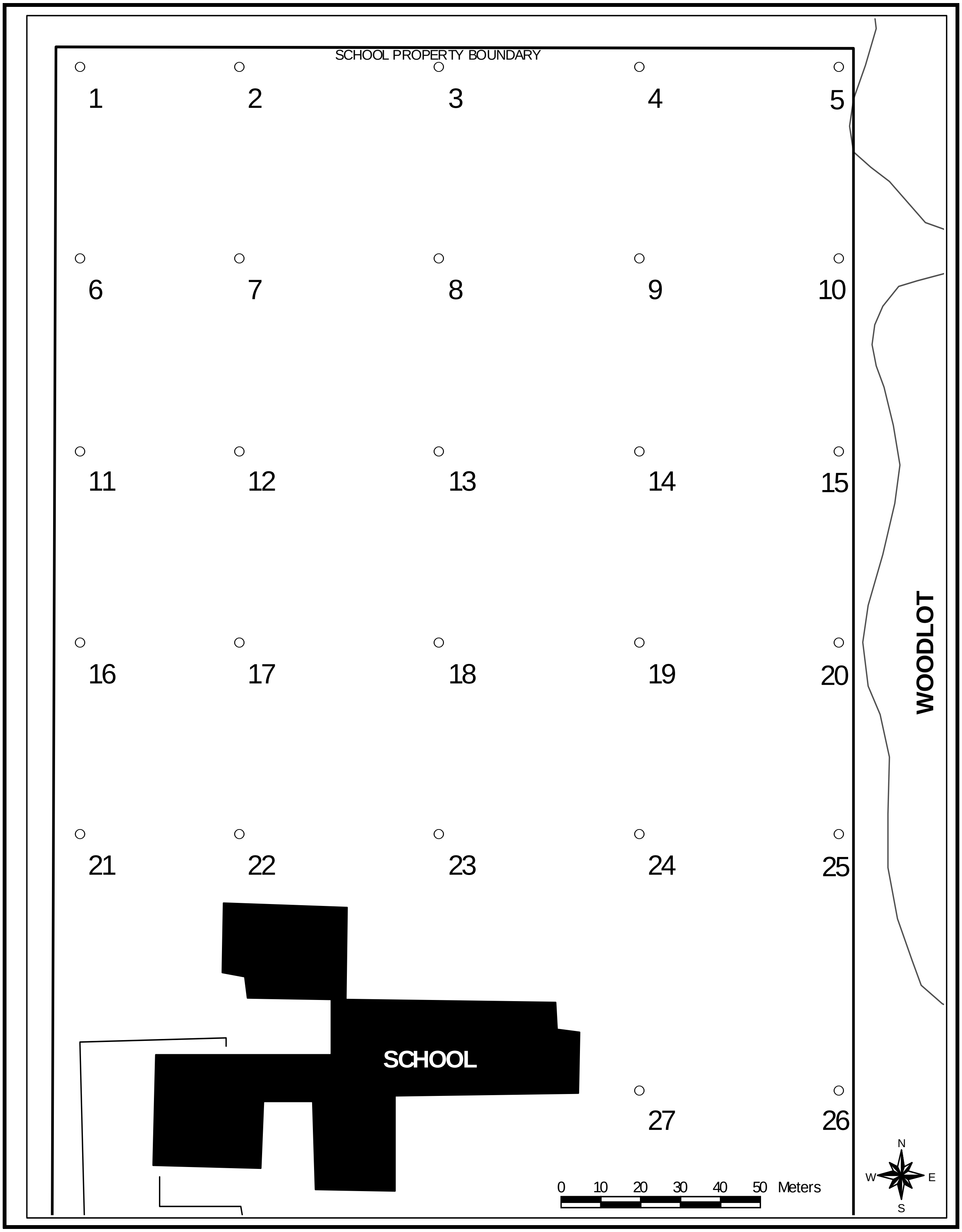


Figure 2: Nickel in Surface Soil (0-5 cm) at Humberstone Public School, February 2001.

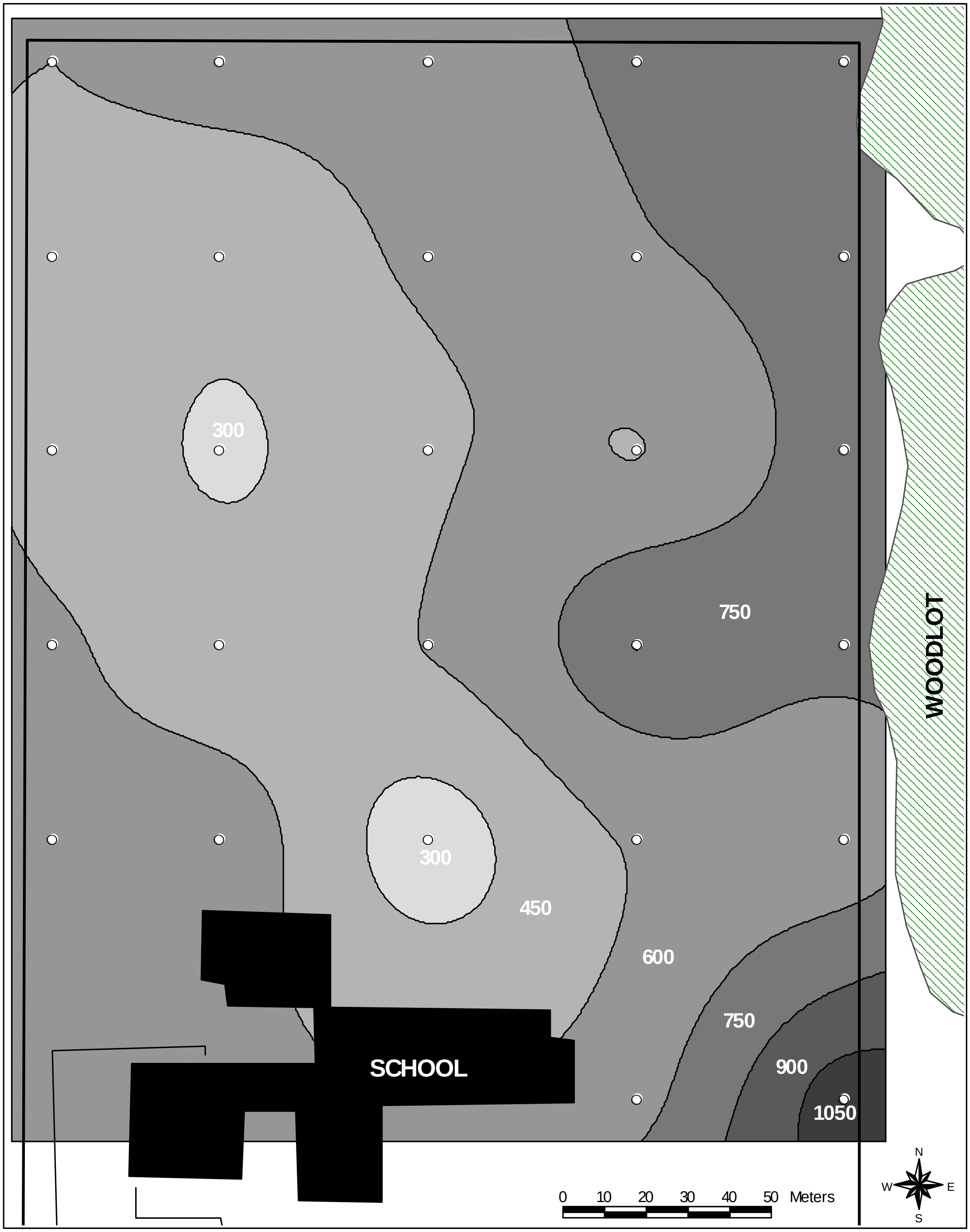


Figure 3: Copper in Surface Soil (0-5 cm) at Humberstone Public School, February 2001.

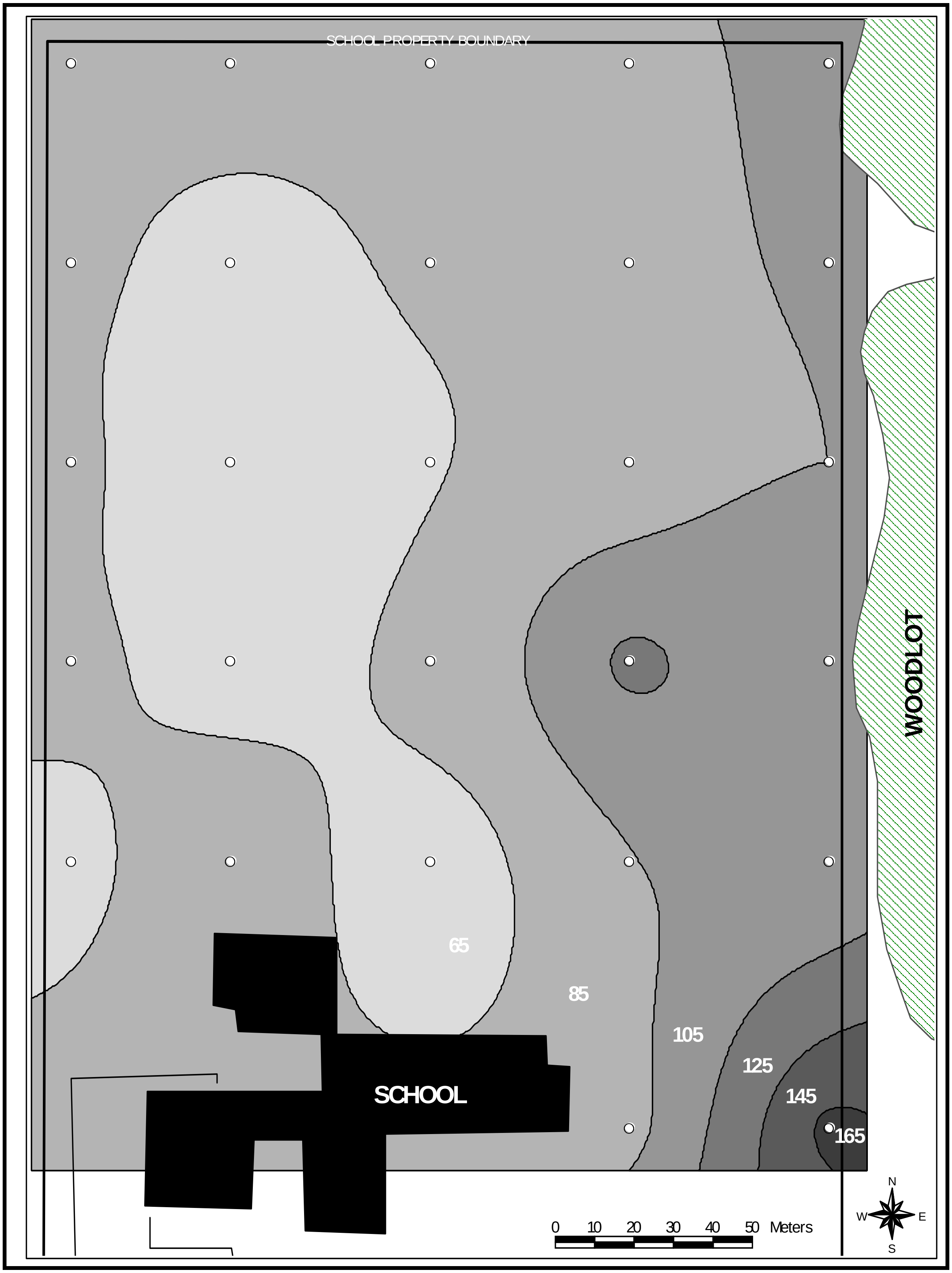


Figure 4: Cobalt in Surface Soil (0-5 cm) at Humberstone Public School, February 2001.

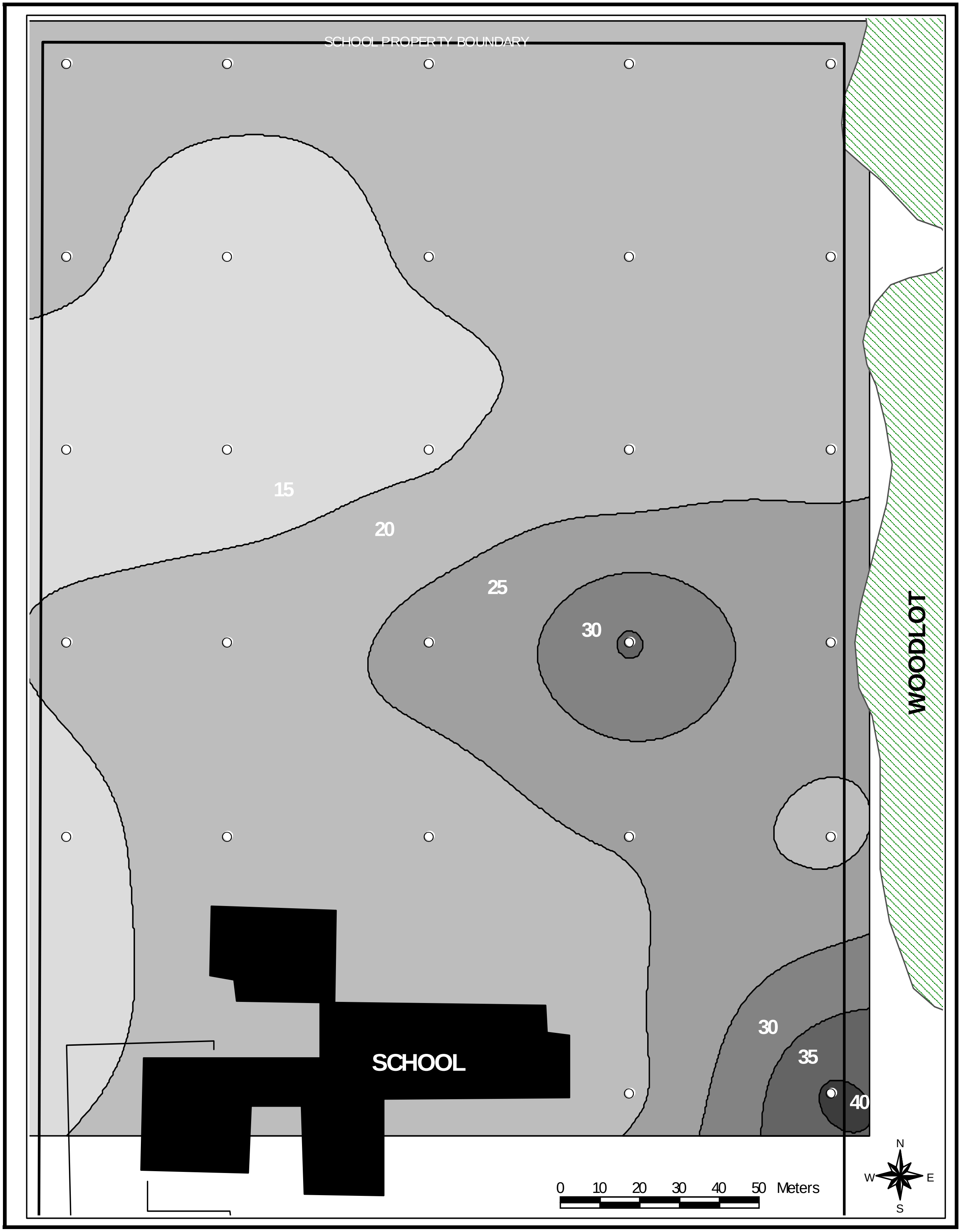


Figure 5: Arsenic in Surface Soil (0-5 cm) at Humberstone Public School, February 2001.

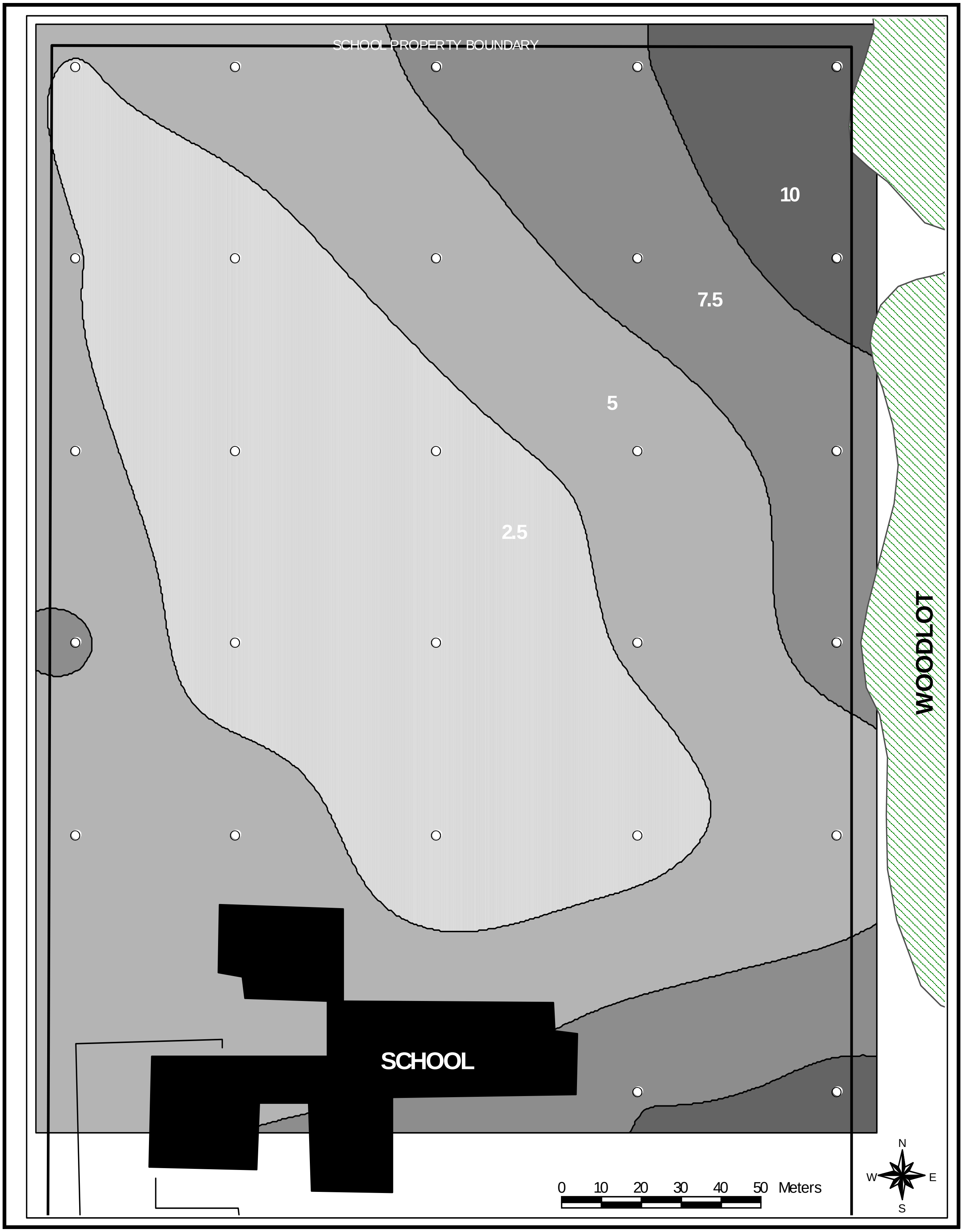


Figure 6: Selenium in Surface Soil (0-5 cm) at Humberstone Public School, February 2001.

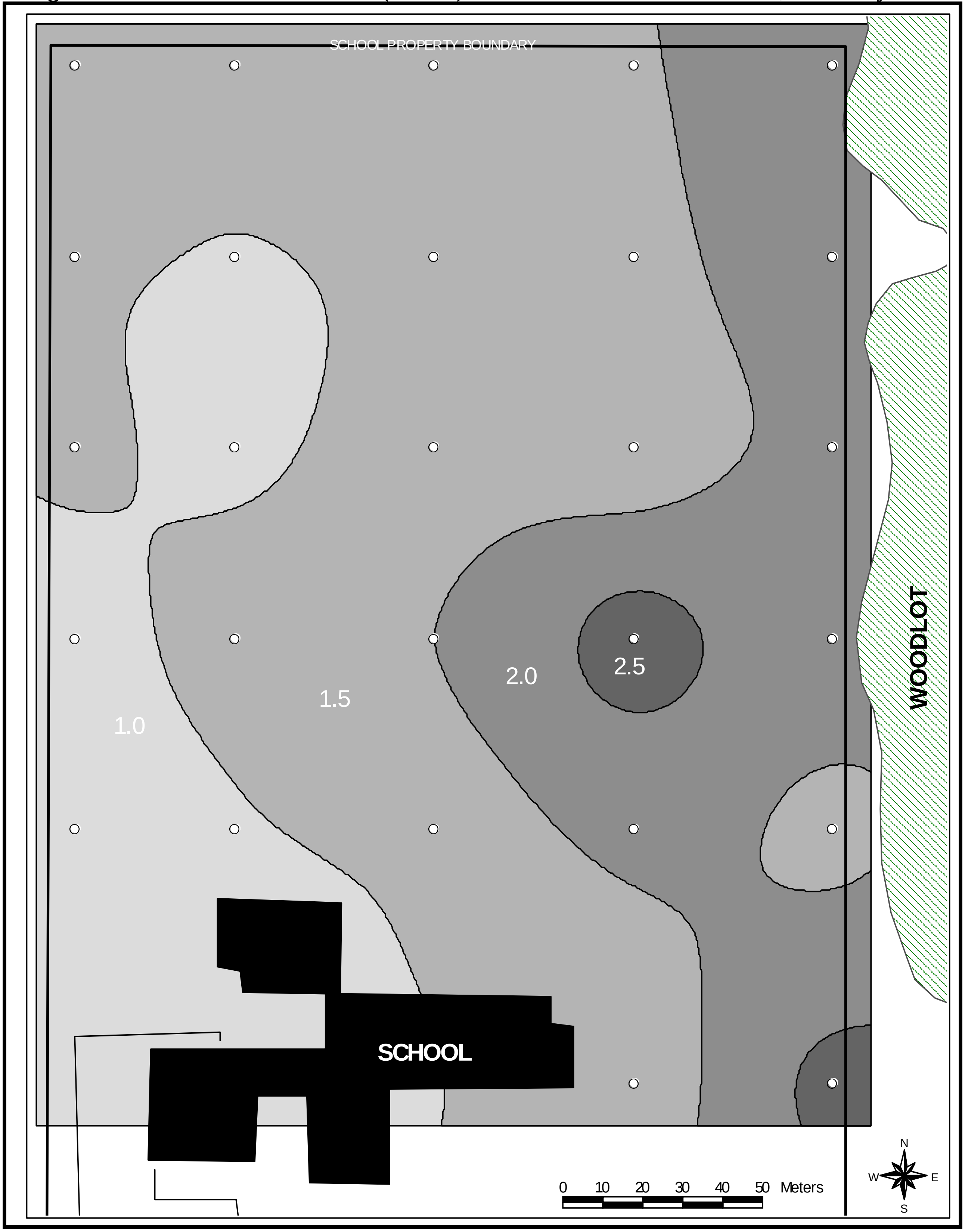
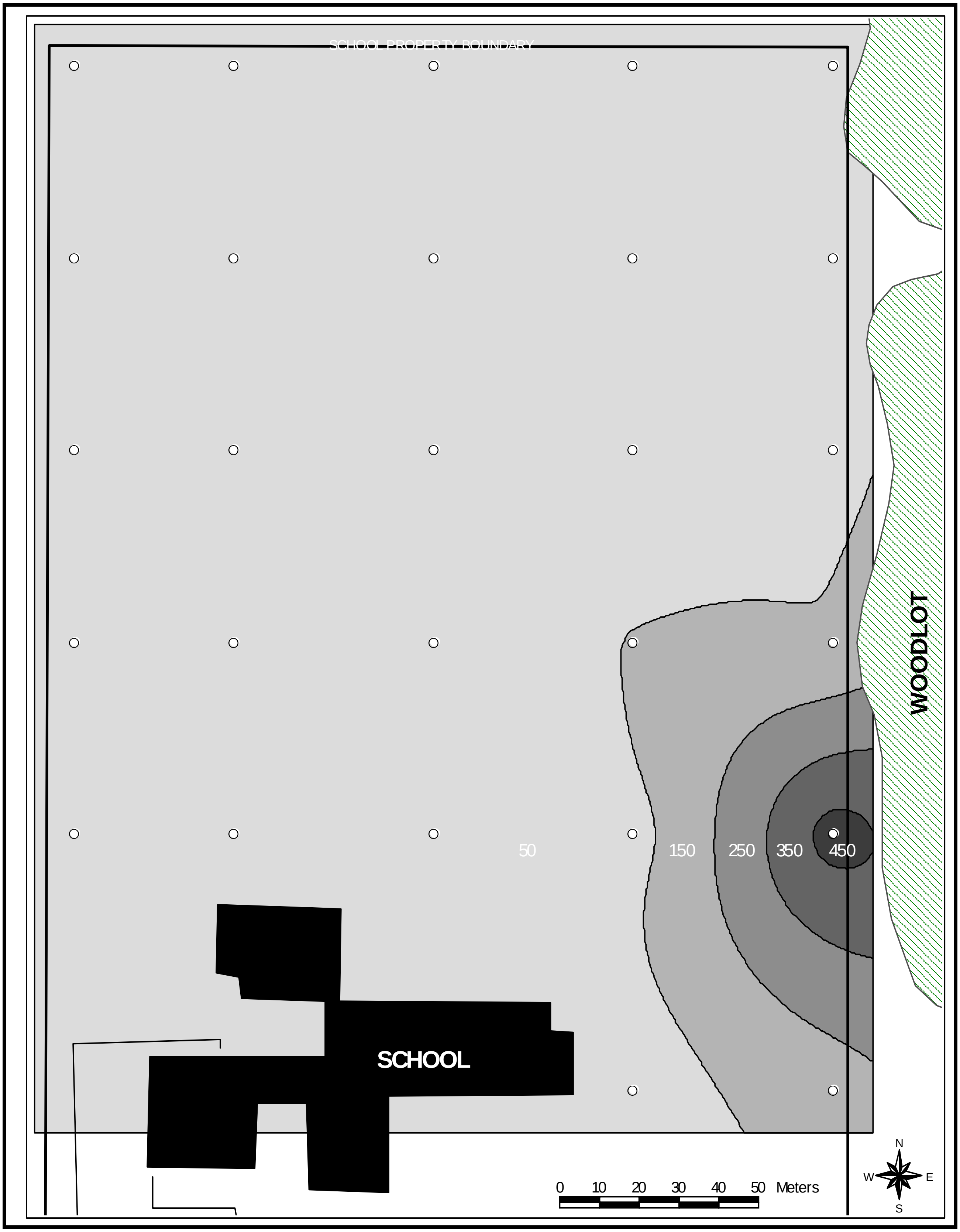


Figure 7: Zinc in Surface Soil (0-5 cm) at Humberstone Public School, February 2001.



Appendix A

Derivation and Significance of the MOE Soil Remediation Criteria (Clean-up Guidelines)

The MOE soil clean-up *Guidelines* have been developed to provide guidance for cleaning up contaminated soil. The *Guidelines* are not legislated Regulations. Also, the *Guidelines* are not action levels, in that an exceedence does not automatically mean that a clean-up must be conducted. The *Guidelines* were prepared to help industrial property owners decide how to clean-up contaminated soil when property is sold and/or the land-use changes. Most municipalities insist that contaminated soil is cleaned up according to the MOE *Guidelines* before they will approve a zoning change for redevelopment, therefore, even though the *Guideline* is voluntary most industrial property owners and developers are obliged to use it. For example, the owner of an industrial property who plans to sell the land to a developer who intends to build residential housing can use the *Guideline* to clean up the soil to meet the residential land-use criteria. In this way previously-contaminated industrial land can be re-used for residential housing without concern for adverse environmental effects.

The *Guideline* contains a series of Tables (A through F), each having criteria for soil texture, soil depth, and ground water use for various land-use categories (eg, agricultural, residential, industrial). Table F *criteria* reflect the upper range of background concentrations for soil in Ontario. An exceedence of Table F indicates the likely presence of a contaminant source. Tables A through E *criteria* are effects-based and are set to protect against the potential for adverse effects to human health, ecological health, and the natural environment, whichever is the most sensitive. By protecting the most sensitive parameter the rest of the environment is protected by default. The *Guideline criteria* take into consideration the potential for adverse effects through direct contact, and through contaminant transfer from soil to indoor air, from ground water or surface water through release of volatile gases, from leaching of contaminants in soil to ground water, or from ground water discharge to surface water. However, the *Guideline criteria* ***may not*** ensure that corrosive, explosive, or unstable soil conditions will be eliminated.

If the decision is made that remedial action is needed, the *criteria* in Tables A to F of the *Guideline* can be used as clean-up targets. In some cases, because of economic or practical reasons, it may not be possible to clean up a site using the generic *criteria* in Tables A to F. The *Guideline* provides a process, called a *site specific risk assessment*, which is used to evaluate the soil contamination with respect to conditions that are unique to the contaminated site. In a *site specific risk assessment* the proponent examines all the potential pathways through which the contamination may impact the environment and must demonstrate that because of conditions unique to that site the environment and human health will not be adversely effected if contamination above the generic *criteria* in Table A to E is left in place.

When contamination is present and a change in land-use is not planned, for example residential properties and public green spaces near a pollution source, the *Guideline* may be used in making decisions about the need for remediation. This is different from the previously described situation where a company that caused contamination on their own property decides to clean up the soil, usually at the insistence of the municipality who will not approve a zoning change unless remediation is conducted. Decisions on the need to undertake remedial action when the *Guideline criteria* are exceeded ***and*** where the land-use is not changing are made on a site by site basis using *site specific risk assessment* principals and are usually contingent on the contaminants having caused an adverse environmental effect or there is a demonstrated likelihood that the contamination may cause an adverse effect. Because of the long history of industrial operation and our practice of living close to our work place the soil in many communities in Ontario is contaminated above the effects-based *criteria* in the MOE *Guidelines*. In practice, remediation of contaminated soil on privately-owned residential property and public green spaces has only been conducted in communities when the potential for adverse health effects has been demonstrated.

The soil clean-up *Guidelines* were developed from published U.S. EPA and Ontario environmental data bases. Currently there are criteria for about 25 inorganic elements and about 90 organic compounds. Criteria were developed only if there were sufficient, defendable, effects-based data on the potential to cause an adverse effect. All of the criteria address human health and aquatic toxicity, but terrestrial ecological toxicity information was not available for all elements or compounds. The development of these clean-up *Guidelines* is a continuous program, and criteria for more elements and compounds will be developed as additional environmental data become available. Similarly, new information could result in future modifications to the existing *Guidelines*.

For more information on the MOE's soil clean-up *Guidelines* please refer to the *Guideline for Use at Contaminated Sites in Ontario. Revised February 1997*, Ontario Ministry of Environment and Energy, PIBs 3161E01, ISBN 0-7778-6114-3. This document is also available on the MOE web site at www.ene.on.ca, look under *Contaminated Sites: Clean-up Guideline*.

Appendix B

Derivation and Significance of the MOE Soil Background Concentrations

(Soil Clean-up Guideline - Table F)

The Table F criteria in the MOE *Guideline for Use at Contaminated Sites in Ontario* represent the expected background range of various chemicals in soil in Ontario. Ontario Typical Ranges (OTR) were derived from a province-wide soil sampling program conducted to determine the distribution of chemical concentrations resulting from natural geological processes and normal human activity in surface soil in Ontario remote from the influence of known point sources of pollution. OTRs are developed for several land use categories.

OTRs are based on the analytical data from pre-defined sampling, processing and analytical protocols. Complete details on the OTR development process can be found in the MOE report "*Ontario Typical Range of Chemical Parameters in Soil, Vegetation, Moss Bags and Snow*" MOEE 1993. This report describes the development of the OTR_{98}, which represents 98% of the data in the OTR distribution. From a statistical aspect, this is equivalent to the mean plus two standard deviations of a normally distributed population.

A review of the OTR database indicated that a high degree of sampling variability can occur at any given site when concentrations are at background levels, especially when sampling for organic contaminants. Therefore, replicate sampling would be necessary to address variability due to sampling, as well as analytical variability. In order to minimize costly replicate sampling and analysis to proponents in situations where there is little or no danger of effects, the Table F soil background criteria were set at a value equal to the OTR_{98} plus two coefficients of variation (OTR_{98} + 2CVws). The coefficient of variation, in this context, is the average "within site" sampling variability around the OTR_{98}, expressed as a percent coefficient of variability (CVws). This was calculated by taking the average of the "within site" coefficients of variation of all points between the OTR_{98} upper and lower confidence limits (MOEE, 1993). The percent value of 2CVws is converted to an absolute value and added to the OTR_{98}, which becomes the Table F criterion. If the chemical concentration in a single sample is above Table F (OTR_{98} + 2CVws), one can be certain (with 97.5% confidence) that the OTR98 has been exceeded for that chemical.

Rural parkland OTR_{98} values were the basis for the Table F soil background concentrations for the agricultural land use category while urban parkland OTR98 values were the basis for the other land use categories. The term "urban" is defined here as any property that lies within an area that is fully serviced by both municipal water and sewage systems.

Reference

Ontario Typical Range of Chemical Parameters in Soil, Vegetation, Moss Bags, and Snow. MOEE Report Number HCB-151-3512-93, PIBs Number 2792, ISBN 0-778-1979-1.

Appendix C

Derivation and Significance of the MOE "Ontario Typical Range" Soil Guidelines

The MOE "Ontario Typical Range" (OTR) guidelines are being developed to assist in interpreting analytical data and evaluating source-related impacts on the terrestrial environment. The OTRs are used to determine if the level of a chemical parameter in soil, plants, moss bags, or snow is significantly greater than the normal background range. An exceedence of the OTR_{98} (the OTR_{98} is the actual guideline number) may indicate the presence of a potential point source of contamination.

The OTR_{98} represents the expected range of concentrations of chemical parameters in surface soil, plants, moss bags, and snow from areas in Ontario not subjected to the influence of known point sources of pollution. The OTR_{98} represents 97.5 percent of the data in the OTR distribution. This is equivalent to the mean plus two standard deviations, which is similar to the previous MOE "Upper Limit of Normal" (ULN) guidelines. In other words, 98 out of every 100 background samples should be lower than the OTR_{98}.

The OTR_{98} may vary between land use categories even in the absence of a point source of pollution because of natural variation and the amount and type of human activity, both past and present. Therefore, OTRs are being developed for several land use categories. The three main land use categories are Rural, New Urban, and Old Urban. Urban is defined as an area that has municipal water and sewage services. Old Urban is any area that has been developed as an urban area for more than 40 years. Rural is all other areas. These major land use categories are further broken into three subcategories; Parkland (which includes greenbelts and woodlands), Residential, and Industrial (which includes heavy industry, commercial properties such as malls, and transportation rights-of-way). Rural also includes an Agricultural category.

The OTR guidelines apply only to samples collected using standard MOE sampling, sample preparation, and analytical protocols. Because the background data were collected in Ontario, the OTRs represent Ontario environmental conditions.

The OTRs are not the only means by which results are interpreted. Data interpretation should involve reviewing results from control samples, examining all the survey data for evidence of a pattern of contamination relative to the suspected source, and where available, comparison with effects-based guidelines. The OTRs are particularly useful where there is uncertainty regarding local background concentrations and/or insufficient samples were collected to determine a contamination gradient. OTRs are also used to determine where in the anticipated range a result falls. This can identify a potential concern even when a result falls within the guideline. For example, if all of the results from a survey are close to the OTR_{98} this could indicate that the local environment has been contaminated above the anticipated average, and therefore the pollution source should be more closely monitored.

The OTRs identify a range of chemical parameters resulting from natural variation and normal human activity. As a result, it must be stressed that values falling within a specific OTR98 should not be considered as acceptable or desirable levels; nor does the OTR_{98} imply toxicity to plants, animals or humans. Rather, the OTR_{98} is a level which, if exceeded, prompts further investigation on a case by case basis to determine the significance, if any, of the above normal concentration. Incidental, isolated or spurious exceedences of an OTR_{98} do not necessarily indicate a need for regulatory or abatement activity. However, repeated and/or extensive exceedences of an

OTR_{98} that appears to be related to a potential pollution source does indicate the need for a thorough evaluation of the regulatory or abatement program.

The OTR_{98} supersedes the Phytotoxicology ULN guideline. The OTR program is on-going. The number of OTRs will be continuously updated as sampling is completed for the various land use categories and sample types. For more information on these guidelines please refer to Ontario Typical Range of Chemical Parameters in Soil, Vegetation, Moss Bags, and Snow, MOEE Report Number HCB-151-3512-93, PIBs Number 2792, ISBN 0-778-1979-1.