OFFICE OF THE SCIENCE ADVISOR

GUIDANCE

CHAPTER 8

DDT IN SOIL: GUIDANCE FOR THE ASSESSMENT OF HEALTH RISK TO HUMANS

ABSTRACT

This Guidance Document was developed to addresses the risk to human health posed by the insecticide DDT in soil. The term "DDT" used herein describes p,p'-DDT, also known as 4,4-DDT, with the American Chemical Society name of 1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane. Within this document, the term " DDT_{tot}" refers to DDT and it's decomposition products DDD and DDE. All three agents are ubiquitous in California soil, due to the legal application of DDT for agricultural purposes prior to cancellation of the usage of DDT two decades ago. DDT_{tot} is a known animal carcinogen, which prompts the concern for human health.

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ACRONYMS

AAL	Applied Action Level
ATSDR	Agency for Toxic Substances and Disease Registry
CAS	Chemical Abstract Service
CDFA	California Department of Food and Agriculture
DDD	Isomers of dichlorodiphenyldichloroethane (trivial name); in older literature, often referred to as "TDE" *
DDE	Isomers of dichlorodiphenyldichloroethene (trivial name) *
DDT	Isomers of dichlorodiphenyltrichloroethane (trivial name)*
DDT_{tot}	Sum of isomers of DDT, DDD, and DDE
DHS	California Department of Health Servi ces
DTSC	California Department of Toxic Substances Control
FDA	United States Food and Drug Administration
IARC	International Agency for the Research of Cancer
IRIS	Integrated Risk Information System available by computer on-line from
OSWER	Office of Solid Waste Emergency Response (USEPA)
RAGS	Risk Assessment Guidance for Superfund manual from USEPA
TRAS	Toxicology and Risk Assessment Section
TSB	Technical Services Branch
TTLC	Total Threshold Limit Concentration
USEPA	United States Environmental Prot ection Agency

* See Appendix 18 for Chemical Abstract Service nomenclature.

DDT IN SOIL: GUIDANCE FOR THE ASSESSMENT OF HEALTH RISK TO HUMANS

1 INTRODUCTION

1.1 PURPOSE

This Guidance Document of the Department of Toxic Substances Control (DTSC) was developed to provide a risk assessment approach to DTSC personnel, as well as the general public, for use in: 1) quantitating adverse health risks to humans from exposure to soil contaminated with DDT, DDD, and/or DDE, and 2) calculating soil remediation levels which are health protective, on a site-specific basis. Specifically targeted is agricultural land being developed for new uses, assuming that DDT is present due to previous legal application on crops and not to illegal or inappropriate disposal practices. Soil is assumed to be the exclusive medium of exposure, unless other pathways are identified.

If other pathways are identified, a comprehensive risk assessment may be necessary.

1.2 OVERVIEW OF THE PROBLEM

DDT and it's metabolites, DDD and DDE, are ubiquitous contaminants in California farm land due to legal use of DDT, in the past, on crops for pest control. Pressure for development has placed much agricultural land into consideration for new uses. Concern for health risks to humans from exposure to DDT in developed farm land has posed whether remediation of DDT in soil is necessary.

DTSC, as a regulatory entity, is permitted to become involved only when DDT contamination is due to illegal or improper disposal. The California Department of Pesticide Regulation regulates current pesticide application only. Presently, no State agency has clear authority to regulate the remediation of soil containing DDT which got there from legal application to crops. Total Threshold Limit Concentrations (TTLCs) are often misused to fill this void. TTLCs are intended to provide a legal basis in deciding whether waste is hazardous in order to determine disposal procedures. The TTLC for DDT is not health-based and is therefore inappropriate for use as a generic remediation goal for DDT in soil. This Guidance Document provides guidance for site-specific risk determination, as well as calculation of remediation values appropriate for each individual situation.

To this end, a number of receptor- and case-specific exposure scenarios were constructed according to "real world" lifestyle and exposure estimates. "Typical" and "High" exposures were developed. The scenarios include the following:

1. Lifetime exposure in a residential setting (default, Appendices 1 and 2).

2. Residential exposure for 30 years for adults who work away from the home (Appendices 3 and 4).

3. Residential exposure for 30 years for adults who are homemakers, employed at home, or otherwise are at home for the full day (Appendices 5, 6, and 7).

4. Residential exposure for children of ages 1 through 17 (Appendices 8 through 11).

5. Recreational exposure in a community park for children of ages 1 through 17 years (Appendices 12 and 13).

6. Exposure at school for children of ages 6 through 17 (Appendices 14 and 15).

7. Inhalation of wind-borne dust/soil in a residential setting (Appendix 16).

8. Exposure by consumption of home-grown produce (Appendix 17).

In addition, three examples for calculation of soil remediation levels were developed. The first example was calculated with the default exposure values for adults living at home for 70 years. Example number two was developed using life-style specific exposure estimates for adults who live and work at the residence for 30 years. The third example concerns children living at home from birth to age 18.

Finally, the risk from consuming home-grown produce containing translocated DDT from soil is compared with the risk from consuming organochlorine pesticides present in the "average" American diet.

1.3 LIMITATIONS

- This document is not intended to be a general guide for risk assessment. It was written as guidance on how to develop case-specific exposure scenarios for the estimation of risk. Readers are referred to USEPA's Risk Assessment Guidelines for Superfund (USEPA, 1989a) for

guidance on risk assessment parameters and procedures.

- Many of the assumptions used in the Appendices are based on personal or collective judgement and have no literature reference. Examples include the amount of time that teenagers spend at home on weekends, the amount of time that children are awake per day, and the surface area of exposed skin in children playing in a community park or attending school during warm or cool weather.

- In order to be health-protective, the risk assessment process uses numerous conservative assumptions to compensate for uncertainties in extrapolating from the results of animal tests to human exposure, and in estimating exposure where actual measurements are not available or possible. As such, the levels of risk calculated for the exposure scenarios in this document are likely to overestimate actual risk.

- This document is subject to change in accordance with new information. Therefore, readers should confer with DTSC regarding revisions to the document and which versions of the document are obsolete.

2 DEFINITIONS

Chemical Abstract Service (CAS) nomenclature are used to identify DDT as well as the metabolites/environmental degradation products, DDD and DDE, which are found in soil.

CAS nomenclature is given in Appendix 17 for the isomeric forms of DDT, DDD, and DDE which are likely to be found. The p,p'- isomers are most commonly found, although o,p'- isomers are occasionally detected. The m,p'- isomers are generally not found, as they were minor byproducts of the manufacturing process for DDT. The commercial process for synthesis of technical grade DDT involved condensation of chloral hydrate with chlorobenzene in the presence of sulfuric acid (IARC, 1979). According to IARC, the DDT isomers in technical DDT consisted of 65 to 80 percent of the p,p'-, 15 percent to 21 percent of the o,p'-, up to 1 percent m,p'-, and traces of o,o'- isomer. In addition, p,p'-DDD and dicofol could be present in concentrations up to 4 percent or 1.5 percent, respectively.

The term "DDT_{tot}" in this document, will be used generically to describe all isomers of DDT, DDD and DDE. Otherwise, the specific acronyms DDT, DDD, or DDE will refer to the p,p'-isomer of each entity only.

In order to avoid redundancy, the specific acronyms DDT, DDD, or DDE will refer to the p,p'-isomer of each chemical entity. DDT_{tot} will be used to refer to any of these three chemicals. Note that "DDT_{tot}" is equivalent to the term "DDTr" which frequently is used in other publications.

3 SOURCES OF CONTAMINATION

This document was developed to provide guidance concerning DDT_{tot} in soil which is present solely from previous legal agricultural activities. However, the exposure scenarios presented in the Appendices may be useful towards directing other pesticide remediation efforts regardless of contaminant source.

DDT_{tot} is ubiquitous in California soil due to heavy agricultural usage prior to cancellation in 1972. The extent of soil contamination has been documented by the California Department of Food and Agriculture (CDFA, 1985), as well as in numerous remedial investigation reports reviewed by this office. Therefore, agricultural land which is currently developed or being considered for new uses, such as residential tracts or parks, frequently contains DDT_{tot}.

Oftentimes, the levels of soil contamination with DDT_{tot} are greater than 1 ppm (1mg/kg), which exceeds the "Total Threshold Limit Concentration" (TTLC) for DDT_{tot}. TTLC's (Title 22, CCR, 66700) are promulgated values which are used for hazardous waste classification, i.e., to determine whether waste material is hazardous waste and must be taken to a hazardous waste facility, or can be disposed of otherwise. Therefore, the TTLC of 1 ppm for DDT_{tot} would determine whether disposal of excavated soil containing DDT_{tot} must involve a hazardous waste facility. However, the TTLC for DDT_{tot} is often misused as a "clean-up number" for remediation of agricultural land containing DDT_{tot} due to prior use on crops.

At the present time, DTSC lacks the authority to regulate DDT_{tot} which is in the soil due to previous legal application procedures on crops. Soil such as this containing DDT_{tot} is considered a hazardous waste only if removed from the site. DDT_{tot} in soil due to spillage or improper disposal activities, in contrast, may be regulated by existing DTSC procedures. Therefore, remedial action and/or border zone determinations may be applicable to portions of agricultural land containing localized areas of contamination due to spillage or improper pesticide disposal.

The purpose of this document is to provide guidance for the health-based appraisal of risk associated with exposure to DDT_{tot} in soil. This is to avoid the misuse of the TTLC, which is not health-based, for the determination of whether remediation is necessary.

4 SITE CHARACTERIZATION

The sampling protocol for a property must be appropriate for use in a quantitative risk assessment, or the data will be of little value.

A health risk appraisal can be no better than the data collection effort. To quote USEPA's Risk Assessment Guidance for Superfund (USEPA, 1989a): "The

sampling strategies for a site must be appropriate for use in a quantitative risk assessment; if inappropriate, even the strictest QA/QC procedures...will not ensure the usability of the sample results."

The sampling protocol should be directed at defining plausible human exposure, as well as the extent of contamination. Both requirements are case-specific. For example, sampling of surface soil only would provide assessment of actual exposure in cases where the soil was intended to remain undisturbed, except for minor landscaping. Where construction or landscaping needs require excavation of subsurface soil to the surface, sampling of subsurface soil is necessary to evaluate human exposure. While complete delineation of the extent of both horizontal and vertical contamination is desirable, it may be required by local agencies.

Good sampling strategies, based on site characterization, also may justify exclusion of areas whose geography or vegetation preclude human access or contact.

The reader is referred to Volumes 1 and 3 of the DTSC "Guidance for Site Characterization and Multimedia Risk Assessment for Hazardous Substances Release Sites".

DDT_{tot} is a ubiquitous contaminant in California soil. Therefore, "background" soil data obtained from nearby areas are regarded to be of little value in the risk appraisal process for DDT_{tot} in soil. DDT_{tot} is a synthetic compound, so there is no natural "background" concentration in soil as there is for entities such as arsenic or asbestos. However, DDT is ubiquitous in the California environment due to widespread application prior to cancellation of use in 1972. The extent of contamination was reported by California Department of Food and Agriculture (CDFA, 1985). To quote: "CDFA collected 99 soil samples in 32 California counties from locations where DDT had been used in the past. All samples contained DDTr...Based on analysis of historical and empirical evidence, CDFA concluded that residues from legal applications of DDT, before its use was banned, appear to be the source of this contamination."

Because of widespread contamination, "background" samples taken offsite will likely contain DDT_{tot}. The soil levels could be equivalent to or greater than those found on site, confounding interpretation.

An alternative method is suggested : that "background" (off-site) exposure to DDT_{tot} be considered to be that amount present in the average American diet. Such information is available from the U.S. Food and Drug Administration (FDA). FDA extensively monitors pesticide levels in raw agricultural commodities as well as in prepared foods. Studies on prepared foods are often referred to as "Total Diet Studies" or "Market Basket Studies." In general, 234 individual food types are purchased four times a year in various cities. The foods are prepared as if to be eaten (peeled, cooked, etc.) and analyzed for over 200 pesticides. These results are used in conjunction with consumption information to calculate the average daily

intake for each pesticide detected. Analysis of prepared food allows estimation of pesticide consumption in foods in the final form in which they are usually eaten, such as bread and apple pie. Results of a recent Total Diet Study can be found in Appendix C of the FDA pamphlet describing the program and available from FDA (FDA, 1989).

5 HAZARD IDENTIFICATION

DDT_{tot} is considered to be a "probable human carcinogen" by the U.S. Environmental Protection Agency (USEPA) and the Office of Environmental Health Hazard Assessment of the California Environmental Protection Agency.

Numerous studies have shown that DDT, DDD, and DDE are carcinogens in laboratory animals. These studies have received extensive review elsewhere and will not be described in this document (USEPA, 1984; ATSDR, 1989, IRIS, 1991). Based on the animal data, scientists at USEPA classified DDT, DDD, and DDE as "B2" carcinogens, that is, probable human carcinogens. The Toxicology and Risk Assessment Section (TRAS) agrees with that classification. USEPA also considers these agents to act as carcinogens by a non-threshold mechanism. TRAS leaves open the possibility that DDT_{tot} may be carcinogenic through a non- genotoxic, threshold mechanism. In the meantime, the examples provided in this document assume a mechanism having no threshold.

To date, available data in humans have shown no correlation between DDT_{tot} exposure and human cancer. The most recent study was that of Austin et al. (1989). In that study, DDT and DDE serum levels were quantitated in over 900 subjects who received a ten year prospective follow up for mortality. To quote: "There was no relation between either overall mortality or cancer mortality and increasing serum DDT levels." Previous reports also have shown no association between human cancer and exposure to DDT_{tot} (See Higginson, 1985).

However, the weight of evidence from animal studies advises that caution is prudent before discounting carcinogenic activity of DDT_{tot} in humans. Therefore, TRAS, in accord with USEPA, regards DDT_{tot} to be a "probable" human carcinogen in the absence of definitive epidemiological evidence to show otherwise.

6 DOSE RESPONSE

Cancer potency slope factors derived by the U.S. Environmental Protection Agency (USEPA) for DDT, DDD, or DDE, will be used for risk characterization. Slope factors given in the USEPA Integrated Risk Information System or Health Effects Assessment Summary Tables (IRIS and HEAST, respectively) will be used for dose-response estimates. The current slope factors are 0.34 kg-day/mg for DDT and DDE, and 0.24 kg-day/mg for DDD (IRIS, 1991). For the sake of simplicity,

0.34 kg-day/mg may be used for DDT_{tot} as a default value. Alternatively, the risk assessor may wish to use separate slope factors for DDT/DDE or DDD.

7 EXPOSURE

For the purpose of this Guidance, exposure to DDT_{tot} in soil is assumed to occur exclusively by ingestion of soil and the contact of soil with exposed skin. Examples were developed according to a residential scenario representing high-density housing, a community park and a school.

7.1 Residential Exposure Default Values

The default values for exposure frequency, duration, and body weight will be daily for 24 hours per day, 30 or 70 years, per a 70 year lifetime, and 70 kg for adults (USEPA, 1989a), respectively, for a residential scenario. However, TRAS encourages the development of other values and exposure scenarios on a case-specific basis, such as partial daily exposure for adults who work away from the residence on a daily basis, children/adolescents who attend school on a daily basis and leave "home" after graduation from secondary school, workplaces, or community parks, where exposure is periodic rather than continuous, less than lifetime, and could involve individuals weighing less than 70 kg. Examples of alternative, case-specific, scenarios are provided in the Appendices.

7.2 Soil Ingestion Rates

Default values for soil ingestion are 100 mg/day for adults, and 200 mg/day for individuals 6 years of age and less, according to guidance provided by USEPA (USEPA, 1989a, Page 4-40).

Note, however, that there are no universally agreed-upon rates for daily soil ingestion. Sedman (1989) performed an extensive review of the literature, which was available for children only. Using several data sources, a number of estimates for soil ingestion were derived for different age groups. Average age-specific values ranged from 590 mg/day for ages 1-2 to 110 mg/day for ages 17-18. Adults (ages 18-70) were assumed to be constant at 100 mg/day. A soil ingestion value of 150 mg/day was recommended for estimation of exposure for a 70 year lifetime. A description of how these values were derived via an exponential function curve fitting program is beyond the scope of this document.

Following Sedman's evaluation, Calabrese et al. (1989) published an elegant study using a mass balance approach to follow the fate of eight tracer elements in children. The tracers were normal constituents of soil. Fecal excretion of tracers was quantitated under control conditions, as was tracer ingestion via the diet. The mass balance difference was regarded to

represent tracer intake via ingestion of soil. Ingestion of house dust was also considered, because the investigators found that tracer concentrations in house dust were comparable to those in outdoor soil. Results were reported in terms of soil ingestion, dust ingestion, and both values combined.

Median values for three of the tracers (aluminum, silicon, and yttrium) were regarded by the authors to be the most reliable, and gave soil ingestion rates of 29, 40, or 9 mg/day, respectively. Mean values were approximately four times greater, being 153, 154, or 85 mg/day for aluminum, silicon, or yttrium, respectively. The respective ninety-fifth percentile values were 223, 276, or 106 mg/day. The investigators regarded that there were no differences in values calculated from soil ingestion alone, or with inclusion of ingestion of house dust. Median values are comparable by either method, but the ninety-fifth percentile values are about two-fold greater when dust ingestion was included, being 478, 653, or 159 mg/day, respectively. TRAS concludes that values for dust and soil combined are more appropriate than for soil alone.

USEPA (1989a) recommended daily soil ingestion rates of 200 mg/day for children of ages one though six, and 100 mg/day for all older individuals. Based on Sedman's recommendations (1989) and the results of Calabrese et al. (1989), TRAS concurs with USEPA's recommendations. This represents a difficult problem, but TRAS feels that these values are health-protective when used with a typical residential scenario. Children with pica, or adults in occupational scenarios with individuals handling soil daily, would require separate estimates. In any event, TRAS will consider alternative values if based on laboratory data from animals, experimental data from human studies, and/or reasonable assumptions.

As examples, a number of plausible site- and receptor-specific scenarios were developed for Guidance. These are presented in the Appendices. The first scenario uses default values of 100 mg soil/day for 70 years (Appendix 1). The second scenario concerns adults who work outside of the home, and therefore ingest soil only while home (Appendix 3). A third scenario was developed for adults who reside at home for 30 years as homemakers or individuals self-employed at home (Appendix 5). No soil ingestion is assumed to occur during sleep or while away on a three week annual vacation. Children of ages of 1 through 17 were considered in a fourth scenario, where there is no residential soil ingestion while at school, sleeping, or away on vacations (Appendix 8). An eighteen year duration of exposure was chosen, assuming that the individuals will move away after high school graduation for reasons such as vocation, education, military service, and/or marriage. A fifth and sixth scenario was developed for ingestion of soil while using a community park (Appendix 12 and 13) or attending school (Appendix 14 and 15).

Exposure by soil ingestion according to these scenarios is summarized in Table 1.

7.3 Gastrointestinal Absorption Of DDT_{tot} From Ingested Soil

The systemic absorption of DDT_{tot} from ingested soil is assumed to be 100 percent. Other values will be considered if based on experimental data generated by accepted scientific practices.

The systemic absorption of soil-borne DDT_{tot} from ingested soil is not known. Oral absorption of p,p'-DDT from other vehicles is known to be at least 80 percent (see Smith, Section 15.3.1.2, in Hayes and Laws, 1991). Adsorption of DDT_{tot} to soil could be expected to hinder absorption somewhat. However, the effects of digestion physiology, such as displacement from soil binding sites by gastric acid or liver bile acids, solubilization of organic molecules by bile acids, or dissolution of DDT_{tot} itself by bile acids and/or dietary fat with systemic re-uptake via enterohepatic circulation, is probable. Therefore, systemic absorption of DDT_{tot} from soil is considered to be 100 percent, in order to be health-protective in the absence of laboratory data.

7.4 Contact Rate Of Soil With Skin

The default value for daily contact of soil with skin (i.e., exposure) is assumed to be 450 mg/day for a residential scenario. Other values are encouraged to be developed on a site or receptor specific basis where warranted.

There are no universally accepted values for the average daily rate of skin contact with soil. Numerous case-specific factors impact upon the daily rate of soil contact with skin. As Sedman (1989) has aptly summarized: "The surface area of skin exposed to soil, the amount of soil that adheres to the exposed skin [soil adherence factor], the type of soil particles that adhere to skin, and the distribution of these particles in soil would be expected to influence the level of dermal exposure to toxic substances in soil."

Sedman estimated an average daily exposure rate to soil of 450 mg/day for lifetime residential exposure scenario. The head, neck, lower arms, hands, and feet were assumed to be exposed on a daily basis. A soil adherence factor of 0.5 mg soil/cm^2 of skin was estimated from three data sets showing adherence values of 0.2, 0.5 and 0.9 mg/cm^2. However, soil load was assumed to decrease with age, due to differences in play-relaxation behavior paradigms with age. The dermal exposure rates thus calculated were age specific. A range of daily dermal exposure rates of 1025 mg/day

for ages 1-2 to 403 mg/dy for ages 17-18 was calculated, with ages 18 and over (adult) having rates of 360 mg/day. For a 70 year lifetime, this is equivalent to 450 mg/day.

Alternative scenarios can be calculated according to guidance provided in USEPA's "Risk Assessment Guidance for Superfund" manual (USEPA (1989a) in conjunction with exposure data given in USEPA's "Exposure Factors Handbook" (USEPA, 1989b).

A number of plausible dermal exposure scenarios were developed according to site and/or receptor-specific factors. Examples are given in the Appendices. Scenario one uses the default value of 450 mg/day for 70 years (Appendix 2). The second scenario concerns adults who work outside of the home, and therefore come in contact with residential soil and house dust only while home (Appendix 4). A third scenario was developed for adults who reside at home for 30 years as homemakers or individuals self-employed at home (Appendices 6 and 7). No dermal contact with soil is assumed to occur during sleep or while away on a three week annual vacation. Children of ages of 1 through 18 were considered in a fourth scenario, where there is no contact with residential soil while at school, sleeping, or away on vacations (Appendices 9 through 11). An eighteen year duration of exposure was chosen, assuming that the individuals will move away after high school graduation for reasons such as vocation, education, military service, and/or marriage. A fifth and sixth scenario was developed for dermal contact with soil while using a community park (Appendices 12 and 13) or attending school (Appendices 14 and 15).

Exposure to DDT_{tot} by dermal contact with soil according to these scenarios is summarized in Table 1, assuming that the concentration of DDT_{tot} in soil is 1 mg/kg.

7.5 Systemic Absorption Of Soil-Borne DDT_{tot} Across Skin

The systemic absorption of DDT_{tot} from soil in contact with exposed skin is assumed to be 5 percent of that in contact with skin per 24 hours.

The absorption of DDT from soil through skin was investigated in studies funded by TRAS (Wester et al., 1990). In live monkeys, the absorption of DDT in soil was 3.3 percent of the applied dose over a 24 hour period. That figure was 18.9 percent when acetone was used as a vehicle rather than soil. In a system using human cadaver skin, 1.0 percent of the applied dose of DDT in soil was absorbed. The percent absorption was 18.1 percent with an acetone vehicle, similar to that noted in the monkey. Earlier studies have demonstrated that the percutaneous absorption of DDT is dependent on not only the vehicle but also on the area of the body to which the mixture was applied (Feldman and Wester, 1974). Based on the results of Wester et al.

(1990) with DDT in soil along with those of earlier investigators using organic vehicles, TRAS recommends that 5 percent be used as a default figure for the systemic absorption of soil-borne DDT_{tot} from soil through skin. In other words, the dose absorbed systemically represents 5 percent of the dose administered dermally.

Note that the 5 percent dermal absorption figure is specific for DDT_{tot}. In the absence of relevant data, best professional judgement must be used for other chemicals in conjunction with existing information. For example, Smith cites the differences between the acute oral vs dermal toxicity between DDT and dieldrin. To quote Smith: "...DDT is poorly absorbed by skin from solutions, and the absorption of solid material is so poor that it is difficult or impossible to measure...In contrast, even solid dieldrin, if very finely ground, is absorbed so effectively through the skin that it is about half as toxic when applied dermally as when administered by mouth" (Smith, Section 15.2.2.1, in Hayes and Laws, 1991). Therefore, the 5 percent dermal absorption figure for DDT utilized in this Guidance Standard can not be used automatically as a default for other compounds. Note that CAPCOA and SCAQMQ (CAPCOA, 1992; and SCAQMD, 1988) proposed some generic figures for dermal absorption of volatile organic compounds, and Howd et al (1990) and Howd (1991) proposed dermal absorption values for a number of organic compounds, based on several modeling schemes.

A dermal absorption value of 4.2 percent was recently presented for soil-borne chlordane in a preliminary report (Maibach et al, 1992). This value, or one derived from the data, will be considered for use when the data are published in a peer-reviewed journal and available for independent evaluation. Until then, TRAS recommends the use of 10 percent for dermal absorption of chlordane from soil, in accordance with SCAQMD (1988) guidance for organic chemicals in general, except as modified by CAPCOA (1992) recommendations.

8 OTHER ROUTES OF EXPOSURE

8.1 Water

The examples developed in the Appendices of this document assume that there is no contamination of usable surface or ground water with DDT_{tot}. If ground and/or surface water are contaminated with DDT_{tot}, a multi-media risk assessment is necessary.

8.2 Inhalation Of Dust

The risk due to inhalation of dust containing DDT_{tot}, in a residential scenario, is insignificant. Inhalation of vapors containing DDT_{tot} would not be expected because DDT_{tot} is practically nonvolatile.

Inhalation of dust (soil) containing DDT_{tot} is a probable route of exposure, in addition to soil ingestion and skin contact with soil. However, the risks associated with inhalation of dust containing agricultural concentrations of DDT_{tot} are insignificant. Using a derivative of the USEPA (1989a) equation on page 6-44, entitled "Residential Exposure: Inhalation of airborne (Vapor Phase) Chemicals," the inhalation exposure under a reasonable worst-case residential scenario was calculated. The assumptions, calculations, and results are shown in Appendix 16. The assumptions include a 30 year exposure period in an extremely dusty location. Respirable dust is assumed to be 50 ug/m^3, a condition unlikely to be encountered around any residence on a continuous basis. The lifetime daily dose level would be 6.12×10^{-9} mg/kg-day, which poses an estimated upper bound risk of 2×10^{-9}.

8.3 Ingestion Of Home-Grown Produce

The ingestion of homegrown produce is not included in the current Guidance Standard. The high-density nature of residential development of old agricultural land in California generally precludes vegetable gardening to any meaningful degree. Moreover, the data void for plant-uptake of DDT from soil makes estimations of exposure from modeled results difficult to evaluate. Exposure via ingestion of home-grown produce, however, should be considered on a site-specific basis. Examples would include residential development in rural areas with property sizes allowing gardens, high density housing tracts having "community" garden areas, ethnic neighborhoods in which growing of produce is according to cultural dictates.

Due to the nature of high-density housing typical of new residential development of old agricultural land in California, the growing of produce in meaningful amounts is considered unlikely to occur in such tracts. Therefore, TRAS regards the ingestion of homegrown produce to be an insignificant pathway for exposure to DDT_{tot} relative to those of soil ingestion and dermal contact with soil.

However, should single-unit or low-density housing areas or tracts having community garden space be under consideration, guidance from CAPCOA (1992), USEPA (1989a, 1991a), and SCAQMD (1988) is recommended. In general, these documents provide models and/or default assumptions which can be used to estimate the uptake of chemicals from soil into plants, utilizing octanol:water partition coefficients (Kow) and organic carbon partition coefficients (Koc) for specific compounds, in conjunction with organic carbon soil content. To date, however, the model is not sufficiently

validated for general use in risk assessment, e.g., to estimate the uptake of pesticides into edible portions of produce or whether the pesticides of interest actually transpose into edible portions of produce or remain sequestered in the roots.

With these caveats, one can model the plant uptake of DDT_{tot} into home-grown produce, and estimate exposure via ingestion using default assumptions provided in any of the above-mentioned four documents. Such an exercise is presented in Appendix 18, using a concentration of DDT_{tot} in the soil of 1 ppm (1 mg DDT/kg soil) as an example. Based on information in Section 2.4 of the OSWER Directive (USEPA, 1991a), updating previous assumptions (USEPA, 1989a and 1989b), the average "reasonable worst case" consumption of homegrown vegetables or fruit is 80 g/day or 42 g/day, respectively, for a total of 122 g/day. An exposure scenario for DDT based on consumption of home-grown produce is presented in Appendix 17.

Consider, however, that such an estimation is region and case-specific, and, as stated by USEPA (1989a) in Exhibit 6-18, page 6-46, that the fraction ingested ("FI") is "[a] Pathway-specific value [and] (should consider location and size of [the] contaminated area relative to that of residential areas, as well as anticipated usage patterns)." Therefore, in the opinion of TRAS, high-density tract housing would preclude the use of such reasonable worst case" estimations, or even the use of ingestion of homegrown produce itself, in the estimation of exposure to DDT in the soil.

Should such estimations be warranted due to site-specific factors, TRAS recommends that exposure and risk from consumption of homegrown produce be compared to that from consumption of commercial produce for perspective. Such a comparison can be made from data given in the U.S. Food and Drug Administration's (FDA) "Total Diet Survey," which is representative of the "average" American diet. Results from the 1988 (FDA, 1989) survey are summarized in Tables 3 and 4 , and present exposure and risk estimations for DDT_{tot}, as well as the summed risk estimations for eight other persistent organochlorine/animal carcinogen pesticides which were detected and quantitated in food.

Risk managers may use such comparisons to place into perspective site-specific situations in which the risk from homegrown produce will replace that from commercial produce.

9 RISK CHARACTERIZATION

Characterization of risk from exposure to DDT_{tot} via the soil will be conducted according to accepted methods, and be performed or approved by individuals qualified via education and experience to conduct a risk assessment.

Risk associated with exposure to DDT_{tot} in soil was calculated from the scenarios given in the Appendices, as follows:

Risk = Exposure x Slope Factor

Where:

Risk = The probability that cancer will occur to an individual exposed for a lifetime (unitless).

Exposure = "Lifetime Average Daily Dose" (LADD) in mg/kg-day. LADD is the dose of DDT_{tot} received over a specified period of time, which is then averaged over a 70 year lifetime.

Slope Factor = 0.34 (mg/kg-day)-1 = 0.34 kg-day/mg.

Then:

Risk = $LADD_{DDT}$ x 0.34 kg-day/mg

LADD is a case-specific value, and should be estimated in a manner similar to that provided for guidance in the Appendices. The following example is taken from Appendix 4 (dermal exposure):

Assume:

Concentration of DDT in soil = 1 mg DDT_{tot}/kg soil (1 ppm).

Route of exposure = Dermal contact, i.e., contact of exposed skin with soil containing DDT_{tot}.

Exposure scenario = Adults living at one residence for 30 years, but working away from the residence on 5 days per week for 49 weeks per year, as developed in Appendix 4.

$LADD_{DDT}$ = 1.88x10-7 mg DDT_{tot}/kg-day

Then:

Risk = 1.88x10-7 mg/kg-day x 0.34 kg/day-mg

$= 6.4x10^{-8}$

A risk of 6.4x10-8 is equivalent to 6 additional cases per hundred million individuals exposed for a lifetime. The term "additional" denotes cases which are exposure-related and occur in addition to the normal "background" cancer rate, which is approximately one individual in four which live for a 70 year lifetime.

For this document, soil was considered to be the exclusive medium of exposure because soil is typically the only medium of concern for agricultural land being

used for other purposes such as high density residential development. The scenarios given as examples in the Appendices were developed assuming that DDT_{tot} was present in soil at a concentration of 1 mg DDT_{tot}/ kg soil. If the concentration of DDT_{tot} found in soil is greater or less than 1 mg/kg, the case-specific exposure and risk levels given in Tables 1 and 2 can be multiplied by that soil concentration (in mg/kg) to yield the exposure and risk levels associated with that particular concentration of DDT_{tot} in soil.

10 ACCEPTABLE RISK

For the purposes of this Guidance document, an "acceptable" risk is defined to be a risk which is no greater than $1x10^{-6}$. However, given the numerous uncertainties and conservatism in the risk assessment process, risks which are "greater" than $1x10^{-6}$ can be justified on a site-specific, receptor-specific, or regulatory-specific basis.

The level of risk which constitutes an "Acceptable Risk" is a risk management decision solely, and shall not influence the risk assessment process. Note that the risk manager/governmental health administrator must exercise flexibility in selection of an acceptable level of risk, according to case/site-specific considerations as well as relevant health concerns. A risk of "$1x10^{-6}$" represents an excess cancer prevalence not exceeding one case per million individuals exposed per lifetime. Note, however, that other California regulatory processes consider a risk level of $1x10^{-5}$ as being acceptable. Proposition 65, the Clean Water Act of 1988 (Title 26, CCR) is an example. Therefore, other criteria may be justified in defining acceptable risk of DDT_{tot} in soil on a case-specific basis.

11 SOIL REMEDIATION LEVELS

Selection of soil remediation levels involves two distinct processes:

1. The development of exposure scenarios based on either default values or case and/or receptor--specific assumptions.

2. A risk management decision, separate from the risk appraisal process, regarding what constitutes "acceptable" risk.

In order to establish soil remediation levels (SRLs), risk assessors must provide risk managers with appropriate exposure scenarios relevant to intended land use or estimations of actual receptor lifestyles. Examples of such scenarios are given in the following Appendices:

Appendices 1-7: For adults exposed to residential soil by ingestion or dermal contact.

Appendices 8-11: For children exposed to residential soil by ingestion or dermal contact.

Appendices 12 and 13: For children to soil by ingestion or dermal contact through use of a community park.

Appendices 14 and 15 : For children exposed at school.

Appendix 16: For adults exposed in a residential setting by inhalation of wind-borne soil/dust.

Appendix 17: For ingestion of home-grown produce by adults.

Then, risk managers must decide two pivotal issues:

- The appropriate exposure scenario(s), based on actual or intended land use.
- The level of risk which is acceptable for the given exposure scenario(s) and receptor population at risk.

Soil remediation levels (SRLs) can be calculated once the appropriate exposure scenarios have been developed, the total risk due to exposure from each pathway is summed, and the level of "acceptable" risk is chosen.

The exposure scenarios for DDT_{tot} located in Appendices 1-17 were developed on the assumption that DDT_{tot} was present in the soil at a concentration of 1 mg DDT_{tot}/kg soil (1 ppm). The risk values given in Table 2 were calculated from those scenarios. To calculate risk values based on other soil concentrations of DDT_{tot}, the values in Table 2 can be multiplied by the concentration of DDT_{tot}, expressed as ppm or mg DDT_{tot}/kg soil, found in soil.

11.1 Calculation

Calculation of a SRL for each scenario can be done simply, according to the following equation:

$$SRL = \frac{\text{"Acceptable" Risk}}{\text{Calculated Risk}}$$

SRLs were calculated using the exposure scenarios developed in Appendices 1-17. The results are given in Table 5. Three are shown below for illustration:

11.2 Example One: Adult Residential Default

The following default assumptions are used: lifetime exposure for 70 years, soil ingestion of 100 mg/day, dermal contact with soil is 450 mg/day, and a dermal absorption factor of 5 percent of soil-borne DDT through the skin. The soil concentration of DDT_{tot} in these examples is assumed to be 1 ppm (1 mg DDT/kg soil) which is the soil concentration value used for development of risk values given in Table 2, using the soil ingestion exposure scenario from Appendix 1 in conjunction with the dermal exposure soil scenario developed in Appendix 2. The summed risk from each pathway (Table 2) is 6.0×10^{-7}. Assuming that risk management determines that 1×10^{-5} is an acceptable level of individual risk, the case specific SRL for a 1×10^{-5} risk can be calculated as follows:

$$SRL = \frac{1 \times 10^{-5}}{6.0 \times 10^{-7}} = 16.7 \text{ mg DDT/kg soil} = 16.9 \text{ ppm}$$

If risk management were to determine that the acceptable risk level was 1×10^{-6} rather than 1×10^{-5}, then the SRL would be reduced by a factor of 10, to 1.7 mg DDT/kg soil, or 1 .7 ppm. Such a calculation was performed by this author for a presentation delivered at the Society of Toxicology meeting in February, 1991, by Liao et al.(1991).

11.3 Example Two: Adult Residential For 30 Years

SRLs were calculated for scenarios with adults who stay at home as homemakers or individuals employed at home, and live there for 30 years. The soil ingestion and dermal contact exposure scenarios given in Appendices 5 or 7, respectively, were used in this example. The combined risk from each pathway, associated with DDT_{tot} in soil (Table 2) is 4.6×10^{-7}. Assuming that risk management determines that 1×10^{-5} is an acceptable level of individual risk, the case specific SRL is as follows:

$$SRL = \frac{1 \times 10^{-5}}{4.6 \times 10^{-7}} = 21.7 \text{ mg DDT/kg soil} = 21.7 \text{ ppm}$$

If risk management were to determine that the acceptable risk level was 1×10^{-6} rather than 1×10^{-5}, then the SRL would be reduced by a factor of 10, to 2.2 mg DDT/kg soil, or 2 .2 ppm.

11.4 Example Three: Children Living Wi th Parents

In this example, SRLs were calculated for scenarios with children who live with their parents from birth to age 18, and then move out. The soil ingestion and dermal contact exposure scenarios given in Appendices 8 or 11, respectively, were used in this example. The combined risk from each pathway, associated with a DDT_{tot} soil at a concentration of 1 mg DDT_{tot}/kg soil, is $7.0x10^{-7}$ (Table 2). Assuming that risk management determines that $1x10^{-5}$ is an acceptable level of individual risk, the case specific SRL is as follows:

$$SRL = \frac{1x10^{-5}}{7.0x10^{-7}} = 14.3 \text{ mg DDT/kg soil} = 14.3 \text{ ppm}$$

If risk management were to determine that the acceptable risk level was $1x10^{-6}$ rather than $1x10^{-5}$, then the SRL would be reduced by a factor of 10, to 1.4 mg DDT/kg soil, or 1 .4 ppm.

11.5 Caveat

The SRLs listed above and in Table 5 are CASE-SPECIFIC for the exposure scenarios developed in the Appendices. They are examples only, are NOT intended for generic use, and should NOT be considered as generic "action levels" for soil remediation. SRLs must be developed on a case-specific basis, according to case-specific assumptions and parameters regarding exposure, as shown by the examples given in the Appendices.

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TABLE 1

SUMMARY OF RESIDENTIAL EXPOSURE TO DDT IN SOIL*

Scenario	Lifetime Average Daily Dose (mg/kg-day)		
	Ingestion	**Dermal**	**Total**
RESIDENTIAL ADULT			
Seventy Year (Default)	1.43×10^{-6}	3.21×10^{-7}	1.75×10^{-6}
Thirty Year - Works Away From Home	3.29×10^{-7}	1.88×10^{-7}	5.17×10^{-7}
Thirty Year - Homemaker or Works at Home (Typical Case)	5.34×10^{-7}	3.06×10^{-7}	8.40×10^{-7}
Thirty Year - Homemaker or Works at Home ("High Exposure Level")	5.34×10^{-7}	8.21×10^{-7}	1.36×10^{-6}
Inhalation of Soil	N/A**	N/A	6.12×10^{-9}
Ingestion of Home-grown Produce	N/A	N/A	8.40×10^{-6}
RESIDENTIAL CHILDREN, AGES 1 THROUGH 17			
Typical Case	1.17×10^{-6}	2.70×10^{-7}	1.44×10^{-6}
"High Exposure" Scenario Case One	1.17×10^{-6}	4.47×10^{-7}	1.62×10^{-6}
"High Exposure" Scenario Case Two	1.17×10^{-6}	8.86×10^{-7}	2.06×10^{-6}
COMMUNITY PARK, AGES 1 THROUGH 17	1.29×10^{-7}	6.52×10^{-8}	1.94×10^{-7}
SCHOOL, AGES 6 THROUGH 17	1.12×10^{-7}	1.24×10^{-8}	1.24×10^{-7}

* Assumes that concentration of DDT_{tot} in soil is 1 mg DDT_{tot}/kg soil (1 ppm).

** N/A = Not applicable

TABLE 2

SUMMARY OF RISK FROM RESIDENTIAL EXPOSURE TO DDT IN SOIL*

Scenario	Lifetime Excess Cancer Risk		
	Ingestion	Dermal	Total
RESIDENTIAL ADULT			
Seventy Year (Default)	4.9×10^{-7}	1.1×10^{-7}	6.0×10^{-7}
Thirty Year - Works Away From Home	1.1×10^{-7}	6.4×10^{-8}	1.7×10^{-7}
Thirty Year - Homemaker or Works at Home Typical Case	1.8×10^{-7}	1.0×10^{-7}	2.8×10^{-7}
Thirty Year - Homemaker or Works at Home "High Exposure Level"	1.8×10^{-7}	2.8×10^{-7}	4.6×10^{-7}
Inhalation of Soil	N/A**	N/A	2.1×10^{-9}
Ingestion of Home-grown Produce	N/A	N/A	2.9×10^{-6}
RESIDENTIAL CHILDREN, AGES 1 THROUGH 17			
Typical Case	4.0×10^{-7}	9.2×10^{-8}	4.9×10^{-7}
"High Exposure" Scenario Case One	4.0×10^{-7}	1.5×10^{-7}	5.5×10^{-7}
"High Exposure" Scenario Case Two	4.0×10^{-7}	3.0×10^{-7}	7.0×10^{-7}
COMMUNITY PARK, AGES 1 THROUGH 17	4.4×10^{-8}	2.2×10^{-8}	6.6×10^{-8}
SCHOOL, AGES 6 THROUGH 17	3.8×10^{-8}	4.2×10^{-9}	4.2×10^{-8}

* Assumes that concentration of DDT_{tot} in soil is 1 mg DDT_{tot}/kg soil (1 ppm).

** N/A = Not applicable

TABLE 3

FOOD AND DRUG ADMINISTRATION TOTAL DIET STUDY EXPOSURE TO ORGANOCHLORINE PESTICIDES IN FOOD*

	Pesticide Consumption (mg/kg-day)		
	Infants (6-11 months)	**Teenagers** (14-16 years)	**Seniors** (60-65 years)
BHC-alpha and beta[a]	0.8×10^{-6}	1.4×10^{-6}	1.0×10^{-6}
BHC-gamma (lindane)	0.8×10^{-6}	1.4×10^{-6}	0.9×10^{-6}
Chlordane	0.7×10^{-6}	0.7×10^{-6}	1.0×10^{-6}
DDT[b]	68.1×10^{-6}	26.4×10^{-6}	11.5×10^{-6}
Dieldrin	11.4×10^{-6}	4.9×10^{-6}	3.9×10^{-6}
Heptachlor[c]	4.0×10^{-6}	1.7×10^{-6}	0.7×10^{-6}
Hexachlorobenzene	1.6×10^{-6}	1.1×10^{-6}	0.6×10^{-6}
Toxaphene	8.7×10^{-6}	7.8×10^{-6}	11.6×10^{-6}

* Assumes consumption of commercial produce.

a BHC = benzene hexachloride

b Sum of DDT, DDD, and DDE

c Sum of heptachlor and heptachlor epoxide

TABLE 4

FOOD AND DRUG ADMINISTRATION TOTAL DIET STUDY
RISK FROM CONSUMPTION OF ORGANOCHLORINE PESTICIDES IN FOOD*

	Excess Cancer Risk		
	Infants (6-11 months)	**Teenagers (14-16 years)**	**Seniors (60-65 years)**
BHC-alpha and betaa	3.0x10-6	5.3x10-6	3.8x10-6
BHC-gamma (lindane)	1.0x10-6	1.8x10-6	1.2x10-6
Chlordane	9.0x10-7	9.0x10-7	1.3x10-6
DDTb	2.3x10-5	9.0x10-6	3.9x10-6
Dieldrin	1.8x10-4	7.8x10-5	6.2x10-5
Heptachlorc	2.7x10-5	1.2x10-5	4.8x10-6
Hexachlorobenzene	2.6x10-6	1.8x10-6	1.0x10-6
Toxaphene	9.6x10-6	8.6x10-6	1.3x10-5
Sum of Risk	2.5x10-4	1.2x10-4	9.1x10-5

Arithmetic Mean - All Groups: $1.5x10^{-4}$

* Assumes consumption of commercial produce.

a BHC = benzene hexachloride (slope factor used is average of both)

b Sum of DDT, DDD, and DDE (slope factor used is for DDT)

c Sum of heptachlor and heptachlor epoxide (slope factor used is average of both)

TABLE 5

SITE SPECIFIC SOIL REMEDIATION LEVELS (SRLs) CALCULATED FROM EXPOSURE SCENARIOS IN THE APPENDICES

SCENARIO	RISK[a] ->	SRL (ppm) at Risk Determined to be "Acceptable"		
		$1x10^{-6}$	$5x10^{-6}$	$1x10^{-5}$
RESIDENTIAL ADULT				
Seventy Year (Default)	$6.0x10^{-7}$	1.67	8.3	16.7
Thirty Year - Works Away From Home	$1.7x10^{-7}$	5.88	29.4	58.8
Thirty Year – Homemaker or Works at Home Typical Case	$2.8x10^{-7}$	3.57	17.9	35.7
Thirty Year - Homemaker or Works at Home "High Exposure Level"	$4.6x10^{-7}$	2.17	10.9	21.7
Ingestion of Home-grown Produce	$2.9x10^{-6}$	0.34	1.7	3.4
RESIDENTIAL CHILDREN, AGES 1 THROUGH 18				
Typical Case	$4.9x10^{-7}$	2.04	10.2	20.4
"High Exposure" Scenario Case One	$5.5x10^{-7}$	1.82	9.1	18.2
"High Exposure" Scenario Case Two	$7.0x10^{-7}$	1.42	7.1	14.2
COMMUNITY PARK, CHILDREN, AGES 1 THROUGH 17	$6.6x10^{-8}$	15.15	75.8	151.5
SCHOOL, AGES 6 THROUGH 17	$4.2x10^{-8}$	23.81	119.0	238.1

[a] Total risk values taken from Table 2.

APPENDIX 1

RESIDENTIAL SOIL INGESTION
ADULT
DEFAULT LIFETIME EXPOSURE

1 ASSUMPTIONS

1.1 Adults live at residence for 70 years.

1.2 Time spent at residence is 24 hours/day, 7 days/week, 52 weeks/year, for an entire 70 year lifetime.

1.3 Soil ingestion rate for adults is 100 mg/day (USEPA, 1989a, Page 6-40).

1.4 Fraction of DDT_{tot} which is absorbed systemically from ingested soil is 1.0, i.e., 100 percent. One-hundred percent oral absorption of soil-borne DDT_{tot} is assumed, in the absence of experimental information obtained with soil as the medium of exposure.

1.5 Body weight value of adult is 70 kg (USEPA, 1989a, Page 6-40).

1.6 Concentration of DDT_{tot} in soil = 1 ppm = 1 mg DDT_{tot}/kg soil.

1.7 Exposure to contaminated soil occurs only while adult is awake and at home. Adult is always home.

2 CALCULATIONS

Calculations were based on the following equation adapted from USEPA (USEPA, 1989a, Page 6-40):

$$\text{Intake} = \frac{CS \times CF \times IR \times FI \times ABS \times EF \times ED}{BW \times AT}$$

Where:

Intake = Daily dose of DDT_{tot} averaged over a lifetime, in mg/kg-day. Also known as "Lifetime Average Daily Dose" (LADD).

CS = DDT_{tot} concentration in soil, in mg DDT_{tot}/kg soil

CF = Conversion factor = 10-6 kg/mg

IR = Soil ingestion rate, in mg soil/day

ABS = Fraction of soil-borne DDT_{tot} absorbed systemically (unitless), i.e., percent absorbed/100.

FI = Fraction of soil per day coming from contaminated source (unitless). Assumes soil ingestion occurs only while receptors are awake, and the residence is the only contaminated area of interest.

EF = Exposure frequency in days per year, i.e., "days/week x weeks/year."

ED = Exposure duration in years.

BW = Body weight in kilograms.

AT = Averaging time: period over which exposure is averaged, in days. For carcinogens, AT typically is a human lifetime in days, which is "365 days/year x 70 years."

Calculation of "Intake" is as follows:

Where:

FI = 1.0, because the total source of contaminated soil is the residence.
EF = 365 days/year
ED = 70 years
AT = 365 days/year x 70 years

These cancel out as follows:

$$\frac{FI \times EF \times ED}{AT} = \frac{1.0 \times 365 \text{ days/year} \times 70 \text{ years}}{365 \text{ days/year} \times 70 \text{ years}} = 1.0$$

The remaining equation becomes:

$$Intake = \frac{CS \times CF \times IR \times ABS}{BW}$$

Where:

CS = 1 mg DDT_{tot}/kg soil
CF = 10-6 kg/mg
IR = 100 mg soil/day
ABS = 1.0
BW = 70 kg body weight

Then Intake ("LADD"):

$$Intake = \frac{1 \text{ mg } DDT_{tot}/\text{kg soil} \times 10^{-6} \text{ kg/mg} \times 100 \text{ mg soil/day} \times 1.0}{70 \text{ kg}}$$

$$= 1.43 \times 10^{-6} \text{ mg } DDT_{tot}/\text{kg-day}$$

APPENDIX 2

RESIDENTIAL DERMAL SOIL EXPOSURE
ADULT
DEFAULT LIFETIME EXPOSURE

1 ASSUMPTIONS

1.1 Adults live at residence for 70 years.

1.2 Time spent at residence is 24 hours/day, 7 days/week, 52 weeks/year, for an entire 70 year lifetime.

1.3 Rate of soil contact with skin is 450 mg/day (Sedman, 1989).

1.4 Fraction of soil-borne DDT_{tot} which is absorbed systemically through the skin in 24 hours (dermal absorption) 0.05, i.e., 5 percent. Five percent dermal absorption of soil-borne DDT_{tot} is based on the data of Wester et al. (1990).

1.5 Body weight value of adult is 70 kg (USEPA, 1989a, Page 6-40).

1.6 Concentration of DDT_{tot} in soil = 1 ppm = 1 mg DDT_{tot}/kg soil.

1.7 Exposure to contaminated soil occurs only while adult is awake and at home. Adult is always home.

2 CALCULATIONS

Calculations were based on the following equation adapted from USEPA (USEPA, 1989a, Page 6-41):

$$\text{Absorbed Dose} = \frac{CS \times CF \times SA \times AF \times ABS \times FI \times EF \times ED}{BW \times AT}$$

Where:

Absorbed Dose = Daily dose of DDT_{tot} averaged over a lifetime, in mg/kg-day. Also known as "Lifetime Average Daily Dose."

CS = DDT_{tot} concentration in soil, in mg DDT_{tot}/kg soil

CF = Conversion factor = 10-6 kg/mg

SA = Surface area of skin exposed to soil = cm^2 skin/day

AF = Adherence factor of soil to skin = mg soil/cm^2 skin

ABS = Fraction of soil-borne DDT_{tot} absorbed systemically (unitless), i.e., percent absorbed/100.

FI = Fraction of soil per day coming from contaminated source (unitless). Assumes skin contact occurs only while receptors are awake, and the residence is the only contaminated area of interest.

EF = Exposure frequency in days per year, i. e., "days/week x weeks/year."

ED = Exposure duration in years
BW = Body weight in kilograms
AT = Averaging time: period over which exposure is averaged, in days. For carcinogens, AT typically is a human lifetime in days, which is "365 days/year x 70 years."

Calculation of "Absorbed Dose" is as follows:

Where:
FI = 1.0, because the total source of contaminated soil is at the residence.
EF = 365 days/year
ED = 70 years
AT = 365 days/year x 70 years

These cancel out as follows:

$$\frac{FI \times EF \times ED}{AT} = \frac{1.0 \times 365 \text{ days/year} \times 70 \text{ years}}{365 \text{ days/year} \times 70 \text{ years}} = 1.0$$

The remaining equation becomes:

$$\text{Absorbed Dose} = \frac{CS \times CF \times SA \times AF \times ABS}{BW}$$

Where:
CS = 1 mg DDT_{tot}/kg soil
CF = 10-6 kg/mg
SA x AF = 450 mg/day, by default
ABS = 0.05
BW = 70 kg body weight

Then:

$$\text{Absorbed Dose} = \frac{1 \text{ mg } DDT_{tot}/\text{kg soil} \times 10^{-6} \text{ kg/mg} \times 450 \text{ mg soil/day} \times 0.05}{70 \text{ kg}}$$

$$= 0.321 \times 10^{-6} \text{ mg } DDT_{tot}/\text{kg-day}$$

APPENDIX 3

RESIDENTIAL SOIL INGESTION
ADULT FOR 30 YEARS
WORKS AWAY FROM HOME

1 ASSUMPTIONS

1.1 Adults live at residence for 30 years, but are away from home on a periodic basis.

1.2 Time spent at residence:

1.2.1 Weekdays: At work for 8 hours/day, 5 days/week, for 49 weeks/year, and at home 16 hours/day, 5 days/week, for 49 weeks/year.

1.2.2 Weekends: At home 20 hours/day, 2 days/week, for 49 weeks/year.

1.2.3 Vacations: Away from home 24 hours/day for 3 weeks/year.

1.3 Soil ingestion rate for adults is 100 mg/day (USEPA , 1989a, Page 6-40).

1.4 Fraction of DDT_{tot} which is absorbed systemically from ingested soil is 1.0, i.e., 100 percent. One-hundred percent oral absorption of soil-borne DDT_{tot} is assumed, in the absence of experimental information obtained with soil as the medium of exposure.

1.5 Body weight value of adult is 70 kg (USEPA, 1989a, Page 6-40).

1.6 Concentration of DDT_{tot} in soil = 1 ppm = 1 mg DDT_{tot}/kg soil.

1.7 Exposure to contaminated soil occurs only while adult is awake and at home.

2 CALCULATIONS

Calculations were based on the following equation adapted from USEPA (USEPA, 1989a, Page 6-40):

$$\text{Intake} = \frac{CS \times CF \times IR \times ABS \times FI \times EF \times ED}{BW \times AT}$$

Where:

Intake = Daily dose of DDT_{tot} averaged over a lifetime, in mg/kg-day. Also known as "Lifetime Average Daily Dose" (LADD).

CS = DDT_{tot} concentration in soil, in mg DDT_{tot}/kg soil

CF = Conversion factor = 10-6 kg/mg

IR = Soil ingestion rate, in mg soil/day

ABS = Fraction of soil-borne DDT_{tot} absorbed systemically (unitless), i.e., percent absorbed/100.

FI = Fraction of soil per day coming from contaminated source (unitless). Assumes soil ingestion occurs only while receptors are awake, and

the residence is the only contaminated area of interest.
EF = Exposure frequency in days per year, i.e., "days/week x weeks/year."
ED = Exposure duration in years
BW = Body weight in kilograms
AT = Averaging time: period over which exposure is averaged, in days. For carcinogens, AT typically is a human lifetime in days, which is "365 days/year x 70 years."

Calculation of "Intake" was broken up into several components, for simplifying exposure calculations, as follows:

1. First, the total period of exposure, in days, was calculated, as follows:

FI x EF x ED = Total Days Exposed

The "Total Days Exposed" was calculated for an adult living at a residence for a total of 30 years, but leaving the home to work for 8 hours/day, 5 days/week, 49 weeks/year, as follows:

Where:
FI = hours exposed/hours awake per day
EF = days/week x weeks/year exposed
ED = duration of exposure period, in years.

Weekday Exposure:
FI = hours at home awake/total hours awake. Time awake is 16 hours/day, with 8 hours/day spent away from home at work. Therefore, the time spent at home awake = 16-8 = 8 hours/day, and FI = 8 hours home/16 hours awake.
EF = weekdays home/week x weeks home/year, i.e., 5 days/week x 49 weeks/year.
ED = 30 years.

The "Total Weekdays Exposed" is as follows:
8 hours/16 hours x 5 days/week x 49 weeks/year x 30 years = 3,675 Days

Weekend Exposure:
FI = hours at home awake/total hours awake. Time awake is 16 hours/day, with 4 hours/day spent away from home for shopping, errands, or recreation. Therefore, the time spent at home awake = 16-4 = 12 hours/day, and FI = 12 hours home/16 hours awake.
EF = weekend days home/week x weeks home/year, i.e., 2 days/week x 49 weeks/year.
ED = 30 years.

The "Total Weekend Days Exposed" is as follows:

12 hours/16 hours x 2 days/week x 49 weeks/year x 30 years = 2,205 Days

Total Days Exposed = Weekdays + Weekends
= 3,675 days + 2,205 days
= 5,880 days

2. "Total Soil Dose" is then calculated, as follows:

$$\text{Total Soil Dose} = \frac{\text{Total Days Exposed} \times \text{IR}}{\text{BW}}$$

Where:

Total Days Exposed = 5,880 days
IR = 100 mg/day
BW = 70 kg

$$\text{Total Soil Dose} = \frac{5{,}880 \text{ days} \times 100 \text{ mg soil/day}}{70 \text{ kg}}$$

= 8,400 mg soil/kg body weight

3. This dose of soil averaged over a lifetime ("Lifetime Average Daily Dose of Soil;" $LADD_{soil}$) is calculated as follows:

$$LADD_{soil} = \frac{\text{Total Soil Dose}}{\text{AT}}$$

Where:

Total Soil Dose = 8,400 mg soil/kg body weight
AT = 365 days/year x 70 years

$$LADD_{soil} = \frac{8{,}400 \text{ mg soil/kg body weight}}{365 \text{ days/year} \times 70 \text{ years}}$$

= 0.329 mg soil/kg body weight-day

4. The absorbed dose of DDT_{tot} averaged over a lifetime ("Lifetime Average Daily Dose of DDT_{tot}; $LADD_{DDT}$) is as follows:

$$LADD_{DDT} = LADD_{soil} \times CS \times CF \times ABS$$

Where:

$LADD_{soil}$ = 0.329 mg soil/kg body weight
CS = 1 mg DDT_{tot}/kg soil
CF = 10-6 kg/mg
ABS = 1.0

$LADD_{DDT}$ = 0.329 mg soil/kg-day x 1 mg DDT_{tot}/kg soil x 10-6 kg/mg x 1.0

= 0.329x10-6 mg DDT_{tot}/kg-day

= 3.29x10-7 mg DDT_{tot}/kg-day

Note, in this example, that $LADD_{DDT}$ is equivalent to "Intake" in the equation adapted from USEPA.

APPENDIX 4

RESIDENTIAL DERMAL SOIL EXPOSURE
ADULT FOR 30 YEARS
WORKS AWAY FROM HOME

1 ASSUMPTIONS

1.1 Adult lives at residence for 30 years, but is away from home on a periodic basis.

1.2 Time spent at residence:

1.2.1 Weekdays: At work for 8 hours/day, 5 days/week, for 49 weeks/year, and at home 16 hours/day, 5 days/week, for 49 weeks/year.

1.2.2 Weekends: At home 20 hours/day, 2 days/week, for 49 weeks/year.

1.2.3 Vacations: Away from home 24 hours/day for 3 weeks/year.

1.3 Body parts exposed to soil are head and hands, with surface area of 2290 cm^2, males and females combined (USEPA, 1989b, Page 4-11)

1.4 Factor for adherence of soil to skin = 0.5 mg soil/cm^2 (see Sedman, 1989, or discussion).

1.5 Fraction of soil-borne DDT_{tot} which is absorbed systemically through the skin in 24 hours (dermal absorption) is 0.05, i.e., 5 percent. Five percent dermal absorption of soil-borne DDT_{tot} is based on the data of Wester et al (1990).

1.6 Body weight value of adult is 70 kg (USEPA, 1989a, Page 6-40).

1.7 Concentration of DDT_{tot} in soil = 1 ppm = 1 mg DDT_{tot}/kg soil.

1.8 Exposure to contaminated occurs only while adult is awake and at home.

2 CALCULATIONS

Calculations were based on the following equation adapted from USEPA (USEPA, 1989a, Page 6-41):

$$\text{Absorbed Dose} = \frac{CS \times CF \times SA \times AF \times ABS \times FI \times EF \times ED}{BW \times AT}$$

Where:

Absorbed Dose = Daily dose of DDT_{tot} averaged over a lifetime, in mg/kg-day. Also known as "Lifetime Average Daily Dose" (LADD).

CS = DDT_{tot} concentration in soil, in mg DDT_{tot}/kg soil

CF = Conversion factor = 10-6 kg/mg

SA = Surface area of skin exposed to soil = cm^2 skin/day

AF = Adherence factor of soil to skin = mg soil/cm^2 skin

ABS = Fraction of soil-borne DDT_{tot} absorbed systemically (unitless), i.e.,

percent absorbed/100.
FI = Fraction of soil per day coming from contaminated source (unitless). Assumes skin contact occurs only while receptors are awake, and the residence is the only contaminated area of interest.
EF = Exposure frequency in days per year , i.e., "days/week x weeks/year."
ED = Exposure duration in years
BW = Body weight in kilograms
AT = Averaging time: period over which exposure is averaged, in days. For carcinogens, AT typically is a human lifetime in days, which is "365 days/year x 70 years."

Calculation of "Absorbed Dose" was broken up into several components, for simplifying exposure calculations, as follows:

1. First, the total period of exposure, in days, was calculated, as follows:

FI x EF x ED = Total Days Exposed

The "Total Days Exposed" was calculated for an adult living at a residence for a total of 30 years, but leaving the home to work for 8 hours/day, 5 days/week, 49 weeks/year, as follows:

Where:
FI = hours exposed/hours awake per day
EF = days/week x weeks/year exposed
ED = duration of exposure period, in years.

Weekday Exposure:
FI = hours at home awake/total hours awake. Time awake is 16 hours/day, with 8 hours/day spent away from home at work. Therefore, the time spent at home awake = 16-8 = 8 hours/day, and FI = 8 hours home/16 hours awake.
EF = weekdays home/week x weeks home/year, i.e., 5 days/week x 49 weeks/year.
ED = 30 years.

The "Total Weekdays Exposed" is as follows:
8 hours/16 hours x 5 days/week x 49 weeks/year x 30 years = 3,675 Days

Weekend Exposure:
FI = hours at home awake/total hours awake. Time awake is 16 hours/day, with 4 hours/day spent away from home for shopping, errands, or recreation. Therefore, the time spent at home awake = 16-4 = 12 hours/day, and FI = 12 hours home/16 hours awake.
EF = weekend days home/week x weeks home/year, i.e., 2 days/week x 49 weeks/year.

ED = 30 years.

The "Total Weekend Days Exposed" is as follows:

12 hours/16 hours x 2 days/week x 49 weeks/year x 30 years = 2,205 Days

Total Days Exposed = Weekdays + Weekends
= 3,675 days + 2,205 days
= 5,880 days

2. "Total Soil Dose" is then calculated, as follows:

$$\text{Total Soil Dose} = \frac{\text{Total Days Exposed} \times SA \times AF}{BW}$$

Where:

Total Days Exposed = 5,880 days
SA = 2290 cm^2 soil/day
AF = 0.5 mg soil/cm^2 skin
BW = 70 kg

$$\text{Total Soil Dose} = \frac{5{,}880 \text{ days} \times 2290 \text{ cm}^2 \text{ skin/day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{70 \text{ kg}}$$

= 96,180 mg soil/kg body weight

3. This dose of soil averaged over a lifetime ("Lifetime Average Daily Dose of Soil;" $LADD_{soil}$) is calculated as follows:

$$LADD_{soil} = \frac{\text{Total Soil Dose}}{AT}$$

Where:

Total Soil Dose = 96,180 mg soil/kg body weight
AT = 365 days/year x 70 years

$$LADD_{soil} = \frac{96{,}180 \text{ mg soil/kg body weight}}{365 \text{ days/year} \times 70 \text{ years}}$$

= 3.764 mg soil/kg body weight-day

4. The absorbed dose of DDT_{tot} averaged over a lifetime ("Lifetime Average Daily Dose of DDT_{tot}; $LADD_{DDT}$) is as follows:

$$LADD_{DDT} = LADD_{soil} \times CS \times CF \times ABS$$

Where:

$LADD_{soil}$ = 3.764 mg soil/kg body weight
CS = 1 mg DDT_{tot}/kg soil
CF = 10-6 kg/mg
ABS = 0.05

$LADD_{DDT}$ = 3.764 mg soil/kg-day x 1 mg DDT_{tot}/kg soil x 10-6 kg/mg x 0.05

= 0.188x10-6 mg DDT_{tot}/kg-day

= 1.88x10-7 mg DDT_{tot}/kg-day

Note, in this example, that $LADD_{DDT}$ is equivalent to "Absorbed Dose" in the USEPA equation above.

APPENDIX 5

RESIDENTIAL SOIL INGESTION
ADULT FOR 30 YEARS
HOMEMAKER OR EMPLOYED AT HOME

1 ASSUMPTIONS

1.1 Adults live at residence for 30 years.
1.2 Time spent at residence:
1.2.1 Weekdays: At home 24 hours/day, 5 days/week, for 49 weeks/year.
1.2.2 Weekends: At home 20 hours/day, 2 days/week, for 49 weeks/year.
1.2.3 Vacations: Away from home 24 hours/day for 3 weeks/year.
1.3 Soil ingestion rate for adults is 100 mg/day (USEPA, 1989a, Page 6-40).
1.4 Fraction of DDT_{tot} which is absorbed systemically from ingested soil is 1.0, i.e., 100 percent. One hundred percent oral absorption of soil-borne DDT_{tot} is assumed, in the absence of experimental information obtained with soil as the medium of exposure.
1.5 Body weight value of adult is 70 kg (USEPA, 1989a, Page 6-40).
1.6 Concentration of DDT_{tot} in soil = 1 ppm = 1 mg DDT_{tot}/kg soil.
1.7 Exposure to contaminated soil occurs only while adults are awake and at home.

2 CALCULATIONS

Calculations were based on the following equation adapted from USEPA (USEPA, 1989a, Page 6-40):

$$\text{Intake} = \frac{CS \times CF \times IR \times ABS \times FI \times EF \times ED}{BW \times AT}$$

Where:

Intake = Daily dose of DDT_{tot} averaged over a lifetime, in mg/kg-day. Also known as "Lifetime Average Daily Dose."
CS = DDT_{tot} concentration in soil, in mg DDT_{tot}/kg soil
CF = Conversion factor = 10-6 kg/mg
IR = Soil ingestion rate, in mg soil/day
ABS = Fraction of soil-borne DDT_{tot} absorbed systemically (unitless), i.e., percent absorbed/100.
FI = Fraction of soil per day coming from contaminated source (unitless). Assumes soil ingestion occurs only while receptors are awake, and the residence is the only contaminated area of interest.
EF = Exposure frequency in days per year, i.e., "days/week x weeks/year."
ED = Exposure duration in years

BW = Body weight in kilograms
AT = Averaging time: period over which exposure is averaged, in days. For carcinogens, AT typically is a human lifetime in days, which is "365 days/year x 70 years."

Calculation of "Intake" was broken up into several components, for simplifying exposure calculations, as follows:

1. First, the total period of exposure, in day s, was calculated, as follows:

FI x EF x ED = Total Days Exposed

The "Total Days Exposed" was calculated for an adult living at a residence for a total of 30 years, and staying home daily as a homemaker or for employment within the home or on the residence property.

Where:
FI = hours exposed/hours awake per day.
EF = days/week x weeks/year exposed.
ED = duration of exposure period, in years.

Weekday Exposure:
FI = hours at home awake/total hours awake. T ime awake is 16 hours/day, with all 16 hours/day spent at home. Therefore, FI = 16 hours home awake/16 hours awake. EF = weekdays home/week x weeks home/year, i.e., 5 days/week x 49 weeks/year.
ED = 30 years.

The "Total Weekdays Exposed" is as foll ows:
16 hours/16 hours x 5 days/week x 49 weeks/year x 30 years = 7,350 Days

Weekend Exposure:
FI = hours at home awake/total hours awake. Time awake is 16 hours/day, with 4 hours/day spent away from home for shopping, errands, or recreation. Therefore, the time spent at home = 16-4 = 12 hours/day, and FI = 12 hours home awake/16 hours awake.
EF = weekend days home/week x weeks home/year, i.e., 2 days/week x 49 weeks/year.
ED = 30 years.

The "Total Weekend Days Exposed" is as follows:
12 hours/16 hours x 2 days/week x 49 weeks/year x 30 years = 2,205 Days

Total Days Exposed = Weekdays + Weekends
= 7,350 days + 2,205 days
= 9,555 days

2. "Total Soil Dose" is then calculated, as follows:

$$\text{Total Soil Dose} = \frac{\text{Total Days Exposed} \times \text{IR}}{\text{BW}}$$

Where:

Total Days Exposed = 9,555 days
IR = 100 mg/day
BW = 70 kg

$$\text{Total Soil Dose} = \frac{9{,}555 \text{ days} \times 100 \text{ mg soil/day}}{70 \text{ kg}}$$

$$= 13{,}650 \text{ mg soil/kg body weight}$$

3. This dose of soil averaged over a lifetime ("Lifetime Average Daily Dose of Soil;" $LADD_{soil}$) is calculated as follows:

$$LADD_{soil} = \frac{\text{Total Soil Dose}}{\text{AT}}$$

Where:

Total Soil Dose = 13,650 mg soil/kg body weight
AT = 365 days/year x 70 years

$$LADD_{soil} = \frac{13{,}650 \text{ mg soil/kg body weight}}{365 \text{ days/year} \times 70 \text{ years}}$$

$$= 0.534 \text{ mg soil/kg body weight-day}$$

4. The absorbed dose of DDT_{tot} averaged over a lifetime ("Lifetime Average Daily Dose of DDT_{tot}; $LADD_{DDT}$) is as follows:

$$LADD_{DDT} = LADD_{soil} \times CS \times CF \times ABS$$

Where:

$LADD_{soil}$ = 0.534 mg soil/kg body weight
CS = 1 mg DDT_{tot}/kg soil
CF = 10-6 kg/mg
ABS = 1.0

$LADD_{DDT}$ = 0.534 mg soil/kg-day x 1 mg DDT_{tot}/kg soil x 10-6 kg/mg x 1.0

= 0.534x10-6 mg DDT_{tot}/kg-day

= 5.34x10-7 mg DDT_{tot}/kg-day

Note, in this example, that $LADD_{DDT}$ is equivalent to "Intake" in the equation adapted from USEPA.

APPENDIX 6

RESIDENTIAL DERMAL SOIL EXPOSURE
ADULT FOR 30 YEARS
HOMEMAKER OR EMPLOYED AT HOME

1 ASSUMPTIONS

1.1 Adults live at residence for 30 years.

1.2 Time spent at residence:

1.2.1 Weekdays: At home 24 hours/day, 5 days/week, for 49 weeks/year.

1.2.2 Weekends: At home 20 hours/day, 2 days/week, for 49 weeks/year.

1.2.3 Vacations: Away from home 24 hours/day for 3 weeks/year.

1.3 Body parts exposed to soil are head and hands, with surface area of 2290 cm^2, males and females combined (USEPA, 1989b, Page 4-11)

1.4 Factor for adherence of soil to skin = 0.5 mg soil/cm^2 (see Sedman, 1989, for discussion).

1.5 Fraction of soil-borne DDT_{tot} which is absorbed systemically through the skin in 24 hours (dermal absorption) is 0.05, i.e., 5 percent. Five percent dermal absorption of soil-borne DDT_{tot} is based on the data of Wester et al (1990).

1.6 Body weight value of adult is 70 kg (USEPA, 1989a, Page 6-40).

1.7 Concentration of DDT_{tot} in soil = 1 ppm = 1 mg DDT_{tot}/kg soil.

1.8 Exposure to contaminated soil occurs only while adults are awake and at home.

2 CALCULATIONS

Calculations were based on the following equation adapted from USEPA (USEPA, 1989a, Page 6-41):

$$\text{Absorbed Dose} = \frac{CS \times CF \times SA \times AF \times ABS \times FI \times EF \times ED}{BW \times AT}$$

Where:

Absorbed Dose = Daily dose of DDT_{tot} averaged over a lifetime, in mg/kg-day. Also known as "Lifetime Average Daily Dose."

CS = DDT_{tot} concentration in soil, in mg DDT_{tot}/kg soil

CF = Conversion factor = 1 0-6 kg/mg

SA = Surface area of skin exposed to soil = cm^2 skin/day

AF = Adherence factor of soil to skin = mg soil/cm^2 skin

ABS = Fraction of soil-borne DDT_{tot} absorbed systemically (unitless), i.e., percent absorbed/100.

FI = Fraction of soil per day coming from contaminated source (unitless).

Assumes skin contact occurs only while receptors are awake, and the residence is the only contaminated area of interest.

EF = Exposure frequency in days per year, i.e., "days/week x weeks/year."
ED = Exposure duration in years.
BW = Body weight in kilograms.
AT = Averaging time: period over which exposure is averaged, in days. For carcinogens, AT typically is a human lifetime in days, which is "365 days/year x 70 years."

Calculation of "Absorbed Dose" was broken up into several components, for simplifying exposure calculations, as follows:

1. First, the total period of exposure, in days, was calculated, as follows:

FI x EF x ED = Total Days Exposed

The "Total Days Exposed" was calculated for an adult living at a residence for a total of 30 years, and staying home daily as a homemaker or for employment in the home or on the residence property.

Where:
FI = hours exposed/hours awake per day
EF = days/week x weeks/year exposed
ED = duration of exposure period, in years.

Weekday Exposure:
FI = hours at home awake/total hours awake. Time awake is 16 hours/day, with all 16 hours/day spent at home. Therefore, FI = 16 hours home awake/16 hours awake.
EF = weekdays home/week x weeks home/year, i.e., 5 days/week x 49 weeks/year.
ED = 30 years.

The "Total Weekdays Exposed" is as follows:
16 hours/16 hours x 5 days/week x 49 weeks/year x 30 years = 7,350 Days

Weekend Exposure:
FI = hours at home awake/total hours awake. Time awake is 16 hours/day, with 4 hours/day spent away from home for shopping, errands, or recreation. Therefore, the time spent at home = 16-4 = 12 hours/day, and FI = 12 hours home awake/16 hours awake.
EF = weekend days home/week x weeks home/year, i.e., 2 days/week x 49 weeks/year.
ED = 30 years.

The "Total Weekend Days Exposed" is as follows:
12 hours/16 hours x 2 days/week x 49 weeks/year x 30 years = 2,205 Days

Total Days Exposed = Weekdays + Weekends
= 7,350 days + 2,205 days
= 9,555 days

2. "Total Soil Dose" is then calculated, as follows:

$$\text{Total Soil Dose} = \frac{\text{Total Days Exposed} \times SA \times AF}{BW}$$

Where:

Total Days Exposed = 9,555 days
SA = 2290 cm^2 soil/day
AF = 0.5 mg soil/cm^2 skin
BW = 70 kg

$$\text{Total Soil Dose} = \frac{9{,}555 \text{ days} \times 2290 \text{ cm}^2 \text{ skin/day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{70 \text{ kg}}$$

= 156,293 mg soil/kg body weight

3. This dose of soil averaged over a lifetime ("Lifetime Average Da ily Dose of Soil;" $LADD_{soil}$) is calculated as follows:

$$LADD_{soil} = \frac{\text{Total Soil Dose}}{AT}$$

Where:

Total Soil Dose = 156,293 mg soil/kg body weight
AT = 365 days/year x 70 years

$$LADD_{soil} = \frac{156{,}293 \text{ mg soil/kg body weight}}{365 \text{ days/year} \times 70 \text{ years}}$$

= 6.117 mg soil/kg body weight-day

4. The absorbed dose of DDT_{tot} averaged over a lifetime ("Lifetime Average Daily Dose of DDT_{tot}; $LADD_{DDT}$) is as follows:

$$LADD_{DDT} = LADD_{soil} \times CS \times CF \times ABS$$

Where:

$LADD_{soil}$ = 6.117 mg soil/kg body weight
CS = 1 mg DDT_{tot}/kg soil
CF = 10-6 kg/mg
ABS = 0.05

$LADD_{DDT}$ = 6.117 mg soil/kg-day x 1 mg DDT_{tot}/kg soil x 10-6 kg/mg x 0.05

= 0.306x10-6 mg DDT_{tot}/kg-day

= 3.06x10-7 mg DDT_{tot}/kg-day

Note, in this example, that $LADD_{DDT}$ is equivalent to "Absorbed Dose" in the USEPA equation above.

APPENDIX 7

RESIDENTIAL DERMAL SOIL EXPOSURE
ADULT FOR 30 YEARS
HOMEMAKER OR EMPLOYED AT HOME
A "HIGH EXPOSURE LEVEL" SCENARIO

1 ASSUMPTIONS

DIFFERENCE FROM "TYPICAL" CASE - Forearms and lower legs were exposed, in addition to head and hands.

1.1 Adults live at residence for 30 years.

1.2 Time spent at residence:

1.2.1 Weekdays: At home 24 hours/day, 5 days/week, for 49 weeks/year.

1.2.2 Weekends: At home 20 hours/day, 2 days/week, for 49 wee ks/year.

1.2.3 Vacations: Away from home 24 hours/day for 3 weeks/year.

1.3 Body parts exposed to soil are head, forearms, hands, and lower legs for males, with surface area of 6150 cm^2 (USEPA, 1989b, Page 4-11). No information was given for adult females.

1.4 Factor for adherence of soil to skin = 0.5 mg soil/cm^2 (see Sedman, 1989, for discussion).

1.5 Fraction of soil-borne DDT_{tot} which is absorbed systemically through the skin in 24 hours (dermal absorption) is 0.05, i.e., 5 percent. Five percent dermal absorption of soil-borne DDT_{tot} is based on the data of Wester et al (1990).

1.6 Body weight value of adult is 70 kg (USEPA, 1989a, Page 6-40).

1.7 Concentration of DDT_{tot} in soil = 1 ppm = 1 mg DDT_{tot}/kg soil.

1.8 Exposure to contaminated soil occur s only while adults are awake and at home.

2 CALCULATIONS

Calculations were based on the following equation adapted from USEPA (USEPA, 1989a, Page 6-41):

$$\text{Absorbed Dose} = \frac{CS \times CF \times SA \times AF \times ABS \times FI \times EF \times ED}{BW \times AT}$$

Where:

Absorbed Dose = Daily dose of DDT_{tot} averaged over a lifetime, in mg/kg-day. Also known as "Lifetime Average Daily Dose."

CS = DDT_{tot} concentration in soil, in mg DDT_{tot}/kg soil

CF = Conversion factor = 10-6 kg/mg

SA = Surface area of skin exposed to soil = cm^2 skin/day

AF = Adherence factor of soil to skin = mg soil/cm^2 skin

ABS = Fraction of soil-borne DDT_{tot} absorbed systemically (unitless), i.e., percent absorbed/100.
FI = Fraction of soil per day coming from contaminated source (unitless). Assumes skin contact occurs only while receptors are awake, and the residence is the only contaminated area of interest.
EF = Exposure frequency in days per year, i.e., "days/week x weeks/year."
ED = Exposure duration in years.
BW = Body weight in kilograms.
AT = Averaging time: period over which exposure is averaged, in days. For carcinogens, AT typically is a human lifetime in days, which is "365 days/year x 70 years."

Calculation of "Absorbed Dose" was broken up into several components, for simplifying exposure calculations, as follows:

1. First, the total period of exposure, in days, was calculated, as follows:

FI x EF x ED = Total Days Exposed

The "Total Days Exposed" was calculated for an adult living at a residence for a total of 30 years, and staying home daily as a homemaker or for employment in the home on the residence property.

Where:
FI = hours exposed/hours awake per day
EF = days/week x weeks/year exposed
ED = duration of exposure period, in years.

Weekday Exposure:
FI = hours at home awake/total hours awake. Time awake is 16 hours/day, with all 16 hours/day spent at home. Therefore, FI = 16 hours home awake/16 hours awake.
EF = weekdays home/week x weeks home/year, i.e., 5 days/week x 49 weeks/year.
ED = 30 years.

The "Total Weekdays Exposed" is as follows:

16 hours/16 hours x 5 days/week x 49 weeks/year x 30 years = 7,350 Days

Weekend Exposure:
FI = hours at home awake/total hours awake. Time awake is 16 hours/day, with 4 hours/day spent away from home for shopping, errands, or recreation. Therefore, the time spent at home = 16-4 = 12 hours/day, and FI = 12 hours home awake/16 hours awake.
EF = weekend days home/week x weeks home/year, i.e., 2 days/week x 49

weeks/year.
ED = 30 years.

The "Total Weekend Days Exposed" is as follows:

12 hours/16 hours x 2 days/week x 49 weeks/year x 30 years = 2,205 Days

Total Days Exposed = Weekdays + Weekends
= 7,350 days + 2,205 days
= 9,555 days

2. "Total Soil Dose" is then calculated, as follows:

$$\text{Total Soil Dose} = \frac{\text{Total Days Exposed} \times SA \times AF}{BW}$$

Where:

Total Days Exposed = 9,555 days
SA = 6150 cm^2 soil/day
AF = 0.5 mg soil/cm^2 skin
BW = 70 kg

$$\text{Total Soil Dose} = \frac{9{,}555 \text{ days} \times 6150 \text{ cm}^2 \text{ skin/day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{70 \text{ kg}}$$

= 419,738 mg soil/kg body weight

3. This dose of soil averaged over a lifetime ("Lifetime Average Daily Dose of Soil;" $LADD_{soil}$) is calculated as follows:

$$LADD_{soil} = \frac{\text{Total Soil Dose}}{AT}$$

Where:

Total Soil Dose = 419,738 mg so il/kg body weight
AT = 365 days/year x 70 years

$$LADD_{soil} = \frac{419{,}738 \text{ mg soil/kg body weight}}{365 \text{ days/year} \times 70 \text{ years}}$$

= 16.428 mg soil/kg body weight-day

4. The absorbed dose of DDT_{tot} averaged over a lifetime ("Lifetime Average Daily Dose of DDT_{tot}; $LADD_{DDT}$) is as follows:

$$LADD_{DDT} = LADD_{soil} \times CS \times CF \times ABS$$

Where:

LADDsoil = 16.428 mg soil/kg body weight
CS = 1 mg DDT_{tot}/kg soil
CF = 10-6 kg/mg
ABS = 0.05

$LADD_{DDT}$ = 16.428 mg soil/kg-day x 1 mg DDT_{tot}/kg soil x 10-6 kg/mg x 0.05

= 0.821x10-6 mg DDT_{tot}/kg-day

= 8.21x10-7 mg DDT_{tot}/kg-day

Note, in this example, that $LADD_{DDT}$ is equivalent to "Absorbed Dose" in the USEPA equation above.

APPENDIX 8

RESIDENTIAL SOIL INGESTION
CHILDREN AGES 1 THROUGH 17

1 ASSUMPTIONS

1.1 Children live at residence (with parents) from birth to age 18, then leave. They stay at home for 24 hours per day each day during ages 1 through 5, and attend school away from home for 8 hours per day during ages 6 through 17.

1.2 Time spent at residence:

1.2.1 Ages 1 through 5:

Home for 24 hours per day continuously, except during a 3 week holiday and vacation period during which they accompany parents in travel away from home.

1.2.2 Ages 6 through 17:

Schoolyear weekdays: At school 8 hours per day, 5 days per week, for 36 weeks per year, and at home 16 hours per day, 5 days per week for 36 weeks per year.

Schoolyear weekends: At home 21 to 24 hours per day (age-dependent), 2 days per week, for 36 weeks per year.

Note: A school year of 36 weeks is based on California requirements that public schools must have classes for about 180 days per year (180 days -- 5 days/week = 36 weeks).

Vacation from school: At home 16 to 24 hours per day (age-dependent), 7 days per week, for 13 weeks/year.

Note: All age groups are away from home for 3 weeks per year for holidays and vacations.

1.3 Soil ingestion is 200 mg/day for ages 1 through 6, and 100 mg/day for ages 7 and older (USEPA, 1989a, Page 6-40 ; USEPA 1989b, Pages 2-40 to 2-59).

1.4 Fraction of ingested DDT_{tot} which is absorbed systemically is 1.0, i.e., 100 percent. One-hundred percent oral absorption of soil-borne DDT_{tot} is assumed, in the absence of experimental information obtained with soil as the medium of exposure.

1.5 Body weight values - means of fiftieth percentile values for males and females, combined (USEPA, 1989b, Pages 5-44 and 5-45):

Ages 1 through 5 = 15.0 kg
Age 6 = 21.5 kg
Ages 7 through 17 = 43.5 kg

1.6 Concentration of DDT_{tot} in soil = 1 ppm = 1 mg DDT_{tot}/kg soil.

1.7 Exposure to contaminated soil occurs only while children are awake and at home.

2 CALCULATIONS

Calculations were based on the following equation adapted from USEPA (USEPA, 1989a, Page 6-40):

$$\text{Intake} = \frac{CS \times CF \times IR \times ABS \times FI \times EF \times ED}{BW \times AT}$$

Where:

Intake = Daily dose of DDT_{tot} averaged over a lifetime, in mg/kg-day. Also known as "Lifetime Average Daily Dose."
CS = DDT_{tot} concentration in soil, in mg DDT_{tot}/kg soil.
CF = Conversion factor = 10-6 kg/mg.
IR = Soil ingestion rate , in mg soil/day.
ABS = Fraction of soil-borne DDT_{tot} absorbed systemically (unitless), i.e., percent absorbed.
FI = Fraction of soil per day coming from contaminated source (unitless). Assumes soil ingestion occurs only while receptors are awake.
EF = Exposure frequency in days per year, i.e., "days/week x weeks/year."
ED = Exposure duration in years.
BW = Body weight in kilograms.
AT = Averaging time: period over which exposure is averaged, in days. For carcinogens, AT typically is a human lifetime in days, which is "365 days/year x 70 years."

Calculation of "Intake" was broken up into several components, for simplifying exposure calculations, as follows:

1. First, the total period of exposure, in days, was calculated, as follows:

$$FI \times EF \times ED = \text{Total Days Exposed}$$

Where:

FI = hours exposed/hours awake per day.
EF = days/week x weeks/year exposed.
ED = duration of exposure period, in years.

The "Total Days Exposed" was calculated for each age group, according to weekday or weekend activities. The Age 6 group was treated separately, because six year old children are assumed to go to school, but the default value for soil ingestion included children of age six and younger. A different default value is used for children of age 7 and older. Therefore, for the purposes of this example, the six year old group was not included with either the 1 through 5 year old children or those of age 7 through 17, but was treated separately.

Ages 1 through 5

FI x EF x ED = Total Days Exposed: Ages 1 Through 5

Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 12 hours/day for this age group, all of which is spent at home. Therefore, FI = 12 hours home/12 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for entire day, 7 days/week for 49 weeks/year.

ED = 5 years (age 1 through 5).

The "Total Days Exposed" is as follows:

12 hours/12 hours x 7 days/week x 49 w eeks/year x 5 years = 1,715 Days

Age 6

FI x EF x ED = Total Days Exposed: Age 6

Weekdays Exposed During Schoolyear, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 13 hours/day for this age group, with 8 hours/day spent at school. Therefore, hours awake at home = 13-8 = 5 hours, and FI = 5 hours awake at home/13 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for 5 weekdays/week, 36 weeks/year.

ED = 1 year (age 6 only).

The "Total Weekdays Exposed" is as follows:

5 hours/13 hours x 5 days/week x 36 weeks/year x 1 year = 69.2 Days

Weekends Exposed During Schoolyear, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 13 hours/day for this age group, all of which is spent at home. Therefore, FI = 13 hours home/13 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for 2 weekend days/week for 36 weeks/year.

ED = 1 year (age 6 only).

The "Total Weekend Days Exposed" is as follows:

13 hours/13 hours x 2 days/week x 36 weeks/year x 1 years = 72.0 Days

Vacation From School Exposure, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 13 hours/day for this age group, 11 hours of which is spent at home (with 2 hours/day spent at a park or friend's residence). Therefore, FI = 11 hours at home/13 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for all 7 days/week during school vacation for 13 weeks/year.

ED = 1 year (age 6 only).

The "Total Vacation Days Exposed" is as follows:

11 hours/13 hours x 7 days/week x 13 weeks/year x 1 year = 77.0 Days

Total Days Exposed = Weekdays + Weekends + School Vacation

= 69.2 days + 72.0 days + 77.0 days

= 218.2 days

Ages 7 Through 17

FI x EF x ED = Total Days Exposed: Ages 7 Through 17

Weekdays Exposed During Schoolyear, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 16 hours/day for this age group, with 8 hours/day spent at school. Therefore, hours awake at home = 16-8 = 8 hours, and FI = 8 hours awake at home/16 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for 5 weekdays/week, 36 weeks/year.

ED = 11 years (age 7 through 17).

The "Total Weekdays Exposed" is as foll ows:

8 hours/16 hours x 5 days/week x 36 weeks/year x 11 years = 990.0 Days

Weekends Exposed During Schoolyear, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 16 hours/day for this age group, 13 hours of which is spent at home (with 3 hours/day spent at a park or friend's residence). Therefore, FI = 13 hours home/16 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for 2 weekend days/week for 36 weeks/year.

ED = 11 years (age 7 through 17).

The "Total Weekend Days Exposed" is as follows:

13 hours/16 hours x 2 days/week x 36 weeks/year x 11 years = 643.5 Days

Vacation From School Exposure, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 16 hours/day for this age group, with 8 hours/day spent at home (and 8 hours/day at the park, beach, or friend's residence). Therefore, FI = 8 hours at home/16 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for all 7 days/week during school vacation for 13 weeks/year.

ED = 11 years (age 7 through 17).

The "Total Vacation Days Exposed" is as follows:

8 hours/16 hours x 7 days/week x 13 weeks/year x 11 years = 500.5 Days

Total Days Exposed = Weekdays + Weekends + School Vacation

= 990.0 days + 643.5 days + 500.5 days

= 2,134.0 days

2. "Total Soil Dose" is then calculated, as follow s:

$$\text{Total Soil Dose} = \frac{\text{Total Days Exposed x IR}}{\text{BW}}$$

Where:

IR = 200 mg/day for ages 1 through 6, and 100 mg/day for ages 7 and older.

BW = 15.0 kg for ages 1 through 5, 21.5 kg for age 6, and 43.5 kg for ages 7 through 17.

Ages 1 Through 5

$$\text{Total Soil Dose} = \frac{\text{1,715 days x 200 mg soil/day}}{\text{15.0 kg}}$$

= 22,866.7 mg soil/kg body weight

Age 6

$$\text{Total Soil Dose} = \frac{218.2 \text{ days} \times 200 \text{ mg soil/day}}{21.5 \text{ kg}}$$

$$= 2{,}029.8 \text{ mg soil/kg body weight}$$

Ages 7 Through 17

$$\text{Total Soil Dose} = \frac{2{,}134.0 \text{ days} \times 100 \text{ mg soil/day}}{43.5 \text{ kg}}$$

$$= 4{,}905.7 \text{ mg soil/kg body weight}$$

Total Soil Dose: Ages 1 Through 17
= (22,866.7 + 2,029.8 + 4,905.7) mg soil/kg body weight
= 29,802 mg soil/kg body weight

3. This dose of soil averaged over a lifetime ("Lifetime Average Daily Dose of Soil;" LADDsoil) is calculated as follows:

$$\text{LADDsoil} = \frac{\text{Total Soil Dose}}{\text{AT}}$$

Where:
Total Soil Dose = 29,802 mg soil/kg body weight
AT = 365 days/year x 70 years

$$\text{LADDsoil} = \frac{29{,}802 \text{ mg soil/kg body weight}}{365 \text{ days/year} \times 70 \text{ years}}$$

$$= 1.166 \text{ mg soil/kg body weight-day}$$

4. The absorbed dose of DDT_{tot} averaged over a lifetime ("Lifetime Average Daily Dose of DDT_{tot}; $LADD_{DDT}$) is as follows:

$$LADD_{DDT} = LADDsoil \times CS \times CF \times ABS$$

Where:

$LADD_{soil}$ = 1.166 mg soil/kg body weight
CS = 1 mg DDT_{tot}/kg soil
CF = 10-6 kg/mg
ABS = 1.0

$LADD_{DDT}$ = 1.166 mg soil/kg-day x 1 mg DDT_{tot}/kg soil x 10-6 kg/mg x 1.0

= 1.17x10-6 mg DDT_{tot}/kg-day

Note, in this example, that $LADD_{DDT}$ is equivalent to "Intake" in the equation adapted from USEPA.

APPENDIX 9

RESIDENTIAL DERMAL SOIL EXPOSURE
CHILDREN AGES 1 THROUGH 17
A "TYPICAL" EXPOSURE SCENARIO

1 ASSUMPTIONS

1.1 Children live at the residence (with parents) from birth to age 18, the n leave. They stay at home for 24 hours per day each day during ages 1 through 5, and attend school away from home for 8 hours per day during ages 6 through 17.

1.2 Time spent at residence:

1.2.1 Ages 1 through 5:

Home for 24 hours per day continuously, except during a 3 week holiday and vacation period during which they accompany parents in travel away from home.

1.2.2 Ages 6 through 17:

Schoolyear weekdays: At school 8 hours per day, 5 days per week, for 36 weeks per year, and at home 16 hours per day, 5 days per week for 36 weeks per year.

Schoolyear weekends: At home 21 to 24 hours per day (age-dependent), 2 days per week, for 36 weeks per year.

Note: A school year of 36 weeks is based on California requirements that public schools must have classes for about 180 days per year (180 days -- 5 days/week = 36 weeks).

Vacation from school: At home 16 to 24 hours per day (age-dependent), 7 days per week, for 13 weeks.

Note: All age groups are away from home for 3 weeks per year for holidays and vacations.

1.3 Body parts and surface area of skin exposed to soil - head and hands, based on best estimate of data from USEPA (USEPA, 1989b, Pages 4-12 and 13, and 4-30 and 31):

Ages 1 -> 5 = 1400 cm^2
Age 6 = 1520 cm^2
Ages 7 -> 17 = 2050 cm^2

1.4 Factor for adherence of soil to skin = 0.5 mg soil/cm^2 (see Sedman, 1989, for discussion).

1.5 Fraction of soil-borne DDT_{tot} which is absorbed systemically through the skin in 24 hours (dermal absorption) is 0.05, i.e., 5 percent. Five percent dermal absorption of soil-borne DDT_{tot} is based on the data of Wester et al (1990).

1.6 Body weight values - means of fiftieth percentile values for males and females, combined (USEPA, 1989b, Pages 5-44 and 5-45):

Ages 1 through 5 = 15.0 kg
Age 6 = 21.5 kg

Ages 7 through 17 = 43.5 kg

1.7 Concentration of DDT_{tot} in soil = 1 ppm = 1 mg DDT_{tot}/kg soil.

1.8 Exposure to contaminated soil occurs only while children are awake and at home.

2 CALCULATIONS

Calculations were based on the following equation adapted from USEPA (USEPA, 1989a, Page 6-41):

$$\text{Absorbed Dose} = \frac{CS \times CF \times SA \times AF \times ABS \times FI \times EF \times ED}{BW \times AT}$$

Where:

Absorbed Dose = Daily dose of DDT_{tot} averaged over a lifetime, in mg/kg-day. Also known as "Lifetime Average Daily Dose."
CS = DDT_{tot} concentration in soil, in mg DDT_{tot}/kg soil
CF = Conversion factor = 10-6 kg/mg
SA = Surface area of skin exposed to soil = cm^2 skin/day
AF = Adherence factor of soil to skin = mg soil/cm^2 skin
ABS = Fraction of soil-borne DDT_{tot} absorbed systemically (unitless), i.e., percent absorbed/100.
FI = Fraction of soil per day coming from contaminated source (unitless). Assumes skin contact occurs only while receptors are awake, and the park is the only contaminated area of interest.
EF = Exposure frequency in days per year, i.e., "days/week x weeks/year."
ED = Exposure duration in years.
BW = Body weight in kilograms.
AT = Averaging time: period over which exposure is averaged, in days. For carcinogens, AT typically is a human lifetime in days, which is "365 days/year x 70 years."

Calculation of "Absorbed Dose" was broken up into several components, for simplifying exposure calculations, as follows:

1. First, the total period of exposure, in days, was calculated, as follows:

$$FI \times EF \times ED = \text{Total Days Exposed}$$

Where:

FI = hours exposed/hours awake per day
EF = days/week x weeks/year exposed
ED = duration of exposure period, in years.

The "Total Days Exposed" was calculated for three age groups, 1 through 5

years, 6 years, and 7 through 17 years, according to weekday or weekend activities. The Age 6 group wastreated separately, as follows: six year old children are assumed to go to school along with the older children, but the default value for soil ingestion used in the other Appendices for 6 year old children was identical to that for younger children and different from that for children of age 7 and older. Therefore, to be consistent with the soil ingestion scenarios in the other Appendices, the six year old group was not included with either the 1 through 5 year old children or those of age 7 through 17, but was treated separately.

Ages 1 through 5

FI x EF x ED = Total Days Exposed: Ages 1 Through 5

Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 12 hours/day for this age group, all of which is spent at home. Therefore, FI = 12 hours home/12 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for entire day, 7 days/week for 49 weeks/year.

ED = 5 years (age 1 through 5).

The "Total Days Exposed" is as follows:

12 hours/12 hours x 7 days/week x 49 weeks/year x 5 years = 1,715 Days

Age 6

FI x EF x ED = Total Days Exposed: Age 6

Weekdays Exposed During Schoolyear, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 13 hours/day for this age group, with 8 hours/day spent at school. Therefore, hours awake at home = 13-8 = 5 hours, and FI = 5 hours awake at home/13 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for 5 weekdays/week, 36 weeks/year.

ED = 1 year (age 6 only).

The "Total Weekdays Exposed" is as follows:

5 hours/13 hours x 5 days/week x 36 weeks/year x 1 year = 69.2 Da ys

Weekends Exposed During Schoolyear, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 13 hours/day for this age group, all of which is spent at home. Therefore, FI = 13 hours home/13 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for 2 weekend days/week for 36 weeks/year.
ED = 1 year (age 6 only).

The "Total Weekend Days Exposed" is as follows:
13 hours/13 hours x 2 days/week x 36 weeks/year x 1 years = 72.0 Days

Vacation From School Exposure, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 13 hours/day for this age group, 11 hours of which is spent at home (with 2 hours/day spent at a park or friend's residence). Therefore, FI = 11 hours at home/13 hours awake.
EF = days at home/week x weeks at home/year. Assume child is home for all 7 days/week during school vacation for 13 weeks/year.
ED = 1 year (age 6 only).

The "Total Vacation Days Exposed" is as follows:
11 hours/13 hours x 7 days/week x 13 weeks/year x 1 year = 77.0 Days

Total Days Exposed = Weekdays + Weekends + School Vacation

= 69.2 days + 72.0 days + 77.0 days

= 218.2 days

Ages 7 Through 17

FI x EF x ED = Total Days Exposed: Ages 7 Through 17

Weekdays Exposed During Schoolyear, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 16 hours/day for this age group, with 8 hours/day spent at school. Therefore, hours awake at home = 16-8 = 8 hours, and FI = 8 hours awake at home/16 hours awake.
EF = days at home/week x weeks at home/year. Assume child is home for 5 weekdays/week, 36 weeks/year.
ED = 11 years (age 7 through 17).

The "Total Weekdays Exposed" is as follows:
8 hours/16 hours x 5 days/week x 36 weeks/year x 11 years = 990.0 Days

Weekends Exposed During Schoolyear, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 16 hours/day for this age group, 13 hours of which is spent at home (with 3 hours/day spent at a park or friend's residence). Therefore, FI = 13 hours home/16 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for 2 weekend days/week for 36 weeks/year.
ED = 11 years (age 7 through 17).

The "Total Weekend Days Exposed" is as follows:
13 hours/16 hours x 2 days/week x 36 weeks/year x 11 years = 643.5 Days

Vacation From School Exposure, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 16 hours/day for this age group, with 8 hours/day spent at home (and 8 hours/day at the park, beach, or friend's residence). Therefore, FI = 8 hours at home/16 hours awake.
EF = days at home/week x weeks at home/year. Assume child is home for all 7 days/week during school vacation for 13 weeks/year.
ED = 11 years (age 7 through 17).

The "Total Vacation Days Exposed" is as follows:
8 hours/16 hours x 7 days/week x 13 weeks/year x 11 years = 500.5 Days

Total Days Exposed = Weekdays + Weekends + School Vacation

= 990.0 days + 643.5 days + 500.5 days

= 2,134.0 days

2. "Total Soil Dose" is then calculated, as follows:

$$\text{Total Soil Dose} = \frac{\text{Total Days Exposed} \times SA \times AF}{BW}$$

Where:

SA = 1400 cm^2/day for ages 1 through 5
= 1520 cm^2/day for age 6
= 2050 cm^2/day for ages 7 through 17
AF = 0.5 mg soil/cm^2 skin
BW = 15.0 kg for ages 1 through 5, 21.5 kg for age 6, and 43.5 kg for ages 7 through 17.

Ages 1 Through 5

$$\text{Total Soil Dose} = \frac{1{,}715 \text{ days} \times 1400 \text{ cm}^2/\text{day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{15.0 \text{ kg}}$$

= 80,033 mg soil/kg body weight

Age 6

$$\text{Total Soil Dose} = \frac{218.2 \text{ days} \times 1520 \text{ cm}^2/\text{day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{21.5 \text{ kg}}$$

= 7,713.1 mg soil/kg body weight

Ages 7 Through 17

$$\text{Total Soil Dose} = \frac{2{,}134.0 \text{ days} \times 2050 \text{ cm}^2/\text{day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{43.5 \text{ kg}}$$

= 50,283.9 mg soil/kg body weight

Total Soil Dose: Ages 1 Through 17

= (80,033 + 7,713.1 + 50.283.9) mg soil/kg
= 138,030 mg soil/kg body weight

3. This dose of soil averaged over a lifetime ("Lifetime Average Daily Dose of Soil;" $LADD_{soil}$) is calculated as follows:

$$LADD_{soil} = \frac{\text{Total Soil Dose}}{AT}$$

Where:

Total Soil Dose = 138,030 mg soil/kg body weight
AT = 365 days/year x 70 years

$$LADD_{soil} = \frac{138{,}030 \text{ mg soil/kg body weight}}{365 \text{ days/year} \times 70 \text{ years}}$$

$$= 5.402 \text{ mg soil/kg body weight-day}$$

4. The absorbed dose of DDT_{tot} averaged over a lifetime ("Lifetime Average Daily Dose of DDT_{tot}; $LADD_{DDT}$) is as follows:

$$LADD_{DDT} = LADD_{soil} \times CS \times CF \times ABS$$

Where:

$LADD_{soil}$ = 5.402 mg soil/kg-day
CS = 1 mg DDT_{tot}/kg soil
CF = 10-6 kg/mg
ABS = 0.05

$LADD_{DDT}$ = 5.402 mg soil/kg-day x 1 mg DDT_{tot}/kg soil x 10-6 kg/mg x 0.05

= 0.270x10-6 mg DDT_{tot}/kg-day

= 2.70x10-7 mg DDT_{tot}/kg-day

Note, in this example, that $LADD_{DDT}$ is equivalent to "Absorbed Dose" in the USEPA equation above.

APPENDIX 10

RESIDENTIAL DERMAL SOIL EXPOSURE
CHILDREN AGES 1 THROUGH 17
A "HIGH" EXPOSURE SCENARIO, NUMBER ONE

1 ASSUMPTIONS

DIFFERENCE FROM "TYPICAL" CASE - Arms and legs were exposed on weekends and school vacations, in addition to head and hands, in children of age 6 and older.

1.1 Children live at residence from birth to age 18, then leave. They stay at home for 24 hours per day each day during ages 1 through 5, and attend school away from home for 8 hours per day during ages 6 through 17.

1.2 Time spent at residence:

1.2.1 Ages 1 through 5:

Home for 24 hours/day continuously, except during a 3 week holiday and vacation period during which they accompany parents in travel away from home.

1.2.2 Ages 6 through 17:

Schoolyear weekdays: At school 8 hours/day, 5 days/week, for 36 weeks/year, and at home 16 hours per day, 5 days per week for 36 weeks/year.

Schoolyear weekends: At home, 21 to 24 hours/day (age-dependent), 2 days/week, for 36 weeks/year.

Note: A school year of 36 weeks is based on California requirements that public schools must have classes for about 180 days per year (180 days -- 5 days/week = 36 weeks).

Vacation from school: At home 16 to 24 hours/day (age dependent), 7 days/week, for 13 weeks/year.

Note: All age groups are away from home for 3 weeks per year for holidays and vacations.

1.3 Body parts and surface area of skin exposed to soil, based on best estimate of data from USEPA (USEPA, 1989b, Pages 4-12 and 13, and 4-30 and 31):

Ages 1 -> 5	= 1400 cm^2	head and hands, everyday.
Age 6	= 1520 cm^2	head and hands, weekdays in school year.
	= 4970 cm^2	head, hands, arms, and legs, weekends in school year, and school vacations.
Ages 7 -> 17	= 2050 cm^2	head and hands, weekdays in school year
	= 8010 cm^2	head, hands, arms, and legs, weekends in school year, and school vacations.

1.4 Factor for adherence of soil to skin = 0.5 mg soil/cm^2 (see Sedman, 1989, for discussion).

1.5 Fraction of soil-borne DDT_{tot} which is absorbed systemically through the

skin in 24 hours (dermal absorption) is 0.05, i.e., 5 percent. Five percent dermal absorption of soil-borne DDT_{tot} is based on the data of Wester et al (1990).

1.6 Body weight values = means of fiftieth percentile values for males and females, combined:

Ages 1 through 5 = 15.0 kg
Age 6 = 21.5 kg
Ages 7 through 17 = 43.5 kg

1.7 Concentration of DDT_{tot} in soil = 1 ppm = 1 mg DDT_{tot}/kg soil.

1.8 Exposure to contaminated soil occurs only while children are awake and at home.

2 CALCULATIONS

Calculations were based on the following equation adapted from USEPA (USEPA, 1989a, Page 6-41):

$$\text{Absorbed Dose} = \frac{CS \times CF \times SA \times AF \times ABS \times FI \times EF \times ED}{BW \times AT}$$

Where:

Absorbed Dose = Daily dose of DDT_{tot} averaged over a lifetime, in mg/kg-day. Also known as "Lifetime Average Daily Dose."
CS = DDT_{tot} concentration in soil, in mg DDT_{tot}/kg soil
CF = Conversion factor = 10-6 kg/mg
SA = Surface area of skin exposed to soil = cm^2 skin/day
AF = Adherence factor of soil to skin = mg soil/cm^2 skin
ABS = Fraction of soil-borne DDT_{tot} absorbed systemically (unitless), i.e., percent absorbed/100.
FI = Fraction of soil per day coming from contaminated source (unitless). Assumes skin contact occurs only while receptors are awake, and the park is the only contaminated area of interest.
EF = Exposure frequency in days per year, i.e., "days/week x weeks/year."
ED = Exposure duration in years.
BW = Body weight in kilogram s.
AT = Averaging time: period over which exposure is averaged, in days. For carcinogens, AT typically is a human lifetime in days, which is "365 days/year x 70 years."

Calculation of "Absorbed Dose" was broken up into several components, for simplifying exposure calculations, as follows:

1. First, the total period of exposure, in days, was calculated, as follows:

FI x EF x ED = Total Days Exposed

Where:

FI = hours exposed/hours awake per day
EF = days/week x weeks/year exposed
ED = duration of exposure period, in years.

The "Total Days Exposed" was calculated for three age groups, 1 through 5 years, 6 years, and 7 through 17 years, according to weekday or weekend activities. The Age 6 group was treated separately, as follows: six year old children are assumed to go to school along with the older children, but the default value for soil ingestion used in the other Appendices for 6 year old children was identical to that for younger children and different from that for children of age 7 and older. Therefore, to be consistent with the soil ingestion scenarios in the other Appendices, the six year old group was not included with either the 1 through 5 year old children or those of age 7 through 17, but was treated separately.

Ages 1 through 5

FI x EF x ED = Total Days Exposed: Ages 1 Through 5

Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 12 hours/day for this age group, all of which is spent at home. Therefore, FI = 12 hours home/12 hours awake.
EF = days at home/week x weeks at home/year. Assume child is home for entire day, 7 days/week for 49 weeks/year.
ED = 5 years (age 1 through 5).

The "Total Days Exposed" is as follo ws:
12 hours/12 hours x 7 days/week x 49 weeks/year x 5 years = 1,715 Days

Age 6

FI x EF x ED = Total Days Exposed: Age 6

Weekdays Exposed During Schoolyear, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 13 hours/day for this age group, with 8 hours/day spent at school. Therefore, hours awake at home = 13-8 = 5 hours, and FI = 5 hours awake at home/13 hours awake.
EF = days at home/week x weeks at home/year. Assume child is home for 5 weekdays/week, 36 weeks/year.
ED = 1 year (age 6 only).

The "Total Weekdays Exposed" is as follows:
5 hours/13 hours x 5 days/week x 36 weeks/year x 1 year = 69.2 Days

Weekends Exposed During Schoolyear, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 13 hours/day for this age group, all of which is spent at home. Therefore, FI = 13 hours home/13 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for 2 weekend days/week for 36 weeks/year.

ED = 1 year (age 6 only).

The "Total Weekend Days Exposed" is as follows:
13 hours/13 hours x 2 days/week x 36 weeks/year x 1 years = 72.0 Days

Vacation From School Exposure, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 13 hours/day for this age group, 11 hours of which is spent at home (with 2 hours/day spent at a park or friend's residence). Therefore, FI = 11 hours at home/13 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for all 7 days/week during school vacation for 13 weeks/year.

ED = 1 year (age 6 only).

The "Total Vacation Days Exposed" is as follows:
11 hours/13 hours x 7 days/week x 13 weeks/year x 1 year = 77.0 Days

Total Days Exposed = Weekdays + Weekends + School Vacation

= 69.2 days + 72.0 days + 77.0 days

= 218.2 days

Ages 7 Through 17

FI x EF x ED = Total Days Exposed: Ages 7 Through 17

Weekdays Exposed During Schoolyear, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 16 hours/day for this age group, with 8 hours/day spent at school. Therefore, hours awake at home = 16-8 = 8 hours, and FI = 8 hours awake at home/16 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for 5 weekdays/week, 36 weeks/year.

ED = 11 years (age 7 through 17).

The "Total Weekdays Exposed" is as follows:
8 hours/16 hours x 5 days/week x 36 weeks/year x 11 years = 990.0 Days

Weekends Exposed During Schoolyear, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 16 hours/day for this age group, 13 hours of which is spent at home (with 3 hours/day spent at a park or friend's residence). Therefore, FI = 13 hours home/16 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for 2 weekend days/week for 36 weeks/year.

ED = 11 years (age 7 through 17).

The "Total Weekend Days Exposed" is as follows:
13 hours/16 hours x 2 days/week x 36 weeks/year x 11 years = 643.5 Days

Vacation From School Exposure, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 16 hours/day for this age group, with 8 hours/day spent at home (and 8 hours/day at the park, beach, or friend's residence). Therefore, FI = 8 hours at home/16 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for all 7 days/week during school vacation for 13 weeks/year.

ED = 11 years (age 7 through 17).

The "Total Vacation Days Exposed" is as follows:
8 hours/16 hours x 7 days/week x 13 weeks/year x 11 years = 500.5 Days

Total Days Exposed = Weekdays + Weekends + School Vacation

= 990.0 days + 643.5 days + 500.5 days

= 2,134.0 days

2. "Total Soil Dose" is then calculated, as follows:

$$\text{Total Soil Dose} = \frac{\text{Total Days Exposed} \times SA \times AF}{BW}$$

Where:

SA = 1400 cm^2/day for ages 1 through 5 throughout year.
= 1520 cm^2/day for age 6, on weekdays during school year.
= 4970 cm^2/day for age 6, on weekends during school year, during school vacations.

= 2050 cm^2/day for ages 7 through 17, on weekdays during school year.
= 8010 cm^2/day for ages 7 through 17, on weekends during school year, and during school vacations.
AF = 0.5 mg soil/cm^2 skin
BW = 15.0 kg for ages 1 through 5, 21.5 kg for age 6, and 43.5 kg for ages 7 through 17.

Ages 1 Through 5

$$\text{Total Soil Dose} = \frac{1{,}715.0 \text{ days} \times 1400 \text{ cm}^2\text{/day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{15.0 \text{ kg}}$$

= 80,033 mg soil/kg body weight

Age 6

Weekdays During School Year

$$\text{Total Soil Dose} = \frac{69.2 \text{ days} \times 1520 \text{ cm}^2\text{/day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{21.5 \text{ kg}}$$

= 2,446.1 mg soil/kg body weight

Weekends During School Year

$$\text{Total Soil Dose} = \frac{72.0 \text{ days} \times 4970 \text{ cm}^2\text{/day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{21.5 \text{ kg}}$$

= 8321.9 mg soil/kg body weight

Vacation From School

$$\text{Total Soil Dose} = \frac{77.0 \text{ days} \times 4970 \text{ cm}^2\text{/day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{21.5 \text{ kg}}$$

= 8,899.8 mg soil/kg body weight

Total Soil Dose Age 6
= (2,446.1 + 8,321.9 + 8,899.8) mg soil/kg body weight
= 19,668 mg soil/kg body weight

Ages 7 Through 17

Weekdays During School Year

$$\text{Total Soil Dose} = \frac{990.0 \text{ days} \times 2050 \text{ cm}^2/\text{day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{43.5 \text{ kg}}$$

= 23,327.6 mg soil/kg body weight

Weekends During School Year

$$\text{Total Soil Dose} = \frac{643.5 \text{ days} \times 8010 \text{ cm}^2/\text{day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{43.5 \text{ kg}}$$

= 59,246.4 mg soil/kg body weight

Vacation From School

$$\text{Total Soil Dose} = \frac{500.5 \text{ days} \times 8010 \text{ cm}^2/\text{day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{43.5 \text{ kg}}$$

= 46,080.5 mg soil/kg body weight

Total Soil Dose Age 7 Through 17
= (23,327.6 + 59,246.4 + 46,080.5) mg soil/kg body weight
= 128,655 mg soil/kg body weight

Total Soil Dose Ages 1 Through 17
= (80,033 + 19,668 + 128,655) mg soil/kg
= 228,356 mg soil/kg body weight

3. This dose of soil averaged over a lifetime ("Lifetime Average Daily Dose of Soil;" $LADD_{soil}$) is calculated as follows:

$$LADD_{soil} = \frac{\text{Total Soil Dose}}{AT}$$

Where:

Total Soil Dose = 228,356 mg soil/kg body weight
AT = 365 days/year x 70 years

$$LADD_{soil} = \frac{228{,}356 \text{ mg soil/kg body weight}}{365 \text{ days/year} \times 70 \text{ years}}$$

$$= 8.938 \text{ mg soil/kg body weight-day}$$

4. The absorbed dose of DDT_{tot} averaged over a lifetime ("Lifetime Average Daily Dose of DDT_{tot}; $LADD_{DDT}$) is as follows:

$$LADD_{DDT} = LADD_{soil} \times CS \times CF \times ABS$$

Where:

$LADD_{soil}$ = 8.938 mg soil/kg body weight-day
CS = 1 mg DDT_{tot}/kg soil
CF = 10-6 kg/mg
ABS = 0.05

$LADD_{DDT}$ = 8.938 mg soil/kg-day x 1 mg DDT_{tot}/kg soil x 10-6 kg/mg x 0.05

= 0.447x10-6 mg DDT_{tot}/kg-day

= 4.47x10-7 mg DDT_{tot}/kg-day

Note, in this example, that $LADD_{DDT}$ is equivalent to "Absorbed Dose" in the equation adapted from USEPA.

APPENDIX 11

RESIDENTIAL DERMAL SOIL EXPOSURE
CHILDREN AGES 1 THROUGH 17
A "HIGH" EXPOSURE SCENARIO, NUMBER TWO

1 ASSUMPTIONS

DIFFERENCE FROM "TYPICAL" CASE - Arms and legs were exposed, in addition to head and hands, in children of all ages.

1.1 Children live at residence from birth to age 18, then leave. They stay at home for 24 hours per day each day during ages 1 through 5, and attend school away from home for 8 hours per day during ages 6 through 17.

1.2 Time spent at residence:

1.2.1 Ages 1 through 5:

Home for 24 hours/day continuously, except during a 3 week holiday and vacation period during which they accompany parents in travel away from home.

1.2.2 Ages 6 through 17:

Schoolyear weekdays: At school 8 hours/day, 5 days/week, for 36 weeks/year, and at home 16 hours per day, 5 days per week for 36 weeks/year.

Schoolyear weekends: At home 21 to 24 hours/day (age-dependent), 2 days/week, for 36 weeks/year.

Note: A school year of 36 weeks is based on California requirements that public schools must have classes for about 180 days per year (180 days -- 5 days/week = 36 weeks).

Vacation from school: At home 16 to 24 hours/day (age-dependent), 7 days/week, for 13 weeks/year.

Note: All age groups are away from home for 3 weeks per year for holidays and vacations.

1.3 Area of skin exposed to soil, based on best estimate of data from USEPA (USEPA, 1989b, Pages 4-12 and 13, and 4-30 and 31), is head, hands, arms, and legs, as follows:

Ages 1 -> 5 = 4040 cm^2
Age 6 = 4970 cm^2
Ages 7 -> 17 = 8010 cm^2

1.4 Factor for adherence of soil to skin = 0.5 mg soil/cm^2 (see Sedman, 1989, for discussion).

1.5 Fraction of soil-borne DDT_{tot} which is absorbed systemically through the skin in 24 hours (dermal absorption) is 0.05, i.e., 5 percent. Five percent dermal absorption of soil-borne DDT_{tot} is based on the data of Wester et al (1990).

1.6 Body weight values = means of fiftieth percentile values for males and females, combined (USEPA, 1989b, Pages 5-44 and 5-45):

Ages 1 -> 5 = 15.0 kg
Age 6 = 21.5 kg
Ages 7 -> 17 = 43.5 kg

1.7 Concentration of DDT_{tot} in soil = 1 ppm = 1 mg DDT_{tot}/kg soil.

1.8 Exposure to contaminated soil occurs only while children are awake and at home.

2 CALCULATIONS

Calculations were based on the following equation adapted from USEPA (USEPA, 1989a, Page 6-41):

$$\text{Absorbed Dose} = \frac{CS \times CF \times SA \times AF \times ABS \times FI \times EF \times ED}{BW \times AT}$$

Where:

Absorbed Dose = Daily dose of DDT_{tot} averaged over a lifetime, in mg/kg-day. Also known as "Lifetime Average Daily Dose."
CS = DDT_{tot} concentration in soil, in mg DDT_{tot}/kg soil
CF = Conversion factor = 10-6 kg/mg
SA = Surface area of skin exposed to soil = cm^2 skin/day
AF = Adherence factor of soil to skin = mg soil/cm^2 skin
ABS = Fraction of soil-borne DDT_{tot} absorbed systemically (unitless), i.e., percent absorbed/100.
FI = Fraction of soil per day coming from contaminated source (unitless). Assumes skin contact occurs only while receptors are awake, and the park is the only contaminated area of interest.
EF = Exposure frequency in days per year, i.e., "days/week x weeks/year."
ED = Exposure duration in years.
BW = Body weight in kilograms.
AT = Averaging time: period over which exposure is averaged, in days. For carcinogens, AT typically is a human lifetime in days, which is "365 days/year x 70 years."

Calculation of "Absorbed Dose" was broken up into several components, for simplifying exposure calculations, as follows:

1. First, the total period of exposure, in days, was calculated, as follows:

$$FI \times EF \times ED = \text{Total Days Exposed}$$

Where:

FI = hours exposed/hours awake per day
EF = days/week x weeks/year exposed
ED = duration of exposure period, in years.

The "Total Days Exposed" was calculated for three age groups, 1 through 5 years, 6 years, and 7 through 17 years, according to weekday or weekend activities. The Age 6 group was treated separately, as follows: six year old children are assumed to go to school along with the older children, but the default value for soil ingestion used in the other Appendices for 6 year old children was identical to that for younger children and different from that for children of age 7 and older. Therefore, to be consistent with the soil ingestion scenarios in the other Appendices, the six year old group was not included with either the 1 through 5 year old children or those of age 7 through 17, but was treated separately.

Ages 1 through 5

FI x EF x ED = Total Days Exposed: Ages 1 Through 5

Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 12 hours/day for this age group, all of which is spent at home. Therefore, FI = 12 hours home/12 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for entire day, 7 days/week for 49 weeks/year.

ED = 5 years (age 1 through 5).

The "Total Days Exposed" is as follows:
12 hours/12 hours x 7 days/week x 49 weeks/year x 5 years = 1,715 Days

Age 6

FI x EF x ED = Total Days Exposed: Age 6

Weekdays Exposed During Schoolyear, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 13 hours/day for this age group, with 8 hours/day spent at school. Therefore, hours awake at home = 13-8 = 5 hours, and FI = 5 hours awake at home/13 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for 5 weekdays/week, 36 weeks/year.

ED = 1 year (age 6 only).

The "Total Weekdays Exposed" is as follows:
5 hours/13 hours x 5 days/week x 36 weeks/year x 1 year = 69.2 Days

Weekends Exposed During Schoolyear, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 13 hours/day for this age group, all of which is

spent at home. Therefore, FI = 13 hours home/13 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for 2 weekend days/week for 36 weeks/year.

ED = 1 year (age 6 only).

The "Total Weekend Days Exposed" is as follows:

13 hours/13 hours x 2 days/week x 36 weeks/year x 1 years = 72.0 Days

Vacation From School Expos ure, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 13 hours/day for this age group, 11 hours of which is spent at home (with 2 hours/day spent at a park or friend's residence). Therefore, FI = 11 hours at home/13 hours awake.

EF = days at home/week x weeks at home/year. Assume that child is home for all 7 days/week during school vacation for 13 weeks/year.

ED = 1 year (age 6 only).

The "Total Vacation Days Exposed" is as follows:

11 hours/13 hours x 7 da ys/week x 13 weeks/year x 1 year = 77.0 Days

Total Days Exposed = Weekdays + Weekends + School Vacation

= 69.2 days + 72.0 days + 77.0 days

= 218.2 days

Ages 7 Through 17

FI x EF x ED = Total Days Exposed: Ages 7 Through 17

Weekdays Exposed During Schoolyear, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 16 hours/day for this age group, with 8 hours/day spent at school. Therefore, hours awake at home = 16-8 = 8 hours, and FI = 8 hours awake at home/16 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for 5 weekdays/week, 36 weeks/year.

ED = 11 years (age 7 through 17).

The "Total Weekdays Exposed" is as follows:

8 hours/16 hours x 5 days/week x 36 weeks/year x 11 years = 990.0 Days

Weekends Exposed During Schoolyear, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 16 hours/day for this age group, 13 hours of which is spent at home (with 3 hours/day spent at a park or friend's

residence). Therefore, FI = 13 hours home/16 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for 2 weekend days/week for 36 weeks/year.

ED = 11 years (age 7 through 17).

The "Total Weekend Days Exposed" is as follows:

13 hours/16 hours x 2 days/week x 36 weeks/year x 11 years = 643.5 Da ys

Vacation From School Exposure, Where:

FI = hours awake at home/total hours awake per day. Time awake is assumed to average 16 hours/day for this age group, with 8 hours/day spent at home (and 8 hours/day at the park, beach, or friend's residence). Therefore, FI = 8 hours at home/16 hours awake.

EF = days at home/week x weeks at home/year. Assume child is home for all 7 days/week during school vacation for 13 weeks/year.

ED = 11 years (age 7 through 17).

The "Total Vacation Days Exposed" is as fol lows:

8 hours/16 hours x 7 days/week x 13 weeks/year x 11 years = 500.5 Days

Total Days Exposed = Weekdays + Weekends + School Vacation

= 990.0 days + 643.5 days + 500.5 days

= 2,134.0 days

2. "Total Soil Dose" is then calculated, as follows:

$$\text{Total Soil Dose} = \frac{\text{Total Days Exposed} \times SA \times AF}{BW}$$

Where:

SA = 4040 cm^2/day for ages 1 through 5 throughout year.
= 4970 cm^2/day for age 6
= 8010 cm^2/day for ages 7 through 17.

AF = 0.5 mg soil/cm^2 skin

BW= 15.0 kg for ages 1 through 5, 21.5 kg for age 6, and 43.5 kg for ages 7 through 17.

Ages 1 Through 5

$$\text{Total Soil Dose} = \frac{1{,}715.0 \text{ days} \times 4040 \text{ cm}^2\text{/day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{15.0 \text{ kg}}$$

= 230,953.3 mg soil/kg body weight

Age 6

$$\text{Total Soil Dose} = \frac{218.2 \text{ days} \times 4970 \text{ cm}^2\text{/day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{21.5 \text{ kg}}$$

= 25,219.9 mg soil/kg body weight

Ages 7 Through 17

$$\text{Total Soil Dose} = \frac{2134.0 \text{ days} \times 8010 \text{ cm}^2\text{/day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{43.5 \text{ kg}}$$

= 196,475.1 mg soil/kg body weight

Total Soil Dose Ages 1 Through 17
= (230,953.3 + 25,219.9 + 196,475.1) mg soil/kg
= 452,648 mg soil/kg body weight

3. This dose of soil averaged over a lifetime ("Lifetime Average Daily Dose of Soil;" $LADD_{soil}$) is calculated as follows:

$$LADD_{soil} = \frac{\text{Total Soil Dose}}{AT}$$

Where:
Total Soil Dose = 452,648 mg soil/kg body weight
AT = 365 days/year x 70 years

$$LADD_{soil} = \frac{452{,}648 \text{ mg soil/kg body weight}}{365 \text{ days/year} \times 70 \text{ years}}$$

$$= 17.716 \text{ mg soil/kg body weight-day}$$

4. The absorbed dose of DDT_{tot} averaged over a lifetime ("Lifetime Average Daily Dose of DDT_{tot}; $LADD_{DDT}$) is as follows:

$$LADD_{DDT} = LADD_{soil} \times CS \times CF \times ABS$$

Where:

$LADD_{soil}$ = 17.716 mg soil/kg body weight-day
CS = 1 mg DDT_{tot}/kg soil
CF = 10-6 kg/mg
ABS = 0.05

$LADD_{DDT}$ = 17.716 mg soil/kg-day x 1 mg DDT_{tot}/kg soil x 10-6 kg/mg x 0.05

= 0.886x10-6 mg DDT_{tot}/kg-day

= 8.86x10-7 mg DDT_{tot}/kg-day

Note, in this example, that $LADD_{DDT}$ is equivalent to "Absorbed Dose" in the equation adapted from USEPA.

APPENDIX 12

COMMUNITY PARK - SOIL INGESTION
CHILDREN OF AGES 1 THROUGH 17

1 ASSUMPTIONS

1.1 Children visit park on a periodic basis from age 1 through 17, for a total exposure period of 17 years.

1.2 Time spent at park:

1.2.1 Ages 1 through 5: 1 hour/day, 4 days/week, 49 weeks/year.

1.2.2 Ages 6 through 17:

Schoolyear weekdays: 2 hours/day, 3 days/week, 36 weeks/year.

Schoolyear weekends: 2 hours/day, 2 days/week, 36 weeks/year.

Note: A school year of 36 weeks is based on California requirements that public schools must have classes for about 180 days per year (180 days -- 5 days/week = 36 weeks).

Vacation from school: 4 hours/day, 4 days/week, 13 weeks/year.

Note: All age groups are away from home for 3 weeks per year for holidays and vacations.

1.3 Soil ingestion is 200 mg/day for all ages. Note that USEPA recommends 200 mg/day for ages 1 through 6, and 100 mg/day for ages 7 and older (USEPA, 1989a, Page 6-40 ; USEPA 1989b, Pages 2-40 to 2-59). For this community park scenario, however, children of age 6 and older are assumed to engage in "rough and tumble" and competitive sport activities, which could increase the soil ingestion rate above that described by USEPA for residential exposure scenarios. Therefore, a soil ingestion value of 200 mg/day was used for that age group. Children of ages 5 and less were assumed to be accompanied by an adult and not "rough and tumble," and therefore not exceed the 200 mg/day figure recommended by USEPA.

1.4 Fraction of ingested DDT_{tot} which is absorbed systemically is 1.0, i.e., 100 percent. One-hundred percent oral absorption of soil-borne DDT_{tot} is assumed, in the absence of experimental information.

1.5 Body weight values = means of fiftieth percentile values for males and females, combined (USEPA, 1989b, Pages 5-44 and 5-45):

Ages 1 -> 5 = 15.0 kg
Age 6 = 21.5 kg
Ages 7 -> 17 = 43.5 kg

1.6 Concentration of DDT_{tot} in soil = 1 ppm = 1 mg DDT_{tot}/kg soil.

1.7 Exposure to contaminated soil occurs only while children are in the park.

2 CALCULATIONS

Calculations were based on the following equation adapted from USEPA (USEPA, 1989a, Page 6-40):

$$\text{Intake} = \frac{CS \times CF \times IR \times ABS \times FI \times EF \times ED}{BW \times AT}$$

Where:

Intake = Daily dose of DDT_{tot} averaged over a lifetime, in mg/kg-day. Also known as "Lifetime Average Daily Dose."
CS = DDT_{tot} concentration in soil, in mg DDT_{tot}/kg soil.
CF = Conversion factor = 10-6 kg/mg.
IR = Soil ingestion rate, in mg soil/day.
ABS = Fraction of soil-borne DDT_{tot} absorbed systemically (unitless), i.e., percent absorbed/100.
FI = Fraction of soil per day coming from contaminated source (unitless). Assumes soil ingestion occurs only while receptors are awake, and the park is the only contaminated area of interest.
EF = Exposure frequency in days per year, i.e., "days/week x weeks/year."
ED = Exposure duration in years.
BW = Body weight in kilograms.
AT = Averaging time = period over which exposure is averaged, in days. For carcinogens, AT typically is a human lifetime in days, which is "365 days/year x 70 years."

Calculation of "Intake" was broken up into several components, for simplifying exposure calculations, as follows:

1. First, the total period of exposure, in days, was calculated, as follows:

$$FI \times EF \times ED = \text{Total Days Exposed}$$

Where:

FI = hours at park per day/hours awake per day.
EF = days/week x weeks/year exposed
ED = duration of exposure period, in years.

The "Total Days Exposed" was calculated for three age groups, 1 through 5 years, 6 years, and 7 through 17 years, according to weekday or weekend activities. The Age 6 group was treated separately, as follows: six year old children were assumed to go to school along with the older children, but the default value for soil ingestion in 6 year olds was identical to that for younger children and different from that for children of age 7 and older. Therefore, for the purposes of this example, the six year old group was not

included with either the 1 through 5 year old children or those of age 7 through 17, but was treated separately.

Ages 1 through 5

FI x EF x ED = Total Days Exposed: Ages 1 Through 5

Where:

FI = hours in park per day/total hours awake per day. The total time awake is assumed to average 12 hours/day for this age group, with 1 hour/day spent at the park accompanied by an adult. Therefore, FI = 1 hour in park/12 hours awake.

EF = days at park/week x weeks at park/year. Assume that an adult takes the child to the park 4 days/week, 49 weeks/year.

ED = 5 years (age 1 through 5).

The "Total Days Exposed" is as follows:
1 hour/12 hours x 4 days/week x 49 weeks/year x 5 years = 81.7 Days

Age 6

FI x EF x ED = Total Days Exposed: Age 6

Weekdays Exposed During Schoolyear, Where:

FI = hours in park per day/total hours awake per day. Time awake is assumed to be 13 hours/day for this age group, with 2 hours/day spent at the park accompanied by other children. Therefore, FI = 2 hours in park/13 hours awake.

EF = days at park/week x weeks at park/year. Assume child visits the park 3 days/week x 36 weeks/year.

ED = 1 year (age 6 only).

The "Total Weekdays Exposed " is as follows:
2 hours/13 hours x 3 days/week x 36 weeks/year x 1 year = 16.6 Days

Weekends Exposed During Schoolyear, Where:

FI = hours in park per day/total hours awake per day. The total time awake is assumed to be 13 hours/day for this age group, with 2 hours/day spent at the park accompanied by adults or other children. Therefore, FI = 2 hours in park/13 hours awake.

EF = days at park/week x weeks at park/year. Assume that the child visits the park 2 days/week x 36 weeks/year.

ED = 1 year (age 6 only).

The Total Weekend Days Exposed is as follows:

2 hours/13 hours x 2 days/week x 36 weeks/year x 1 year = 11.1 Days

Vacation From School, Where:

FI = hours in park per day/total hours awake per day. The total time awake is assumed to be 13 hours/day for this age group, with 4 hours/day spent at the park accompanied by adults or other children. Therefore, FI = 4 hours in park/13 hours awake.

EF = days at park/week x weeks at park/year.
= 4 days/week x 13 weeks/year.

ED = 1 year (age 6 only).

The "Total Vacation Days Exposed" is as follows:

4 hours/13 hours x 4 days/week x 13 weeks/year x 1 year = 16.0 Days

Total Days Exposed = Weekdays + Weekends + School Vacation

= 16.6 Days + 11.1 Days + 16.0 Days

= 43.7 Days

Ages 7 Through 17

FI x EF x ED = Total Days Exposed: Ages 7 Through 17

Weekdays Exposed During Schoolyear, Where:

FI = hours in park per day/total hours awake per day. The total time awake is assumed to be 16 hours/day for this age group, with 2 hours/day spent at the park accompanied by other children. Therefore, FI = 2 hours in park/16 hours awake.

EF = days at park/week x weeks at park/year
= 3 days/week x 36 weeks/year.

ED = 11 years (age 7 through 17).

The "Total Weekdays Exposed" is as follows:

2 hours/16 hours x 3 days/week x 36 weeks/year x 11 years = 148.5 Days

Weekends Exposed During Schoolyear, Where:

FI = hours in park per day/total hours awake per day. The total time awake is assumed to be 16 hours/day for this age group, with 2 hours/day spent at the park. Therefore, FI = 2 hours in park/16 hours awake.

EF = days at park/week x weeks at park/year.
= 2 days/week x 36 weeks/year.

ED = 11 years (age 7 through 17).

The "Total Weekend Days Exposed" is as follows:
2 hours/16 hours x 2 days/week x 36 weeks/year x 11 years = 99.0 Days

Vacation From School, Where:

FI = hours in park per day/total hours awake per day. The total time awake is assumed to be 16 hours/day for this age group, with 4 hours/day spent at the park. Therefore, FI = 4 hours in park/16 hours awake.
EF = days at park/week x weeks at park/year.
= 4 days/week x 13 weeks/year.
ED = 11 years (age 7 through 17).

The "Total Vacation Days Exposed" is as follows:
4 hours/16 hours x 4 days/week x 13 weeks/year x 11 years = 143.0 Days

Total Days Exposed = Weekdays + Weekends + School Vacation

= 148.5 Days + 99.0 Days + 143.0 Days

= 390.5 Days

2. Total Soil Dose" is then calculated, as follows:

$$\text{Total Soil Dose} = \frac{\text{Total Days Exposed} \times \text{IR}}{\text{BW}}$$

Where:

IR = 200 mg/day for all ages.
BW = 15.0 kg for ages 1 through 5, 21.5 kg for age 6, and 43.5 kg for ages 7 through 17.

Ages 1 Through 5

$$\text{Total Soil Dose} = \frac{81.7 \text{ days} \times 200 \text{ mg soil/day}}{15.0 \text{ kg}}$$

= 1,089.3 mg soil/kg body weight

Age 6

$$\text{Total Soil Dose} = \frac{43.7 \text{ days} \times 200 \text{ mg soil/day}}{21.5 \text{ kg}}$$

= 406.5 mg soil/kg body weight

Ages 7 Through 17

$$\text{Total Soil Dose} = \frac{390.5 \text{ days} \times 200 \text{ mg soil/day}}{43.5 \text{ kg}}$$

= 1,795.4 mg soil/kg body weight

Total Soil Dose: Ages 1 Through 17 = (1,089.3 + 406.5 + 1,795.4) mg soil/kg

= 3,291 mg soil/kg body weight

3. This dose of soil averaged over a lifetime ("Lifetime Average Daily Dose of Soil;" $LADD_{soil}$) is calculated as follows:

$$LADD_{soil} = \frac{\text{Total Soil Dose}}{AT}$$

Where:

Total Soil Dose = 3,291 mg soil/kg body weight
AT = 365 days/year x 70 years

$$LADD_{soil} = \frac{3{,}291 \text{ mg soil/kg body weight}}{365 \text{ days/year} \times 70 \text{ years}}$$

= 0.129 mg soil/kg body weight-day

4. The absorbed dose of DDT_{tot} averaged over a lifetime ("Lifetime Average Daily Dose of DDT_{tot}; $LADD_{DDT}$) is as follows:

$$LADD_{DDT} = LADD_{soil} \times CS \times CF \times ABS$$

Where:

$LADD_{soil}$ = 0.129 mg soil/kg body weight-day
CS = 1 mg DDT_{tot}/kg soil
CF = 10-6 kg/mg
ABS = 1.0

$LADD_{DDT}$ = 0.129 mg soil/kg-day x 1 mg DDT_{tot}/kg soil x 10-6 kg/mg x 1.0

= 0.129x10-6 mg DDT_{tot}/kg-day

= 1.29x10-7 mg DDT_{tot}/kg-day

Note, in this example, that $LADD_{DDT}$ is equivalent to "Intake" in the equation adapted from USEPA.

APPENDIX 13

COMMUNITY PARK - DERMAL SOIL EXPOSURE INDIVIDUALS OF AGES 1 THROUGH 17

1 ASSUMPTIONS

1.1 Children visit park on a periodic basis from age 1 through 17, for a t otal exposure period of 17 years.

1.2 Time spent at park:

1.2.1 Ages 1 through 5: 1 hour/day, 4 days/week, 49 weeks/year.

1.2.2 Ages 6 through 17:

Schoolyear weekdays: 2 hours/day, 3 days/week, 36 weeks/year.

Schoolyear weekends: 3 hours/day, 2 days/week, 36 weeks/year.

Note: A school year of 36 weeks is based on California requirements that public schools must have classes for about 180 days per year (180 days - 5 days/week = 36 weeks).

Vacation from school: 4 hours/day, 4 days/week, 13 weeks/year.

Note: All age groups are away from home for 3 weeks per year for holidays and vacations.

1.3 Body parts and surface area of skin exposed to soil - age and activity specific - based on best estimate of data from USEPA (USEPA, 1989b, Pages 4-12 and 13, and 4-30 and 31).

All days - head and hands:

Ages 1 -> 5 = 1400 cm^2

Weekdays - head and hands:

Age 6 = 1520 cm^2

Ages 7 -> 17 = 2050 cm^2

Weekends and school vacation - head, hands, arms, and legs:

Age 6 = 4970 cm^2

Ages 7 -> 17 = 8010 cm^2

Assume that children in the 1 through 5 year old group are accompanied by parents and do not engage in rough play activities or have different clothing covering on weekends than on weekdays.

1.4 Factor for adherence of soil t o skin = 0.5 mg soil/m^2 (see Sedman, 1989, for discussion).

1.5 Fraction of soil-borne DDT_{tot} which is absorbed systemically through the skin in 24 hours (dermal absorption) is 0.05, i.e., 5 percent. Five percent dermal absorption of soil-borne DDT_{tot} is based on the data of Wester et al (1990).

1.6 Body weight values - means of fiftieth percentile values for males and females, combined (USEPA, 1989b, Pages 5-44 and 5-45):

Ages 1 -> 5 = 15.0 kg

Age 6 = 21.5 kg

Ages 7 -> 17 = 43.5 kg

1.7 Concentration of DDT_{tot} in soil = 1 ppm = 1 mg DDT_{tot}/kg soil.
1.8 Exposure to contaminated soil occurs only while children are in the park.

2 CALCULATIONS

Calculations were based on the following equation adapted from USEPA (USEPA, 1989a, Page 6-41):

$$\text{Absorbed Dose} = \frac{CS \times CF \times SA \times AF \times ABS \times FI \times EF \times ED}{BW \times AT}$$

Where:

Absorbed Dose = Daily dose of DDT_{tot} averaged over a lifetime, in mg/kg-day. Also known as "Lifetime Average Daily Dose."
CS = DDT_{tot} concentration in soil, in mg DDT_{tot}/kg soil
CF = Conversion factor = 10-6 kg/mg
SA = Surface area of skin exposed to soil = cm^2 skin/day
AF = Adherence factor of soil to skin = mg soil/cm^2 skin
ABS = Fraction of soil-borne DDT_{tot} absorbed systemically (unitless), i.e., percent absorbed/100.
FI = Fraction of soil per day coming from contaminated source (unitless). Assumes skin contact occurs only while receptors are awake, and the park is the only contaminated area of interest.
EF = Exposure frequency in days per year, i.e., "days/week x weeks/year."
ED = Exposure duration in years.
BW = Body weight in kilograms.
AT = Averaging time: period over which exposure is averaged, in days. For carcinogens, AT typically is a human lifetime in days, which is "365 days/year x 70 years."

Calculation of "Absorbed Dose" was broken up into several components, for simplifying exposure calculations, as follows:

1. First, the total period of exposure, in days, was calculated, as follows:

$$FI \times EF \times ED = \text{Total Days Exposed}$$

Where:

FI = hours exposed/hours awake per day
EF = days/week x weeks/year exposed
ED = duration of exposure period, in years.

The "Total Days Exposed" was calculated for three age groups, 1 through 5 years, 6 years, and 7 through 17 years, according to weekday or weekend activities. The Age 6 group was treated separately, as follows: six year old children are assumed to go to school along with the older children, but the default value for soil ingestion used in the other Appendices for 6 year old children was identical to that for younger children and different from that for children of age 7 and older. Therefore, to be consistent with the soil ingestion scenarios in the other Appendices, the six-year-old group was not included with either the 1 through 5-year-old children or those of age 7 through 17, but was treated separately.

Ages 1 through 5

FI x EF x ED = Total Days Exposed: Ages 1 Through 5

Where:

FI = hours in park per day/total hours awake per day. Time awake is assumed to average 12 hours/day for this age group, with 1 hour/day spent at the park accompanied by an adult. Therefore, FI = 1 hour in park/12 hours awake.

EF = days at park/week x weeks at park/year. Assume adult takes child to park 4 days/week for 49 weeks/year.

ED = 5 years (age 1 through 5).

The "Total Days Exposed" is as follows:
1 hour/12 hours x 4 days/week x 49 weeks/year x 5 years = 81.7 Days

Age 6

FI x EF x ED = Total Days Exposed: Age 6

Weekdays Exposed During Schoolyear, Where:

FI = hours in park per day/total hours awake per day. Time awake is assumed to average 13 hours/day for this age group, with 2 hours/day spent at the park after school accompanied by other children. Therefore, FI = 2 hours in park/13 hours awake.

EF = days at park/week x weeks at park/year. Assume child visits park 3 days/week after school for 36 weeks/year.

ED = 1 year (age 6 only).

The "Total Weekdays Exposed" is as follows:
2 hours/13 hours x 3 days/week x 36 weeks/year x 1 year = 16.6 Days

Weekends Exposed During Schoolyear, Where:

FI = hours in park per day/total hours awake per day. Time awake is assumed to average 13 hours/day for this age group, with 2 hours/day spent at the park accompanied by adults or other children. Therefore, FI = 2 hours in park/13 hours awake.

EF = days at park/week x weeks at park/year. Assume child visits park 2 days/week during weekend for 36 weeks/year.

ED = 1 year (age 6 only).

The "Total Weekend Days Exposed" is as follows:

2 hours/13 hours x 2 days/week x 36 weeks/y ear x 1 years = 11.1 Days

Vacation From School Exposure, Where:

FI = hours in park per day/total hours awake per day. Time awake is assumed to average 13 hours/day for this age group, with 4 hours/day spent at the park accompanied by adults or other children. Therefore, FI = 4 hours in park/13 hours awake.

EF = days at park/week x weeks at park/year. Assume child visits park 4 days/week during school vacation for 13 weeks/year.

ED = 1 year (age 6 only).

The "Total Vacation Days Exposed" is as follow s:

4 hours/13 hours x 4 days/week x 13 weeks/year x 1 year = 16.0 Days

Total Days Exposed = Weekdays + Weekends + School Vacation

= 16.6 days + 11.1 days + 16.0 days

= 43.7 days

Ages 7 Through 17

FI x EF x ED = Total Days Exposed: Ages 7 Through 17

Weekdays Exposed During Schoolyear, Where:

FI = hours in park per day/total hours awake per day. Time awake is assumed to average 16 hours/day for this age group, with 2 hours/day spent at the park after school accompanied by other children. Therefore, FI = 2 hours in park/16 hours awake.

EF = days at park/week x weeks at park/year. Assume child visits park 3 days/week after school for 36 weeks/year.

ED = 11 years (age 7 through 17).

The "Total Weekdays Exposed" is as follows:

2 hours/16 hours x 3 days/week x 36 weeks/year x 11 years = 148.5 Days

Weekends Exposed During Schoolyear, Where:

FI = hours in park per day/total hours awake per day. Time awake is assumed to average 16 hours/day for this age group, with 2 hours/day spent at the park accompanied by adults or other children. Therefore, FI = 2 hours in park/16 hours awake.

EF = days at park/week x weeks at park/year. Assume child visits park 2 days/week during weekend for 36 weeks/year.

ED = 11 years (age 7 through 17).

The "Total Weekend Days Exposed" is as follows:

2 hours/16 hours x 2 days/week x 36 weeks/year x 11 y ears = 99.0 Days

Vacation From School Exposure, Where:

FI = hours in park per day/total hours awake per day. Time awake is assumed to average 16 hours/day for this age group, with 4 hours/day spent at the park accompanied by adults or other children. Therefore, FI = 4 hours in park/16 hours awake.

EF = days at park/week x weeks at park/year. Assume child visits park 4 days/week during school vacation for 13 weeks/year.

ED = 1 year (age 6 only).

The "Total Vacation Days Exposed" is as follows:

4 hours/16 hours x 4 days/week x 13 weeks/year x 11 years = 143.0 Days

Total Days Exposed = Weekdays + Weekends + School Vacation

= 148.5 days + 99.0 days + 143.0 days

= 390.5 days

2. "Total Soil Dose" is then calculated, as follows:

$$\text{Total Soil Dose} = \frac{\text{Total Days Exposed} \times \text{SA} \times \text{AF}}{\text{BW}}$$

Where:

SA = 1400 cm^2/day for ages 1 through 5 throughout year.

SA on weekdays = 1520 cm^2/day for age 6 and 2050 cm^2/day for ages 7 through 17.

SA on weekends and school vacations = 4970 cm^2/day for age 6 and 8010 cm^2/day for ages 7 through 17.

AF = 0.5 mg soil/cm^2 skin

BW = 15.0 kg for ages 1 through 5, 21.5 kg for age 6, and 43.5 kg for ages 7 through 17.

Ages 1 Through 5

$$\text{Total Soil Dose} = \frac{81.7 \text{ days} \times 1400 \text{ cm}^2/\text{day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{15.0 \text{ kg}}$$

= 3,812.7 mg soil/kg body weight

Age 6

Weekdays

$$\text{Total Soil Dose} = \frac{16.6 \text{ days} \times 1520 \text{ cm}^2/\text{day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{21.5 \text{ kg}}$$

= 586.8 mg soil/kg body weight

Weekends

$$\text{Total Soil Dose} = \frac{11.1 \text{ days} \times 4970 \text{ cm}^2/\text{day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{21.5 \text{ kg}}$$

= 1,283.0 mg soil/kg body weight

School vacation

$$\text{Total Soil Dose} = \frac{16.0 \text{ days} \times 4970 \text{ cm}^2/\text{day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{21.5 \text{ kg}}$$

= 1,849.3 mg soil/kg body weight

Total Soil Dose Age 6 = (586.8 + 1,283.0 + 1,849.3) mg soil/kg

= 3,719.1 mg soil/kg body weight

Ages 7 Through 17

Weekdays

$$\text{Total Soil Dose} = \frac{148.5 \text{ days} \times 2050 \text{ cm}^2/\text{day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{43.5 \text{ kg}}$$

$$= 3{,}499.1 \text{ mg soil/kg body weight}$$

Weekends

$$\text{Total Soil Dose} = \frac{99.0 \text{ days} \times 8010 \text{ cm}^2/\text{day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{43.5 \text{ kg}}$$

$$= 9{,}114.8 \text{ mg soil/kg body weight}$$

School vacation

$$\text{Total Soil Dose} = \frac{143.0 \text{ days} \times 8010 \text{ cm}^2/\text{day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{43.5 \text{ kg}}$$

$$= 13{,}165.9 \text{ mg soil/kg body weight}$$

Total Soil Dose Ages 7 Through 17
= (3,499.1 + 9,114.8 + 13,165.9) mg soil/kg
= 25,779.8 mg soil/kg body weight

Total Soil Dose Ages 1 Through 17
= (3,812.7 + 3,719.1 + 25,779.8) mg soil/kg
= 33,312 mg soil/kg body weight

3. This dose of soil averaged over a lifetime ("Lifetime Average Daily Dose of Soil;" $LADD_{soil}$) is calculated as follows:

$$LADD_{soil} = \frac{\text{Total Soil Dose}}{AT}$$

Where:

Total Soil Dose = 33,312 mg soil/kg body weight
AT = 365 days/year x 70 years

$$LADD_{soil} = \frac{33{,}312 \text{ mg soil/kg body weight}}{365 \text{ days/year} \times 70 \text{ years}}$$

$$= 1.304 \text{ mg soil/kg body weight-day}$$

4. The absorbed dose of DDT_{tot} averaged over a lifetime ("Lifetime Average Daily Dose of DDT_{tot}; $LADD_{DDT}$) is as follows:

$$LADD_{DDT} = LADD_{soil} \times CS \times CF \times ABS$$

Where:

$LADD_{soil}$ = 1.304 mg soil/kg body weight-day
CS = 1 mg DDT_{tot}/kg soil
CF = 10-6 kg/mg
ABS = 0.05

$LADD_{DDT}$ = 1.304 mg soil/kg-day x 1 mg DDT_{tot}/kg soil x 10-6 kg/mg x 0.05

= 0.0652x10-6 mg DDT_{tot}/kg-day

= 6.52x10-8 mg DDT_{tot}/kg-day

Note, in this example, that $LADD_{DDT}$ is equivalent to "Absorbed Dose" in the equation adapted from USEPA.

APPENDIX 14

SOIL INGESTION EXPOSURE AT SCHOOL CHILDREN AGES 1 THROUGH 17

1 ASSUMPTIONS

1.1 Children attend school at the same location from grades 1 through 12, from ages 6 through 17.

1.2 Time spent at school: 8 hours/day, 180 days/year, for 12 years.

Note: A school year of 180 days is based on California requirements for public schools to receive State funding.

1.3 Average soil ingestion rate is 110 mg/day for ages 6 through 17, which represents a combination of the 200 mg/day for 6 year olds and the 100 mg/day figure for individuals 7 years and older, recommended by USEPA (1989a, Page 6-40)

1.4 Factor for adherence of soil to skin = 0.5 mg soil/cm^2 (see Sedman, 1989, for discussion).

1.5 Fraction of soil-borne DDT_{tot} which is absorbed systemically from ingested soil = 1.0, i.e., 100 percent. One hundred percent oral absorption of soil-borne DDT_{tot} is assumed, in the absence of experimental information obtained with soil as the medium of exposure.

1.6 Body weight values = means of fiftieth percentile values for males and females, combined (USEPA, 1989b, Pages 5-44 and 5-45): Ages 6 through 17 = 41.6 kg

1.7 Concentration of DDT_{tot} in soil = 1 ppm = 1 mg DDT_{tot}/kg soil.

1.8 Exposure to contaminated occurs only while children are at school.

2 CALCULATIONS

Calculations were based on the following equation adapted from USEPA (USEPA, 1989a, Page 6-41):

$$\text{Intake} = \frac{CS \times CF \times IR \times FI \times ABS \times EF \times ED}{BW \times AT}$$

Where:

Intake = Daily dose of DDT_{tot} averaged over a lifetime, in mg/kg-day. Also known as "Lifetime Average Daily Dose."

CS = DDT_{tot} concentration in soil, in mg DDT_{tot}/kg soil

CF = Conversion factor = 10-6 kg/mg

IR = Soil ingestion rate, in mg/day

ABS = Fraction of soil-borne DDT_{tot} absorbed systemically (unitless), i.e., percent absorbed/100.
FI = Fraction of soil per day coming from contaminated source (unitless). Assumes soil ingestion occurs only while receptors are awake, and the school property is the only contaminated area of interest.
EF = Exposure frequency in days per year.
ED = Exposure duration in years.
BW = Body weight in kilograms.
AT = Averaging time: period over which exposure is averaged, in days. For carcinogens, AT typically is a human lifetime in days, which is "365 days/year x 70 years."

Calculation of "Intake" was broken up into several components, for simplifying exposure calculations, as follows:

1. First, the total period of exposure, in days, was calculated, as follows:

FI x EF x ED = Total Days Exposed

Where:
FI = hours at school/total hours awake per day. Time awake is assumed to average 16 hours/day for this age group, and 8 hours/day are spent at school. Therefore, FI = 8 hours at school/16 hours awake.
EF = days at school/year, which is a total of 180 days.
ED = 12 years (age 6 through 17 ; grades 1 through 12).

The "Total Days Exposed" for each of two dress patterns is as follows:
8 hours/16 hours x 180 days/year x 12 years = 1080 Days

2. "Total Soil Dose" is then calculated, as follows:

$$\text{Total Soil Dose} = \frac{\text{Total Days Exposed} \times \text{IR}}{\text{BW}}$$

Where:
Total Days Exposed = 1080 days
IR = 110 mg soil/day
BW= 41.6 kg

$$\text{Total Soil Dose} = \frac{1{,}080 \text{ days} \times 110 \text{ mg soil/day}}{41.6 \text{ kg}}$$

$$= 2{,}856 \text{ mg soil/kg body weight}$$

3. This dose of soil averaged over a lifetime ("Lifetime Average Daily Dose of Soil;" $LADD_{soil}$) is calculated as follows:

$$LADD_{soil} = \frac{\text{Total Soil Dose}}{AT}$$

Where:

Total Soil Dose = 2,856 mg soil/kg body weight
AT = 365 days/year x 70 years

$$LADD_{soil} = \frac{2{,}856 \text{ mg soil/kg body weight}}{365 \text{ days/year} \times 70 \text{ years}}$$

$$= 0.112 \text{ mg soil/kg body weight-day}$$

4. The absorbed dose of DDT_{tot} averaged over a lifetime ("Lifetime Average Daily Dose of DDT_{tot}; $LADD_{DDT}$) is as follows:

$$LADD_{DDT} = LADD_{soil} \times CS \times CF \times ABS$$

Where:

$LADD_{soil}$ = 0.112 mg soil/kg body weight-day
CS = 1 mg DDT_{tot}/kg soil
CF = 10-6 kg/mg
ABS = 1.0

$$LADD_{DDT} = 0.112 \text{ mg soil/kg-day} \times 1 \text{ mg } DDT_{tot}\text{/kg soil} \times 10\text{-}6 \text{ kg/mg} \times 1.0$$

$$= 0.112\text{x}10\text{-}6 \text{ mg } DDT_{tot}\text{/kg-day}$$

$$= 1.12\text{x}10\text{-}7 \text{ mg } DDT_{tot}\text{/kg-day}$$

Note, in this example, that $LADD_{DDT}$ is equivalent to "Intake" in the equation adapted from USEPA.

APPENDIX 15

DERMAL SOIL EXPOSURE AT SCHOOL CHILDREN AGES 1 THROUGH 17

1 ASSUMPTIONS

1.1 Children attend school at the same location from grades 1 through 12, from ages 6 through 17.

1.2 Time spent at school: 8 hours/day, 180 days/year, for 12 years.

Note: A school year of 180 days is based on California requirements for public schools to receive State funding.

1.3 Body parts and surface area of skin exposed to soil, based on best estimate of data from USEPA (USEPA, 1989b, Pages 4-12 and 13, and 4-30 and 31), for this age group:

2030 cm^2 = Head and hands, 90 days of school year, cool weather.

7740 cm^2 = Head, arms, hands, and legs, remaining 90 days of school year, warm weather.

1.4 Factor for adherence of soil to skin = 0.5 mg soil/cm^2 (see Sedman, 1989, for discussion).

1.5 Fraction of soil-borne DDT_{tot} which is absorbed systemically through the skin in 24 hours (dermal absorption) is 0.05, i.e., 5 percent. Five percent dermal absorption of soil-borne DDT_{tot} is based on the data of Wester et al (1990).

1.6 Body weight values = means of fiftieth percentile values for males and females, combined (USEPA, 1989b, Pages 5-44 and 5-45): Ages 6 through 17 = 41.6 kg.

1.7 Concentration of DDT_{tot} in soil = 1 ppm = 1 mg DDT_{tot}/kg soil.

1.8 Exposure to contaminated occurs only while children are at school.

2 CALCULATIONS

Calculations were based on the following equation adapted from USEPA (USEPA, 1989a, Page 6-41):

$$\text{Absorbed Dose} = \frac{CS \times CF \times SA \times AF \times ABS \times FI \times EF \times ED}{BW \times AT}$$

Where:

Absorbed Dose = Daily dose of DDT_{tot} averaged over a lifetime, in mg/kg-day. Also known as "Lifetime Average Daily Dose."

CS = DDT_{tot} concentration in soil, in mg DDT_{tot}/kg soil

CF = Conversion factor = 10-6 kg/mg

SA = Surface area of skin exposed to soil = cm^2 skin/day
AF = Adherence factor of soil to skin = mg soil/cm^2 skin
ABS = Fraction of soil-borne DDT_{tot} absorbed systemically (unitless), i.e., percent absorbed/100.
FI = Fraction of soil per day coming from contaminated source (unitless). Assumes skin contact occurs only while receptors are awake, and the school grounds are the only contaminated areas of interest.
EF = Exposure frequency in days per year, i.e., "days/week x weeks/year."
ED = Exposure duration in years.
BW = Body weight in kilograms.
AT = Averaging time: period over which exposure is averaged, in days. For carcinogens, AT typically is a human lifetime in days, which is "365 days/year x 70 years."

Calculation of "Absorbed Dose" was broken up into several components, for simplifying exposure calculations, as follows:

1. First, the total period of exposure, in days, was calcula ted, as follows:

FI x EF x ED = Total Days Exposed

Where:

FI = hours at school/total hours awake per day. Time awake is assumed to average 16 hours/day for this age group, and 8 hours/day are spent at school. Therefore, FI = 8 hours home/16 hours awake.
EF = days at school/year, which is a total of 180 days, divided into two 90 day segments, between which students change dress according to weather changes.
ED = 12 years (age 6 through 17 ; grades 1 through 12).

The "Total Days Exposed" for each of the two dress segments is as follows:
8 hours/16 hours x 90 days/year x 12 years = 540 Days

2. "Total Soil Dose" is then calculated, as follows:

$$\text{Total Soil Dose} = \frac{\text{Total Days Exposed} \times SA \times AF}{BW}$$

Where:

Total Days Exposed = 540 days per dress period
SA = 2030 cm^2/day for 90 days when dressing for cool weather in "long clothes."
= 7740 cm^2/day for 90 days when dressing for warm weather in shorts and short sleeve shirts.
AF = 0.5 mg soil/cm^2 skin
BW = 41.6 kg

Exposure While Dressed in "Long Clothes:"

$$\text{Total Soil Dose} = \frac{540 \text{ days} \times 2030 \text{ cm}^2\text{/day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{41.6 \text{ kg}}$$

= 13,175.4 mg soil/kg body weight

Exposure While Dressed in "Short Clothes:"

$$\text{Total Soil Dose} = \frac{540 \text{ days} \times 7740 \text{ cm}^2\text{/day} \times 0.5 \text{ mg soil/cm}^2 \text{ skin}}{41.6 \text{ kg}}$$

= 50,235.5 mg soil/kg body weight

Total Soil Dose During Grades 1 Through 12
= (13,175.4 + 50,235.5) mg soil/kg
= 63,411 mg soil/kg body weight

3. This dose of soil averaged over a lifetim e ("Lifetime Average Daily Dose of Soil;" $LADD_{soil}$) is calculated as follows:

$$LADD_{soil} = \frac{\text{Total Soil Dose}}{AT}$$

Where:

Total Soil Dose = 63,411 mg soil/kg body weight
AT = 365 days/year x 70 years

$$LADD_{soil} = \frac{63{,}411 \text{ mg soil/kg body weight}}{365 \text{ days/year} \times 70 \text{ years}}$$

= 2.482 mg soil/kg body weight-day

4. The absorbed dose of DDT_{tot} averaged over a lifetime ("Lifetime Average Daily Dose of DDT_{tot}; $LADD_{DDT}$) is as follows:

$$LADD_{DDT} = LADD_{soil} \times CS \times CF \times ABS$$

Where:

$LADD_{soil}$ = 2.482 mg soil/kg body weight-day
CS = 1 mg DDT_{tot}/kg soil
CF = 10-6 kg/mg
ABS = 0.05

$LADD_{DDT}$ = 2.482 mg soil/kg-day x 1 mg DDT_{tot}/kg soil x 10-6 kg/mg x 0.05

= 0.124x10-6 mg DDT_{tot}/kg-day

= 1.24x10-8 mg DDT_{tot}/kg-day

Note, in this example, that $LADD_{DDT}$ is equivalent to "Absorbed Dose" in the equation adapted from USEPA.

APPENDIX 16

RESIDENTIAL INHALATION EXPOSURE
ADULT FOR 30 YEARS
HOMEMAKER OR WORKS AT HOME

1 ASSUMPTIONS

1.1 Adult lives at the residence for 3 0 years.

1.2 Time spent at residence:

1.2.1 Weekdays: At home 24 hours/day, 5 days/week, for 49 weeks/year.

1.2.2 Weekends: At home 20 hours/day, 2 days/week, for 49 weeks/year.

1.2.3 Vacations: Away from home 24 hours/day for 3 weeks/year.

1.3 Ventilation rate = 20 m^3/day.

1.4 Total dust concentration = 200 ug/m^3

1.5 Concentration of dust available for alveolar deposition (particles < 10 um in size) = 50 ug/m^3

1.6 Systemic absorption of DDT_{tot} from alveolar dust = 100%.

1.7 Body weight value for adult is 70 kg (USEPA, 1989a, Page 6-40).

1.8 Concentration of DDT_{tot} in dust is 1 ppm = 1 mg DDT_{tot}/kg soil.

2 CALCULATIONS

Calculations were based on the following equation adapted from USEPA (USEPA, 1989a, Page 6-44):

$$\text{Intake} = \frac{CA \times CS \times CF \times IR \times ET \times EF \times ED}{BW \times AT}$$

Where:

Intake = Daily dose of DDT_{tot} averaged over a lifetime, in mg/kg-day. Also known as "Lifetime Average Daily Dose" (LADD).

CA = Concentration of dust in air, in mg/m^3

CS = Concentration of DDT_{tot} in dust, in mg/kg

CF = Conversion factor = 10-6 kg/mg

IR = Inhalation rate, in m^3/day

ET = Exposure time, in hours/day

EF = Exposure frequency, in days/year, i.e., "days/week x weeks/year."

ED = Exposure duration, in year

BW = Body weight
AT = Averaging time: period over which exposure is averaged, in days. For carcinogens, AT typically is a human lifetime in days, which in this example scenario, is "365 days/year x 70 years."

Where:

CA = 50 ug dust/m^3 = 0.05 mg dust/m^3, all of which is assumed to be respirable, i.e., particle sizes of 10 microns or less.
CS = 1 mg DDT_{tot}/kg soil
CF = 10-6 kg/mg
IR = 20 m^3/day
ET = 24 hours/day; assumes windows are open all year.
EF = 7 days/week x 49 weeks/year
ED = 30 years
BW = 70 kg
AT = 365 days/year x 70 years

Accordingly, Intake ("LADD") =

$$LADD = \frac{0.05 \text{ mg dust/m}^3 \times 1 \text{ mg DDT}_{tot}\text{/kg} \times 10\text{-}6 \text{ kg/mg} \times 20 \text{ m}^3\text{/day} \times 365 \text{ days/ yr} \times 30 \text{ yrs}}{70 \text{ kg} \times 365 \text{ days/ yr} \times 70 \text{ yrs}}$$

= 0.00612x10-6 mg DDT_{tot}/kg-day

= 6.12x10-9 mg DDT/kg-day

APPENDIX 17

INGESTION OF HOME-GROWN PRODUCE
ADULT

1 ASSUMPTIONS

1.1 Adult lives at residence for 30 years.
1.2 Adult body weight is 70 kg.
1.3 Residence has sufficient space for small garden.
1.4 Amount of homegrown produce and fruit consumed = 78 g/day.
1.5 Concentration of DDT_{tot} in soil = 1 ppm
1.6 Systemic absorption of DDT from produce/fruit = 100%.

2 CALCULATIONS

The concentration of DDT_{tot} taken up into the homegrown produce was calculated according to the following equation from CAPCOA (CAPCOA, 1992, Page E-II-9), with values for Koc and Kow taken from Superfund Public Health Evaluation Manual (USEPA, 1986, Page 122), as follows:

$$Ctrans = CS \times UF2$$

Where:

Ctrans = Concentration in plant due to root uptake, in ug/kg.
CS = Concentration of DDT_{tot} in soil, in ug DDT_{tot}/kg soil.
UF2 = Uptake factor, which is calculated as follows:

$$UF2 = [(0.03 \times Kow^{0.77}) + 0.82]/(Koc \times Foc)$$

Where:

0.03, 0.77, and 0.82 = Empirical constants.
Kow = Octanol:water partition coefficient. Log Kow values from USEPA (1986, Page 122):
DDT log Kow = 6.19; Kow = 1,548,817
DDE log Kow = 7.00; Kow = 10,000,000
DDD log Kow = 6.20; Kow = 1,584,893
Koc = Organic carbon partition coefficient. Values from USEPA (1986, Page 122):
DDT = 243,000
DDE = 4,400,000
DDD = 770,000
Foc = Fraction of organic carbon in the soil = 0.1 (CAPCOA, 1992, Page E-II-10).

UF2 Calculations:

$UF2_{DDT}$ = [(0.03 x 1,548,8170.77) + 0.82]/(243,000 x 0.1) = 0.08790

UF2DDE = [(0.03 x 10,000,0000.77) + 0.82]/(4,400,000 x 0.1) = 0.01674

UF2DDD = [(0.03 x 1,584,8930.77) + 0.82]/(770,000 x 0.1) = 0.02824

Ctrans Calculations:

$C_{trans\text{-}DDT}$ = 1,000 ug DDT/kg soil x 0.08790 = 87.90 ug DDT/kg plant

Ctrans-DDE = 1,000 ug DDE/kg soil x 0.01674 = 16.74 ug DDE/kg plant

Ctrans-DDD = 1,000 ug DDD/kg soil x 0.02824 = 28.24 ug DDD/kg plant

Exposure to DDT_{tot} was then calculated according to the following equation adapted from USEPA (1989b, Page 1-8 in Part II):

$$\text{Lifetime Average Daily Exposure} = \frac{C \times CR \times CF \times ED}{BW \times LT \times 365 \text{ days/year}}$$

Where:

Lifetime Average Daily Exposure = Daily dose of DDT_{tot} averaged over a lifetime, in mg/kg-day.
C = Ctrans-DDT = Contaminant concentration in produce, in mg DDT/kg produce.
CR = Consumption rate, in g produce/day.
CF = Conversion factor = 10-3 kg/g
ED = Exposure duration, in days, i.e., "days ingested/year x years"
BW = Body weight, in kg
LT = Lifetime in years

For the purposes of this exercise, DDT alone was modeled in this system, because the estimated plant uptake factor (see UF2 above) for DDT was greater than that for either DDE or DDD. CR and ED were selected from USEPA figures (1989b, Pages 1-8 through 1-11, in Part II), and represent a "typical" scenario. Accordingly:

C = Ctrans-DDT = 0.0879 mg DDT/kg produce
CR: Homegrown vegetables = 50 g/day
Homegrown fruit = 28 g/day
Total homegrown produce eaten = 78 g/day
CF = 10-6 kg/mg
ED = 20 percent of time, assuming long harvest periods;
= 0.2 x 365 days/year x 30 years = 2,190 days per 30 years
BW = 70 kg
LT = 70 years

Lifetime Average Daily Exposure:

$$= \frac{78 \text{ g food/day} \times 0.0879 \text{ mg DDT/kg produce} \times 10\text{-}3 \text{ kg/g} \times 2{,}190 \text{ days/year}}{70 \text{ kg} \times 70 \text{ yrs} \times 365 \text{ days/year}}$$

= 0.00840x10-3 mg DDT/kg-day

= 8.40x10-6 mg DDT/kg-day

APPENDIX 18

CHEMICAL ABSTRACTS SERVICE (CAS) NOMENCLATURE FOR DDT, DDD, AND DDE

o,p'-DDT
1-(o-chlorophenyl)-1-(p-chlorophenyl)-2,2-trichloroethane

m,p'-DDT
1-(m-chlorophenyl)-1-(p-chlorophenyl)-2,2-trichloroethane

p,p'-DDT (also known as 4,4-DDT)
1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane

o,p'-DDD
1-(o-chlorophenyl)-1-(p-chlorophenyl)-2,2-dichloroethane

m,p'-DDD
1-(m-chlorophenyl)-1-(p-chlorophenyl)-2,2-dichloroethane

p,p'-DDD (known as "TDE" in older literature)
1,1-dichloro-2,2-bis(p-chlorophenyl)ethane

o,p'-DDE
1-(o-chlorophenyl)-1-(p-chlorophenyl)-2,2-dichloroethene

m,p'-DDE
1-(m-chlorophenyl)-1-(p-chlorophenyl)-2,2-dichloroethene

p,p'-DDE
1,1-dichloro-2,2-bis(p-chlorophenyl)ethene

OSA-DDT-SOIL.10