

PHYTOTOXICOLOGY SURVEYS
CONDUCTED IN
THE TOWN OF ELMIRA

APRIL 1993



Ministry of
Environment
and Energy

1/4/93

ISBN 0-7778-0832-3

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Sulco Canada Colours Ltd., 1990
Varnicolour Chemical Ltd., 1990**

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PIBS 2285

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ARB-027-92-Phyto

PHYTOTOXICOLOGY SURVEYS CONDUCTED IN THE TOWN OF ELMIRA

EXECUTIVE SUMMARY

In 1989 and 1990, collections of surface soil and/or vegetation were made in the vicinity of three industrial operations in the Town of Elmira. For the most part, only slight exceedences of ULN guidelines occurred for a few elements and these could usually be explained on a basis that did not implicate any of the three sources that were under investigation. The exception to this was the contamination of soil samples collected at the Varnicolor storage yard. Spills of material from tanks on site contributed to soil contamination with iron, zinc and/ or sulphur-based acid at two sites and to a lesser extent with boron, cadmium, chromium and molybdenum. Dry lumps of paint found on the ground contained highly-elevated concentrations of several elements (Cr, Pb, Zn, Cu, Mo, Cd, Co) in various combinations. The survey made no attempt to investigate potential contamination of soil at depths below the rooting zone of vegetation.

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PHYTOTOXICOLOGY SURVEYS CONDUCTED IN THE TOWN OF ELMIRA, 1989 -1990

1. INTRODUCTION

The Town of Elmira is a centre for several small chemical industries. The discovery of NDMA in the water supplies for the Town in November, 1989, prompted considerable concern for the local residents. This concern extended to possible contamination of soil and vegetation from air and surface-water transport from the chemical industries. A request was made to the Phytotoxicology Section in late September, 1989 by staff of the Cambridge District Office of the Ontario Ministry of the Environment to conduct a survey of inorganic contaminants in soil and vegetation. In the spring of 1990, additional surveillance studies were requested. This report is a compilation of the data obtained from the investigations conducted in the vicinity of the Uniroyal Corporation, Sulco Canada Ltd. and Varnicolor Chemical Ltd.

Sample sites were selected around each of the sources noted based on several considerations. These included the scale of the operation, nature of the probable contaminants, availability of vegetation which still had attached foliage at the time of the initial visit and at various distances and directions including the residential parts of the Town. One site 1.8 km east of Elmira was selected as a reference site to establish background concentrations for the various test parameters as all species were available here.

It is recognized that other potential sources of contaminants exist in the Town. The identity of these sources and the potentially associated contaminants were not available when the surveys were carried out. As will be shown, these contaminants were not identified as problems at the sites where samples were actually collected.

2. UNIROYAL SURVEY

Since 1943, the Uniroyal Corporation has operated a chemical production facility in the Town of Elmira. Production includes herbicides, fungicides and materials utilized in the production of rubber tires. Uniroyal is the largest industry in Elmira.

Sample Collection

On October 4, 1989, a vegetation and soil survey was established in the Elmira area centred on the Uniroyal operation. At this late date in the growing season, only limited opportunities for foliage sampling existed because of leaf senescence. Sufficient foliage for sampling purposes was available at 9 locations (Figure 1). Single samples of foliage of Carolina poplar, silver maple, forage or soil (0-5 cm) were collected as shown in the table below:

Samples were returned to the Phytotoxicology laboratory for processing. Vegetation samples were oven-dried, ground in a Wiley mill and stored in glass bottles. The soil was air-dried, crushed to pass through a 45 mesh sieve and stored in glass bottles. The samples were forwarded to the Laboratory Services Branch, Ministry of the Environment for chemical analysis. The tests included copper (Cu), nickel (Ni), lead (Pb), zinc (Zn), iron (Fe), manganese (Mn), phosphorus (P), nitrogen (N), aluminum (Al), cadmium (Cd), cobalt (Co), chromium (Cr), potassium (K), molybdenum (Mo), sodium (Na), strontium (Sr) and vanadium (V). In addition, the soils were analyzed for calcium (Ca) and magnesium (Mg) and the vegetation was analyzed for chlorine (Cl) and sulphur (S). Some of these elements were historically included in certain pesticide formulations produced by Uniroyal.

Locations of sample collection sites in the vicinity of Uniroyal Corporation					
Site	Location	Poplar	Maple	Forage	Soil
1	Hwy 86, 1.8 km east of lights (Background Site)	X	X	X	X
2	Southeast corner of Elmira Union Cemetery		X	X	X
3	Vacant lot at northeast corner of Uniroyal property at Hwy 86	X	X	X	X
4	North edge of Bolender Park	X	X	X	X
5	West side of Waterloo Rd 25, 1.0 km north of Hwy 86	X		X	X
6	Between sewage treatment plant and Canagagigue Creek	X		X	X
7	North side Woolwich Rd. 27, 1.7 km east of Arthur St.		X	X	X
8	Woolwich Rd. 27, 100 m east of Arthur St.	X		X	X
9	North side of junction of Erb and Union St.		X		

Results

The analytical results for samples collected in the vicinity of Uniroyal are presented in Table 1. The table also includes rural Upper Limit of Normal (ULN) guidelines established for the respective types of samples (See Appendix for explanation). Values exceeding the available ULN are highlighted. Interpretation of elemental concentrations were based on a comparison with these Upper Limit of Normal guidelines established by the Phytotoxicology Section, Air Resources Branch.

The majority of chemical element concentrations fell within the normal range for the respective sample types (below the ULN) or did not show a pattern that was indicative of contamination resulting from emissions from the Uniroyal operation. Some elements, however, did not fit within the normal concentration range or pattern.

In most instances, calcium and magnesium concentrations in soil exceeded their ULN values. This is not considered as an indication of contamination but rather reflects the calcareous nature of the native clay soil in the area.

Cadmium exceeded the vegetation ULN value in poplar foliage at all but one site in contrast to the non-detectable values in maple and forage samples collected at the same locations. This pattern is not unusual in that poplar is known to be an accumulator species for zinc. Because zinc and cadmium have generally similar chemical properties, the patterns of co-occurrence in poplar foliage is to be expected. This is confirmed in the chemical analysis which showed zinc present in poplar foliage in concentrations about one order of magnitude greater than in maple foliage. In the same samples, zinc concentrations exceed cadmium concentrations by nearly two orders of magnitude.

Sodium values for poplar are greater than the ULN at all sites and for maple at one site (Site 2). Because, chloride values for both poplar and maple foliage also exceed the ULN at five out of six sites, and the fact that most of the sample trees are close to roadways, the source of sodium and chloride is believed to be residual deicing salt applied to the roadways.

The manganese concentration exceeds the ULN for forage at Site 8 but is highest in maple foliage collected at Site 2 (No ULN has been established for tree foliage). Otherwise, there is no distribution pattern to implicate Uniroyal as an important source of this element.

Samples of poplar foliage collected at Sites 1, 6 and 8 contained sulphur in concentrations exceeding the ULN. No confirmatory pattern for elevated sulphur was noted in the other vegetation species collected at the same locations. The data would suggest that poplar normally contains higher sulphur concentrations (2 to 10 times) than do the other species sampled. Poplar is known to be an accumulator of zinc and cadmium. This investigation appears to suggest that poplar is also an accumulator of sulphur.

Conclusions

Analysis of vegetation and soil samples collected in Elmira in 1989 failed to detect any pattern in chemical element composition that could be attributed to emissions from the Uniroyal operation. Certain patterns were evident that indicated 1) a calcareous type of soil, 2) species-specific accumulation of some elements, and 3) that residual road salt might have been taken up by trees.

3. SULCO CANADA COLOURS LTD.

Sulco Canada Colours Ltd. produces sulphuric acid and oleum in a small plant located in the southeast portion of Elmira. In early May, 1990, a process upset at operation resulted in the release of SO₂ to the atmosphere. Injury to sensitive vegetation (alfalfa and sweet clover) to the south and west of the operation was observed. A request for a follow-up survey was forwarded to the Phytotoxicology Section by the Cambridge District Office.

Sample Collection

On August 8, 1990, a survey was established and conducted in the vicinity of the Sulco Canada Colours Ltd. property. A total of 9 sampling stations were selected as shown in the table below.

Results and Conclusions

Injury to vegetation typical of acute SO₂ was noted south and west of the Sulco operation in May, 1990 following a spill of the chemical. The analytical results for the grass samples collected in the vicinity of Sulco collected in August, 1990 are presented in Table 2, along with the respective ULN guidelines. Only three elements exceeded the ULN. These included copper at Sites 7 and 8, zinc at Sites 2 and 7 and manganese at Sites 5 and 6. None of these elevated metal concentrations was considered to be in the toxic range. Concentrations of Ni, Pb, Cd, Co, Cr, Mo and V were very low (near or below detection limits) in most samples. The pattern of chemical distribution failed to implicate Sulco Canada Colours as a source of vegetation contamination. Elevated manganese appears as an extension of the zone of elevated manganese associated with the nearby Varnicolor Chemical operation (see below). The chemical spill appears not to have had any long-term consequences for vegetation.

Location of sample collection sites in the vicinity of Sulco Canada		
Site	Location	Comment
1	Northeast corner of Sulco property outside fence	Small lumps of sulphur along rail spur
2	East of south entrance to Uniroyal operation and east of water pollution control plant	
3	Southeast corner of Sulco property outside fence	
4	Southeast of Sulco along Canagagigue Creek	
5	Southwest corner of Sulco property on roadside	
6	East of Union St., half way between First and Howard St.	
7	Northwest corner of Sulco property outside fence	Patches of killed grass, possibly fertilizer runoff
8	West of Union St between South and Park St.	Near transformer station
9	North side of Hwy 86, 1.4 km east of Canagagigue Creek	Control site

4. VARNICOLOR CHEMICAL LTD.

The Varnicolor Chemical Ltd operation handles a variety of chemical materials and reclaims solvents, blends wastes for fuel, recovers freon, produces paints, and stores various petroleum-based materials. The company operates a complex on Union St. between Howard and First St. as well as a storage yard at the east end of Oriole Parkway. Surveys of the Varnicolor sites were requested by the Cambridge District Office, MOE to determine whether contamination of soil and vegetation was occurring.

4A. VARNICOLOR CHEMICAL - STORAGE YARD, ORIOLE PARKWAY

On August 8, 1990, the storage yard site at the end of Oriole Parkway was examined. The boundaries to this property were not clear but the area may have covered about 2 ha. The site appeared to have been created or surfaced, at least in part, by deposition of fill material. Mounds of earth were still present on the east side of the operational area. At least 26 species of weeds were noted and these varied in number and density of growth.

Conspicuous on the site were 16 metal tanks or truck bodies of various sizes and types. Some of these were quite large and rusting. Other debris, a truck cab and wood piles were noted. Some material had escaped from the tanks and was evident as oily residue or rusty surface deposits. Lumps of brightly coloured material (likely dried paint) were common on the surface of the yard.

Sample Collection

The nature of the site precluded systematic sampling of soil, therefore sample sites were chosen based partly on evidence of surface contamination. Soil material was collected at six sites and ten samples of representative paint chips/lumps were collected from the ground surface as available. The locations of the sample locations for soil are shown in the sketch map of the site (Figure 3). The notes on the individual sites are as follows:

Locations of soil sample collection in Varnicolor Chemical storage yard, Oriole Parkway		
Site	Soil Depth	Location
A	0 - 1 cm	Between truck Tanks #3 and #4; oily residue on surface
B	0 - 1 cm	East end of Tank #9; rusty residue on surface
C	0 - 1 cm	West end of Tank #11; rusty residue on surface with red paint chips; vegetation killed adjacent to residue
D	0 - 1 cm	General yard area east of Tank #5
E	0 - 5 cm	Piles of soil on east of yard; weedy
F	0 - 5 cm	Flat area of fill, lower than rest of yard; sandy soil

Preparation of soil samples for inorganic analysis was the same as previously described. Paint samples were washed in tap water and scrubbed to remove adhering soil then rinsed in distilled water. After air drying, the samples were crushed in a mortar and pestle and stored in glass bottles. Analysis of samples was completed by the Laboratory Services Branch for Cu, Ni, Pb, Zn, Fe, Mn, Al, Cd, Co, Cr, Mo, Na, Sr, S and V. The soils were also analyzed for boron (B), pH and electrical conductivity (EC).

Samples of soil from the same six sites were also collected for organic analysis using standard sampling procedures. The samples were submitted to the Laboratory Services Branch to be analyzed for polycyclic aromatic hydrocarbon compounds and solvent extractables.

Results

The analytical results for the soil and paint chips collected at the Oriole Parkway yard are presented in Table 3. Also included are the urban ULN values for soil. Values exceeding the ULN are highlighted.

Two of the soil samples (B and C) contained elements in concentrations that exceeded the ULN. Of note was sample C for which the corresponding ULN's for Zn, Fe, B, Cd, and Cr were exceeded. The highest Cu, Ni, Pb and Na concentrations were also encountered in this sample but these were within the ULN range. Elevated Cd, Mo and S were found in the sample from Site B. The high S content and low pH of the soil suggests that the surface residue included sulphuric or a related acid. The soil EC at Sites B and D are high enough to inhibit the growth of salt-sensitive plant species (Appendix II).

Elevated concentrations of elements were found in various combinations in nine of the ten paint samples. One of the grey-blue samples had low elemental concentrations while the remainder of the samples contained elevated concentrations of two to six elements. Elevated chromium was noted in eight of the paint samples while it was more usual for elements to be present in two or three paint samples. Of special note was the high Pb concentration in yellow paint, Zn in pale yellow paint, Cu in dark blue and dark green paint, and molybdenum in crimson paint.

Of the 16 compounds in the PAH test list, only one sample (Sample A) had a measurable amount of PAH (Table 4). This was fluoranthene at 250 ng/g and the concentration is not environmentally significant. Detectable traces of phenanthrene, pyrene, benzo(a)anthracene, chrysene, benzo(k)fluoranthene, benzo(b)fluorene, benzo(a)pyrene and indeno(1,2,3-cd)pyrene were noted in one or more of the soil samples. Samples from Sites A and C had solvent extractable measures of 46818 (4.6%) and 34191 (3.4%) ug/g. These confirm the observations of oily residues at these locations. Measurements of 1916 and 1740 ug/g solvent extractables at Sites B and D are intermediate between the most contaminated areas and the more typical soils at 252 and 120 ug/g. Interim guidelines for PAH were not exceeded at any sample site.

Conclusions

The storage yard at the east end of Oriole Parkway had a collection of unsightly metal tanks. Spilled material at two sites had contaminated surface soil with iron, zinc and/ or sulphur-based acid and to a lesser extent with boron, cadmium, chromium and molybdenum. Dry lumps of paint found on the ground contained highly elevated concentrations of several elements in various combinations. The high metal concentrations are believed to be related to the pigments used to provide colours in the paint.

4B. VARNICOLOR CHEMICAL - MAIN PLANT

On August 20, 1990, a survey was carried out around the main plant of Varnicolor Chemical. The site includes several buildings or fenced areas on the southwest corner of Union and First Streets. There is a vacant lot to the west. To the south, there is an open field with a number of old rusting tanks. There is an apple orchard to the north and an open field on the east of Union Street.

Sample Collection

Nine sites were selected for sampling purposes around the Varnicolor main plant. The locations of the sites are shown in Figure 4. Samples of soil (0 - 5 cm), triplicate samples of grass or single samples of alfalfa were collected as available at each site. The sites and samples are summarized in the table below.

The samples were returned to the Phytotoxicology laboratory for processing as described above. The samples were then submitted to the Laboratory Services Branch, MOE for analysis. The analysis included tests for Cu, Ni, Pb, Zn, Fe, Mn, P, N, Al, arsenic (As), Ca, Cd, Cl, Co, Cr, K, Mg, Mo, Na, Sr, S, antimony (Sb), selenium (Se) and V. Soil samples were also analyzed for PAH compounds.

Locations of sample collection sites in the vicinity of Varnicolor Chemical main plant				
Site No.	Location	Soil	Grass	Alfalfa
1	North side Howard St, junction of vacant lot and open field	X	X	X
2	Edge of vacant lot directly west of tank farm	X	X	X
3	Vacant area north east of Town water tank and horseshoe pitch	X	X	
4	North side First St at west side of orchard	X		
5	West side of Union St just north of transformer station	X	X	
6	East side of Union St at bend in First St.	X	X	
7	Field at east end of First St extension	X	X	X
8	East side of Union St. directly east of Varnicolor	X	X	
9	West side of Union St. about 50 m north of Oriole Parkway	X	X	

Results

The results of the chemical analysis for vegetation are presented in Table 5 together with the respective urban ULN guidelines. Except for manganese and sodium, all chemical element concentrations were below the ULN. Ni, As, Cd, Co, Cr, Mo, V, Sb, Cu, and Al and Se concentrations were at or below the detection limit. Manganese exceeded the ULN at four sites (Sites 2, 3, 6 and 8). These sites are in close proximity to the Varnicolor plant. The survey around Sulco Canada Colours that overlaps this area also identified elevated manganese in grass at the two sites nearest to the Varnicolor operation. The concentrations of sodium in alfalfa exceeded the ULN for two of the three sites where this species was available. No obvious source of the sodium was evident, especially in the field at Site 7, and there is no relationship between these elevated concentrations and the Varnicolor operation. The elevated sodium may be attributable to a natural affinity of alfalfa for the element which is apparent when compared to grass collected at the same locations.

Measurable PAH concentrations were found in soils from only two sample sites (Table 6). Fluoranthene was measured at both Sites 5 and 7. Benzo(a)anthracene and chrysene were found only at Site 5 while pyrene, benzo(k)fluoranthene, benzo(b)fluorene, benzo(a)pyrene, and indeno(1,2,3-cd)pyrene were found at only Site 7. These concentrations were all well-below the CCME interim guidelines and are of no environmental significance.

Solvent extractable measurements ranged from 304 to 1126 ug/g. The two highest values were found at Sites 1 and 6.

Conclusions

A survey of vegetation in the vicinity of the Varnicolor Chemical main plant found only elevated concentrations of manganese and sodium in grass tissues. Although elevated above normal (ULN), the concentrations encountered are not considered to be phytotoxic to grass. Neither inorganic nor organic compounds showed no consistent distribution pattern with respect to the Varnicolor operation.

PAH and solvent extractable measurements failed to implicate Varnicolor Chemical as a significant source of these materials.

5 DISCUSSION AND RECOMMENDATIONS

The historical sources or operations with potential for contamination were not known or readily available at the time that the present sampling was carried out. The analytical tests conducted to date were not exhaustive and it is possible that other types of contaminants may have been present in the soil. At the majority of sample locations where samples were collected, no noteworthy contamination was identified (except in the Varnicolor storage yard and a few sites near Sulco Ltd). This does not preclude possible contamination at other locations and at greater depths. The sites chosen however, were considered satisfactory as representing the sources of concern and the areas of respective potential impact. Full characterization of any existing or historical contamination would require an intensive sampling program with analysis for a larger suite of chemicals. Additional sampling is recommended if a reasonable or justifiable concern for a specific location or area is identified. Wide-scale sampling without a clear purpose would likely prove to be a fruitless investment of resources.

The sample analysis did not include pesticides. If any pesticides had been discovered (at least in low concentrations), it would be very difficult to distinguish between those emitted by the source industries, use by local residents or the local municipality (or their registered pesticide applicators) and use by agricultural operations which surround the Town. In any case, no vegetation injury that could be attributed to pesticides was encountered in either year.

The sampling was conducted only to identify possible contamination of surface soil and subsequent uptake of the contaminants into vegetation. Any contamination of vegetation should reflect a combination of both air and soil contamination but this was not demonstrated. Samples were collected in all directions from the sources; however, no strong pattern of contamination with respect to prevailing winds was found. Movement of any contaminants in surface water was not evident. Surface drainage patterns were not detected and were not associated with injured vegetation as might have been expected if such movement of contaminants in water had been a problem.

6. SUMMARY

In 1989 and 1990, collections of surface soil and/or vegetation were made in the vicinity of three industrial operations in the Town of Elmira. For the most part, only slight exceedences of ULN guidelines occurred for a few elements and these could usually be explained on a basis that did not implicate any of the three sources that were under investigation. The exception to this was the contamination of soil samples collected at the Varnicolor storage yard. Spills of material from tanks on site contributed to soil contamination with iron, zinc and/ or sulphur-based acid at two sites and to a lesser extent with boron, cadmium, chromium and molybdenum. Dry lumps of paint found on the ground contained highly-elevated concentrations of several elements (Cr, Pb, Zn, Cu, Mo, Cd, Co) in various combinations.

7. TABLES AND FIGURES

Table 1 Concentrations of various chemical elements in plant tissue and soil collected in the vicinity of Uniroyal, Elmira, October 4, 1989.

Site	Species	Cu	Ni	Pb	Zn	Fe	Mn	P %	N %	Al	Ca
1	Carolina Poplar	6.5	0.8 <T	3.2 <T	350	84	42	0.20	1.9	48	ND
3	Carolina Poplar	9.8	1.2 <T	2.5 <W	450	74	53	0.07	1.7	43	ND
4	Carolina Poplar	8.1	0.6 <T	1.2 <T	130	110	73	0.11	2.3	43	ND
5	Carolina Poplar	7.3	1.8 <T	2.3 <T	150	340	69	0.11	1.8	220	ND
6	Carolina Poplar	7.5	0.9 <T	2.5 <W	330	120	68	0.15	1.9	50	ND
8	Carolina Poplar	7.6	1.0 <T	2.5 <W	300	57	56	0.12	1.6	45	ND
1	Silver Maple	10.0	0.5 <W	1.4 <T	39	140	60	0.13	1.7	83	ND
2	Silver Maple	1.9	0.5 <W	1.4 <T	27	260	210	0.12	1.2	81	ND
3	Silver Maple	5.2	0.5 <W	1.6 <T	33	99	59	0.21	1.7	47	ND
4	Silver Maple	8.4	0.5 <W	1.8 <T	32	130	38	0.14	2.6	58	ND
7	Silver Maple	3.8	0.5 <W	0.8 <T	19	98	20	0.07	1.2	57	ND
9	Silver Maple	3.7	0.5 <W	2.1 <T	27	120	47	0.08	1.2	66	ND
1	Forage	5.2	0.5 <W	1.5 <T	14	130	46	0.21	2.0	85	ND
2	Forage	2.7	0.8 <T	1.6 <T	22	92	34	0.26	1.2	41	ND
3	Forage	2.2	0.6 <T	2.4 <T	15	150	31	0.19	1.2	65	ND
4	Forage	4.1	0.6 <T	1.5 <T	21	140	40	0.20	2.7	66	ND
5	Forage	2.0	0.5 <W	1.5 <T	15	150	42	0.10	1.1	87	ND
6	Forage	2.8	1.7 <T	2.2 <T	15	340	42	0.10	0.8	200	ND
7	Forage	2.9	0.9 <T	1.8 <T	14	250	31	0.15	1.3	210	ND
8	Forage	5.2	0.5 <W	1.5 <T	23	89	81	0.34	2.1	45	ND
1	Soil (0-5 cm)	25	11	38	88	16000	430	0.12	0.4	12000	47000
2	Soil (0-5 cm)	16	11	17	88	15000	430	0.08	0.2	10000	41000
3	Soil (0-5 cm)	27	13	86	110	15000	630	0.19	0.5	11000	68000
4	Soil (0-5 cm)	21	14	20	76	19000	450	0.11	0.4	14000	20000
5	Soil (0-5 cm)	19	11	32	70	13000	400	0.06	0.3	9400	69000
6	Soil (0-5 cm)	24	13	23	82	16000	440	0.10	0.3	10000	52000
7	Soil (0-5 cm)	19	10	30	81	10000	190	0.08	0.3	10000	60000
8	Soil (0-5 cm)	17	10	27	82	16000	410	0.12	0.3	13000	13000
ULN	Foliage	20	5	30	250	500	NG	NG	NG	500	30000
	Forage	7	5	20	40	500	50	NG	NG	NG	NG
	Soil	60	60	150	500	35000	700	NG	NG	NG	NG

Concentrations reported as ug/g unless otherwise indicated.

Underlined values exceed the applicable rural ULN guideline (See Appendix II). Note: ULN for zinc is not valid for poplar foliage.

ND = No data; NG = No guideline; <W at or below analytical detection limit; <T = trace amount, interpret with caution

Table 1 (Cont'd)

Site	Species	Cd	Ci %	Co	Cr	K %	Mg	Mo	Na	Sr	S %	V
1	Carolina Poplar	6.8	0.98	1.0 <T	1.1 <T	0.89	ND	0.4 <T	1500	83	0.44	0.5 <W
3	Carolina Poplar	5.0	<u>0.40</u>	1.4	1.1 <T	1.20	ND	0.4 <T	<u>240</u>	35	<u>0.39</u>	0.5 <W
4	Carolina Poplar	2.0	0.19	1.0 <T	0.9 <T	1.20	ND	0.5 <T	<u>100</u>	88	0.24	0.5 <W
5	Carolina Poplar	0.8	<u>0.29</u>	1.3	1.5 <T	0.92	ND	0.6 <T	<u>780</u>	60	0.33	0.5 <W
6	Carolina Poplar	3.8	0.11	1.8	1.4 <T	0.60	ND	0.6 <T	<u>260</u>	97	<u>0.85</u>	0.5 <W
8	Carolina Poplar	4.7	<u>0.25</u>	1.3	1.3 <T	0.75	ND	0.8 <T	<u>1500</u>	41	<u>0.62</u>	0.5 <W
1	Silver Maple	0.1 <W	<u>0.64</u>	0.2 <W	1.3 <T	0.60	ND	0.3 <T	41	18	0.12	0.5 <W
2	Silver Maple	0.1 <W	0.14	0.2 <W	0.9 <T	0.61	ND	0.3 <T	<u>55</u>	12	0.09	0.5 <W
3	Silver Maple	0.1 <W	0.20	0.2 <W	0.8 <T	0.90	ND	0.2 <W	18	11	0.10	0.5 <W
4	Silver Maple	0.1 <W	<u>0.56</u>	0.2 <W	1.0 <T	0.92	ND	0.2 <W	22	22	0.13	0.5 <W
7	Silver Maple	0.1 <W	<u>0.89</u>	0.2 <W	0.5 <T	0.99	ND	0.2 <T	13	15	0.08	0.5 <W
9	Silver Maple	0.1 <W	<u>0.66</u>	0.2 <W	1.3 <T	0.59	ND	0.3 <T	28	37	0.07	0.5 <W
1	Forage	0.1 <W	0.78	0.4 <T	0.9 <T	1.50	ND	0.9 <T	140	21	0.15	0.5 <W
2	Forage	0.1 <W	0.73	0.2 <W	0.6 <T	1.30	ND	0.8 <T	140	6	0.18	0.5 <W
3	Forage	0.1 <W	0.74	0.5 <T	0.9 <T	1.10	ND	0.5 <T	100	11	0.12	0.5 <W
4	Forage	0.1 <W	1.00	0.4 <T	0.7 <T	1.60	ND	0.6 <T	57	19	0.18	0.5 <W
5	Forage	0.1 <W	0.32	0.3 <T	0.8 <T	0.62	ND	0.6 <T	53	8	0.11	0.5 <W
6	Forage	0.1 <W	0.16	0.4 <T	2.2 <T	0.37	ND	0.8 <T	65	9	0.18	0.6 <T
7	Forage	0.1 <W	0.82	0.8 <T	0.9 <T	0.96	ND	0.5 <T	34	12	0.19	0.5 <W
8	Forage	0.1 <W	1.00	0.2 <T	0.9 <T	1.50	ND	0.7 <T	120	17	0.16	0.5 <W
1	Soil (0-5 cm)	0.7	ND	7.4	19.0	880	<u>20000</u>	0.9 <T	420	45	ND	30
2	Soil (0-5 cm)	0.4	ND	6.7	18.0	820	<u>16000</u>	0.3 <T	150	39	ND	30
3	Soil (0-5 cm)	0.6	ND	8.1	20.0	850	<u>15000</u>	1.1	170	92	ND	28
4	Soil (0-5 cm)	0.6	ND	8.4	21.0	1000	<u>10000</u>	0.6 <T	180	33	ND	34
5	Soil (0-5 cm)	0.4	ND	6.4	18.0	730	<u>28000</u>	0.7 <T	190	52	ND	26
6	Soil (0-5 cm)	0.6	ND	7.3	20.0	870	<u>21000</u>	1.3	190	49	ND	27
7	Soil (0-5 cm)	0.5	ND	4.9	17.0	580	<u>28000</u>	0.6 <T	190	40	ND	25
8	Soil (0-5 cm)	0.4	ND	7.0	19.0	870	<u>6800</u>	1.2	150	20	ND	33
ULN	Foliage	1	0.15%	2	8	NG	7000	1.5	50	NG	0.4%	5
	Forage	0.5	1.00%	2	5	NG	NG	6	NG	NG	0.5%	6
	Soil	3	NG	25	50	NG	10000	2	NG	NG	0.1%	70

Concentrations reported as ug/g unless otherwise indicated.

Underlined values exceed the applicable rural ULN guideline (See Appendix II). Note: ULN for cadmium is not valid for poplar foliage.

ND = No data; NG = No guideline; <W at or below analytical detection limit; <T = trace amount, interpret with caution

Table 2 Concentrations of various chemical elements in grass tissue collected in the vicinity of Sulco Chemical, Elmira, August 8, 1990.

Site No.	Cu	Ni	Pb	Zn	Fe	Mn	Al	Cd	Co	Cr	Mo	Na	Sr	S %	V
1	2.9	0.5 <T	0.5 <W	13	58	15	23 <T	0.1 <W	0.2 <T	0.5 <W	0.2 <W	13	10.0	0.17	0.5 <W
2	4.9	0.8 <T	0.6 <T	84	64	23	24 <T	0.1 <W	0.3 <T	0.5 <W	0.6 <T	15	10.0	0.26	0.5 <W
3	1.8 <T	0.5 <T	0.5 <W	7	61	13	24 <T	0.1 <W	0.2 <W	0.5 <W	0.3 <T	16	9.4	0.14	0.5 <W
4	3.1	0.7 <T	0.5 <W	28	50	38	20 <T	0.1 <W	0.2 <W	0.5 <W	0.5 <T	12	8.0	0.44	0.5 <W
5	2.3 <T	0.9 <T	1.1 <T	11	120	59	77	0.1 <W	0.2 <W	0.8 <W	0.5 <T	36	13.0	0.16	0.5 <W
6	2.4 <T	0.7 <T	0.5 <W	9	96	<u>79</u>	46	0.1 <W	0.2 <W	0.8 <W	1.1	31	8.2	0.16	0.5 <W
7	<u>8.5</u>	0.8 <T	0.5 <W	<u>44</u>	70	16	25 <T	0.1 <W	0.2 <W	0.6 <W	0.7 <T	13	19.0	0.24	0.5 <W
8	<u>8.7</u>	0.8 <T	1.8 <T	33	100	11	46	0.1 <W	0.2 <W	0.6 <W	0.5 <T	57	15.0	0.18	0.5 <W
9	3.5	0.9 <T	0.7 <T	9	86	19	47	0.1 <W	0.2 <W	0.6 <W	0.7 <T	58	17.0	0.18	0.5 <W
ULN	7	5	20	40	500	50	NG	0.5	2	5	6	NG	NG	0.5%	6

Concentrations reported as ug/g unless otherwise indicated.

Underlined values exceed the applicable ULN guideline (See Appendix).

ND = No data; NG = No guideline; <W at or below analytical detection limit; <T = trace amount, interpret with caution

Table 3. Concentrations of various chemical elements soil and paint collected Varnicolor Chemical, Elmira, August 8, 1990

Site Sample	Cu	Ni	Pb	Zn	Fe	Mn	Al	B	pH	EC ms/cm
A Soil 0 - 1 cm	18	16	41	81	13000	350	8600	8.2	5.80	0.286
B Soil 0 - 1 cm	33	30	100	59	27000	220	7200	11.0	3.93	0.516
C Soil 0 - 1 cm	42	49	320	<u>1300</u>	<u>120000</u>	550	5000	<u>86.0</u>	7.78	0.295
D Soil 0 - 1 cm	24	13	66	74	9100	340	5400	9.2	6.69	0.684
E Soil 0 - 5 cm	15	16	14	61	18000	580	14000	5.1	6.97	0.167
F Soil 0 - 5 cm	14	15	7 <T	43	13000	400	9300	7.7	6.94	0.203
ULN	100	60	500	500	35000	700		15		
Paint Yellow	3 <T	9	350000	160	960 <T	13 <T	6400			
Paint Crimson	10	340	63000	910	3800	91	3100			
Paint Grey-blue	58	9	640	150	4300	150	3200			
Paint Black	34	10	400	70	9400	180	2200			
Paint Grey-blue	36	8	21	20 <T	3000	33	590	<T		
Paint Bright Blue	1400	390	2000	76	12000	160	6700			
Paint Pale yellow	12 <T	15	520	124000	8700	230	5100			
Paint Wine	37	7100	170	130	63000	310	780	<T		
Paint Dark Blue	2600	200	100	51	5200	150	12000			
Paint Dark Green	5700	19	170	78	64000	76	2600			

Site Sample	Cd	Co	Cr	Mo	Na	Sr	S (%)	V
A Soil 0 - 1 cm	1.3	5.4	21	0.2 <W	180	58.0	0.060	34
B Soil 0 - 1 cm	<u>7.30</u>	3.9	48	<u>4.0</u>	280	53.0	4.300	27
C Soil 0 - 1 cm	<u>7.60</u>	3.7	<u>55</u>	<u>2.2</u>	660	29.0	0.069	41
D Soil 0 - 1 cm	0.69	4.7	27	0.4 <T	370	74.0	0.021	26
E Soil 0 - 5 cm	0.29	6.3	23	0.2 <W	140	22.0	0.014	41
F Soil 0 - 5 cm	0.06 <T	4.6	17	0.2 <W	200	56.0	0.010	32
ULN	4.00	25.0	50	3	NG	NG	NG	70
Paint Yellow	7.40	7.4	65000	12.0	1200	7.7	30	
Paint Crimson	3.80	160.0	15000	2000	710	51.0	15	
Paint Grey-blue	0.45	15.0	96	1.8	250	32.0	8	
Paint Black	15.00	8.6	59	2.9	230	13.0	8	
Paint Grey-blue	0.27	1.9	4 <T	0.7 <T	49	3.2 <T	<2 <T	
Paint Bright Blue	0.61	9.3	390	0.9 <T	140	18.0	13	
Paint Pale yellow	20.00	15.0	25000	2.8 <T	640	46.0	20	
Paint Wine	0.12 <W	220.0	76	3.4	95	20.0	15	
Paint Dark Blue	0.12 <W	13.0	63	2.1 <T	600	43.0	10 <T	
Paint Dark Green	1.60	38.0	43	3.0	370	22.0	15	

Concentrations reported as ug/g unless otherwise indicated.

Underlined values exceed the applicable ULN guideline (See Appendix I).

ND = No data; NG = No guideline; <W at or below analytical detection limit; <T = trace amount, interpret with caution

EC = Electrical conductivity in millisiemens/cm, see Appendix II

Table 4.

Concentrations of organic compounds in soil samples collected at Varnicolor Chemical storage yard - August 8, 1990

Compound	Site						CCME
	A	B	C	D	E	F	
Dibenzo(a,h)anthracene	40 <W	40 <W	40 <W	40 <W		40 <W	10,000
Benzo(g,h,i)perylene	40 <W	40 <W	40 <W	40 <W		40 <W	NG
Naphthalene	20 <W	20 <W	20 <W	20 <W		20 <W	50,000
Acenaphthalene	20 <W	20 <W	20 <W	20 <W		20 <W	NG
Acenaphthene	20 <W	20 <W	20 <W	20 <W		20 <W	NG
Fluorene	20 <W	20 <W	20 <W	20 <W		20 <W	NG
Phenanthrene	90 <T	20 <W	20 <W	20 <W		20 <W	50,000
Anthracene	20 <W	20 <W	20 <W	20 <W		20 <W	NG
Fluoranthene	250	20 <W	20 <W	20 <W		20 <W	NG
Pyrene	200 <T	20 <W	20 <W	20 <W		90 <W	100,000
Benzo(a)anthracene	70 <T	20 <W	20 <W	80 <T		120 <W	10,000
Chrysene	80 <T	20 <W	20 <W	50 <T		50 <W	NG
Benzo(k)fluoranthene	80 <T	20 <W	20 <W	40 <T		60 <W	10,000
Benzo(b)fluorene	200 <T	20 <W	20 <W	50 <T		100 <W	10,000
Benzo(a)pyrene	80 <T	20 <W	20 <W	20 <W		50 <W	NG
Indeno(1,2,3-cd)pyrene	80 <T	40 <W	40 <W	40 <W		40 <W	10,000
Solvent Extractables	46818	1916	34191	1740	252	120	

Concentrations of all PAH compounds are in ng/g dry weight (ppb). Values indicated by <T are measurable trace concentrations while <W showed no measurable concentration of the compound.

Solvent extractable concentrations are in ug/g dry weight (ppm).

NG = No guideline

CCME = Canadian Council of Ministers of the Environment Interim Remediation Criteria for industrial/commercial soil.

Table 5. Concentrations of various chemical elements in grass and alfalfa tissue collected in the vicinity of Varnicolor Chemical main plant, Elmira, August 20, 1990.

Species Site No.	Cu	Ni	Pb	Zn	Fe	Mn	P (%)	N (%)	Al	As	Ca		
Grass													
1	2.0 <T	0.7 <T	1.7	12	55	49	0.13	0.90	19 <T	0.2 <W	5267		
2	3.5	0.8 <T	0.6 <W	12	64	107	0.16	1.31	23 <T	0.2 <W	4833		
3	2.8	0.5 <T	0.5 <W	17	27	89	0.04	0.78	9 <T	0.2 <W	3500		
5	4.6	0.7 <T	0.5 <T	18	52	38	0.38	1.97	14 <T	0.2 <W	4100		
6	1.9	0.7 <T	0.7 T	17	97	108	0.24	1.23	39	0.2 <W	4400		
7	1.8 <T	0.7 <T	0.5 <W	7	50	30	0.13	0.85	22 <T	0.2 <W	3267		
8	1.8 <T	0.5 <T	0.7 <T	9	75	97	0.20	0.81	34	0.2 <W	4200		
9	2.6 <T	0.8 <T	0.5 <W	23	75	43	0.20	1.02	32	0.2 <W	4600		
Alfalfa													
1	9.2	1.1 <T	0.8 <T	18	55	18	0.21	2.8	11 <T	0.2 <W	13000		
2	5.9	1.0 <T	0.5 <W	15	34	10	0.17	2.3	5 <W	0.2 <W	11000		
7	7.9	1.1 <T	0.5 <W	18	58	19	0.29	3.1	9 <T	0.2 <W	14000		
ULN													
Grass	7	5	20	40	500	50	NG	NG	NG	8	NG		
Foliage	20	7	60	250	1000	100	NG	NG	500	2	NG		
Species Site No.	Cd	Cl %	Co	Cr	K %	Mg	Mo	Na	Sr	S %	V	Sb	Se
Grass													
1	0.1 <W	0.25	0.2 <W	0.5 <W	0.97	1037	0.7 <T	15	6.8	0.15	0.5 <W	0.2 <W	0.2 <W
2	0.1 <W	0.52	0.2 <W	0.5 <W	1.67	1567	0.9 <T	30	6.9	0.25	0.5 <W	0.2 <W	0.2 <W
3	0.1 <W	0.41	0.2 <W	0.5 <W	1.40	850	0.5 <T	38	4.6	0.13	0.5 <W	0.2 <W	0.2 <W
5	0.1 <W	0.65	0.2 <W	0.5 <W	2.47	1633	1.0 <T	11	9.1	0.25	0.5 <W	0.2 <W	0.2 <W
6	0.1 <W	0.33	0.2 <W	0.5 <W	1.23	1267	0.4 <W	37	8.8	0.20	0.5 <W	0.2 <W	0.2 <W
7	0.1 <W	0.51	0.3 <T	0.5 <W	0.92	867	0.2 <W	67	8.2	0.12	0.5 <W	0.2 <W	0.2 <W
8	0.1 <W	0.25	0.2 <W	0.5 <W	1.27	1133	0.4 <T	22	5.8	0.16	0.5 <W	0.2 <W	0.2 <W
9	0.1 <W	0.32	0.2 <T	0.5 <W	1.12	1160	0.3 <W	24	6.9	0.14	0.5 <W	0.2 <W	0.2 <W
Alfalfa													
1	0.1 <W	0.76	0.2 <W	0.5 <W	1.9	1600	0.7 <T	510	22.0	0.25	0.5 <W	0.2 <W	0.2 <W
2	0.1 <W	0.41	0.2 <W	0.5 <W	1.6	1500	0.4 <T	87	17.0	0.21	0.5 <W	0.2 <W	0.2 <W
7	0.1 <W	0.43	0.2 <W	0.5 <W	1.5	3200	0.5 <T	1100	25.0	0.33	0.5 <W	0.2 <W	0.2 <W
ULN Grass	0.5	1	2	5	NG	NG	6	NG	NG	0.5	6	NG	0.5
ULN Foliage	2	NG	2	8	NG	7000	1.5	350	NG	0.4	5	0.5	0.7

Values are means of triplicate samples for grass, single samples for alfalfa as ug/g dry weight except as indicated. Underlined values exceed the respective ULN (See Appendix). Underlined values exceed the applicable urban ULN guideline (See Appendix 1).
 ND = No data; NG = No guideline; <W at or below analytical detection limit; <T = trace amount, interpret with caution

Table 6. Concentrations of organic compounds in soil samples collected in the vicinity of the Varnicolor Chemical main plant - August 20, 1990

Compound	Site										CCME
	1	2	3	4	5	6	7	8	9		
Dibenzo(a,h)anthracene	40 <W	40 <W	40 <W	40 <W	40 <W	40 <W	40 <W	40 <W	40 <W	40 <W	10,000
Benzo(g,h,i)perylene	40 <W	40 <W	40 <W	40 <W	58 <W	40 <W	350 <T	40 <W	40 <W	40 <W	NG
Naphthalene	20 <W	20 <W	20 <W	20 <W	20 <W	20 <W	20 <W	20 <W	20 <W	20 <W	50,000
Acenaphthalene	20 <W	20 <W	20 <W	20 <W	20 <W	20 <W	20 <W	20 <W	20 <W	20 <W	NG
Acenaphthene	20 <W	20 <W	20 <W	20 <W	20 <W	20 <W	20 <W	20 <W	20 <W	20 <W	NG
Fluorene	20 <W	20 <W	20 <W	20 <W	20 <W	20 <W	20 <W	20 <W	20 <W	20 <W	NG
Phenanthrene	20 <W	20 <W	20 <W	20 <W	280 <T	20 <W	151 <T	20 <W	20 <W	20 <W	50,000
Anthracene	20 <W	20 <W	20 <W	20 <W	470 <T	20 <W	20 <W	20 <W	20 <W	20 <W	NG
Fluoranthene	75 <T	70 <T	53 <T	81 <T	440	89 <T	400	21 <T	20 <W	20 <W	NG
Pyrene	62 <T	20 <W	20 <W	62 <T	370 <T	84 <T	316	20 <W	20 <W	20 <W	100,000
Benzo(a)anthracene	38 <T	35 <T	20 <W	36 <T	203	52 <T	191 <T	20 <W	20 <W	20 <W	10,000
Chrysene	65 <T	59 <T	42 <T	59 <T	244	62 <T	85 <T	20 <W	20 <W	20 <W	NG
Benzo(k)fluoranthene	50 <T	42 <T	20 <W	33 <T	160 <T	42 <T	287	23 <T	20 <W	20 <W	10,000
Benzo(b)fluorene	20 <W	20 <W	20 <W	62 <T	161 <T	20 <W	319	26 <T	20 <W	20 <W	NG
Benzo(a)pyrene	20 <W	20 <W	20 <W	20 <W	184 <T	51 <T	249	20 <W	20 <W	20 <W	10,000
Indeno(1,2,3-cd)pyrene	40 <W	40 <W	40 <W	40 <W	40 <W	40 <W	500	51 <T	40 <W	40 <W	10,000
Solvent Extractables	1126	304	381	564	565	996	579	530	478		

Concentrations of all PAH compounds are in ng/g dry weight (ppb). Values shown in bold are measurable concentrations. NG = No guideline; <W = at or below analytical detection limit; <T = trace amount, interpret with caution

CCME = Canadian Council of Ministers of the Environment Interim Remediation Criteria for Industrial Commercial Soil

Solvent extractable concentrations are in ug/g dry weight (ppm).

Figure 1. Locations of sample sites in the vicinity of Uniroyal Corporation, Elmira, Ontario, October 1989

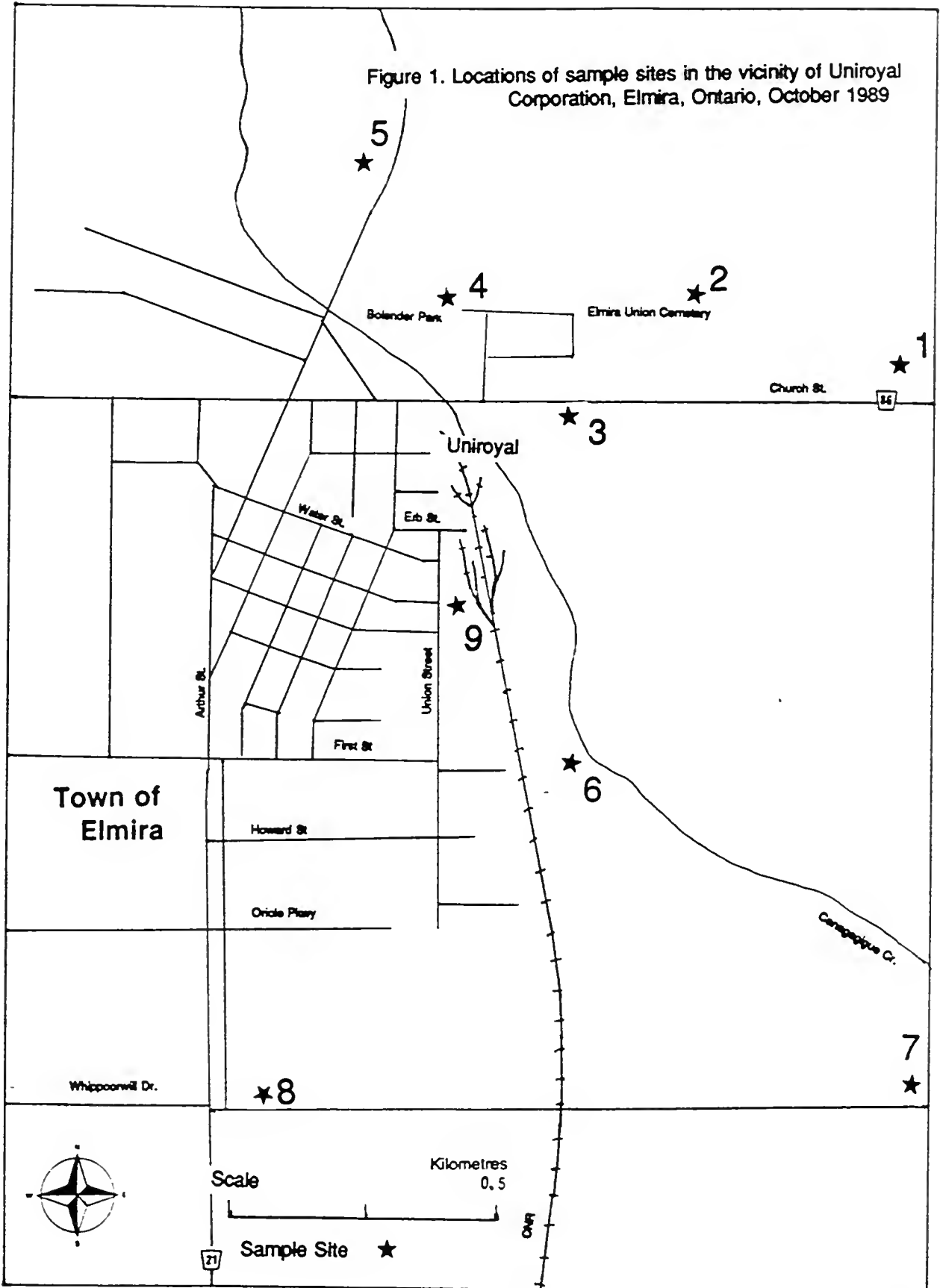


Figure 2. Locations of sample sites in the vicinity of Sulco Canada Colours, Elmira, Ontario, August, 1990

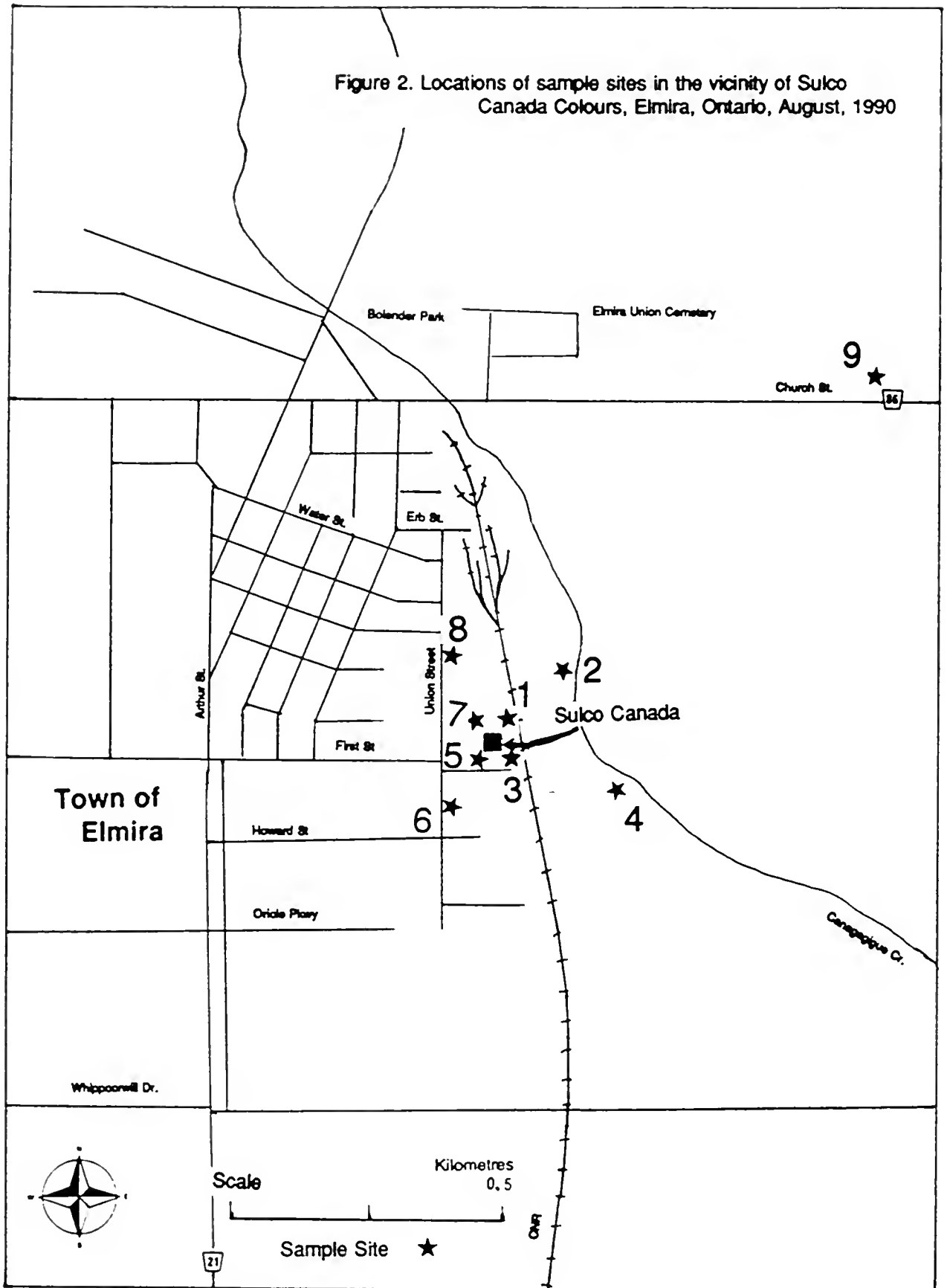


Figure 3. Sketch map showing locations of Sample Sites in the Varnicolor Chemical storage yard, Elmira, Ontario, August, 1990

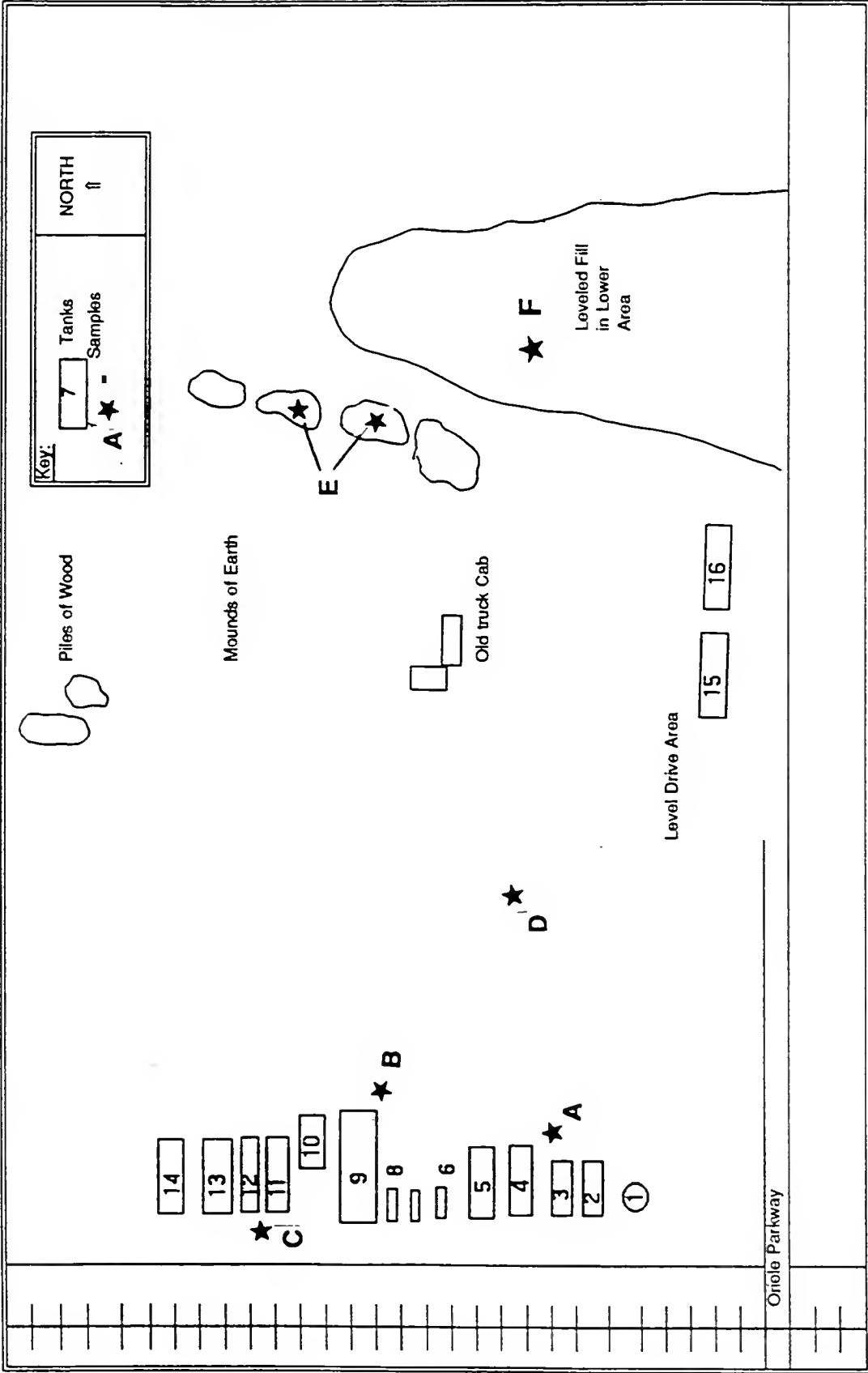
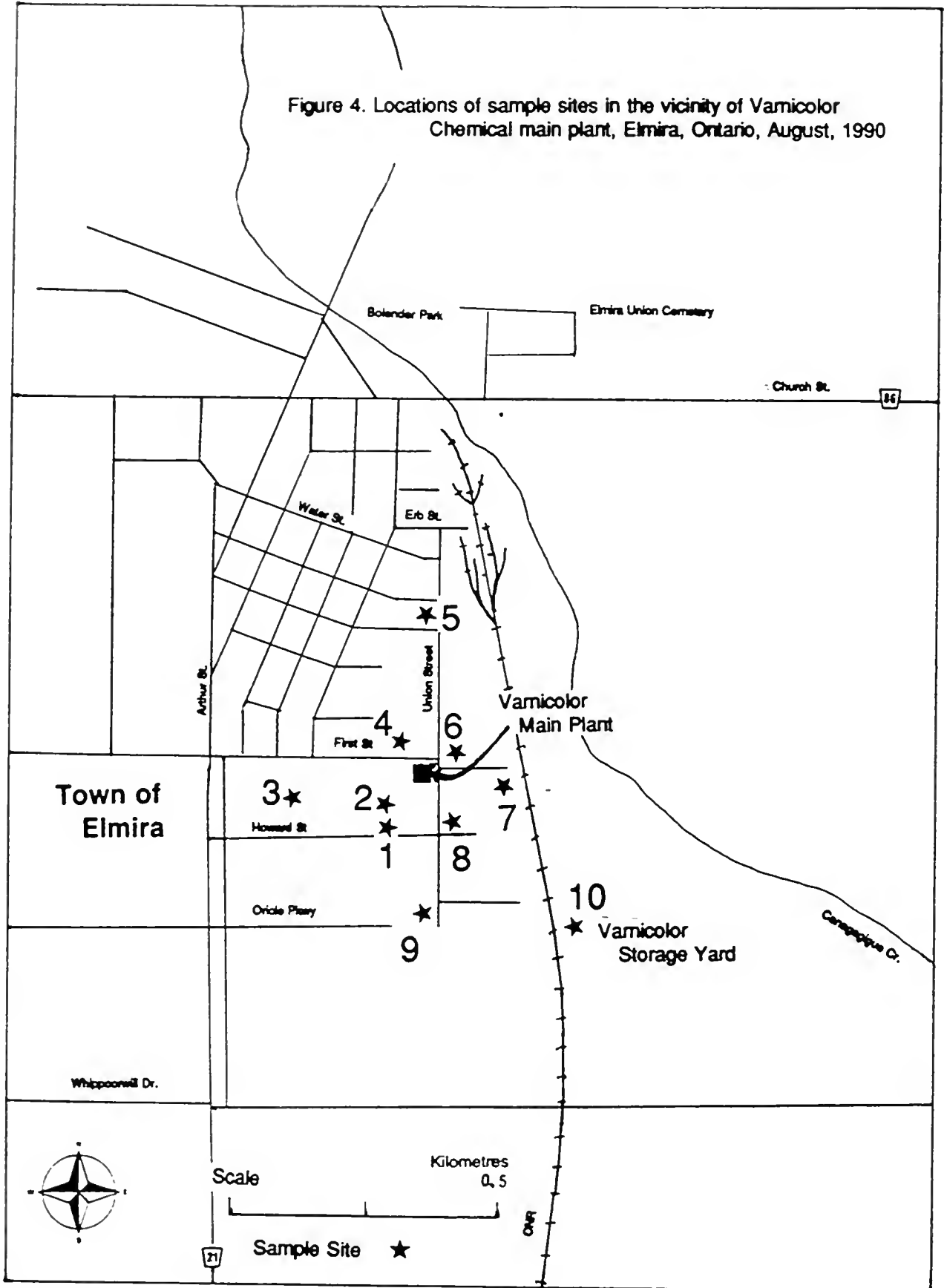


Figure 4. Locations of sample sites in the vicinity of Varnicolor Chemical main plant, Elmira, Ontario, August, 1990



APPENDIX I.

Derivation and Significance of the MOE Phytotoxicology "Upper Limits of Normal" Contaminant Guidelines.

The MOE Upper Limits of Normal (ULN) contaminant guidelines represent the expected maximum concentration in surface soil, foliage (trees and shrubs), grass, moss bags, and snow from areas in Ontario not exposed to the influence of a pollution source. Urban ULN guidelines are based on samples collected from urban centres, whereas rural ULN guidelines were developed from non-urbanized areas. Samples were collected by Phytotoxicology staff using standard sampling procedures (reference: *Ontario Ministry of the Environment 1992, Phytotoxicology Field Investigation Manual*). Chemical analyses were conducted by the MOE Laboratory Services Branch.

The ULN is the arithmetic mean plus three standard deviations of the suitable background data for each chemical element and parameter. This represents 99% of the sample population. This means that for every 100 samples that have not been exposed to a pollution source, 99 will fall below the ULN.

The ULNs do not represent maximum desirable or allowable limits. Rather, they are an indication that concentrations that exceed the ULN may be the result of contamination from a pollution source. Concentrations that exceed the ULNs are not necessarily toxic to plants, animals, or people. Concentrations that are below the ULNs are not known to be toxic.

ULNs are not available for all elements. This is because some elements have a very large range in the natural environment and the ULN, calculated as the mean plus three standard deviations, would be unrealistically high. Also, for some elements, insufficient background data is available to confidently calculate ULNs. The MOE Phytotoxicology ULNs are constantly being reviewed as the background environmental data base is expanded. This will result in more ULNs being established and may amend existing ULNs.

APPENDIX II

Soil Electrical Conductivity

Soil electrical conductivity (EC) is a measure of the total salts in the soil. Although EC is most commonly used to assess the degree of soil salt contamination from natural salt deposits, the use of winter de-icing compounds on roads, and the application of brine solutions for summer roadway dust control, EC also includes the measure of natural soil mineral and nutrient salts. An elevated soil EC can interfere with the plant's ability to absorb moisture and essential nutrients from the soil. An excessively elevated soil EC reverses the soil's natural osmotic pressure gradient and can actually draw moisture out of the plant. Therefore, plants exposed to salt-contaminated soil may be deprived of adequate moisture and nutrients, or in extreme cases, become desiccated as if experiencing severe drought, even though soil moisture is not limited.

The Phytotoxicology Processing Laboratory conducts soil EC measurements on a 2:1, water:soil suspension. The Ontario Ministry of Agriculture and Food (OMAF) Publication 296 (*Ontario Field Crop Recommendations, 1987*) contains a table that relates soil EC to phytotoxic response. This table is reproduced below. The unit of measure is millisiemens/cm (mS/cm, note: 1 siemen = 1 mho). OMAF considers an EC of 0.7 mS/cm to be excessive. However, an EC as low as 0.5 mS/cm can injure salt-sensitive plants.

Soil EC Interpretation		
EC ("Salt") millisiemens/cm	Rating	Plant Response
0-0.25	L	Suitable for most plants if recommended amounts of fertilizer are used.
0.026-0.45	M	Suitable for most plants if recommended amounts of fertilizer are used.
0.46-0.70	H	May reduce emergence and cause slight to severe damage to salt sensitive plants.
0.71-1.00	E	May prevent emergence and cause slight to severe damage to most plants.
>1.00	E	Expected to cause severe damage to most plants.
L - Low M - Moderate H - High E - Excessive		

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