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From : "Newton, Michael" [redacted]
To : "Deborah Watkins" [redacted]>, "Nathan Karch" [redacted]>, "Michael Ginevan" [redacted] "Jack Petrello" [redacted], "Bonnie Sceurman" [redacted]
Subject : Data on liquid contact and probable dose of phenoxyx and TCDD resulting from aerial spraying in Vietnam
Date : Thu, 14 Apr 2005 14:19:36 -0700
Attachment(s) : 2 file(s)/document(s) | Total File Size: 181K

Greetings, All;

The attached Expert Report I prepared for the class action suit in the '80s contains an analysis of routes of exposure for troops in VN. I just did a bit of clean-up on the table of actual dosages, and the margins of safety explained in the text have changed somewhat. If one updates the NOELs, one can re-calculate the MOSs to conform with current thinking. I wanted you all to get a look at the way things appeared 20 years ago.

Even though the NOELs may have changed, the calculations of contact are derived from information I published in 1982, with Norris, based on actual measured dosages on skin of male and male workers with 900 cm2 of skin contact with saturated emulsions of 2,4,5-T esters ranging through the array of concentrations one might put in an aircraft. Total contact with skin was far greater at the highest concentrations than would have occurred anywhere in VN under aerial sprays.

Please note work by Lavy et al in two pieces of work that demonstrate the difficulty of dislodging residues from foliage in recently treated areas:

Lavy, T. L., L. A. Norris, J. D. Mattice and D. B. Marx 1987 Exposure of forestry ground workers to 2,4-D, picloram and diclorprop. Environ. Toxicol. Chemistry 6:2009-224

Lavy, T. L., J. S. Shepard and d. C. Bouchard 1980 Field worker exposure and helicopter spray pattern of 2,4,5-T. Bull Environm. Contam. Toxicol. 24:90-96

Harris, S. A., K. R. Solomon and G. R Stephenson 1992 Expossure of homeowners and bystanders to 2,4-dichlorophenoxyacetic acid (2,4-D) Env. Sci. & Health. Part B. Pesticides, Food Contaminants and Agricultural Wastes. 27(1):23-38. (Note 15 refs)

The above three bits of work make very clear that a deposit of phenoxys applied just enough in advance of contact to dry residues moderately was enough to make 2,4-D, 2,4,5-T, diclorprop and picloram virtually immobile under rubbing contact unless vegetation green stains show up on the intercepting surface. No info about TCDD there.

Weber et al (1989) did a very nice job of showing that TCDD penetrates through all the layers of skin very poorly even with a very high loading per unit of surface. That paper is:

Weber, W. D., Zesch, A. and Rozman, K 1991 Penetration, distribution and kinetics of 2,3,7,8 tetrachlorodibenzo-p-dioxin in human skin in virto. Archives Toxicol. 65:421-428

I think the case can be made that my estimates of penetration greatly overstate the expected penetration of TCDD through the skin of soldiers

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. if one works backwards from the doses Weber et al used and quantities penetrating in the next 15 hours. We can't forget that he applied it in acetone, which would be a great penetrant, whereas our observations with phenoxy esters were that a very small percentage passes through the skin.

Hope this helps. I have copies of all except the Harris paper.

Mike

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ExprtRpt,orange20... (118KB)

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Orange exposureTab... (63KB)

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Table 1. DOSAGES OF 2,4-D, 2,4,5-T AND TCDD ENCOUNTERED BY FIELD SOLDIERS IN VIETNAM UNDER VARIOUS CONDITIONS OF EXPOSURE TO AGENT ORANGE. TCDD CALCULATED ON THE BASES OF 0.5 AND 40 PARTS TCDD PER MILLION PARTS 2,4,5-T. SAFETY FACTORS FOR 2,4-D AND 2,4,5-T BASED ON ACUTE NOEL OF 40 mg/kg; FOR TCDD, ACUTE NOEL IS 0.0001 mg/kg.

SITUATION	PROBABLE DOSE mg/kg				EXTREME DOSE mg/kg				SAFETY FACTOR EXTREME DOSE mg/kg			
			TCDD				TCDD				TCDD	
	2,4-D	2,4,5-T	.5 ppm	40 ppm	2,4-D	2,4,5-T	.5 ppm	40 ppm	2,4-D	2,4,5-T	.5 ppm	40 ppm
Soldier under forest being sprayed-dermal	.0002	.0002	10^{-11}	$8.4x10^{-9}$	.002	.002	10^{-10}	$8.4x10^{-8}$	17,760	17,760	>90,000	1,184
Above soldier, dermal plus inhalation plus water	.009	.009	$4.5x10^{-9}$	$3.6x10^{-7}$	.09	.09	$4.5x10^{-8}$	$3.6x10^{-6}$	444	444	2,222	28
Soldier eating food that was sprayed in kitchen	ND (not detectable)	ND	$1.5x10^{-9}$	$1.25x10^{-7}$	.1	.1	$5x10^{-8}$	$4x10^{-6}$	400	400	2,000	25
Soldier eating out of open can food source only	.0015	.0015	$7.8x10^{-10}$	$6.2x10^{-8}$	.05	.05	$2.5x10^{-8}$	$2x10^{-6}$	800	800	4,000	50
Soldier in tee shirt, sprayed directly, no hat or forest cover - dermal	.0072	.0072	$3.38x10^{-9}$	$2.7x10^{-7}$	.072	.072	$3.38x10^{-8}$	$2.7x10^{-6}$	555	555	2,960	37
Same soldier, dermal plus inhalation, plus bathing & drinking	.0166	0166	$5.0x10^{-10}$	$6.7x10^{-8}$	.166	.166	$5x10^{-8}$	$6.7x10^{-6}$	240	240	1,194	15
Soldier not sprayed, but living in recently	ND	ND	ND	ND	ND	ND	ND	ND	∞	∞	∞	∞
Soldier walking through a defoliated area	0	0	0	0	0	0	0	0	∞	∞	∞	∞

Soldier driving through defoliated area	0	0	0	0	0	0	0	0	∞	∞	∞	∞
Ranch Hand handler of Orange (4 hrs. skin contact, 2 sq.	-	-	-	-	.85	.85	$4.2x10^{-7}$	$3.4x10^{-5}$	47	47	240	3

- **DRAFT 4/12/01-**

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EXPERT REPORT OF MICHAEL NEWTON, Ph.D.

I. QUALIFICATIONS

Dr. Newton is Professor Emeritus of Forest Ecology, Department of Forest Science, Oregon State University, Corvallis, Oregon. His general qualifications are listed on the attached curriculum vitae. His specific qualifications include 41 years of full-time research as a forest ecologist, in which the action, fate in forested ecosystems and effects on animals of phenoxy herbicides and their contaminants have been major foci of his scientific investigations. He made four trips to Viet Nam in 1972, totaling about three months, with specific responsibilities for investigating the fate and degradation of phenoxy herbicides and picloram on behalf of the National Academy of Sciences Committee on Effects of Herbicides in Viet Nam. He has conducted numerous experiments in the United States that corroborate that the Viet Nam experiences were not exceptional, and that the behavior of these herbicides in the Tropics was describable in terms of what is known from other parts of the world.

2. SUMMARY OF TESTIMONY

Dr. Newton has been working as a full-time research scientist in the area of forest vegetation management since 1960. During that time he has made intensive investigation of the use of phenoxy and related herbicides, and has himself been heavily and repeatedly exposed to these herbicides and is highly familiar with their modes of action in plants, animals and ecosystems. He has worked intensively with estimation of risk as the result of using pesticides, he has done direct experimentation on the absorption of phenoxy herbicides by humans resulting after contact with the products. During the 12 weeks in Viet Nam, he inspected patterns of herbicidal activity and distribution in the field, and also conducted experiments on the persistence of these

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EXPERT REPORT OF MICHAEL NEWTON, Ph.D.

I. QUALIFICATIONS

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products in the southeast Asian environment. He has conducted experiments with Agent-Orange in Viet Nam, The Philippines and in North America, and will express the findings from Viet Nam in terms of what is generally known about these products and their contaminants.

Dr. Newton will testify as to how to combine toxicology information about phenoxy herbicides and TCDD with the information regarding exposure and dosage. He will distinguish between chronic and acute toxicity data and chronic and acute dosage. He will describe the various opportunities that field troops in Viet Nam may have had for exposure to Agent Orange, and express the range of possible acute and chronic dosages in terms of the accepted data on acute and chronic toxicology of 2,4-D, 2,4,5-T and TCDD in the world literature.

Among facts not generally known there are several pieces of unpublished information relating to the ability of humans to accumulate phenoxy herbicides from the environment in which they are working. These will be worked in with the experimental dermal and inhalation data to develop a scenario of maximum total dosage in worst case exposures to Agent Orange in Viet Nam. These will then be modified to develop an expected level of dosage for troops in Viet Nam.

III. SCIENTIFIC PRINCIPLES AND ASSUMED FACTS

Opinions held relating to the facts:

1. Toxicity is the ability for a substance to produce some adverse effect on an organism when a specific dose is administered. The more toxic the substance the lower the dose. No synthetic product is known to produce intoxication at doses below those that can be detected and calculated today. I accept that single doses of 2,4-D or 2,4,5-T do not appear to cause injury at doses of 40 mg/kg or lower, and

that single doses of TCDD do not cause injury at 0.0001 mg/kg or lower.

2. There are two kinds of toxicity, acute and chronic. Acute is the type of intoxication that follows a single large dose; chronic is the type of effect that follows a succession of doses, usually lower than are required to produce acute effects.

3. Chronic toxicity data are not very useful in estimating effects of single doses, and vice versa.

4. 2,4-D, 2,4,5-T and TCDD are the components of Agent Orange relevant to this case. Each has known toxicological properties in humans and many species of animals. My research in environmental chemistry and routes of human exposure permits me to establish a potential range of dosage for people exposed to Agent Orange. My experience in the infantry and as a scientist, having spent about three months in the forest of Viet Nam, permits me to adapt domestic experience and research to the Viet Nam scene.

5. Potential contact is limited by the rate of deposit in the human environment. This in turn, is determined by the rate of release from the aircraft minus losses to evaporation and interception while the spray falls to the ground.

   Orange was mostly applied by C-123 cargo aircraft. These were equipped with spray gear that distributed three gallons of Orange on each hectare (100 x 100 meters) Spray material was released from a height of about 45 meters in drops with a volume-adjusted mean diameter of about 0.367mm (=367 microns)(Young et al., 1978). This means that half the drops were smaller than this, and about one-third of the volume was in the size range below 250 microns, the size that is most subject to displacement by wind. Small drops of this type shrink rapidly from evaporation, leading to a major reduction in deposition. They spread to a very thin film on leaves, and this film rapidly absorbs and becomes extremely difficult to dislodge.

The total deposit, if it all reached the ground, was only 1.14 ml per square meter. This deposit, placed in tiny drops averaging .0084 ml/drop, would place 138.3 drops per square meter, or one drop for each 72.3 square centimeters. Most of those square meters in forested areas would be in foliage elevated substantially aboveground and out of reach of contact. The average of these drops would contain only 4 milligrams of 2,4,5-T and 8-12 nanograms of TCDD at the average dioxin content of Orange (1.98-2.98 parts TCDD per million of 2,4,5-T)

Behavior of the deposits once on foliage or organic litter is notable. First, the deposit is so light that one would have to be alert to notice that any spray had landed on bare skin; deposits on clothing have undetectable impact. Any claim to have been soaked with defoliants is surely false.

The rapid spread and absorption of Orange resembles that of diesel fuel. In moments, the deposits are no longer discernible; the volatile ester has considerable tendency to evaporate, and its low viscosity and oily nature cause it to penetrate any plant material quickly. In a matter of a few hours, deposits are virtually non-dislodgeable without considerable effort, and then only with abrasion of foliage or use of detergents. There have been no recorded human exposures leading to physiological dosage from contact with treated foliage that has dried.

Actual deposition of Orange under conditions of no forest cover were evaluated by Harrigan (1970). He observed actual ground deposit rates of 24.4 liters per hectare. In my own research, I have conducted spray operations over forests of various densities, with the finding that leaves catch most of the spray before it reaches the ground (Newton et al, 1984; 1992). For each layer of leaves, about half of a coarse spray (0.8 mm diameter of drops of average volume) is intercepted; more of a fine spray is intercepted because of lateral displacement and interception by stems and other vertical objects. The drops of Orange applied in Vietnam were less than half this diameter, hence less than one eighth of the volume of those in my research, and were therefore more likely intercepted before they reached the ground. I also measured leaf area in a Viet Nam forest, observing that it had on average, four to five thicknesses of leaves. That is, those forests had enough foliage that over each square meter of ground there was 4-5 square meters of leaves. Calculating that half or more of the spray is intercepted by foliage, less than 1/16 to 1/32 ($=0.5^4$ to 0.5^5) of the applied material reaches the ground. Thus, in most forests justifying defoliation to increase visibility there would be no more than a liter or two of Orange per hectare actually reaching the vicinity of troops. By the above logic, those troops would have to expose bare skin to those deposits within minutes, or be directly exposed to the spray while application was in progress in order to obtain a detectable burden of the herbicides in their bodies.

6. The dosage actually received by persons exposed to phenoxy herbicides is almost entirely a function of degree of dermal contact with the liquid substance. There is little evidence that the product can be removed readily from soil/vegetation after drying. Dosages resulting from inhalation, consumption of water and contaminated food is negligible. The dosage of

TCDD is probably even more confined to direct liquid contact with skin in any environment in which there is no large body of dioxin-containing material. Vietnam forests had no such dioxin source other than fire because most of the upland forests were sprayed once or not at all, and surficial deposits of dioxin on foliage would likely degrade immediately (Crosby and Wong, 1982). One may therefore calculate exposure and dosage in terms of the horizontal projection of exposed skin surface and density of deposit rate not intercepted by foliage.

7. A small percentage of phenoxy herbicides, in the range of 0.2 - 5.7 percent of skin deposit, can be expected to enter the body through the skin. The properties of TCDD suggest that a lower percentage of this product will penetrate skin because of its tendency to adhere to surface proteins. Clothing is a near-perfect protective barrier against phenoxys and/or TCDD coming in contact with skin unless the person is handling bulk quantities when a spill occurs. This protection is especially effective when the volume of chemical applied is too low to show appreciable wetting, which was the situation in Viet Nam.

8. Very little of the applied herbicide or TCDD is likely to reach soil under a forest, hence troops bivouacs under a forest canopy would not lead to a detectable uptake of TCDD. Newrton et al (1984; 1992) observed that such herbicide as penetrates the green foliage of forest cover almost inevitably lands on dead foliage and twig litter. This material intercepts and binds the oily material instantly, preventing it from reaching the soil. Whereas the phenoxy herbicides will hydrolyze and form the more water-soluble acids, TCDD will not. As long as they are on a surficial deposit, exposed to ultra-violet radiation, and provided a hydrogen donor, the dioxin will degrade in place quickly. This degradation will be slower than in full sunlight, but the material will be so

tightly bound to the foliage, (as with dirty oil to clothing that has been laundered) that it will not come off on personnel.

9. My experience in the field in Viet Nam, and my work with servicemen there, suggest that a small minority of servicemen in Viet Nam were subjected to being sprayed in any way, and that there is probably no valid way of establishing whether individuals did get sprayed. Among other considerations, these applications were typically done where there were no friendly troops, as a measure to permit returning fire in the event of hostile ground fire.

   The infrequency of applications suggests that those who were sprayed once were unlikely to be sprayed again, hence no chronic exposure could have occurred. Acute toxicology data and dosage are therefore the only relevant information in determining the risk to sprayed troops, or lack thereof.

10. The range of doses for troops where spraying was in progress may be calculated:
    a) The doses of 2,4,5-T and 2,4-D released from the aircraft were about 14.3 kg/ha of each.

    b) A man in tee shirt, with hat off, would have about .18m^2 of skin exposed to the spray pattern, = 1/53,797 hectare.
    c) Skin deposit, assuming 100 percent of product penetrates leaf cover to reach the ground, would be .27 gram each of 2,4-D and 2,4,5-T. If there were 40ppm TCDD in the 2,4,5-T, the most contaminated known lot, the deposit of TCDD would have been about 11 millionths of a gram. Expected contact under sheltering vegetation would be less than a millionth of a gram.

    d) If five percent of the chemicals were actually absorbed, individuals would have received .0054 grams each of the 2,4-D and 2,4,5-T and 0.2 millionths of a gram of TCDD will maximum exposure, but expected absorption would be something like .00034g each of 2,4-D and 2,4,5-T and .0125 millionths of a gram of TCDD even if this exposure had been from the most contaminated lot of Orange.

e) If the person weighed 75 kg the actual dosage level for this extreme worst-exposed field soldier would have been

5.4 ÷ 75 kg = < .072 mg/kg body wt.
of 2,4-D plus
< .072 mg/kg 2,4,5-T

and for TCDD

.0000002g ÷ 75 kg = .000027 mg/kg of TCDD.

f) There have been no single dose studies of 2,4-D or 2,4,5-T showing harmful effects at 40 mg/kg, and this must be regarded as maximum safe dose. So the most heavily exposed field soldier will not have received more than 1/555 of the dose at which absolutely no harmful effects would be expected, assuming the human to be equal in sensitivity to the most sensitive test animals, and to be in a most sensitive physiological state, e.g., pregnant.

g) There have been no single-dose studies with TCDD showing harmful effects at .0001 mg/kg, hence this may be regarded the maximum safe dose. The most heavily exposed field soldier sprayed with Orange would have received no more than 1/37 of the maximum safe dose. If the Orange contained 0.5 parts TCDD per million parts 2,4,5-T, the maximum dose would have been 1/2960 of the maximum safe dose.

h) The above analysis has relied on the relevant dose/response literature cited by the plaintiff's witnesses **(I will need current info on this from Nate)** and by Newton and Dost (1981) and Newton and Norris (1982) to arrive at this estimate of safety for the single most heavily exposed individual. Thus, it is virtually certain that the most heavily dosed soldier was perfectly safe from injury due to Orange. The likelihood of any individual being exposed to more than 1/10 this quantity of Orange is remote for many reasons, and the likelihood of being within 1/100 of the dosage level calculated for TCDD is even more remote because of the low rate of use of Orange containing high levels of TCDD. I therefore conclude that it was not practically possible for a field soldier in Viet Nam to encounter even a mild level of intoxication from being sprayed by Orange.

10. It was not possible for a field soldier in Viet Nam to receive more than a minuscule dose of Orange by inhalation.

a) Inhalation of drops $< 10\mu m$ in diameter is possible. The proportion of chemical in this range of drop sizes is a small fraction of one percent and the duration of this presence in the air is short. Given an application released from 150 feet, and one percent of the application in drops capable of being inhaled, the fine drops would be suspended in a layer 150 feet deep for perhaps five minutes at the very most. A hectare is 10,000 square meters. If the spray for that hectare were dispersed as an aerosol in a layer 45m deep, the fine spray, which is 1 percent of the 14.3 kg/ha of each phenoxy herbicide, amounts to .143 kg dispersed in $432,151 m^3$ of air, with an average concentration of $3.3 \times 10^{-7} g/m^3$. Inhalation of a moderately active person is at the rate of about 1.5^3/hr., so the worst-case field soldier might expect no more than .00000033 x 1.5 grams per hour, = .0000005g total or less, total inhalation dose or .6.6 x 10^{-10} mg/kg of 2,4-D or 2,4,5-T during the application and settling-out period. If the spray had the worst level of TCDD contamination, inhalation would equal a maximum dose of 2.7 x 10^{-15} mg/kg.

These doses are so far below the known action levels of these substances as to be effectively zero doses. Trivial as the above doses are, they over-state the probable maximum dose by a considerable margin. In the presence of any breeze whatever, the movement of a spray cloud through a forest will clear the spray out of the air quickly. If this were not the case, drift damage from the forest would be a widespread national problem, which it is not.

There is evidence that TCDD degrades quickly in sunlight, and conditions in spray drops are ideal for the most rapid breakdown. One may postulate that these processes decrease both the inhalation dose of phenoxys and the contamination of such doses with TCDD. Such calculations would be meaningless, however, because the entire dosage spectrum is so far below the range of measurable toxic effects.

b) Orange has the ability to evaporate. The n-butyl esters of 2,4-D and 2,4,5-T are among the more volatile preparations of these common weed killers, and one must consider the vapors resulting from evaporation in the inhalation picture. TCDD has virtually no volatility, hence exposure from this source may be ignored.

The highest concentrations of vapor ever recorded for a phenoxy herbicide were measured where Orange was being prepared for incineration. A hot enclosed area where barrels were being dumped had atmospheric concentrations of 2,4,5-T ranging below 10 millionths of a gram per cubic meter of air (< 12 ug/yd^3 It is virtually inconceivable that such concentrations were reached in the field in Viet Nam. Assuming they did occur, the soldier breathing 2 yd^3/hr. during the three hours after spraying would inhale .072mg each of 2,4-D and 2,4,5-T, with negligible TCDD or about .001 mg/kg = 1/40,000 of maximum safe dose.

Minor amounts of vapor would be inhaled over the next day or two, but hydrolysis of the ester and absorption by vegetation rapidly remove the source, and chronic exposure by this route, even at very low levels, is not possible.

11. Contamination of water and food are very minor opportunities for taking in a dose of Orange by field soldiers. I will consider each possible exposure route.
   a) Direct contamination of water. Under certain limited circumstances, troops were forced to rely on drinking water from open streams. Most of the defoliation missions were in areas of gentle or flat terrain, where streams are relatively deep. Most of the streams had some forest cover overhanging them so as to intercept much of the 2.8 ml of spray that would fall on each square meter. If we consider only the worst case, an open stream only 30 cm deep, the concentration immediately after spraying would have been 9.35 ml of Orange/m^3 of water (about .48 grams each of 2,4-D and 2,4,5-T) which, when dispersed, would be .48 g 2,4,5-T per million milliliters of water, or = .48 parts per million 2,4-D plus .48 ppm 2,4,5-T. At 40ppm TCDD in 2,4,5-T, concentrations of TCDD in water would be $.48 \times 10^{-6} \times 4 \times 10^{-5} = 1.92 \times 10^{-11}$ = roughly 20 parts per trillion momentarily, which is one tenth of the upper limit of solubility of TCDD in water. TCDD has never been found in water. The material apparently has such an affinity for gravel, mud or debris in streams that it

quickly leaves the water and ties up.

But let us assume that someone is foolish enough to collect a day's water supply from this stream immediately after spraying, and during that day he drinks two quarts of the water, and puts a gallon (two loads) in his helmet for washing and shaving. So he's been in intimate contact with six liters of water containing 0.02 ppb TCDD and .48 ppm each of 2,4-D and 2,4,5-T. If he miraculously were to absorb all of each chemical, the intake of TCDD would be 120 *billionths* of a gram of TCDD and that of 2,4-D and 2,4,5-T would be 3 mg each. The total dose of each would be 1.5 *nano*gram/kg TCDD, (1/6 of the average fat concentration in Americans today) and .35 mg/kg each of 2,4-D and 2,4,5-T or less than 1/100 of the maximum safe dose of either one, but maximum possible absorption would be no more than 1/4 of this, mostly from drinking the water.

The chances of encountering such a dose are very remote, and the chance of exceeding the calculated dose of TCDD is out-of-the-question because of the solubility limit of TCDD.

The concentrations of phenoxy herbicides have been calculated in streams of various sorts in forest spray operations of Oregon, on the same basis I have used here, that is, theoretical deposit of a full application rate on open water of a certain depth. I have evaluated the quantities that have actually occurred, and found that they are virtually never more than a tenth of the calculated maximum, even at the downstream end of a large spray area immediately after treatment.

Concentrations in water decrease rapidly after application. The applications in Oregon are relevant here because the same processes are at work. They show that herbicides decrease rapidly in concentration within hours of application, and are gone within 2-5 days altogether. Existing data regarding high concentration of TCDD in water suggest there will be a rapid decrease in TCDD because of its affinity for gravel, mud and organic debris. Disappearance is so rapid that fish do not accumulate a detectable body burden before the material is gone from the water (Norris 1981, 1983).

TCDD has never been detected in water to the best of my knowledge.

My opinion is that it is very unlikely that any field soldiers would have been dosed with TCDD at levels more than 1/100 of my calculations because:

(1) TCDD levels were usually much lower than 40ppm in the 2,4,5-T.

(2) Water would seldom have been collected immediately after a spray.

(3) Few, if any, streams would have been contaminated at more than 1/10 of the 2,4-D and 2,4,5-T concentrations given initially, and 1/100 of the TCDD content calculated.

Thus, it is my opinion not only that harmful doses did not occur from water, but that they could not have occurred unless an aircraft loaded with Orange crashed in the water.

b) Open food containers and cooking equipment may be alleged as a source of dosage for Orange. The range of dosage from this source may be calculated. Consider two scenarios, an army kitchens unit preparing hot food in the field, and individual soldiers preparing rations.

The kitchen unit may have open cooking utensils containing the prepared meal at the time of spraying. A kitchen unit for a company of 190 men will probably not have more than ten square feet of open food container, maximum. If this should receive a maximum application rate of Orange containing 40ppm TCDD, there will be 1.35 grams each of 2,4-D and 2,4,5-T in the food, and 54 millionths of a gram TCDD in a one-time-only dose. The individual soldier would receive 1/190 of this amount, or a maximum of 7.1mg each of 2,4,5-T and 2,4-D and .28 millionths of a gram of TCDD. For a 160 pound man, these are doses of 0.1 mg/kg each of the phenoxys and .000004 mg/kg of TCDD. If the food were cooking, the phenoxys would evaporate away quickly, but if not, the dose would be 1/400 of a safe maximum dose of 2,4-D or 2,4,5-T, and 1/75 of a maximum safe dose of TCDD.

For the soldier eating his canned rations (not prepared by mess personnel, an open can of C-rations has an exposed surface about 2 1/2 inches across or .033 sq. foot. If the maximum dose of Orange were to fall in the can, the amount of 2,4-D and 2,4,5-T would be .135 x .033g or .004 gram each and .16 millionths of a gram TCDD. The dose for a 160 pound man would be .05 mg/kg each of 2,4-D and 2,4,5-T (1/800 of maximum safe dose) and .000002 mg/kg TCDD, or 1/50 of a maximum safe dose.

These doses would be unlikely because field kitchens tend to be covered, and field troops would not voluntarily leave food containers open to a spray without attempting to cover them. Directly sprayed food would probably be thrown away.

Over-all, the additions of dosage from food and water beyond those of dermal exposure would be trivial, and the probable numbers of people exposed in this way very small.

In summary, the above calculations describe the absolute maximum acute dosages that could be encountered by Viet Nam servicemen under a variety of circumstances. For the reasons stated, the probable doses for field soldiers were much lower, and the vast majority of field soldiers probably received no measurable dosage. Field and Garrison troops may have encountered a variety of insecticides, insect repellents, disinfectants, fuels, fungicides, PCB's, chlorinated benzenes, fungi, yeasts, molds, bacteria mycotoxins and other agents capable of producing some sort of health disorders in humans or animals. Garrison soldiers probably at no time received measurable dosages of Orange.

Table 1 lists the actual doses probably received by field soldiers during spray operations that included them directly. Those who entered spray areas more than a few hours after treatment probably received no measurable dose. Those walking on roads or trails, or those driving through areas sprayed more than an hour or two previous probably did not receive measurable dosage of phenoxys, and received no dosage of TCDD whatever unless it was in the exhaust of a preceding vehicle.

12. The absence of significant excesses of major health problems in the Ranchhand workers who were very heavily exposed to Orange is definitive evidence for the conservative nature of the above calculations. Applicators always receive heavier exposure, by far, than those in the field. In this regard, it is noteworthy that Orange was produced during a period

when quality control of TCP production was improving, and TCDD levels were dropping. There is no documented record of chloracne or other definitive signs of TCDD intoxication among domestic spray workers prior to 1965, despite high levels of TCDD in domestic production. Furthermore, there were far more applications in the U.S. than in Viet Nam, and exposures were typically heavy during the 20 or so years of heavy domestic use prior to 1970. One may postulate realistically that tens of thousands of right-of-way workers would have had far heavier exposures to 2,4,5-T and TCDD than occurred in <u>any</u> cohort of Viet Nam veterans. This, again, is evidence, a) that humans appear to tolerate relatively high doses of TCDD, and b) that exposure to 2,4-D, 2,4,5-T or TCDD in Viet Nam <u>could not</u> have caused illness in field troops.

Table 1. DOSAGES OF 2,4-D, 2,4,5-T AND TCDD ENCOUNTERED BY FIELD SOLDIERS IN VIETNAM UNDER VARIOUS CONDITIONS OF EXPOSURE TO AGENT ORANGE. TCDD CALCULATED ON THE BASES OF 0.5 AND 40 PARTS TCDD PER MILLION PARTS 2,4,5-T. SAFETY FACTORS FOR 2,4-D AND 2,4,5-T BASED ON ACUTE NOEL OF 40 mg/kg; FOR TCDD, ACUTE NOEL IS 0.0001 mg/kg.

SITUATION	PROBABLE DOSE mg/kg				EXTREME DOSE mg/kg				SAFETY FACTOR EXTREME DOSE mg/kg			
			TCDD				TCDD				TCDD	
	2,4-D	2,4,5-T	.5 ppm	40 ppm	2,4-D	2,4,5-T	.5 ppm	40 ppm	2,4-D	2,4,5-T	.5 ppm	40 ppm
Soldier under forest being sprayed-dermal	.0002	.0002	10^{-11}	$8.4x10^{-9}$	.002	.002	10^{-10}	$8.4x10^{-8}$	17,760	17,760	>90,000	1,184
Above soldier, dermal plus inhalation plus water	.009	.009	$4.5x10^{-9}$	$3.6x10^{-7}$	.09	.09	$4.5x10^{-8}$	$3.6x10^{-6}$	444	444	2,222	28
Soldier eating food that was sprayed in kitchen	ND (not detectable)	ND	$1.5x10^{-9}$	$1.25x10^{-7}$	.1	.1	$5x10^{-8}$	$4x10^{-6}$	400	400	2,000	25
Soldier eating out of open can food source only	.0015	.0015	$7.8x10^{-10}$	$6.2x10^{-8}$	.05	.05	$2.5x10^{-8}$	$2x10^{-6}$	800	800	4,000	50
Soldier in tee shirt, sprayed directly, no hat or forest cover - dermal	.0072	.0072	$3.38x10^{-9}$	$2.7x10^{-7}$	.072	.072	$3.38x10^{-8}$	$2.7x10^{-6}$	555	555	2,960	37
Same soldier, dermal plus inhalation, plus bathing & drinking	.0166	0166	$5.0x10^{-10}$	$6.7x10^{-8}$	.166	.166	$5x10^{-8}$	$6.7x10^{-6}$	240	240	1,194	15
Soldier not sprayed, but living in recently defoliated forest	ND	ND	ND	ND	ND	ND	ND	ND	∞	∞	∞	∞
Soldier walking through a defoliated area	0	0	0	0	0	0	0	0	∞	∞	∞	∞
Soldier driving through defoliated area	0	0	0	0	0	0	0	0	∞	∞	∞	∞

Ranch Hand handler of Orange (4 hrs. skin contact, 2 sq. ft.)	-	-	-	-	.85	.85	$4.2x10^{-7}$	$3.4x10^{-5}$	47	47	240	3