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Transport of Lawn-Applied 2,4-D from Turf to Home: Assessing the Relative Importance of Transport Mechanisms and Exposure Pathways

by

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Foreword

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Traditional considerations of indoor human exposure to pollutants have focused primarily on indoor use of products containing toxic chemicals and/or infiltration of pollutants from the outdoor environment. It is becoming increasingly evident, however, that other mechanisms of contaminant transport are very important. The current work provides quantitative evidence for the importance of familial activity patterns as significant contributors to the indoor levels of lawn-applied pesticides following applications. Important activity patterns include the activity levels of children and pets, and whether outdoors shoes, those of the applicator and the children, are worn indoors. The data gathered here allow estimates of in-home 2,4-D exposures of children from the inhalation and non-dietary ingestion pathways.

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Abstract

Transport of 2,4-D from the residential lawn into the home was measured following both homeowner and commercial application of this herbicide. Collection of floor dust in five rooms of each house, both prior to and after application, indicated that turf residues are transported indoors and that the gradient in 2,4-D surface loading ($\mu g/m^2$) through the house follows the traffic pattern from the entry. Removal of shoes at the door, and the activity level of the children and pets, were the most significant factors affecting residue levels indoors after application. Spray drift and fine particle intrusion accounted for relatively little of the residues on floors. Prior to application, 2,4-D floor dust surface loadings were approximately 0.1 to 5 $\mu g/m^2$; one week after application, these levels were 1-228 $\mu g/m^2$ on carpeted floors in occupied homes, and 0.5 to 2 $\mu g/m^2$ in unoccupied homes. Dislodgeable carpet surface residues of 2,4-D were highly correlated with 2,4-D dust levels, and indicated that approximately 1% of the dust is readily available for dermal contact. Tabletop levels of 2,4-D were approximately 10% of carpet loadings, and were largely due to in-home dust resuspension.

Non-dietary ingestion of carpet dust and inhalation for a 1-yr old child in these homes may produce exposures of 0.04-7 $\mu g/day$. These exposure estimates would be substantially higher, 4-70 $\mu g/day$, if the non-dietary ingestion was based on contact and transfer from hard surfaces such as contaminated table tops. In limited cases, these hypothetical exposures would approach the U.S. EPA IRIS RfD limits for 2,4-D of 10 $\mu g/kg/day$.

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Acknowledgment

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Chapter 1
Introduction

Approximately 80-90% of U.S. households report using pesticides (1,2). With detection of pesticides in indoor air and house dust months to years post-application, researchers have concluded that pesticides are highly persistent in the indoor residential environment (3- 10). The ubiquitous presence of insecticides such as chlorpyrifos and permethrins in indoor air and dust suggests primary indoor use. However, migration of residues from the house foundation, crawl-space or basement, and track-in from lawn and garden may be contributory (3,4,5). The presence of discontinued organochlorine pesticides, such as dieldrin and chlordane, appears to be due to the infiltration and migration into the home of residues originally applied to foundations (4,6,7). For 2,4-dichlorophenoxyacetic acid (2,4-D), carbaryl and chlorothalonil, which are applied exclusively outdoors, their presence indoors implies that residues have been transported indoors via one or more transport mechanisms, including track-in (i.e., transport via foot traffic).

Recent studies of pesticide levels in the air and house dust of farmers' and farm workers' homes have shown that pesticide residues are transported from the outside to the indoor environment (9,11). In one study, organophosphate insecticides were detected in house dust inside the houses of pesticide applicators living adjacent to the orchard in which they were used, as well as those of non-applicator farm workers living more than 50 feet from the orchard, and in nearby homes of families not engaged in agricultural activities (9). Job activity and home location were interdependent predictors of indoor pesticide levels. Spray drift, volatilization, soil/foliar resuspension, track-in on shoes and/or transport on clothing are assumed to have played important roles in the transport of residues.

Agricultural spray drift of 3-5% of application rates has been measured for nonvolatile 2,4-D amine formulations (12,13). Soil resuspension rates of a nonvolatile dicamba salt in an aerated chamber were determined to be 6-8% of the application rate (14). Since both of these mechanisms involve the airborne transport of submicron to micron (μm) particles and/or aerosols (15), it is reasonable to assume that tine particles containing 2,4-D can be resuspended from residential turf by wind, penetrate the exterior of the home through cracks and crevices, windows and doors, and be deposited on interior surfaces. Field simulated studies following lawn applications of 2,4-D, chlorpyrifos and chlorothalonil have shown that residential track-in of pesticide residues can occur, and that walking over treated turf as much as one week after application results in transport of residues by shoes from turf to carpets. The residues on carpets following track-in were proportional (3-4%) to the dislodgeable turf residues, and the loadings of the pesticides on the carpet surface were well correlated with carpet dust residues.(10,16).

The study discussed here was carried out in actual homes to determine the relative importance of spray drift, foliar resuspension intrusion and track-in of 2,4-D in the residential environment, to assess the effects of family activity patterns on 2,4-D transport, and estimate potential indoor residential exposure of young children.

The line drawing in Figure 1 depicts the integration of transport and exposure. As illustrated there, the application of a pesticide to a lawn can result in transport to the indoor environment by a variety of factors and mechanisms, and young children inside the home may be exposed to residues brought indoors by their hand contact with contaminated surfaces. The hand-to-mouth activities of young children are assumed to be major routes for their non-dietary ingestion of contaminated materials.

Residential Pesticide Exposure Scenario

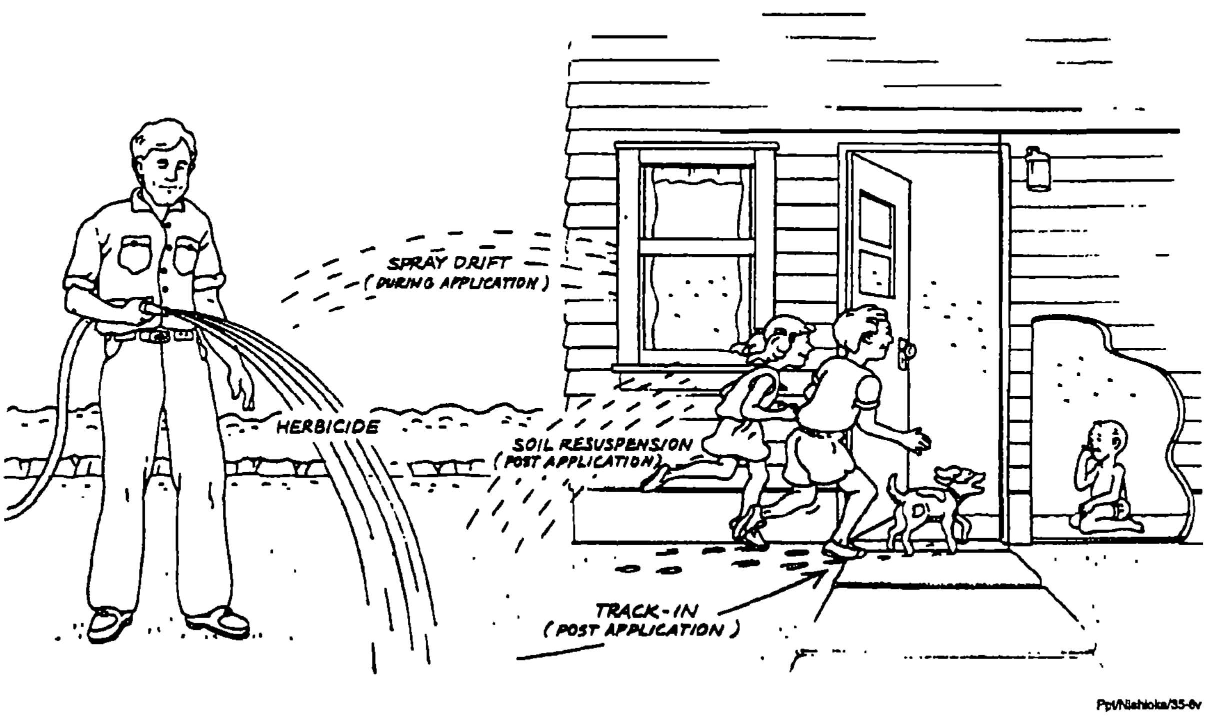

Figure 1. Pesticide transport mechanisms in the residential environment.

Chapter 2
Conclusions

This manuscript provides data on the extent to which lawn-applied 2,4-D was tracked into actual homes, and disbursed throughout the floors of the house along the family traffic pattern, following lawn applications by both homeowners and commercial applicators. It also shows dislodgeable carpet surface residues of 2,4-D to be well correlated with 2,4-D carpet dust levels in these homes, suggesting that a portion of the residues transported indoors onto floors may be readily available for dermal contact.

The inferences that may drawn here are limited by the relatively small number of homes. However, to the extent that these homes represent the general population, we can deduce that familial factors (children, pets, and shoes) may have a greater effect on indoor residential exposures than application factors such as spray drift.

Indoor air, surface wipe and floor dust samples were collected at multiple locations within occupied and unoccupied homes both prior to and following lawn application of 2,4-D to assess the relative importance of pesticide transport mechanisms from turf to indoor environment. Spray drift and foliar resuspension intrusion were minimal contributors (<1%) to indoor levels in homes with high child and pet activity, but these mechanisms were important (-100%) in homes with low activity levels and a policy of consistent removal of outdoor shoes. Track-in was the most significant factor in high activity homes, with the applicator's shoes, the pet, and children with shoes responsible for ~65%, 25%, and 10%, respectively, for floor levels. Resuspension of floor dust was the major source of 2,4-D for levels in air (up to 10 ng/m^3 in PM10) and on tables and window sills (-10% of floor levels).

Four different approaches were considered here to estimate the potential pre- and post-application exposures of a 1 -yr old child in these homes. Three methods of estimating exposures assumed non-dietary ingestion (NDI) exposures due to hand-to-mouth transfer of carpet dust, and the fourth method assumed NDI exposures due to contact and transfer from smooth surfaces such as a table top. The pre-application exposures (inhalation and NDI) due to carpet dust were approximately 0.01-o. 1 µg/day. The post-application exposures (inhalation and NDI) due to carpet dust were approximately 10-100 fold higher, 0.04-7 &day. Contact with solid surfaces suggested post-application exposures of 4-70 µg/day, which is approximately 10 fold higher than exposures predicted from carpet dust contact and ingestion. Exposures may occur in some homes shortly after application that approach the U.S. EPA IRIS Reference Dose (RfD) for 2,4-D (10 µg/kg/day; 100 µg/day for a 10 kg 1-yr old child).

Chapter 3
Recommendations

The data generated in these field studies suggest that contact with smooth surfaces, followed by non-dietary ingestion (via hand-to-mouth transfer) may result in exposures 10 fold higher than contact with carpeted floors. These exposure estimates are based on very limited studies of child activity patterns and dermal transfer rates. Both activity patterns of children and dermal transfer rates require additional investigation to refine exposure estimates that might be made from these, and other, micro-environmental measurements.

In addition, 2,4-D is applied agriculturally to grains, and thus may enter the food chain and result in dietary exposures. Studies need to be carried out in which 2,4-D is either measured directly in the foods consumed within the home, or estimated exposure profiles drawn from databases of residue levels in commonly-consumed foods. These dietary ingestion levels need to be compared with the non-dietary ingestion levels to elucidate the relative routes of exposure in the residential environment.

Since exposure must be assessed definitively through the monitoring of biological markers, studies need to be conducted to compare 2,4-D levels in residents' urine with both dietary and micro-environmental measurements. In this regard, dietary ingestion rates need to be compared with non-dietary ingestion rates for better assessment of the relative importance of the several routes contributing to total or aggregate human exposures.

Chapter 4
Experimental Methods

Study Design: In designing this study, we assumed that specific sampling methods and sampling locations inside the home could be used to assess the magnitude and relative importance of transport mechanisms and exposure pathways. Our linkage of these two concepts is shown in Table 1. As indicated there, we assumed that spray drift, intrusion of resuspended foliar residues, and track-in contributed to indoor residue levels. We anticipated that foliar resuspension intrusion might be detectable in indoor air on the third day post-application, and lacking that, that this intrusion would result in detectable and equal deposition to floors, sills, and table tops throughout a house. Track-in would include residues brought in on the applicator's shoes and clothing, as well as residues tracked in subsequent to the application, and would result in a residue concentration gradient from the entry point. In-home particle resuspension (17) could overshadow distinct intrusion mechanisms, but the differences between homes and between occupied and unoccupied homes was expected to provide data for the disaggregation of these effects.

To carry out this design we identified sampling locations through a home, including a frequently used entry area, a main living area, dining area, kitchen and child's bedroom that would constitute the primary living spaces of any home. To collect the necessary data, sampling methods would include vacuum sampling for floor dust residues, wipes of solid surfaces such as bare floors, table tops and indoor window sills, dislodgeable residue sampling of carpet surfaces, and air sampling by particle size.

Table 1. Sampling Methods used to Link Transport Mechanisms and Exposure Pathways

Sampling Method	2,4-D Transport Mechanism	Exposure Pathway
2-h Air sampling	Spray drift intrusion	Inhalation
24-h Air sampling	Spray drift/applicator clothing (Dayl) In-home dust resuspension (Day3)	Inhalation Inhalation
Air exchange rate	Foliar resuspension intrusion	Inhalation
Sill/table wipe	Foliar resuspension intrusion In-home dust resuspension	Non-Dietary Ingestion (NDI)
Dislodgeable carpet surface residue	Track-in	Dermal Contact/ NDI
Floor dust (vacuum/wipe)	Track-in Foliar resuspension intrusion	Ncn-Dietary Ingestion

Homeowners in the Columbus, OH area who routinely use lawn chemicals were recruited for this study. Each family consisted of two adults, two to three school-age children, and one pet (one home had no pets). Homes were single story with basement (except one split level), surrounded on all sides by turf, and carpeted in the main living room and a child's bedroom. The sampling period at each home consisted of two one-week periods: a pre-application (background) week, and a post-application week. Pre-application sampling took place late March through April, and post-application sampling took place mid-April through mid-June. The post-application week was initiated by the lawn application of 2,4-D.

The sampling in pre- and post-application weeks was nearly identicial and consisted of indoor air sampling for 24 hrs on the first and third days (Day 1 and Day 3) of the week; wipe sampling of sills, tables, and bare floors after a week (on Day 8); collection of a carpet surface dislodgeable residue sample on Day 8; and vacuum sampling of floors on Day 8. An additional indoor air sample was collected during the actual 2,4-D lawn application. Deposition coupons on the lawn were used to estimate 2,4-D application rates. An integrated air exchange rate measurement was made during the post-application week. All air sampling was conducted in the main living area of the home. A schematic representation of the sampling locations is shown in Figure 2.

During both the pre-and post-application week, homeowners were asked to refrain from cleaning (sweeping, vacuuming, mopping) so as not to disturb the normal deposition and distribution of residues. Since approximately 47% of Americans vacuum floors only once or twice a week (1 8), standardization of this activity for this study is not inconsistent with typical activity patterns. Otherwise, families had no constraints on their normal activities. Due to mild weather during the monitoring period, heating and air-conditioning were not needed; windows were frequently open.

The above sampling design was used in both the first and second years of the study, with homeowners making their own lawn applications in the first year, and a commercial applicator making the lawn applications in the second year. Seven families participated in the first year;

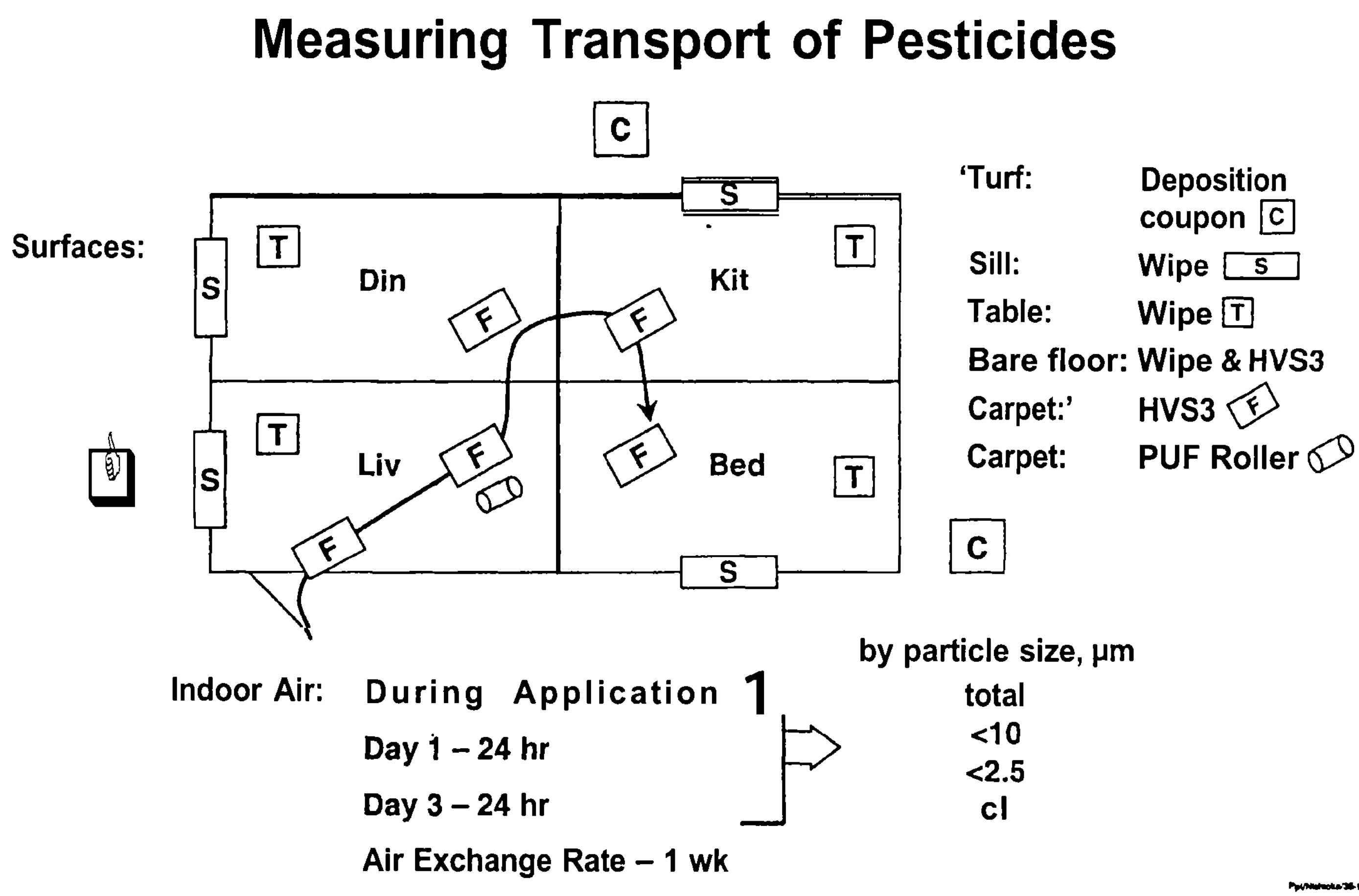

Figure 2. Sampling locations and study design for homeowner and commercial application studies.

four of these families (representing several important activity patterns) were included in the second year, together with two recently-constructed, unoccupied homes. Homeowners applied any one of about eight commercially-available post-emergence herbicide formulations consisting of dicamba, mecoprop and 2,4-D (e.g., KMart K-Gro™), with a desired lawn application rate of approximately 80 mg 2,4-D/m^2. Homeowners used their own application equipment, either a hose-end sprayer or pressurized pump sprayer. The commercial applicator applied the K-Gro formulation with a commercial (ChemLawn) spray gun designed to minimize small droplets.

The third year of the study focussed on collection of simultaneous dermal wipe samples, table wipe samples, and vacuumed floor dust samples on three separate days after the lawn application. First morning void urine samples were also collected on the morning following each dermal wipe sample, so as to ascertain whether urinary excretion of 2,4-D could be tied to microenvironmental levels and/or dermal contaminant levels. The dermal wipe samples and urine samples were collected from the adult applicator and one resident child. During this study, families were asked to live as normally as possible, and they were free to vacuum and dust on their normal schedule. This study included four families. A schematic representation of this sampling design is shown in Figure 3.

In accordance with HHS regulations, the study design, protocol and informed consent were reviewed and approved by Battelle's Human Subjects Review Panel.

Sampling Sequence: The sampling events in each home for the studies conducted in the first two years, and the sequence of events on Day 8, the rooms where samples were collected, and the areas (or volumes) sampled are detailed in Table 2. As listed there, all sample collection was carried out in either the entry room (Entry), the central/main living area (Liv) of the home, a dining room (Din), kitchen (Kit), or a child's bedroom (Bed).

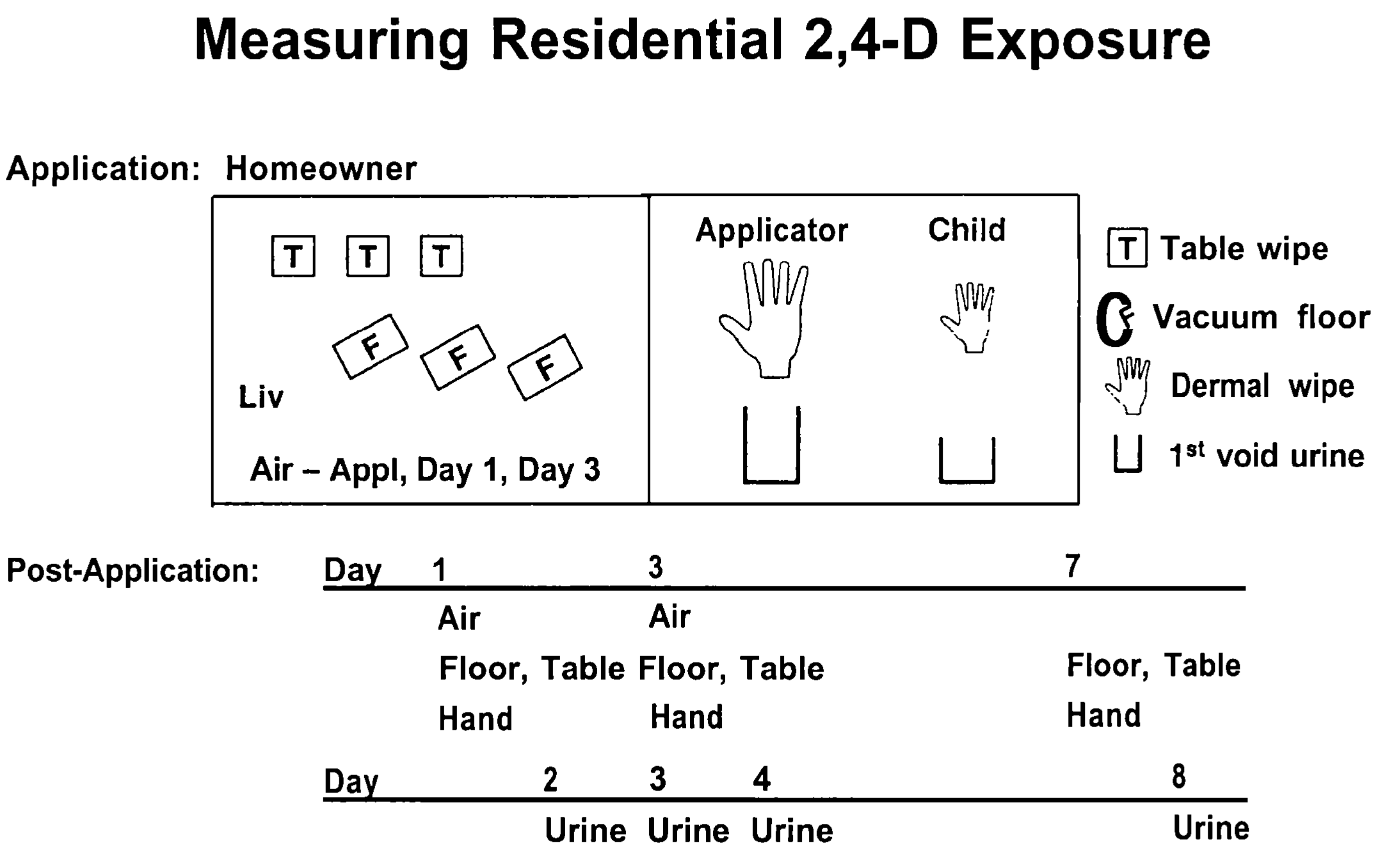

Figure 3. Sampling location and study design for temporal intrusion and exposure study.

Table 2. Sampling Sequence at Each Home: Pre-application, Application and Post-application

Day	Sample/Sequence"	Air Volume or Area Sampled	Room[b]
Day 1- Application	2 h Indoor air	1.76 m^3	Liv
Day 1 (Pre and Post)	24 h Indoor air	5.76 m^3	Liv
Day 3 (Post)	24 h Indoor air	5.76 m^3	Liv
Day 8 (Pre and Post)	Sill wipe	area available	Liv, Din[d], Kit, Bed
	Table wipe	0.08 m^2	Liv, Din, Kit, Bed
	Bare floor wipe	0.2 m^2; adjacent to area to be vacuumed	Entry, Din, Kit (as available)
	Dislodgeable carpet . surface residue	0.48 m^2; perimeter of area to be vacuumed	Liv
	Vacuumed dust; bare or carpet floor	1-2 m^2; as available	Entry, Liv, Din, Kit, Bed

a) Samples collected on Day 8 Were collected in the order listed here, with wipe collection of settled surface dust being collected prior to vacuum collection to avoid contamination of surfaces with resuspended dust.
b) Room in which sample collected: Liv- main living room, Din- dining room or area, Kit-kitchen, Bed- child's bedroom, Entry- primary entry area.
c) Samples collected in both pre-application week (Pre) and in post-application week (Post).
d) No samples collected in Din during commercial applicator study.

Air Sampling: A four-stage cascade impactor sampler (Delron Research Products) was used for indoor air sampling during application events. It consisted of a series of stages (glass plates coated with polyethylene glycol 1000 to limit particle bounce) and a final filter (PTFE coated glass fiber filter, T60A20; Pall/Gelman) separated by impactor jets for the following particle/aerosol sizes: <1 µm, 1-2 µm, 2-8 µm, and >8 µm. The outlet critical orifice provided a consistent sampling rate of 12.5 L/min with a 370 watt diaphram pump.

Indoor air sampling on the first and third days of each sampling week (Dayl, Day3) was carried out for 24 h with four collocated samplers (Model 2500; URG), each designed to collect a different air particulate size: <1 µm, <2.5 µm (PM2.5), <10 µm (PM10), and total suspended particulate (TSP) matter (generally <20 µm). Each sampler consisted of an inlet jet and impactor plate for particle size discrimination, 27-mm filter (T60A20; Pall/Gelman), and polyurethane foam (PUF) sorbent trap (27-mm x 76-mm; URG). Impactor plates were oiled with 50 µL of silicone oil (Dow-Coming 704). Samplers were located within the breathing zone height, 1.1 m above the floor, separated from each other by 45 cm, and operated at 4 L/min. Pumps were placed in a ventilated polystyrene foam box. The volume of sound produced by the URG sampler pumps was sufficiently low that families could talk and watch television in the same room.

Schematic representations of these air sampling tools are shown in Figure 4. As shown there, the cascade impactor separates a single air stream into four separate particle sizes. Four separate URG 2500 samplers must be used to achieve the same particle size information. The advantage, though, to the URG samplers is the fact that all particles less than the designated cut point 'are collected, rather than a slice of the airstream. Because measured levels are increasingly greater in each succeeding particle size sample, the chances of detecting low air level concentrations are enhanced with each successively larger particle size inlet used.

Air exchange and infiltration rates were determined using the Brookhaven National Laboratory (BNL) Air Infiltration Measurement System, which employs small diffusive perfluorocarbon

Size Selective Air Sampling: Two Approaches

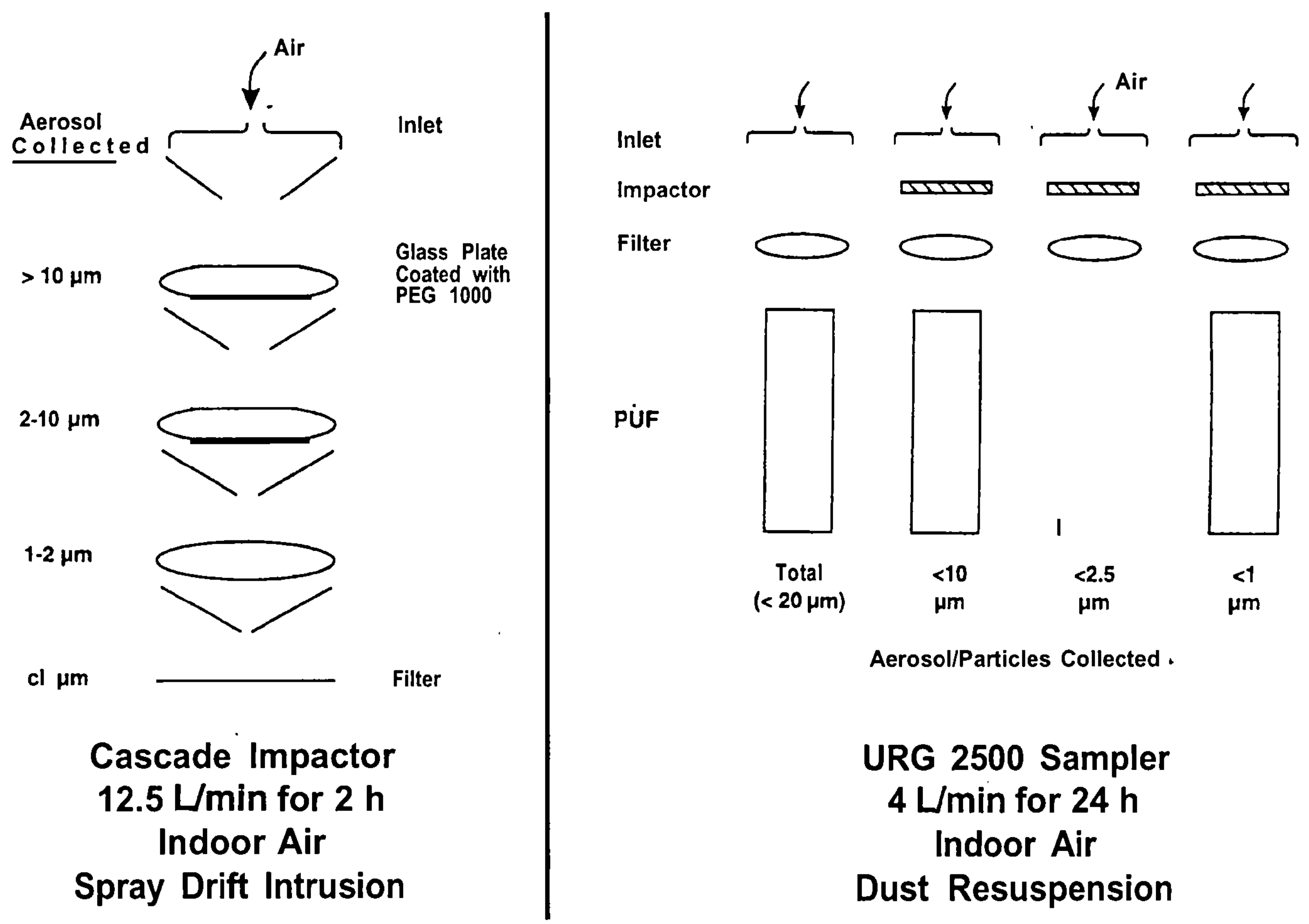

Figure 4. Air sampling tools for particle size selective sampling.

tracer sources and small diffusive samplers (19). Sources and samplers were deployed throughout the homes at the time of applications and retrieved at the conclusion of the one week sampling period. The 3-zone model was used by BNL in these analyses.

<u>Wipe Sampling</u>: A similar sampling method was used for collecting residues from window sills, table tops and bare floors. A cotton gauze wipe (one-half of a Johnson&Johnson SOF-WICK^{R} dressing sponge) was moistened with 2 mL of a "sweat simulant" (70:30 phosphate buffer:acetonitrile) just prior to use. The moistening solution bears similarity to sweat in both the salt content and organic content (20). The designated surface was wiped once in a single direction, the wipe was then folded to the inside, and the surface was wiped a second time, orthogonal to the first direction of wipes. The entire flat surface of a window sill was wiped. Instead of sampling homeowners' table tops, an 850 cm^2 Formica^{R} square was placed on each designated table surface at time zero each week, for wipe sampling on Day 8. As indicated in Table 2, a 0.2 m^2 area was wiped on bare (uncarpeted) floors. In the first year's study, side-by-side wipe and vacuum samples were collected from many bare floors. The wipe sample was collected first, as the vacuum exhaust was likely to disturb adjacent surface residues.

<u>Floor Dust Sampling</u>: The dislodgeable carpet surface residue samples were collected with the EPA/SwRI Polyurethane Foam (PUF) Roller; floor dust samples were collected using the HVS3 vacuum sampler. Line drawings of these two sampling tools are included in Figure 5. The PUF Roller and HVS3 have been described in detail elsewhere (3,9). The PUF Roller collection sleeve was moistened with the aforementioned "sweat simulant". With this solvent mixture, the otherwise rigid PUF becomes soft, pliable, and slightly moist to the touch, so that the PUF surface is consistent with the intent of the roller to simulate a child's hand contact with a surface. (Water-moistened PUF is somewhat rigid, with discontinuous beads of water, and it may not be a good surrogate for skin.) The carpet surface dislodgeable residue sample was collected around the perimeter of the floor area to be vacuumed. A single pass with the PUF Roller was made

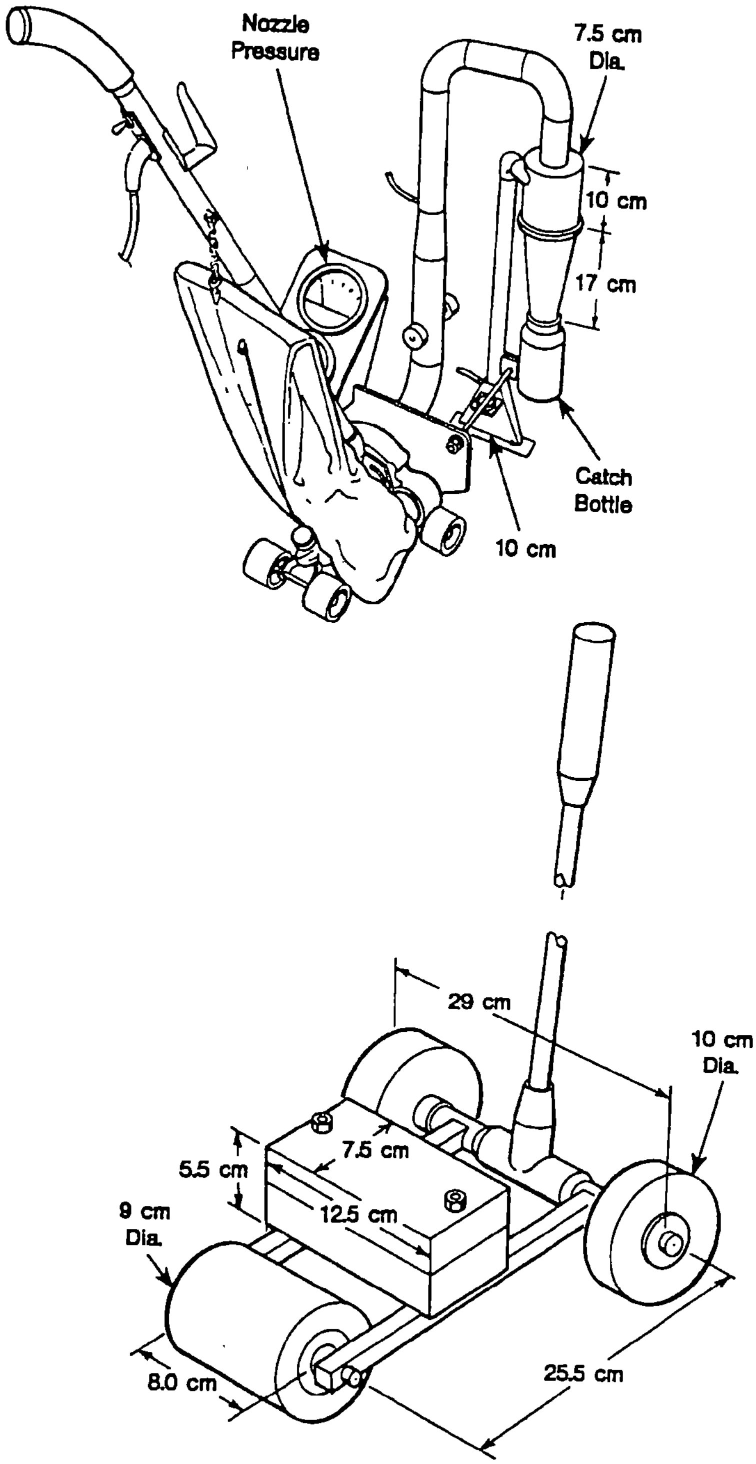

Figure 5. Schematic representations of PUF roller and HVS3 vacuum samples.

over this area; the sleeve was removed from the core and placed in the zip-seal polyethylene bag that was used for storage and extraction.

Each floor dust sample was collected by four passes with the HVS3 vacuum over the designated area, two passes each in orthogonal directions. The sampled area was as close to a 2 m^2 area as possible, while remaining in an area of general foot traffic. Schematic representations of the floor plan of each home, and the locations where samples were collected, are included in Appendices A and B.

<u>Dermal Wipe Sampling</u>: Homeowners and children were supplied with individually bottled wipes (a single SOF-WICK gauze), each wipe pre-moistened with 4 mL of a 50:50 mixture of isopropanol:water. Each participant received their allotment of wipes for the post-application week in a small cooler containing chemical ice packs (Blue Ice). After wiping their hands for 10 sec, the participants returned the wipe to its individual container. Samples were stored there during the sampling week. Homeowners were asked to recycle several Blue Ice packs between their own freezer and the cooler, to maintain temperatures in the coolers. Wipe samples were returned to the laboratory at the end of the sampling week. The pre-application period consisted of a single day of sampling, in which participants were instructed how to wipe hands. This one sample from the adult and the child was returned to the laboratory together with the table top and vacuumed floor dust samples.

<u>Urine Samples</u>: In a manner similar to the dermal wipe samples, each participant was supplied with pre-labelled polyethylene urine bottles, that were stored in a small cooler containing two Blue Ice packs. Homeowners were asked to recycle several Blue Ice packs between their own freezer and the cooler, to maintain a cool temperature in the sample cooler. Urine samples, each a first morning void sample, were collected in individual polyethylene bottles. Urine samples were retrieved frequently during the week and returned to the laboratory for storage.

Lawn Application Rates: Deposition coupons placed on the lawn consisted of a full Johnson&Johnson SOF-WICK[R] dressing gauze backed by aluminum foil, pinned lightly to the ground. After application, the gauze was placed in an extraction tube, and the foil backing was rinsed into this container.

Preparation of Samnlinn Media: All SOF-WICK wipes were pre-extracted overnight using Soxhlet extraction in methylene chloride prior to use. The wipes were dried thoroughly in a heated vacuum chamber and then pre-packaged in zip-seal bags by home for use. The air sampler filters were pre-extracted by rinsing with methylene chloride. The air sampler PUF sorbents were pre-extracted with acetone before use, and then dried in the vacuum dessicator. The PUF Roller sleeves were pre-cleaned individually by extraction in a zip-seal polyethylene bag, with solvent squeezed manually through the PUF sleeves ten times. The solvents that were used in sequence included 200 ml of distilled/deionized water (one extraction; xl), then 150 mL of 70:30 acetonitrile:phosphate buffer (sodium acid phosphate) pH=3, repeated four times (x4). Sleeves were squeezed to near dryness and dried further for 30 min using a vacuum dessicator held at 23-25 in. Hg at 40°C with a stream of dry N2 (approximately 10 mL/min) flowing through the dessicator. The cleaned filters, wipes, PUF were stored in polyethylene zip-seal bags at -78°C prior to use.

The cascade impactor plates were cleaned with concentrated acid, rinsed with distilled/deionized water, and muffled overnight at 450 °C before use. The urine and HVS3 dust collection bottles were pre-rinsed with high purity acetone and dried. The glass bottles for the dermal wipe samples were rinsed with acetone and methanol and then muffled overnight before placing moistened wipes into them.

Samnle Storage: Prior to field use, all pre-cleaned media were stored at -78°C. During field collection at a home, collected samples were stored in coolers with either dry ice or Blue Ice for chilling. Environmental media and dermal wipe samples were returned to the laboratory and stored at -78°C until extraction. Urine samples were stored at 4°C until extraction.

Field and Laboratory QA/QC: All sample media included both blank and spike field and laboratory QC samples. Each home had a field collected wipe blank and a wipe spike in both pre- and post-application weeks; a field blank and field spike for the 24 h air samplers. There was one field blank cascade impactor for the entire suite of homes each year, and one field blank and field spike of a PUF sleeve for the entire suite of homes each year. All QA/QC results are detailed in Appendices A, B, and C.

Chemical Analysis Methods: A similar extraction and cleanup methodology was applied to all environmental and dermal wipe matrices, albeit scaled to the size of the sample type. The basic methodology is presented below; with variations for each matrix as listed in Table 3.
Each sample was spiked with the 3,4-D as a surrogate recovery standard (SRS) at a level similar to that expected for 2,4-D, *viz.,* 100 ng for air samples (filters, PUF, plates), surface wipe samples, dermal wipe samples, and carpet dislodgeable residue samples, and 500 ng for dust. samples. Samples were extracted with 70:30 acetonitrile:phosphate buffer (0.1 M sodium acid phosphate) at pH 3. Wipe, filter and impactor plate media were extracted using sonication for 10 min; dust samples were sonicated for 10 min, centrifuged, and 80% of the extract was removed. PUF samples (air and dislodgeable residue sleeves) were extracted in an appropriately-sized, zippered polyethylene bag by squeezing the solvent through the PUF.

Distilled/deionized water was added to the extract, the pH was adjusted to 12 with 1M NaOH, and the extract was partitioned twice with n-hexane. Rotary evaporation at 48°C was used to remove excess acetonitrile from the PUF sample extracts (80 mL for air PUF and 400 mL for PUF Roller sleeve), after adjusting to pH 12. Emulsions at the interface of dust extracts were broken using either NaCl, a few drops of Antifoam^{R} A (Aldrich), and/or by chilling the

Table 3. Variations in Extraction/Cleanup Methods for Differing Media Analyzed

	Variation in Standard Procedure, Scaled to Size of Sample Matrix				
Sample type	Extraction solvent[a]	Extraction method	First water addition	Hexane partition	Second water addition
Air filter	5 mL x 2	Sonicate	loomL	20 mL x 2	100 mL
Air PUF	30 mL x 4	Squeeze	80mL	20 mL x 2	70 mL
Impactor plate	5 mL x 2	Sonicate	100 mL	20 mL x 2	100 mL
Impactor filter	10 mL x 2	Sonicate	100 mL	20 mL x 2	100 mL
Surface wipe	20 mL x 2	Sonicate	360 mL	20 mL x 2	0 mL
PUF Roller sleeve	150 mL x 4	Squeeze	150 mL	25 mL x 2	0 mL
Floor dust	25 mL	Sonicate	100 mL	20 mL x2	80 mL
Dermal wipe	40 mL x 2	Sonicate	0 mL	25 mL x 2	40 mL

a) Solvent volume added and number of repeats.

separator-y funnel for a few minutes. After discarding the hexane, additional water was added and a solid phase extraction (SPE) method was used for further cleanup.

An octadecyl hydrocarbon-bonded silica SPE extraction cartridge (C 18 SPE; 6 mL volume, 500 mg loading; Baker) was conditioned in sequence with 10 mL methanol, 10 mL distilled/deionized water, and 4 mL of 1: 10 acetonitrile: 0.025 M phosphoric acid. The extract and rinses were loaded onto the conditioned SPE cartridge without allowing the cartridge to go dry. After loading, the SPE cartridge was air-dried for 2 h on the manifold and then eluted with 2 mL of 1: 1 hexane:diethyl ether (x2).

The SPE eluate was concentrated to near dryness; the internal standard (IS) 2,6-D was added at the same level as the SRS, the extract was adjusted to 1 mL with 5% methanol in methyl-t-butyl ether, then methylated with ethereal diazomethane generated ***in situ*** from Diazald, carbitol and 37 percent aqueous KOH. After methylation, the solutions were allowed to stand for 30 min. Dry N_2 was used to purge the residual diazomethane; the solution was adjusted to a final 1 mL volume. Multi-level calibration standards were analyzed concurrently with samples. Samples that exceeded the. calibration range were diluted, respiked with IS, remethylated, and reanalyzed.

A 100 mL aliquot of each urine sample was spiked with the SRS 3,4-D and analyzed by the following procedure. A 20 mL aliquot of concentrated HCl was added to the urine, and it was heated at 90°C for 1 hr to hydrolyze the protein-conjugated herbicide acids. After, cooling to room temperature, the sample was transfered to a separator-y funnel, and the pH was adjusted to pH=12 with 10 N NaOH. The extract was partitioned twice with 25 mL of hexane, and the hexane extract was discarded. The urine sample was then acidified to pH=1 with concentrated HCl. This sample was applied to a Cl8 SPE cartridge, which was topped with silanized glass wool for collection of the denatured protein. The SPE, concentration and derivatization methods that followed were identical to those described above for the environmental media.

Sample extracts of environmental media and dermal wipes were analyzed using gas chromatography with electron capture detection (GC/ECD; Hewlett Packard 5890 GC). Chromatographic conditions included the following: 60 m DB-5 column (0.25 mm i.d., 0.25 µm film thickness; J&W Scientific); temperature program from 100-150 °C at 6 °C/min, 150-215 °C at 2 °C/min, and 2 15-300 °C at 25 °C/min. Confirmation analyses were conducted using GC/MS with similar chromatographic conditions and full scan electron impact (EI) analyses. The urine sample extracts were analyzed using GC/MS, with chromatographic conditions identical to those listed above, in the multiple ion detection (MID) mode. The ions monitored for 2,4-D, 3,4-D and 2,6-D were identical: m/z 234 for identification and quantification, m/z 236 for verification.

Method Validations: Recoveries of dicamba and 2,4-D from the various sampling media were generally 85-95%, and are summarized in Table 4, Section A. Retention and atmospheric phase distribution of both free acids and amine salts during 24 h air sampling at 4 L/min with room temperature air and varying levels of humidity are detailed in Table 4, Section B. The free acids were found to migrate from filter to PUF sorbent at both 50 and 80% relative humidities (RH). In contrast, the amine salts, though water soluble, remain largely (>80%) on the filter. Average percentage recoveries for 3,4-D in field samples were: 99 ± 11 (n=28) for cascade impactor samples; 96 ± 21 (n=84) for URG air filter samples; 83 ± 23 (n=126) for surface wipe samples; 93 ± 17 (n=70) for floor dust samples; 99 ± 21 (n=14) for surface dislodgeable residue PUF Roller samples. Field spike recoveries of 2,4-D were: 92 ± 27% (n=1 1) for wipes, 77 ± 3 (n=2) for air filters, and 80% (n=1) for PUF.

Table 4. Recoveries of Herbicide Acids from Sampling Media

Section A:	Recovery of Spike, %					
	Spike of Free Acid			Spike of Amine Salt Formulation		
	Dicamba	2,4-D	3,4-D	Dicamba	2,4-D	3,4-D
	0.5 µg	1 µg	1 µg	0.1 µg	1 µg	1 µg
Air filter (n=3)	86±2	90±2	99±6	90±1	93±1	95±4
Air PUF (n=3)	84±3	86±3	88±3	93±1	90±1	95±4
Impactor plate(n=2)	82±3	83±2	88±1	92±2	93±1	91±1
Surface wipe (n=2)	68±3	86±1	87±1	NT"	NT	NT
PUF Roller (n=2)	84±6	105±4	105±2	NT	NT	NT
Dust (n=3)	87±2	84±9	93±6	NT	NT	NT
Deposition Coupon(n=2)	NT	NT	NT	86±3 (6.5 µg)[b]	89±1 (65 µg)[b]	NT

a) NT= not tested   b) spike level equivalent to anticipated lawn application deposition

Section B:	Retention and Distribution with 24 h Air Sampling, %			
	Free Acid		Amine Salt	
	Dicamba	2,4-D	Dicamba	2,4-D
Temp/humidity[a]	0.5 µg	1 µg	0.1 µg	1 µg
RT/50% RH: filter	26±3	72±2	81(n=1)	82±1
PUF	57±5	21±1	22(n=1)	ND[b]
Sum	83	93	103	82
RT/80% RH: filter	13±1	67±1	77±1	85±3
PUF	83±1	30±1	12±2	ND
Sum	96	97	89	85

a) Temperature; RT= Room Temperature; Humidity; RH= Relative Humidity.
b) ND= not detected

Chapter 5
Results and Discussion

Establishing Track-In in the Residential Environment: The potential for transport of lawn-applied herbicides into the home via walking over treated turf was demonstrated earlier in a series of track-in simulations (10,16). For those demonstrations, at selected times during a one week period following a lawn application, five adults walked through a defined area of pesticide-treated turf 20 times each, stepped onto a low, rigid platform after each pass over the turf, and proceeded to walk across a section of residential carpet before walking over the treated turf on the next pass. A very good correlation was observed between the dislodgeable 2,4-D turf residues and both the 2,4-D carpet dust loading ($\mu g/m^2$) and the 2,4-D carpet surface dislodgeable residues, with r^2 equal to 0.81 and 0.98, respectively. Based on these results, and the fact that 2,4-D was present at readily detectable levels in nine (out of nine tested) residential house dust samples, we designed the present study to verify whether track-in also occurs under actual residential conditions, and the extent to which it occurs following a lawn application.

The 2,4-D floor dust loadings in six occupied homes are shown in Figure 6. This figure includes both the pre-application 2,4-D levels and the levels of 2,4-D one week after the homeowner's lawn-application. Three phenomena are readily identified from these data. First, 2,4-D is detectable on all floors in all homes one week after the lawn application. Second, 2,4-D is present on all floors in all homes prior to lawn application; however, 2,4-D floor dust loadings one week post-application are significantly higher than those levels at the end of the pre-application week. Third, there appears to be a gradient in the 2,4-D floor dust loading throughout each home which corresponds to the traffic pattern through the house that family members follow when entering from the outdoors.

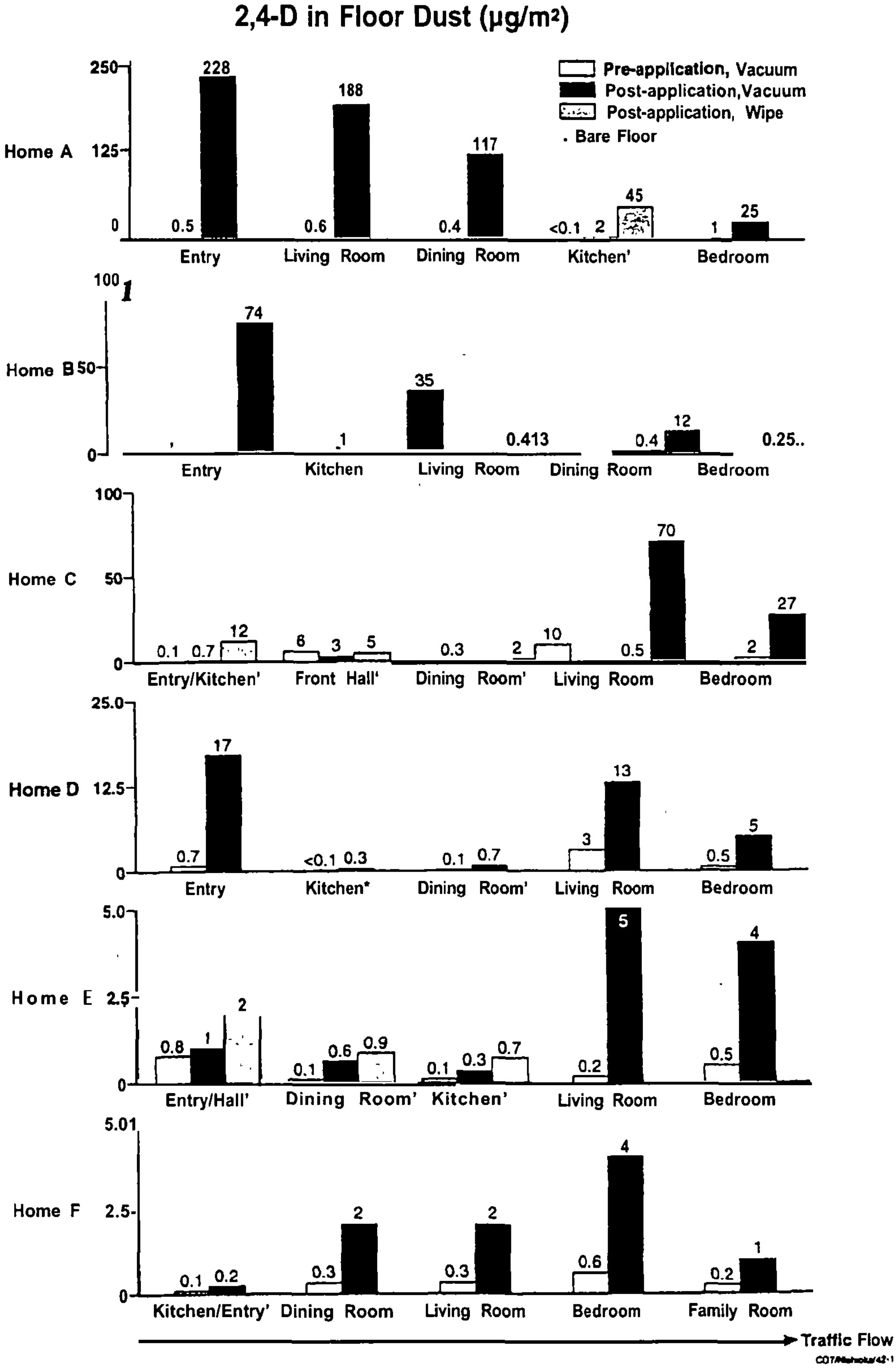

Figure 6. 2,4-D floor loadings following homeowner application.

For completely (or nearly completely) carpeted homes, the 2,4-D floor dust loadings were highest in the entry area, and dropped to sequentially lower levels throughout the house along the traffic pattern of the home. This gradient in 2,4-D floor levels from high to low was evident whether calculated on the basis of 2,4-D surface loading ($\mu g/m^2$) or 2,4-D dust concentration ($\mu g/g$), and is consistent with our expectation of track-in from an external location. This same gradient in the 2,4-D floor levels was evident in both the pre-and post-application floor dust samples, although much more pronounced in the post-application period. The average pre-application 2,4-D level in these homes, 0.5 $\mu g/m^2$, is similar to the average level reported previously for the nine homes in which sampling was done approximately 5-6 months after the general 2,4-D application period in Columbus, OH. In the main living room area (Liv) of these homes, post-application levels ranged from approximately 2-200 $\mu g/m^2$, or a 4-400 fold increase over pre-application background levels. [Note: Dicamba was detected in these samples in the same ratio as found in the formulation, 10% of the 2,4-D level. Dicamba will not be discussed further because of this similarity. The data for dicamba are listed in Appendices A, B, and C.]

The track-in gradient is most readily discernible in this data set in Homes A and B which had carpeted entryways and carpeting throughout most of the house. Any bias in accumulation mode or sampling between bare and carpeted floors may have been largely eliminated by virtue of having carpeting throughout the house. A slightly different track-in gradient is observed for homes such as Home C and E (Figure 6) which had a substantial number of uncarpeted floors in the early sections of the house traffic pattern. Two distinct gradients in 2,4-D floor dust loadings appeared within these homes: one gradient established for the uncarpeted floor areas and a second established for the carpeted areas. Note that the bare floor areas (sheet vinyl, wood, etc) are designated in Figure 6 with an asterisk (*). The post-application 2,4-D loadings on these bare floors are 5-20 fold lower than the loading on the nearest sequential carpeted area.

Contrary to intuition, the difference in 2,4-D loadings between bare and carpeted areas is due to factors other than the dust loading, as illustrated by data in Table 5. For representative Home B

Table 5. Comparison of 2,4-D Dust Loadings and Dust Concentrations for Homes with and without a Carpeted Entry

2,4-D in HVS3-Collected Floor Dust

Home B: Carpeted Throughout				Home C: Many Bare Floors Throughout			
Room	Floor[a]	2,4-D Loading, $\mu g/m^2$	2,4-D Conc, $\mu g/g$	Room	Floor	2,4-D Loading, $\mu g/m^2$	2,4-D Conc, $\mu g/g$
Entry	C	74	67	Entry/Kit	V	0.71	1.6
Kit	c	35	57	Hall	W	3.1	1.2
Liv	C	13	28	Din	W	1.7	1.7
Din	C	12	20	Liv	C	70	14
Bed	C	5.3	7.8	Bed	C	27	11

a) Flooring Types: C- carpet; V- sheet vinyl; W- wood.

(carpeted throughout), the dust loading was remarkably similar in all rooms (0.5- 1.1 g/m^2), and the single 2,4-D gradient throughout the house was observed in both the 2,4-D loading and the 2,4-D dust concentration. This suggests that if track-in is the primary transport/intrusion mechanism, the 2,4-D initially tracked into the home at the entry is diluted as it is dispersed along the traffic pattern. For Home E (having both bare and carpetted floors), not only is the dust loading low on the bare floors, but the concentration of 2,4-D in that dust (1-2 µg/g) is also quite low, relative to the concentration of 2,4-D in the carpeted Liv floor dust (14 µg/g). If track-in was the primary transport mechanism in these homes, then the 2,4-D tracked in at the beginning of the week, presumably at higher concentrations, is transported to, and accumulates in, the carpeted areas of the house by in-house activity. The 2,4-D tracked-in later in the week at lower levels, may be that which was found on the entry floors at sampling time.

The 2,4-D floor dust loadings in homes one week after commercial lawn application are shown in Figure 7. [Note: Floor dust samples were not collected in the dining area (Din) this time, and only wipe sampling was used for bare floors.] Trends identified above are again evident. First, 2,4-D was detected, with one exception, in all post-application floor dust samples, including the floor dust from the unoccupied homes (X and Y). Second, with exception of a few wipe samples from bare floors, 2,4-D was present in pre-application dust samples, but at levels that were more variable than in the previous year, ranging here from 0.2-5 $\mu g/m^2$. Again, the post-application levels were significantly higher than pre-application levels. Third, the track-in traffic gradient was again evident in these homes. This latter observation indicates that track-in cannot be attributed solely to track-in upon reentry by the applicator, since in no case did the commercial applicator come into the house.

Several additional trends were also identified. First, in the main living areas of Homes A and B there was approximately a three-fold reduction in 2,4-D levels relative to the first study, contrasted with a three-fold increase in 2,4-D levels in Homes E and F. Since the homeowners in Homes B, E and F removed or thoroughly rinsed shoes after self-application and

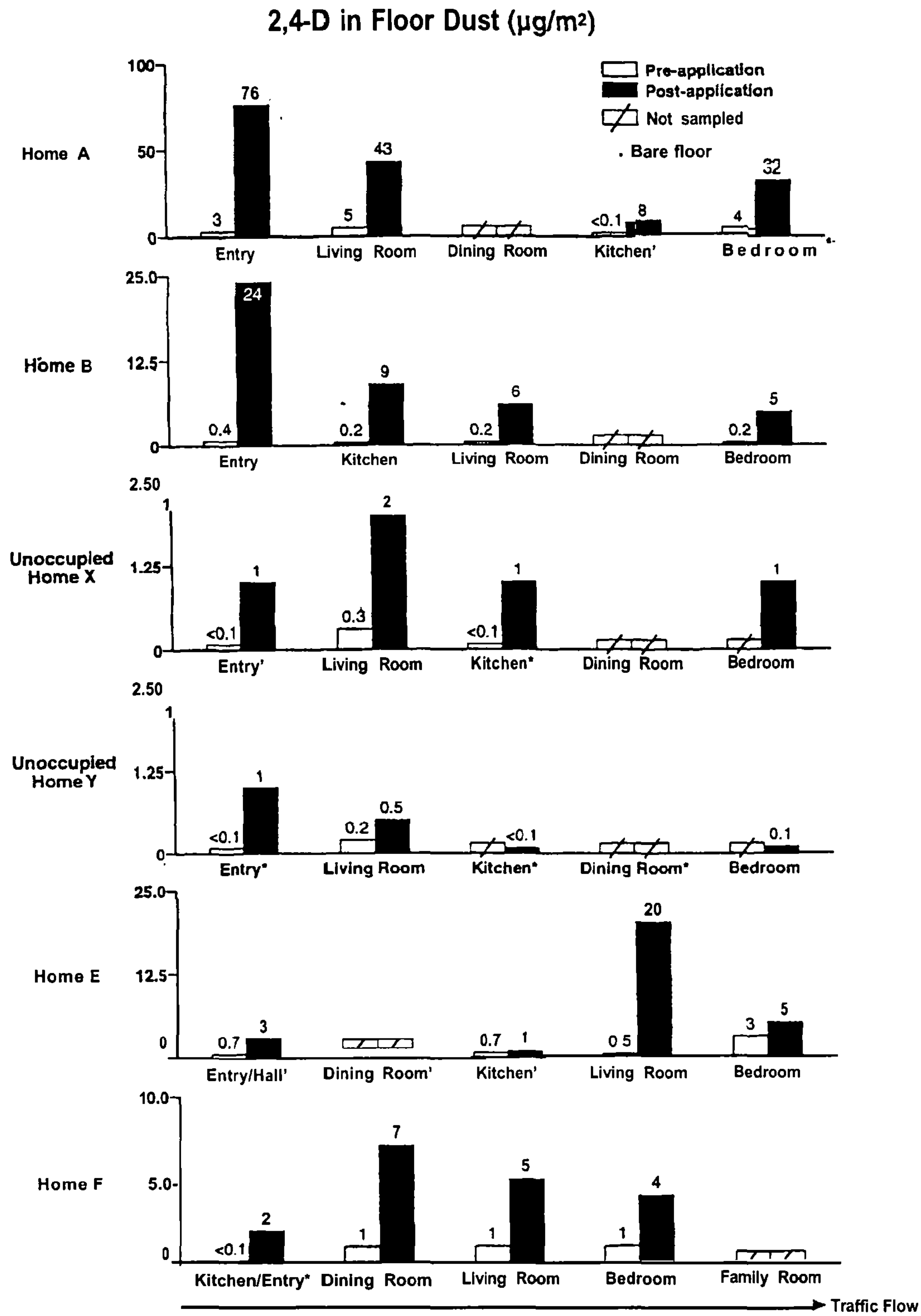

Figure 7. 2,4-D floor loadings following commercial application.

before reentry, the differences observed here between homeowner and commercial application methods may indicate that activity patterns of the family can overshadow the effect of a variable such as the applicator's reentry into the home. Second, in the four occupied homes participating in both studies (A, B, E and F), the 2,4-D loadings in the child's bedroom were nearly identical for homeowner and commercial application. This may suggest that a child will establish an individualized track-in pattern that is most evident in his/her bedroom. Third, the increase in 2,4-D loadings in the floor dust of the unoccupied homes after lawn treatment may point to transport mechanisms other than track-in.

Due to the ethical obligation of informing homeowners of results of the first study before inviting them to participate in the second study, the design of the commercial-applicator study was somewhat compromised. Changes in family behavior were evident, and the results tended to confirm the overarching importance of family activity patterns to track-in. In Homes A and B, greater vigilance was exercised with respect to track-in by pets and children in the first few days after commercial application. In homes E and F, parental reminders to children to remove shoes at the door was not enforced as stringently as in the first year of the study, with the higher 2,4-D floor loadings suggestive of increased track-in of residues. The change in lifestyle apparently resulted from the E and F homeowners' conclusion, reached upon reviewing the data from the first study, that they had been overly cautious relative to other participants.

Although Homes X and Y are designated as unoccupied, some traffic did occur in these homes during the study. In Home X, the builder's agent spent 4 h/day there answering phone calls; this agent entered through the garage and spent her time indoors. Access to Home Y was more restricted, although one client inadvertently visited the home near the end of the week. In both homes, sampling teams made multiple visits to the homes, but limited their potential foot track-in by removing shoes at the door. These scenarios, in comparison with fully occupied homes, suggest that the post-application 2,4-D floor dust levels of Homes X and Y were caused minimally by track-in; other intrusion mechanisms may have been more important, notably resuspension of 2,4-D from turf followed by fine particle intrusion of the closed house

(Home Y), and an incremental addition of fine particle penetration as doors and windows were opened (Home X).

Comuarison of Wine and Vacuum Samplinε for Bare Floors: While not the focus of this sampling effort, some minor conclusions may be drawn about wipe and vacuum sampling from data obtained. The surface loadings of 2,4-D are listed in Table 6 for bare floors where both wipe and vacuum samples were collected. Data are categorized by the sampling time (pre- or post-application), by the floor type, and whether outdoor shoes were worn indoors.

In the pre-application period, wipe and vacuum sampling appear to give comparable results for relatively smooth wood floors, as indicated by the ratio approximately equal to 1. The collection efficiencies of these techniques differ significantly for smooth vinyl and grooved wood (e.g., parquet or worn) floors, with wipe collection being more efficient on the vinyl floor. Vacuum collection gives apparently higher loadings than the wipe on the grooved wood floor, but this is probably due to collection of dust from within grooves that is not reached by a wipe. Wipe data may be preferable for comparisons of surface loadings in rooms that have wood floors.

If trends from these limited number of samples are meaningful, it appears that equivalent efficiency in sampling bare floors shifts in the post-application period. Approximately equal loadings are now measured in the samples from vinyl floors in cases where outdoor shoes were not worn indoors, and from grooved wood floors (with or without shoes worn). Data for smooth wood floors is equivocal. The major difference in collection is observed in 2,4-D loadings from smooth vinyl floors where outdoor shoes are worn, with wipe sampling providing a more efficient collection of residues.

Comnarison of 2.4-D Loadinεs in Dust and Carpet Surface Dislodgeable Residues: We observed here a very high degree of correlation (r^2=0.98) between the 2,4-D floor dust loading (collected

Table 6. Comparison of 2,4-D Loading on Bare Floors with Wipe and Vacuum Sampling

	2,4-D Loading, µg/m²					
	Pre-application			Post-application		
Flooring type and shoes worn indoors?	Wipe	Vacuum	W/V[a]	Wipe	Vacuum	W/V
Vinyl						
yes	0.32	0.08	4	22.7	1.6	14
				9.17	0.71	13
no	NT[b]	NT	NT	0.67	0.59	1.1
				0.56	0.26	2.2
Wood-smooth"						
yes	0.34	0.30	1.1	5.09	1.65	3.1
	0.55	0.61	0.9			
no	NT	NT	NT	NT	NT	NT
Wood-grooved[d]						
yes	0.32	5.74	0.06	2.50	3.13	0.8
no	NT	NT	NT	1.58	1.47	1.1

a) W/V: Ratio of 2,4-D Loading, Wipe to Vacuum.
b) NT: not tested (sample not collected or no home available with those characteristics).
c) Tongue and groove wood floor with few gaps or breaks in surface.
d) Parquet flooring and/or worn tongue and groove flooring with uneven surface.

with the HVS3) and the 2,4-D carpet surface dislodgeable residue loading (collected with the PUF Roller). This correlation appears to hold well despite the diversity of carpet types involved. The slope of 0.0085 corresponds to an approximate 100: 1 ratio between 2,4-D dust loading and 2,4-D carpet surface dislodgeable residue, and thus implies that aproximately 1% of the dust is located on the carpet surface and readily available for dermal contact.

2.4-D in Indoor Air bv Particle Size: The averages and ranges of indoor air 2,4-D concentrations by particle size following homeowner and commercial applications are shown in Figure 8. The indoor 2,4-D PM2.5 and PM10 concentrations for both applications are shown in Figure 9. The average data are summarized in Table 7. As seen in Figure 8 and Table 7, concentrations found indoors during homeowner applications covered more narrow ranges, especially for the two smallest particle size ranges, than that found on either the first day (Dayl), or the third day (Day3). Since windows and doors at all homes were open during applications (except at unoccupied homes), spray drift intrusion was anticipated. The average 2,4-D level in each particle size range was lower by about a factor of 2 during commercial applications than during homeowner applications. There was also a significant difference in the <1 µm particle size concentrations between the two types of applications, but this may have been due to slightly different collection protocols. For the homeowner applications, a consistent air sample collection time of 2 h was used. Because this sampling time exceeded the time required for application, most homeowners completed spray application and reentered the home before the cascade impactor sampler was stopped. Therefore, from the Application vs Dayl air data alone, we cannot separate the contributions of spray drift from that of the homeowner reentering wearing contaminated clothing. For example, much of the fine particulate 2,4-D concentration, especially <1 pm, in the application sample may have been due to tine particles released from the homeowner's clothing. [Note: 2,4-D was not detected in any pre-application air sample.]

In the days following both types of applications, most of the respirable concentrations (<2.5 µm) were associated with sub-urn particles. Following homeowner applications, approximately

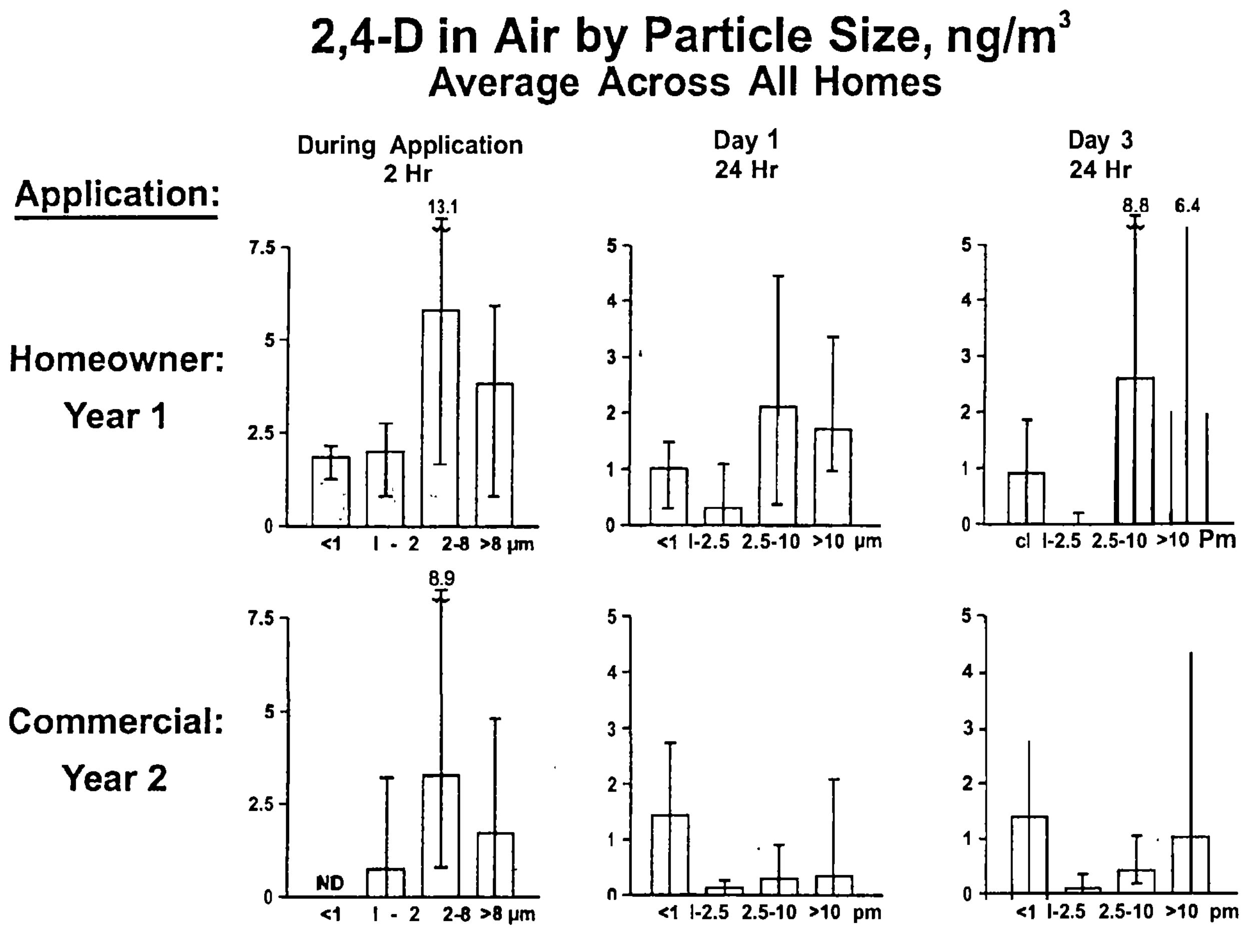

Figure 8. 2,4-D in indoor air by particle size ranges.

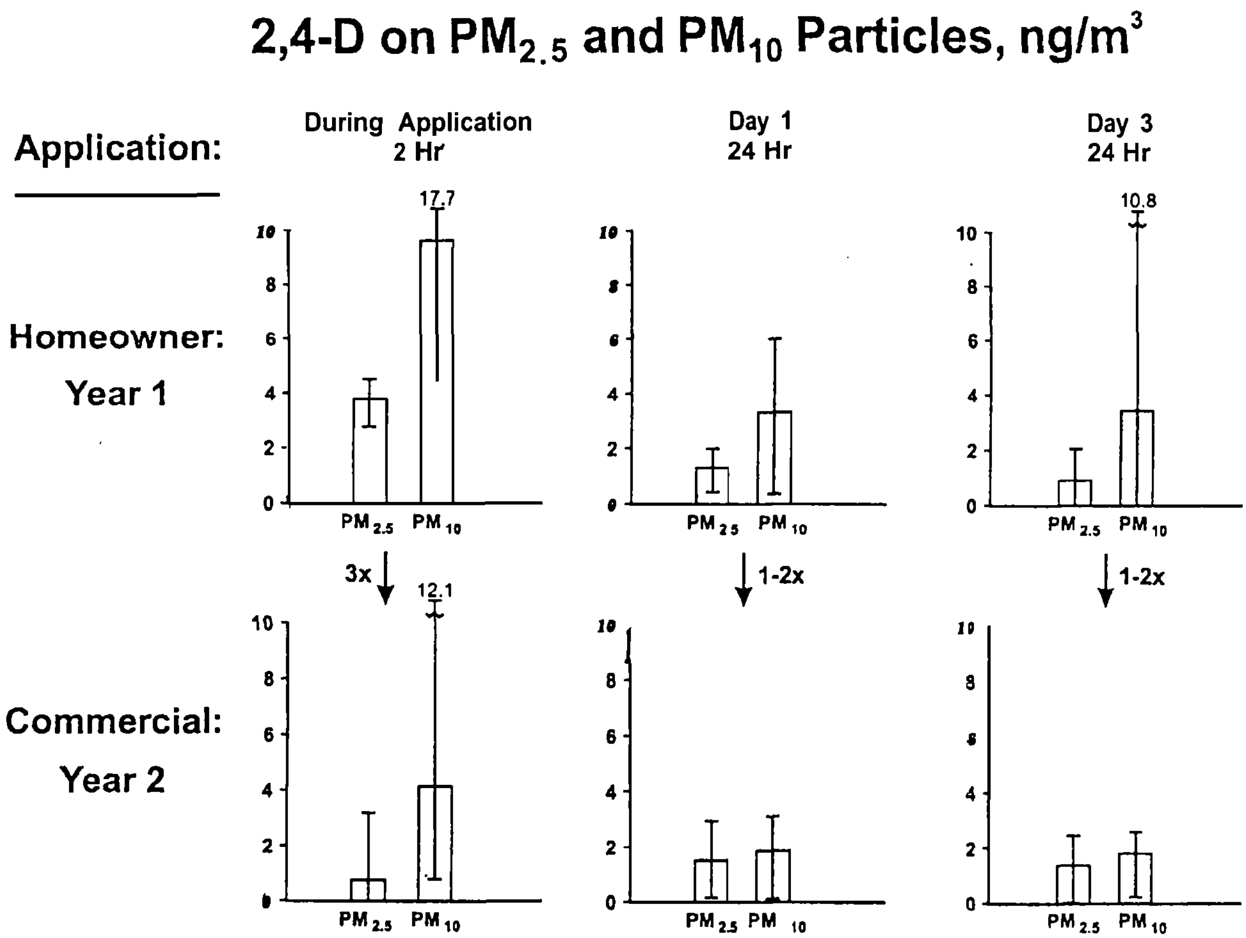

Figure 9. 2,4-D in indoor air by particle size PM2.5 and PM10.

Table 7. Comparison of 2,4-D Air Concentrations by Particle Size

A:Homeowner Application		Application	Day1	Day3
2,4-D TSP Concentration, ng/m^3		13.5	9.2	8.7
PM Size Range	Deposition	Distribution of Total 2,4-D by Size Range, %		
<1 µm	alveoli	14	9	9
1-2.5 µm (1-2 µm for application)	alveoli	15	13	5
2.5-10 µm (2-8 µm for application)	trachea/larynx	43	33	33
>10 µm (>8 µm for application)	nose/mouth	28	45	53
PM Size	Designation	Percent of Total 2,4-D, %		
PM2.5 (<2.5 µm)	respirable PM	29	22	14
PM10 (<10 pm)	inspirable PM	72	55	47
B: Commercial Application		Application	Day1	Day3
2,4-D TSP Concentration, ng/m^3		7.8	2.7	3.8
PM Size Range	Deposition	Distribution of Total 2,4-D, %		
<1 µm	alveoli	0	'64	46
1-2.5 µm (1-2 µm for application)	alveoli	15	5	2
2.5-10 µm (2-8 µm for application)	trachea/larynx	53	8	14
>10 µm (>8 µm for application)	nose/mouth	33	22	38
PM Size	Designation	Percent of Total 2,4-D, %		
PM2.5 (<2.5 µm)	respirable PM	15	69	48
PM10 (<10 µm)	inspirable PM	68	77	62

65% of the 2,4-D found on TSP was associated with inspirable particles (<10 pm), and 25% was on respirable particles (<2.5 μm). Following the commercial application, approximately 75% was inspirable, and 70% was respirable. It is interesting to note that approximately the same level of 2,4-D on <1 μm particles was found in indoor air following both application methods, despite the absence of these particles during the initial application event by the commercial applicator.

Following homeowner applications, calculations of 2 h vs. 24 h air levels suggested that on Day1 for active homes and homes where the applicator wore shoes indoors, only 25% of the indoor air level could be attributed to intrusion during the first 2 h; in contrast, in a low activity home where the applicator did not wear shoes indoors, 100% of the Day1 air level could be attributed to 2,4-D intrusion during the first 2 h.

When examining the air data on a home by home basis, the higher 2,4-D air levels were associated with homes with active children and pets, and especially with those where shoes were also worn indoors. Likewise, the homes where 2,4-D was not detected in air were those with low levels of activity and/or no shoes worn indoors.

<u>2.4-D on Table Tops and Window Sills</u>: The 2,4-D was not detected *on* table tops during the pre-application period, and on only three (out of 40) window sills. However, 2,4-D was detected at measurable levels on all sills and table tops at the end of the post-application period in all homes, with the minor exception of a few sills and table surfaces in one unoccupied home. The ranges of post-application surface loadings on floors, tables and window sills in each home are listed in Table 8. These levels are depicted in graphical form in Figures 10-12. Figures 10 and 11 show the pre- and post-application levels of 2,4-D on table tops and indoor window sills, respectively, by home and by room in the homeowner-application study. Figure 12 shows the post-application levels of 2,4-D on window sills and table tops in the commercial applicator study.

Table 8. **Ranges of 2,4-D Surface Loadings in Homes: Post-application Ranges of 2,4-D Surface Loadings along Traffic Gradient of Each Home**

			Range of 2,4-D Surface Loadings, µg/m^2			
occupancy	Home	Application	Carpeted floor	Bare floor	Table	Window sill
Occupied	A	Homeowner	228 - 25	45	27 - 6.4	22 - 4.8
	A	Commercial	76 – 32	7.9	10 - 3.2	8.2 – 2.6
	B	Homeowner	74 – 5.3	NS"	5.1 - 2.1	3.4 – 1.7
	B	Commercial	24 – 5.2	NS	2.5 - 1.9	1.8 – 1.2
	C	Homeowner	70-27	12-5	3.1 - 1.7	3.8 – 1.1
	D	Homeowner	17-4.5	0.7 – 0.3	2.0 - 1.4	2.0 – 0.6
	E	Homeowner	5.0 – 3.6	2 – 0.7	4.8 - 1.3	1.4-0.9
	E	Commercial	20 – 5.0	3 - 1	4.8 - 0.8	3.9 – 0.5
	F	Homeowner	1.9 – 1.2	0.2	3.5 - 0.5	1.9 – 0.8
	F	Commercial	6.5 – 4.4	2.2	1.3 - 0.9	5.7 – 0.5
Unoccupied	X	Commercial	1.9 – 0.8	1.0 - 0.8	0.8 - 0.4	0.2 - 0.02
	Y	Commercial	0.5 - 0.05	1.0	ND, co.02	ND, co.02

a) NS- not sampled; no bare floors in designated areas.

Spatial Distribution
2,4-D on Tables After 1 Week Accumulation ($\mu g/m^2$)

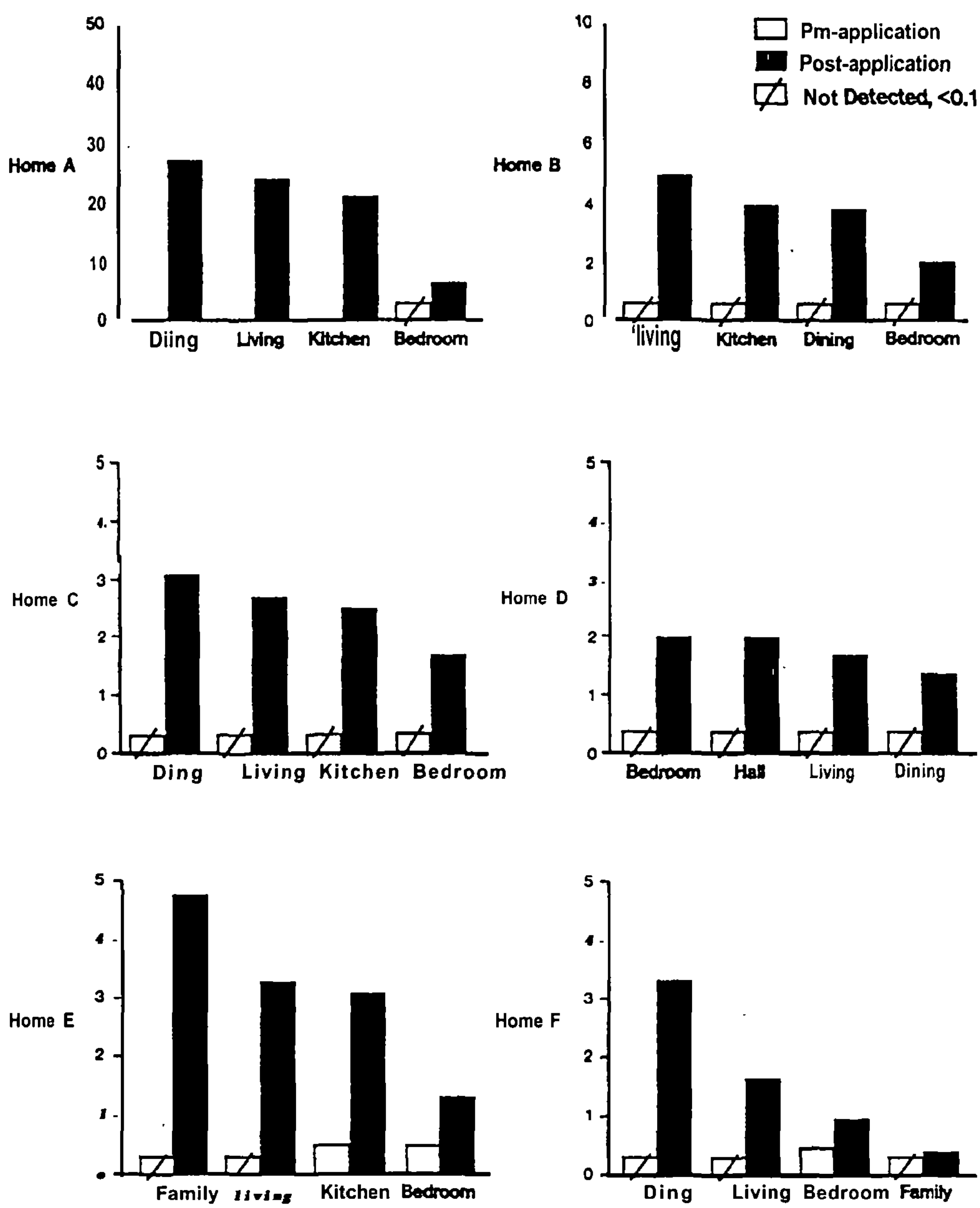

Figure IO. 2,4-D on table tops following homeowner application.

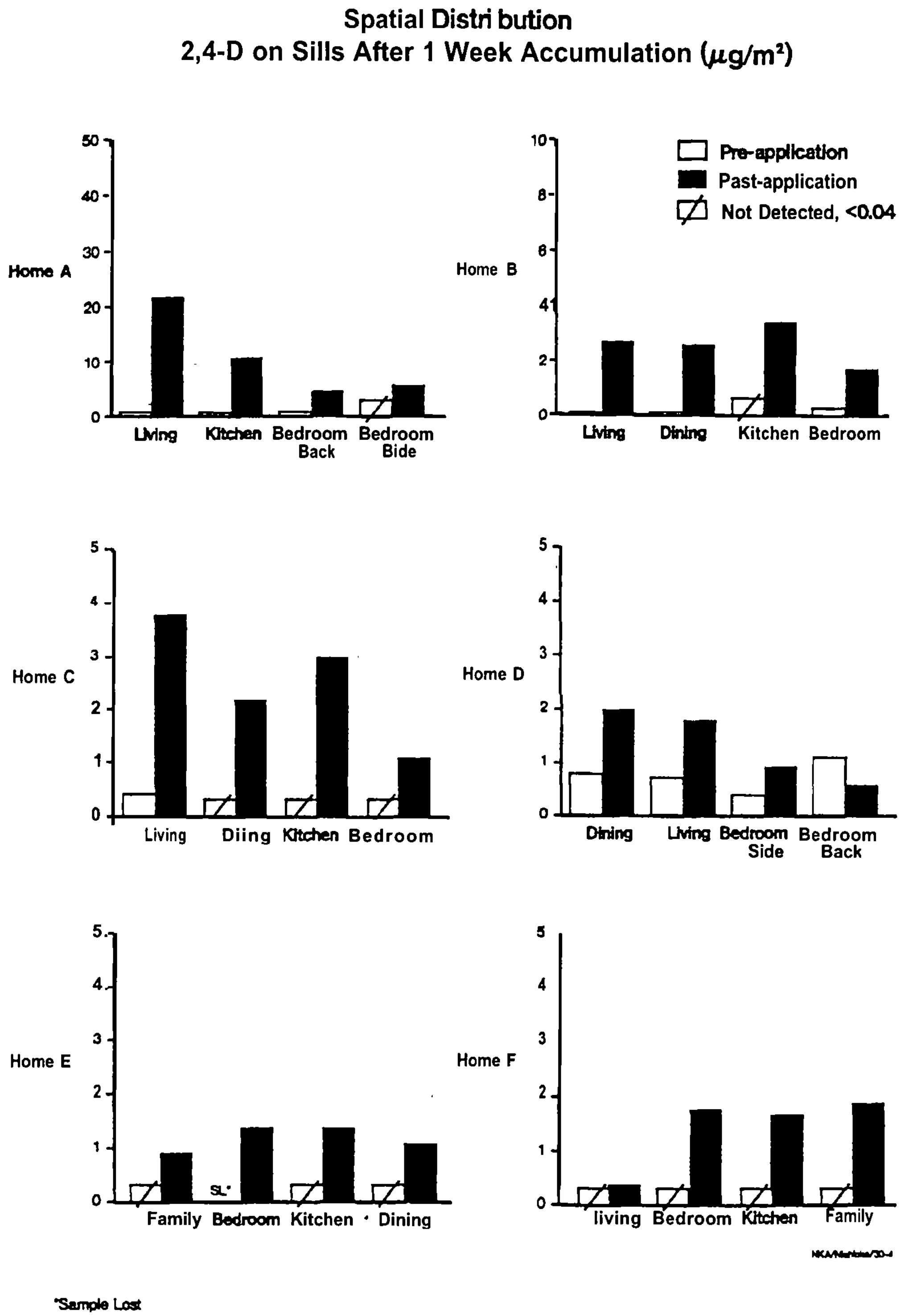

Figure II. 2,4-D on window sills following homeowner application.

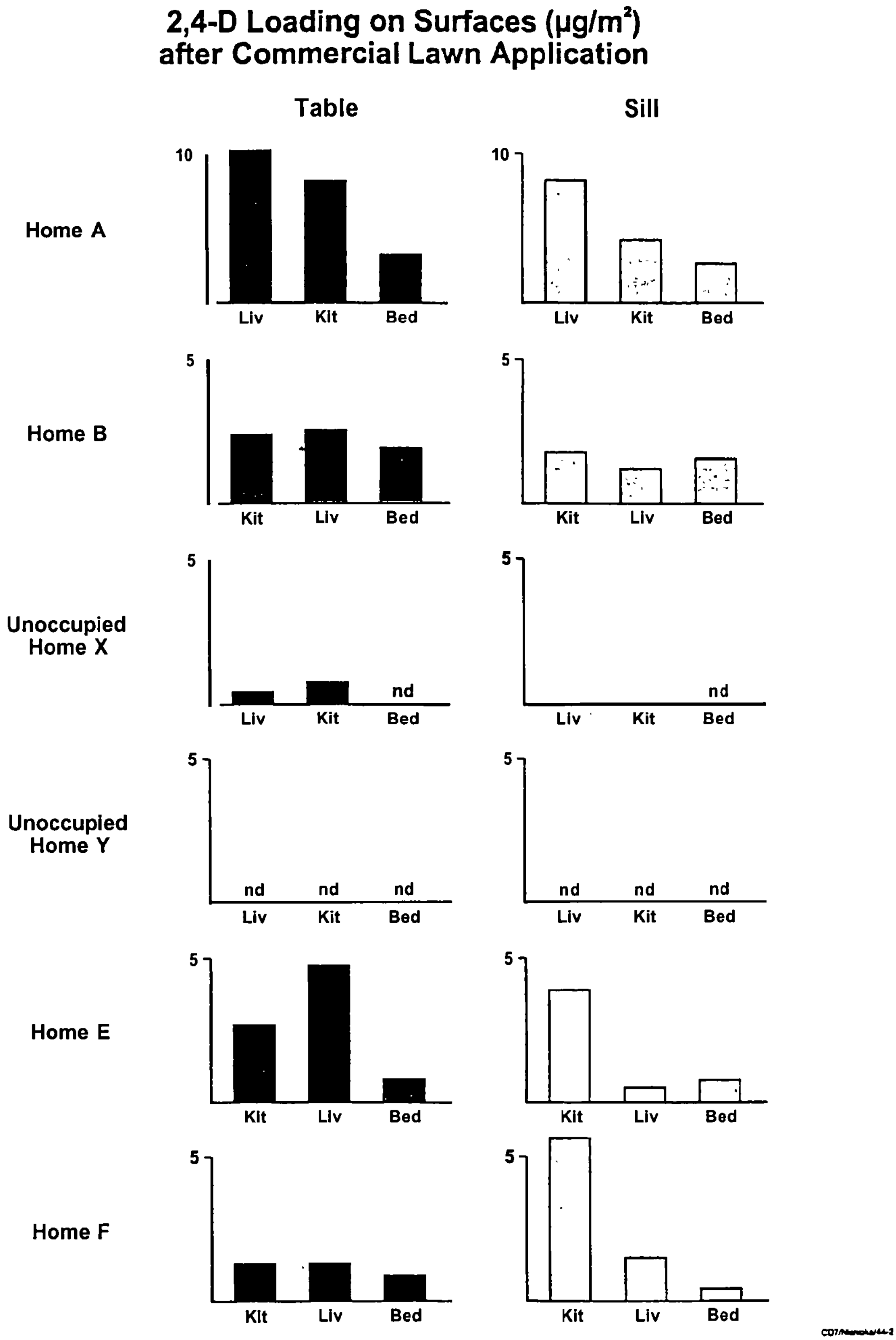

Figure 12. 2,4-D on window sills following commercial application.

As shown in these figures, in most homes the 2,4-D levels on sills and table tops showed a gradient similar to that seen for the floor loadings, from high to low with the direction of traffic through the home. In those homes exhibiting pronounced gradients (e.g., homes A, B, and C), the 2,4-D loadings on tables and sills were approximately 10% and 8%, respectively, of the floor loadings. The observation of traffic-dependent gradients in table and sill surface 2,4-D loadings, combined with the levels of activity in these homes, strongly implies that dust resuspension within the home was the major source of 2,4-D residues found on sills and tables. The 10 to 1 ratio here of floor to table 2,4-D surface loadings closely resembles the 10: 1 ratio for resuspension rates by activity: 10” h^{-1} for normal traffic and play and 10^{-4} h^{-1} for reading (10). In one home carpeted throughout, and thus a similar surface for resuspension, post-application 2,4-D floor loadings were highly correlated with both sill and table loadings, r^2= 0.82 and 0.95, respectively.

The 2,4-D loadings on surfaces in the principal living area and the 2,4-D air concentrations were compared, and correlations among the matrices are listed in Table 9. Correlations are high (>0.85) between surface loading and 2,4-D TSP and PM10 concentrations, and poor between surfaces and 2,4-D PM2.5 concentrations. These results are consistent with other reports that deposition of larger particles contributes more to surface loadings than smaller particles (21).

For several homes characterized as having limited child and pet activity and/or homes where shoes were not worn indoors, the gradient on the sills, and to some extent on the tables, was barely evident (e.g., homes E and F with homeowner application). In these homes, the 2,4-D loadings on floors, sills, and tables were comparable and generally in the range of 1-2 $\mu g/m^2$. These consistent levels of 2,4-D on all surfaces are suggestive of foliar resuspension intrusion, and are low compared with the levels that were found following resuspension of floor dust in high activity homes, up to 25 $\mu g/m^2$.

Table 9. Correlations Between 2,4-D Air Particulate Levels on Day 3 and 2,4-D Surface Loadings in the Living Area

Pearson correlation: 2,4-D Liv surface loading ($\mu g/m^2$) and 2,4-D air level (ng/m^3)

Surface	TSP	PM10	PM2.5
Table	0.96	0.90	0.46
Window sill	0.93	0.87	0.44
Floor	0.89	0.88	0.45

Temnoral Profile of Intrusion: The data gathered in the third year of the program were used to assess the temporal profile of intrusion and appearance of residues on table surfaces. Data were collected at four homes, each with a distinctly different set of family activity patterns. Despite the differences in activity patterns, especially with respect to cleaning and vacuuming, which were allowed this time during the one week post-application period, there was still a distinct trend in accumulation in all homes. The intrusion and accumulation of 2,4-D on the living room floor and living room table continued through the sampling week, albeit at different rates for the four homes. The totals by week's end and the percentage of that total accumulated between each sampling period (application to Dayl, Dayl to Day3, and Day3 to Day7) are listed in Table 10. As shown there, the peak accumulation on the table top follows after the peak accumulation on the floor. This finding is consistent with earlier data suggesting that most of the residues on tables comes from resuspension of material originally tracked-in onto the floor. The 2,4-D levels on the hands of the adult applicator and the resident child are listed in Table 11. There were substantial differences, a factor of 2000, between the levels on the different applicator's hands, from as little as 29 ng on the hands of the applicator wearing heavy gloves to 57 µg on the hands of the applicator not wearing gloves. Over the one-week sampling period, the 2,4-D levels on the applicator hands declined to approximately 2X pre-application levels. The levels on the children's hands showed some apparently different trends. In the high activity home, the levels on the child's hands appeared to increase throughout the week, as did the floor, air and table residue levels. In the other homes, the levels on the child's hands varied throughout the week. In one case the level was highest on the day of application, possible from touching contaminated clothing. The comparison of 2,4-D levels in air, on surfaces, and on hands for the high activity home is shown in Figure 13. There was a substantial amount of rain at this home 24 h after application; despite the wash-off effect of the rain in removing turf residues, there were sufficient residue levels remaining for track-in over the remainder of the week.

The urine analysis method remained problematic, and we do not ascribe much significance to the data, albeit to show trends. The total 2,4-D amounts excreted in the first morning void of

Table 10. Temporal Profile of 2,4-D Intrusion on Floors and Table Tops

Home	Activity Descriptors[a]				Surface	7-day Cumulative Loading, $\mu g/m^2$	Accumulation, %		
							D1	D3	D7
BY	HiC	HiP	S	As	Floor	17	35	43	21
					Table	3.1	6	30	**64**
Zm	ModC	LoP	S	NAS	Floor	4.1	15	59	26
					Table	1.6	13	34	53
Rr	HiC	LoP	NS	NAS	Floor	2.5	62	30	8
					Table	0.12	nd	58	42
cs	LoC	LOP	s	NAS	Floor	2.4	14	36	50
					Table	0.12	nd	42	58

a) activity descriptors:

HiC- high child activity,
ModC- moderate child activity
LoC- low child activity
HiP- high pet activity
LoP- low pet activity
S- family outdoor shoes worn indoors
NS- family outdoor shoes not worn indoors
AS- applicator shoes worn indoors
NAS- applicator shoes not worn indoors

Table 11. Temporal Profile of 2,4-D on Application and Resident Child Hands

		Total 2,4-D on Hands, ng			
Home	Subject	Pre-Appl.	Post-Appl. Dav 1	Post-Appl. Day 3	Post-Appl. Day 7
BY	adult	26	56,900”	378	51
	child	100	10[b]	95	1060
Zm	adult	1740”	28,300	864	179
	child	17	92	8	53
Cs	adult	nd[d]	29”	40	25
	child	nd	nd[f]	68	nd
Rr	adult	24	927	600	52
	child	46	41	nd	22

a) Application made just before dinner; applicator finished job and then wiped hands for sample.
b) Child not at home during application (at swim practice); came in and wiped hands for sample.
c) Residual level from application made 3 weeks earlier (washed out by heavy rains within 12 hours of application, so reapplied).
d) By the looks of the lawn, no 2,4-D had been applied for 1-2 years.
e) Applicator wore gloves during application.
f) Child not at home during application.

2,4-D Temporal Profile in High Activity Home

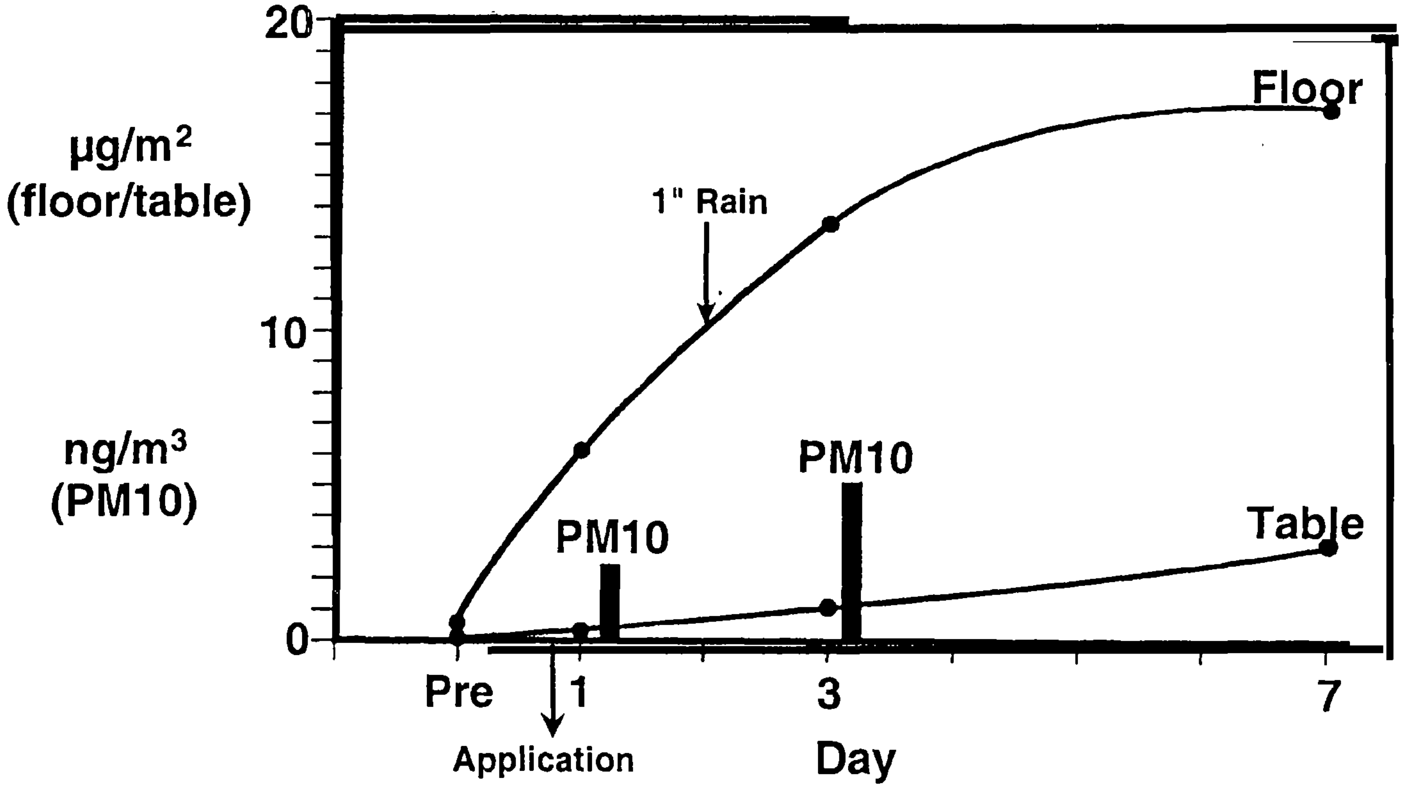

Figure 13. Temporal profile of 2,4-D on table tops, floor and in air for high activity homes.

applicator and child are listed in Table 12. As shown there, the applicator values rise about 500 ng over background within the first few days, and return to baseline, and this is consistent with literature values of ~36 h half-life. The excretion profiles of the children also seem to show an increase over background levels within the first few days after application. Since the air levels, as determined from the stationary micro-environmental samplers, do not indicate sufficient exposure levels for these biomarker levels, we assume that the personal inhalation exposure levels of the children were significantly higher than what might be inferred from the central air monitoring location. It remains possible that contact with the applicator or a trip across the lawn may have been responsible for the urine levels. There does not appear to be a correlation with dermal wipe amounts; however, this results was not unexpected, as the children were typically 10-12 yrs old, and not prone to extensive hand-to-mouth activity. Their dermal wipe levels, though, may be better used to assess their contact with contaminated surfaces. In that regard, the children's hand wipe data and table surface loadings are moderately well-correlated: $r^2 = 0.73$ for a linear fit and $r^2=0.97$ for a polynomial fit. Using recently derived transfer coefficients and contact areas (22), it appears that children may have contacted hard surfaces 10-100 times before hands were wiped.

Role of Activity Patterns: The two-year study presented above is limited by the small number of homes studied. However, the extent to which these homes represent important trends and factors in the general population, we hypothesize that familial factors have a greater effect on transport and residential exposure than application factors such as spray drift. In particular, the levels of child and pet activities, and whether family members wear their outdoor shoes indoors are the factors that were significantly different among these homes. A multivariate analysis, with ANOVA, was used to deconvolute the data into the contributions from different activities to the post-application 2,4-D loadings on the floor, sill and table top surfaces of the main living area. The incremental contributions of these factors are listed in Table 13. As shown there, a high activity dog and the applicator's shoes worn indoors were the most significant factors, followed

Table 12. Temporal Profile of 2,4-D in Adult Applicator and Resident Child Urine

		Total 2,4-D Excreted in First Morning Void, ng				
Home	Subject	Pre-Appl.	Post-Appl. Day 2	Post-Appl. Day 3	Post-Appl. Day 4	Post-Appl. Day 8
BY	adult	1097	1116	1568	1220	655
	child	107"	78	597	503	198
Zm	adult	116"	419	220	405	65
	child	625(?)[a,b]	190	175	714	288
Cs	adult	1875(?)[a,b]	199	159	615	237
	child	109"	405	876	316	nd
Rr	adult	2122(?)[a,b]	1208	836	300	560
	child	97"				

a) Analysis using GC/ECD rather than GC/MS.
b) ? - suspect value; not repeated with GC/MS analysis.

Table 13. Contributions of Transport Mechanisms to 2,4-D Loadings on Living Area Surfaces

	µg/m²			% of total		
Parameter	Floor	Table	Sill	Floor	Table	Sill
Application						
Spray drift	~0	~0	~0	0	0	0
Ventilation of home						
Closed home[a]	0.3	0.1	0.1	0.2	0.4	0.4
Open home[b]	1.4	0.4	0.8	0.7	1	3
Track-in						
Applicator shoes	50.5	~0	1.2	27	~0	5
High activity children	8.7	5.3	2.4	--[c]	--	--
with shoes	17.3	5.1	2.5	9	18	11
Moderate activity children	2.4	4.2	2.5	--	--	--
with shoes	11.1	4.1	2.5	--	--	--
Low activity children	~0	0.3	0.4	--	--	--
with shoes	3.0	0.1	0.5	--	--	--
Low activity dog	13.7	3.0	3.4	--	--	--
High activity dog	117.5	22.8	18.4	63	80	80

a) Closed home intrusion through cracks.
b.) Open house intrusion via opening/closing of doors and windows.
c) Calculation of parameter distribution limited to high activity children with shoes and high activity dog.

by high activity children and their shoes. Only the high pet activity factor and applicator's shoes were significant at $p<0.05$ confidence level.

The applicator's shoes contributed significantly to floor loadings (27%), but less so to levels on sills and tables (0-5%). Instead, the activity levels of children and dogs seemed to drive the loadings on the sills and table, and this presumably through the resuspension of floor dust during their play. In fact, an active dog may have been responsible for 63% of the residues on the floors and 80% of the residues on the tables and sills one week after lawn application.

While the absolute contributions or relative order of these parameters in affecting indoor levels may not have been predicted intuitively, the results appear consistent with our understanding of family dynamics. In particular, the high activity homes studied were those with at least two boys in the 8-12 age bracket who were within two to three years of each other in age and who had friends in the immediate neighborhood. In the case of the home with the high activity dog, the dog was in contact with the treated turf within an hour of application, whereas children were not.

Turf Application Rates and Air Exchange Rates: The application rates and air exchange rates may also affect indoor air and surface levels. Five of the seven homes at which homeowner applications were made had similar air exchange rates, 250-300 m^3/h; one was substantially higher, 400 m^3/h, and one was substantially lower, 125 m^3/h. The manufacturer-suggested application rate of 80 mg/m^2 for 2,4-D was rarely achieved. Most deposition coupons indicated application rates of 30-70 mg/m^2, and many homeowners deliberately applied less in areas where children played frequently. Deposition rates at one home averaged 150 mg/m^2 and rates at another home were extremely low, 10 mg/m^2 and this was probably due to the fact that application was made on a slightly windy day.

Effects of Activity Patterns on Indoor Levels: The post-application levels of 2,4-D in three homes are shown in Figure 14. This figure presents the levels on floor, table and sill surfaces, air

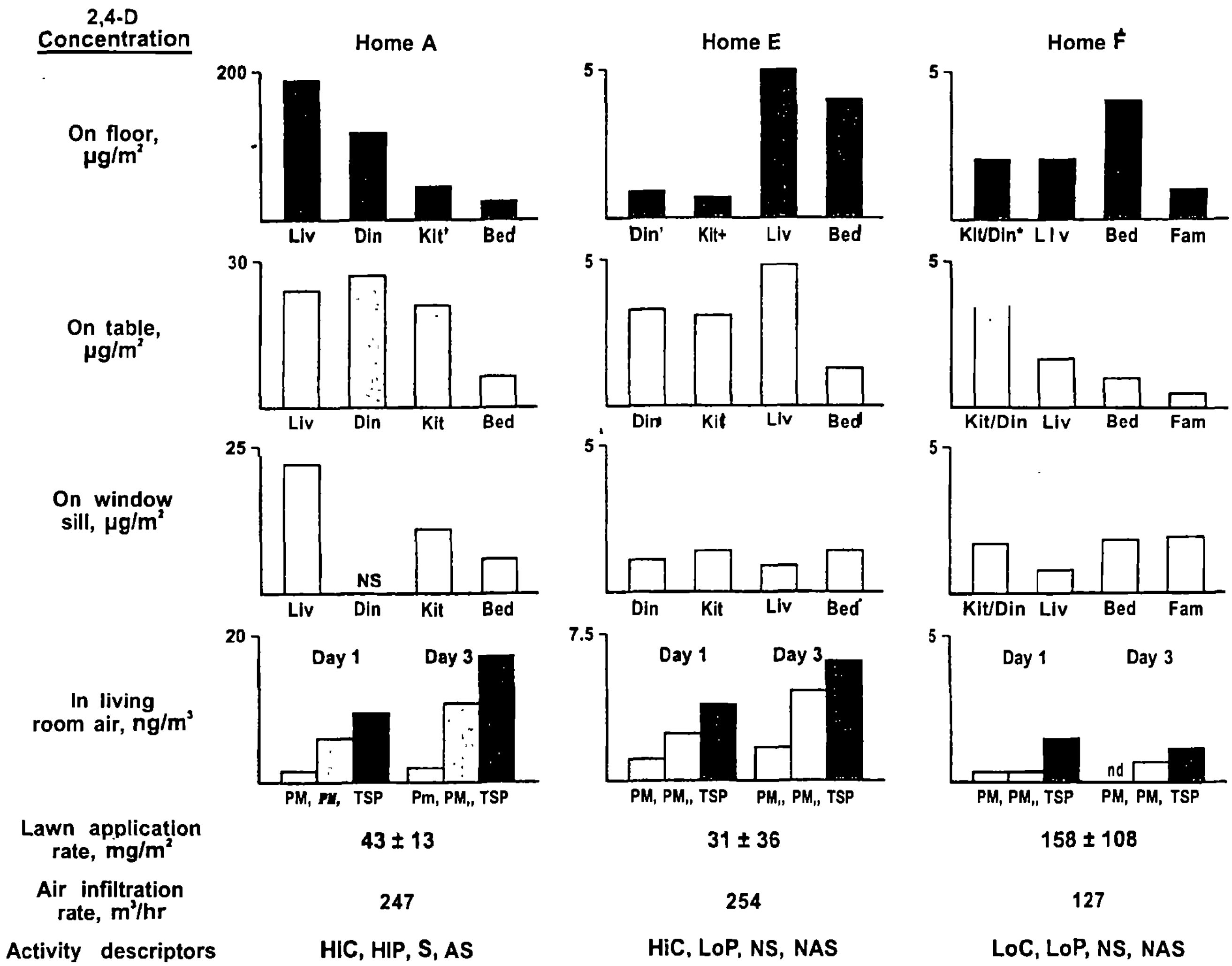

Figure 14. Comparison of activity patterns on indoor levels of 2,4-D.

levels on Day1 and Day3, lawn application rate, air infiltration rate, and the activity descriptors for that household. As shown there, the household with the highest lawn application rate (F) also had the lowest air exchange rate, the lowest indoor residue levels, and occupants consistently removed shoes upon entering the house. In a home with high child activity and a no-shoes policy (E), indoor residues were also low. In contrast, the home with an active dog and children, and shoes worn indoors, had significantly higher indoor levels despite application rates and air exchange rates equivalent to Home E. It appears, therefore, that homeowners can control a large portion of 2,4-D intrusion into the house through a strict "no outdoor-shoes worn indoors" policy. Control over track-in by a dog is more difficult, although the homeowners with the high activity pet were able to limit its activity level when participating in the second study.

Control of Intrusion:To limit intrusion of this pesticide into the home, it may be advisable to limit the contact of indoor-outdoor pets with the treated turf, and/or to wash the animals frequently in the first week after lawn treatment. It also appears that homeowners can apply lawn care products with no more indoor intrusion occuring than with commercial applications if the applicator's shoes are removed before he/she enters the home. Although the role of his/her clothing, such as contamination on pant legs, could not be deduced from the small data set here, it appears reasonable to suggest that use of coveralls that are removed before reentering the house can also limit track-in intrusion of pesticides. Finally, consistent removal of shoes at the door not only by the applicator, but by all family members, appears to result in substantially lower track-in of lawn-applied chemicals.

The use of an entry mat and uncarpeted floors has been suggested (23), together with other control measures, as ways to limit track-in of pollutants and accumulation, and thereby reduce the potential for childrens' indoor exposures via dermal contact and non-dietary ingestion (hand-to-mouth) of dust while playing on floors. These data provide an interesting corollary, in that a carpeted entry, where children are less likely to play, may serve as a retainer for tracked-in pollutants, and prevent their migration into carpeted living areas where children may play.

Uncarpeted entries, or bare floors with a smooth-surface or short-pile entry mat, may only exacerbate the migration of pollutants into carpeted living areas.

Estimating Indoor Exposure: Four different approaches for estimating the pre- and post-application inhalation and non-dietary ingestion exposures of a 1 -yr old are given for comparison in Table 14. The dermal penetration route was not considered here because of the low skin permeability (<3%) of the 2,4-D amine salt (24). For post-application exposures, the Day 3 PM10 air level in the home and an 8.7 m^3/day inhalation volume was used for each approach (18). For non-dietary ingestion, the first approach combined the 2,4-D dislodgeable surface loading determined with the PUF roller and assumed that the average area of both of a 1-yr old child's hands to be 0.031 m^2 (18). It also assumed 12 h of activity/day with essentially continuous contact of the hands with the living area floor, and 10 hand-to-mouth events/h (25). The second approach employed the current U.S Environmental Protection Agency estimate of 100 mg of dust ingestion/day (18). The third method used human activity descriptors associated with the household to estimate a 2,4-D carpet loading, with extrapolation to a dislodgeable carpet surface loading. This value was then combined with a child's total hand area and rate of hand-to-mouth used in the first scenario. Whereas the first three estimations were based on contact with the living room floor, the fourth approach to estimating exposure was based on surface loadings of 2,4-D on the living room table. For that one, an 80% dust transfer rate (22) was combined with the hand area and activity rates used in the other scenarios. The first three methods were in excellent agreement, especially the PUF Roller and EPA dust ingestion approaches, this due in part to the very high degree of correlation (r^2=0.98) between the 2,4-D carpet dust loadings and dislodgeable carpet surface loadings. The Pearson correlations between exposure estimates demonstrate this parity; r=0.90 for PUF Roller *vs* 100 mg dust ingestion and r=0.93 for 100 mg dust ingestion with activity descriptors. The major differences in exposure estimates between the PUF Roller and 100 mg dust ingestion method appeared in those homes where the dust loadings were low. Measured dust loadings were 0.2-10 g dust/m*. In homes with the lower dust loadings, the 100 mg dust ingestion rate may tend to overestimate the non-dietary ingestion.

Table 14. Estimated Post-Application 2,4-D Daily Exposure (Non-Dietary Ingestion and Inhalation) for One-Yr Old Child in Different Home Environments: Comparison between Four Methods for Estimating the Non-Dietary Ingestion Component

	Estimated Combined Inhalation and Non-Dietary Ingestion Post-Application Exposure (μg/day) based on: [a]			
Home Activity Descriptors	PUF Roller[b]	100 mg Dust Ingestion"	Activity Descriptors[d]	Contact with Smooth Surface[e]
HiP AS HiC S[f]	6.4	6.8	7.0	67
LoP NAS HiC S	2.9	1.9	1.2	28
LoP AS HiC S	1.4	1.4	3.1	7.6
LoP NAS HiC S	0.73	0.83	0.90	13
LoP NAS LoC S	0.52	0.63	0.68	4.8
LoP N A S ModC S	**0.38*[g]**	2.8	0.99	14
LoP N A S HiC N S	0.38	1.0	0.90	13
LoP N A S LoC N S	0.21	0.75	0.57	3.7
LoP N A S ModC S	**0.09***	1.1	0.99	7.2
LoP N A S LoC N S	**0.08***	0.81	0.57	4.8
LoP N A S LoC S	**0.04***	0.50	0.68	6.0
Mean exposure, μg/day	1.2	1.7	1.6	16
Median exposure, μg/day	0.38	1.0	0.9	
Exposure Range, μg/day	0.04-6.4	0.5-6.8	0.57-7.0	3.7-67

a) Inhalation exposure: Pre-application =O; Post-application = PM10 2,4-D Day3 concentration (ng/m^3) x 8.7 m^3/day inhalation volume.
b) Non-dietary ingestion (NDI) exposure = 2,4-D dislodgeable carpet surface loading (μg/m^2)·x average 1 -yr old child hand area x 10 hand-to-mouth events/h x 12 h/day.
c) NDI = 0.1 g dust ingestion /day x 2,4-D concentration in dust (μg/g).
d) NDI = sum of 2,4-D floor loadings due to activity descriptors x 0.01 (ratio of 2,4-D PUF Roller loading to 2,4-D carpet dust loading) x hand area x 10 hand-to-mouth/h x 12 h/day.
e) NDI= 2,4-D Liv table surface loading (μg/m^2) x 80% transfer rate x hand area x 10 hand-to-mouth/h x 12 h/day.
f) Activity descriptors: HiP= high pet activity; LoP= low pet activity; AS= applicator's shoes worn indoors; NAS= no applicator shoes worn indoors; HiC= high child activity; S= shoes worn indoors by family; NS= no shoes worn indoors by family.
g) Homes for which significant difference exists between estimated exposures based on PUP Roller dislodgeable residues and 100 mg dust ingestion.

The exposure estimates based on contact with the table tops (fourth scenario) were higher than floor dust exposures by a factor of 10. If dermal contact and hand-to-mouth activity are limited to a single palm, the exposures are approximately twice the values obtained with the floor dust ingestion estimates. These estimates suggest that contact with smooth surfaces may be a more significant contributor to non-dietary ingestion that previously considered.

In the post-application period, the inhalation component was small, relative to the non-dietary ingestion component. Where shoes were worn indoors, inhalation exposure was 0-2% of the total estimated exposure; for the homes where shoes were not worn indoors, inhalation exposures were about 10% of the total.

The pre-application exposure estimates shown in Table 15 were limited to a few representative homes. These exposures estimates were approximately 0.01-o. 1 µg/day, a factor of 10-l 00 fold lower than after application.

Comnarisons with Exnosure Limit Standards: The first three methods showed mean exposures of 1.2-l .7 µg/day (0.1-0.2 µg/kg/day for a 10 kg child), with an upper range estimate of 6-7 µg/day. For comparison, the World Health Organization's Acceptable Daily Intake (ADI) for 2,4-D is 300 µg/kg/day and the U.S. EPA Integrated Risk Information System (IRIS) Reference dose (Rfd) is 10 µg/kg/day (26). Our calculated exposures, then, are less than the RfD, the daily exposure without risk over a lifetime, in both pre-and post-application times. However, our hypothetical NDI exposures may approach the RfD shortly after application, if contact with smooth surfaces is shown to follow patterns established in preliminary laboratory tests. The exposures due to contact with smooth surfaces, then, is an area that will require greater study before the value of these estimates can be established.

Table 15. Estimated Pre-Application 2,4-D Daily Exposure (Non-Dietary and Inhalation) for One-Yr Old Child in Different Home Environments: Comparison between Three Methods for Estimating Non-Dietary Ingestion Component

Home Activity Descriptors	Estimated Combined Inhalation and Non-Dietary Ingestion Pre-Application Exposure (μg/day) based on: PUF Roller[a]	100 mg Dust Ingestion[b]	Activity Descriptors	Contact with Smooth Surface[c]
HiP HiC S[d]	0.02	0.08	NA[e]	0.19
LoP HiC S	0.02	0.03	NA	0.14
LoP ModC S	0.01	0.07	NA	0.10
LoP HiC NS	0.01	0.05	NA	0.06
LoP LoC NS	0.01	0.06	NA	0.10

a) See footnotes a and b, Table 11; with exception that surface dislodgeable residue loading estimated from 2,4-D carpet dust loading (x0.01).
b) See footnotes a and c, Table 11.
c) See footnotes a and d, Table 11; with exception that table surface loading estimated from 2,4-D carpet dust loading (x0.1).
d) NA= not applicable; calculation assumes 2,4-D applied to lawn.

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APPENDIX A

Table 1. Concentration of 2,4-D in Air During Application (Cascade Impactor), Yrl

	Concentration of 2,4-D by Particle Size, ng/m^3				Conc. by PM, ng/m^3	
Home	<1 µm	1-2 µm	2-8 µm	>8 µm	PM2.5*	PM10*
BY	2.15	2.31	4.59	4.7	4.46	9.05
Rn	2.16	2.64	5.25	3.44	4.80	10.05
Zm	1.86	2.78	13.06	3.95	4.64	17.7
SC	1.68	1.39	2.77	2.15	3.07	5.84
Ad	1.97	0.81	6.52	0.79	2.78	9.30
Rr	1.54	1.39	1.68	5.91	2.93	4.61
Lb	1.68	2.72	6.60	5.68	4.40	11.00
Average	1.86	2.01	5.78	3.80	3.87	9.65
Std Dev	0.24	0.80	3.69	1.86	0.89	4.23
Range	1.54-2.16	0.80-2.78	1.68-13.06	0.79-5.91	2.78-4.80	4.61-17.7

* PM2.5= sum of concentrations (<1 µm + 1-2 pm)
* PM10= sum of concentrations (<1 µm + 1-2 µm + 2-8 µm)

Table 2. Concentration of 2,4-D in Air on Day1 and Day 3 (URG Sampler), Yrl

	Concentration of 2,4-D by Particle Size, ng/m^3				Conc. by PM, ng/m^3	
Home	<1 µm	<2.5 µm	<10 µm	TSP	PM2.5	PM10
By- day 1	1.52	1.52	6.04	9.47	1.52	6.04
By- day 3	1.93	loss	10.75	17.16	1.93	10.75
Rn- day 1	1.39	1.96	3.29	4.94	1.96	3.29
Rn- day 3	1.70	**1.34***	2.88	3.48	1.70	2.88
Zm- day 1	1.51	1.55	4.48	5.46	1.55	4.48
Zm- day 3	nd	0.17	1.27	4.03	0.17	1.27
Sc- day 1	0.34	1.46	lab loss	1.39	1.46	lab loss
Sc- day 3	nd	nd	nd	nd	0.00	0.00
Ad- day I	0.64	**0.51***	1.42	2.14	0.64	1.42
Ad- day 3	nd	0.00	0.24	0.24	0.00	0.24
Rr- day 1	0.98	1.11	2.42	3.91	1.11	2.42
Rr- day 3	1.68	**1.32***	4.63	6.12	1.68	4.63
Lb- day 1	0.36	nd*	0.37	1.48	0.36	0.37
Lb- day 3	nd	nd	0.69	1.15	0.00	0.69
Average-day 1	0.96 ±0.52	1.16 ±0.68	3.00 ±2.06	4.11 ● 2.87	1.23 ±0.56	3.00 ±2.06
Average-day3	0.76 ±0.95	0.41 ● 0.63	2.92 ±3.82	4.60 h5.97	0.79 ± 0.92	2 92 h3.82
Range-day 1	0.34 -1.52	0.00 -1.96	0.37 -6.04	1.39 -9.47	0.36 -1.96	0.37 -6.04
Range-day 3	0.00 -1.93	0.00 -1.34	0.00 -10.75	0.00 -17.16	0.00 -1.93	0.00 -10.75

* 2,4-D concentration in 2.5 pm fraction is less than the concentration in the 1.0 µm fraction; cause unknown

Table 3. Concentration of 2,4-D in Air by Particle Size Range (URG Sampler), Yrl

	Conc of 2,4-D by Particle Size Range, ng/m^3				Conc. by PM, ng/m^3	
Home	<1 µm	1-2.5 µm	2.5-10 µm	>10 µm	PM2.5	PM10
By- day 1	1.52	0.00	4.52	3.43	1.52	6.04
By- day 3	1.93	0.00	8.82	6.41	1.93	10.75
Rn- day 1	1.39	0.57	1.33	1.66	1.96	3.29
Rn- day 3	1.70	0.00	1.54	0.60	1.70	2.88
Zm- day 1	1.51	0.03	2.93	0.98	1.55	4.48
Zm- day 3	0.00	0.17	1.11	2.75	0.17	1.27
Sc- day 1	0.34	1.13	lab loss	0.00	1.46	lab loss
Sc- day 3	0.00	0.00	0.00	0.00	0.00	0.00
Ad- day 1	0.64	00.00	0.91	0.72	0.64	1.42
Ad- day 3	0.00	0.00	0.24	0.00	0.00	0.24
Rr- day 1	0.98	0.13	1.31	1.48	1.11	2.42
Rr- day 3	1.68	0.00	3.31	1.49	1.68	4.63
Lb- day 1	0.36	0.00	0.37	1.11	0 36	0.37
Lb- day 3	0.00	0.00	0.69	0.45	0.00	0.69
Average-day1	0.96 k0.52	0.27 ● 0.43	1.90 ±1.54	1.56 ±0.98	1.23 ±0.56	3.00 ±2.06
Average-day3	0.76 ● 0.95	0.02 ±0.06	2.24 ±3.10	1 67 ±2.30	0.79 ± 0.92	2 92 ±3.82
Range- hay 1	0 34 -1.52	0.00 -1.13	0.37 -4.52	0.72 -3.43	0.36 -1.96	0.37 -6 04
Range- day 3	0.00 - 1.93	0.00 -0.17	0 00 -8.82	0 00 -6.41	0 00 -1.93	0.00 -10.75

Table 4. Recovery of 3,4-D in Air Samples, Yrl

Time/home	Recovery of 3,4-D. in Particle Size Sample, %				ave 3,4-D
Application	<1 µm	1-2 µm	2-8 µm	>8 µm	
BY	111	95	90	94	
Rn	116	104	99	94	
Zm	115	95	98	101	
SC	109	107	98	92	
Ad	103	104	112	107	
Rr	107	101	98	32	
Lb	100	90	88	78	99 ± 11
URG-day 1	<1 µm	<2.5 µm	<10 µm	TSP	
BY	81	87	80	80	
Rn	80	88	85	82	
Zm	82	83	83	85	
SC	112	90	90	110	
Ad	94	91	94	95	
Rr	77	82	79	77	
Lb	106	62	60	102	86 ± 12
URG-day 3	<1 µm	<2.5 µm	<10 µm	TSP	
BY	99	94	91	94	
Rn	90	85	113	90	
Zm	102	69	66	63	
SC	131	123	130	131	
Ad	109	109	104	100	
Rr	89	95	105	87	
Lb	146	142	140	147	105 ± 24

Table 5. Surface Loading of 2,4-D on Sills and Tables, ug/m^2, Yr 1

Home	Time	Surface Loading of 2,4-D on Sill or Table, $\mu g/m^2$				recovery
By-Sill		**Liv**	**Kit**	**Bed-back**	**Bed-side**	3,4-D,
	pre-2,4-D	0.88	nd	0.90	nd	
	3,4-D, %	47	83	100	88	
	post-2,4-D	22.2	10.5	4.83	5.90	
	3,4-D, %	52	70	72	69	
By-Table		**Liv**	**Kit**	**Din**	**Bed**	
	pre-2,4-D	nd	nd	nd	nd	
	3,4-D, %	86	88	91	90	
	post-2,4-D	24.0	21.1	27.3	6.41	
	3,4-D, %	66	77	68	73	77 ± 14
Rn-Sill		**Liv**	**Kit**	**Din**	**Bed**	
	pre-2,4-D	nd	nd	nd	nd	
	3,4-D, %	78	93	88	92	
	post-2,4-D	3.82	3.01	2.16	1.08	
	3,4-D, %	64	70	62	61	
Rn-Table		**Liv**	**Kit**	**Din**	**Bed**	
	pre-2,4-D	nd	nd	nd	nd	
	3,4-D, %	94	96	102	88	
	post-2,4-D	2.69	2.49	3.11	1.55	
	3,4-D, %	81	91	76	72	83 ± 14

Table 5. Surface Loading of 2,4-D on Sills and Tables, ug/m², Yr 1 (Continued)

Home	Time	Surface Loading of 2,4-D on Sill or Table, μg/m²				recovery
Zm-Sill		**Kit**	**Liv**	**'Din**	**Bed**	3,4-D
	pre-2,4-D	nd	nd	nd	nd	
	3,4-D, %	121	101	102	120	
	post-2,4-D	3.36	2.71	2.55	1.72	
	3,4-D, %	73	59	55	68	
Zm-Table		**Kit**	**Liv**	**Din**	**Bed**	
	pre-2,4-D	nd	nd	nd	nd	
	3,4-D, %	161	114	154	157	
	post-2,4-D	4.04	5.05	3.93	2.08	
	3,4-D, %	87	100	77	80	104 ±34
SC-Sill		**Din**	**Liv**	**Bed-Child**	**Bed-Adult**	
	pre-2,4-D	0.78	0.71	nd	1.15	
	3,4-D, %	36	62	92	89	
	post-2,4-D	1.97	1.80	0.92	0.56	
	3,4-D, %	44	50	76	80	
SC-Table		**Liv**	**Hall**	**Din**	**Bed**	
	pre-2,4-D	nd	nd	nd	nd	
	3,4-D, %	114	115	101	110	
	post-2,4-D	1.74	1.98	1.39	2.00	
	3,4-D, %	82	79	86	79	82 ± 23

Table 5. Surface Loading of 2,4-D on Sills and Tables, ug/m^2, Yr 1 (Continued)

Home	Time	Surface Loading of 2,4-D on Sill or Table, µg/m^2				recovery
Ad-Sill		**Liv**	**Kit**	**Din**	**Bed**	3,4-D
	pre-2,4-D	**0.40**	lab loss	0.52	nd	
	3,4-D, %	**69**		77	78	
	post-2,4-D	**0.77**	0.65	0.53	0.51	
	3,4-D, %	**75**	84	74	74	
Ad-Table		**Fam**	**Liv**	**Din**	**Bed**	
	pre-2,4-D	nd	nd	0.82	nd	
	3,4-D, %	70	78	83	75	
	post-2,4-D	2.18	0.53	0.48	0.29	
	3,4-D, %	84	106	105	111	82 ± 17
Rr-Sill		**Liv**	**Kit**	**Din**	**Bed**	
	pre-2,4-D	nd	nd	nd	lab loss	
	3,4-D, %	113	70	109	-	
	post-2,4-D	0.93	1.43	1.08	1.37	
	3,4-D, %	63	62	64	48	
Rr-Table		**Liv**	**Kit**	**Din**	**Bed**	
	pre-2,4-D	nd	0.52	nd	0.51	
	3,4-D, %	127	67	121	60	
	post-2,4-D	4.76	3.08	3.30	1.28	
	3,4-D, %	79	80	75	99	86 ± 26

Table 5. Surface Loading of 2,4-D on Sills and Tables, ug/m^2, Yr 1 (Continued)

Home	Time	Surface Loading of 2,4-D on Sill or Table, µg/m^2				recovery
Lb-Sill		**Liv**	**Kit**	**Fam**	**Bed**	3,4-D
	pre-2,4-D	nd	nd	nd	nd	
	3,4-D, %	58	100	55	62	
	post-2,4-D	0.39	1.72	1.89	1.83	
	3,4-D, %	76	75	71	68	
Lb-Table		**Liv**	**Din**	**Fam**	**Bed**	
	pre-2,4-D	nd	nd	nd	0.50	
	3,4-D, %	53	54	59	58	
	post-2,4-D	1.66	3.45	0.45	1.01	
	3,4-D, %	81	59	76	76	69 ± 13

Table 6. Surface Loading by Traffic Pattern: 2,4-D and Dicamba in Floor Dust with HVS3 Collection, Yrl

Home (type)/Time	Surface Loading of Analyte in Dust, µg/m²					recovery
BY	**Entry**	**Liv**	**Din**	**Kit***	**Bed**	3,4-D
pre-dicamba	0.05	0.05	0.04	co.01	0.14	
pre-2,4-D	0.54	0.64	0.39	0.03	1.07	
3,4-D rec, %	97	108	98	90	107	
post-dicamba	7.20	10.4	4.23	0.15	2.03	
post-2,4-D	228	188	117	1.60	24.6	
3,4-D rec, %	99	83	101	98	73	95 ± 11
Rn	**Kit***	**Entry***	**Din***	**Liv**	**Bed**	
pre-dicamba	0.01	0.43	0.03	0.08	0.19	
pre-2,4-D	0.08	5.74	0.30	0.48	2.22	
3,4-D rec, %	118	58	75	77	112	
post-dicamba	0.05	0.27	0.13	3.77	1.11	
post-2,4-D	0.71'	3.13	1.65	70.0	26.6	
3,4-D rec, %	92	90	100	71	69	93 ± 19
Zm	**Entry**	**Kit**	**Liv**	**Din**	**Bed**	
pre-dicamba	0.07	0.05	0.16	0.04	0.03	
pre-2,4-D	1.17	1.06	0.35	0.44	0.19	
3,4-D rec, %	65	40	79	57	121	
post-dicamba	2.32	1.06	0.59	0.64	0.31	
post-2,4-D	73.8	34.9	13.0	11.6	5.25	
3,4-D rec, %	83	83	119	89	106	84 ±26

Table 6. Surface Loading by Traffic Pattern: 2,4-D and Dicamba in Floor Dust with HVS3 Collection, Yrl (Continued)

Home	Surface Loading of Analyte in Dust, µg/m²					recovery
SC	**Entry**	**Din***	**Kit***	**Liv**	**Bed**	3,4-D
pre-dicamba	0.04	0.01	co.01	0.16	0.10	
pre-2,4-D	0.67	0.09	0.03	2.73	0.45	
3,4-D rec, %	104	94	92	73	89	
post-dicamba	2.53	0.06	0.02	1.56	0.84	
post-2,4-D	17.4	0.66	0.25	12.7	4.51	
3,4-D rec, %	88	91	91	101	108	93 ± 10
Ad	**Entry**	**Fam**	**Kit**	**Din***	**Bed**	
pre-dicamba	0.05	0.05	0.04	0.03	0.02	
pre-2,4-D	0.82	0.82	0.95	0.61	0.24	
3,4-D rec, %	35	37	47	52	26	39 ± 10
post-dicamba	0.26	0.13	0.11	nd	0.01	
post-2,4-D	3.06	‘1.39	1.39	0.02	0.10	
3,4-D rec, %	89	92	129	114	113	107 ± 17
Rr	**Entry***	**Din***	**Kit***	**Liv**	**Bed**	
pre-dicamba	0.06	co.01	co.01	0.02	0.03	
pre-2,4-D	0.81	0.08	0.05	0.21	0.54	
3,4-D rec, %	99	98	101	100	101	
post-dicamba	0.11	0.05	0.02	0.44	0.28	
post-2,4-D	1.47	0.59	0.26	4.97	3.63	
3,4-D rec, %	93	94	102	86	143	99 ± 11

#- suspect spiking error

Table 6. Surface Loading by Traffic Pattern: 2,4-D and Dicamba in Floor Dust with HVS3 Collection, Yrl (Continued)

Home	Surface Loading of Analyte in Dust, µg/m²					recovery
Lb	**Ent/Kit***	**Din**	**Liv**	**Bed**	**Fam**	3,4-D
pre-dicamba	co.01	0.03	0.03	0.04	0.02	
pre-2,4-D	0.07	0.28	0.34	0.62	0.23	
3,4-D **rec,** %	93	97	98	47	114	
post-dicamba	0.01	0.17	0.17	0.46	0.09	
post-2,4-D	0.19	1.90	1.92	4.02	1.16	
3,4-D **rec,** %	95	94	104	79	108	93 ±19

Table 7. Surface Loading by Traffic Pattern: 2,4-D on Bare Floors by Wipe, Yrl

Home/ Time	Surface Loading of Analyte in Dust, $\mu g/m^2$					recovery
BY	**Entry**	**Liv**	**Din**	**Kit***	**Bed**	3,4-D
pre-2,4-D				**NS**		
post-2,4-D				22.7		
3,4-D, %				55		55
Rn	**Kit***	**Entry***	**Din***	**Liv**	**Bed**	
pre-2,4-D	0.32	0.32	0.34			
3,4-D, %	84	74	66			
post-2,4-D	9.17	2.50	5.09			
3,4-D, %	71	65	73			72 ± 7
Ad	**Kit**	**Liv**	**Entry**	**Din***	**Bed**	
pre-2,4-D				0.55		
3,4-D, %				74		
post-2,4-D				lab loss		
3,4-D, %				lab loss		7 4
Rr	**Entry***	**Din***	**Kit***	**Liv**	**Bed**	
pre-2,4-D	**NS**	**NS**	**NS**			
post-2,4-D	1.58	0.67	0.56			
3,4-D, %	77	88	77			81 ± 6

NS- not sampled

Table 8. Modelling Surface Loading of 2,4-D on Bare Floors, Yrl

			Pre-Application		Post-Application	
Home	Room	Flooring	Wipe	HVS3	Wipe	HVS3
BY	Kit	s s	(0.09)*	0.03	22.7	1.6
Rn	Kit	s s	0.32	0.08	9.17	0.71
	Entry	RS	0.32	5.74	2.50	3.13
	Din	1/2 RS	0.34	0.30	5.09	1.65
Zm	none					
SC	Kit	s s	(0.09)	0.03	(2.50)	0.25
	Din	SS	(0.27)	0.09	(6.60)	0.66
Ad	Din	1/2 RS	0.55	0.61	(0.06)	0.02
Rr	Entry	RN	(0.08)	0.81	1.58	1.47
	Din	S N	(0.08)	0.08	0.67	0.59
	Kit	SN	(0.05)	0.05	0.56	0.26
Lb	Kit	SN	(0.07)	0.07	(0.19)	(0.19)

	pre-application wipe/vac ratio	post-application wipe/vac ratio
SS- smooth floor/shoes worn	3	10
1/2RS- slightly rough/shoes worn	~ equal	3
RS- rough surface/shoes worn	0.1	~ equal
RN-rough surface/no shoes	0.1	~ equal
SN-smooth floor/no shoes	~ equal	~ equal

* estimated with respect to HVS3 data and above listed ratios

Table 9. Comparison of Surface Loading of 2,4-D from Collection by PUF Roller and HVS3 on Living Room Carpet, Yrl

	Surface Loading of 2,4-D by PUF Roller and HVS3 Collection, µg/m²					
	Pre-Application Sampling			Post-Application Sampling		
Home	PUF Roller	3,4-D,%*	HVS3	PUF Roller	3,4-D,%*	HVs3
BY	0.01	93	0.64	1.69	95	188
Rn	0.06	89	0.48	0.38	93	70
Zm	co.01	101	0.35	0.10	107	13
SC	0.03	90	0.67	0.14	108	17.4
Ad	co.01	103	0.82	0.01	52	3.06
Rr	0.13	90	0.21	0.09	118	4.97
Lb	co.01	149	0.34	co.01	102	1.92
	HVS3 vs PR	ave 3,4-D		HVS3 vs PR	ave 3,4-D	
	r^2= 0.29	102 ± 21		r^2= 0.98	96 ± 21	

* recovery of 3,4-D from analysis of PUF Roller sleeve

Table 10. Comparison of Air Exchange Rates and 2,4-D Deposition Coupon Levels, Yr 1

	Infiltration Rate	Air Exchange Rate	2,4-D Deposition, mg/m²* Coupon Placement with respect to Home			
Home	m^3/hr	L/hr	Coupon 1	Coupon 2	Coupon 3	average
BY	247	0.5	27.7	48.2	51.4	42.5
			NW	S	NE	
Rn	289	0.6	‘54.9	42.6	54.0	50.5
			SE	SW	N	
Zm	407	0.7	18.0	19.1	20.5	19.2
			W	S	E	
SC	249	0.6	53.3	72.9	40.2	55.5
			NW	SW	E	
Ad	300	0.6	4.7	4.3	18.8	9.2
			NW	SW	E	
Rr	254	0.6	8.2	11.0	72.6	30.6
			SE	W	NE	
Lb	127	0.3	40.1	251	183	158
			N	SW	SE	

* Desired application rate= 84 mg/m^2

Table 11. QA/QC Samples for Air Samples, Yrl

Medium	QA/QC Type	Amount of Analyte: Level or Recovery of 2,4-D Recovery of 3,4-D, %	Average: ng or % %	Equivalent Air Conc, ng/m^3
URG-filter	field blank	2,4-D, ng: 7.3, 4.3, 5.4, 7.7 3,4-D, %: 92, 95, 96, 93	6.1 ± 1.5 94 ± 2	1.1 (100 ng)*
	lab blank	2,4-D, ng: 4.7, 3.0, 0.9 3,4-D, %: 91, 110, 115	2.9 ± 1.9 105 ± 13	0.5 (100 ng)*
	solvent blank	2,4-D, ng: 0.0 3,4-D, %: 87	0.0 87	0.0 (100 ng)*
	field spike	2,4-D, %: 80, 74 3,4-D, %: 93, 94	77 ± 3 94 ± 1	17.4 (100 ng)*
	lab spike with storage	2,4-D, %: 85, 74, 77 3,4-D, %: 90, 74, NS	79 ± 6 82 ± 8	17.4 (100 ng)*
	solvent spike	2,4-D, %: 89 3,4-D, %: 75	89 75	17.4 (100 ng)*
URG-PUP	field blank	2,4-D: 13.4, 10.5, 13.9, 13.5 3,4-D: 97, 95, 103, 83	12.8 ±1.6 95 ± 8	2.2 (100 ng)*
	lab blank	2,4-D:9.5,30.6,8.9,10.4,10.3 3,4-D: 96, 93, 101, 97, 100	9.8 ± 0.7 97 ± 3	1.7 (100 ng)*
	solvent blank	2,4-D, ng: 13.8, 19.1, 12.7 3,4-D, %: 85, 80, 98	15.2 ±3.4 88 ± 9	2.6 (100 ng)*

* ng quantity of 3,4-D spiked; NS- not spiked

Table 11. QA/QC Samples for Air Samples, Yrl (Continued)

Medium	QA/QC Type	Amount of Analyte: Level or Recovery of 2,4-D Recovery of 3,4-D, %	Average: ng or % %	Equivalent Air Conc, ng/m^3
URG-PUP	field spike	2,4-D, %: 80 3,4-D, %: 52	80 52	17.4 (100 ng)*
	lab spike	2,4-D, %: 90, 92, 27 3,4-D, %: 93, 82, 101	91 ± 1 92 ± 10	17.4 (100 ng)*
	lab spike with storage	2,4-D, %: 85, 85, 85 3,4-D, %: 99, 100, 99	85 ± 0 99 ± 1	17.4 (100 ng)*
	solvent spike	2,4-D, %: 86, 99 3,4-D, %: NS, NS	93 ± 6 NS	17.4 (NS)*
CasImp-plate	field blank	2,4-D, ng: 8.66, 6.35, 5.15 3,4-D, %: 101, 99, 109	6.7 ± 1.8 103 ± 5	4.5 (100 ng)*
	lab blank	2,4-D, ng: 11.29, 9.16 3,4-D,%: 104, 98	10.2 ±1.0 101 ± 3	6.8 (100 ng)*
CasImp-filter	field blank	2,4-D, ng: 5.66 3,4-D,%: 103	5.7 103	3.8 (100 ng)*

Table 12. QA/QC Samples for Dust Samples (Floors/Sills/Tables), Yrl

QA/QC Type: Home-Application Period	Total 2,4-D measured, ng	3,4-D Recovery, % (100 ng spike)	Equivalent 2,4-D loading, $\mu g/m^2$
Wipe Field Blank			(table loading)
By: pre-appl	36.0	93	0.42
By: post-appl	21.5	78	0.25
Rn: pre-appl	24.9	109	0.29
Rn: post-appl	32.8	83	0.38
Zm: pre-appl	22.9	143	0.27
Zm: post-appl	21.3	93	0.25
Sc: pre-appl	36.0	93	0.42
Sc: post-appl	13.2	95	0.15
Ad: pre-appl	40.6	81	0.48
Ad: post-appl	20.5	113	0.24
Rr: pre-appl	12.1	134	0.14
Rr: post-appl	23.8	94	0.28
Lb: pre-appl	24.9	68	0.29
Lb: post-appl	19.4	88	0.23
average	25 ± 8.5	98 ± 21	0.29 ± 0.10
PUF Roller- blank	5.5	102	0.010 (floor loading)
Dust-solvent blank	9.7	79	0.005 (floor loading)
	12.9	NS	0.006 (floor loading)
	12.0	NS	0.006 (floor loading)
	19.0	157	0.010 (floor loading)
	8.7	NS	0.004 (floor loading)
	177	94	0.089 (floor loading)
	54	95	0.027 (floor loading)
average	19.4 ± 17.3	106 ± 35	0.010 ± 0.009

Table 12. QA/QC Samples for Dust Samples (Floors/Sills/Tables), Yrl (Continued)

QA/QC Type: Home-Application Period	2,4-D Recovery,% (100 ng spike)	3,4-D Recovery, % (100 ng spike)	Equivalent 2,4-D loading, $\mu g/m^2$
Wipe Field Spike			(table loading)
By: pre-appl	122	122	1.17
By: post-appl	111	87	1.17
Rn: pre-appl	43	99	1.17
Rn: post-appl	101	80	1.17
Zm: pre-appl	63	87	1.17
Zm: post-appl	103	73	1.17
SC: post-appl	74	47	1.17
Ad: pre-appl	140	76	1.17
Ad: post-appl	92	84	1.17
Rr: post-appl	88	73	1.17
Lb: post-appl	79	88	1.17
average	92 ± 27	83 ± 18	1.17
PUF Roller- spike	71	104	0.21 (floor)
Dust-solvent spike	113 (2 µg)	88 (0.5 µg)	1 .0 (floor)
	75 (0.5 µg)	78 (0.5 µg)	0.25 (floor) .
	88 (2 µg)	89 (0.5 µg)	1 .0 (floor)
	89 (2 µg)	93 (0.5 µg)	1 .0 (floor)
average	91 ± 16	87 ± 6	1 .0 (floor)

Table 13. Calibration Ranges Used by Media/Sample Type, Yrl

Air Samples (pre- and post-application)
URG Filter, URG PUF, Cascade Impactor

Solution Name	Concentration of Analyte in Standard Solution, μg/mL		
	2,4-D	3,4-D (SRS)	2,6-D (IS)
Air 100	0.100	0.100 (100% rec)	0.100
Air 50	0.050	0.075 (75% rec)	0.100
Air25	0.025	0.050 (50% rec)	0.100
Air 10	0.010	0.025 (25% rec)	0.100
Air0	0.000	0.000 (0% rec)	0.100

Wipe Samples (pre-application)
Table, Sill, Floor

Solution Name	Concentration of Analyte in Standard Solution, μg/mL		
	2,4-D	.3,4-D (SRS)	2,6-D (IS)
Wipe 100	0.100	0.100 (100% rec)	0.100
Wipe 50	0.050	0.050 (50% rec)	0.100
Wipe 25	0.025	'0.025 (25% rec)	0.100
Wipe 10	0.010	0.010 (10% rec)	0.100
Wipe 5	0.005	0.005 (5% rec)	0.100
Wipe 0	0.000	0.000 (0% rec)	0.100

Table 13. Calibration Ranges Used by Media/Sample Type, Yr1 (Continued)

Wipe Samples (post-application)
Table, Sill, Floor

Solution Name	Concentration of Analyte in Standard Solution, µg/mL		
	2,4-D	3,4-D (SRS)	2,6-D (IS)
Wipe 1000	1.000	0.100 (100% rec)	0.100
Wipe 500	0.500	0.050 (50% rec)	0.100
Wipe 200	0.200	0.020 (20% rec)	0.100
Wipe 100	0.100	0.010 (10% rec)	0.100
Wipe 50	0.050	0.050 (50% rec)	0.100
Wipe 20	0.020	0.020 (20% rec)	0.100
Wipe 10	0.010	0.010 (10% rec)	0.100
Wipe 0	0.000	0.000 (0% rec)	0.100

Floor Dust Samples (pre- and post-application)
HVS3-Collected Dust

Solution Name	Concentration of Analyte in Standard Solution, µg/mL		
	2,4-D	3,4-D (SRS)	2,6-D (IS)
Dust 2000	2.000	0.500 (100% rec)	0.500
Dust 1000	1.000	0.375 (75% rec)	0.500
Dust 500	0.500	0.250 (50% rec)	0.500
Dust 200	0.200	0.125 (25% rec)	0.500
Dust 100	0.100	0.500 (100% rec)	0.500
Dust 0	0.000	0.000 (0% rec)	0.500

Table 13. Calibration Ranges Used by Media/Sample Type, Yrl (Continued)

PUF Roller Samples (pre- and post-application)
Floor Dust Dislodgeable Residues

Solution Name	Concentration of Analyte in Standard Solution, µg/mL		
	2,4-D	3,4-D (SRS)	2,6-D (IS)
PUF 100	0.100	0.100 (100% rec)	0.100
PUF 50	0.050	0.075 (75% rec)	0.100
PUF 20	0.020	0.050 (50% rec)	0.100
PUF 10	0.010	0.025 (25% rec)	0.100
PUF 0	0.000	0.000 (0% rec)	0.100

Lawn Coupons Samples (post-application)
Application Deposition Coupons

Solution Name	Concentration of Analyte in Standard Solution, µg/mL		
	2,4-D	3,4-D (SRS)	2,6-D (IS)
coup 2000	2.000	not added	0.500
coup 1000	1.000	not added	0.500
coup 500	0.500	not added	0.500
coup 200	0.200	not added	0.500
coup 100	0.100	not added	0.500
Coup 0	0.000	not added	0.500

Table 14. Air Volumes Sampled, Yrl

	Total Air Volume Sampled in Particle Size Range, m^3			
Home: sample	<1 μm	<2.5 μm	<10 μm	TSP
By: pre-URG	6.01	5.85	5.56	5.78
post 1 -URG	5.80	5.83	5.74	5.81
post3-URG	5.85	SL	5.84	5.85
cascade impactor	1.50	1.50	1.50	1.50
Rn: pre-URG	5.69	5.70	5.67	5.55
postl-URG	5.42	5.42	5.66	5.50
post3-URG	5.75	5.73	5.78	5.78
cascade impactor	1.71	1.71	1.71	1.71
Zm: pre-URG	5.64	5.58	5.70	5.72
post1-URG	6.52	6.57	6.52	6.66
post3-URG	5.77	5.95	6.03	5.62
cascade impactor	2.93	2.93	2.93	2.93
Sc: pre-URG	5.78	5.84	5.82	5.73
post1-URG	6.15	6.01	SL	6.03
post3-URG	6.11	6.63	6.56	6.66
cascade impactor	1.50	1.50	1.50	1.50

Table 14. Air Volumes Sampled, Yrl (Continued)

	Total Air Volume Sampled by Particle Size Range, m^3			
Home: sample	<1 µm	<2.5 µm	<10 µm	TSP
Ad: pre-URG	6.30	6.45	6.47	6.26
post 1 -URG	5.96	6.09	6.12	7.27
post3-URG	5.75	5.88	5.80	5.38
cascade impactor	0.75	0.75	0.75	0.75
Rr: pre-URG	5.71	5.86	5.77	5.34
post 1 -URG	5.29	5.82	5.84	5.82
post3-URG	7.06	6.94	6.89	6.89
cascade impactor	1.66	1.66	1.66	1.66
Lb: pre-URG	5.82	5.82	5.82	5.82
post1-URG	5.47	5.59	5.64	5.53
post3-URG	5.58	5.58	5.72	5.78
cascade impactor	1.50	1.50	1.50	1.50

Table 15. Surface Areas Wiped or Vacuumed and Dust Quantity Collected, Yrl

Home	Floor Area Sampled, m^2			HVS3 Floor Dust, g		Sill Area, m^2	Table Area, m^2
Traffic Density/Room	HVS3	Wipe	PUF Roller	pre-appl	post-appl		
By: Entry	0.84			0.70	2.22		
Liv	2.0		0.48	1.7	5.59	0.142	0.0854
Din	1.68			1.19	2.71	(0.094)	0.0854
Kit*	1.0	0.2		--	--	0.054	0.0854
Bed	1.68			2.71	4.79	0.045	0.0854
Rn: Kit*	2.0	0.2		--	--	0.0497	0.0854
Entry*	1.58	0.2		6.87	4.07		
Din*	1.98	0.2		1.98	1.95	0.0697	0.0854
Liv	2.0		0.48	3.35	10.08	0.118	0.0854
Bed	1.76			5.15	4.37	0.059	0.0854
Zm: Entry	2.0			2.03	2.22		
Kit	2.0			2.01	1.23	0.0948	0.0854
Liv	2.0		0.48	0.98	0.95	0.2748	0.0854
Din	2.0			1.26	1.16	0.2250	0.0854
Bed	1.0			0.86	0.67	0.0929	0.0854
Sc: Din*	1.0	NT"		--	--	0.0939	0.0854
Kit*	2.0	NT		--	--	(0.1357)	0.0854
Entry	1.0			1.05	2.76		
Liv	2.0		0.48	4.64	4.02	0.1056	0.0854
Bed	1.98			2.05	1.87	0.1275	0.0854

Table 15. Surface Areas Wiped or Vacuumed and Dust Quantity Collected, Yrl (Continued)

Home	Floor Area Sampled, m^2			HVS3 Floor Dust, g		Sill Area, m^2	Table Area, m^2
Traffic Density/Room	HVs3	wipe	PUF Roller	pre-appl	post-appl		
Ad: Entry	1.6			3.10	1.33		
Liv	2.0		0.48	3.28	0.56	(0.1839)	0.0854
Kit	0.54			1.43	0.17	0.1161	0.0854
Din*	2.0*	0.2		2.17	--	0.2371	0.0854
Bed	2.0			1.81	0.02	0.0919	0.0854
Rr: Entry*	1.98	0.2		4.40	1.57		
Din*	1.5	0.2			--	0.1008	0.0854
Kit*	1.2	0.2			--	0.1008	0.0854
Liv	2.0		0.48	0.95	0.99	0.2015	0.0854
Bed	2.0			1.33	0.96	0.1234	0.0854
Lb: Entry*	1.4	NT			--		
Kit	(1.7)[b]			0.64	0.39	0.0429	(0.0854)
Liv	2.0		0.48	1.11	0.48	0.1974	0.0854
Din	(2.0)			1.04	0.93	(0.0206)	(0.0854)
Bed	2.0			1.21	0.77	0.0426	0.0854

* bare floor
a) NT= not tested
b) floor listed here is a surrogate room for the one indicated

Table 16. Comparison of Floor Dust Loading, 2,4-D Loading, and 2,4-D Dust Concentration, Yr1

Home		Home Location				
BY		**Entry**	**Liv**	**Din**	**Kit***	**Bed**
Pre	dust g/m^2	0.70	0.85	0.60	NM[a]	1.36
	2,4-D $\mu g/m^2$	0.54	0.64	0.39	0.03	1.07
	2,4-D $\mu g/g$	0.76	0.75	0.65	NM	0.79
Post	dust g/m^2	2.64	2.80	1.61	NM	2.85
	2,4-D $\mu g/m^2$	228	188	117	1.60	24.6
	2,4-D $\mu g/g$	86.2	67.3	72.3	NM	8.63
Rn		**Kit***	**Entry***	**Din***	**Liv**	**Bed**
Pre	dust g/m^2	NM	4.35	1.00	1.68	**2.93**
	2,4-D $\mu g/m^2$	0.08	5.74	0.30	0.48	2.22
	2,4-D $\mu g/g$	NM	1.32	0.30	0.29	0.76
Post	dust g/m^2	0.45	2.58	0.98	5.04	2.48
	2,4-D $\mu g/m^2$	0.71	3.13	1.65	70.0	26.6
	2,4-D $\mu g/g$	1.57	1.22	1.68	13.9	10.7

a) NM- not measured; dust quantitiy was not weighed as the amount was very small; dust was extracted directly in the collection bottle

Table 16. Comparison of Floor Dust Loading, 2,4-D Loading, and 2,4-D Dust Concentration, Yrl (Continued)

		Home Location				
Zm		**Entry**	**Kit**	**Liv**	**Din**	**Bed**
Pre	dust g/m^2	1.02	1.01	0.49	0.63	0.86
	2,4-D $\mu g/m^2$	1.17	1.06	0.35	0.44	0.19
	2,4-D $\mu g/g$	1.15	1.05	0.72	0.70	0.22
Post	dust g/m^2	1.11	0.62	0.48	0.58	0.67
	2,4-D $\mu g/m^2$	73.8	34.9	13.0	11.6	5.25
	2,4-D $\mu g/g$	66.5	56.7	27.5	20.0	7.84
SC		**Entry**	**Din***	**Kit***	**Liv**	**Bed**
Pre	dust g/m^2	1.05	NM	NM	2.32	1.04
	2,4-D $\mu g/m^2$	0.67	**0.09**	0.03	2.73	0.45
	2,4-D $\mu g/g$	0.64	NM	NM	1.17	0.43
Post	dust g/m^2	2.76	NM	NM	2.01	**0.94**
	2,4-D $\mu g/m^2$	17.4	0.66	0.25	12.7	4.51
	2,4-D $\mu g/g$	6.30	NM	NM	6.30	4.77

Table 16. Comparison of Floor Dust Loading, 2,4-D Loading, and 2,4-D Dust Concentration, Yrl (Continued)

		Home Location				
Ad		**Entry**	**Fam**	**Kit**	**Din***	**Bed**
Pre	dust g/m^2	1.94	1.64	2.65	1.09	0.91
	2,4-D μg/m^2	0.82	0.82	0.95	0.61	0.24
	2,4-D μg/g	1.20	1.34	0.76	1.08	1.03
Post	dust g/m^2	0.83	0.28	0.31	0.01	0.01
	2,4-D μg/m^2	3.06	1.39	1.39	0.02	0.10
	2,4-D μg/g	3.68	4.97	4.41	3.08	10.2
Rr		**Entry***	**Din***	**Kit***	**Liv**	**Bed**
Pre	dust g/m^2	2.44	NM	NM	0.48	0.67
	2,4-D μg/m^2	0.81	0.08	0.05	0.21	0.54
	2,4-D μg/g	0.33	NM	NM	0.45	0.82
Post	dust g/m^2	0.79	NM	NM	0.50	0.48
	2,4-D μg/m^2	1.47	0.59	0.26	4.97	3.63
	2,4-D μg/g	1.85	NM	NM	10.0	7.56

Table 16. Comparison of Floor Dust Loading, 2,4-D Loading, and 2,4-D Dust Concentration, Yrl (Continued)

		Home Location				
Lb		**Ent/Kit***	**Din**	**Liv**	**Bed**	**Fam**
Pre	dust g/m^2	NM	0.38	NM	0.61	NM
	2,4-D $\mu g/m^2$	0.07	0.28	0.34	0.62	0.23
	2,4-D $\mu g/g$	NM	0.75	NM	1.02	NM
Post	dust g/m^2	NM	0.23	0.24	0.39	0.47
	2,4-D $\mu g/m^2$	0.19	1.90	1.92	4.02	1.16
	2,4-D $\mu g/g$	NM	8.29	8.00	10.45	2.50

Table 17. Designation of Homes by Activity Patterns, Yr 1

	Activity Pattern Descriptor8			
	Child Activity	Shoes Worn Indoors	Pet Activity	Applicator Shoes Worn Indoors
BY	HiC	S	HiP	As
Rn	HiC	S	LOP	As
Zm	ModC	S	LOP	NAs
SC	LoC	S	LOP	NAs
Ad	LoC	S	LOP	NAs
Rr	HiC	NS	LOP	NAs
Lb	LoC	NS	LOP	NAs

a) activity descriptors

HiC- high child activity
ModC- moderate child activity
LoC- low child activity
S- family outdoor shoes worn indoors
NS- family outdoor shoes not worn indoors
HiP- high pet activity
LoP- low pet activity
As- applicator's shoes worn indoors
NAs- applicator's shoes not worn indoors

APPENDIX B

Table 1. Concentration of 2,4-D in Air During Application (Cascade Impactor), Yr2

	Concentration of 2,4-D by Particle Size, ng/m^3				Conc. by PM, ng/m^3	
Home	<1 μm	1-2 μm	2-8 μm	>8 μm	PM2.5*	PM10*
BY	0.00	1.39	4.99	4.83	1.39	6.38
Zm	0.00	3.21	8.88	0.31	3.21	12.09
Rr	0.00	0.00	1.58	4.10	0.00	1.58
Lb	0.00	0.00	1.13	0.94	0.00	1.13
Nc	0.00	0.00	0.84	1.23	0.00	0.84
KY	0.00	0.74	2.17	0.00	0.74	2.91
Average	0.00	0.89	3.27	1.90	0.89	4.16
Std Dev	0.00	1.27	3.13	2.05	1.27	4.39
Range	0-0	o-3.21	0.84-8.88	0-4.83	0-3.21	0.84-12.1

* PM2.5= sum of concentrations (<1 μm + 1-2 μm)

* PM1 0= sum of concentrations (<1 μm + 1-2 μm + 2-8 μm)

Table 2. Concentration of 2,4-D in Air on Day 1 and Day 3 (URG Sampler), Yr2

	Concentration of 2,4-D by Particle Size, ng/m³				Conc. by PM, ng/m³	
Home	<1 µm	<2.5 µm	<10 µm	TSP	PM2.5	PM10
By- day 1	1.90	2.17	2.13	4.21	2.17	2.13
By- day 3	2.78	**2.47*[a]**	SL **(2.47)[b]**	6.81	2.47	**(2.47)[b]**
Zm- day 1	1.22	**1.20***	1.88	2.28	1.20	1.88
Zm- day 3	1.58	**1.26***	2.31	2.62	1.26	2.31
Rr- day 1	2.73	2.91	3.12	3.05	2.91	3.12
Rr- day 3	1.09	**SL** (1.09)	1.84	2.32	(1.09)	1.84
Lb- day 1	1.37	1.51	1.53	1.42	1.51	1.53
Lb- day 3	1.89	2.20	2.59	3.45	2.20	2.59
NC- day 1	0.33	**SL** (0.33)	0.92	0.51	(0.33)	0.92
NC- day 3	0.77	1.14	1.42	1.61	1.14	1.42
Ky- day 1	0.00	0.16	0.12	0.30	0.16	0.12
Ky- day 3	0.22	**0.03*** (0.22)	0.23	0.16	(0.22)	0.23
Average-day1	1.26± 1.00	1.38±1.06	1.62±1.03	1.96±1.52	1.38±1.06	1.62±1.03
Average-day3	1.39± 0.90	1.37±0.88	1.81±0.89	2.83±2.24	1.37±0.88	1.81±0.89
Range-day 1	0-2.73	0.16-2.91	0.12-3.12	0.30-4.21	0.16-2.91	0.12-3.12
Range-day 3	0.22-2.78	0.03-2.47	0.23-2.59	0.16-6.81	0.03-2.47	0.23-2.59

a) 2,4-D concentration in 2.5 µm fraction is less than the concentration in the 1 .O µm fraction; cause unknown
b) pump failure occurred at this particle size; data from the next smaller particle size used instead

Table 3. Concentration of 2,4-D in Air by Particle Size Range (URG Sampler), Yr2

	Conc of 2,4-D by Particle Size Range, ng/m^3				Conc. by PM, ng/m^3	
Home	<1 μm	1-2.5 μm	2.5-10 μm	>10 μm	PM2.5	PM10
By- day 1	1.90	0.27	0.00	2.08	2.17	2.13
By- day 3	2.78	0.00	SL (0)[a]	(4.34)	2.47	(2.47)”
Zm- day 1	1.22	0.00	0.68	0.40	1.20	1.88
Zm- day 3	1.58	0.00	1.05	0.31	1.26	2.31
Rr- day 1	2.73	0.17	0.21	0.00	2.91	3.12
Rr- day 3	1.09	SL	(0.75)	0.48	(1.09)	1.84
Lb- day 1	1.37	0.14	0.03	0.00	1.51	1.53
Lb- day 3	1.89	0.31	0.39	0.86	2.20	2.59
Nc-.day 1	0.33	SL (0)	(0.59)	0.00	(0.33)	0.92
NC- day 3	0.77	. 0.37	0.28	0.01	1.14	1.42
Ky- day 1	0.00	0.17	0.00	0.18	0.16	0.12
Ky- day 3	0.22	0.00	0.01	0.00	0.22	0.23
Average-day 1	**1.26±1.00**	0.13±0.11	0.25±0.31	**0.44±0.82**	**1.38±1.06**	**1.62±1.03**
Average-day3	**1.39±0.90**	**0.14±0.19**	**0.41±0.41**	**1.03±1.65**	1.4M0.82	1.81zk0.89
Range- day 1	0.00-2.73	0.00-0.17	0.00-0.68	0.00-2.08	0.16-2.91	0.12-3.12
Range- day 3	0.22-2.78	0.00-0.3 1	0.19-1.05	0.00-4.34	0.03-2.47	0.23-2.59

a) see footnotes a) and b) of Table A-2

Table 4. Recovery of 3,4-D in Air Samples, Yr2

Time/home	Recovery of 3,4-D in Particle Size Sample, %				average
Application	<1 μm	1-2 μm	2-8 μm	>8 μm	
BY	115	83	62	67	
Zm	78	60	65	67	
Rr	60	94	67	62	
Lb	113	103	96	102	
Nc	72	64	61	57	
KY	102	94	80	102	80 ± 19
URG-day 1	<1 μm	<2.5 μm	<10 μm	TSP	
BY	99	89	103	97	
Zm	87	94	95	98	
Rr	63	86	82	89	
Lb	87	85	94	97	
Nc	73	73	77	79	
KY	86'	83	8 7	86	87 ± 9
URG-day. 3	<1 μm	<2.5 μm	<10 μm	TSP	
BY	77	69	75	77	
Zm	74	85	83	85	
Rr	89	78	90	87	
Lb	87	85	94	97	
Nc	84	79	81	83	
KY	87	86	88	87	84 ± 6

Table 5. Surface Loading of 2,4-D on Sills and Tables, Yr2

Home	Time	Surface Loading of 2,4-D on Sill or Table, µg/m²				recovery
By-Sill		**Liv**	**Kit**	**Bed-side**	**Bed-back**	3,4-D
	pre-2,4-D	nd	nd	**NS**	nd	
	3,4-D, %	88	92	**NS**	91	
	post-2,4-D	8.23	4.20	**NS**	2.64	
	3,4-D, %	60	77	**NS**	68	
By-Table		**Liv**	**Kit**	**Din**	**Bed**	
	pre-2,4-D	nd	nd	**NS**	nd	
	3,4-D, %	88	105	**NS**	101	
	post-2,4-D	10.2	8.17	**NS**	3.24	
	3,4-D, %	80	71	**NS**	75	83 ± 14
Zm-Sill		**Kit**	**Liv**	**Din**	**Bed**	
	pre-2,4-D	1.77	0.46	**NS**	1.41	
	3,4-D, %	69	71	**NS**	69	
	post-2,4-D	1.81	1.23	**NS**	1.58	
	3,4-D, %	82	76	**NS**	79	
Zm-Table		**Kit**	**Liv**	**Din**	**Bed**	
	pre-2,4-D	nd	nd	**NS**	nd	
	3,4-D, %	98	92	**NS**	84	
	post-2,4-D	2.39	2.54	**NS**	1.93	
	3,4-D, %	77	78	**NS**	73	**79 ± 9**

Table 5. Surface Loading of 2,4-D on Sills and Tables, Yr2 (Continued)

Home	Time	Surface Loading of 2,4-D on Sill or Table, μg/m²				recovery
Rr-Sill		**Kit**	**Din**	**Liv**	**Bed**	3,4-D
	pre-2,4-D	nd	**NS**	nd	nd	
	3,4-D, %	80	**NS**	88	79	
	post-2,4-D	3.90	**NS**	0.51	0.76	
	3,4-D, %	98	**NS**	77	82	
Rr-Table		**Kit**	**Din**	**Liv**	**Bed**	
	pre-2,4-D	nd	**NS**	nd	nd	
	3,4-D, %	83	**NS**	83	89	
	post-2,4-D	2.69	**NS**	4.77	0.80	
	3,4-D, %	75	**NS**	84	75	83 ± 7
Lb-Sill		**Din**	**Liv**	**Kit**	**Bed**	
	pre-2,4-D	nd	nd	NS	nd	
	3,4-D, %	101	103	NS	97	
	post-2,4-D	5.66	1.51	NS	0.45	
	3,4-D, %	79	81	NS	71	
Lb-Table		**Kit**	**Liv**	**Din**	**Bed**	
	pre-2,4-D	nd	nd	**NS**	nd	
	3,4-D, %	119	113	**NS**	111	
	post-2,4-D	1.31	1.32	**NS**	0.89	
	3,4-D, %	94	110	**NS**	70	**96** ± 17

Table 5. Surface Loading of 2,4-D on Sills and Tables, Yr2 (Continued)

Home	Time	Surface Loading of 2,4-D on Sill or Table, μg/m²				recovery
Nc-Sill		**Liv**	**Kit**	**Din**	**Bed**	3,4-D
	pre-2,4-D	**NS**	nd	**NS**	NS	
	3,4-D, %	**NS**	111	**NS**	NS	
	post-2,4-D	0.02	0.15	**NS**	nd	
	3,4-D, %	88	86	**NS**	103	
NC-Table		**Liv**	**Kit**	**Din**	**Bed**	
	pre-2,4-D	**NS**	NS	**NS**	**NS**	
	3,4-D, %	**NS**	NS	**NS**	**NS**	
	post-2,4-D	**0.44**	0.77	**NS**	nd	
	3,4-D, %	**96**	99	**NS**	89	**96 ± 9**
Ky-Sill		**Liv**	**Kit**	**Din**	**Bed**	
	pre-2,4-D	nd	NS	**NS**	**NS**	
	3,4-D, %	84	NS	**NS**	**NS**	
	post-2,4-D	nd	nd	**NS**	nd	
	3,4-D, %	78	73	**'NS**	75	
Ky-Table		**Liv**	**Kit**	**Din**	**Bed**	
	pre-2,4-D	**NS**	NS	**NS**	**NS**	
	3,4-D, %	**NS**	NS	**NS**	**NS**	
	post-2,4-D	nd	nd	**NS**	nd	
	3,4-D, %	69	71		68	**74 ± 6**

Table 6. Surface Loading by Traffic Pattern of 2,4-D and Dicamba in Floor Dust with HVS3 Collection from Carpets and Surface Wipe of Bare Floors, Yr2

Home (type)	Surface Loading; of Analyte in Dust, $\mu g/m^2$					recovery
BY	**Entry**	**Liv**	**Din**	**Kit***	**Bed**	3,4-D
pre-dicamba	0.18	0.30	NS	nd	0.33	
pre-2,4-D	3.16	4.92	NS	nd	4.29	
3,4-D rec, %	**80**	82	NS	73	83	
post-dicamba	**4.49**	4.02	NS	1.04	2.34	
post-2,4-D	**75.9**	42.5	NS	7.85	31.9	
3,4-D rec, %	**88**	95	NS	76	73	81 ± 8
Zm	**Entry**	**Kit**	**Liv**	**Din**	**Bed**	
pre-dicamba	0.01	nd	0.01	NS	0.02	
pre-2,4-D	0.43	0.19	0.17	NS	0.22	
3,4-D rec, %	83	79	72	NS	78	
post-dicamba	1.74	0.42	0.36	NS	0.24	
post-2,4-D	23.8	8.72	5.63	NS	5.21	
3,4-D rec, %	85	73	92	NS	103	83 ± 10
Rr	**Entry***	**Din***	**Kit***	**Liv**	**Bed**	
pre-dicamba	0.05	NS	0.05	0.02	0.14	
pre-2,4-D	0.68	NS	0.68	0.54	2.65	
3,4-D rec, %	88	NS	77	122	94	
post-dicamba	0.23	NS	0.15	1.05	0.30	
post-2,4-D	2.64	NS	1.41	20.1	5.01	
3,4-D rec, %	67	NS	65	85	93	86 ± 18

Table 6. Surface Loading by Traffic Pattern of 2,4-D and Dicamba in Floor Dust with HVS3 Collection from Carpets and Surface Wipe of Bare Floors, Yr2 (Continued)

Home	Surface Loading of Analyte in Dust, µg/m²					recovery
Lb	**Ent/Kit***	**Din**	**Liv**	**Fam**	**Bed**	3,4-D
pre-dicamba	nd	0.05	0.03	**NS**	0.06	
pre-2,4-D	nd	1.02	0.65	**NS**	1.04	
3,4-D **rec, %**	78	97	94	**NS**	91	
post-dicamba	0.14	0.36	0.24	**NS**	0.36	
post-2,4-D	2.22	6.50	4.62	**NS**	4.40	
3,4-D **rec, %**	65	89	99	**NS**	92	88 ± 11
Nc (unoccupied)	**Entry***	**Liv**	**Kit***	**Din**	**Bed**	
pre-dicamba	'nd	0.02	nd	**NS**	**NS**	
pre-2,4-D	nd	0.25	nd	**NS**	**NS**	
3,4-D **rec, %**	84	115	92	**NS**	**NS**	
post-dicamba	0.06	0.20	nd	**NS**	0.08	
post-2,4-D	0.98	1.90	0.76	**NS**	0.81	
3,4-D **rec, %**	8 1	106	79	**NS**	115	96 ± 16
Ky (unoccupied)	**Entry***	**Liv**	**Kit***	**Din***	**Bed**	
pre-dicamba	nd	nd	NS	**NS**	**NS**	
pre-2,4-D	nd	0.24	NS	**NS**	**NS**	
3,4-D **rec, %**	78	74	NS	**NS**	**NS**	
post-dicamba	0.11	0.04	nd	**NS**	nd	
post-2,4-D	1.02	0.54	nd	**NS**	0.05	
3,4-D **rec, %**	86	95	78	**NS**	90	84 ± 8

Table 7. Surface Loading by Traffic Pattern: 2,4-D on Bare Floors by Wipe, Yr2

Home/ Time	Surface Loading of Analyte in Dust, $\mu g/m^2$					recovery
BY	**Entry**	**Liv**	**Din**	**Kit***	**Bed**	3,4-D
pre-2,4-D				nd		
3,4-D, %				73		
post-2,4-D				7.85		
3,4-D, %				76		75 ± 2
Rr	**Entry***	**Din***	**Kit***	**Liv**	**Bed**	
pre-2,4-D	0.68	**NS**	0.68			
3,4-D, %	88	NS	77			
post-2,4-D	2.64	NS	1.41			
3,4-D, %	67	NS	65			74 ± 11
Lb	**Ent/Kit***	**Din**	**Liv**	**Bed**	**Fam**	
pre-2,4-D	nd					
3,4-D, %	78					
post-2,4-D	2.22					
3,4-D, %	65					72 ± 6
Nc (unoccupied)	**Entry***	**Liv**	**Kit***	**Din**	**Bed**	
pre-2,4-D	nd		nd			
3,4-D, %	84		92			
post-2,4-D	0.98		0.76			
3,4-D, %	81		79			84 ± 6
Ky (unoccupied)	**Entry***	**Liv**	**Kit***	**Din***	**Bed**	
pre-2,4-D	nd		**NS**	**NS**		
3,4-D, %	78		**NS**	**NS**		
post-2,4-D	1.02		nd	**NS**		
3.,4-D, %	86		78	**NS**		81 ± 5

Table 8. Comparison of Surface Loading of 2,4-D from Collection by PUF Roller and HVS3 on Living Room Carpet, Yr2

	Surface Loading of 2,4-D by PUF Roller and HVS3 Collection, µg/m²					
	Pre-Application Sampling			Post-Application Sampling		
Home	PUF Roller	3,4-D,%*	HVS3	PUF Roller	3,4-D,%*	HVS3
BY	0.22	55	4.92	0.77	69	42.5
Zm	ND"	67	0.17	0.02	98	5.63
Rr	ND	70	0.54	0.19	72	20.1
Lb	ND	46	0.65	0.05	72	4.62
Nc	NS[b]	NS	0.25	0.23	71	1.90
Ky	NS	NS	0.24	0.18	63	0.54
	HVS3 vs PR	ave 3,4-D		HVS3 vs PR	ave 3,4-D	
	r^2= NT	60 ± 11		r^2= 0.96	74 ± 12	

* recovery of 3,4-D from analysis of PUF Roller sleeve
a) ND= not detected
b) NS= not sampled

Table 9. Comparison of Air Exchange Rates and 2,4-D Deposition Coupon Levels, Yr 2

Home	Infiltration Rate m^3/hr	Air Exchange Rate L/hr	2,4-D Deposition, mg/m^2* Coupon Placement with respect to Home: Coupon 1	Coupon 2	Coupon 3	average
BY	117	0.25	48.7	41.8	46.8	45.8
			S	NW	NE	
Zm	831	1.43	40.0	66.9	59.9	55.6
			W	E	S	
Rr	78	0.19	55.4	57.2	21.5	44.7
			SW	SE	NE	
Lb	177	0.43	45.3	46.8	38.4	43.5
			S	N	W	
Nc	203	0.17	38.4	41.9	64.3	48.2
			W	E	SE	
KY	70	0.10	50.8	43.5	50.8	48.3
			SW	SE	NE	

* Desired application rate= 84 mg/m^2

Table 10. QA/QC Samples for Air Samples, Yr2

Medium	QA/QC Type	Amount of Analyte: Level or Recovery of 2,4-D Recovery of 3,4-D, %	Average: ng or % %	Equivalent Air Conc, ng/m^3
URG-filter	field blank (pre)	2,4-D, ng: 3.6, 5.4, 0.3, 0.0, 3,4-D, %: 92, 96, 80, 78	listed below	
	field blank (post)	2,4-D, ng: 2.7, 0.0, 0.3, 0.0 3,4-D, %: 93, 81, 82, 82	1.5 ± 2.1 86 ± 7	0.3 (50 ng)*
	lab blank	2,4-D, ng: 0.0, 11.3 3,4-D, %: 76, 83	5.7 ± 5.7 80 ± 3	1.0 (50 ng)*
	lab spike w storage	2,4-D, %: 102, 89 3,4-D, %: 87, 85	96 ± 7 86 ± 1	8.7 (50 ng)*
	lab spike	2,4-D, %: 111, 79 3,4-D, %: 92, 92	95 ± 16 92 ± 0	8.7 (50 ng)*
	solvent spike	2,4-D, %: 76 3,4-D, %: 85	76 85	8.7 (50 ng)*
URG-PUF	field blank (pre)	2,4-D, ng:6.1, 4.2, 13.6, 8.3 3,4-D, %: 77, 64, 95, 62	listed below	
	field blank (post)	2,4-D,ng:10.5, 8.8, 13.7, 26.3 3,4-D, %: 89, 65, 88, 125	11.4±6.9 83 ± 21	2.0 (50 ng)*
	lab spike	2,4-D,%: 67, 71, 57, 90 3,4-D,%: 72, 61, 56, 75	71 ± 14 66 ± 9	8.7 (50 ng)*

* ng quantity of 3,4-D spiked

Table 10. QA/QC Samples for Air Samples, Yr2 (Continued)

Medium	QA/QC Type	Amount of Analyte: Level or Recovery of 2,4-D Recovery of 3,4-D, %	Average: ng or % %	Equivalent Air Conc, ng/m^3
Cascade Impactor-plate	field blank	2,4-D, ng: 2.2, 2.2, 2.3 3,4-D, %: 94, 72, 101	2.2 ± 0.1 89 ± 15	1.5 (50 ng)*
	lab blank	2,4-D, ng:15.6, 18.4, 16.2 3,4-D,%: NS, NS, NS	16.7±1.5 NS	11.1 NS
	lab spike	2,4-D, %: 62 3,4-D,%: 57	62 57	33.3 (50 ng)*
Cascade Inpactor-filter	field blank	2,4-D, ng: 7.8 3,4-D, %: 112	7.8 112	5.2 (50 ng)*
	lab spike	2,4-D, %: 59 3,4-D, %: 52	59 52	33.3 (50 ng)*

Table 11. QA/QC Samples for Dust Samples (Floors/Sills/Tables), Yr2

QA/QC Type: Home-Application Period	Total 2,4-D measured, ng	3,4-D Recovery, % (250 ng spike)	Equivalent 2,4-D loading, µg/m²
Wipe Field Blank			(table loading)
By: pre-appl	159	89	1.86
By: post-appl	96	78	1.12
Zm: pre-appl	63	78	0.74
Zm: post-appl	26	79	0.30
Rr: pre-appl	47	80	0.55
Rr: post-appl	49	104	0.57
Lb: pre-appl	179	109	2.10
Lb: post-appl	50	104	0.59
NC: pre-appl	48	92	0.56
NC: post-appl	38	108	0.44
Ky: pre-appl	154	94	1.80
Ky: post-appl	166	74	1.94
lab blank	148	7 7	1.73
lab spike	79	7 2	1.17
PUF Roller			
field blank	259,292	59%, 79%	0.54, 0.61
lab blank	229,311	73%, 90%	0.48, 0.65
Dust-solvent blank	0.0	NS	0.000 (floor loading)
	0.0	122	0.000 (floor loading)

Table 11. QA/QC Samples for Dust Samples (Floors/Sills/Tables), Yr2 (Continued)

QA/QC Type: Home-Application Period	2,4-D Recovery,% (100 ng spike)	3,4-D Recovery, % (250 ng spike)	Equivalent 2,4-D loading, $\mu g/m^2$
Wipe Field Spike			(table loading)
By: pre-appl	102	93	1.17
By: post-appl'	160	73	1.17
Zm: pre-appl	99	74	1.17
Zm: post-appl	140	84	1.17
Rr: pre-appl	117	86	1.17
Rr: post-appl	172	104	1.17
Lb: pre-appl	110	109	1.17
Lb: post-appl	173	84	1.17
NC: pre-appl	115	96	1.17
NC: post-appl	130	83	1.17
Ky: pre-appl	NT	NT	1.17
Ky: post-appl	137	79	1.17
lab spike	79	72	1.17
PUF Roller			
lab spike	83%, 59%	86%, 83%	1.04

Table 12. Surface Areas Wiped or Vacuumed and Dust Quantity Collected, Yr2

Home	Floor Area Sampled, m^2			HVS3 Floor Dust, g		Sill Area, m^2	Table Area, m^2
Traffic Density/Room	HVS3	Wipe	PUF Roller	pre-appl	post-appl		
By: Entry	1.0			1.39	1.59		
Liv	2.24		0.48	1.68	5.12	0.142	0.0854
Din	NS"			NS	NS	NS	NS
Kit*	NS	0.2		--	--	0.054	0.0854
Bed	2.0			1.40	5.02	0.094	0.0854
Zm: Entry	2.0			1.75	2.40		
Kit	2.0			0.16	0.95	0.0948	0.0854
Liv	2.0		0.48	0.34	0.71	0.2748	0.0854
Din	NS			NS	NS	NS	NS
Bed	2.0			0.62	1.13	0.0929	0.0854
Rr: Entry*	NS	'0.2			--		
Din*	NS	NS		NS	NS	NS	NS
Kit*	NS	0.2		--	--	0.1008	0.0854
Liv	2.0		0.48	1.99	4.96	0.2015	0.0854
Bed	21.75			0.42	0.96	0.1234	0.0854
Lb: Entry*	NS	0.2		--	--		
Din	1.6			0.51	0.99	0.0429	0.0854
Liv	2.0		0.48	0.58	1.28	0.1974	0.0854
Kit	NS			NS	NS	NS	NS
Bed	2.0			0.59	0.95	0.0426	0.0854

Table 12. Surface Areas Wiped or Vacuumed and Dust Quantity Collected, Yr2 (Continued)

Home	Floor Area Sampled, m^2			HVS3 Floor Dust, g		Sill Area, m^2	Table Area, m^2
Traffic Density/Room	HVS3	wipe	PUF Roller	pre-appl	post-appl		
NC: Entry*	NS	0.2		--	--		
Liv	2.0		0.48	0.94	1.12		0.0854
Kit*	NS	0	2	--	--		0.0854
Din*	NS	NS		NS	NS	NS	NS
Bed	2.0			NS	1.03		0.0854
Ky: Entry*	NS	0.2		--	--		
Liv	2.0		0.48	0.22	0.23	0.0519	0.0854
Kit*	NS	0.2		NS	--	0.0519	0.0854
Din*	NS	NS		NS	NS	NS	NS
Bed	2.0			NS	0.12	0.0519	0.0854

* bare floor
a) NS= not sampled

Table 13. Comparison of Floor Dust Loading, 2,4-D Loading and 2,4-D Dust Concentration, Yr2

		Home Location				
BY		**Entry**	**Liv**	**Din**	**Kit**	**Bed**
Pre	dust, g/m^2	0.70	0.83	**NS**	wipe	0.89
	2,4-D μg/m^2	3.16	4.92	**NS**	wipe	4.29
	2,4-Dμg/g	4.54	5.92	**NS**	wipe	4.84
Post	dust, g/m^2	1.59	2.29	**NS**	wipe	2.51
	2,4-D μg/m^2	75.9	42.5	**NS**	wipe	31.9
	2,4-Dμg/g	47.7	18.6	**NS**	wipe	12.7
Zm		**Entry**	**Kit**	**Liv**	**Din**	**Bed**
Pre	dust, g/m^2	0.88	0.11	0.16	**NS**	0.34
	2,4-D μg/m^2	0.43	0.19	0.17	**NS**	0.22
	2,4-Dμg/g	0.49	1.65	1.03	**NS**	0.63
Post	dust, g/m^2	1.20	0.48	0.36	**NS**	0.57
	2,4-D μg/m^2	23.8	8.72	5.63	**NS**	5.21
	2,4-Dμg/g	19.9	18.4	15.9	**NS**	9.22
Rr		**Entry**	**Din**	**Kit**	**Liv**	**Bed**
Pre	dust, g/m^2	wipe	**NS**	wipe	1.11	0.28
	2,4-D μg/m^2	wipe	**NS**	wipe	0.54	2.65
	2,4-Dμg/g	wipe	**NS**	wipe	0.49	9.45
Post	dust, g/m^2	wipe	**NS**	wipe	2.48	0.55
	2,4-D μg/m^2	wipe	**NS**	wipe	20.1	5.01
	2,4-Dμg/g	wipe	**NS**	wipe	8.11	9.13

Table 13. Comparison of Floor Dust Loading, 2,4-D Loading and 2,4-D Dust Concentration, Yr 2 (Continued)

		Home Location				
Lb		**Ent/Kit**	**Din**	**Liv**	**Bed**	**Fam**
Pre	dust, g/m^2	wipe	0.35	0.33	0.41	**NS**
	2,4-D $\mu g/m^2$	wipe	1.02	0.65	1.04	**NS**
	2,4-Dμg/g	wipe	2.89	1.96	2.54	**NS**
Post	dust, g/m^2	wipe	0.62	0.64	0.48	**NS**
	2,4-D $\mu g/m^2$	wipe	6.50	4.62	4.40	**NS**
	2,4-Dμg/g	wipe	10.5	7.22	9.26	**NS**
Nc		**Entry**	**Liv**	**Kit**	**Din**	**Bed**
Pre	dust, g/m^2	wipe	**.47**	wipe	**NS**	**NS**
	2,4-D $\mu g/m^2$	wipe	0.25	wipe	**NS**	**NS**
	2,4-Dμg/g	wipe	0.53	wipe	**NS**	**NS**
Post	dust, g/m^2	wipe	0.56	wipe	**NS**	0.52
	2,4-D $\mu g/m^2$	wipe	1.90	wipe	**NS**	0.81
	2,4-Dμg/g	**wipe**	3.40	wipe	**NS**	1.57
KY		**Entry**	**Liv**	**Kit**	**Din**	**Bed**
Pre	dust, g/m^2	wipe	0.11	NS	**NS**	**NS**
	2,4-D $\mu g/m^2$	wipe	0.24	NS	**NS**	**NS**
	2,4-Dμg/g	wipe	2.18	NS	**NS**	**NS**
Post	dust, g/m^2	wipe	0.12	wipe	**NS**	0.06
	2,4-D $\mu g/m^2$	wipe	0.54	wipe	**NS**	0.05
	2,4-Dμg/g	wipe	4.66	wipe	**NS**	0.90

Table 14. Designation of Homes by Activity Patterns, Yr 2

	Activity Pattern			
	Child Activity	Shoes Worn Indoors	Pet Activity	Applicator Shoes Worn Indoors
BY	Hi C	S	Lo P(~)[a]	NAS
Zm	Mod C	S	Lo P	NAS
Rr	Hi C	NS(~)[b]	LOP	NAS
Lb	Lo c	NS(~)[b]	LOP	NAS
Nc (unoccupied)	Lo c	NS	LOP	NAS
Ky (unoccupied)	Lo C	NS	Lo P	NAS

a) dog was kept under greater control after application

b) removal of shoes at the door was not enforced as stringently as in the first year study

Table 15. Air Volumes Sampled, Yr2

	Total Air Volume Sampled in Particle Size Range, m^3			
Home: sample	<1 µm	<2.5 µm	<10 µm	TSP
By: pre-URG	5.64	5.57	5.60	5.67
post1-URG	5.59	5.63	5.50	5.56
post3-URG	5.80	5.85	stopped	5.73
cascade impactor	0.73	0.73	0.73	0.73
Zm: pre-URG	5.86	3.96	5.77	5.52
post 1 -URG	5.61	5.70	5.55	5.68
post3-URG	6.01	5.98	6.10	6.09
cascade impactor	0.78	0.78	0.78	0.78
Rr: pre-URG	5.56	5.98	5.66	5.26
post1-URG	5.79	5.92	5.96	6.04
post3-URG	5.84	stopped	6.01	5.98
cascade impactor	0.81	0.81	0.81	0.81
Lb: pre-URG	5.71	5.36	5.53	5.58
post 1 -URG	5.70	5.30	5.57	5.87
post3-URG	5.83	5.70	5.86	5.83
cascade impactor	1.0	1.0	1.0	1.0

Table 15. Air Volumes Sampled, Yr2 (Continued)

	Total Air Volume Sampled by Particle Size Range, m^3			
Home: sample	<1 µm	<2.5 µm	<10 µm	TSP
Nc: pre-URG	NS	NS	NS	NS
post1-URG	6.08	stopped	5.97	5.51
post3-URG	5.54	5.68	5.75	5.90
cascade impactor	0.94	0.94	0.94	0.94
Ky: pre-URG	NS	NS	NS	NS
post 1 -URG	5.84	5.92	5.68	5.81
post3-URG	6.13	6.17	6.36	5.47
cascade imuactor	0.75	0.75	0.75	0.75

APPENDIX C

Table 1. 2,4-D in Air by Particle Size, Application 2h Samples, Yr3

Indoor Concentration of 2,4-D during Application, ng/m^3				
Home	<1 μm	1-2 μm	2-8 μm	8-20 μm
BY	nd, <3[a]	nd	nd	nd
Zm	3.3	3.3	15.3	8.7
c s	nd	nd	nd	nd
Rr	nd	nd	nd	nd

a) nd= not detected, less than detection limit given

Table 2. 2,4-D in Air by Particle Size, Post-Application 24h Samples, Yr3

Indoor Concentration of 2,4-D Post Application, ng/m^3					
Home	Day	TSP	<10 µm	<2.5 µm	<1 µm
BY	Day 1	4.78	2.43	0.67	2.42
	Day 3	3.80	5.06	1.03	0.88
Zm	Day 1	6.40	3.54	1.42	2.13
	Day.3	0.89	0.65	0.24	0.18
Cs	Day 1	0.39	SL[a]	0.15	0.37
	Day 3	1.22	0.88	0.56	1.10
Rr	Day 1	0.22	0.07	SL	ND
	Day 3	ND, <0.1[b]	ND	ND	ND

a) SL= sample lost from pump failure

b) ND= not detected, less than detection limit given

Table 3. Surface Loading of 2,4-D on Living Room Table and Floor, Yr3

Home	Surface	Surface Loading of 2,4-D, $\mu g/m^2$ Pre-Appl.	Post-Appl. Day 1	Post-Appl. Day 3	Post-Appl. Day 7
BY	Table-incremental'“'	0.05	0.18	0.94	1.97
	Floor-incremental (m)[b]	0.60	6.14	7.38	3.65
	Table-cumulative (m)[c]	-	0.18	1.12	3.09
	Floor-cumulative[d]	-	6.14	13.52	17.17
Zm	Table-incremental	0.03	0.21	0.54	0.84
	Floor-incremental	0.04	0.63	2.43	1.06
	Table-cumulative	-	0.21	0.75	1.59
	Floor-cumulative	-	0.63	3.06	4.12
Rr	Table-incremental	0.01	co.01	0.07	0.05
	Floor-incremental	0.10	1.55	0.75	0.20
	Table-cumulative	-	co.01	0.07	0.12
	Floor-cumulative	-	1.55	2.30	2.50
c s	Table-incremental	0.01	co.01	0.05	0.07
	Floor-incremental	0.03	0.33	0.88	1.23
	Table-cumulative	-	co.01	0.05	0.12
	Floor-cumulative	-	0.33	1.21	2.44

(a) Incremental addition of 2,4-D that is added in each interval: Application to end of Day 1; Day 1 to Day 3; Day 3 to Day 7.
(b) Same as (a); measurement (m) is made on floors as incremental additions.
(c) Summed additions; measurement (m) on tables taken as cumulative loadings.
(d) Summed loadings incremental additions.

Table 4. Personal Exposure Data: Handwipes, Yr3

Total 2,4-D on Hands, ng

Home	Subject	Pre-Appl.	Post-Appl. Day 1	Post-Appl. Day 3	Post-Appl. Day 7
BY	adult	26	56,900”	378	51
	child	100	10[b]	95	1060
Zm	adult	1740”	28,300	864	179
	child	17	92	8	53
Cs	adult	nd[d]	29”	40	25
	child	nd	nd[f]	68	nd
Rr	adult	24	927	600	52
	child	46	41	nd	22

a) Application made just before dinner; applicator finished job and then wiped hands for sample

b) Child not at home during application (at swim practice); came in and wiped hands for sample

c) Residual level from application made 3 weeks earlier (washed out by heavy rains within 12 hours of application, so reapplied)

d) By the looks of the lawn, no 2,4-D had been applied for 1-2 years

e) Applicator wore gloves during application

f) Child not at home during application

Table 5. Personal Exposure Data: Urine, Yr3

		Total 2,4-D Excreted in First Morning Void, ng				
Home	Subject	Pre-Appl.	Post-Appl. Day 2	Post-Appl. Day 3	Post-Appl. Day 4	Post-Appl. Day 8
BY	adult	1097	1116	1568	1220	655
	child	107"	78	597	503	198
Zm	adult	116"	419	220	405	65
	child	625(?)[a,b]	190	175	714	288
Cs	adult	1875(?)[a,b]	199	159	615	237
	child	109"	405	876	316	nd
Rr	adult	2122(?)[a,b]	1208	836	300	560
	child	97"				

a) Analysis using GC/ECD rather than GC/MS

b) ? - suspect value; not repeated with GC/MS analysis

Table 6. Lawn Deposition Rates of 2,4-D, Yr3

	Deposition, mg/m^2			
	Coupon 1	Coupon 2	Coupon 3	Average
BY	29.6	32.6	22.7	28.3
Zm	22.7	19.3	24.8	22.3
c s	53.8	0	0	17.9
Rr	2.27	1.05	0.75	1.4