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FILE  
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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SUBJECT: DBCP Experimental Use Permit Review

~~FROM~~ *To* Henry Jacoby, Product Manager 21  
Registration Division TS-767

~~THE~~ *From* Chemist, Environmental Fate Branch  
Hazard Evaluation Division

THRU: Susan Sherman, Acting Deputy Director  
Hazard Evaluation Division

THRU: Dr. Gunter Zweig, Chief  
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This memorandum summarizes my assessment of the DBCP Experimental Use Permit 5481-EUP-R, received January 24, 1980. Briefly, my recommendation is to allow the experimental use permit as proposed but with stringent requirements on selection of use sites. Care should be taken when selecting use sites in order to minimize the potential for ground water contamination. In this memorandum, I explain how to select the use sites.

Background

Amvac Chemical Corp. proposes to test a new closed chemical transfer and applicator system. Amvac feels that use of this system will reduce crop residues and worker exposure to DBCP. Thus they wish to generate this data to use in the cancellation hearings.

However, no mention is made anywhere in the proposal about the possibility of ground water contamination.

Amvac proposes to test a maximum total of 12,000 pounds of DBCP, 256 acres, and 41 crops. At the treatment sites (which will be in different areas depending on availability), workers will sample air, soil foliage, bark, crops, and decontamination rinsate. The soil samples will be one inch deep, and the air samples will be taken at various times during and after transfer and application. Fields will be posted and various precautions will be taken to protect workers. Detailed methods for sampling and analysis are attached to the proposal.

Impact on Risk Analysis

Results from the proposed EUP may significantly increase our knowledge about exposure during mixing/loading operations and reverse transfer. Applicator exposure data will probably not have a large impact on our exposure analysis. There will be no impact on our knowledge of drinking water contamination.

Recommendation

Dave Severn, of my branch, reviewed the worker exposure aspects of the proposal and has no comment.

I am concerned about possible contamination of ground water. Therefore, I propose that the following criteria be used by Amvac or their coworkers to select the DBCP application sites. Use of these criteria will minimize the potential for ground water contamination. They are listed in order of decreasing preference, from most preferable to least preferable.

1. Sampling sites should be selected that do not overlie aquifers\*, and are not in the immediate vicinity of aquifers (approximately 1/2 to 1 mile).
2. Sampling sites should be selected that are not recharge sites for aquifers or in the immediate vicinity of aquifers. An example of such a suitable site is a field that overlies an artesian aquifer that is confined by an impervious clay layer. Recharge data can be obtained from United States Geological Survey staff (district and sub-district offices), state water management district staff, and in some cases local university scientists and USDA regional staff (extension agents and staff of the Soil Conservation Service).
3. If application sites overlie aquifers, they should be chosen using the criteria below. When the criteria are properly applied, DBCP that leaches should be retained in the soil

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\*For the purpose of this document, I define aquifers as strata of water bearing material (e.g., rock, sand) capable of sustaining potable water supplies in small private wells (a few gallons per minute) or greater quantities.

profile long enough so that 95% of the DECP in the soil is hydrolyzed before reaching the water table (the top of the aquifer). The calculations for the criteria are simplistic and based on our present state of knowledge which is constantly improving. Data required to apply these criteria are aquifer recharge rates, depth to the water table, and percent organic carbon content of the soil. Recharge rates and water table elevations can be obtained from the information sources identified above. Recharge rates can also be estimated by subtracting evapotranspiration rates (calculated from pan evaporation data multiplied by a pan coefficient) and runoff rates (estimated) from the annual precipitation and irrigation water rates (in/yr or ft/yr) for the site of concern. Changes in soil moisture storage capacity need not be considered because they are usually minimal. Percent organic carbon information can be obtained from extension agents. Note that I refer to organic carbon and not organic matter. The difference is a factor of 1.72.

In my assessment I have considered the soil to be composed of an upper layer and a lower layer. The upper layer is the top three feet of soil and the lower layer is all soil between the top layer and the aquifer.\*

With this in mind, the tables below should be used in the following manner. In Table I, locate the appropriate recharge rate and organic carbon content to determine the approximate length of time DECP will be retained in the top three feet of soil.

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\* Justifications for this assumption and others, as well as detailed calculations, are attached as the Appendix.

Table 1.<sup>1</sup> Approximate Residence Time in Years<sup>2</sup> of DBCP in the Top Three Feet Upper Layer of Soil Profiles with Various Recharge Rates and Organic Contents

% Organic Carbon <sup>3</sup>	Recharge Rates <sup>4</sup>									
	1	2	4	6	9	12	16	20	25	30
0	1.8	0.90	0.45	0.30	0.20	0.15	0.11	0.089	0.072	0.060
1	9.4	4.6	2.4	1.6	1.0	.78	.58	.46	.38	.32
2	17	8.4	4.2	2.8	1.9	1.4	1.1	.84	.68	.56
3	24	12	6.0	4.0	2.8	2.0	1.5	1.2	.98	.82
4	32	16	8.0	5.4	3.6	2.6	2.0	1.6	1.3	1.1
4	40	16	10	6.6	4.4	3.2	2.4	2.0	1.6	1.3
7	54	28	14	9.2	6.0	4.6	3.4	2.8	2.2	1.8
10	76	38	10	13	8.6	6.4	4.8	3.8	3.0	2.6

<sup>1</sup> Calculations and justifications for values in this table appear in the Appendix.

<sup>2</sup> Error is unknown. See the discussion in the Appendix.

<sup>3</sup> Percent organic carbon on the basis of the top 1-1/2 feet of soil. Thus in the calculations in the Appendix this value was divided by  $\frac{1.5 \text{ ft}}{3 \text{ ft}} = 2$ , which yielded the percent organic carbon averaged over the top three feet.

<sup>4</sup> Recharge rates (percolation rates) in inches of water per year.

The time in years from Table I is then added to the time in years obtained from Table II. The values in Table II are estimates of the length of time DECP will be retained in the lower layer. The only data required to use Table II are recharge rates and aquifer depths.

Table II.<sup>1</sup> Approximate Residence Time in Years<sup>2</sup> of DECP in the Lower Layer of Soil Profiles<sup>3</sup> with Various Recharge Rates and Aquifer Depths

Aquifer Depths	Recharge Rates (in/yr)									
	1	2	4	6	9	12	16	20	25	30
20 ft.	51	26	13	8.5	5.7	4.2	3.2	2.6	2.0	1.7
30	81	40	20	14	9.0	6.8	5.1	4.0	3.2	2.7
40	111	56	28	18	12	9.2	6.9	5.6	4.4	3.7
50	141	70	35	24	16	12	8.8	7.0	5.6	4.7
70	201	100	50	34	22	17	13	10	8.0	6.7
90	261	130	65	44	29	22	16	13	10	8.7
120	351	175	88	58	39	29	22	18	14	12
150	441	220	110	74	49	37	28	22	18	15
200	592	295	148	98	66	49	37	30	24	20

<sup>1</sup> Calculations and justifications for values in this table appear in the Appendix. This table cannot be used when it is likely that the subsoil is very porous with a high concentration of solution channels.

<sup>2</sup> Residence time in years. Error is unknown. See the discussion in the Appendix.

<sup>3</sup> The lower layer is bounded by the aquifer and the top three feet of soil.

Thus an estimate of the total residence time of DBCP in the vertical profile can be obtained by locating the appropriate environmental parameters on the two matrices, reading the residence time in each matrix and summing the two times together.

Allowable use sites are those sites for which the total residence time is 25 years or greater. At this point sufficient hydrolysis of DBCP would have occurred such that exposure potential is greatly minimized. These estimates are based on our present understanding of the behavior of organics in the soil profile, which is still an evolving state of the art.

Two sample calculations are as follows.

Example 1

A site in the Southeast is selected where the recharge rate is 20 in/yr, the organic carbon content in the top 1-1/2 ft is 2%, and the water table is 70 ft deep. The total residence time of DBCP in the soil profile will be  $0.84 \text{ yr} + 10 \text{ yr} = 10.8 \text{ yr}$  which is less than 25 yrs so the site is not allowed.

Example 2

A similar site is selected which is nearby. Organic carbon is 2%, recharge rate is 20 in/yr, water table depth is 200 ft. Residence time equals  $.84 \text{ yr} + 30 \text{ yr} = 30.8 \text{ yr}$ , which is greater than 25 years, thus use of DBCP is allowed.

I consulted with soil physicist Carl Enfield, EPA - Ada, Ok., on this scheme, and several of his suggestions were incorporated. Dave Severn, EFB/HED, also provided helpful comments on the worker exposure aspect of this EUP.

Stuart Z. Cohen

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## APPENDIX

### Choice of Division of Soil Profile into Two Layers

In this scheme separate calculations are performed for the upper and lower soil zones, which are bounded by the surface at the top an imaginary line three feet deep in between, and the water table below. Two zones were chosen because 1) the behavior of water (hydrologic balance) varies much more widely near the surface than deeper in the soil profile, and 2) the behavior of DECP should be much different near the surface than deeper in the soil profile due to organic matter near the surface. It is reasonable to consider a three feet depth as the lower limit of the root zone, where almost all evapotranspiration takes place. Below this zone, transient variation of recharge rates is not expected to be very great. I assumed binding of DECP was due solely to the organic matter present (e.g., see Chiou, et al., 1979) and that all organic carbon is present in the top 1-1/2 ft. of the soil profile. Therefore, in my calculations I averaged the organic carbon content over the 3 ft. upper layer (e.g., 2% x 1.5 ft/3 ft = 1%). It is noteworthy that Hydrocomp, Inc., and EPA also divided the soil profile into different zones for the purpose of hydrologic balance (Johanson, et al., 1979). These zones are surface (1/8"), upper (6.0"), and lower (72.0").

### General Equation for Leaching Velocity of DECP

The equation used was

$$V_s = V_w / R, \text{ where}$$

$V_s$  = apparent velocity of solute through the soil profile,  
 $V_w$  = velocity of water through the soil profile,  
and  $R$  = retardation factor of solute.

Also  $V_s = V_r / \Theta$  and  
 $R = 1 + \rho K_d / \Theta$ , where  
 $\Theta$  = water content of soil  
 $V_r$  = annual recharge (percolation) rate of water,  
 $\rho$  = bulk density of soil, and  
 $K_d$  = soil water distribution coefficient obtained or calculated from a linear adsorption isotherm,

This equation is basic, simplistic, and familiar to soil physicists. Enfield, et al. (1980) briefly discuss it.

To simplify and generalize use of the equation, I set  $\rho = 1.5 \text{ gm/cc}$  and  $\Theta = .25$  (25% moisture content). For these two generalizations, there will probably be a greater error in  $\Theta$ , which often varies between 0.1 and 0.35 in the unsaturated zone.



This equation assumes the pesticide moves downward through the soil in a plug flow, rather than a broadened band which is more realistic. However, this assumption should not introduce a significant error into my calculations. This equation also assumes recharge is steady state rather than transient. In fact, recharge water moves faster when delivered in intermittent, intense rain storms rather than steady application. Therefore I have multiplied the water velocity rates for the upper layer by a factor of 5 (or divided the DECP residence time in the upper layer by a factor of 5). This conservative factor also allows for the fact that during transient events the  $K_d$  will likely overestimate the actual amount of soil-bound DBCP.

#### Calculations

Calculations were performed in the following manner. A  $K_{oc}$  (the  $K_d$  normalized to the organic carbon content of soil) was determined by averaging the values obtained by Enfield and Wilson, EPA-Ada (1980) and Chiou, et al. (1979).

$$\begin{aligned} K_{oc} &= K_{om} \times 1.724 = 75 \times 1.724 = 129 \text{ (Chiou, et al.)} \\ K_{oc} &= 150 \text{ (Enfield \& Wilson)} \\ K_{oc} \text{ (average)} &= 140. \end{aligned}$$

As discussed above, the % CC for each soil was divided by two in order to average this 1-1/2 ft value over 3 ft.  $K_d$  was then determined for each soil by multiplying CC times  $K_{oc}$ . Example: for a 3% organic carbon soil,  $140 \times .03/2 = 2.10$ .  $K_d$  values were then used in the equation for the retardation factor (discussed above):

$$R = 1 + \frac{\rho K_d}{\theta}$$

The particular value of  $R$  was then used to calculate  $V_s$  (leaching velocity of solute) for each recharge rate:  $V_s$

$$V_s = (V_r/\theta)/R$$

$V_s$  was multiplied by the conservative factor 10, which was discussed above and is also discussed below in the section on error analysis.

This value was then used to calculate the residence time of DECP in the upper layer by dividing the depth of the upper layer (3 ft) by  $V_s$ , expressed in ft/yr.

$$t = d/V_s$$

These are the values that appear in Table I.

Values for Table II were calculated in the following manner. Since I assumed all organic carbon was present in the top 1-1/2

ft. of soil, for the lower layer  $K_d = 0$ , and  $R = 1$ . So  $V_r = V_s$ . For an aquifer of depth  $x$ ,  $d = x - 3$  since the top 3 ft. have already been considered in the calculations for Table II above. Once again, the equation  $t = d/V_s$  is used to estimate residence times of DBCP in the lower layer. Thus the values for a specific environment for Table I and Table II will yield an estimate of the total DBCP residence time in the soil profile.

#### Justification for 25 Year Cutoff Value

Twenty five years was selected as the desirable residence time based on the hydrolysis half life of DBCP. This half life is approximately three to four years under ambient conditions. Using the first order decay equation:

$$\ln \frac{C_0}{C} = kt,$$

one obtains 15 years as the time required to 95% degradation. A 10 year safety factor was added because of the various assumptions made in this modeling procedure. Use of the equation above assumes that all of the DBCP in the soil profile is available for hydrolysis. That is, I arbitrarily assume that DBCP bound to the soil can also be hydrolyzed.

#### Error Analysis

The above method was applied to field data on aldicarb in Long Island. Calculated  $V_s$  was 10 ft/yr for a 6 feet deep aquifer and 12 ft/yr for a 4 feet deep aquifer. General  $V_s$  estimations for that region are 6 ft/yr. This is favorable agreement because it indicates that designating the conservative factor 5 is erring on the side of environment safety, and the error should decrease as the aquifer depth increases. This latter phenomenon is due to the assumption that most of my calculational error is in the upper layer, which becomes less important as the lower layer becomes greater (aquifer becomes deeper).

#### REFERENCES

Chiou, C.T., L.J. Peters, and V. H. Freed; "A Physical Concept of Soil-Water Equilibria for Nonionic Organic Compounds", Science, 206, 831-832, 1979.

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