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Pilot Study

Pesticides in Ground Water

Final Report

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Maine Geological Survey
DEPARTMENT OF CONSERVATION
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REPORT TO THE 114TH MAINE STATE LEGISLATURE ENERGY AND NATURAL RESOURCES COMMITTEE: Pilot Pesticides in Ground Water Study Final Report

by

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EXECUTIVE SUMMARY

In 1985, the State of Maine began a three year evaluation of the effect of agricultural practices on ground water quality. In the three years of this project, water samples were collected from 61 overburden and 39 bedrock wells in areas heavily used for potato, blueberry, market crop, and apple production.

Results from the three years of the study indicate that while pesticide residues are present in the ground water in some areas of Maine, concentrations are low. Of 229 samples taken in the study, only one contained pesticide (dinoseb) concentrations above an established health standard, and only six exceeded statistically sound levels of detection. Thirty-four samples contained pesticide residues at trace levels, detectable using current analytical techniques, but too low in concentration to allow statistically sound quantification. Because the samples were chosen to define the "worst case" situation, pesticide residues do not appear to be a widespread threat to ground water quality in Maine at this time.

Interpretation of the data suggests that conclusions drawn from studies in other states may not be entirely valid in Maine. Research in Wisconsin, California and Massachusetts indicates that ground water in sand and gravel deposits is most vulnerable to contamination from pesticides; Maine's study shows that bedrock wells may be more at risk. Pesticides were detected more frequently in bedrock wells than in overburden wells. Bedrock wells also have higher mean nitrate levels than overburden wells (8.2 mg/l vs. 4.4 mg/l).

Pesticides detected in potato areas include methamidophos, metribuzin, dinoseb, endosulfan, dicamba, chlorothalonil, and picloram. Methamidophos was most frequently found (10 wells), and was found in the highest concentration, trace to 10.5 ug/l.

Hexazinone was found in trace amounts in 2 wells in blueberry areas; arsenic (0.037 mg/l) was found in an orchard well; and trace levels of alachlor and atrazine were found in different wells near market gardens. No other pesticides were detected in these areas.

Nitrate levels exceeding 10 mg/l (as N) were found in 21 of the 100 wells sampled. Mean nitrate levels were highest in market garden areas (8.6 mg/l), and lowest in areas used for blueberry cultivation (0.1 mg/l).

Considerable effort was put into development of an analytical technique for ethylene thiourea (ETU). ETU is a breakdown product of the fungicides maneb and mancozeb, the most widely used agricultural chemicals in Maine. Sixty-nine samples were collected and analyzed for ETU, but the results of quality control studies on the analytical technique invalidated the results. A discussion of the ETU program is given in Appendix B. Further research of ETU will be necessary to determine the threat to drinking water supplies.

Most samples collected for this study were not analyzed for aldicarb (Temik), because a sufficient database already existed. Since 1980 the Rhone-Poulenc Ag Company, formerly Union Carbide, has collected water samples from 304 sites selected for their proximity to areas where the pesticide aldicarb was used. Forty-seven percent of these sites showed detectable levels of the pesticide in at least one sample. Levels of aldicarb in wells at most of these sites have dropped since the Maine Board of Pesticides Control imposed restrictions on the use of Temik in 1984.

CONVERSIONS

Concentration

grams per liter (g/l)	=	parts per thousand (ppt)
milligrams per liter (mg/l)	=	parts per million (ppm)
micrograms per liter (ug/l)	=	parts per billion (ppb)

Temperature

Celsius to Fahrenheit $^{o}C = 5/9(^{o}F - 32)$

Fahrenheit to Celsius $^{o}F = (9/5\ ^{o}C) - 32$

Introduction

The investigation of the impact on ground water of agricultural practices in Maine was prompted by the detection of chemicals used for agricultural purposes in the ground water in other states. In a survey begun in 1983 (Scarano, 1986), 25% of wells sampled in potato growing areas of Massachusetts showed detectable levels of the pesticide aldicarb (Temik), which is commonly used in Maine. The Connecticut Department of Environmental Protection conducted a study beginning in late 1983 in which over 2500 water supply wells were tested for the soil fumigant ethylene dibromide (EDB); 321 of these wells were found to be contaminated at a level greater than 0.1 ug/l, the Connecticut drinking water standard for EDB (Marin and Droste, 1986). In California, more than 50 different pesticides have been found in ground water basins throughout the state (Litwin et al., 1983).

Early studies in Maine also indicated a need for further investigation. Since 1980 the Rhone-Poulenc Ag Company, formerly Union Carbide, has collected water samples from 304 sites selected for their proximity to areas where the pesticide aldicarb (Temik) was used. Forty-seven percent of these sites showed detectable levels of the pesticide (Jones, pers. commun., 1987). Concentrations as high as 77 ug/l aldicarb were found (these concentrations have begun to drop since the Maine Board of Pesticides Control imposed restrictions on the use of Temik in 1984). A 1982 study by researchers at the University of Maine at Orono detected traces of the pesticide azinphos methyl (Guthion) in ground water from the blueberry growing regions of Washington and Hancock Counties (Bushway et al., 1982). A study in Carleton County, New Brunswick, Canada, immediately adjacent to the potato growing region of northern Maine, showed residues of aldicarb (Temik) and elevated nitrate levels in agricultural areas (Ecobichon et al., 1985).

To determine the extent of the ground water contamination problems in agricultural areas of Maine, the Ground Water Policy Review Committee of the Land and Water Resources Council recommended to former governor Joseph E. Brennan in December, 1984, that a state-wide project investigating the impact of agricultural practices on ground water quality be conducted. Governor Brennan and the Legislature accepted the recommendation and directed the Maine Geological Survey, Department of Conservation, to coordinate an inter-agency, three year investigative study, with annual progress reports to the Legislature's Energy and Natural Resources Committee. Participants in the study include representatives of the Maine Geological Survey, Department of Conservation; Bureau of Agriculture and Rural Resources and Pesticides Control Division, Department of Agriculture, Food and Rural Resources; Water Quality Control and Oil and Hazardous Materials Bureaus, Department of Environmental Protection; Environmental Health Unit, Health Engineering, and Maine Public Health Laboratory, Department of Human Services; Location and Environment Unit, Department of Transportation; Natural Resources Division, State Planning Office; and the Maine office of the Water Resources Division, U.S. Geological Survey.

Analytical Methods

In 1985 a pesticide ranking matrix was developed as a screening process to determine which pesticides were most likely to be found in ground water. A discussion of the factors and the ranking procedure is presented in the attached "Pesticides Selection Project" report (Appendix A). The ranking depends on available data from other state and national studies, as well as Pesticides Control Board records. It has been updated to reflect recent improvements in analytical techniques and the results of this study.

All samples were analyzed by the Maine Public Health Laboratory using gas chromatograph methods developed by the Maine Public Health Laboratory, Maine Department of Human Services. Most of the chemicals can be found by one of two "screens" (class I or II screens) that detect a wide spectrum of organic chemicals. Other chemicals can be detected by special tests if their presence is suspected (see Table 1). Nitrate analyses were done using an auto analyzer/cadmium coil reduction method.

During the first year of the study class I screens were done using an ether extraction method (USEPA, 1982). The following year, due to potential health risks to lab personnel from the ether, a new solid phase method was used (Baker, 1986). However, since the Safe Drinking Water Act requires that a liquid-liquid extraction method be used, class I screens for the final year of the study were again done using the ether extraction process. Results from the two methods are similar.

In 1985, results from the special test for methamidophos (Monitor) were not reported because breakdown of the chemical in the sample bottles yielded unrealistically low values. Studies conducted during the winter 1985-86 led to improved recovery rates for methamidophos. Results for methamidophos from all three years of the study are presented in Table 2 (at the back of this report), although the amount detected from 1985 samples may have been lower than the true concentration.

Results from the special test for ethylene thiourea (ETU) have been omitted from Table 2 because quality control studies raise questions about the reliability of the ETU analyses. A discussion of the problems encountered during the ETU study is presented in the attached "Ethylene Thiourea in Maine Ground Water" report (Appendix B).

Results for the special test for aldicarb (Temik) have been reported for nine samples. Generally, however, samples collected for this study have not been analyzed for Temik. An extensive ground water sampling program conducted by the Rhone-Poulenc Ag Company, formerly Union Carbide, concentrated on Temik use areas in Maine (Jones, 1987).

Sampling Plan

Sampling locations were chosen to provide information on pesticide concentrations in various types of aquifers, as well as to cover different agricultural areas of the State. Only wells adjacent to fields where pesticides are used were selected. Based on results from the 1985 Pesticides in Ground Water Program, however, 1986 and 1987 sampling was concentrated in potato growing areas in Aroostook County, where agricultural chemical use is the highest.

TABLE 1

METHODS FOR PESTICIDE ANALYSES USED BY THE MAINE PUBLIC HEALTH LABORATORY

CHEMICALS	SYNONYMS	METHOD	UG/L MLD	STATE MAX. EXPOSURE GUIDELINE (UG/L)
Alachlor		II	1.25	2
Aldicarb	Temik	Sp-2	1.00	2
Atrazine		II	3.00	2
Azinphos'methyl	Guthion	II	5.00	25
Butylate	Sutan	II	2.30	
Captan		II	1.25	100
Carbaryl	Sevin	II	50.00	164
Carbofuran	Furadan	II	6.00	40
Chlorothalonil	Bravo	II	1.25	15
Chlorpyrifos	Dursban	II	1.25	
Cyanazine		II	19.00	9
2,4-D		I	1.25	70
2,4,5-T		I	1.25	21
2,4,5-TP	Silvex	I	.25	1
Diazinon		II	1.25	0.63
Dicamba	Banvel	I	1.25	9
Difolitan		II	1.25	
Disulfoton	Disyston	II	6.00	0.3
DNBP	Premerge, Dinoseb	I	1.25	2
Endosulfan	Thiodan	II	1.00	
Endrin		II	.50	0.2
Eptam	EPTC	II	1.25	
ETU	Maneb, Mancozeb**	Sp-1	5.00	3.0
Imidan	Phosmet	II	12.50	
Lindane		II	.50	0.2
Linuron	Lorox	II	12.00	40
Malathion		II	1.25	40
Methomyl	Lannate	Sp-3	6.00	50
Methoxychlor		II	1.50	100
Methyl Parathion		II	.60	2
Metribuzin	Sencor	II	0.25	175
Methamidophos	Monitor	Sp-4	10.00	
PCNB	Terraclor	II	1.50	71
Picloram	Tordon	I	1.25	300
Simazine		II	8.00	35
Triclopyr	Garlon	I	.50	
Trifluralin	Treflan	II	.60	2
Hexazinone	Velpar	II	20.00	210

METHOD: I and II are general screens. Special tests (Sp-#) are run for aldicarb, ETU, methomyl and methamidophos.

MLD: "Minimum Level of Detection" of the analysis under our conditions for which statistically sound recovery data are available. In many cases lower values can be detected but are reported as "trace" because accurate quantification at such low levels is unreliable.

**ETU is actually a breakdown product of maneb and mancozeb.

Blanks in the column for Maximum Exposure Guideline indicate that no guideline has been developed.

SPECIAL NOTE: This information effective 1/5/89. It will be updated as laboratory techniques and needs change.

Whenever possible, monitoring wells installed by the Maine Geological Survey (MGS), Maine Department of Environmental Protection (MDEP), and U.S. Geological Survey (USGS) cooperative Aquifer Mapping Project were sampled, as were similar wells from the USGS-MGS Saco River Valley study. Use of these wells minimized logistical sampling problems and uncertainty about well construction.

In areas where monitoring wells were not available, private household wells were sampled. Private wells were used mostly in Aroostook County, and in orchard sampling in central Maine. Eight monitoring wells, installed in Aroostook County as part of the Aquifer Mapping Project, were sampled to supplement the private well Aroostook County data base.

Sample locations were chosen to assess worst case situations. It was assumed, based on the results and sampling plans from other states (Litwin et al., 1983; Cohen et al., 1984; Goethel et al., 1984; Deubert, 1985; Corte-Real, 1986), that ground water in sand and gravel deposits would be most vulnerable to contamination, and that ground water from till and bedrock would be less vulnerable. Thus, a majority of the samples in the first two years of the study were collected from surficial wells in sand and gravel aquifers. However, the results from the 1985 and 1986 sampling showed a higher percentage of bedrock wells than surficial wells contained pesticide residues. Thus, in 1987 the sampling emphasis was shifted.

The sampling program for the third year of the study again concentrated in Aroostook County. Three wells that had tested positive in 1985 and 1986 were sampled monthly in an attempt to identify temporal contamination trends. More sampling of bedrock wells was done to provide data for comparison with results from the first two years work which concentrated on surficial wells. To further this comparison, adjacent bedrock and surficial wells were chosen for sampling.

A breakdown of all wells sampled for the project by geologic setting and crop type is shown below.

Crop Type	Sand and Gravel	Till	Bedrock
Potatoes	27	10	31
Orchard/Tree Farm	0	3	3
Forage Crop/Market Garden	9	0	1
Blueberries	11	0	0

Sampling Methods

Sampling of wells was conducted during the growing season, from mid-June to early November, with most wells sampled more than once during this period. All wells that tested positive for pesticides in one year were re-sampled the following year.

Samples from monitoring wells were collected using a gas bladder portable pump. To ensure that samples were representative of the local ground water quality, at least 3 well volumes were pumped before sampling. Conductivity and water temperature were measured during pumping, and samples were taken once these two parameters stabilized.

With the exception of water collected for nitrate analyses, samples from monitoring wells were filtered to remove sediment. In 1985, filtering was done using 0.45 micron membrane filters with paper pre-filters. Recovery tests run by the Maine Public Health Laboratory following the 1985 sampling showed that certain groups of chemicals were adsorbed to the paper and membrane filters. To overcome this adsorption problem, 1.6 micron fiberglass filters were used in 1986 and 1987.

Samples from private wells, since they are sediment free, were not filtered. The tap was allowed to run until the conductivity and temperature stabilized before sampling. All samples were refrigerated and delivered to the Maine Public Health Laboratory as soon as possible after collection.

Results

During the three years of this study a total of 229 pesticide samples have been collected from 95 wells. Fourteen percent of these samples were positive (mostly at trace levels, detectable using current analytical techniques, but too low in concentration to allow statistically sound quantification). Only 6 samples had pesticide concentrations exceeding trace levels. Combined results of the chemical analyses from the three years of the study are presented in Table 2 at the back of this report, and are summarized in Tables 3, 4, and 5.

In 1985, the first year of the study, 62 samples were collected from 45 wells. These samples included 36 from wells near potato fields, 10 from wells in the blueberry barrens, 11 from wells near forage crop/market gardens, and 5 from wells in orchards. Sixteen of these samples tested positive with at least one positive reported from each crop type (Tolman, 1986).

Fifty-nine wells were sampled in 1986. One-hundred-nineteen samples were analyzed including 105 from wells near potato fields, 6 from wells in blueberry areas, 4 from wells near forage crop/market gardens and 4 from wells in orchards. Two additional wells in agricultural areas were sampled but were only analyzed for nitrate. Only 14 samples tested positive for pesticides in 1986, all from potato growing areas. Three of the positives were for the herbicides dicamba (well #63, 10-15-86; well #76, 10-30-86) and picloram (well #68, 7-29-86). These chemicals are generally used for turf maintenance and for clearing right-of-ways rather than for agricultural purposes. Their detection in agricultural areas may be coincidental (Neil et al., 1987).

In 1987, the final year of the study, 48 samples were collected from 27 wells. These samples included 42 from wells in potato areas, 5 from wells in blueberry barrens and 1 from a tree farm. Four additional wells near cropped fields were sampled but were analyzed only for nitrate. The herbicide alachlor was detected at trace levels in samples from 3 of the wells in blueberry barrens, and the fungicide chlorothalonil was detected at trace levels in samples from the other two wells in blueberry barrens. Discussions with the blueberry growers indicate that neither of those chemicals are used in blueberry agriculture. Therefore, the results are considered false positives. The results are reported in Table 2 but are not figured into analysis of data. Discounting the apparent false positives for the blueberry samples, only 2 samples tested positive for pesticides in 1987. Both positives were from wells in the potato growing areas that had tested positive in the previous year.

Table 3. - Summary of results.

A. Percentage of wells having detectable levels of pesticides in at least one sampling period; by well and crop type.

	Well Type				
Crop Type	Sand & Gravel	Till	Bedrock	All Well Types	Number of Wells by Crop Type
Potato	15%	20%	42%	28%	68
Orchard	a	0%	33%	17%	6
Blueberry	18%	a	a	18%	11
Market Garden/ Forage Crop	22%	a	0%[b]	20%	10
All Crop Types	17%	15%	40%	25%	
Number of Wells by Well Type	47	13	35		95

B. Percentage of samples with detectable pesticide levels; by sample and crop type.

	Sample Type				
Crop Type	Sand & Gravel	Till	Bedrock	All Well Types	Number of Samples by Crop Type
Potato	6%	10%	23%	15%	183
Orchard	a	0%	25%	10%	10
Blueberry	10%	a	a	10%	21
Market Garden/ Forage Crop	14%	a	0%[c]	13%	15
All Crop Types	8%	8%	23%	14%	
Number of Samples by Sample Type	100	37	92		229

Table 3. - Summary of results (cont.).

C. Percentage of wells with nitrate levels exceeding drinking water standards in at least one sampling period; by well and crop type.

	Well Type				
Crop Type	Sand & Gravel	Till	Bedrock	All Well Types	Number of Wells by Crop Type
Potato	15%	17%	32%	23%	73
Orchard	a	0%	0%	0%	6
Blueberry	0%	a	a	0%	11
Market Garden/ Forage Crop	33%	a	100%[b]	40%	10
All Crop Types	15%	13%	32%	21%	
Number of Wells by Well Type	47	15	38		100

D. Percentage of samples with nitrate levels exceeding drinking water standards; by sample and crop type.

	Sample Type				
Crop Type	Sand & Gravel	Till	Bedrock	All Well Types	Number of Samples by Crop Type
Potato	16%	10%	32%	23%	163
Orchard	a	0%	0%	0%	10
Blueberry	0%	a	a	0%	21
Market Garden/ Forage Crop	21%	a	100%[c]	27%	15
All Crop Types	13%	9%	31%	20%	
Number of Samples by Sample Type	90	35	84		209

[a] No wells fall into this category.

[b] There was only one bedrock well in this category.

[c] There was only one sample in this category.

The low number of positive samples for 1987 seems inconsistent with the previous two years results. Some of this discrepancy may be due to analytical problems. Between 1986 and 1987 an entirely new staff came on at the Maine Public Health Laboratory. Also, from early June through early August, 1987 both of the MPHL gas chromatographs were down for repairs. While all the samples submitted were extracted within the suggested holding time, many of the chemicals of concern are unstable even in extract and may have decomposed below detection limit before the analysis could be completed.

Nitrate analyses were done on 209 samples collected from 100 wells. A breakdown of average nitrate concentrations is shown in Table 4.

Table 4. - Mean nitrate levels in well water.

	Number of Samples	Mean Nitrate (mg/l as N)	Standard Deviation
Crop Type			
Potato	163	6.7	5.3
Orchard	10	1.1	1.2
Blueberry	21	0.1	0.1
Market Garden/ Forage Crop	15	8.6	11.5
Overburden Material			
Sand and Gravel	97	4.4	6.0
Till	112	7.2	5.7
Well Type			
Sand and Gravel	90	4.3	6.1
Till	35	4.6	3.6
Bedrock	84	8.2	6.0

Mean nitrate levels are highest in areas used for market garden/forage crop production, areas overlain by till, and in bedrock wells. The lowest mean nitrate levels are found in blueberry growing areas, areas overlain by sand and gravel, and in overburden wells in sand and gravel.

In the three years of the study, nitrate and dinoseb were the only substances found in concentrations exceeding health advisories or proposed recommended maximum concentration levels in drinking water. Forty-one samples representing 21 wells exceeded the nitrate standard of 10 mg/l as nitrogen (Maine Department of Human Services, 1983). The dinoseb level in well 37 (6-17-86) was 2.3 ug/l, which exceeds the Recommended Maximum Exposure Guideline of 2.0 ug/l (Maine Department of Human Services, 1986). Sixteen of the 46 chemicals of concern to this study have no Maximum Exposure Guideline developed for them (Maine Department of Human Services, 1988). Only 6 samples exceeded statistically sound levels of detection; all other pesticide concentations were at trace levels. A summary of the pesticides detected in well water is given in Table 5.

Table 5. - Pesticides detected in well water.

Pesticide	Number of Wells Sampled	Number of Wells With Detectable Pesticide Levels*	Number of Samples Analyzed	Number of Samples With Detectable Pesticide Levels*	Maximum Concentration Found (ug/l)
Alachlor	95	1	203	1	trace
Aldicarb	9	0	9	0	nd
Arsenic	39	1	50	1	37
Atrazine	95	1	203	1	trace
Azinphos'methyl	95	0	203	0	nd
Butylate	95	0	203	0	nd
Captan	95	0	203	0	nd
Carbaryl	95	0	203	0	nd
Carbofuran	95	0	203	0	nd
Chlorothalonil	95	1	203	1	trace
Chlorpyrifos	95	0	203	0	nd
Copper	8	0	12	0	nd
Cyanazine	95	0	203	0	nd
2,4-D	74	0	149	0	nd
2,4,5-T	74	0	149	0	nd
2,4,5-TP	74	0	149	0	nd
Diazinon	95	0	203	0	nd
Dicamba	74	2	149	2	trace
Difolitan	95	0	203	0	nd
Disulfoton	95	0	203	0	nd
Dinoseb	74	8	149	9	2.3
Endosulfan	95	2	203	2	trace
Endrin	95	0	203	0	nd
Eptam	95	0	203	0	nd
Hexazinone	95	2	203	2	trace
Imidan	95	0	203	0	nd
Lindane	95	0	203	0	nd
Linuron	95	0	203	0	nd
Malathion	95	0	203	0	nd
Methomyl	7	0	7	0	nd
Methoxychlor	95	0	203	0	nd
Methyl Parathion	95	0	203	0	nd
Metribuzin	95	4	203	6	0.49
Methamidophos	46	10	72	10	10.5
PCNB	95	0	203	0	nd
Picloram	74	1	149	1	1.4
Simazine	95	0	203	0	nd
Triclopyr	74	0	149	0	nd
Trifluralin	95	0	203	0	nd

* Includes all wells/samples where pesticides were determined to be present, even if the concentrations were below statistically sound levels of detection.

nd = not detected

Interpretation of Results

The Pesticide Project was designed to investigate potential pesticide contamination in worst case situations, specifically, intensely farmed areas in the most geologically sensitive environments. Originally, ground water in sand and gravel deposits was thought to be the most sensitive to contamination, with water from till somewhat less at risk, and water from bedrock fractures the least vulnerable. Analysis of the combined data from this study does not corroborate this assumption.

Of 100 samples from wells in sand and gravel overburden, 8 (8%) gave a positive result for some pesticide. Of 36 samples from wells in till overburden, 3 (8%) gave a positive result for some pesticide. Of 92 samples from bedrock wells, 21 (23%) gave a positive result for some pesticide.

In the three years of the study, a total of 68 wells have been tested for the suite of pesticides used on potatoes. Of 31 bedrock wells that have been tested, 13 (42%) have had at least one positive pesticide sample. Of the 10 overburden wells in till, 2 (20%) had at least one positive pesticide sample. Out of 27 overburden wells in sand and gravel, 4 (15%) have had at least one positive pesticide sample.

This trend is also apparent for nitrate. Twelve (32%) of the 38 bedrock wells tested had at least one sample exceed the drinking water standard for nitrate. Nine (14%) of the 63 overburden wells tested had at least one sample exceed this limit. In samples from potato growing areas, 11 (32%) of 34 bedrock wells and six (15%) of 39 overburden wells tested had at least one sample exceed the limit for nitrate. The average nitrate level in sand and gravel wells was 4.3 mg/l, in till wells 4.6 mg/l, and in bedrock wells 8.2 mg/l.

During this study only 4 samples have shown traces of more than one chemical; all four were samples from bedrock wells. Of 64 wells sampled more than once, 6 had two or more positive samples; 5 of these were bedrock wells.

These results must be considered preliminary. Since this was a pilot pesticide project, only a limited number of samples have been analyzed, and the sampling plan was not designed to be statistically random. However, in contrast to studies in other states, these data suggest that bedrock wells may be more susceptible to contamination from agricultural practices than overburden wells. The data also indicate that overburden wells from till areas may be as susceptible to contamination as overburden wells in sand and gravel areas.

There is an apparent correlation between time of sampling and the percentage of samples giving positive results. The percentage of the samples yielding detectable levels of pesticides is higher in June (18%), July (22%), and August (20%) than in later months (0% to 10%). In 1987 a monthly sampling of three wells was done to confirm this trend (Table 2, well #'s 30, 70, 75). Each was a different well type and all had tested positive the previous year. Sampling was done from June through October. While there were not enough positive samples collected to be conclusive, the two positives found were collected in August.

Analysis of the data from this study indicates that chemicals applied to potatoes pose the greatest threat of contamination to ground water in Maine. Of 21 samples from blueberry growing areas of Washington and Hancock Counties, mostly on sandy glacial deltas, only two samples showed traces of one chemical, hexazinone. Nine samples from the orchards of central Maine had no detectable levels of organic compounds; one had low levels of arsenic. Fifteen samples from forage crop/market garden areas in the glacial deposits of the western Maine valleys gave two positive results, one for the herbicide atrazine and one for the herbicide alachlor. One-hundred-eighty-three samples have been taken from a variety of geologic environments in the potato growing areas of northern and western Maine; 27 of these have had detectable levels of chemicals. Seven different chemicals have been detected in potato growing areas; methamidophos, metribuzin, dinoseb, endosulfan, chlorothalonil, dicamba and picloram. Ethylene thiourea was also detected, but questionable reliability of the laboratory procedure prevented reporting those results here (see Appendix B). Results from a study by the Rhone-Poulenc Ag Company show that the pesticide aldicarb (Temik) has also been detected in potato growing areas (Jones, 1987).

Summary

Results from this study indicate that while pesticide residues are present in the ground water in some areas of Maine, concentrations are low. Of 229 samples taken in the study to date, only one contained pesticide (dinoseb) concentrations above an established health standard (2.0 ug/l), and only six exceeded statistically sound levels of detection.

Interpretation of the data suggests that conclusions drawn from studies in other states may not be entirely valid in Maine. Research in Wisconsin, California, and Massachusetts indicated that ground water in sand and gravel deposits was most vulnerable to contamination from pesticides; Maine's study shows that bedrock wells may be more at risk.

While this pilot pesticide project has produced useful data, additional research is required. The EPA now requires each state to develop a Pesticide Management Strategy if that state wishes to use chemicals that pose significant risk of contaminating ground water. Several such chemicals are used in Maine's agricultural industry. Without basic data on which to base sound management decisions, the EPA will be forced to set more stringent standards than may be necessary to prevent ground water contamination by pesticides.

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TABLE 2 : PESTICIDES IN GROUND WATER STUDY RESULTS

WELL #	CROP TYPE	TOWN	OVERBURDEN MATERIAL	WELL TYPE	DEPTH TO WATER (FT)	DATE SAMPLED	NITRATE (mg/l)	PESTICIDES DETECTED	FILTERED	TESTS RUN
1	BLUEBERRIES	T19M BPP	S & G	OVB	47'	10/02/85	0	NONE	YES[1]	II,AS,NO3
						07/31/86	< .2	NONE	YES	II,I,NO3
2	BLUEBERRIES	COLUMBIA	S & G	OVB	16'	10/03/85	0	NONE	YES[1]	II,AS,NO3
						09/04/86	.23	NONE	YES	II,I,NO3
						08/25/87	< .2	trace(alachlor)[5]	YES	II,NO3
3	BLUEBERRIES	COLUMBIA	S & G	OVB	22'	10/03/85	0	NONE	YES[1]	II,AS,NO3
						08/25/87	< .2	trace(alachlor)[5]	YES	II,NO3
4	BLUEBERRIES	COLUMBIA	S & G	OVB	30'	10/03/85	0	trace(hexazinone)	YES[1]	II,AS,NO3
						09/04/86	< .2	NONE	YES	II,I,NO3
5	BLUEBERRIES	T18MD BPP	S & G	OVB	21'	10/03/85	0	NONE	YES[1]	II,AS,NO3
						09/04/86	< .2	NONE	YES	II,I,NO3
						08/25/87	< .2	trace(alachlor)[5]	YES	II,NO3
6	BLUEBERRIES	DEBLOIS	S & G	OVB	13'	10/04/85	< .2	trace(hexazinone)	YES[1]	II,AS,NO3
						09/04/86	.22	NONE	YES	II,I,NO3
						08/25/87	< .2	trace(chlorothalonil)[5]	YES	II,NO3
7	BLUEBERRIES	AURORA	S & G	OVB	49'	10/01/85	0	NONE	YES[1]	II,AS,NO3
8	BLUEBERRIES	WHITNEYVILLE	S & G	OVB	4'	09/26/85	0	NONE	YES[1]	II,AS,NO3
9	BLUEBERRIES	NORTHFIELD	S & G	SPR[4]	0'	09/26/85	0	NONE	NO	II,AS,NO3
10	BLUEBERRIES	MEDDYBEMPS	S & G	OVB	5'	09/25/85	< .2	NONE	YES[1]	II,AS,NO3
11	BLUEBERRIES	DEBLOIS	S & G	OVB	15'	09/04/86	.21	NONE	YES	II,I,NO3
						08/25/87	< .2	trace(chlorothalonil)[5]	YES	II,NO3
12	ORCHARD	NEWPORT	TILL	BR	--	07/15/85	0	.037 mg/l(arsenic)	NO	II,DITH,NO3,AS,CU
13	ORCHARD	GREENE	TILL	OVB	1'	09/13/85	1.2	NONE	NO	II,NO3,CU,AS
						10/07/86	1.5	NONE	NO	II,NO3,CU,AS
14	ORCHARD	TURNER	TILL	OVB	--	07/10/85	.64	NONE	NO	II,DITH,NO3,AS,CU
						10/09/86	.47	NONE	NO	II,NO3,CU,AS
15	ORCHARD	TURNER	TILL	BR	--	07/10/85	.25	NONE	NO	II,DITH,NO3,AS,CU
						10/09/86	.2	NONE	NO	II,NO3,CU,AS
16	ORCHARD	TURNER	TILL	OVB	--	07/10/85	.82	NONE	NO	II,DITH,NO3,AS,CU
						10/09/86	1.11	NONE	NO	II,NO3,CU,AS

TABLE 2 : PESTICIDES IN GROUND WATER STUDY RESULTS (cont'd)

WELL #	CROP TYPE	TOWN	OVERBURDEN MATERIAL	WELL TYPE	DEPTH TO WATER (FT)	DATE SAMPLED	NITRATE (mg/l)	PESTICIDES DETECTED	FILTERED	TESTS RUN
17	FORAGE CROP/ MARKET GARDEN	CHINA	S & G	OVB	14'	07/09/85	16.2[3]	NONE	NO	II,METH,AS,NO3
						09/16/86	1.47	NONE	YES	II,NO3
18	FORAGE CROP/ MARKET GARDEN	NORRIDGEWOCK	S & G	OVB	7'	07/11/85	1.82	.19UG/L(alachlor)	YES[1]	II,NO3
					10'	09/17/86	<.2	NONE	YES	II,NO3
20	FORAGE CROP/ MARKET GARDEN	FRYEBURG	S & G	OVB	11'	07/23/85	3.47	NONE	YES[1]	II,METH,NO3
21	FORAGE CROP/ MARKET GARDEN	FRYEBURG	S & G	OVB	5'	07/23/85	0	NONE	YES[1]	II,METH,NO3
22	FORAGE CROP/ MARKET GARDEN	FRYEBURG	S & G	OVB	13'	07/23/85	6.94	NONE	YES[1]	II,METH,NO3
	POTATO					09/18/86	7.14	NONE	YES	II,I,NO3
23	FORAGE CROP/ MARKET GARDEN	FRYEBURG	S & G	OVB	12'	07/24/85	7.68	NONE	YES[1]	II,METH,NO3
						11/21/85	4.41	NONE	YES[1]	II,I,AS,NO3
						09/18/86	1.06	NONE	YES	II,I,NO3
24	FORAGE CROP/ MARKET GARDEN	FRYEBURG	S & G	OVB	13'	07/24/85	0	NONE	YES[1]	II,NO3
25	FORAGE CROP/ MARKET GARDEN	UNITY	S & G	OVB	16'	07/09/85	12.4[3]	NONE	NO	II,AS,NO3,METH
26	FORAGE CROP/ MARKET GARDEN	CANTON	S & G	OVB	15'	07/10/85	41.5[3]	trace(atrazine)	NO	II,AS,NO3,METH,TEM
27	FORAGE CROP/ MARKET GARDEN	PITTSFIELD	TILL	BR	--	08/01/85	24.8[3]	NONE	NO	II,NO3
28	POTATO	WOODLAND	TILL	BR	--	07/16/85	1.67	NONE	NO	II,I,TEM,AS,NO3
						09/18/85	1.51	NONE	NO	II,I,MON,NO3
29	POTATO & PEAS	PRESQUE ISLE	TILL	BR	--	07/16/85	2.67	trace(methamidophos)	NO	II,I,MON,AS,NO3
						09/18/85	3.40	NONE	NO	II,I,MON,NO3
30	POTATO	FT.FAIRFIELD	S & G	OVB	~20'	07/16/85	5.85	trace(methamidophos)	NO	II,I,MON,AS,NO3
						09/17/85	5.17	NONE	NO	II,I,MON,NO3
						07/08/86	4.99	NONE	NO	II,I,NO3
						09/25/86	5.58	NONE	NO	II,I,MON,NO3
						10/29/86	--	NONE	NO	I
						06/03/87	4.55	NONE	NO	II,I,NO3
						07/06/87	5.03	NONE	NO	II,NO3
						08/04/87	4.63	NONE	NO	II,MON,NO3
						09/01/87	4.93	NONE	NO	II,MON,NO3
						10/06/87	4.96	NONE	NO	II,I,MON,NO3

TABLE 2 : PESTICIDES IN GROUND WATER STUDY RESULTS (cont'd)

WELL #	CROP TYPE	TOWN	OVERBURDEN MATERIAL	WELL TYPE	DEPTH TO WATER (FT)	DATE SAMPLED	NITRATE (mg/l)	PESTICIDES DETECTED	FILTERED	TESTS RUN
31	POTATO & PEAS	LIMESTONE	TILL	BR	--	07/17/85	12.4[3]	trace(metribuzin)	NO	II,I,AS,NO3
						09/17/85	9.50	NONE	NO	II,I,MON,NO3
						06/17/86	10.9[3]	NONE	NO	II,I,NO3
						09/17/86	10.4[3]	trace(methamidophos)	NO	II,MON,NO3
						10/15/86	--	NONE	NO	I
						10/05/87	11.1[3]	NONE	NO	II,I,MON,NO3
32	POTATO & VEGETABLES	PRESQUE ISLE	TILL	BR	--	07/17/85	5.55	trace(metribuzin) trace(dinoseb)	NO	II,I,AS,NO3
						09/18/85	4.26	NONE	NO	II,I,MON,NO3
						06/18/86	4.88	NONE	NO	II,I,NO3
						09/25/86	5.22	NONE	NO	II,I,MON,NO3
33	POTATO	PRESQUE ISLE	TILL	BR	--	07/16/85	22.2[3]	trace(metribuzin)	NO	II,I,AS,NO3
						09/17/85	11.3[3]	NONE	NO	II,I,MON,NO3
						06/17/86	19.7[3]	trace(endosulfan)	NO	II,I,NO3
						09/25/86	11.5[3]	trace(dinoseb)	NO	II,I,MON,NO3
						10/16/86	--	NONE	NO	I
34	POTATO	MAPLETON	TILL	BR	15'	07/17/85	4.63	trace(dinoseb)	NO	II,I,AS,NO3
						09/18/85	6.8	NONE	NO	II,I,MON,NO3
						06/19/86	5.95	NONE	NO	II,I,NO3
						09/24/86	10.6[3]	NONE	NO	II,NO3
						10/14/86	--	NONE	NO	I
35	POTATO	PRESQUE ISLE	TILL	BR	--	07/17/85	5.75	NONE	NO	II,I,AS,NO3
						09/17/85	4.26	NONE	NO	II,I,MON,NO3
36	POTATO	BRIDGEWATER	TILL	BR	12'	07/17/85	4.61	10.5UG/L(methamidophos) trace(dinoseb)	NO	II,I,MON,AS,NO3
						09/18/85	4.6	NONE	NO	II,I,MON,NO3
						06/18/86	7.48	NONE	NO	II,I,NO3
						09/26/86	6.70	NONE	NO	II,I,MON,NO3
						10/16/86	--	NONE	NO	I
37	POTATO	FT.FAIRFIELD	TILL	BR	--	07/16/85	10.2[3]	trace(dinoseb)	NO	II,I,AS,NO3
						09/17/85	11.0[3]	NONE	NO	II,I,MON,AS,NO3,CU
						06/17/86	7.88	2.3UG/L(dinoseb)	NO	II,I,NO3
						09/25/86	8.28	NONE	NO	II,NO3
38	POTATO/ FORAGE CROP	PITTSFIELD	TILL	BR	--	08/01/85	10.1[3]	trace(methamidophos)	NO	II,I,MON,AS,NO3,CU
39	POTATO	PITTSFIELD	TILL	BR	--	08/01/85	9.5	trace(methamidophos) trace(dinoseb)	NO	II,I,MON,AS,NO3,CU

TABLE 2 : PESTICIDES IN GROUND WATER STUDY RESULTS (cont'd)

WELL #	CROP TYPE	TOWN	OVERBURDEN MATERIAL	WELL TYPE	DEPTH TO WATER (FT)	DATE SAMPLED	NITRATE (mg/1)	PESTICIDES DETECTED	FILTERED	TESTS RUN
40	POTATO/ MARKET GARDEN	PITTSFIELD	TILL	BR	--	08/01/85	24.8[3]	NONE	NO	II,NO3
41	POTATO	FRYEBURG	S & G	OVB	16'	07/23/85	17.2[3]	trace(endosulfan)	YES[1]	II,I,NO3,AS
						09/13/85	15.2[3]	NONE	YES[1]	II,MON,NO3,AS
						11/22/85	19.2[3]	NONE	YES[1]	II,I,NO3,AS
42	POTATO	FRYEBURG	S & G	OVB	13'	07/24/85	2.56	NONE	YES[1]	II,I,NO3,AS,TEM
43	POTATO	FRYEBURG	S & G	OVB	17'	07/25/85	0	NONE	YES[1]	II,I,NO3,AS,TEM
						09/12/85	<.2	NONE	YES[1]	II,MON,AS,NO3
44	POTATO	FRYEBURG	S & G	OVB	18'	07/24/85	7.17	NONE	YES[1]	II,I,AS,NO3
						09/12/85	6.82	NONE	YES'	II,MON,AS,NO3
45	POTATO/ BEANS	FRYEBURG	S & G	OVB	14'	07/23/85	0.63	NONE	YES[1]	II,TEM,I,NO3,AS
						09/12/85	0.43	NONE	YES[1]	II,MON,AS,NO3
46	POTATO/ BEANS	FRYEBURG	S & G	OVB	10'	07/23/85	0	NONE	YES[1]	II,I,NO3,AS,TEM
	POTATO FORAGE CROP					11/21/85	--	NONE	YES[1]	II,I,AS
						09/18/86	0.22	NONE	YES	II,NO3
47	POTATO/ BEANS	FRYEBURG	S & G	OVB	16'	07/25/86	1.33	NONE	YES[1]	II,I,NO3,AS,TEM
48	POTATO	BRIDGEWATER	S & G	OVB	--	08/26/86	0.70	NONE	NO	II,I,NO3
						09/26/86	<.2	NONE	NO	II,I,MON,NO3
49	POTATO	FT.FAIRFIELD	S & G	OVB	--	07/31/86	7.13	NONE	NO	II,I,NO3
						09/17/86	7.16	NONE	NO	II,NO3
						10/15/86	--	NONE	NO	I
50	POTATO	FT.FAIRFIELD	S & G	OVB	--	07/31/86	7.09	NONE	NO	II,I,NO3
						09/25/86	12.8[3]	NONE	NO	II,I,MON,NO3
						10/29/86	--	NONE	NO	I
51	POTATO	FT.FAIRFIELD	TILL	BR	--	07/30/86	3.78	NONE	NO	II,I,NO3
						09/18/86	4.16	NONE	NO	II,NO3
						10/06/87	4.75	NONE	NO	II,I,MON,NO3
52	POTATO	FT.FAIRFIELD	TILL	BR	--	07/31/86	8.31	NONE	NO	II,I,NO3
						09/17/86	--	NONE	NO	I

TABLE 2 : PESTICIDES IN GROUND WATER STUDY RESULTS (cont'd)

WELL #	CROP TYPE	TOWN	OVERBURDEN MATERIAL	WELL TYPE	DEPTH TO WATER (FT)	DATE SAMPLED	NITRATE (mg/l)	PESTICIDES DETECTED	FILTERED	TESTS RUN
53	POTATO	CARIBOU	S & G	OVB	--	08/12/86	7.37	NONE	NO	II,I,NO3
						09/17/86	8.40	trace(methamidophos)	NO	II,MON,NO3
						10/14/86	--	NONE	NO	I
54	POTATO	FT.FAIRFIELD	S & G	OVB	--	10/30/86	11.0[3]	NONE	NO	II,I,MON,NO3
						07/07/87	11.3[3]	NONE	NO	II,I,NO3
						09/01/87	10.7[3]	NONE	NO	II,MON,NO3
55	POTATO	FT.FAIRFIELD	TILL	OVB	--	07/08/86	7.72	NONE	NO	II,I,NO3
						09/17/86	8.02	---	NO	NO3
56	POTATO	WOODLAND	S & G	OVB	--	06/19/86	4.67	NONE	NO	II,I,NO3
						09/18/86	4.67	NONE	NO	II,MON,NO3
						10/14/86	--	NONE	NO	I
57	POTATO	CARIBOU	TILL	OVB	--	08/09/86	1.82	NONE	NO	II,I,NO3
						10/29/86	1.73	NONE	NO	II,I,NO3,MON
58	POTATO	CHAPMAN	TILL	OVB	3'	08/25/86	1.42	NONE	NO	II,I,NO3
						09/24/86	0.67	trace(methamidophos)	NO	I,MON,NO3
						10/14/86	--	NONE	NO	I
						07/07/87	1.45	NONE	NO	II,I,NO3
						08/31/87	2.96	NONE	NO	II,MON,NO3
59	POTATO	CARIBOU	TILL	OVB	--	07/29/86	7.74	NONE	NO	II,I,NO3
						09/18/86	8.23	NONE	NO	II,MON,NO3
						10/29/86	--	NONE	NO	I
						10/05/87	8.97	NONE	NO	II,I,MON,NO3
60	POTATO	WASHBURN	S & G	SPR[4]	0	07/27/86	0.2	NONE	NO	II,I,NO3
						09/24/86	0.53	NONE	NO	II,I,MON,NO3
						10/14/86	--	NONE	NO	I
61	POTATO	PRESQUE ISLE	TILL	BR	--	08/12/86	6.67	NONE	NO	II,I,NO3
						09/25/86	10.5[3]	NONE	NO	II,I,MON,NO3
						10/30/86	--	NONE	NO	I
62	POTATO	FT.FAIRFIELD	S & G	OVB	--	08/12/86	6.88	NONE	NO	II,I,NO3
						09/18/86	7.07	NONE	NO	II,NO3
						10/29/86	--	NONE	NO	I

TABLE 2 : PESTICIDES IN GROUND WATER STUDY RESULTS (cont'd)

WELL #	CROP TYPE	TOWN	OVERBURDEN MATERIAL	WELL TYPE	DEPTH TO WATER (FT)	DATE SAMPLED	NITRATE (mg/l)	PESTICIDES DETECTED	FILTERED	TESTS RUN
63	POTATO	FT.FAIRFIELD	TILL	BR	--	07/08/86	5.26	NONE	NO	II,I,NO3
						09/17/86	4.89	NONE	NO	II,MON,TEM,NO3
						10/15/86	--	trace(dicamba)[2]	NO	I
						07/06/87	7.67	NONE	NO	II,I,MON,NO3
						09/01/87	9.00	NONE	NO	II,MON,NO3
65	POTATO	FT.FAIRFIELD	S & G	OVB	--	08/26/86	2.22	trace(chlorothalonil)	NO	II,I,NO3
						09/17/86	2.21	NONE	NO	II,MON,NO3
						10/15/86	--	NONE	NO	I
66	POTATO	LIMESTONE	S & G	BR	--	07/30/86	12.2[3]	NONE	NO	II,I,NO3
						09/17/86	9.79	NONE	NO	II,NO3
67	POTATO	WASHBURN	S & G	OVB	--	08/11/86	<.2	NONE	NO	II,I,NO3
						09/24/86	<.2	NONE	NO	II,NO3
68	POTATO	WASHBURN	TILL	BR	--	07/29/86	7.63	1.4UG/L(picloram)[2]	NO	II,I,NO3
						09/24/86	7.56	NONE	NO	II,I,MON,NO3
						10/14/86	--	NONE	NO	I
69	POTATO	CARIBOU	TILL	OVB	--	06/19/86	1.70	NONE	NO	II,I,NO3
						09/18/86	1.67	NONE	NO	II,NO3
70	POTATO	FT.FAIRFIELD	TILL	OVB	--	07/08/86	5.21	NONE	NO	II,I,NO3
						09/17/86	3.72	10UG/L(methamidophos)	NO	II,MON,TEM,NO3
						10/15/86	--	NONE	NO	I
						06/03/87	5.85	NONE	NO	II,I,NO3
						07/06/87	6.30	NONE	NO	II,I,MON,NO3
						08/11/87	6.76	trace(dinoseb)	NO	II,I,NO3
						09/01/87	7.34	NONE	NO	II,MON,NO3
						10/05/87	6.61	NONE	NO	II,I,MON,NO3
71	POTATO	FT.FAIRFIELD	S & G	OVB	--	07/30/86	5.30	NONE	NO	II,I,NO3
						09/18/86	5.47	NONE	NO	II,I,MON,NO3
						10/29/86	--	NONE	NO	I
						10/05/87	3.45	NONE	NO	II,I,MON,NO3
72	POTATO	FT.FAIRFIELD	S & G	OVB	--	07/31/86	13.7[3]	NONE	NO	II,I,NO3
						09/25/86	12.7[3]	NONE	NO	II,NO3
73	POTATO	CARIBOU	TILL	OVB	--	08/11/86	8.25	NONE	NO	II,I,NO3
						09/18/86	8.93	NONE	NO	II,NO3
						10/14/86	--	NONE	NO	I

TABLE 2 : PESTICIDES IN GROUND WATER STUDY RESULTS (cont'd)

WELL #	CROP TYPE	TOWN	OVERBURDEN MATERIAL	WELL TYPE	DEPTH TO WATER (FT)	DATE SAMPLED	NITRATE (mg/l)	PESTICIDES DETECTED	FILTERED	TESTS RUN
74	POTATO	FT.FAIRFIELD	TILL	OVB	0	08/12/86	1.04	NONE	NO	II,I,NO3
						09/18/86	1.98	NONE	NO	II,MON,NO3
75	POTATO	WOODLAND	TILL	BR	--	08/11/86	17.0[3]	trace(metribuzin)	NO	II,I,NO3
								trace(dinoseb)		
						09/24/86	21.2[3]	trace(metribuzin)	NO	II,NO3
						10/14/86	--	NONE	NO	I
						06/03/87	20.1[3]	NONE	NO	II,I,NO3
						07/07/87	19.8[3]	NONE	NO	II,I,MON,NO3
						08/04/87	18.4[3]	.49UG/L(metribuzin)	NO	II,MON,NO3
						09/01/87	20.5[3]	NONE	NO	II,MON,NO3
						10/05/87	19.2[3]	NONE	NO	II,I,MON,NO3
76	POTATO	CARIBOU	TILL	BR	--	08/09/86	7.66	NONE	NO	II,I,NO3
						09/18/86	8.6	trace(methamidophos)	NO	II,MON,NO3
						10/30/86	--	trace(dicamba)	NO	I
						10/05/87	7.16	NONE	NO	II,I,MON,NO3
77	POTATO	FT.FAIRFIELD	S & G	BR	--	08/27/86	4.79	NONE	NO	II,I,NO3
						09/17/86	5.37	NONE	NO	II,NO3
						10/15/86	--	NONE	NO	I
78	POTATO	FT.FAIRFIELD	S & G	OVB	10'	10/31/86	2.87	NONE	YES	II,I,NO3
79	POTATO	WASHBURN	S & G	OVB	8'	10/31/86	1.85	NONE	YES	II,I,NO3
80	POTATO	GRAND ISLE	S & G	OVB	24'	11/12/86	<.2	NONE	YES	II,I,MON,NO3
81	POTATO	PRESQUE ISLE	TILL	OVB	--	11/12/86	11.4[3]	--	YES	NO3
82	POTATO	PRESQUE ISLE	TILL	OVB	--	11/12/86	5.50	NONE	YES	II,I,MON,NO3
83	POTATO	PRESQUE ISLE	S & G	OVB	--	10/30/86	<.2	NONE	YES	II,I,NO3
84	POTATO	PRESQUE ISLE	TILL	BR	--	08/09/86	14.4[3]	NONE	NO	II,I,NO3
						09/25/86	16.9[3]	NONE	NO	II,NO3
						10/29/86	--	NONE	NO	I
85	POTATO	MASARDIS	S & G	OVB	7'	10/30/86	<.2	NONE	YES	II,I,NO3
86	POTATO/ MARKET GARDEN	FT.FAIRFIELD	S & G	OVB	19'	11/12/86	0.47	NONE	YES	II,I,MON,NO3
88	POTATO	FRYEBURG	S & G	OVB	--	11/22/85	<.2	NONE	YES[1]	II,I,AS,NO3
89	POTATO	WOODLAND	TILL	BR	--	07/07/87	4.39	NONE	NO	II,I,NO3
						09/01/87	4.27	NONE	NO	II,MON,NO3

TABLE 2 : PESTICIDES IN GROUND WATER STUDY RESULTS (cont'd)

WELL #	CROP TYPE	TOWN	OVERBURDEN MATERIAL	WELL TYPE	DEPTH TO WATER (FT)	DATE SAMPLED	NITRATE (mg/l)	PESTICIDES DETECTED	FILTERED	TESTS RUN
90	POTATO	FT. FAIRFIELD	TILL	BR	--	07/07/87	5.66	NONE	NO	II,I,NO3
91	POTATO	WOODLAND	TILL	SPR[4]	0	07/07/87 09/01/87	10.0[3] 12.7[3]	NONE NONE	NO NO	II,I,NO3 II,MON,NO3
92	POTATO	FT. FAIRFIELD	TILL	BR	--	07/06/87 09/01/87	1.29 1.59	NONE NONE	NO NO	II,I,MON,NO3 II,MON,NO3
93	POTATO	CHAPMAN	S & G	BR	--	07/07/87 08/31/87	2.07 1.48	NONE NONE	NO NO	II,I,NO3 II,MON,NO3
94	POTATO	EXETER	TILL	BR	--	07/09/87	10.1[3]	NONE	NO	II,I,NO3
95	POTATO	CHARLESTON	TILL	BR	--	07/09/87	3.35	NONE	NO	II,I,NO3
96	POTATO	CORINNA	TILL	SPR[4]	2	07/09/87	1.14	NONE	NO	II,I,MON,NO3
97	POTATO	PRESQUE ISLE	TILL	BR	--	08/04/87 08/31/87	4.03 3.66	NONE NONE	NO NO	II,MON,NO3 II,MON,NO3
99	TREE FARM	OAKFIELD	TILL	BR	--	09/02/87	4.32	NONE	NO	II,MON,NO3
100	POTATO	FT. FAIRFIELD	TILL	BR	8	11/18/87 11/19/87	2.86 2.90	NONE NONE	NO NO	II,I,MON,NO3 II,I,MON,NO3
101	POTATO	FT. FAIRFIELD	TILL	BR	--	01/21/88	7.46	---	NO	NO3
102	POTATO	PRESQUE ISLE	TILL	BR	--	01/21/88	1.01	---	NO	NO3
103	POTATO	EASTON	TILL	BR	--	01/21/88	3.58	---	NO	NO3
104	POTATO	PRESQUE ISLE	S & G	BR	--	01/21/88	7.83	---	NO	NO3

KEY

GEOLOGIC SETTING

S & G = SAND AND GRAVEL
TILL = TILL

WELL TYPE

OVB = OVERBURDEN WELL
BR = BEDROCK WELL
SPR = SPRING/SEEP

TESTS RUN

SCREENS

I = I SCREEN
II = II SCREEN
AS = ARSENIC
CU = COPPER
NO3 = NITRATE

SPECIAL TESTS

DITH = DITHIOCARBAMATE
METH = METHOMYL
TEM = TEMIK
MON = MONITOR

NOTES:

1 - CERTAIN PESTICIDES WERE FILTERED OUT WITH THE FILTERS USED.
2 - NOT AN AGRICULTURAL CHEMICAL. USED AS A RIGHT-OF-WAY HERBICIDE.
3 - EXCEEDS THE STATES' DRINKING WATER STANDARD OF 10.0 mg/l FOR NITRATE.
4 - FOR STATISTICAL PURPOSES SPRING SAMPLE SITES ARE CONSIDERED OVERBURDEN WELLS.
5 - THESE CHEMICALS ARE NOT USED IN BLUEBERRY AGRICULTURE. THEIR DETECTION IS CONSIDERED TO BE A LABORATORY ERROR; THESE RESULTS ARE NOT INCLUDED IN STATISTICAL ANALYSES.

<u>APPENDIX A</u>

Pesticide Selection Project:

Pesticides in Ground Water Group

Contributors

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Overview

The Maine Pesticides in Ground Water Study was recommended by the Ground Water Policy Review Committee. The recommendation was endorsed by then governor Joseph E. Brennan and funding for analytical costs of the study was provided by the Legislature. The study was planned and has been executed by an inter-agency Pesticides in Ground Water Group with representation from the Maine Department of Agriculture, Pesticides Control Board; Maine Department of Environmental Protection; Maine Department of Human Services, Drinking Water Program, Public Health Laboratory; and the U.S. Geological Survey. The Maine Geological Survey was directed to coordinate the project.

The project was conducted over a three-year period, with 1985 as the first year. Because the recommendation was not accepted until the spring of 1985, a quick start was mandatory. The group resolved both to narrow the field of investigation and to utilize the work already done in other states (notably Wisconsin and California) as an aid to design the study.

To guide the selection of pesticides to be analyzed, a pesticide in ground water ranking matrix was developed, as detailed in this appendix. All the scoring and ranking was performed based on data available from existing studies and records. The amount and reliability of data varied among both pesticides and categories. For example, the quantity sold is known much more accurately than the leachability of a particular pesticide. Similarly, one pesticide can be used as either a foliar spray or applied to the soil, with different ground water contamination potentials.

In developing the rankings and selecting sampling locations, a conservative approach was adopted: the "worst case" for any given element was used in the ranking, and wells in the most geologically sensitive locations were selected for sampling. However, new data are being developed by EPA and pesticides manufacturers, particularly on leachability, which may make the rankings less reliable.

The quantity, application, and leachability scores were each developed separately and then combined to yield a total score. The development of each score is explained separately. Quantity and application scores were developed primarily by Pesticides Control Board staff, and leachability scores primarily by the Drinking Water Program.

As the Pesticides Work Group began to function, it immediately became clear that there was a need, due to time and financial constraints, to focus our attention on those pesticides that were both commonly used in Maine and that posed the greatest threat of contamination of ground water. We therefore scored and ranked commonly used, registered pesticides on three attributes: quantity of pesticide sold, method of pesticide application, and the leachability of the pesticide in soils.

Upon completion, the matrix listed 44 pesticides. All 44 were considered for the first round of samples, after which the matrix and analyzed list was refined with new chemicals added to the list.

Quantity Sold

The quantity of pesticide sold was categorized on a scale of 1-10 as follows:

1 = 0 - 5,000 lbs. sold	6 = 30,000 - 40,000 lbs. sold
2 = 5,000 - 10,000 lbs. sold	7 = 40,000 - 50,000 lbs. sold
3 = 10,000 - 15,000 lbs. sold	8 = 50,000 - 60,000 lbs. sold
4 = 15,000 - 20,000 lbs. sold	9 = 60,000 - 300,000 lbs. sold
5 = 20,000 - 30,000 lbs. sold	10 = > 300,000 lbs. sold

The quantity sold and scoring for each pesticide are shown below:

1984 Maine Agricultural Pesticide Sales

Generic Name of Pesticide	Lbs. of Active Ingredient Sold in 1984	Score	Principal Uses
maneb (F)	500,000+	10	Potatoes, apples, broccoli, vegetables, dried beans
mancozeb (F)	581,987	10	Potatoes, apples, broccoli, vegetables, dried beans
dinoseb (H, TK)	323,224	10	Potatoes, peas, dried beans, vegetables
chlorothalanil (F)	129,959	9	Potatoes, broccoli
disulfoton (SI)	58,576	8	Potatoes
phosmet (I)	57,910	8	Apples, potatoes, vegetables
atrazine (H)	54,974	8	Forage corn, sweet corn
methamidophos (I)	47,604	7	Potatoes
captan (F)	37,920	6	Apples, seed treat potatoes, vegetables strawberries, peas
hexazinone (H)	33,540	6	Blueberries
dalapon (H)	32,437	6	Potatoes
metribuzin (H)	24,980	5	Potatoes
linuron (H)	23,825	5	Potatoes
azinphos-methyl (I)	18,033	4	Blueberries, apples, potatoes
diquat (TK)	17,980	4	Topkill potatoes
metolachlor (H)	14,242	3	Forage corn, sweet corn
PCNB (STF)	13,059	3	Seed treat potatoes
aldicarb (SI)	12,906	3	Potatoes
E.P.T.C. (H)	12,847	3	Potatoes, dried beans, beans

carbofuran (SI)	12,291	3	Forage corn, potatoes, vegetables
carbaryl (I)	12,145	3	Vegetables, sweet corn, potatoes, apples
metalaxyl (F)	11,899	3	Potatoes
cyanazine (H)	10,684	3	Forage corn, sweet corn
butylate (H)	10,645	3	Forage corn, sweet corn
alachlor (H)	10,250	3	Forage corn, sweet corn
demeton (I)	9,888	2	Oats, potatoes, apples
glyphosate (H)	9,572	2	Apples, sweet corn, beans, vegetables
endosulfan (I-SI)	8,420	2	Potatoes, apples, vegetables
dodine (F)	7,341	2	Apples
thiabendazole (STF)	6,429	2	Potatoes-seed treatment
simazine (H)	5,985	2	Apples, forage corn, Christmas trees
dichlone (F)	4,855	1	Apples
napropamide (H)	4,734	1	Broccoli, strawberries, vegetables
copper sulfate (F)	4,729	1	Apples
trifluralin (H)	3,848	1	Peas, broccoli, dried beans, vegetables
cupric hydroxide (F)	3,455	1	Apples, dried beans
dicamba (H)	3,100	1	Corn, R.O.W.
benomyl (F)	2,597	1	Blueberries, apples, dried beans, strawberries
oxydemeton-methyl (I)	2,340	1	Potatoes, vegetables
diazinon (I)	2,205	1	Vegetables

KEY:

F = fungicide	SI = soil incorporated granular insecticide
H = herbicide	STF = seed treatment fungicide
I = insecticide	TK = topkill

It should be noted that the top six pesticides are all used on potatoes, and that only 16 of this list are <u>not</u> used on potatoes.

Application Method

The application method and timing is an important variable in determining the likelihood of ground water transport. Clearly, a foliar application during July, a normally dry season, has less chance of reaching ground water than a spring soil injection of the same material. A rating key for pesticide application methods is shown below:

RATING KEY

APPLICATION METHOD	TIMING	DOSE (in maximum number of lbs/acre/year)
4 = Soil incorporated	3 = Spring	3 = 8 and above
3 = Applied to soil	2 = Fall	2 = 3 - 8
2 = Seed treatment	1 = Summer	1 = 0 - 3
1 = Foliar application		

Each chemical was ranked based on its dominant use. The highest score would be generated by a soil incorporated pesticide (4) applied in the spring, during recharge (3) at a rate of 8 or more pounds per acre (3) for a total of 10. The lowest rating would be achieved by a foliar application (1) during the summer (1) at a rate of less than 3 lbs/acre (1); for a score of 3. The results of the application rating are as follows:

PESTICIDE APPLICATION RATING

PESTICIDE	APPLICATION METHOD	TIMING	DOSE	SCORE
dalapon	3	3	3	9
E.P.T.C.	4	3	2	9
disulfoton	4	3	1	8
carbofuran	4	3	1	8
cyanazine	3	3	2	8
butylate	3	3	2	8
alachlor	3	3	2	8
aldicarb	4	3	1	8
napropamide	4	3	1	8
trifluralin	4	3	1	8
PCNB	2	3	3	8
dinoseb	2	2.5	3	7.5
hexazinone	3	3	1	7
metribuzin	3	3	1	7
linuron	3	3	1	7
metolachlor	3	3	1	7
glyphosate	3	3	1	7
simazine	3	3	1	7
atrazine	3	3	1	7
captan	1	3	3	7

thiabendazole	2	3	1	6
maneb or mancozeb	1	1	3	5
phosmet	1	1	3	5
copper sulfate	1	1	3	5
chlorothalanil	1	1	3	5
carbaryl	1	1	3	5
azinphos-methyl	1	1	2	4
diquat	1	2	1	4
methamidophos	1	1	2	4
endosulfan	1	1	2	4
dodine	1	1	2	4
dichlone	1	1	2	4
benomyl	1	1	2	4
metalaxyl	1	1	1	3
demeton	1	1	1	3
cupric hydroxide	1	1	1	3
oxydemeton	1	1	1	3
diazinon	1	1	1	3
picloram	1	1	1	3
dicamba	1	1	1	3

Leachability

The leachability score is subdivided into four parts. First, pragmatically, the pesticide was scored on whether it had been found in ground water. A pesticide found in ground water in Maine, or on EPA's list of mobile pesticides received a 3.

Secondly, the pesticides were rated on laboratory water solubility on an exponential scale, with those soluble at greater than 300 ppm scored as 2. Thirdly, they were scored on their affinity for organic matter in soils, with a low affinity given 1 point. Finally, they were scored on their stability in the soil system. Sub-components of this score were soil degradation, hydrolysis and photodegradation, and laboratory or field half life. The maximum score was 4. The leachability criteria and ratings are shown below:

CRITERIA FOR RATING LEACHABILITY

(1) Found in ground water MAX Score=3

1 - Not found in ground water, but has high leaching potential
2 - Found in ground water
3 - On EPA known "leachers" list or has been found in ground water in Maine.

(2) Solubility in water MAX Score=2

0 - Less than 30 ppm
1 - Greater than 30 ppm
2 - Greater than 300 ppm

(3) Affinity for organic matter MAX Score=1

Kd (Soil/water adsorption coefficient) is less than 5 and usually less than 1 or 2.
Koc (Kd divided by soil organic carbon content) is less than 300-500.

(4) Stability of pesticides

Soil degradation MAX Score=2

1 - Soil half life is greater than 2 to 3 weeks but less than 6 months.

2 - Soil half life is greater than 6 months.

Hydrolysis and photodegradation: MAX Score=1
Hydrolysis half life is greater than 6 months or photolysis half life is greater than 2 - 3 weeks.

Laboratory/field half life: MAX Score=1
Greater than 2 - 3 weeks

LEACHABILITY RATING

Pesticide Name	found in ground water	solubility in water	affinity for organic matter	stability in soils	Total
1. Aldicarb	3	2	1	4	10
2. Carbofuran	3	2	1	4	10
3. Metribuzin	3	2	1	4	10
4. Atrazine	3	1	1	4	9
5. Metholachlor	2	2	1	4	9
6. Picloram	3	2	-	4	9
7. Dinoseb	3	1	1	3	8
8. Alachlor	3	1	1	3	8
9. Simazine	3	0	1	4	8
10. Hexazinone	3	2	1	2	8
11. Azinophos-methyl	3	1	0	3	7
12. Thibendazole	1	2	0	4	7
13. Maneb	3*	1	1	2	7
14. Mancozeb	3*	1	1	2	7
15. Dicamba	3	2	-	2	7
16. Linuron	0	1	1	4	6
17. Paraquat	0	2	0	4	6
18. Endosulfan	3	1	0	2	6
19. Methamidophos	3	1	1	1	6
20. Dalapon	0	2	1	2	5
21. Metalaxyl	0	2	1	2	5
22. Butylate	0	1	1	3	5
23. Glyphosate	0	2	0	3	5
24. Chlorothalonil	3	0	0	2	5
25. E.P.T.C.	0	2	0	2	4
26. Carbaryl	0	1	1	2	4

27. Cyanazine	0	1	1	2	4
28. Dodine	0	2	0	2	4
29. Pentachloro-nitrobenzene	-	-	-	-	4
30. napropamide	-	-	-	-	4
31. Oxydemeton	-	-	-	-	4
32. Diazinon	-	-	-	-	4
33. Endothal	-	-	-	-	4
34. Malathion	-	-	-	-	4
35. Permethrin	0	0	0	3	3
36. Disulfoton	2	0	0	0	2
37. Diquat	0	2	0	0	2
38. Demeton	0	2	0	0	2
39. Dichlone	0	0	0	2	2
40. Triflualin	0	0	0	2	2
41. Methomyl	0	0	0	2	2
42. Benomyl	0	0	0	2	2
43. Phosmet	0	0	0	0	0
44. Captan	0	0	0	0	0

*Found in ground water as breakdown-product ethylene thiourea (ETU).

Summary

The scores were combined using a number of techniques in an attempt to develop a realistic ranking of likelihood for ground water transport. The first attempt utilized a non-parametric, or ordinal, approach, which simply added ranks of pesticides, so that the lowest score was the most likely to be found in ground water. There were some objections that this did not fairly represent the range of variability in the data, so later approaches used the actual scores from each ranking.

The scores of each pesticide for the four parameters were then put into a master matrix shown in the table following this discussion. Column 1 of this table ranks the pesticides in decreasing score. Column 2 is the pesticide name. Column 3 is the quantity sold score. Column 4 is the pesticide application score. Column 5 is the leachability score. Column 6 is the unweighted score, which is the average of the values in columns 3, 4, and 5. Column 7 is the analyzability of each pesticide, based on Maine Public Health Laboratory capabilities.

PESTICIDE IN GROUND WATER RANKING MATRIX

Rank	Pesticide Name	Quantity	How Applied	Leachable	Score	Testable
1	dinoseb	10	7.5	8	8.50	yes
2	atrazine	8	7	9	8.00	yes
3	metribuzin	5	7	10	7.33	yes
4	mancozeb	10	5	7	7.33	yes
5	maneb	10	5	7	7.33	yes
6	carbofuran	3	8	10	7.00	yes
7	aldicarb	3	8	10	7.00	yes
8	hexazinone	6	7	8	7.00	yes
9	dalapon	6	9	5	6.67	yes
10	alachlor	3	8	8	6.33	yes
11	metolachlor	3	7	9	6.33	?
12	chlorothalonil	9	5	5	6.33	yes
13	linuron	5	7	6	6.00	yes
14	disulfoton	8	8	2	6.00	no
15	simazine	2	7	8	5.67	no
16	methamidophos	7	4	6	5.67	yes
17	butylate	3	8	5	5.33	yes
18	E.P.T.C.	3	9	4	5.33	yes
19	azinphos-methyl	4	4	7	5.00	yes
20	cyanazine	3	8	4	5.00	?
21	PCNB	3	8	4	5.00	yes
22	thiabenzadole	2	6	7	5.00	yes
23	glyphosate	2	7	5	4.67	no
24	captan	6	7	0	4.33	yes
25	phosmet	8	5	0	4.33	yes
26	napropamide	1	8	4	4.33	no
27	endosulfan	2	4	6	4.00	yes
28	carbaryl	3	4	4	3.67	yes
29	metalaxyl	3	3	5	3.67	?
30	trifluralin	1	8	2	3.67	yes
31	dicamba	1	3	7	3.67	yes
32	dodine	2	4	4	3.33	no
33	diquat	4	4	2	3.33	no
34	picloram		3	9	3.00	yes
35	diazinon	1	3	4	2.67	yes
36	oxydemeton	1	3	4	2.67	?
37	paraquat	1		6	2.33	no
38	benomyl	1	4	2	2.33	no
39	demeton	2	3	2	2.33	no
40	dichlone	1	4	2	2.33	no
41	copper sulfate	1	5		2.00	yes
42	endothal	1		4	1.67	no
43	malathion	1		4	1.67	yes
44	permethrin	1		3	1.33	no
45	cupric hydroxide	1	3		1.33	yes
46	methomyl	1		2	1.00	no

APPENDIX B

Ethylene Thiourea in Maine Ground Water

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Maine Geological Survey

January, 1989

Background

Ethylene thiourea (ETU) is a contaminant in and a metabolite and environmental decomposition product of the ethylene bis-dithiocarbamate (EBDC) fungicides (USEPA, June 1987). There are five such active ingredients currently registered: mancozeb, maneb, metriam, nabam, and zineb (USEPA, July 1987). Maneb and mancozeb, used to control blight on Maine's potato crop, are the most heavily used pesticides in Maine, with over one million pounds purchased annually (Neil et al., 1987). The parent EBDC compounds are quite insoluble in water and pose little threat of ground water contamination. However, they degrade rapidly in soil (half life 1-2 days) into ETU which is quite soluble and quite mobile under certain soil conditions (USEPA, August, 1987), and which poses a significant threat to ground water.

There is concern regarding the health effects of drinking water contaminated by ETU. The U.S. Environmental Protection Agency has classified ETU as a Group B2 oncogen (probable human carcinogen) (USEPA, June 1987). ETU is also considered a teratogen and a thyroid toxin. EPA does not publish lifetime Health Advisory Limits for B2 carcinogens. However, in August, 1987 EPA did publish a Drinking Water Equivalent Level of 1 ug/l ETU (USEPA, August 1987). Concurrently, the Maine Department of Human Services developed a Maximum Exposure Guideline, based on ETU's teratogenic and carcinogenic potential, of 3 ug/l ETU in drinking water (Frakes, 1987).

Treatment Technologies

No information was found concerning the treatment of drinking water contaminated by ETU. The chemical characteristics of ETU do not appear amenable to any of the conventional ground water treatment technologies. ETU has a high solubility (20 g/l) and is hydrophilic, so treatment with activated carbon probably would not be effective. The structure of ETU indicates it is not ionic and thus ion exchange would be ineffective. Vapor pressure data are unavailable, so the effectiveness of aeration cannot be estimated. However, the high melting point (203°C) and the high solubility indicate that aeration or air stripping would probably not be an effective form of treatment (USEPA, August 1987). ETU does, however, degrade rapidly by photolysis, so exposing contaminated water to UV radiation or sunlight may prove an effective treatment.

Previous Studies

Previous sampling programs that included ETU analyses are rare, and have been inconclusive in documenting ground water contamination due to agricultural use of EBDC fungicides. Cohen and Bowes (1984), in a report on water quality and pesticides done for the California Water Resources Control Board, analyzed one ground water sample for ETU. It was positive at 7 ug/l ETU. This sample was taken from a well at a chemical manufacturing plant and the contamination was not due to agricultural practices. A 1984 study by the New Brunswick Department of Health reported widespread ETU contamination of ground water associated with the potato growing industry in Carleton County (Ecobichon et al., 1985). However, further research revealed that the laboratory method used commonly gave false positive results to ETU analyses so the study was invalidated (Sexsmith, pers. commun., 1988). In a draft health advisory issued in August, 1987 the EPA reported "ETU was not found in sampling performed at 250 ground water stations, according to the STORET database."

Methodology and Results

From 1986 to 1988 the Maine Geological Survey (MGS), together with the Board of Pesticides Control, Maine Department of Agriculture, Food and Rural Resources collected ground water samples to be analyzed for ETU in conjunction with Maine's Pesticides in Ground Water Study. A total of 94 samples from 53 different wells in the potato growing area of northern Maine were analyzed. All ground water samples were collected from domestic wells or monitoring wells adjacent to fields treated with EBDC fungicides, and were analyzed by the Maine Public Health Laboratory.

Prior to 1986 the Maine Public Health Laboratory did not have a method to detect ETU. In early 1986 a procedure originally used in the Iowa Pesticide Hazard Assessment Program was modified and attempted (Iowa Pesticide Hazard Assessment Program, 1981). Laboratory protocol had not yet been fully developed, particularly regarding laboratory holding time and preservation of ETU in the sample bottle. Samples were obtained by running water at the well owner's tap until the storage tank had been emptied and fresh water from the well was obtained. Samples were collected in one liter amber bottles, put on ice and delivered to the laboratory as soon as possible.

Twenty-five water samples were collected and analyzed using the above procedures, but were held more than four months at the laboratory awaiting final development of the analysis method. Three of these samples were positive for what was assumed to be ETU, at trace levels well below the statistically sound laboratory minimum level of detection (MLD). In the fall of 1986 recovery studies run by the Maine Public Health Laboratory using the Iowa analysis procedure, showed that the chromatograph spike was not, in fact, ETU. The method was abandoned and the results invalidated (Collins, 1988).

By early 1987 a new laboratory method for detecting ETU, developed by the EPA for the National Pesticide Survey, was adopted (USEPA, October 1987). Much refined, the MLD for this method is 1.0 ug/l as determined by the Maine Public Health Laboratory staff. The published estimated detection limit from the EPA is 5 ug/l ETU. This methodology specified the laboratory protocol and a maximum holding time of 28 days was suggested.

Eight samples were collected for Maine's Pesticides in Ground Water Study using the same sampling procedures as in 1986 but with analysis made with the new laboratory method. Two of the eight samples analyzed reportedly contained trace levels of ETU. However, laboratory priorities delayed analysis of these samples more than two months, considerably longer than the suggested 28 day holding time. The results are presented in Table 1.

Table 1. Results of ETU analyses using EPA laboratory method and the original sampling procedure.

WELL #	SAMPLE DATE	ANALYSIS DATE	HOLDING TIME	RESULTS (UG/L)
30	10-5/6-87	12-15-87	70 days	N/F (not found)
31	"	"	"	N/F
51	"	"	"	N/F
59	"	"	"	N/F
70	"	"	"	trace
71	"	"	"	trace
75	"	"	"	N/F
76	"	"	"	N/F
PHL Spike - (50.0 ug/l) - Percent Recovery-- 126.7%				

Late in 1987 a new sampling protocol was adopted. Samples are now collected in 60 ml glass vials treated with a preservative, mercuric chloride, to retard further breakdown of the ETU. Also, a duplicate sample, or spare, is taken from each well. Sixty-one samples were collected in several batches using the new sampling procedure and analyzed by the EPA laboratory method. Holding times varied but were generally less than one month. The results for both the samples and the spares are presented in Table 2 at the back of this Appendix.

Discussion

Nearly one-half of the samples shown in Table 2 tested positive for ETU. However, quality control measures used for this study show these results to be questionable.

With each sample collected a duplicate sample, or spare, was also taken. The sample and its spare were collected and transported to the laboratory under identical conditions. Presumably, the results of their analyses should be similar. However, as shown in Table 2, results for a sample frequently were not reproduced by its spare.

Spikes are samples prepared with a known concentration of a particular chemical. With each batch of ETU samples analyzed, the Maine Public Health Laboratory ran spike samples as an internal quality control measure. Additionally, spike samples were prepared in the field and submitted with the other samples. The results of the analyses of spike samples are given in Table 2. Percent recovery from the spike samples prepared at Maine Public Health Laboratory ranged from 27% to 222%. Recovery from the field spikes submitted by MGS ranged from 47% to 128%.

Blanks are samples of deionized water assumed to contain no pesticides. The Maine Public Health Laboratory ran blanks with each batch of ETU samples analyzed. Blank samples were also prepared in the field and submitted with the other samples. The results of the analyses of blank samples are given in Table 2. Three of the "blanks" prepared at the Maine Public Health Laboratory tested positive for what appeared to be ETU. All field blanks submitted were negative.

With the problems encountered with the analysis procedure in mind, it was decided to send duplicate samples to other laboratories for confirmation. The first "splits" were done on 9 samples collected in March, 1988. Duplicate sets of samples were sent to the laboratory at the Rohm and Haas Company, a manufacturer of EBDC fungicides and to the EPA laboratory at Lexington, Massachusetts. The results are shown below.

WELL #	RESULTS (ETU in ug/l)		
	PHL	Rohm and Haas	EPA
Reported MLD	1 ug/l	1 ug/l	5 ug/l
51	trace	N/F	N/F
54	N/F	N/F	N/F
58	1.01	N/F	N/F
59	N/F	N/F	N/F
71	N/F	N/F	N/F
84	trace	N/F	N/F
101	N/F	N/F	N/F
Blank	N/F	N/F	N/F
Spike	(150 ug/l)-71 ug/l	(125 ug/l)-4 ug/l	(190 ug/l)-100+ ug/l
Recovery	47%	3%	53+%

The second splits were made on 15 samples collected in October, 1988. Duplicate samples were sent to Battelle Laboratory in Columbus, Ohio, which the EPA is using for ETU analyses for the National Pesticide Survey. Those results are shown below.

WELL#	RESULTS (ETU in ug/l)	
	PHL	Battelle
105	N/F	N/F
106	N/F	3.0
107	N/F	N/F
108	N/F	N/F
109	N/F	N/F
110	trace	N/F
111	N/F	N/F
112	N/F	N/F
113	N/F	N/F
114	1.13	N/F
115	N/F	N/F
116	N/F	N/F
117	N/F	N/F
Spike (3.0 ug/l)	3.0	N/F
Spike (9.0 ug/l)	10.0	trace

The fact that results from samples and spares are not consistent, the wide range in percentage of recovery from spiked samples, the positive results from supposedly blank samples, and the lack of confirmation of results between laboratories raises doubts on the reliability of the procedure used to detect ETU. For these reasons the results of the ETU analyses were omitted from the full Pesticides in Ground Water report. However, based on the fact that false positives were not found in the field blanks, it appears that positive ETU findings in ground water are real, even if the results can not be accurately quantified.

Summary

Ethylene thiourea is a breakdown product of the most widely used agricultural chemicals in Maine, maneb and mancozeb. It has been classified by the EPA as a probable human carcinogen. It is quite soluble in water and is fairly mobile in the subsurface. As such it poses a significant risk of contaminating ground water. The Medical Advisory Committee of the Maine Board of Pesticides Control considers ETU to be one of the most toxic compounds they have reviewed to date and recommend the Board place the EBDC fungicides on the restricted use list (Jennings, pers. commun., 1989).

The results of this study suggest that ETU may be present in Maine ground water in some agricultural areas. However, the results also show that a reliable laboratory test for ETU in water has not yet been developed, preventing accurate quantification of ETU levels. Considering the toxicity of ETU, and the suggestion that ETU may be present in drinking water wells in Maine, further research on this issue is imperative.

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TABLE 2 - ETU RESULTS

WELL #	SAMPLE DATE	ANALYSIS DATE	HOLDING TIME	RESULTS (ug/l)
100	11-18-87	12-16/17-87	29 days	18.03*
100sp	"	"	"	N/F*
100	11-19-87	"	"	27.68*
100sp	"	"	"	N/F*

MPHL Spike - (10.0 ug/l) - Percent recovery-- 96.3%
MPHL Spike - (20.0 ug/l) - Percent recovery-- 58.1%
MPHL Blank - 0.0 ug/l

*These samples were collected at the beginning (11-18-87) and end (11-19-87) of a 30 hour pump test conducted on this well, which was pumped at a rate of 28 gpm over the 30 hour period. It is possible that the sample bottles were mislabeled, and that both positive results were from samples collected on the same day, either at the beginning or end of the pump test.

104	1-21-88	2-2-88	12 days	1.85
104sp	"	"	"	1.48
89	"	"	"	1.85
89sp	"	"	"	1.85
102	"	"	"	2.27
102sp	"	"	"	2.27
75	"	"	"	N/F
75sp	"	"	"	N/F

MPHL Spike - (10.0 ug/l) - Percent recovery-- 67.5%
MPHL Blank - 0.0 ug/l

57	1-21-88	2-2-88	12 days	2.59
57sp	"	"	"	2.27
30	"	"	"	3.06
30sp	"	"	"	2.76
103	"	"	"	1.96
103sp	"	"	"	2.14
37	"	"	"	1.90
37sp	"	"	"	2.25
50	"	"	"	1.69

MPHL Spike - (10.0 ug/l) - Percent recovery-- 221.9%
MPHL Blank - 0.0 ug/l

50sp	1-21-88	2-2-88	12 days	3.22
54	"	"	"	2.63
54sp	"	"	"	3.95
58	"	"	"	2.87
58sp	"	"	"	3.59
101	"	"	"	2.91
101sp	"	"	"	3.71
84	"	"	"	9.21

MPHL Spike - (15.0 ug/l) - Percent recovery-- 209.9%
MPHL Blank - 0.0 ug/l

TABLE 2 - ETU RESULTS (cont.)

WELL #	SAMPLE DATE	ANALYSIS DATE	HOLDING TIME	RESULTS (UG/L)
33	2-12-88	3-31-88	48 days	N/F
33sp	"	"	"	trace
34	"	"	"	trace
34sp	"	"	"	trace
MPHL Spike - (3.0 ug/l) - Percent recovery-- 167.7%				
MPHL Spike - (5.0 ug/l) - Percent recovery-- 100.6%				
MPHL Blank - 0.0 ug/l				
59	3-8-88	4-1-88	24 days	N/F
59sp	"	"	"	N/F
51	"	"	"	trace
51sp	"	"	"	N/F
84	"	4-4-88	27 days	N/F
84sp	"	"	"	trace
MPHL Spike - (10.0 ug/l) - Percent recovery-- 89.0%				
MPHL Spike - (5.0 ug/l) - Percent recovery-- 117.0%				
MPHL Blank - 0.0 ug/l				
54	3-8-88	4-4-88	27 days	N/F
54sp	"	"	"	N/F
71	"	"	"	N/F
71sp	"	"	"	N/F
101	"	4-1-88	24 days	N/F
101sp	"	"	"	N/F
MPHL Spike - (10.0 ug/l) - Percent recovery-- 122.6%				
MPHL Spike - (20.0 ug/l) - Percent recovery-- 87.7%				
MPHL Blank - 0.0 ug/l				
58	3-8-88	4-5-88	28 days	1.01
58sp	"	"	"	trace
MGS Field Blank		4-4-88	27 days	N/F
MGS Field Blank sp		"	"	N/F
MGS Field Spike - (150.0 ug/l) - Percent recovery-- 46.6%				
MGS Field Spike sp - (150.0 ug/l) - Percent recovery-- 47.5%				
MPHL Spike - (5.0 ug/l) - Percent recovery-- 96.2%				
MPHL Spike - (10.0 ug/l) - Percent recovery-- 93.8%				
MPHL Blank - 0.0 ug/l				
30	7-28-88	9-14-88	48 days	N/F
30sp	"	"	"	N/F
58	"	"	"	2.19
58sp	"	"	"	N/F
84	"	"	"	9.35
84sp	"	"	"	N/F
101	"	"	"	N/F
101sp	"	"	"	N/F
MPHL Spike - (10.0 ug/l) - Percent recovery-- 29.2%				
MPHL Blank - 0.0 ug/l				

TABLE 2 - ETU RESULTS (cont.)

WELL #	SAMPLE DATE	ANALYSIS DATE	HOLDING TIME	RESULTS (UG/L)
30	8-15-88	9-14-88	30 days	N/F
30sp	"	"	"	5.70
58	"	"	"	N/F
58sp	"	"	"	N/F
84	"	"	"	1.93
84sp	"	"	"	N/F
101	"	"	"	2.22
101sp	"	"	"	N/F
MPHL Spike - (20.0 ug/l) - Percent recovery-- 27.0%				
MPHL Blank - 0.0 ug/l				
30	8-26-88	9-14-88	20 days	N/F
30sp	"	"	"	N/F
58	"	"	"	N/F
58sp	"	"	"	8.39
84	"	"	"	N/F
84sp	"	"	"	N/F
101	"	"	"	N/F
101sp	"	"	"	3.48
MPHL Spike - (10.0 ug/l) - Percent recovery-- 113.5%				
MPHL Blank - 0.0 ug/l				
30	9-9-88	9-14-88	5 days	N/F
30sp	"	"	"	N/F
58	"	"	"	N/F
58sp	"	"	"	11.45
84	"	"	"	N/F
84sp	"	"	"	N/F
101	"	"	"	N/F
101sp	"	"	"	N/F
MPHL Spike - (5.0 ug/l) - Percent recovery-- 85.2%				
MPHL Blank - 0.0 ug/l				
30	9-22-88	9-22-88	same day	N/F
30sp	"	"	"	N/F
58	"	"	"	N/F
58sp	"	"	"	N/F
84	"	"	"	N/F
84sp	"	"	"	N/F
101	"	"	"	N/F
101sp	"	"	"	N/F
MPHL Spike - (5.0 ug/l) - Percent recovery-- 145.0%				
MPHL Blank - 3.5 ug/l				

TABLE 2 - ETU RESULTS (cont.)

WELL #	SAMPLE DATE	ANALYSIS DATE	HOLDING TIME	RESULTS (UG/L)
30	10-6-88	10-7-88	1 day	N/F
30sp	"	"	"	N/F
58	"	"	"	N/F
58sp	"	"	"	N/F
84	"	"	"	N/F
84sp	"	"	"	N/F
101	"	"	"	N/F
101sp	"	"	"	1.62
MPHL Spike - (10.0 ug/l) - Percent recovery-- 92.5%				
MPHL Blank - 4.5 ug/l				
105	10-5-88	10-11-88	6 days	N/F
105sp	"	"	"	N/F
106	"	"	"	N/F
106sp	"	"	"	N/F
107	"	"	"	N/F
107sp	"	"	"	N/F
108	"	"	"	N/F
108sp	"	"	"	N/F
109	"	"	"	N/F
MPHL Spike - (10.0 ug/l) - Percent recovery-- 67.5%				
MPHL Blank - 0.0 ug/l				
110	10-5-88	10-11-88	6 days	0.90
110sp	"	"	"	N/F
111	"	"	"	N/F
111sp	"	"	"	N/F
112	"	"	"	N/F
112sp	"	"	"	N/F
113	"	"	"	N/F
113sp	"	"	"	N/F
114	"	"	"	N/F
114sp	"	"	"	1.13
MPHL Spike - (5.0 ug/l) - Percent recovery-- 110.0%				
MPHL Blank - 5.25 ug/l				
115	10-5-88	10-11-88	6 days	N/F
115sp	"	"	"	N/F
116	"	"	"	N/F
116sp	"	"	"	N/F
117	"	"	"	N/F
117sp	"	"	"	N/F
MGS Field Spike - (9.0 ug/l) - Percent recovery-- 111.0%				
MGS Field Spike sp - (9.0 ug/l) - Percent recovery-- 128.0%				
MGS Field Spike - (3.0 ug/l) - Percent recovery-- 100.0%				
MGS Field Spike sp - (3.0 ug/l) - Percent recovery-- 100.0%				
MPHL Spike - (10.0 ug/l) - Percent recovery-- 85.0%				
MPHL Blank - 0.0 ug/l				