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Diazinon & Chlorpyrifos Products: Screening for Water Quality Implications

May 15, 2001

PREFACE

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- Bill Johnson, San Francisco Bay Regional Water Quality Control Board
- Thomas Mumley, Ph.D., San Francisco Bay Regional Water Quality Control Board
- Jim Scanlin, Alameda County Clean Water Program
- Bart Brandenburg, Central Contra Costa Sanitary District
- Nan Singhasemanon, California Department of Pesticide Regulation
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REPORT PREPARER

TDC Environmental
4020 Bayview Avenue
San Mateo CA 94403
www.tdcenvironmental.com

Project Manager: Kelly D. Moran, Ph.D.

DIAZINON & CHLORPYRIFOS PRODUCTS: SCREENING FOR WATER QUALITY IMPLICATIONS

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DIAZINON & CHLORPYRIFOS PRODUCTS: SCREENING FOR WATER QUALITY IMPLICATIONS

EXECUTIVE SUMMARY

On behalf of the San Francisco Estuary Project, TDC Environmental conducted an analysis of the relative potential for release of various diazinon and chlorpyrifos products into surface water. The California Department of Pesticide Regulation (DPR) funded this analysis. The information developed from this project is intended to help DPR, the California State and Regional Water Quality Control Boards, and other interested parties identify potentially problematic sites of use and formulations of diazinon and chlorpyrifos in the urban setting.

Diazinon and chlorpyrifos are among the most commonly used insecticides. Both pesticides have many urban uses; they are also extensively used in agriculture. Since they are so commonly used, it is not surprising that diazinon and chlorpyrifos are also commonly detected in surface waters—in fact, they are among the most commonly found pesticides in the national survey of surface waters conducted by the United States Geological Survey (USGS) (Gilliom, 1999).

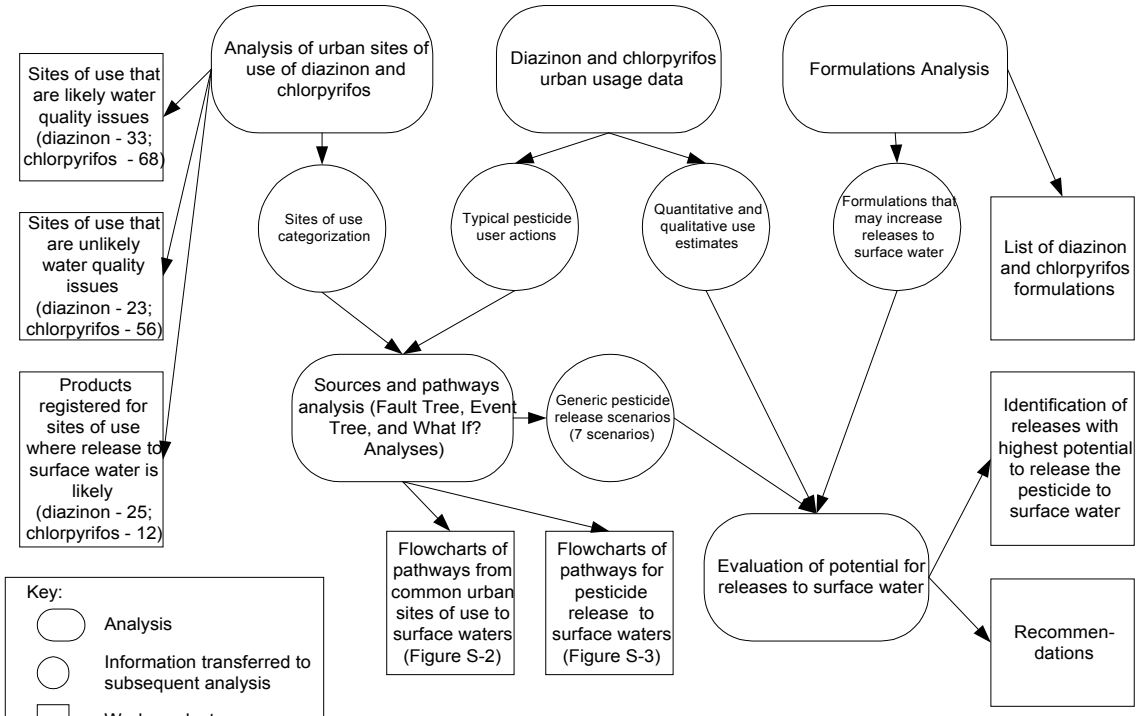
In California, the presence of diazinon and chlorpyrifos in surface waters has proven to be of some concern, as elevated levels of the two pesticides have been linked to findings of toxicity to the USEPA-approved toxicity test species *Ceriodaphnia dubia* in wastewater treatment plant effluent, storm water runoff, urban creeks, estuaries, and a major river (USEPA, August 1999; Bailey, 2000; Hansen, 1995; Santa Clara Valley Urban Runoff Program, 1995; Woodward Clyde, 1995; Katznelson, 1997; Russick, 2001). Much of this toxicity occurs in urban areas, apparently reflecting urban releases—rather than agricultural releases—of diazinon and chlorpyrifos. The intent of this report is to explore whether certain urban sites of use, by their location or certain pesticide formulations, when applied to common urban application sites, are especially likely to release diazinon and chlorpyrifos to surface water, and thus be linked to the identified toxicity.

S.1 Approach to Analysis

The analysis considered the characteristics of diazinon and chlorpyrifos urban sites of use, urban usage data, and the chemical and physical properties of formulations to determine the relative potential for release of diazinon and chlorpyrifos to surface water. A subsequent analysis of sources and pathways created a set of seven generic pesticide release scenarios. The generic scenarios facilitated evaluation of the potential for releases of diazinon and chlorpyrifos to surface water from various sites of use. Figure S-1 (on the next page) shows how the project was conducted and identifies the outcomes of each portion of the analysis.

While this work was being conducted, the USEPA reached landmark agreements with the primary registrants of both diazinon and chlorpyrifos. These agreements will severely limit future urban uses of both pesticides. Recognizing that most of the urban uses of diazinon and chlorpyrifos analyzed in this report will be discontinued in the next

Figure S-1. Project Overview



few years, this report takes an almost generic approach to the analysis where feasible and carefully explains methodology throughout, so that these techniques can be used to evaluate other urban-use insecticides.

S.2 Products, Sites of Use, and Formulations

There are 243 diazinon products and 410 chlorpyrifos registered for use in California.[1] Diazinon products are sold in nine formulations in California. On the basis of the number of products, the most common formulations are granules/flakes and emulsifiable concentrates. According to USEPA, the most widely used formulations are wettable powders, granules, and emulsifiable concentrates (USEPA, November 16 2000). Chlorpyrifos products are sold in 18 formulations in California. On the basis of the number of products, the most common formulations are emulsifiable concentrates, pressurized liquids/sprays/foggers, and granules/flakes. According to USEPA, the most widely used formulations are wettable powders and emulsifiable concentrates (USEPA, June 2000).

For diazinon, there are a total of 171 urban sites of use; for chlorpyrifos, there are 148 urban sites of use. A total of 33 diazinon and 68 chlorpyrifos urban sites of use were classified as likely water quality issues. Applications at these sites involve direct or inevitable discharge to water, treatment of relatively large outdoor areas with the potential to release a relatively large quantity of active ingredient in a single urban

[1] The data for this report were assembled and analyzed between September and December 2000. Product information reflects product registrations that were active at that time.

watershed, or treatment of outdoor hard surface or indoor areas cleaned with water. Twenty-three (23) diazinon and 56 chlorpyrifos urban sites of use were classified as unlikely water quality issues. At these sites, pesticide releases are controlled by facility-specific containment (*e.g.*, landfill leachate management systems) or the application location is not exposed to rain water, cleaning water, runoff, or other water flows (*e.g.*, indoor and substructure areas not washed with water).

Most diazinon and chlorpyrifos products are registered for multiple sites of use. Most products are registered for application on urban sites of use on the likely water quality issues list. Many of the same products are also registered for application on urban sites of use on the unlikely water quality issues list. Twenty-five (25) diazinon and 12 chlorpyrifos products are registered for application to urban sites of use that involve direct or inevitable discharge to surface water.

The water quality review of formulations identified seven formulation properties that increase the potential for a pesticide to be released to surface water: (1) need for mixing; (2) need for application equipment; (3) high active ingredient concentration; (4) design that facilitates suspension or dissolution of active ingredient in water; (5) small particle or other unit of pesticide-containing material that may easily be washed off the application site; (6) pressurized spray or shaker applications that deposit a significant fraction of the pesticide off-target; and (7) pesticide containing particle or other unit with long-term release design that may be transported off the application site by water. On the basis of these issues, the following formulations appear to have the greatest potential to facilitate pesticide releases to surface water: wettable powders, suspensions, flowable concentrates, emulsifiable concentrates, and aqueous concentrates.

Review of readily available information from USEPA regarding specific inert ingredients in diazinon and chlorpyrifos products identified four issues for water quality: inert ingredients may be water pollutants; inert ingredients may contain water pollutants as contaminants or additives; inert ingredients may facilitate transport of the active ingredient to surface waters; and inert ingredients may reduce transport of the active ingredient to surface waters.

S.3 Usage Summary

For diazinon, the most common urban uses are outdoor applications by homeowners, applications by lawn-care operators, and applications by pest control operators. California reporting data show that the major urban use of diazinon by professional applicators is to control pests around structures (residential, commercial, industrial, or institutional). The major urban uses of chlorpyrifos are applications by pest control operators to control termites, applications to turf, applications by pest control operators to control pests other than termites, and homeowner applications. California residential surveys have indicated that applications on impervious surfaces and outdoor landscaping are the most common uses of insecticides by residents.

S.4 Sources and Pathways

Major pathways from common urban diazinon and chlorpyrifos use sites to surface waters involve direct or indirect discharges to storm drains and wastewater treatment

plants. Figure S-2 (on the next page) shows the possible pathways for urban pesticide releases to surface waters. Figure S-3 (on the next page) explores the major pathways between common urban diazinon and chlorpyrifos sites of use and surface waters.

S.5 Relative Potential for Diazinon and Chlorpyrifos Releases to Surface Water From Various Sites of Use and Formulations

The relative potentials for surface water release were divided into four categories: high, possibly high, medium, and low. The description of the basis for each rating and the uses and formulations receiving each rating are noted below.

High—Common applications that release a high fraction of the applied pesticide to surface waters. On the basis of available information, such releases could potentially be large enough to cause environmental effects in receiving waters. Further investigation is recommended. Diazinon and chlorpyrifos uses found to have a high potential for release to surface water are applications or other releases to outdoor impervious surfaces, plants or soil, sewers, and indoor areas washed with water (diazinon only). Formulations with a high potential for release are wettable powders and emulsifiable concentrates.

Possibly High—High use/low release or high release/low use conditions. For pesticides with high aquatic toxicity like diazinon and chlorpyrifos, such releases may be environmentally significant under certain conditions (*e.g.*, when the pesticide is released to a small surface water body or when the release is to a surface water that is effectively small because of limited dilution). Further investigation is recommended. Diazinon and chlorpyrifos uses found to have a possibly high potential for release to surface water are applications or other releases to storm drains, directly to surface water, and underground (chlorpyrifos). The formulations with a possibly high potential for release is granular/flake (diazinon).

Medium—Moderate releases to surface waters. Environmental effects are possible. Further investigation should be considered. Diazinon uses found to have a medium potential for release to surface water are applications and other releases indoors. For chlorpyrifos, applications or other releases in indoor areas washed with water were found to have a medium potential for release to surface water.

Low—Uncommon pesticide releases resulting in transfer of only a small amount of the pesticide to surface waters. Such releases are unlikely to be large enough to cause pesticide-related environmental effects in surface waters. Further investigation is probably unnecessary. Diazinon and chlorpyrifos uses found to have a low potential for release to surface water are applications or other releases underground (diazinon) or indoors in areas not washed with water (chlorpyrifos). Formulations with a low potential for release to surface water are pellet/tablet/cake/briquet (chlorpyrifos) and impregnated materials.

Insufficient information was available to evaluate the following formulations: aqueous (liquid) concentrate, solution/liquid (ready-to-use), dust/powder, suspension, flowable concentrate, granular/flake (chlorpyrifos), paint/coating, microencapsulated, and pressurized liquid/spray/fogger.

Figure S-2. Pathways for Urban Pesticide Release to Surface Waters

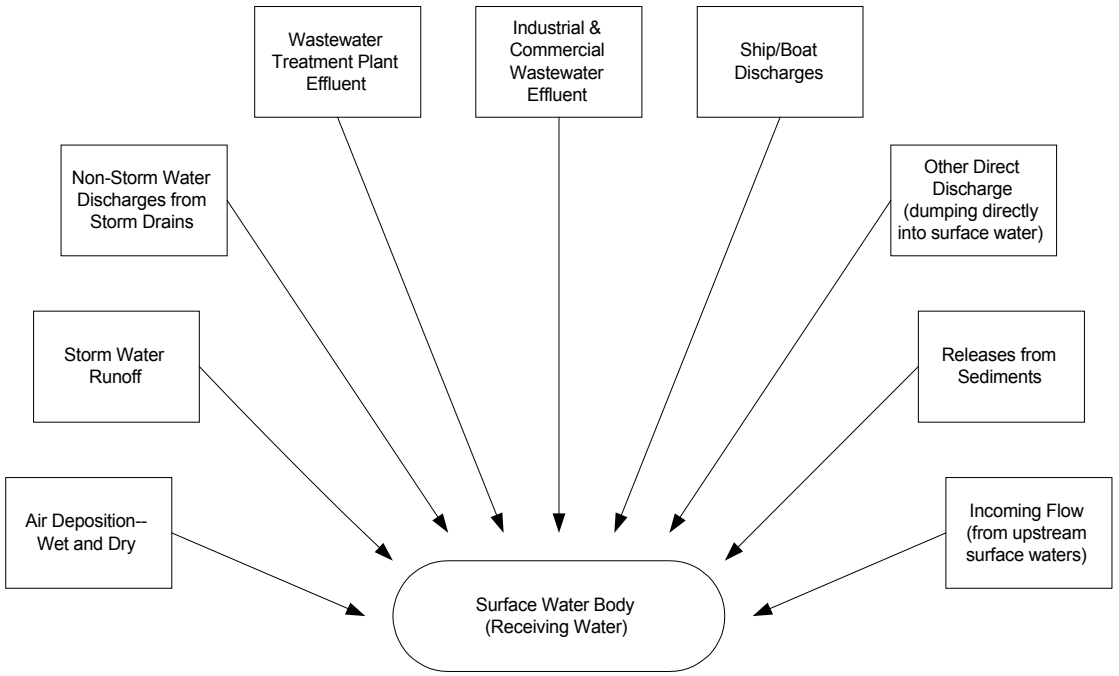
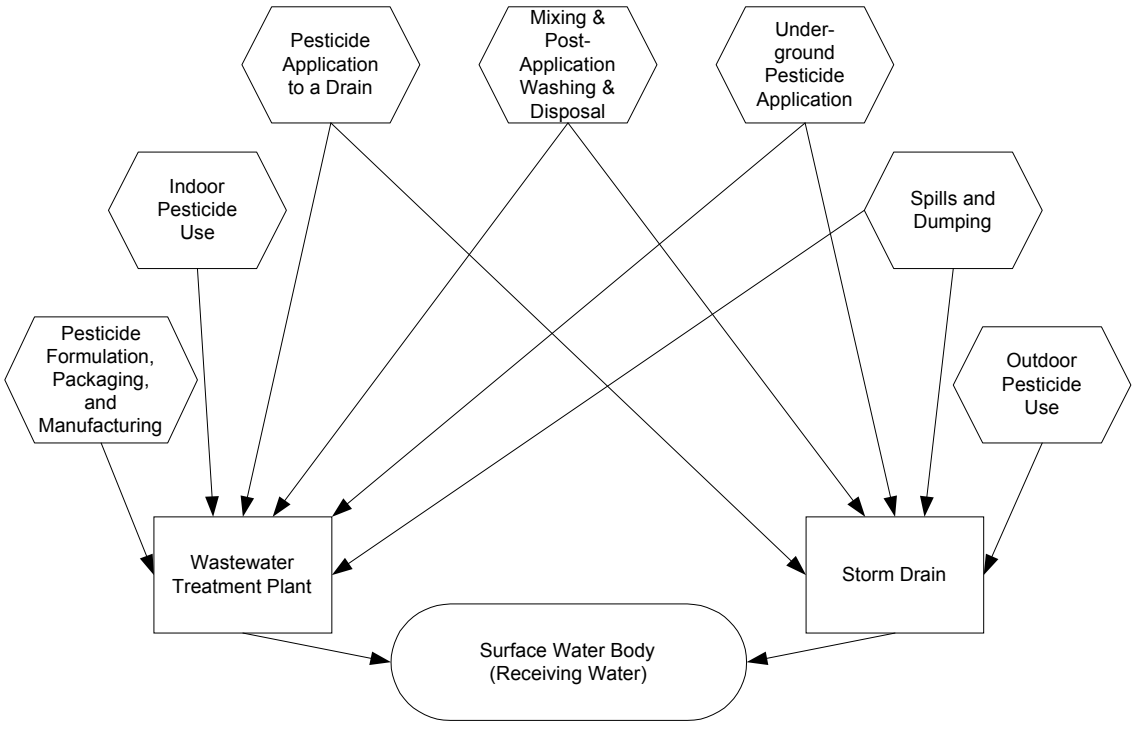


Figure S-3. Major Pathways from Common Urban Diazinon and Chlorpyrifos Uses to Surface Waters



S.6 Conclusions and Recommendations

The conclusions of this report and recommendations for future activities are summarized below:

Conclusion 1: Diazinon and chlorpyrifos applications to impervious surfaces and applications of wettable powders appear to have the greatest potential to release the applied pesticide to surface water.

Conclusion 2: Both the formulation characteristics and the specific inert ingredients used in diazinon and chlorpyrifos products contribute to the potential that these pesticides may be released to surface water. An additional water quality issue is that some inert ingredients are water pollutants.

Conclusion 3: While available data are of sufficient quality to support the analysis in this report, certain data gaps and limitations added uncertainty to portions of the analysis.

Conclusion 4: The highly useful DPR Product/Label database contains some errors.

Recommended Investigations and Actions

Recommendation 1: Conduct screening-level modeling of Master Scenarios in a well-characterized watershed.

Recommendation 2: Review pesticides registered for sites of use that involve direct or inevitable discharge to surface waters to identify the potential for linkage to surface water quality issues.

Recommendation 3: Investigate water quality implications of alternatives to diazinon and chlorpyrifos.

Recommendation 4: When pesticides are registered or re-registered, evaluate all proposed sites of use and consider the environmental effects of each product's formulation.

Recommendation 5: Modify product labels and containers to simplify mixing, application, and post-application washing and disposal procedures and to strengthen surface water protection elements.

Recommendation 6: DPR should consider separating sewers and storm drains into two separate sites of use.

Recommendations Regarding Data Gaps, Errors, and Limitations

Recommendation 7: Obtain additional information regarding the fate and transport of pesticides applied on urban sites of use.

- Recommendation 7.1: Conduct studies to quantify the fate and transport of pesticides applied to impervious surfaces.
- Recommendation 7.2: Conduct studies to better quantify the role that air transport plays in the environmental transport of pesticides to surface water.

Recommendation 8: Obtain an understanding of the relationship of pesticide formulation to water quality.

- Recommendation 8.1: Conduct studies to determine the relationship between formulation and environmental transport of the active ingredient in a pesticide.
- Recommendation 8.2: Investigate the potential water quality impacts from releases of inert ingredients.
- Recommendation 8.3: Seek to identify formulations and application methods that minimize off-site transport of pesticides.

Recommendation 9: Collect additional data regarding urban uses of pesticides.

- Recommendation 9.1: Collect quantitative data regarding urban pesticide use patterns, focusing on non-reported uses and sites of use that are likely water quality issues.
- Recommendation 9.2: Monitor the State of Oregon's new pesticide use reporting system.
- Recommendation 9.3: Collect quantitative data regarding use (or sales) of pesticide formulation types.

Recommendation 10: Track reported pesticide use using the same sites of use as are in the DPR Product/Label database.

Recommendation 11: Create a mechanism to identify and correct errors in the DPR Product/Label database.

1.0 INTRODUCTION

On behalf of the San Francisco Estuary Project, TDC Environmental conducted an analysis of the relative potential for release of various diazinon and chlorpyrifos products into surface water. The California Department of Pesticide Regulation (DPR) funded this analysis. The information developed from this project is intended to help DPR, the California State and Regional Water Quality Control Boards, and other interested parties identify potentially problematic sites of use and formulations of diazinon and chlorpyrifos in the urban setting.

While this work was being conducted, the USEPA reached landmark agreements with the primary registrants of both diazinon and chlorpyrifos. These agreements will severely limit future urban uses of both pesticides. Section 2.3 summarizes elements of the agreements in regard to urban uses of the two pesticides.

Recognizing that most of the urban uses of diazinon and chlorpyrifos analyzed in this report will be discontinued in the next few years, this report takes an almost generic approach to the analysis where feasible and carefully explains methodology throughout, so that these techniques can be used to evaluate other urban-use insecticides.

Some portions of the report use the generic term “pesticide” rather than specifically referring to diazinon or chlorpyrifos. The term was used to simplify the text, to indicate the generic nature of the analysis, and to remind readers that what is being considered is use of a formulated diazinon or chlorpyrifos product, rather than pure active ingredient.

1.1 Background

Diazinon and chlorpyrifos are among the most commonly used insecticides. Both pesticides have many urban uses; they are also extensively used in agriculture. Since they are so commonly used, it is not surprising that diazinon and chlorpyrifos are also commonly detected in surface waters—in fact, they are among the most commonly found pesticides in the national survey of surface waters conducted by the United States Geological Survey (USGS) (Gilliom, 1999).

In California, the presence of diazinon and chlorpyrifos in surface waters has proven to be of some concern, as elevated levels of the two pesticides have been linked to findings of toxicity to the USEPA-approved toxicity test species *Ceriodaphnia dubia* in wastewater treatment plant effluent, storm water runoff, urban creeks, estuaries, and a major river (USEPA, August 1999; Bailey, 2000; Hansen, 1995; Santa Clara Valley Urban Runoff Program, 1995; Woodward Clyde, 1995; Katznelson, 1997; Russick, 2001). Much of this toxicity occurs in urban areas, apparently reflecting urban releases—rather than agricultural releases—of diazinon and chlorpyrifos. Sources for the releases of the two pesticides into surface waters probably include use, misuse, mixing, post-application equipment washing, and improper management of wastes.

On the basis of surface water quality and toxicity data, when USEPA compiled the most recent list of California’s impaired water bodies (under Section 303(d) of the Clean Water Act), it listed 53 water bodies as impaired due to diazinon from urban releases and 7 water bodies as impaired due to chlorpyrifos in urban releases (USEPA, May 12 1999). As a result of the impairment designations and other legal actions, California Regional

Water Quality Control Boards have initiated eight Total Maximum Daily Loads (TMDLs) for diazinon and four chlorpyrifos TMDLs. Most of these TMDLs will address urban sources of the two pesticides.

Since the mid-1990s, local, state, and Federal government agencies have been working to address concerns about toxicity in surface waters due to diazinon and chlorpyrifos. Many of these agencies have coordinated efforts through the Urban Pesticide Toxicity Control Strategy Bay Area/Central Valley Coordinating Committee (Urban Pesticides Committee). This project was designed to address a recurring question on the part of Urban Pesticide Committee members: Are there certain sites of use or formulations of diazinon and chlorpyrifos that are especially likely to be linked to findings of toxicity in surface waters?

1.2 Scope of This Report

The intent of the research documented in this report is to explore whether certain sites of use, by their location or certain pesticide formulations, when applied to common application sites, are especially likely to release diazinon and chlorpyrifos to surface water, and thus be linked to the identified toxicity. The investigation involved organizing and analyzing existing information—no new data was generated for this report. Using the information in this report, agencies and public and private entities working to address these problems can set priorities for future investigations and actions. This report is not intended to be a regulatory document, nor to address regulatory questions regarding water quality impairment or the significance of the identified toxicity.

This study specifically focuses on diazinon and chlorpyrifos releases in urban areas. Releases are defined to include application, pre-application mixing, post-application cleanup, spills, misuse, waste management, and dumping. For purposes of the study, "urban" was broadly defined to include facilities and activities commonly found in California urban areas, like residences, commercial buildings, institutions, parks, golf courses, nurseries, greenhouses, and rights-of-way. Agricultural activities, which have previously been the subject of extensive study, are not addressed in this report.[2]

The report focuses specifically on surface water issues; groundwater is not addressed. Since certain subsurface flows serve as a pathway to connect pesticide releases to surface waters, these flows are considered in the report, but only in relation to surface waters.

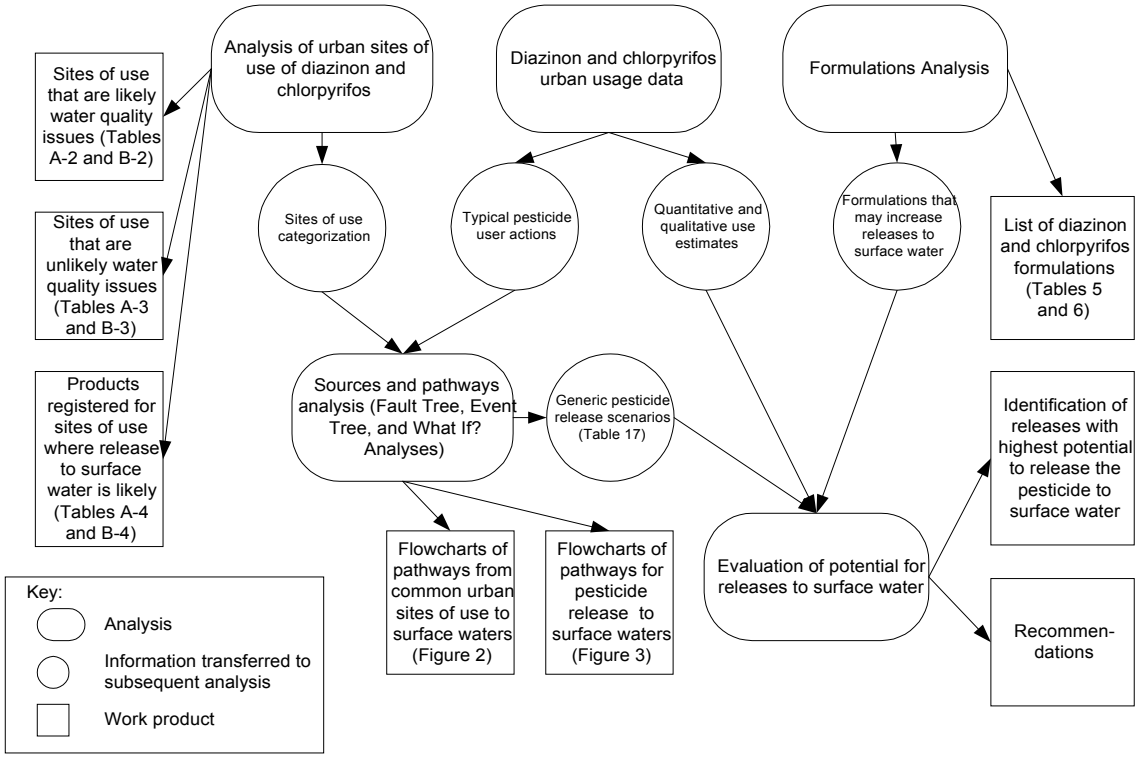
1.3 Report Organization

Figure 1 (on the next page) presents an overview of the project, showing major project elements, the relationship of those elements, and project work products. Section 2 provides background on diazinon and chlorpyrifos. Each subsequent section of this report is dedicated to one element of the project:

- Sites of Use Analysis. Using pesticide label data, information in the DPR Product/Label database and an understanding of sources of pollutant releases to surface waters, TDC Environmental identified the diazinon and chlorpyrifos sites

[2] Air deposition in urban areas from agricultural uses is not addressed, since the use generating the pesticide release is agricultural.

Figure 1. Project Overview



of use that are most and least likely to release the two pesticides to surface waters. Using DPR's Product/Label database, TDC Environmental identified the commercial products that are registered for use on sites determined to be most likely to release the two pesticides to surface waters. Product labels were reviewed to ensure the accuracy of the sites of use and product information. The methods used for this analysis and its results are presented in Section 3.

- Formulations Analysis. Section 4 presents an investigation of the relationship between diazinon and chlorpyrifos product formulations and the potential for surface water runoff of each pesticide. Both physical formulation and inert ingredients are evaluated, using best professional judgment (based on chemistry of the ingredients and experience identifying sources of pollutant releases to surface waters) and limited data from the literature.

- Usage Data. Usage patterns (including use location, usage frequency, application methods, pre-application mixing, and post-application washing and disposal) for both pesticides provide a context for the analysis of surface water release pathways. The amount of pesticide applied (or otherwise released) is a critical factor in evaluating the potential significance of different types of releases. Section 5 summarizes usage information obtained from several California surveys, DPR's records of reported uses, and reviews of product labels and application equipment.

- Sources and Pathways Analysis. The analysis of pathways for release of diazinon and chlorpyrifos to surface waters is in Section 6. For completeness, three analytical approaches are included. The Fault Tree analysis works back from receiving surface waters, through environmental transport pathways, to uses and other releases of diazinon and chlorpyrifos. Focusing on the common activities identified in Section 4, the Event Tree analysis works forward from common uses, misuses, and related activities, tracing the transport of the two pesticides to surface waters. In the What If? Analysis, all diazinon and chlorpyrifos sites of use, mixing, post-application cleanup, and waste management activities are categorized and analyzed. The What If? Analysis results were grouped into generic release situations and compared to the Fault Tree and Event Tree analyses to create a list of generic release situations called "Master Scenarios." Master Scenarios span the realm of actions that release diazinon and chlorpyrifos to surface waters.

- Evaluation of Potential for Surface Water Releases. In Section 7, the Master Scenarios are each evaluated, using a weight of evidence approach, to identify releases that have the potential to reach surface water. Formulations are also briefly reviewed; however, because little formulation-specific use information is available, insufficient information is available for a detailed formulations analysis.

- Conclusions and Recommendations. Section 8 presents the conclusions of this report and recommendations for future activities. The report generated two types of recommendations: actions to fill data gaps, and actions to address the report's major findings.

To prepare this report, TDC Environmental used the DPR Product/Label database, pesticide product labels, pesticide use data reported to the State of California, USEPA risk assessments, technical reports from credible sources, and items from the published scientific literature. A complete list of sources cited in this report is included in Section 9.

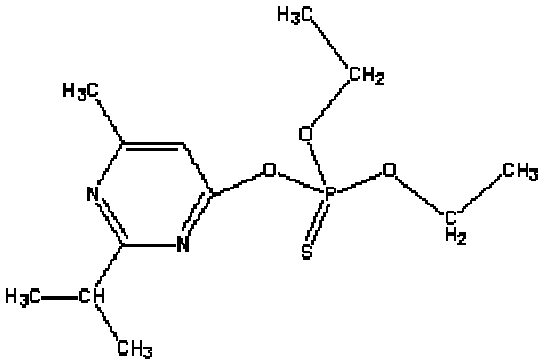
2.0 DIAZINON AND CHLORPYRIFOS

2.1 Diazinon Background Information

Diazinon is a widely used, broad-spectrum organophosphate insecticide. Diazinon first entered commercial production in the 1950s. Basic facts about diazinon and diazinon products are provided in the box below.

Diazinon (o,o-Diethyl o-(2-isopropyl-4-methyl-6-pyrimidinyl) phosphorothioate)

Formula: $C_{12}H_{21}N_2O_3PS$
CAS #: 333-41-5
MW: 304.3
K_{ow} (log): 3.3
Vapor pressure: 1.4×10^{-4} torr at 20° C
Water solubility: 40 mg/l at 20° C
Solvent solubility: Completely miscible in acetone, benzene, cyclohexane, ethyl ether, ethanol, methylene chloride, octanol, and toluene.



Environmental Fate: Diazinon is moderately persistent and mobile in the environment.

- Degrades primarily by microbial metabolism (with half lives of 37 and 39 days in two laboratory aerobic soil metabolism studies)
- Hydrolysis half lives are 23 (pH 5), 138 (pH 7), and 77 days (pH 9)
- Photolysis occurs with half-lives of 14.7 days on soil and 26 days in aqueous solution; however, USEPA does not believe photolysis is likely to be a major route of dissipation in most cases.

Products: Syngenta (formerly Novartis) is the primary manufacturer; Makhteshim-Agan America is a minor supplier. There are multiple formulators.

- About 430 Federally registered products
- About 240 California registered products.

Common formulations: wettable powders, granules, emulsifiable concentrates.

Source: USEPA, *Environmental Risk Assessment for Diazinon*, November 16, 2000.

The introduction to USEPA's revised *Integrated Environmental Risk Characterization* for diazinon provides an excellent summary of the environmental issues related to diazinon use (USEPA, November 16 2000):

> "The primary environmental concerns associated with the use of diazinon are bird kills, contamination of surface water via runoff, and impacts on aquatic species. These are significant concerns because over 6 million pounds of diazinon are used every year across the United States, with 75% being used for non-agricultural purposes (*e.g.*, applied outdoors by homeowners and professional lawn care companies). Outdoor uses of diazinon result in exposure and risk to birds and have caused bird kills. Continued reports of bird kill incidents associated with outdoor uses of diazinon and a recent trend of

increasing numbers of these incidents confirms that the outdoor uses of diazinon are resulting in widespread mortality of birds.

"The impacts of diazinon use on surface water quality are a growing concern because a significant portion of diazinon is used on lawns in urban and suburban areas where runoff is generally high. Diazinon used in these areas is very prone to runoff into creeks, streams, ponds, and other bodies of water. Available water monitoring data clearly demonstrate that the use of diazinon is resulting in widespread contamination of surface water, and that impacts are particularly significant in urban settings. This contamination is resulting in exposure and risk to sensitive aquatic organisms. Potential acute and chronic effects to aquatic invertebrates as well as chronic and sub-lethal effects to fish have been identified.

"Diazinon has been detected in drinking water reservoirs, large and smaller rivers, and in major aquifers. Preliminary laboratory evidence suggests chlorination of drinking water removes diazinon from treated water, transforming it to diazoxon. Diazoxon has also been found at levels about 2.5% of the parent in streams and rivers in California. Oxon degradation products of organophosphate pesticides have been shown to be substantially more toxic than parent compounds. Although diazoxon persistence has not been conclusively established, it may persist long enough to pass through the distribution system to the tap in some systems depending on the sequence of treatment. This aspect of diazinon's environmental fate warrants immediate investigation.

"Diazinon is frequently found in effluent from wastewater treatment facilities (POTWs), 14 of which have been cited out of compliance with the Clean Water Act (NPDES) as a result.[3] Also, diazinon (along with atrazine and chlorpyrifos) has resulted in the initiation of TMDLs. In California, 53 water bodies have been listed as impaired as a result of diazinon, and TMDLs have been initiated in virtually every major urban area of the state as a result. Finally, diazinon is also one of the most frequently detected pesticides in air, rain, and fog, suggesting environmental transport into regions beyond normal areas of use."

2.2 Chlorpyrifos Background Information

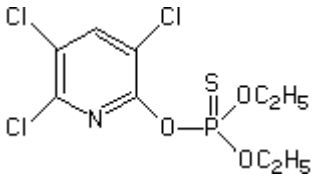
Like diazinon, chlorpyrifos is a widely used, broad-spectrum insecticide. Chlorpyrifos products have been marketed since the 1960s. The box on the next page summarizes chemical and product information for chlorpyrifos.

USEPA reviewed the environmental effects of chlorpyrifos in its risk assessment documents; however, the review and summary are not as complete in regards to surface water as the diazinon review. USEPA's most cogent summary of chlorpyrifos water quality issues was included in a technical briefing on the revised risk assessment (USEPA, June 8, 2000, summarizing the risk assessment USEPA, August 2000). In that summary, USEPA provided the following key findings:

[3] Nationwide.

Chlorpyrifos (o,o-Diethyl o-(3,5,6-trichloro-2-pyridinyl) phosphorothioate)

Formula: $C_9H_{11}Cl_3NO_3PS$
CAS #: 2921-88-2
MW: 350.57
K_{ow} (log): 4.70
Vapor pressure: 1.87×10^{-5} torr at 25° C
Water solubility: 2 mg/l at 25° C
Solvent solubility: soluble in most organic solvents (*e.g.*, acetone, xylene and methylene chloride).



Environmental Fate: Chlorpyrifos is moderately persistent in the environment.

- Degrades primarily by aerobic and anaerobic metabolism. Soil persistence varies over about two orders of magnitude (from a few days to well over 100 days and typically greater than 200 days for termiticidal uses) depending on soil type, environmental conditions, and possibly previous use history at the treatment site.
- Hydrolysis half lives are approximately 72 days (neutral solution), 73 days (acidic solution), and 16 days (basic solution)
- Photolysis occurs with a half-life of 30 days in irradiated pH 7 aqueous solutions.

Note: USEPA does not believe photolysis or hydrolysis are likely to be a major routes of dissipation for chlorpyrifos.

Products: There are five manufacturers of chlorpyrifos—Dow AgroSciences (formerly DowElanco); Makhteshim-Agan (America), Inc.; Gharda; Luxemburg-Pamol; and Cheminova. There are multiple formulators.

- About 822 Federally registered products
- About 410 California registered products

Common formulations: wettable powders, emulsifiable concentrates.

Source: USEPA, *Fate And Environmental Risk Assessment Chapter of the Reregistration Eligibility Science Chapter for Chlorpyrifos*, June 2000.

- Surface Water Toxicity. Biomonitoring studies documented in the USEPA environmental risk assessment for chlorpyrifos show lethal effects on *Ceriodaphnia* in storm drain discharges in California urban areas, in rainfall in the Sacramento Area, in POTW effluents (from home uses, cleaning equipment, etc.), and in streams and rivers.

- Chlorpyrifos Sources. Biomonitoring studies have identified a wide range of sources of chlorpyrifos in these surface waters. The USEPA risk assessment identified the following urban sources as likely contributors to surface water toxicity: termiticide uses, homeowner uses (on lawns, gardens, ornamentals, etc.), use at commercial nurseries, and cleaning of application equipment.

- Incidents. Numerous aquatic incidents have been reported in association with chlorpyrifos use. The wide variety of affected species included fish (according to USEPA, usually large numbers killed), invertebrates, and amphibians. Most

incidents occurred in urban areas. The largest fraction of incidents was related to termiticide uses; urban turf uses were also implicated in many incidents.

USEPA concluded that biomonitoring data indicate "widespread aquatic toxicity in agriculture and urban areas," and that chlorpyrifos uses "pose risks to a broad spectrum of fish and wildlife species."

2.3 USEPA Reregistration Process

Both diazinon and chlorpyrifos are currently under review by the USEPA. The review, called "reregistration," is intended to fulfill requirements to review pesticides registered before the passage of Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) amendments in 1988, as well as to address new safety standards imposed by the Food Quality Protection Act (FQPA). The cornerstone of the reregistration process is an assessment of the human health and environmental risks of a pesticide. To the extent that risks exceed levels deemed acceptable by USEPA, risks must be mitigated by actions designed to reduce human or environmental exposures to the pesticide.

USEPA has completed environmental risk assessments for both diazinon (USEPA, November 16 2000) and chlorpyrifos (USEPA, August 2000). Having solicited public comment on risk management options for the two pesticides, USEPA is currently in the process of developing its risk management plans, which will be incorporated into the "Registration Eligibility Document" (RED) for each pesticide.

At the time that the risk assessments were completed for diazinon and chlorpyrifos, USEPA announced agreements with the major manufacturers of each pesticide. The agreements modify product registrations to mitigate certain risks identified for each pesticide. Neither agreement fully mitigates all worker safety and environmental risks identified by USEPA; therefore, USEPA is anticipated to propose additional risk mitigation actions in the REDs for both pesticides.

The urban portion of the diazinon agreement with major registrants is relatively simple—all non-agricultural urban uses (both residential and non-residential, including all indoor uses)[4] will be phased out by December 31, 2004 (USEPA, January 2001). For chlorpyrifos, the agreement is more complex, leaving numerous urban uses in place, as shown in Table 1 (on the next page). Sales of all phased out chlorpyrifos products are set to end by December 31, 2001, except for termiticides, which may be sold and used until December 31, 2005.

The use changes included in the two agreements are subject to modification until such time as regulatory actions are completed to implement all phases of the agreements for all products. USEPA is still completing agreement negotiations with minor registrants (Myers, 2001). An example of such modifications was the decision by USEPA to add a chlorpyrifos use (use in sewer manholes) to the list of urban uses that would be allowed after implementation of the agreement, despite the fact that the announcement of the agreement delineated that only listed urban uses (not including sewer manholes) would be allowed. USEPA does not plan specific public notice of such changes (which are the

[4]Some agricultural facilities like greenhouses occur in urban areas. Diazinon and chlorpyrifos use may continue at such facilities (depending on the crop produced).

result of subsequent agreements with minor registrants), but they can be ferreted out by monitoring *Federal Register* notices regarding product registration and label changes.

Table 1. Urban Uses of Chlorpyrifos to Remain After Implementation of Agreements with Registrants Completed by March 22, 2001

Location	Uses Allowed
Indoor Non-Residential Locations	• Ship holds • Railroad boxcars • Industrial plants • Manufacturing plants • Food processing plants • Warehouses[a] • Processed wood products treated during the manufacturing process at the manufacturing site or at the mill[b]
Outdoor Non-Residential Locations	• Golf courses (reduced application rate) • Road medians (reduced application rate) • Industrial plant sites (reduced application rate) • Non-structural wood treatment including fence posts, utility poles, railroad ties, landscape timbers, logs, pallets, wooden containers, poles, posts, and processed wood products • Manhole covers[b] • Underground utility cable and conduits[b]
All locations – Public Health Treatments	• Mosquito control (by public health agencies only) • Fire ant mound treatments (restricted to licensed pest control operators)
Residences	• Ant and roach baits in child-resistant packages

[a]Use not in original agreement announcement, but apparently in original agreement (Myers, 2001); first added in September 20, 2000 *Federal Register* notice.

[b]Use not in original agreement announcement; first added in December 6, 2000 *Federal Register* notice.

Note: includes modifications made through March 22, 2001. Additional modifications are possible, but not expected (Myers, 2001).

Source: Myers, 2001; USEPA, June 2000; *Federal Register* notices on September 20, 2000, November 17, 2000, December 6, 2000, and January 25, 2001.

3.0 SITES OF USE

A “site of use” is a location where a pesticide may be applied. During pesticide registration, USEPA and DPR determine the allowable sites of use for each pesticide product. Pesticides may not legally be applied to non-registered sites of use.

Certain sites of use result in an inevitable release of some or all of the applied pesticide to surface water. For example, applications to aquatic areas (DPR site code 65000) directly release a pesticide to surface waters. Similarly, applications to sewage systems (DPR site code 65026, defined to include storm drains) release pesticides to a sewage treatment plant, which is typically not designed to remove pesticides from wastewater (depending on the pesticide and the treatment plant’s design and operation, removal efficiencies from 20 to 90% typically occur), or to a storm drain, which typically discharges the applied pesticide directly to a surface water body. Such sites of use are of greatest interest from a water quality perspective, and thus were the focus of the investigation.

3.1 Approach To Sites of Use Review

The first step of the project was to identify and review the sites of use for diazinon and chlorpyrifos products in order to identify sites of use that would be most likely—and those that would be least likely—to relate to releases of the pesticides to surface waters. The sites of use review involved the following steps:

(1) Develop a comprehensive list of urban sites of use for diazinon and chlorpyrifos.

(2) Analyze allowable urban sites of use to identify sites of use that are particularly likely and those that are particularly unlikely to release diazinon and chlorpyrifos to surface waters. Create a list of “Likely Water Quality Issues” and a list of “Unlikely Water Quality Issues.”

(3) Create a list of products (based on the sites of use identified above) that are particularly likely, when used on one of the sites of use of concern, to release diazinon and chlorpyrifos to surface waters in urban areas.

(4) Conduct a quality assurance review of labels for all products identified the previous step to determine whether the uses of concern are prohibited by label language. (This step is necessary because the list of sites of use in the DPR Product/Label database may contain data entry errors and does not always accurately reflect application restrictions that are included only in label language.)

(5) Revise the lists above to correct for errors identified during the label review.

Appendices A (diazinon) and B (chlorpyrifos) contain the following lists, which are the products of this review:

- Comprehensive list of urban sites of use of diazinon and chlorpyrifos
- List of urban sites of use that are “Likely Water Quality Issues”
- List of urban sites of use that are “Unlikely Water Quality Issues”
- List of products registered for use on the “Likely Water Quality Issues” urban sites with greatest potential release of active ingredient to surface waters

3.2 Data Sources

The primary data sources for sites of use analysis were the California Department of Pesticide Regulation Product/Label database and pesticide product labels. Product labels were obtained from the following sources:

- labels on products displayed for retail sale in California;
- the California Department of Pesticide Regulation;
- the USEPA product label database (contains electronic images of product labels);
- the Oklahoma Department of Agriculture pesticide product label internet site (http://www.kellysolutions.com/ok/) (contained electronic images of product labels; this site has now been supplanted by the USEPA database); and
- manufacturer Internet sites (some contain electronic images of product labels).

California's guidelines, registration requirements, and product specifications may differ from the information provided by the Federal product label; if so, the manufacturer would have registered a California-specific product label. While labels were checked expressly for any California-specific application information, it is possible that the labels from the latter 3 sources differ from the California-specific label (if one exists) and therefore lack certain California-specific restrictions. California labels cannot include any uses that are not included on Federal labels—and thus, labels from these sources are adequate for determining if a use is not allowed (which was the primary purpose of this portion of the label review).

3.3 Diazinon and Chlorpyrifos Urban Sites of Use

Urban sites of use were determined as follows:

(1) Review the general categories for classification of sites of use by DPR. These general categories are sites of use codes that end in "0" (sites 10 through 100) or "000" (sites 1000 through 100000).

(2) Eliminate agricultural crops and other non-urban sites of use. In general, sites between 100 and 31000 are agricultural or other non-urban sites (*e.g.*, forests) and thus could quickly be omitted from consideration. The full lists of diazinon and chlorpyrifos sites in these categories were screened for quality assurance purposes. In that screening, the nurseries site (29510) was identified for inclusion in the urban sites list, because nurseries commonly occur in urban areas. No other special cases were identified.

(3) Conduct a detailed review of registered sites for diazinon and chlorpyrifos in the primarily non-agricultural categories (sites 31000 to 100000). Within this list, a few agricultural sites were identified and excluded from the list. The excluded sites were all agricultural in nature, and included sites like farm animals, mushroom houses, and barns.

In general, the approach to developing the urban sites of use lists was inclusive, rather than exclusive. This approach ensures that this list is comprehensive. The list of urban sites of use for diazinon and chlorpyrifos are included in Appendices A and B (Tables A-1 and B-1). For diazinon, there are a total of 171 urban sites of use; for chlorpyrifos, 148 urban sites of use were identified.

3.4 Water Quality Evaluation of Urban Sites of Use

The evaluation of potential water quality significance of each site of use was based on best professional judgment, taken from the author's personal experience with stormwater runoff and wastewater pollutant discharge pathways. Table 2 (on the next page) explains the evaluation process used to categorize the various types of sites of use into "likely water quality issues" and "unlikely water quality issues." Sites rated as "Low" on the basis of the evaluation were classified as "Unlikely Water Quality Issues." Sites rated as "High" or "Moderately High" were classified as "Likely Water Quality Issues."

Since the classification of a site could vary with the specific location at the site where the pesticide is applied, the lists of likely and unlikely water quality issue sites include certain limitations (see the lists for details). Including the limitations, a total of 33 diazinon and 68 chlorpyrifos urban sites of use were classified as likely water quality issues, and 23 diazinon and 56 chlorpyrifos sites were classified as unlikely water quality issues. These sites are listed in Appendices A and B (Tables A-2, A-3, B-2, and B-3; the tables reflect corrections made during the quality assurance label review described below). Interestingly, sites involving applications to commercial, institutional, and industrial buildings are found on both lists, because the potential for release depends heavily on the application location. Applications to indoor areas not cleaned with water are unlikely to have a pathway for release of meaningful quantities of the applied pesticide to surface water; however, applications to outdoor surfaces in the same locations have significant potential for releases.

3.5 Quality Assurance Label Review

It was not possible to obtain and review all product labels[5] for all products registered for application to all Likely Water Quality Issues sites of use within the project budget and schedule. To ensure that the sites of greatest interest were fully explored, the review process prioritized review of labels from the products with sites of use that involved direct or indirect release of products to surface waters, to sewers, or to storm drains. These sites of use are listed below:

- 65000 – Aquatic Areas, Water Areas (All Or Unspec.)
- 65013 – Drainage Systems (All Or Unspec.)
- 65015 – Human Drinking Water Systems (Potable)
- 65026 – Sewage Systems (Septic Tanks, Sewers, etc.)
- 65031 – Lakes, Ponds, Reservoirs, Etc. (Animal Use)
- 65501 – Aquatic Site – Human/Animal Use (Combined Site)
- 67008 – Sewage Disposal Areas (Municipal And Other)
- 87010 – Carpets (Hospital, Commercial, Household)
- 88003 – Bathroom Premises (Lavatories, Restrooms, etc.)
- 88501 – Toilets, Toilet Bowls, Urinals (All Or Unspec.)

This selection process ensured that products with uses of greatest concern for water quality were carefully checked.

As a result of the review of the product labels, some sites of use that were listed in the DPR Product/Label database were found not to be allowable locations for application of

[5] Refers to actual USEPA-approved label for the product container.

Table 2. Water Quality Evaluation of Urban Sites of Use

Site Type (General Categories)	Evaluation	Potential for Pesticide Release to Surface Water
Water	May involve direct application to water.	High
Sewer (includes storm drain)	Applications involve inevitable flow to sewage treatment plants and discharges to surface water. Sewage treatment plant removal efficiency for these pesticides varies widely (from 20 to 98%; USEPA, 1999; and Chew, 1998). Storm drains typically discharge directly to surface water without treatment.	Moderate – High
Large Outdoor Areas[a]	Large outdoor areas are not well defined, making them difficult to evaluate. Application sites are generally like landscaping, water, or outdoor structure site types. The single most important characteristic of these sites is their large size, which creates potential for application of relatively large quantities of active ingredient in a single urban watershed.	Moderate-High
Wood Treatment	Both outdoor treatment facilities and outdoor use of treated products (assumed to be the most common use) can create relatively direct pathways for releases.	Moderate-High
Residential, Commercial, and Institutional Structures—Indoors and Outdoors; Other Structure-Related Sites[b]	Uses fall into 4 general categories with different levels of concern: (a) Outdoor/pavement and other surfaces—runoff from rain likely. (b) Outdoor/landscaping—see landscaping (moderate). (c) Indoor/surfaces and materials cleaned with water—direct pathway to sewer makes discharge likely. (d) Indoor/areas not cleaned with water (*e.g.*, substructure)—no direct discharge pathway; indirect discharges possible.	(a) High (b) Moderate (c) Moderate (d) Low
Pest Control	Certain pest control uses target a nest or hive. In such cases, releases are unlikely. Other activities, like mosquito control, involve applications to large outdoor areas (see above).	Low-High
Landscaping and Gardens, Nurseries, and Soil Amendments	While relatively large areas may be treated (and thus relatively large amounts of active ingredient used), literature suggests that only a moderate fraction of applied material runs off.	Moderate
Pets	Pet uses can create sewer discharges from pet washing. For animals that are not washed, possible release pathways are limited.	High-Low
Greenhouses	Applications inside greenhouses are unlikely to have a release pathway.	Low
Solid Waste Facilities	Run-on and runoff are tightly controlled at landfills and leachate is contained, limiting potential for releases.	Low

[a]These include sites like highway rights-of-way, mosquito abatement districts, and urban areas (all or unspec.).

[b]These include sites like paint, surface, mothproofing, and fencerows.

Source: TDC Environmental evaluation.

diazinon or chlorpyrifos. For diazinon, the review identified significant errors in the DPR Product/Label database. Of the nine diazinon sites reviewed, six did not appear on any of the reviewed product labels. These six sites were removed from the lists in this report:

- 65000 – Aquatic Areas, Water Areas (All Or Unspec.)
- 65015 – Human Drinking Water Systems (Potable)
- 65031 – Lakes, Ponds, Reservoirs, Etc. (Animal Use)
- 65501 – Aquatic Site – Human/Animal Use (Combined Site)
- 67008 – Sewage Disposal Areas (Municipal And Other)
- 88501 – Toilets, Toilet Bowls, Urinals (All Or Unspec.)

The review identified one instance where the DPR Product/Label database indicated that use in bathroom premises (site code 88003) was cancelled, but the use still appears on the product label (see Table A-4).

For chlorpyrifos, no changes to the sites of use list were needed based on the quality assurance review, as all sites included in the list were on the product labels. The review identified several cases where a product label included a site of concern that was not recorded in the DPR Product/Label database; these instances are noted in Table B-4.

Table 3 lists the five sites of use for diazinon and chlorpyrifos that involve direct or indirect release of products to surface waters, to sewers, or to storm drains.

Table 3. Diazinon and Chlorpyrifos Sites of Use That Involve Direct or Indirect Releases to Surface Waters, Sewers, or Storm Drains

Site Code and Name	Diazinon	Chlorpyrifos
65013 – Drainage Systems (All Or Unspec.)	X	
65026 – Sewage Systems (Septic Tanks, Sewers, etc.)		X
67008 – Sewage Disposal Areas (Municipal And Other)		X
87010 – Carpets (Hospital, Commercial, Household)	X	X
88003 – Bathroom Premises (Lavatories, Restrooms, etc.)	X	X

Source: TDC Environmental

3.6 Products Registered for Sites of Special Water Quality Interest

For diazinon, the 25 products listed in Table A-4 have sites of use that involve direct or indirect release of the pesticide to surface waters, to sewers, or to storm drains. For chlorpyrifos, the 12 products listed in Table B-4 are labeled for such sites of use.

3.7 Effect of USEPA Reregistration Process

As explained in Section 2.3, USEPA is currently completing reregistration of both diazinon and chlorpyrifos. USEPA agreements with manufacturers of both pesticides call for terminating most urban sites of use of the two pesticides. These changes will eliminate many of the urban sites of use found to be likely water quality issues (see Tables A-2 and B-2). On the basis of currently available information (see Section 2.3), no diazinon urban sites of use are anticipated to remain active after December 31, 2004. For chlorpyrifos, urban sites of use found to be likely water quality issues and anticipated to remain active after December 31, 2005 are listed in Table 4 (on the next page). Since the USEPA reregistration process is not final, this information is subject to modification (see Section 2.3).

Table 4. Chlorpyrifos Likely Water Quality Issue Urban Sites of Use to Remain After Implementation of USEPA Agreements with Registrants Completed by March 22, 2001

USEPA Designation for Use Allowed	Corresponding DPR Site Code and Site Name
Manhole covers	65026 - Sewage Systems (Septic Tanks, Sewers, Etc.)
Road medians	67004 - Highway Rights-Of-Way (Roadways, Curbs, Etc.) 67012 - Private Roads, Walkways, Lanes, Patios, Etc.
Mosquito control (by public health agencies only)	68502 - Mosquito Abatement Districts
Golf courses	33007 - Turf, Golf Course (Fairways, Greens, Rough)*
Processed wood products treated during the manufacturing process at the manufacturing site or at the mill (indoors) Non-structural wood treatment including fence posts, utility poles, railroad ties, landscape timbers, logs, pallets, wooden containers, poles, posts, and processed wood products (outdoors)	64003 - Wood Protection - Finished Wood Products 64500 - Wood Protection Treatments (All Or Unspecified) 64501 - Lumber (Seasoned/Unseasoned) 97005 - Wood Surfaces (Seasoned/Unpainted)
Note for sites below: Applies to the portions of these sites that are outdoor hard surfaces or indoor areas cleaned with water	
Industrial plants (indoors), Manufacturing plants (indoors), Industrial plant sites (outdoors)	67009 - Industrial Sites (Lumber Yards, Tank Farms, Etc.)
Ship holds	70004 - Ships, Boat Premises, Etc. (All Or Unspec)
Railroad boxcars	70026 - Railway Trains (All Or Unspec)
Food processing plants (indoors)	71000 - Food Processing/Handling Plant/Area (All/Unspec) 71001 - Bakeries, Bakery Equipment, Etc. 71002 - Bottling Plants (Includes Beverage Bottles) 71003 - Breweries, Distilleries, Beer Beverage Cases, Etc. 71004 - Canneries And Frozen Food Plants 71006 - Feed Mills, Feed Stores, Feed Processing Plants 71008 - Meat Processing Plants (Slaughter Houses, Etc.) 71010 - Wineries, Wine Cellars 71011 - Flour Mills, Flour/Grain Elevators, Etc. 71012 - Egg Processing Plants, Egg Breaking Plants 71019 - Beverage Processing Plants, Etc. (All Or Unspec) 71022 - Fish And Sea Food Processing Plants And Equipment 71033 - Food Processing/Handling Plant/Area (Food Area) 71501 - Food Processing/Handling Plant/Area (Food Area) 71502 - Food Processing/Handling Plant/Area (Nonfood Area)
Warehouses (indoors)	77004 - Commercial Storages Or Warehouses (All Or Unspec)

*The DPR Product/Label database does not specifically list this site for chlorpyrifos, so this site is not considered elsewhere in this document. The site is included here because it is the specific site that would be allowable. Since this site has a character similar to other sites in the "Large Outdoor Area" category of likely water quality issue sites, it is included in this table for completeness.

4.0 FORMULATIONS

Few pesticides contain pure active ingredient. Instead manufacturers formulate pesticides by adding various ingredients such as solvents, emulsifiers, surfactants, and carriers that improve properties like storage lifetime, ease of handling, ease of application, effectiveness, or safety. The added ingredients are called “inert” ingredients or “other” ingredients to differentiate them from the active ingredient. Because the formulation may change the active ingredient’s performance and use, USEPA and DPR individually register each formulated pesticide.

Each formulation has unique physical and chemical characteristics that may affect its potential for release to surface waters (Wauchope, 1980; Willis, 1980; Cohen, 1986). This section contains a review of available information regarding diazinon and chlorpyrifos product formulations to explore the potential relationship between product formulation and releases to surface waters.

4.1 Approach to Formulations Review

The purpose of the formulations review was to compile and evaluate readily available information to investigate the potential relationship between pesticide formulation and potential releases of a pesticide to surface waters. The investigation involved the following steps:

(1) Develop a comprehensive list of formulations of diazinon and chlorpyrifos.

(2) Conduct a screening review of diazinon and chlorpyrifos formulations to identify, based on the characteristics of the formulation types and the associated methods of application, the formulation types that may be particularly likely to release diazinon and chlorpyrifos to surface waters in urban areas.

(3) Develop a list of inert ingredients in diazinon and chlorpyrifos product formulations, using public information sources.

(4) Conduct a screening review of diazinon and chlorpyrifos inert ingredients to identify, based on the characteristics of the inert ingredients, ingredients that may facilitate release of diazinon and chlorpyrifos to surface waters in urban areas.

4.2 Data Sources

The primary data sources for developing the list of formulations were the California Department of Pesticide Regulation Product/Label database and USEPA risk assessments for diazinon and chlorpyrifos. As anticipated, label review of a handful of products (including all products with unusual or inconsistent formulations) identified minor errors in the DPR database; such errors are noted below and were corrected in this report (based on review of the relevant product labels).

To date, information about inert ingredients in pesticides has been considered confidential business information that is not provided to customers and cannot be disclosed by state or Federal government staff. A recent court case has resulted in a change in policy at USEPA, which is disclosing inert ingredients in specific products

under certain conditions, when such information is requested under the Freedom of Information Act. Most of the inert ingredient information included in this report was obtained from USEPA, which provided copies of all previously sent Freedom of Information Act responses regarding diazinon and chlorpyrifos products (the project schedule did not include sufficient time for a project-specific Freedom of Information Act request) (Furlow, 2001). Additional information was obtained from product material safety data sheets (MSDSs), from compilations of Freedom of Information Act data published by the Northwest Coalition for Alternatives to Pesticides (Cox, 1999 and 2000), and from the published literature (Information Ventures Inc., undated). No inert ingredient information was obtained from DPR, whose employees are not allowed to disclose such information.

The list of inert ingredients developed through this data assembly process is not anticipated to be comprehensive, but contains information about sufficient products (about 30 chlorpyrifos and 15 diazinon products) that it is likely to be representative of the range of inert ingredient types present in diazinon and chlorpyrifos products.

4.3 Diazinon and Chlorpyrifos Formulations

Development of a comprehensive list of formulations for diazinon & chlorpyrifos products relied primarily on information from the California Department of Pesticide Regulations Product/Label Database (DPR database). Information from the DPR database was compared to much more limited formulation information available from USEPA in the risk assessments for diazinon and chlorpyrifos (USEPA, August 2000; USEPA, November 16 2000). In general, USEPA and DPR data correlated very well, but DPR data provided significantly more detail about the formulations—for example, using the DPR database, it is possible to identify the number of products for each formulation.

Tables 5 (below) and 6 (on the next page) list the 9 diazinon and 18 chlorpyrifos formulations for products available for sale in California as of September 2000. The tables provide the number of products with each formulation and examples of urban

Table 5. Diazinon Product Formulations

Formulation Type	# Products	Urban Product Examples
Emulsifiable Concentrate	45	Insect spray concentrates
Aqueous (Liquid) Concentrate	18	Concentrates for mixing insect sprays
Solution/Liquid (Ready-To-Use)	18	Home use ant, roach & spider sprays
Dust/Powder	8	Insecticide dust
Wettable Powder	12	Professional applicator products
Granular/Flake	80	Turf products
Impregnated Material	35	Pet flea collars, cattle ear tags
Microencapsulated*	6	Liquid sprays (concentrates and ready-to-use), “controlled-release”
Pressurized Liquid/Spray/Fogger	21	Ant & roach sprays or “bombs”
Total products	**243**	

Note: “# Products” is number of California-registered products as of September 2000.
*In the DPR Product/Label database, one product was listed as “suspension” and one as “flowable concentrate”; formulation was corrected based on product label information.
Sources: DPR Product/Label database, cross-referenced to formulation information in USEPA, November 16, 2000.

products with each formulation. Formulation data from the DPR database was spot-checked for consistency against product names and uses indicated in the database. During spot-checking, the typical uses of products with each formulation was noted. Product labels were checked for formulations that seemed unusual (had few products) or improbable (*e.g.*, a soluble powder listing).

Table 6. Chlorpyrifos Product Formulations

Formulation Type	# Products	Urban Product Examples
Emulsifiable Concentrate	81	Professional & home use insect spray concentrates
Aqueous (Liquid) Concentrate[a]	50	Sprays for lawn, yard, carpets, kennels, plants, home pests
Solution/Liquid (Ready-To-Use)	47	Insect sprays (ant, flea, tick, whitefly mealy bug), indoor and outdoor use, crack & crevice treatment, flea collar
Dust/Powder	5	Ant control dusts
Wettable Powder[b]	11	Professional applicator product
Suspension	5	Yard & kennel spray, flea dip, beetle spray
Flowable Concentrate	7	Home application concentrates for insect control (ants, roaches)
Granular/Flake	66	Lawn & perimeter applications to control insects (ants, fleas, grubs)
Gel/Paste/Cream	10	Roach, ant, and cricket baits
Pellet/Tablet/Cake/Briquet	6	Ant baits
Impregnated Material[c]	37	Pet flea collars, ear tags
Paint/Coating	5	Paints
Microencapsulated	2	One professional use liquid spray for many “controlled release” indoor & outdoor uses (1 manufacturing product)
Pressurized Liquid/Spray/Fogger[d]	75	Insect spray (wasp, hornet, yellow jacket, ant, roach, flea) or fogger
Oil	1	Roach spray with pyrethrins/PBO
Other (Dry)	1	Pesticide for manufacturing and formulation
Other (Liquid)	1	Pesticide for manufacturing and formulation
Total products	**410**	

Note: “# Products” is number of California-registered products as of September 2000.
[a]Includes a product listed in the DPR Product/Label database as dry flowable, but labeled as a water-based concentrate.
[b]Includes a product recorded in the DPR Product/Label database as a “soluble powder” (verified formulation by reviewing product label) and a product listed in the DPR database as “dry flowable” but labeled as wettable powder.
[c]Includes 2 flea collars listed in the DPR Product/Label database as “Other (dry).”
[d]Includes 3 pyrethrin/PBO containing products that were recorded in the DPR Product/Label database as “pressurized gases” (verified formulation by reviewing product label).
Sources: DPR Product/Label database, cross-referenced to formulation information in USEPA, August 2000.

4.4. Water Quality Evaluation of Formulations

Each type of formulation available for diazinon, chlorpyrifos, or both was reviewed to identify associated water quality issues. Water quality issues were identified on the basis of best professional judgment, using information from the literature (Evans, 1998; Cohen, 1986; Hong, 1997; Willis, 1980; Wauchope, 1978), personal experience with stormwater runoff and wastewater pollutant discharge pathways, label instructions for product applications, and discussions of problems associated with application of various formulations obtained from applicator training materials (University of Nebraska, undated, and University of Montana Extension Service, 2000).

Table 7 (on the next page) summarizes the findings of the formulations review. An individual analysis of each diazinon and chlorpyrifos formulation is provided in Appendix C. Formulations found to be of least concern are the bait-type formulations (gel/paste/cream and pellet/tablet/cake/briquet) and impregnated materials. The formulations that appear to be of greatest concern are concentrates, especially wettable powders.

4.5 Diazinon and Chlorpyrifos Product Inert Ingredients

Common types of inert ingredients in pesticides include:

- Adjuvants, which are a special class of inert ingredients that increase the effectiveness of the active ingredient and make application easier and/or safer. Most pesticide formulations contain at least a small percentage of adjuvants. Many of the types of inert ingredients on this list may serve as adjuvants.
- Wetting agents (surfactants), some of the most common adjuvants, alter the dispersing, spreading, and wetting properties of spray droplets or wettable powders.
- Solvents to dissolve the active ingredient into a stable liquid form. These are often petroleum-based solvents; however, water can also serve as a solvent for some pesticides.
- Carriers like clay powder, talc, chalk, ash, or clay, corn, or walnut granules or pellets to facilitate handling of the pesticide.
- Stickers help a pesticide stay on the treated surface (improve the weatherability), particularly from washing by rainfall or irrigation.
- Synergists greatly increase the activity of insecticides by blocking the ability of the insect to break down the insecticide.
- Penetrants help active ingredients penetrate the surface to which the pesticide is applied. Penetrants are used to increase uptake of herbicides into a plant.
- Buffers decrease breakdown of a pesticide caused by exposure to acidic or alkaline water conditions and allow pesticides to be mixed with diluents or other pesticides of different acidity or alkalinity.
- Attractants (like food) to draw pests to bait.
- Emulsifiers allow petroleum-based pesticides to mix with water.
- Invert emulsifiers allow water-based pesticides to mix with petroleum carrier.
- Foaming agents and thickeners reduce drift by foaming or by increasing droplet size.
- Safeners reduce the toxicity of a pesticide formulation to the pesticide handler or to the treated surface.
- Compatibility agents aid in combining two or more pesticides.

Table 7. Summary of Water Quality Review of Diazinon and Chlorpyrifos Formulations

Water Quality Issue	Formulations
Mixing: equipment cleaned after use, potential errors in application rates, need for handling increases chance of spills	Emulsifiable Concentrate Aqueous (Liquid) Concentrate Wettable Powder Suspension Flowable Concentrate Microencapsulated (some products)
Application equipment: generally cleaned after use	Emulsifiable Concentrate Aqueous (Liquid) Concentrate Wettable Powder Suspension Flowable Concentrate Paint/Coating Microencapsulated (some products)
High active ingredient concentration: spills, misuse, and dumping of particular concern	Emulsifiable Concentrate Aqueous (Liquid) Concentrate Wettable Powder Suspension Flowable Concentrate
Designed to facilitate suspension or dissolution of active ingredient in water: may be easily washed off application site by water	Emulsifiable Concentrate Aqueous (Liquid) Concentrate Solution/Liquid (Ready-To-Use) Wettable Powder Suspension Flowable Concentrate (some products)
Small unit of pesticide-containing material: pesticide-containing unit is small enough that it is likely to be washed off of application site (possibly to receiving waters) by water	Dust/Powder Wettable Powder Suspension Flowable Concentrate Granular/Flake Microencapsulated
Pressurized spray or shaker applications: may deposit a significant fraction of the pesticide off-target	Dust/Powder Pressurized Liquid/Spray/Fogger*
Pesticide-containing unit with long-term release design: unit may be transported off site while continuing to release active ingredient	Granular/Flake Microencapsulated

Note: Other (Dry) and Other (Liquid) formulations are omitted from this table as products with these formulations are only for manufacturing and formulating other products.
*The one oil product is a spray so it is included in the Pressurized Liquid/Spray/Fogger category.
Source: TDC Environmental evaluation of diazinon and chlorpyrifos formulations.

- Anti-foaming agents reduce foaming of spray mixtures that require vigorous agitation.
- Tiny plastic beads to microencapsulate a pesticide.

Tables 8 and 9 summarize and Appendix C, Tables C-1 and C-2 list the inert ingredients identified as being present in one or more diazinon (Table C-1) or chlorpyrifos (Table C-2) products. A total of 33 diazinon product inert ingredients and 75 chlorpyrifos product inert ingredients were identified and evaluated. As expected, the types of inert ingredients depended on the product formulation (*e.g.*, solvents in aerosol sprays and surfactants in emulsifiable concentrates and wettable powders).

Table 8. Diazinon Inert Ingredient Overview

Product Type	Examples of Inert Ingredients Identified	Uses of Inert Ingredients Identified
Aerosol	Isobutane, Propane, Hydrotreated light petroleum distillates	Propellant, Solvent
Powder	(All unnamed)	Carrier, Dispersant, pH adjustment, Surfactant
Granule	Paper, Magnesium carbonate	Carrier
Liquid	Xanthan gum, Floral rose perfume, Capsules of crosslinked polyamide-polyurea, Phosphoric acid, Sodium hydroxide, Ethylenediamine hydrochloride, Aromatic petroleum hydrocarbons, Water, 5-Chloro-2-methyl-4-isothiazolin-3-one	Emulsion stabilizer, Fragrance, Microencapsulating agent, pH adjustment, Preservative, Solution stabilizer, Solvent

Source: Information in Appendix C.

Table 9. Chlorpyrifos Inert Ingredient Overview

Product Type	Examples of Inert Ingredients Identified	Uses of Inert Ingredients Identified
Bait	Sweetener (unnamed), Vegetable-based food-grade material (unnamed)	Attractant, Preservative
Powder	Kaolin clay, Talc, Calcium silicate, Lignosulfonic acid, sodium salt	Carrier, Wetting agent, Dispersant, Surfactant
Granule	Paper, Clay, Corn cob	Carrier
Liquid	Epoxidized linseed oil; Dimethicone; Dodecylbenzenesulfonic acid, calcium salt; Hydrocarbon solvents; Water; Dodecylphenol ethoxylate	Binder, Defoamer, Emulsifier, Fragrance, Solvent, Surfactant
Paint	Hercules X-158, Tamol 850, Flexbond 325, Wollastonite NYAD 400, Rhoplex AC-507, Opitwhite, Ethylene glycol, Potassium tripolyphosphate, Hydrocarbon solvents, Water	Color, Dispersant, Durability enhancer, Filler, Latex resin, Pigment, Preservative, Rust inhibitor, Solvent, pH adjustment, Viscosity control agent

Source: Information in Appendix C.

The tables in the appendix provide the type of product that contained the identified ingredient, and the likely use of that ingredient, based on the ingredient's chemistry and its use in similar products (identified from chemical vendor information available on the

internet). Some of the identified inert ingredients are contaminants or preservatives brought by other inert ingredients into the formulation. Insufficient information was available to classify uses at a great level of detail.

4.6 Water Quality Evaluation of Inert Ingredients

The available information about specific inert ingredients in diazinon and chlorpyrifos products suggest that there are four major issues to consider with regards to water quality:

- Inert ingredients may be water pollutants. For example, hydrocarbon solvents and chlorinated solvents are water pollutants. Inert ingredients may also decompose to form water pollutants.
- Inert ingredients may contain water pollutants as contaminants or additives. For example, certain Kaolin clays contain elevated levels of dioxins and furans (Ferrario, 2000), isothiazoline biocides often have copper stabilizers, and mixed hydrocarbon solvents usually contain aromatics like benzene and naphthalene.
- Inert ingredient may facilitate transport of active ingredient to surface waters. As discussed in the previous section, wetting agents (surfactants) and emulsifiers may facilitate dissolution of active ingredients into water like storm water runoff. Certain carriers, like fine particles or the tiny capsules used to microencapsulate a pesticide may be sized such that physical transport of the particle-bound pesticide is facilitated. Fine particles (those less than about 50 microns in diameter, and especially those less than 0.45 microns in diameter) are quite mobile in the environment, including in storm water runoff.
- Inert ingredients may reduce transport of active ingredient to surface waters. For example, stickers help a pesticide say on the treated surface, which should reduce off-site transport of the active ingredient. A probable sticker is epoxidized linseed oil, which forms a coating on a surface after application.

Insufficient information is available to evaluate the potential significance of each of these four issues for inert ingredients in diazinon and chlorpyrifos products. Unlike active ingredients, inert ingredients are not typically evaluated by regulatory agencies for individual or formulation-related environmental effects. For the first two of the four major issues listed above (that relate to specific ingredients), evaluation would require information about ingredient concentrations, application rates, and environmental fate and transport of the ingredients. For the latter two issues, investigation of the environmental fate and transport of active ingredients in various formulations would provide needed information.

5.0 USAGE SUMMARY

Characterization of the relative significance of various diazinon and chlorpyrifos uses requires consideration of the amount of pesticides applied, as well as where they are applied and what formulation is used. Unfortunately, available usage information does not directly correlate to the sites of use described above, and completely omits formulation information. Despite these limitations, California diazinon and chlorpyrifos usage information is probably the best available in the United States.

This section summarizes diazinon and chlorpyrifos usage information, including quantitative usage estimates from USEPA, California reported pesticide use, and surveys of pesticide users, stores, markets, and sewer discharges. Since none of these data sources provide details of applications at specific sites of use, product label instructions and application equipment were also reviewed.

All data is this section is expressed in terms of amount of active ingredient, not amount of formulated product.

5.1 Quantitative Usage Data for Diazinon

National Usage Data

From 1987 through 1996, annual average total national diazinon usage was about 6 million pounds; usage increased to about 13.5 million pounds in 1999. Table 10 shows USEPA's breakdown of total national diazinon use. According to the data, about 75% of national diazinon use is in urban areas. Table 11 (on the next page) provides details for non-agricultural uses, the majority of which are outdoor home and garden uses. Since the USEPA did not revise its estimates to reflect the recent increase in diazinon usage, Tables 10 and 11 do not reflect usage pattern changes that may have occurred when usage increased.

Table 10. Estimated National Diazinon Usage
(Based on Usage Rate of 6 Million Pounds Per Year)

User	Amount (Pounds)	Percent
Homeowners, outdoors	2,340,000	39%
Professional lawn care companies	1,140,000	19%
Pest control operators indoors and outdoors	660,000	11%
Agricultural uses	1,520,000	25%
Homeowner indoor & veterinary uses	341,000	6%
Total use	**6,001,000**	**100.00%**

Source: USEPA, January 29 1999.

California Usage Data

According to USEPA, California is one of the three highest usage states for diazinon. California has its own data collection system that provides significant information about diazinon use in the state. Unlike most states, California collects relatively detailed data

Table 11. Estimated National Non-Agricultural Diazinon Usage (Based on Usage Rate of 6 Million Pounds Per Year)

User	Amount (Pounds)	Percent of Non-Agricultural Use	Percent of Total National Use
Cemeteries	23,000	0.5%	0.4%
Educational facilities	84,000	2.0%	1.4%
Horticulture	192,000	4.5%	3.2%
Landscape contractors	33,000	0.8%	0.6%
Lawn care operators	1,135,000	26.3%	18.9%
Office/retail indoor by certified pest applicator	20,000	0.5%	0.3%
Office/retail outdoor by certified pest applicator	100,000	2.3%	1.7%
Outdoor by consumer	2,290,000	53.1%	38.2%
Parks	110,000	2.6%	1.8%
Pest control operators	621,000	14.4%	10.4%
Recreation outdoor by certified pest applicator	11,000	0.3%	0.2%
Residential indoor by certified pest applicator	149,000	3.5%	2.5%
Residential outdoor by certified pest applicator	716,000	16.6%	11.9%
Roadways	25,000	0.6%	0.4%
Wholesale/manufacturing indoor by certified pest applicator	11,000	0.3%	0.2%
Wholesale/manufacturing outdoor by certified pest applicator	13,000	0.3%	0.2%
Total of sites above (sites overlap)	*5,533,000*		
Total non-agricultural use	**4,480,000**	**100%**	**74.7%**
Total, all use	**6,001,000**		**100%**

Source: USEPA, January 29 1999.

regarding certain applications of pesticides. The following pesticide uses are required to be reported to the County Agricultural Commissioner, who, in turn, reports the data to DPR:

- for the production of any agricultural commodity, except livestock;
- for the treatment of post-harvest agricultural commodities;
- for landscape maintenance in parks, golf courses, and cemeteries;
- for roadside and railroad rights-of-way;
- for poultry and fish production;
- any application of a restricted material;
- any application of a pesticide with the potential to pollute ground water (listed in the California Code of Regulations, Title 3, Division 6, Chapter 4, Subchapter 1, Article 1, Section 6800 [b]) when used outdoors in industrial and institutional settings; and
- any application by a licensed pest control operator.

The primary exceptions to the use reporting requirements are home and garden use and most industrial and institutional uses (those by private applicators) (DPR, 2000).

DPR compiles the annual reports of pesticide use to provide statewide (and county-by-county) data on pesticide use. Table 12 summarizes reported uses of diazinon in California in 1999 and provides a detailed breakdown of reported urban uses. The vast majority of urban reported diazinon uses is for structural pest control (control of pests in and around buildings). According to DPR, these data are preliminary and may be amended or corrected when DPR completes its quality assurance reviews.

Table 12. California Reported Diazinon Usage, 1999

Site of Use	Amount (Pounds)	% of Urban Reported Uses
Food processing/handling plant/area (all/unspecified)	0.3	<0.01%
Fumigation, other	41	0.01%
Greenhouses	20	<0.01%
Landscape maintenance	20,566	5.61%
Public health pest control	33	0.01%
Regulatory pest control	45	0.01%
Rights of way	104	0.03%
Structural pest control	345,528	94.30%
Uncultivated non-agricultural areas (all/unspecified)	110	0.03%
Vertebrate pest control	0.7	<0.01%
Total, Urban Reported Uses	**366,400**	**100%**
Agricultural uses	554,400	
Total, All Reported Uses	**920,800**	

Source: DPR, September 2000; data are preliminary and subject to modification.

5.2 Quantitative Usage Data for Chlorpyrifos

National Usage Data

Nationally, USEPA estimated that about 20 million pounds of chlorpyrifos were used each year before the recent regulatory changes. Table 13 (on the next page) presents USEPA's breakdown of national chlorpyrifos use. Using data on sales and use patterns between 1987 and 1998, USEPA estimated that slightly more than half of chlorpyrifos use was in urban areas. Of that urban use, about half was for one use—structural pest control of subterranean termites. While USEPA did not provide detailed breakdown of urban uses, it indicated that other major non-agricultural uses include golf course and other turf applications, indoor uses, residential perimeter treatments, and use on ornamental plants.

California Usage Data

USEPA data indicate that California is among highest use states for chlorpyrifos. Table 14 (on the next page) summarizes 1999 reported uses of chlorpyrifos in California and provides a detailed breakdown of reported urban uses (non-reported uses, like home and garden uses, are not included in the table). As with diazinon, the majority of urban reported chlorpyrifos use is for structural pest control (control of pests in and around buildings). The other major reported urban use is for landscape maintenance. According to DPR, these data are preliminary and may be amended or corrected when DPR completes its quality assurance reviews.

Table 13. Estimated National Chlorpyrifos Usage

User	Amount (pounds)	Percent of Total Use	Percent of Non-Agricultural Use
Homeowners, outdoors	1,112,000	5.3%	10.3%
Application to turf (golf courses, turf farms, institutional turf, lawn care control operators, and landscape contractors)	2,519,000	12.0%	23.2%
Pest control operators for termite control	5,003,000	23.9%	46.2%
Pest control operators, for other uses (cockroaches, ants, fleas, and other general pests)	1,946,000	9.3%	18.0%
Mosquito Abatement Districts	29,000	0.1%	0.3%
Nursery/greenhouse	227,000	1.1%	2.1%
Agricultural uses	10,124,000	48.3%	--
Total use	**20,960,000**	**100.00%**	

Notes: Non-pest control operator indoor uses appear to have been omitted from USEPA's analysis; total includes turf farms, which are generally agricultural uses.
Source: USEPA, March 19 2000.

Table 14. California Reported Chlorpyrifos Usage, 1999

Site of Use	Amount (Pounds)	% of Urban Reported Uses
Buildings and structures (non-agricultural outdoor)	16	<0.01%
Food processing/handling plant/area (all/unspecified)	0.5	<0.01%
Fumigation, other	0.02	<0.01%
Greenhouses	2	<0.01%
Landscape maintenance	158,187	23.01%
Ornamental turf	2,042	0.30%
Public health pest control	78	0.01%
Regulatory pest control	267	0.04%
Rights of way	444	0.06%
Structural pest control	526,298	76.57%
Uncultivated non-agricultural areas (all/unspecified)	15	<0.01%
Vertebrate pest control	0.02	<0.01%
Total, Urban Reported Uses	**687,300**	**100%**
Agricultural uses	1,518,100	
Total, All Reported Uses	**2,205,400**	

Source: DPR, September 2000; data are preliminary and subject to modification.

5.3 Surveys of Diazinon and Chlorpyrifos Usage in California

The quantitative data presented in the previous sections provide an overview of diazinon and chlorpyrifos uses in urban areas, but do not provide much information about residential uses. Even for reported uses, available quantitative data lack details regarding sites of use, application methods, and formulations. In recent years, three California surveys investigated non-agricultural uses of diazinon and chlorpyrifos, focusing on consumers who purchase and apply pesticides themselves. Additional information is provided by two studies: a joint investigation by DPR and the Central Contra Costa Sanitary District (CCCSD) into releases of diazinon and chlorpyrifos to the CCCSD sewer system (Singhasemanon, 1997) and a professional pest control operator market survey conducted for the City and County of San Francisco (Uribe & Associates, 1999). This section provides a summary of the findings of these five surveys and studies.

Consumer User and Retailer Surveys

Despite the different locations and methods of the three California surveys of consumer pesticide users, the results are remarkably consistent. Appendix D contains summaries of the three California surveys that provide the best currently available information about diazinon and chlorpyrifos residential use patterns and behaviors.

Table 15 summarizes locations where homeowners in San Diego and Alameda County reported applying insecticides.[6] The most common application location was around the foundation of the house (structural pest control), followed by garden (landscaping) applications. While the fraction of respondents reporting each homeowner application location is higher in the Alameda survey than in the San Diego survey, the location lists shown in Table 15 are remarkably consistent.

Table 15. Insecticide Application Sites Reported in Residential Surveys

Location	% San Diego Respondents Reporting Such Applications	% Castro Valley, Alameda County Respondents Reporting Such Applications
Around building foundations	48%	74%
In the garden	33%	50%
On trees or shrubs	30%	41%
On a patio or walkway	22%	48%
On the lawn	22%	30%
Inside the house	18%	NR
On the sides or eaves of house	9%	NR

NR – Not reported
Sources: URS Greiner Woodward Clyde, August 10 2000; Scanlin, September 1997.

All three surveys found that ants were the most common target pest for insecticides, and that summertime is the major application period. On the basis of the surveys, a relatively short list of large retailers appear to dominate pesticide sales (by volume)—

[6] The third survey did not include a survey of residential pesticide applicators.

Home Depot, Costco, Orchard Supply Hardware, Home Base, Target, Wal-Mart and K-Mart. The surveys all found that Ortho is the most common pesticide retail brand.

Central Contra Costa Sanitary District Discharge Survey

In 1996, DPR and Central Contra Costa Sanitary District (CCCSD) surveyed sewer discharges of diazinon and chlorpyrifos into CCCSD's sewer system (Singhasemanon, 1997). The survey evaluated releases from residential areas, certain commercial facilities (pet groomers and kennels) and professional pest control operator facilities.[7]

Most of the diazinon and chlorpyrifos releases to CCCSD's sewer system came from residential areas. This finding is not surprising, given that 82% of CCCSD's flow comes from residences, and USEPA data presented above (see Sections 5.1 and 5.2) indicate that more than half of diazinon and chlorpyrifos use is at residences. It is notable that sewer discharges of diazinon appear to be relatively significant given that a relatively small fraction of diazinon is believed to be applied indoors. These data suggest that discharges associated with post-application cleanup by residential applicators and dumping have the potential to be meaningful.

Commercial facility discharges and sewer discharges from pest control operator facilities comprised a relatively small fraction of the measured releases; however, these discharges equaled or exceeded the sewer flow fraction for the two segments, suggesting that discharges from commercial facilities and pest control operators are either more concentrated or more frequent than those from residences. The report noted that additional commercial release sources not included in the study were likely.

For both diazinon and chlorpyrifos, highly variable sewer discharge concentration data suggest that discharges involved discrete events. For diazinon, such events could involve (but not be limited to) treatment of interior drains, post-application cleanup by applicators, dumping, or discharges from post-application washing of treated surfaces (*e.g.*, carpets). For chlorpyrifos, a similar range of discharge sources is possible; discharges from use of chlorpyrifos-containing pet shampoo (which was legal at the time) would also have contributed to observed pulse discharges.

San Francisco Pest Control Operator Market Survey

The City and County of San Francisco surveyed the market for professional pest control operator (PCO) services in San Francisco (Uribe & Associates, 1999). The marketplace characterization, summarized in Table 16 (on the next page), focused on the potential on identifying the non-residential PCO client base, finding that restaurants are the largest market for PCOs. Additionally, interviews with institutional and government staff identified instances of applications by unlicensed personnel. While the survey did not quantify what fraction of each facility type might use professional pest control services or otherwise apply pesticides, it reveals the nature of potential non-residential urban sites of use for diazinon and chlorpyrifos.

[7] This survey pre-dates the termination of many indoor uses of chlorpyrifos (notably pet shampoo uses), which may significantly affect interpretation of the chlorpyrifos results.

Table 16. San Francisco Pest Control Operator Market Survey

Facility Type	Approximate Number in San Francisco
Restaurants	2700
Office Buildings	80+
Commercial Linen Services	5
Bars, Clubs, Cocktail Lounges	420
Hotels/Motels	640
Pet Kennels/Groomers	45
Veterinary Clinics & Hospitals	45
Grocery & Convenience Stores	490
Bakeries	230
Industry/Warehouses	Not estimated
Schools (K-12)	240
Universities & Technical Colleges	47
Hospitals & Health Centers	20
Convalescent Homes	30
Parks	227
Golf Courses	8
Airports	1
Rights-of-Way	1000+ miles

Source: Uribe & Associates, 1999.

5.4 Product Label Review

Product labels typically provide fairly detailed instructions for mixing, application, and cleaning up after application. Product labels were reviewed with two purposes: (1) to identify instructions regarding applications of particular concern for water quality; and (2) to understand instructions for use of commonly used products.

The product label review was undertaken in two separate phases. The first phase of the review was to review labels for all products on the lists of diazinon and chlorpyrifos products registered for application to urban sites where discharge to surface water is likely (Appendix A, Table A-4 and Appendix B, Table B-4). Table D-1 in Appendix D highlights the typical and notable label instructions identified with regards to application sites that involve direct or indirect, but inevitable discharges to surface waters (products listed in Tables A-4 and B-4).[8]

For drainage system and bathroom sites, instructions simply called for spray application of the pesticide. Carpet application instructions varied; some called for thorough coverage of the carpet, while others suggested focusing application on edges and undersides. Two types of sewer-related uses were noted for chlorpyrifos products: (1) applications directly into drains inside premises being treated and (2) application in sewer manholes. Both such drain applications generally call for spray application; for

[8] About half of these labels were obtained from USEPA and other Internet sources where it was impossible to verify whether the label might differ from the California label. Since the most recent label was used in all cases, since only California-registered products were reviewed, and since no case of a California-specific label for any of these products was identified, the chance that use of these data sources introduced erroneous information is judged to be small.

sewer manholes, instructions call for application of quantities of up to a pint of product (usually a paint) per manhole (about 10 grams of chlorpyrifos per manhole).

The second phase of the label review involved reviewing labels for a wide range of products, focusing on products likely to be commonly used in urban areas, which were obtained through an in-store review (see Appendix D for details). To ensure that a reasonable range of products was included (including products for urban professional applicator use), the in-store review was supplemented by reviewing a random selection of additional labels obtained from manufacturer and USEPA Internet sites. A total of about 40 diazinon product labels and 20 chlorpyrifos product labels were reviewed in detail.[9] Many product labels contain similar or identical language.

Individual containers with the largest amount of active ingredient were liquid concentrates (both diazinon and chlorpyrifos), bags of granules (diazinon) and paint (chlorpyrifos). The concentrates are notable because of their relatively small size, low viscosity, and large amount of active ingredient—spills of such containers in the wrong location (*e.g.,* a gutter) could easily release the entire amount of active ingredient to surface water. Appendix D, Tables D-2 and D-3 provide a summary of the observed product container sizes, formulations, and active ingredient content.

Outdoor uses were the primary uses described on product labels; few products had indoor use instructions. Among outdoor diazinon and chlorpyrifos uses, both above-ground structural and lawn care uses had similar application rates (for diazinon, about 40 to 50 grams of active ingredient per 1000 square feet; for chlorpyrifos about 10 to 45 grams of active ingredient per 1000 square feet); however, structural pest control applications typically called for use of a more concentrated application solution than used for lawn applications. Chlorpyrifos structural or fence post protection uses involving underground trenching had relatively high application rates, calling for applications of as much as 700 grams of active ingredient per 100 lineal feet of structure. Appendix D contains a summary of common and notable label instructions on diazinon and chlorpyrifos products (see text and Tables D-4 and D-5).

The mixing instructions on many products called for use of odd fractional amounts of the pesticides and required the user to estimate the application area. Some diazinon granule bags did not provide application rates; they only gave spreader settings. These factors make highly variable application rates likely.

Post-application cleanup directions often specify cleaning with water, but typically do not provide instructions for managing wastewater. Often, labels call for wrapping the pesticide container in paper prior to putting it in the trash.

5.5 Application Equipment

Application equipment was also briefly reviewed during the store visits. For liquids, common application equipment available for sale included hand sprayers with and without wands, backpack sprayers and hose end sprayers. For solids, various spreaders were available. For dusts, a simple canister and pump was identified. The observed equipment correlates well with common application equipment identified by

[9] Chlorpyrifos products have become increasingly difficult to find, which limited the label review to some extent.

USEPA in diazinon and chlorpyrifos risk assessments: hand held low-pressure handwand, hand-held high pressure handwand, hose-end sprayer, aerosol can, push-type spreader, dust box, bulbous duster, shaker can, belly grinder, and sprinkler can. USEPA also identified equipment probably only used by professionals: aerial sprayer, tractor-drawn granular sprayer, airblast sprayer, hydraulic hand-held sprayer, large tank sprayer, and compressed air sprayer (USEPA, August 2000; USEPA, November 16 2000).

Modern equipment for application of liquids includes markings or settings to simplify measurement of the pesticide into the container. Modern hand and push spreaders provide settings to control the amount of material that is applied. These conveniences greatly increase the odds that a residential user will apply the correct amount of a pesticide. Unfortunately, such settings and conveniences are not present on older equipment that may commonly be found in residences.

Interestingly, the stores did not have pesticide-measuring devices prominently displayed. This finding is of concern because many product labels called for mixing of rather odd amounts (*e.g.*, 1 ¾ oz., 1 ½ tsp), particularly of liquid pesticides.

A significant fraction of the observed pesticide containers provided a mechanism for direct delivery of the pesticide to the application site. Those mechanisms included shaker holes in the tops of small containers of granules and dusts, hose end connectors, and spray nozzles on liquid formulations. One product included a liquid measurement device integrated into its container that facilitates measurements of up to 2 fluid ounces of the liquid concentrate. Such mechanisms eliminate the need for a separate piece of application or measurement equipment.

6.0 SOURCES AND PATHWAYS FOR PESTICIDE RELEASE TO SURFACE WATERS

Once used, various pathways are available for a pesticide to reach surface waters. This section explores the available pathways for urban diazinon and chlorpyrifos releases to surface waters using three different methods. The three methods—Fault Tree Analysis, Event Tree Analysis, and What If? Analysis—are adapted from methods used to analyze accidental releases of hazardous materials. The major adjustment made in the methods was to include consideration of deliberate use of the pesticide chemical as well as releases resulting from likely misuse and accidents. Each method has unique strengths and weaknesses. Together, use of the three methods in combination provides an overall picture of the possible pathways for pesticide releases to surface waters.

The Fault Tree and Event Tree Analyses use deductive techniques that involve similar, but opposite approaches. In Fault Tree Analysis, the analyst works backward from a potential release location to identify deliberate and accidental actions that could cause a chemical release to that location. An Event Tree Analysis works forward from an activity to explore potential chemical releases as a result of that activity. Both methods involve consideration of a flow of materials, which makes them especially applicable to consideration of releases to surface waters. Due to the flow-related emphasis of these analyses, the results are most readily presented graphically, in flowcharts.

The strength of the Fault Tree Analysis is that it identifies all potentially significant pathways for pesticide releases to surface waters. The analysis effectively looks upstream and up pipes to investigate what release sources are available. While this approach is relatively comprehensive in its identification of pathways, it does not provide a comprehensive look at activities that might release pesticides into the identified pathways. The Fault Tree Analysis in this report is relatively generic in nature—as such, it should be useful for looking at urban sources of many other insecticides.

The Event Tree Analysis in this report evaluates common urban uses of diazinon and chlorpyrifos (based on information in the previous section) to explore pathways that may connect pesticides released from those uses to surface water. The strength of this analysis is its ability to link specific use-related activities to specific types of releases of pesticides to surface waters. The weakness of this analysis is that it can be quite lengthy. Since a comprehensive evaluation of all possible uses of diazinon and chlorpyrifos would be lengthy, the analysis focuses on the most common uses of the two pesticides as identified in the California insecticide user surveys described in Section 5.3. The analysis looks primarily at storm water runoff and wastewater pathways, since available information (USEPA, August 1999; Bailey, 2000; Hansen, 1995; Santa Clara Valley Urban Runoff Program, 1995; Woodward Clyde, 1995; Katznelson, 1997; Russick, 2001; USEPA, May 12 1999) suggest that these are the primary release pathways to surface waters. While this analysis is not completely generic, the common uses of diazinon and chlorpyrifos are very broad, and therefore the analysis is likely to encompass common urban uses of most insecticides.

In contrast to the Fault Tree and Event Tree Analyses, the What If? Analysis is a word-based exercise that involves postulating a series of questions about potential diazinon and chlorpyrifos uses, misuse, and accidents (such as what if a material is applied on a manhole cover? What if it rains after a lawn is treated with a granular product? What if

a residential applicator cleans up concentrate measuring and mixing equipment with water?). In this report, the What If? Analysis is used to explore specific diazinon and chlorpyrifos sites of use, specifically considering whether unique or unusual sites or circumstances (those not considered in the Event Tree Analysis) have the potential to cause relatively significant surface water releases of diazinon or chlorpyrifos. Since the lists of sites of use are rather lengthy, the analysis groups the sites into categories for convenience and to avoid redundancy. The strength of this method is that it offers great flexibility to quickly explore a range of possible events and their general consequences. The method's weakness is that it can create a rather overwhelming set of possible pesticide release scenarios.

To interpret the numerous outcomes of the What If? Analysis, the many identified pesticide release scenarios were grouped by common modes and consequences to create "Master Scenarios." In this case, the seven Master Scenarios identified through the What If? Analysis were checked against the outcomes of the Fault Tree and Event Tree analyses to ensure the completeness of the scenario list. As the next section explains, Master Scenarios provide a useful and potentially powerful tool for understanding the relative significance of the wide variety of urban activities that may release pesticides to surface waters.

General Approach

To ensure that the analysis considers diazinon and chlorpyrifos when used in accordance with widespread and commonly recognized practice, this evaluation looks at both legal use (including mixing and post-application cleanup) and reasonably anticipated misuse, dumping, and accidents. Since uses of diazinon and chlorpyrifos are relatively similar (within the scope of this analysis), the two pesticides are considered together for purposes of this section. (From a water quality perspective, the important differences in sites of use between diazinon and chlorpyrifos have previously been elicited and described in the Sites of Use analysis in Section 3.)

The analyses in this section incorporate the following assumptions:

- Releases from spills during any activity would follow the same pathways as releases from application, mixing, and post-application cleanup activities.
- Pesticide uses and releases at a wastewater treatment plant (exclusive of incoming wastewater) are similar to and would follow same pathways as industrial and stormwater releases.
- Pesticides released in the air and then deposited on a surface would behave the same as pesticides released directly onto that type of surface.
- Pesticide releases from off gassing of stored products are assumed to be minor and are not specifically addressed.

In addition, these analysis methods ignore fates for pesticides other than those fates that may directly or indirectly involve release of the pesticide to surface water (*i.e.*, fates like degradation, binding to soil, and releases to groundwater are not considered.)

Since all of these analytical methods rely heavily on the knowledge and experience of the investigator (and the What If? Analysis involves a brainstorming type of activity), technical peer review of the release scenarios was conducted to ensure the completeness of the analysis. For this project, the technical peer review was provided

by the project Technical Peer Review Committee,[10] a small group of experts in surface water quality, storm water runoff, wastewater discharge and treatment systems, and pesticide use.

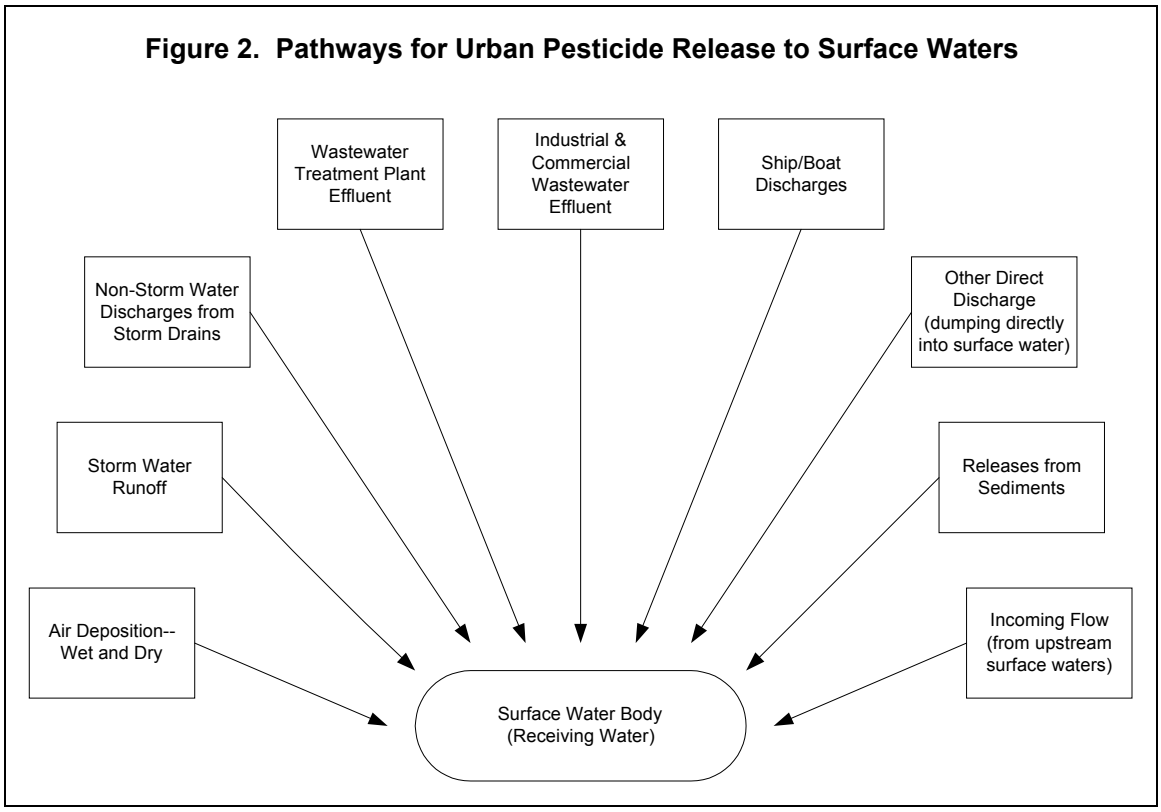
6.1 Fault Tree Analysis

The Fault Tree Analysis seeks to identify potential urban inputs of diazinon and chlorpyrifos to surface waters. It works back from the surface waters, via the various inputs to surface waters, to the common urban pesticide uses, misuses, and accidents that might cause pesticides to reach surface waters. While the Fault Tree analysis attempts to identify all major pathways for pesticide releases to surface waters, it does not include all possible release sources—those are better addressed by the What If? Analysis.

The master flow chart for the Fault Tree Analysis, Figure 2, provides the overall set of possible pathways for urban pesticide releases to surface waters. Separate charts (Appendix E, Figures E-2 through E-8) identify significant sources for releases via seven of the pathways shown in Figure 2. For the other two pathways, no detail charts are provided:

- Other Direct Discharges (dumping direct into surface water)—no further explanation of the illegal activity of dumping a pesticide container into surface water is needed.

Figure 2. Pathways for Urban Pesticide Release to Surface Waters



[10] The Technical Peer Review Committee Members, whose assistance was invaluable, are listed inside the front cover of this report.

- Incoming Flow (from upstream surface waters)—since a plethora of sources is possible, analysis of upstream releases was not feasible. Depending on the nature of upstream watersheds, upstream releases from both agricultural and non-agricultural activities would be possible.

Several possible release sources are omitted from the flowcharts because they were not considered potentially significant sources of pesticide releases under most circumstances:

- subsurface flows,
- septic tank leaks,
- sanitary system overflows, and
- exfiltration from sewers and storm drains into soil, which is then carried by surface or subsurface flows to surface water.

Data Sources

The identification of pathways to surface water was verified by comparing with analyses prepared for two Total Maximum Daily Load (TMDL) analyses (California Regional Water Quality Control Board San Francisco Bay Region, December 6, 2000 and June 30, 2000). The wastewater system evaluation relied on the evaluation of Central Contra Costa Sanitary District's (CCCSD's) system conducted by CCCSD and DPR (Singhasemanon, 1998).

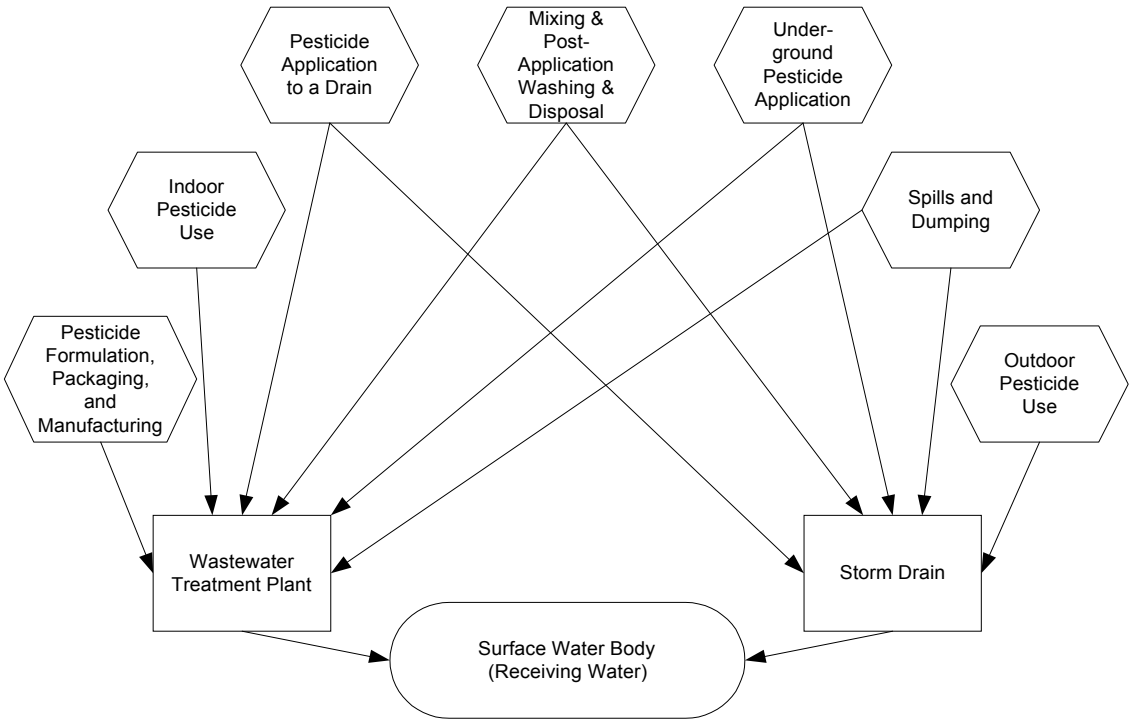
6.2 Event Tree Analysis

The Event Tree prepared for the project seeks to identify major pathways for pesticides to reach surface water from common uses and other releases of diazinon or chlorpyrifos in urban areas. It works from the event of using or otherwise releasing a pesticide into the urban environment, and then seeks to determine the potentially major routes by which that pesticide could reach surface waters. As mentioned above, this Event Tree Analysis focuses on the most common uses of the two pesticides as identified in the California insecticide user surveys described in Section 5.3. Label information summarized in Section 5.4 and the brief application equipment review in Section 5.5 further informed the analysis.

The summary flowchart for the Event Tree analysis, Figure 3 (on the next page), is intended to delineate the common uses, misuses, and accidents involving diazinon and chlorpyrifos in the urban environment and to show the general pathways for flow of the pesticides to surface waters through sewer and storm drain systems. The remaining charts (Appendix E, Figures F-2 through F-8) explore the possible pathways available to connect major uses to releases of diazinon and chlorpyrifos to surface waters.

The Event Tree analysis focuses on the major pathways between point of use or release and surface water—pathways involving storm drains and sewer systems. Minor pathways relating to sewer and storm drain releases (like indirect discharges via landfills or septic system leaching, or pathways that involve human or pet transfer of pesticides from outdoors to indoors or vice versa) were omitted. Other pathways for pesticide transport to surface waters—particularly air deposition—may be important for the environmental fate of some pesticides. For the most part, air transport and subsequent deposition of a pesticide simply changes the location (and possibly the surface) from

Figure 3. Major Pathways from Common Urban Diazinon and Chlorpyrifos Uses to Surface Waters



which the pesticide is released into a surface water pathway. Since air transport of pesticides released in every location may transfer active ingredient to almost every other location, it would be impossible to show the transport and deposition pathways clearly on the flowcharts. Therefore, the flowcharts do not address air transport and deposition.

Data Sources

The list of actions considered in the Event Tree analysis was compiled from the information presented in Section 5. The most important data sources were information on product labels (regarding application location and application instructions) and product use information from sales and use surveys.

6.3 What If? Analysis

Unlike the other two analysis, the What If? Analysis specifically looks at diazinon and chlorpyrifos uses. Each site of use is grouped with other very similar sites (*e.g.*, all ornamental landscaping plants, all interior uses in commercial and industrial buildings) to facilitate analysis and to avoid redundancy. The analysis uses a verbal, brainstorming approach to identify potentially important surface water release pathways from each site of use. The analysis also explores potential releases from mixing, post-application cleanup, accidents (spills), and dumping. The major focus of the What If? Analysis was to explore unique or unusual, but potentially significant circumstances that were not considered in the Event Tree Analysis.

The lists of sites of use for diazinon and chlorpyrifos presented in Appendices A and B (Tables A-1 and B-1) are the lists considered in the What If? Analysis. Sites were grouped on the basis of best professional judgment, looking primarily at the physical similarity of the various sites and secondarily at the interaction of water (rain, wastewater, cleaning water and other water discharges) with the site. The sites of use considered in the What If? Analysis fall into the following categories:

- landscape applications,
- structural pest control,
- other outdoor applications,
- indoor applications,
- applications to pets, and
- sewer applications.

Appendix G, Table G-1 provides the categorization of the sites of use. Due to their nature, several sites are included in more than one category:

- All sites of use for structures that include both interior and exterior uses were included in both the structural pest control and indoor applications categories.
- "Ant dens/hills/mounds (in/out-door) (all/unspecified)" (site 90011) and "Apply directly to pest: no site specified" (site 67502) were included in both the indoor and landscaping categories.

Additional categories were included to consider releases from activities not associated with specific sites of use:

- mixing and post-application cleanup, and
- accidents and dumping.

Using information from the label review (Section 5), certain actions or specific application locations within sites of use that might be of special interest were identified (based on professional judgment) and included in the What If? Analysis in an effort to ensure that the analysis considered unique or unusual potentially significant uses not considered in the Event Tree Analysis.

Due to the nature of outdoor pesticide releases to surface water, many actions that release pesticides to surface water do so in two steps: (1) the use of the pesticide and (2) subsequent washing of a portion of the pesticide into surface water. The analysis includes consideration of the additional events (*e.g.*, rain, washing or other water flow) that are needed to carry the pesticide to surface water. In addition to rain, non-storm water discharges like water washing of outdoor surfaces (*e.g.*, hosing down paths and driveway or high-pressure cleaning of walls, decks, and patios), and over watering of landscaping (that leads to runoff) are common activities that are capable of providing a pathway for carrying diazinon or chlorpyrifos to surface water.

The results of the What If? Analysis are presented in Appendix G, Tables G-2 through G-9.

6.4 Master Scenarios

Use of the Fault Tree, Event Tree, and What If? analyses generated several dozen possible scenarios for release of diazinon and chlorpyrifos to surface water in urban areas. These scenarios have many similarities, which allow them to be grouped by

common modes and consequences. The goal of master scenario development is to group together similar types of releases into the shortest possible generic list of actions that does not omit potentially important uses or release pathways. Grouping to create generic master scenarios allows further focused analysis of releases.

The What If? Analysis formed the basis of Master Scenario development. The What If? Analysis results were reviewed and categorized into groups with common elements. Using the physical nature of the location where the pesticide was released as the common element allowed creation of a manageable list of generic release conditions, which became the Master Scenarios. The preliminary scenarios were first checked against all portions of the What If? Analysis to ensure that all release situations were included (note the Master Scenario column in Tables G-2 through G-9). Then, the scenarios were reviewed against the Fault Tree and Event Tree analyses, again to ensure that all situations were included in the master list.

Table 17 (on the next page) presents the identified Master Scenarios for environmental releases of diazinon and chlorpyrifos. The Master Scenarios are scenarios for uses or other releases of a pesticide to the environment. Similarity of pathways for releases to surface water was the major reason for grouping releases into one master scenario. All pathways for transport of diazinon or chlorpyrifos—including air transport—should be considered in future analyses of any Master Scenario.

Table 17. Master Scenarios: Diazinon and Chlorpyrifos in Urban Areas

Name	Description
Direct release to surface water	A pesticide is applied or is directly released (from misuse, an accident, or dumping) to surface water like a drainage channel, creek, marsh, or the shore of a river, bay, or the ocean.
Storm drain release	A pesticide is applied or is directly released to a storm drain (from misuse, an accident, or dumping). The storm drain flows directly to a surface water body like a creek, river, bay, or the ocean.
Sewer release	A pesticide is applied or is directly released (from misuse, an accident, or dumping) to a drain connected to a sewer system. The drain flows to a sewage treatment plant, which treats the water prior to its discharge to a river, bay, or the ocean.
Outdoor impervious surface release	A pesticide is applied or is directly released (from misuse, an accident, or dumping) to an outdoor hard surface. A subsequent event, like rain, may wash the pesticide into a storm drain or directly into a surface water body. Some of the pesticide may evaporate, after which it may be: (1) transported to another outdoor surface (from which it may be subject to future release), (2) collected by rain water (which then flows into a storm drain), or (3) deposited directly or by rain into a surface water body.
Plant or soil release	A pesticide is applied or is directly released (from misuse, an accident, or dumping) to outdoor plants (such as turf, trees, or ornamental vegetation) or soil. A subsequent event, like rain, may wash the pesticide into a storm drain or directly into a surface water body. Some of the pesticide may evaporate, after which it may be: (1) transported to another outdoor surface (from which it may be subject to future release), (2) collected by rain water (which then flows into a storm drain), or (3) deposited directly or by rain into a surface water body.
Indoor release	A pesticide is applied or is directly released (from misuse or an accident) indoors. The treated indoor item or surface is subsequently cleaned with water, with a solution that is disposed of down a drain, or with tools (like sponges, cloths, and mops) that are later washed with water.
Underground release	A pesticide is applied or is directly released (from misuse or an accident) underground. The application solution may flow into a sewer or storm drain lateral or into a neighboring surface water body (like a creek) at the time of application. Subsurface water flows after application may wash the pesticide to a sewer or storm drain lateral or into a neighboring surface water body (like a creek).

7.0 EVALUATION OF THE RELATIVE POTENTIAL FOR DIAZINON AND CHLORPYRIFOS RELEASES TO SURFACE WATER FROM VARIOUS SITES OF USE AND FORMULATIONS

This section explores the potential for releases to surface water quality associated with various uses of diazinon and chlorpyrifos, building on the concepts developed in previous sections. As the previous sections have described, application of diazinon and chlorpyrifos at certain sites of use is more likely to release the applied pesticide to surface water than applications at other sites of use. Similarly, available data regarding runoff from applications of various pesticide formulations suggests that applications of certain diazinon and chlorpyrifos product formulations may be more prone to releasing the applied pesticide to surface water than application of other product formulations.

The analysis in this section is qualitative in nature, reflecting the weight of existing evidence. This analysis is intended to assist with the setting of priorities for future activities by DPR and others—it is not intended to make regulatory determinations, which are the purview of DPR and the State and Regional Water Quality Control Boards.

The analysis in this section addresses two of the factors (site of use and formulation) influencing the amount of active ingredient that may be released to surface water from a pesticide application. These factors are the focus of this report because they are general and are controllable with mechanisms not available for control of individual applications. Many other factors influence surface water releases from pesticide applications. For example, the relationship of application to storm events is critical to runoff fraction—if a significant rain event occurs soon after application, three or more times as much pesticide may run off than would have run off under “normal” conditions (Wauchope, 1978). Pre-application and post-application irrigation both tend to increase pesticide runoff, apparently because saturated soils generate a greater quantity of runoff, and thus increase the volume of flow from the irrigated application site during a rain event (Evans, 1998).

7.1 Data Sources

The analysis in this section relies heavily on information regarding the relative amount of diazinon and chlorpyrifos released to the environment, which is summarized in Section 5. Data regarding the fraction of applied pesticide that is released to surface waters was obtained from the literature and supplemented with professional judgment. For the most part, available data do not include the air transport pathway, which means that the data likely understate potential releases. Although the available information is limited, it is sufficient to support a screening level of analysis of sites of use.

Only colloquial information regarding the frequency of use of various formulations was identified and little data exist comparing runoff from various formulations. Available information is sufficient to allow a very limited risk screening by product formulation.

7.2 Significance Grid—An Evaluation Tool

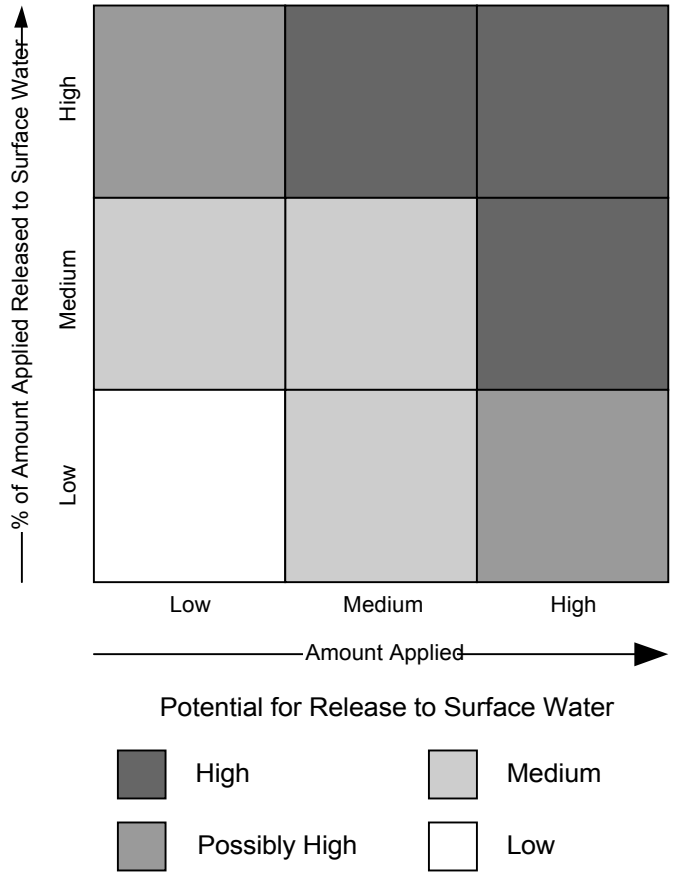
The potential for surface water releases associated with a particular type of pesticide release depends not only on where the pesticide is released, but also on what fraction of the pesticide is released to surface water, and how much (total) of the pesticide is

released. A tool from hazards analysis—the significance grid—provides a convenient method of evaluating the relationship of these two factors and identifying situations that have the greatest potential to release pesticides to surface water. The USEPA publication *Technical Guidance for Hazards Analysis* (USEPA, 1987) defines the significance grid method. The significance grid is a convenient tool for relating two factors to identify risk priorities. In hazards analysis, the significance grid is used to identify facilities in a community with the greatest potential for a harmful release of hazardous substances. This commonly used method provides a convenient way to organize two sets of related environmental information to screen specific activities for the relative potential for environmentally meaningful releases.

The relationship of the fraction of a pesticide released to surface water and the amount of the pesticide applied at the site of use to the relative potential for a pesticide release to surface water can be expressed by a 9-square significance grid, with one axis representing the fraction of the amount applied that is released to surface water, and the other axis representing the total amount of pesticide released under the scenario being evaluated (see Figure 4). Within the grid, four levels of relative potential for releases to surface water are assigned. With sufficient information, the grid can be used to screen the potential for surface water pesticide releases.

Using the significance grid method requires defining terms on each axis. These definitions are necessarily arbitrary, even when based on impartial criteria. Ideally, it would be possible to link the definitions to specific environmental outcomes (*e.g.*, toxicity of surface waters to laboratory test species); however, lack of data precludes such direct linkages. Instead, a conservative approach was used to avoid underestimating potential for releases. Given that toxicity tests indicate that certain aquatic species are particularly sensitive to diazinon and chlorpyrifos yet diazinon and

Figure 4. Evaluation of Potential for Pesticide Releases to Surface Water



chlorpyrifos are among the nation's most heavily used urban pesticides, a conservative approach seems appropriate.

Definitions for the fraction of the amount applied that is released to surface waters were selected on the basis of similar definitions in the literature (*e.g.*, Wauchope, 1978; Capel, February 2001; and Capel, May 2001 all refer to releases greater than 2% as catastrophic) and recognition that estimates indicate that release fractions of 0.5% or less may be sufficient to create environmental levels of diazinon and chlorpyrifos in surface water that have been linked to toxicity in laboratory tests (*e.g.*, Cooper, 1996 and Lee, 1999). The definitions selected were:

- High—2% or more of released pesticide may reach surface water.
- Medium—0.1% to 2% of released pesticide may reach surface water.
- Low—less than 0.1% of released pesticide may reach surface water.

Studies have shown that the application rate of a pesticide active ingredient is roughly proportional to the amount removed by storm water runoff, all other factors being equal (Wauchope, 1980; Capel, May 2001). This report assumes that this correlation is true for all pathways for surface water releases—in other words, when more active ingredient is applied, more is available for potential release to surface waters. The following definitions were used:

- High—Uses and other releases reported by one or more sources as exceeding 10% of all use of the pesticide. Includes uses cited as common in non-quantitative user surveys.
- Medium—Uses and other releases reported by one or more sources as exceeding 1% of all use of the pesticide. Includes uses and releases documented in non-quantitative user surveys.
- Low—Use or other release not mentioned by USEPA, DPR, or surveys.

Again, looking at the relatively high toxicity and major use of the two pesticides, a conservative approach was deemed appropriate and was therefore applied in the assignment of the above definitions.

Sections of the 9-square grid were assigned potentials for surface water releases on the basis of the following definitions:

- High—Involves common applications that release a high fraction of the applied pesticide to surface waters. On the basis of available information, such releases could potentially be large enough to cause environmental effects in receiving waters. Further investigation is recommended.
- Possibly High—Involves high use/low release or high release/low use conditions. For pesticides with high aquatic toxicity like diazinon and chlorpyrifos, such releases may be environmentally significant under certain conditions (*e.g.*, when the pesticide is released to a small surface water body or when the release is to a surface water that is effectively small because of limited dilution). Further investigation is recommended.
- Medium—Involves moderate releases to surface waters; environmental effects are possible. Further investigation should be considered.
- Low—Uncommon pesticide releases resulting in transfer of only a small amount of the pesticide to surface waters. Such releases are unlikely to be large enough to cause pesticide-related environmental effects in surface waters. Further investigation is probably unnecessary.

7.3 Sites of Use Evaluation

Evaluating the potential significance of releases from each individual site of use would be a tedious process—and one that would not be possible with current data on pesticide uses, which do not break out applications on individual sites of use. Analyzing similar sites together simplifies the analysis, while providing the opportunity to elicit the cumulative importance of certain types of releases that might individually be relatively unimportant. In the previous section, Master Scenarios were developed that encompassed all diazinon and chlorpyrifos releases. Because they are generic in nature, yet differentiated on the basis of properties important to water quality analysis, the master scenarios provide a convenient tool for consideration of potential impacts of various pesticide releases in the urban environment.

Tables 18 and 19 (on the next two pages) and Figure 5 (which summarizes the information in Tables 18 and 19) present the evaluation of the potential for diazinon and chlorpyrifos releases to surface water for the Master Scenarios, using a weight of evidence approach. Based on available information, outdoor impervious surface releases, plant or soil releases, and sewer releases should be high priorities for further investigation.

Figure 5. Evaluation of Master Scenarios for Potential for Pesticide Releases to Surface Water

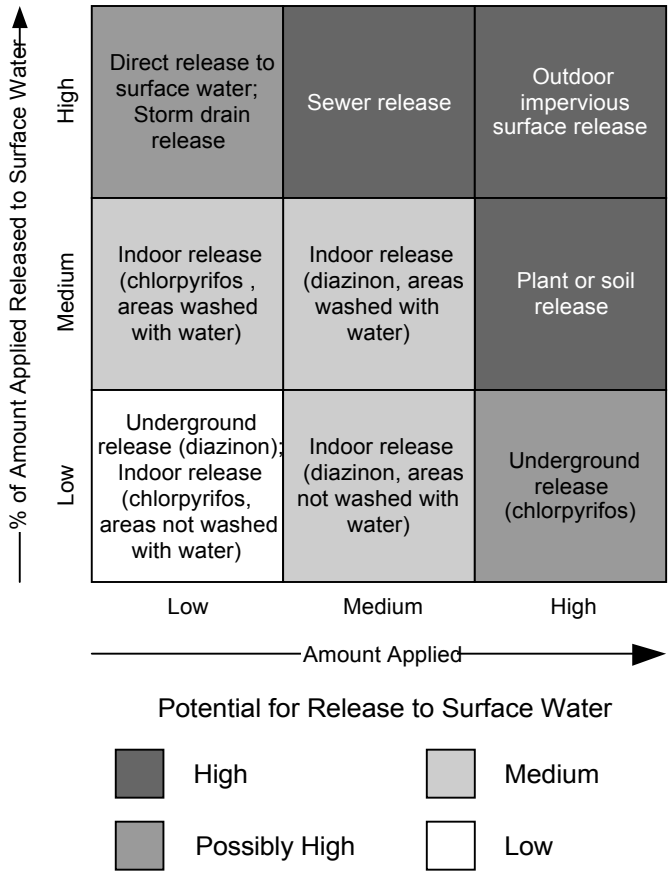


Table 18. Master Scenarios—Weight of Evidence Estimate of Amount of Pesticide Applied

Scenario	Information Available to Estimate Amount Applied	Rating
Direct release to surface water	While direct applications to surface water were listed on diazinon product labels, and dumping into surface waters is possible for both pesticides, none of the available data sources identified the amount of diazinon and chlorpyrifos released directly to surface waters.	*Low*
Storm drain release	Dumping of pesticides or wastes from post-application cleanup into storm drains is possible; however, none of the available data sources attempt to estimate the amount of diazinon and chlorpyrifos released in this manner. Since samples from well-studied storm drain discharges tend to have relatively consistent diazinon and chlorpyrifos concentrations (rather than highly variable concentrations indicative of event-based releases), dumping is believed to be infrequent (Scanlin, June 30 1997).	*Low*
Sewer release	While sewer uses are not called out in any of the available survey data, the frequency with which such uses appear on product labels and the fact that USEPA has brought sewer system uses back for chlorpyrifos at the request of manufacturers suggest that such uses may occur with relative regularity. The CCCSD sewer survey indicates relatively frequent variable discharges, suggesting that post-application cleanup and dumping also occur with some regularity.	*Medium*
Outdoor impervious surface release	Outdoor applications for structural pest control are among the most common uses (see Section 5). A large fraction of these applications would occur on impervious surfaces (building walls, driveways, patios, decks, and walkways).	High
Plant or soil release	The other most common diazinon and chlorpyrifos application is application to landscaping (see Section 5).	High
Indoor release	Manufacturers voluntarily removed most indoor uses of chlorpyrifos from product labels in the late 1990s. While certain uses identified in this report remain, data presented in Section 5 suggest that such uses are relatively low. For diazinon, USEPA estimates that 6% of diazinon use is indoors, and the CCCSD survey indicates that sewer discharges likely occur from indoor releases at commercial facilities and residents.	Low (chlorpyrifos) Low or Medium (diazinon)
Underground release	According to USEPA, almost half of urban chlorpyrifos use is to control termites in structures—such applications are typically (but not always) underground applications. For diazinon, usage data do not call out underground uses, and label directions do not commonly include such uses, so the amount released in this manner is likely to be low.	High (chlorpyrifos) Low (diazinon)

Note: *Italics* indicate that the rating is highly uncertain.
Source: TDC Environmental evaluation of available information.

Table 19. Master Scenarios—Weight of Evidence Estimate of Fraction of Applied Pesticide Released to Surface Waters

Scenario	Information Available to Estimate Fraction of Amount Applied Released to Surface Water	Rating
Direct release to surface water	With direct application to surface water, 100% of the active ingredient is released.	High
Storm drain release	No studies were found that evaluate the fraction of a pesticide applied to a storm drain that is released from a storm drain into a surface water body. Since residence times in storm drain systems are typically short, removal processes like sediment uptake, evaporation or decomposition, are unlikely to remove large fractions of a pesticide from a discharge.	High
Sewer release	A study of San Francisco Bay area sewage treatment plants found an average of 15% of diazinon in wastewater treatment plant influent flow remains in plant effluent (range 2 to 36%). The same study found that an average of 45% of chlorpyrifos in sewage treatment plant influent flow was released in plant effluent (range 11 to 100%) (Chew, 1998). Data from the USEPA Permit Compliance system show a mean release efficiency of 74% diazinon entering sewage treatment plants (USEPA, November 16, 2000).	High
Outdoor impervious surface release	Only one study evaluating pesticide runoff from an outdoor impervious surface was identified (Scanlin, 1997). While that study found very high levels of diazinon in runoff from paved surfaces (up to 1 mg/l), it did not quantify releases nor estimate the fraction of applied material that was removed by the runoff. In the revised risk assessment for diazinon, USEPA noted its opinion that runoff from outdoor impervious surfaces may be significant: "Diazinon applied in urban and suburban environments is often applied to impervious surfaces such as driveways, sidewalks, patios, and home foundations. Although some photodegradation will occur, since there is little microbial activity on these surfaces most is available for wash-off and evaporation" (USEPA, November 16, 2000). A study of pesticide wash off from coated glass plates provides the only other identified relevant information. In that study, a simulated 25 mm rainstorm removed essentially all of the applied diazinon (Cohen, 1986).	*High*
Plant or soil release	About 1% of diazinon applied to turf has been found to run off (Sudo, 1992 and Evans, 1998). This data is consistent with an estimate that about 1% of applied water insoluble pesticide quantity runs off an agricultural field (Wauchope, 1978). Previous studies have found that runoff from turf and runoff from agricultural sites are similar in terms of the percent of active ingredient removed in runoff (Evans, 1998).[11]	Medium
Indoor release	No literature was identified that specifically evaluated release of diazinon or chlorpyrifos to the sewer from indoor releases of the pesticides. A study of food-handling establishments established that interior applications of diazinon and chlorpyrifos resulted in detectible levels on surfaces other than the target surface, and found diazinon and chlorpyrifos residues on interior surfaces up to 6 months after applications (Leidy, 1985). For uses in locations not cleaned with water, the potential for release is probably low, since pathways for release would be limited. The length of residue persistence indoors, together with the likelihood that active washing would remove more of a pesticide from a surface than would be removed by rain or other passive washing, together suggest that medium removal levels are possible.	Low (not washed with water) Medium (washed with water)
Underground release	While no literature specific to underground applications of diazinon or chlorpyrifos was identified, an analysis of pesticide runoff from agricultural fields concluded that about 0.0031% of soil-incorporated pesticides were lost in surface runoff (Capel, May 2001). For chlorpyrifos, the USEPA identified several incidents where structural pest control was linked to a fish kill in a nearby stream; however, it is unclear whether any of these incidents involved underground injection. According to USEPA, such incidents will be prevented if revised label language is followed (USEPA, June 2000).	Low

Source: TDC Environmental evaluation of available information. Note: *Italics* indicate that the rating is highly uncertain.

[11] This analysis relies on the most applicable data available, which involve measurements of runoff relatively near the application site (test plot, golf course, or field). These studies were deemed most applicable because urban discharges usually travel relatively short distances prior to encountering storm drains.

7.4 Formulation Evaluation

Insufficient information is available to provide a full evaluation of potential significance of various diazinon and chlorpyrifos formulations. This section compiles available information to identify data gaps and to determine where limited available data suggest priorities for future research.

A significant limitation in available data regarding pesticide formulations is that it rarely differentiates among the various similar pesticide formulations. This is particularly a problem for liquid pesticide formulations. Chemically, a liquid emulsifiable concentrate is completely different than an aqueous concentrate; however the specific type of liquid formulation is rarely noted in the literature, particularly in consumer surveys.

Fraction of Applied Pesticide Released to Surface Waters

Available data clearly indicate that pesticide formulation affects the amount of active ingredient that is released from the application site by storm water runoff. Unfortunately, a review of the literature did not identify any systematic investigation of the relationship of formulation type to runoff. Some individual investigations comparing two formulations exist in the literature; it should be noted that all but one of these investigations involved runoff from fields (none looked at applications to impervious surfaces).

Only one study specifically addressed the effect of formulation on diazinon runoff; no such studies were identified for chlorpyrifos. The diazinon study compared runoff of liquid and granular diazinon formulations from turf test plots. The investigators found that the quantity of diazinon in runoff from application of a liquid formulation was twice the quantity of diazinon in runoff from application of a granular formulation. Based on these results, the researchers speculated that the difference might be due to the slow-release nature of the granules and the presence of emulsifiers in the liquid (apparently an emulsifiable concentrate formulation) that facilitate re-dissolution of diazinon in runoff (Evans, 1998). In another investigation of the environmental fate of diazinon, the researchers noted, “[c]ommercial formulations of many insecticides, by the fact that they contain various surfactants, may be expected to exhibit more severe washoff behavior” (Cohen, 1986).

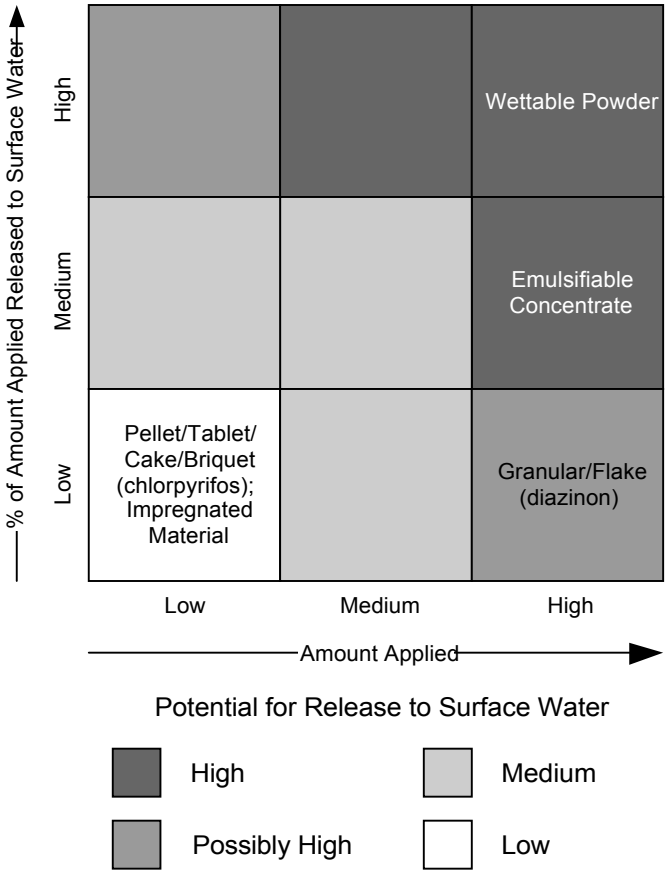
A few other studies compared one formulation to another. A study of dithiopyr granule compared to emulsifiable concentrate applications found results similar to the diazinon study described above (Hong, 1997). Another study found that emulsifiable concentrates were more resistant to removal by rain than dusts or wettable powders, perhaps because the emulsifiable concentrate formulation is capable of penetrating vegetation surfaces (unlike powders, which sit on the surface) (Willis, 1980). A literature review compiled information showing some consistency in runoff fractions of various pesticides in the same formulation. The reviewer found that water insoluble pesticides applied in emulsion formulations runoff more than water-soluble pesticides; he also concluded that about 2% of the active ingredient from a typical wettable powder application would be carried off the application site by storm water runoff (Wauchope, 1978). Another reviewer suggested that as much as 5% of the active ingredient in wettable powder formulations run off of the application site in storm water (Evans, 1998).

Amount Applied

Retail store shelf surveys compiled for this project found that the most common product types were ready to use liquids, liquid concentrates (primarily emulsifiable concentrates), and granules (diazinon only). USEPA did not provide quantitative data regarding use of various formulations; however, its diazinon risk assessment stated that wettable powders, granules, and emulsifiable concentrates were the most common formulations nationally (it did not differentiate urban and agricultural uses, nor did it provide similar information for chlorpyrifos) (USEPA, November 16, 2000).

Figure 6 summarizes available information for evaluating the significance of various diazinon and chlorpyrifos formulations (all information in this figure is relatively uncertain). Insufficient information was available to evaluate the following formulations: aqueous (liquid) concentrate, solution/liquid (ready-to-use), dust/powder, suspension, flowable concentrate, granular/flake (chlorpyrifos), paint/coating, microencapsulated, pressurized liquid/spray/ fogger. Based on the very limited information, it appears that wettable powder, emulsifiable concentrate, and diazinon granular formulations should be priorities for further investigation.

Figure 6. Evaluation of Formulations for Potential for Pesticide Releases to Surface Water



8.0 CONCLUSIONS AND RECOMMENDATIONS

This section presents the conclusions of this report and recommendations for future activities. It also identifies major data gaps, limitations, and errors and identifies recommended actions to address the identified deficiencies.

8.1 Conclusions

Conclusion 1: Diazinon and chlorpyrifos applications to impervious surfaces and applications of wettable powders appear to have the greatest potential to release the applied pesticide to surface water.

Diazinon and chlorpyrifos applications or other releases to outdoor impervious surfaces are the most likely to release these pesticides to surface water. Applications or other releases to plants or soil and sewer releases also have a relatively high potential for release of pesticides to surface water. The relative potential for releases from the following uses is possibly high: direct release to surface water, storm drain releases, and underground release of chlorpyrifos. (Section 7.3)

On the basis of relatively limited available information, wettable powders appear to be the formulation with the greatest potential to release diazinon and chlorpyrifos to surface water. Emulsifiable concentrates also have a high potential for release to surface water and granules (diazinon only) were found to have a possibly high potential for release. To better assess the runoff potential for five diazinon and 14 chlorpyrifos formulations, additional information regarding the amounts used and their runoff potential is needed. (Section 7.4)

On the basis of USEPA public notices through March 22, 2001, it is anticipated that USEPA agreements with registrants will phase out all urban sites of use for diazinon that are likely water quality issues, but 28 chlorpyrifos urban sites of use found to pose likely water quality issues will remain active. (This conclusion is subject to change based on future USEPA regulatory activity). (Section 3.7)

Conclusion 2: Both the formulation characteristics and the specific inert ingredients used in diazinon and chlorpyrifos products contribute to the potential that these pesticides may be released to surface water. An additional water quality issue is that some inert ingredients are water pollutants.

The water quality review of formulations identified seven formulation properties that increase the potential for a pesticide to be released to surface water: (1) need for mixing; (2) need for application equipment; (3) high active ingredient concentration; (4) design that facilitates suspension or dissolution of active ingredient in water; (5) small particle or other unit of pesticide-containing material that may easily be washed off application sites; (6) pressurized spray or shaker applications that deposit a significant fraction of the pesticide off-target; and (7) pesticide containing particle or other unit with long-term release design that may be transported off application sites by water. On the basis of these issues, the following formulations have the greatest potential to facilitate pesticide releases to surface water: wettable powders, suspensions, flowable concentrates, emulsifiable concentrates, and aqueous concentrates. (Section 4.4)

Review of readily available information from USEPA regarding specific inert ingredients in diazinon and chlorpyrifos products identified four issues for water quality (Section 4.6):

- Inert ingredients may be water pollutants.
- Inert ingredients may contain water pollutants as contaminants or additives.
- Inert ingredient may facilitate transport of active ingredient to surface waters.
- Inert ingredients may reduce transport of active ingredient to surface waters.

Conclusion 3: While available data are of sufficient quality to support the analysis in this report, certain data gaps and limitations added uncertainty to portions of the analysis.

The most important data gaps, limitations, and errors are listed below.

- Data on reported uses of pesticides in California do not break out applications by the sites of use listed in the DPR Product/Label database. This limits the ability to evaluate the amount of a pesticide applied on certain sites of use. For example, applications to sewer manholes—a reportable application—are not broken out in DPR's reports of pesticide use.

- Because pesticide applications by residents and private applicators at residences, industrial sites, and institutions do not require reporting, available data on such applications are limited. Surveys fill some of this gap; however, surveys are generally limited (both geographically and by user type) and have limited accuracy, since they are based on the memories of survey respondents who are generally not pesticide experts. Certain user types have not been surveyed (*e.g.*, private applicators at industrial and institutional sites).

- Available data do not break out pesticide sales or applications by formulations. To the extent that formulation-specific information is available, it rarely differentiates among various liquid or powder formulations, even though these formulations may be very different chemically.

- While pesticide runoff from agricultural fields is well studied and several studies have explored runoff from turf, no publications were identified that explored runoff from pesticide application to impervious surfaces.

- Very little data exist that relate pesticide formulation to releases in runoff. The relationship of pesticide formulation to runoff has only been explored for a limited set of pesticide formulations, and only in the agricultural setting.

Conclusion 4: The highly useful DPR Product/Label database contains some errors.

Quality assurance steps included in the methodology identified and corrected certain errors in DPR's Product/Label database. Given the relatively large number of products reviewed during this study, relatively few errors were identified. The errors were identified from quality assurance reviews of the USEPA-approved product labels. The errors identified were inaccurately recorded product sites of use and formulations. The identified errors, which are noted in the report (in Sections 3 and 4), do not affect the quality of the analysis.

8.2 Recommendations

Recommended Investigations and Actions

Recommendation 1: Conduct screening-level modeling of Master Scenarios in a well-characterized watershed.

Quantitative mathematical modeling of pesticide releases in a model watershed would provide a quantitative estimate of the potential contribution from each release scenario to pesticide levels in surface water. Screening-level modeling is recommended to identify potentially significant releases for more detailed investigation. A model currently being developed by Alameda County (with financial support from DPR) may be appropriate for this purpose. At a minimum, the modeling should address those uses identified in this study as high priorities for future investigation: diazinon and chlorpyrifos applications or other releases to outdoor impervious surfaces, plants or soil, and the sewer system.

With a screening-level model, it would be possible to estimate the order of magnitude of diazinon or chlorpyrifos release under each Master Scenario that would create toxicity in receiving waters in the modeled watershed and to conduct a sensitivity analysis to evaluate the relative importance of changes in each release scenario. Adding pesticide use information to the model would provide a method to estimate typical and maximum concentrations of pesticides in the model watershed's receiving surface water (which could be compared to levels of concern) and would provide an opportunity to validate the model with monitoring data from the modeled watershed.

Recommendation 2: Review pesticides registered for sites of use that involve direct or inevitable discharge to surface waters to identify the potential for linkage to surface water quality issues.

In recent years, urban pesticide use has been found to cause or contribute to several surface water quality problems. Examples of currently registered products implicated in such problems include diazinon, chlorpyrifos, copper-based root control products, tributyltin cooling water additives, copper-based algaecides, and biocides used on ships and boats. A proactive review of pesticides that are most likely to be released to surface waters would assist state agencies with future work planning, and would provide opportunities to identify voluntary response strategies or to fill data gaps before a problem develops.

Recommendation 3: Investigate water quality implications of alternatives to diazinon and chlorpyrifos.

In response to the upcoming phase-out of most urban uses of diazinon and chlorpyrifos, use of other pesticides is likely to increase. State and Federal agencies should consider identifying and investigating likely common alternatives to diazinon and chlorpyrifos to determine whether increasing their use may create water quality issues. Priorities for investigation include pesticides that may be applied to sites with the highest potential to release pesticides to surface water (outdoor impervious surfaces, plants or soil, and sewer systems). Investigations should also address alternatives to recently phased out

chlorpyrifos products like pet shampoos. Early identification of issues would provide opportunities for voluntary and market-based actions to prevent development of water quality problems.

Recommendation 4: When pesticides are registered or re-registered, evaluate all proposed sites of use and consider the environmental effects of each product's formulation.

As this report shows, certain sites of use and certain product formulations have relatively high potential to release a pesticide to surface waters. Urban sites of use are not generally reviewed carefully during product registration—for example, the USEPA did not review the environmental effects of sewer manhole uses of chlorpyrifos in its re-registration process (USEPA, August 2000). A thorough review of sites of use and formulations at the time a pesticide is registered or re-registered would provide an opportunity to identify and prevent potential water quality problems associated with pesticide use.

Recommendation 5: Modify product labels and containers to simplify mixing, application, and post-application washing and disposal procedures and to strengthen surface water protection elements.

While certain product labels and containers contain clear, simple instructions and excellent instructions and warnings to protect surface water from releases, other labels are problematic, calling for mixing of odd fractional amounts of pesticides, or instructing users to wash up with water without telling the user how to manage the resulting wastewater (see Appendix D-3). Certain containers incorporate measuring or delivery devices, greatly simplifying application procedures. If all labels and containers were modified to incorporate the elements in the best labels, it is likely that unintentional pesticide releases would be reduced. (Label modifications require USEPA approval.)

Recommendation 6: DPR should consider separating sewers and storm drains into two separate sites of use.

One of the DPR coded sites of use includes both sewers and storm drains. Discharges to these two sets of pipes have very different transport pathways, since discharges to sewer systems receive treatment by a wastewater treatment plant prior to discharge to a surface water body, while storm drain discharges typically flow directly to surface water without treatment. Creating two separate sites of use would recognize the differences in these pathways.

Recommendations Regarding Data Gaps, Errors, and Limitations

Recommendation 7: Obtain additional information regarding the fate and transport of pesticides applied on urban sites of use.

Although extensive research has been conducted regarding the environmental fate and transport of pesticides applied to agricultural sites, relatively few studies have addressed the environmental implications of pesticide applications in urban settings—and most of these studies relate to pesticide uses on turf (Evans, 1998).

DPR is currently sponsoring two sets of studies that should begin to fill this significant data gap. In Irvine, the Irvine Ranch Water District and the Southern California Coastal Water Research Project are investigating diazinon and chlorpyrifos in runoff from various urban land use categories. At California State University, Fresno, the Center for Irrigation Technology is developing a generic method and suitable equipment to conduct diazinon runoff studies under simulated rainfall/irrigation conditions and differing environmental conditions. This latter study will focus on runoff from turf and other bare soil and vegetated surfaces and will explore the effect of diazinon formulation on runoff.

Recommendation 7.1: Conduct studies to quantify the fate and transport of pesticides applied to impervious surfaces.

Among the most common urban insecticide sites of use are outdoor impervious surfaces. Data regarding the portion of such applications lost in storm water and non-storm water urban runoff are essential to evaluating the environmental significance of these widespread uses. Additionally, many indoor impervious surfaces are subject to treatment. Data regarding the portion of such applications lost in cleaning activities are needed to evaluate significance of such uses, which probably release pesticides to sewage treatment plants. Test plot studies using methods similar to those used for agricultural and turf studies could provide information in a manner comparable to data from other sources. With funding from DPR, Alameda County is currently conducting what may be the first controlled investigation of pesticide runoff from impervious surfaces.

Recommendation 7.2: Conduct studies to better quantify the role that air transport plays in the environmental transport of pesticides to surface water.

Despite diazinon's and chlorpyrifos' relatively low vapor pressure, studies cite significant volatilization of diazinon from surfaces, particularly in the presence of water, which may enhance volatilization (USEPA, November 16 2000; Cohen, 1986; Whang, 1993). Available data suggest that wet deposition may be a significant pathway for diazinon and chlorpyrifos transport (Russick, 2001; Katznelson, 1997). One researcher noted (Whang, 1993):

> "Post-application volatilization of pesticides and subsequent atmospheric transport is a primary means by which pesticides may be dispersed throughout the general environment. It is the source of pesticides found in air, rain, or fog that indicates local, regional, and global transport."

More information is needed to include this transport pathway in environmental fate and transport models. DPR is planning to fund studies to address aerial transport of pesticides in urban areas. Test plot evaluations would provide data in a manner comparable to data from other sources.

Recommendation 8: Obtain an understanding of the relationship of pesticide formulation to water quality.

While the fate and transport of pesticide active ingredients are studied relatively thoroughly during the pesticide registration process, the affects of formulation on transport and environmental impacts of pesticide use are not well documented.

Recommendation 8.1: Conduct studies to determine the relationship between formulation and environmental transport of the active ingredient in a pesticide.

The limited available information suggest that both the physical and chemical properties of inert ingredients can alter the environmental transport of pesticides from application sites to surface waters. Test plot studies of commercial products with different formulations would provide data regarding the affect of formulation on runoff and on volatilization. Investigations should consider applications on urban site types, like impervious surfaces. The environmental transport properties of commonly used formulations are of the greatest interest and should be the priority for testing.

Recommendation 8.2: Investigate the potential water quality impacts from releases of inert ingredients.

Some inert ingredients may be water pollutants themselves, or may contain water pollutants. The potential significance of releasing these materials to the environment when a pesticide is applied is currently unknown.

Recommendation 8.3: Seek to identify formulations and application methods that minimize off-site transport of pesticides.

Certain formulations (like impregnated materials and baits), certain adjuvants (like "stickers"), and certain application methods (like soil incorporation) dramatically reduce the fraction of an applied pesticide than runs off when exposed to water. Use of pesticide products with properties that minimize off-site pesticide transport has the potential to reduce surface water releases of pesticides.

Recommendation 9: Collect additional data regarding urban uses of pesticides.

In a recent report, USEPA noted (USEPA, August 21 2000):

> "Compared to agriculture, the universe of non-agricultural pesticide use data is still quite sparse. As mentioned throughout this paper, data on pesticide use in non-agricultural sites – both residential and commercial – are important for refining risk assessments and management plans in the drinking water, environmental, and public health areas. . . . . Because pesticides are used on such a wide range of non-agricultural sites, EPA would greatly benefit from increased coordination among its stakeholders to find ways to collect and provide the Agency with use-related data in these sites."

Recommendation 9.1: Collect quantitative data regarding urban pesticide use patterns, focusing on non-reported uses and sites of use that are likely water quality issues.

The importance of a particular pathway of release of pesticides to surface waters depends on both the fate and transport of pesticides flowing through that pathway and the total amount of pesticide applied at the originating site of use. Few data are available to document urban uses of pesticides like diazinon and

chlorpyrifos, creating great uncertainties in the evaluation of relative risks of various sites of use. More detailed quantitative information regarding use patterns—particularly for non-reported urban uses—is needed to pinpoint the highest risk uses. With funding from DPR, the University of California is conducting a pesticide sales and use survey in Southern California that will provide information on non-reported urban pesticide uses. DPR anticipates funding sales and use surveys in the San Francisco Bay Area, Central Valley, and Los Angeles. Among the greatest needs is information that can be linked to specific sites of use that are likely water quality issues (*e.g.*, applications to water, sewers, storm drains, urban impervious surfaces, and urban landscaping).

Recommendation 9.2: Monitor the State of Oregon's new pesticide use reporting system.

Under a legislative mandate, the State of Oregon is initiating a pesticide use reporting system designed to include the major urban uses not included in California's program (household uses and private applicator uses at industrial and institutional sites) (Rothlein, 2000). The Oregon program will also address pesticide uses that are currently reported in California. While the information collected regarding household and private applicator uses will not be specific to California, it is likely to be valuable in setting priorities for future California data collection activities.

Recommendation 9.3: Collect quantitative data regarding use (or sales) of pesticide formulation types.

Currently, no quantitative data are publicly available to define which pesticide formulations are most commonly used. Without this information, only a very limited assessment of the potential water quality significance of various formulations is possible. For urban areas, the highest priorities are identifying which formulations are the most commonly used and which formulations are frequently applied on the sites of use with greatest potential for release of pesticides to surface water (outdoor impervious surfaces, plants or soil, and sewer systems).

Recommendation 10: Track reported pesticide use using the same sites of use as are in the DPR Product/Label database.

DPR's annual summaries of pesticide use data (*e.g.*, DPR, 2000) index pesticide use by site in accordance with site descriptions that do not directly correlate with individual sites of use in the DPR Product/Label database. Unless reported sites of use either match the database sites of use or are cross-referenced to the database sites of use, the quantity of a pesticide applied to a specific site of use cannot be determined—even if all applications at the site are reported. The most important sites to record individually for water quality purposes are those sites that involve direct or inevitable discharge to surface water, such as water, sewer, and storm drain application sites.

Recommendation 11: Create a mechanism to identify and correct errors in the DPR Product/Label database.

This study identified differences between information on USEPA-approved product labels and product information recorded in the DPR Product/Label database. If a comprehensive quality assurance review of the database is impossible, it would be useful to provide a mechanism for database users to notify DPR of apparent errors in the database and for DPR to confirm and correct any errors.

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GLOSSARY AND ABBREVIATIONS

Active ingredient – Pesticide product ingredient registered to control the pest(s) that are the target of the product (*e.g.*, diazinon and chlorpyrifos)

Adjuvants - a class of inert ingredients that increase the effectiveness of the active ingredient and make application easier and/or safer

Best Management Practices - Feasible actions that, if taken, will minimize pollutant discharges to the sewer and storm drains

CAS# - Chemical Abstracts Service number (unique chemical identifying code)

CCCSD – Central Contra Costa Sanitary District

DPR - Department of Pesticide Regulation

EC – Emulsifiable Concentrate

FIFRA - Federal Insecticide, Fungicide, and Rodenticide Act

Formulation – Complete pesticide product, including active ingredient and all other ingredients

FQPA - Food Quality Protection Act

Inert ingredient – Pesticide product ingredients other than the active ingredient

K_{ow} – Octanol/water partition coefficient

MSDS – Material Safety Data Sheet

M.W. – Molecular weight

NPDES - National Pollutant Discharge Elimination System

PCO - Pest control operator

POTW - Publicly operated treatment works (sewage treatment plants)

Product Label – The label on a pesticide product offered for retail sale

ppt - Parts per trillion (nanograms per liter).

RED - Registration Eligibility Document

Regional Board - California Regional Water Quality Control Board

Site of use - Location where a pesticide may legally be applied

State Board - State Water Resources Control Board.

TMDL - Total Maximum Daily Load

USEPA - United States Environmental Protection Agency

WP – Wettable powder

APPENDIX A. DIAZINON SITES OF USE

Information in this appendix:

Table A-1. Comprehensive List of Urban Diazinon Sites of Use (171 Sites)

Site Code	Site Name	Site Code	Site Name
29510	Nurseries (All Or Unspec)	31284	Primrose
31000	Ornamental Herbaceous Plants (All Or Unspec)	31297	Succulents (All Or Unspecified)
31003	Ornamental Herbaceous Flowering Plants (All/Un)	31306	Velvetplant, Java Velvetleaf
31004	Ornamental Herbaceous Foliage Plants (All/Un)	31340	Arrowhead (Sagittaria Spp.)
31005	Ornamental Bulb, Corm, Rhizome Plants (All/Unspec)	31418	Aluminum Plant; Pilea Candierei
31011	African Daisy/Gazania/Gazania Longiscara	31450	Spider Plant; Chlorophytum Comosum
31012	African Violets/Saintpaulia	32000	Ornamental Plants (Herb. & Woody) (All Or Unspec)
31013	Ageratum/Flossflower/Pussy-Foot	32002	Ornamental Vines (Herb. & Woody) (All Or Unspec.)
31017	Alyssum (Gold-Dust; Goldentuft)	32501	Gardens (Ornamental, Flower, Rock, Shrub, Etc.)
31034	Begonia (Fiberous & Tuberous Rooted)	33005	Ornamental Grasses, Northern
31046	Cacti (Family Cactaceae)	33007	Turf, Golf Course (Fairways, Greens, Rough)
31057	Carnation	33008	Ornamental Turf (All Or Unspec)
31058	Celosia	33009	Ornamental Ground Covers (All Or Unspec)
31065	Chrysanthemum (Mum)	33010	Ornamental Lawns, Lawns (All Or Unspec)
31071	Coleus	33011	Ornamental Grasses
31095	Echinopsis (Cactus); Echinopsis Spp.	33028	Dichondra (Ground Cover)
31106	Garden Balsam/Balsam; Impatiens Balsamina	33044	Vinca (Ground Cover) (Periwinkle, Myrtle)
31108	Geranium	33112	Ivy (All Or Unspec) (Ground Cover)
31111	Gladiolus	33125	Sedum (Ground Cover) (Stonecrop)
31117	Gypsophila (Baby's Breath)	33128	Gazania (Ground Cover)
31122	Hoya (Variegated Hoya, Indian Rope Plant)	34000	Ornamental Shrubs (All Or Unspec) (Woody/Herb.)
31127	Jade Plant	34006	Ornamental Broadleaf Evergreen Shrubs
31136	Maranta	34007	Ornamental Deciduous Shrubs
31137	Marigold	34018	Aralia (Aralia Spp.)
31149	Pansies	34022	Azalea (Rhododendron Species)
31154	Petunias	34031	Boxwood (Box Tree) (Buxus Spp.)
31161	Marigold, Pot	34036	Camellia
31170	Sage, Ornamental/Scarlet; Salvia Spp.	34053	Euonymous
31190	Sedum, Stonecrop	34055	Feijoa (Pineapple Guava) (Feijoa Spp.)
31191	Strawflower	34058	Pyracantha (Firethorn)
31206	Verbena	34063	Gardenia
31213	Zinnia	34070	Holly (Yaupon) (Inkberry) (Ilex Spp.)
31228	Lily, Canna (Canna) (Canna Hybrids)	34072	Honeysuckle (Lonicera Spp.)
31267	Snakeplant; Sansevieria Trifasciata Prain.	34076	Ivy (Hedera)

Table A-1. Comprehensive List of Urban Diazinon Sites of Use (Continued)

Site Code	Site Name	Site Code	Site Name
34083	Lantana (Shrub Verbena) (Lantana Spp.)	35098	Pine; Pinus Spp.
34087	Leucothoe; Leucothoe Spp.	35099	Podocarpus; Podocarpus Spp.
34088	Ligustrum (Privet) (Ligustrum Spp.)	35101	Poplar (Populus Spp.)
34089	Lilac	35116	Spruce
34100	Heavenly Bamboo (Sacred Bamboo); Nandina Domestica	35119	Sycamore (Planetree) (Buttonwood) (Plantus Spp.)
34102	Oleander (Nerium Spp.)	35128	Willow (Salix Spp.)
34106	Pachysandra (Pachysandra Spp.)	35130	Yew (Taxus Species)
34109	Vinca (Photinia)	35136	Mimosa
34113	Pittosporum	39001	Ornamental Ferns (All Or Unspec)
34118	Rhododendron (Species/Hybrids/Cultivars) (Azalea)	39003	Ornamental Nurseries (Stock, Crops, Etc.)
34120	Rose	39005	Ornamental Plants - Greenhouse (All Or Unspec)
34130	Spirea (Spiraea Spp.)	40000	Soil Application (Ag-Crop, Orn-Plant Situations)
34134	Lilac (Syringa) (Syringa Spp.)	40008	Soil Application, Preplant-Outdoor (Seedbeds,Etc.)
35000	Ornamental And/Or Shade Trees (All Or Unspec)	40502	Soil Beneath Host Plants
35005	Ornamental Broadleaf Evergreen Trees (All/Unspec)	46000	Storage Areas & Processing Equipment (All/Unspec)
35006	Ornamental Deciduous Trees (All Or Unspec)	46027	Storage Areas - Full (All Or Unspec)
35007	Ornamental Conifers (All Or Unspec)	46028	Feed/Food Storage Areas - Empty
35008	Ornamental Flowering Trees (Fruit, Nut, Etc.)	46029	Feed/Food Storage Areas - Full
35028	Birch (Betula Spp.)	46502	Feed/Food Storage Areas (Unspecified)
35043	Dogwood (Ornamental)	46503	Non Feed/Food Storage Areas (Unspecified)
35044	Douglas-Fir (Pseudotsuga Spp.)	54000	Pets (All Or Unspec)
35049	Elm; Ulnus Spp.	54002	Cats (All Or Unspec) (Pet)
35051	Fir (True Firs) (Abies Spp.)	54003	Dogs (All Or Unspec) (Pet)
35056	Crabapple, Flowering (Ornamental); Malus=Pyrus Spp	56001	Animals (Unspecified)
35057	Dogwood, Flowering; Cornus Florida	56005	Horses (Race, Draft, Show, Riding, Etc.)
35060	Plum, Flowering (Ornamental); Prunus Spp.	61015	Greenhouses (In Use)
35070	Honeylocust (Gleditsia Spp.)	63000	Household Or Domestic Dwellings (All Or Unspec)
35073	Juniper; Juniperus Spp.	63001	Household Or Domestic Dwellings (Indoor)
35077	Locust	63003	Household Or Domestic Dwellings (Outdoor)
35083	Maple; Acer Spp.	64500	Wood Protection Treatments (All Or Unspecified)
35084	Cypress, Monterey (Cupressus Spp.)	64501	Lumber (Seasoned/Unseasoned)
35093	Oak (Quercus Spp.)	65013	Drainage Systems (All Or Unspec)
35097	Palm; Family Palmae	67000	Uncultivated Non-Ag Areas (All Or Unspec)

Table A-1. Comprehensive List of Urban Diazinon Sites of Use (Continued)

Site Code	Site Name	Site Code	Site Name
67002	Recreational Areas, Tennis Courts, Parks, Etc.	74000	Hospitals & Related Institutions (All Or Unspec)
67003	Buildings And Structures (Non-Ag Outdoor)	74016	Nursing Homes
67004	Highway Rights-Of-Way (Roadways, Curbs, Etc.)	74501	Hospital Critical & Semi-Critical Items (Combined)
67011	Paved Areas, Pre-Paving Applications	76000	Morgues, Mortuaries, Funeral Homes (All Or Unspec)
67012	Private Roads, Walkways, Lanes, Patios, Etc.	77000	Commercial, Institutional Or Industrial Areas
67013	Rights-Of-Way (Unspec) (Firelanes, Etc.)	77004	Commercial Storages Or Warehouses (All Or Unspec)
67016	Soil Sterilization Of Uncult., Non-Ag Areas	77005	Commercial/Institut./Indust. Bldgs. (Nonfood-Fum.)
67501	Wasteland(S) (Distinct From Pasture/Rangeland)	77501	Schools (Indoor) (School Yards Use 67002)
67502	Apply Directly To Pest: No Site Specified	77502	Non-Feed/Non-Food Processing Plants
68002	Urban Areas (All Or Unspec) (Residential, Etc.)	87010	Carpets (Hospital, Commercial, Household)
70000	Commercial Transport Facilities (All Or Unspec)	88003	Bathroom Premises (Lavatories, Restrooms, Etc.)
71000	Food Processing/Handling Plant/Area (All/Unspec)	89000	Refuse And Solid Waste Sites (All Or Unspec)
71501	Food Processing/Handling Plant/Area (Food Area)	89001	Refuse And Solid Waste Containers
71502	Food Processing/Handling Plant/Area (Nonfood Area)	90011	Ant Dens/Hills/Mounds (In/Out-Door) (All/Unsp)
72000	Eating Establishments (All Or Unspec)	90013	Beehives, Bee Colony (Diseased, Nuisance)
72004	Eating Establishments (Non-Food Areas)	92501	Pets And Domestic Animals (Combined Site)
72006	Eating Establishments (Equipment & Utensils)	92502	Commercial - Industrial Uses (Combined Site)
72501	Eating Establishments (Food Handling/Serving Area)	100003	Landscape Maintenence
73000	Food Marketing, Storage & Distribution Facilities		

Table A-2. Diazinon Urban Sites of Use - Likely Water Quality Issues

Type	Site Code	Site Name
Water – Sites involving direct release to surface water		
	65013	Drainage Systems (All Or Unspec)
Sewer – Sites involving direct or inevitable release to sewer systems		
	87010	Carpets (Hospital, Commercial, Household)
	88003	Bathroom Premises (Lavatories, Restrooms, Etc.)
Large Outdoor Areas		
	67000	Uncultivated Non-Ag Areas (All Or Unspec)
	67004	Highway Rights-Of-Way (Roadways, Curbs, Etc.)
	67012	Private Roads, Walkways, Lanes, Patios, Etc.
	67013	Rights-Of-Way (Unspec) (Firelanes, Etc.)
	67016	Soil Sterilization Of Uncult., Non-Ag Areas
	67501	Wasteland(s) (Distinct From Pasture/Rangeland)
	68002	Urban Areas (All Or Unspec) (Residential, Etc.)
Wood Treatment – Applies to outdoor sites only		
	64500	Wood Protection Treatments (All Or Unspecified)
	64501	Lumber (Seasoned/Unseasoned)
Residential, Commercial & Institutional Structures - Applies to the portions of these sites that are outdoor hard surfaces or indoor areas cleaned with water		
	63000	Household Or Domestic Dwellings (All Or Unspec)
	63003	Household Or Domestic Dwellings (Outdoor)
	67002	Recreational Areas, Tennis Courts, Parks, Etc.
	67003	Buildings And Structures (Non-Ag Outdoor)
	70000	Commercial Transport Facilities (All Or Unspec)
	71000	Food Processing/Handling Plant/Area (All/Unspec)
	71501	Food Processing/Handling Plant/Area (Food Area)
	71502	Food Processing/Handling Plant/Area (Nonfood Area)
	72000	Eating Establishments (All Or Unspec)
	72004	Eating Establishments (Non-Food Areas)
	72501	Eating Establishments (Food Handling/Serving Area)
	73000	Food Marketing, Storage & Distribution Facilities
	74000	Hospitals & Related Institutions (All Or Unspec)
	74016	Nursing Homes
	74501	Hospital Critical & Semi-Critical Items (Combined)
	76000	Morgues, Mortuaries, Funeral Homes (All Or Unspec)
	77000	Commercial, Institutional Or Industrial Areas
	77004	Commercial Storages Or Warehouses (All Or Unspec)
	77005	Commercial/Institut./Indust. Bldgs. (Nonfood-Fum.)
	77502	Non-Feed/Non-Food Processing Plants
	92502	Commercial - Industrial Uses (Combined Site)

Table A-3. Diazinon Urban Sites of Use - Unlikely Water Quality Issues

Type	Site Code	Site Name
Solid Waste		
	89000	Refuse And Solid Waste Sites (All Or Unspec)
	89001	Refuse And Solid Waste Containers
Greenhouses		
	61015	Greenhouses (In Use)
Animals - Does not include any application to animals that are washed with water		
	56001	Animals (Unspecified)
	56005	Horses (Race, Draft, Show, Riding, Etc.)
Pest Control - For application methods that apply the pesticide into the hive or nest only		
	90011	Ant Dens/Hills/Mounds (In/Out-Door) (All/Unsp)
	90013	Beehives, Bee Colony (Diseased, Nuisance)
Residential, Commercial & Institutional Structures - only for indoor and substructure areas not washed with water; excludes underground injection of termiticides		
	63001	Household Or Domestic Dwellings (Indoor)
	70000	Commercial Transport Facilities (All Or Unspec)
	71000	Food Processing/Handling Plant/Area (All/Unspec)
	71502	Food Processing/Handling Plant/Area (Nonfood Area)
	72000	Eating Establishments (All Or Unspec)
	72004	Eating Establishments (Non-Food Areas)
	73000	Food Marketing, Storage & Distribution Facilities
	74000	Hospitals & Related Institutions (All Or Unspec)
	74016	Nursing Homes
	76000	Morgues, Mortuaries, Funeral Homes (All Or Unspec)
	77000	Commercial, Institutional Or Industrial Areas
	77004	Commercial Storages Or Warehouses (All Or Unspec)
	77005	Commercial/Institut./Indust. Bldgs. (Nonfood-Fum.)
	77501	Schools (Indoor) (School Yards Use 67002)
	77502	Non-Feed/Non-Food Processing Plants
	92502	Commercial - Industrial Uses (Combined Site)

Table A-4. Diazinon Products Registered For Application to Urban Sites Where Discharge to Surface Water is Likely

Product Name and USEPA Registration Number	% Diazinon	Relevant Site Codes and Names
D.Z.N. Diazinon 50W (100-460-ZA)	50	65013 - Drainage Systems (All Or Unspec)
D.Z.N. Diazinon AG500 (100-461-ZA)	48	65013 - Drainage Systems (All Or Unspec)
D.Z.N. Diazinon 4E (100-463-ZA)	47.5	88003 - Bathroom Premises (Lavatories, Restrooms, Etc.) [Note: DPR Product/Label database indicates use is cancelled, but it remains on the label.]
Prentox Diazinon 50W Insecticide (655-456-AA)	50	65013 - Drainage Systems (All Or Unspec)
Prentox Diazinon AG500 Insecticide (655-459-ZA)	48	65013 - Drainage Systems (All Or Unspec)
Wilbur-Ellis Diazinon 4 Spray (2935-388-ZA)	48	65013 - Drainage Systems (All Or Unspec)
Diazinon AF500 Insecticide (5905-248-AA)	48	65013 - Drainage Systems (All Or Unspec)
Prokil Diazinon 4EC (10163-68-AA)	48	65013 - Drainage Systems (All Or Unspec)
Gowan Diazinon 4E (10163-100-AA)	48	65013 - Drainage Systems (All Or Unspec)
Gowan Diazinon 50 WP (10163-103-AA)	50	65013 - Drainage Systems (All Or Unspec)
Drexel Diazinon Insecticide (19713-91-ZA)	48.2	65013 - Drainage Systems (All Or Unspec)
Clean Crop Diazinon 50 W (100-460-ZA-3)	50	65013 - Drainage Systems (All Or Unspec)
Clean Crop Diazinon Ag500 Insecticide (34704-41-AA)	48	65013 - Drainage Systems (All Or Unspec)
Terand Roach And Ant Killer (7405-2-AA-48295)	0.5	87010 - Carpets (Hospital, Commercial, Household); 88003 - Bathroom Premises (Lavatories, Restrooms, Etc.)
Diazinon 50W (51036-108-AA)	50	65013 - Drainage Systems (All Or Unspec)
Clean Crop Diazinon 50WP Insecticide (34704-435-AA)	50	65013 - Drainage Systems (All Or Unspec)
Diazinon 50 WP Insecticide (34704-435-AA-6)	50	65013 - Drainage Systems (All Or Unspec)
Gowan Diazinon 50 WSB (10163-163-AA)	50	65013 - Drainage Systems (All Or Unspec)
Diazinon AG500 (100-461-ZA)	48	65013 - Drainage Systems (All Or Unspec)
All Pro Diazinon 50 WP Insecticide (769-954-ZA)	50	65013 - Drainage Systems (All Or Unspec)
All Pro Diazinon AG500 (769-689-ZA)	48	65013 - Drainage Systems (All Or Unspec)
D.Z.N. Diazinon AG600 WBC (100-784-AA)	56	65013 - Drainage Systems (All Or Unspec)
United Horticultural Supply Professional (34704-435-ZB-6)	50	65013 - Drainage Systems (All Or Unspec)
Diazinon 50 WP Insecticide (19713- 492-AA)	50	65013 - Drainage Systems (All Or Unspec)
Clean Crop Diazinon AG600 WBC (100- 784-AA- 3)	56	65013 - Drainage Systems (All Or Unspec)

APPENDIX B. CHLORPYRIFOS SITES OF USE

Information in this appendix:

Table B-1. Comprehensive List of Chlorpyrifos Urban Sites of Use (148 Sites)

Site Code	Site Name	Site Code	Site Name
29510	Nurseries (All Or Unspec)	35008	Ornamental Flowering Trees (Fruit, Nut, Etc.)
31000	Ornamental Herbaceous Plants (All Or Unspec)	35098	Pine; Pinus Spp.
31003	Ornamental Herbaceous Flowering Plants (All/Un)	39000	Ornamental Nonflowering Plants (All Or Unspec)
31004	Ornamental Herbaceous Foliage Plants (All/Un)	39001	Ornamental Ferns (All Or Unspec)
31005	Ornamental Bulb, Corm, Rhizome Plants (All/Unspec)	39003	Ornamental Nurseries (Stock, Crops, Etc.)
31057	Carnation	39005	Ornamental Plants - Greenhouse (All Or Unspec)
31065	Chrysanthemum (Mum)	40000	Soil Application (Ag-Crop, Orn-Plant Situations)
32000	Ornamental Plants (Herb. & Woody) (All Or Unspec)	40005	Soil Application, Preplant-Indoor(Greenhouse, Etc.)
32002	Ornamental Vines (Herb. & Woody) (All Or Unspec.)	40006	Mulch (Including Mulching Straw, Hay, Paper)
32004	Ornamental Plants (Deciduous) (All Or Unspec)	40008	Soil Application, Preplant-Outdoor (Seedbeds,Etc.)
32005	Ornamental Evergreens (All Or Unspec)	40501	Soil Application, (Houseplant Potting Soil)
32010	House Plants	40502	Soil Beneath Host Plants
32501	Gardens (Ornamental, Flower, Rock, Shrub, Etc.)	40503	Soil Amendment (Ph, Mineral, Texture Adjustment)
33007	Turf, Golf Course (Fairways, Greens, Rough)	44000	Proc. Or Manuf. Non-Food Prod. (All Or Unspec)
33008	Ornamental Turf (All Or Unspec)	46000	Storage Areas & Processing Equipment (All/Unspec)
33009	Ornamental Ground Covers (All Or Unspec)	46026	Storage Areas - Empty (All Or Unspec)
33010	Ornamental Lawns, Lawns (All Or Unspec)	46027	Storage Areas - Full (All Or Unspec)
33011	Ornamental Grasses	46031	Non Feed/Food Storage Areas - Full
33028	Dichondra (Ground Cover)	46501	Storage Areas (Unspecified)
33112	Ivy (All Or Unspec) (Ground Cover)	46502	Feed/Food Storage Areas (Unspecified)
34000	Ornamental Shrubs (All Or Unspec) (Woody/Herb.)	46503	Non Feed/Food Storage Areas (Unspecified)
34006	Ornamental Broadleaf Evergreen Shrubs	54000	Pets (All Or Unspec)
34007	Ornamental Deciduous Shrubs	54002	Cats (All Or Unspec) (Pet)
34118	Rhododendron (Species/Hybrids/Cultivars) (Azalea)	54003	Dogs (All Or Unspec) (Pet)
34120	Rose	56001	Animals (Unspecified)
35000	Ornamental And/Or Shade Trees (All Or Unspec)	56005	Horses (Race, Draft, Show, Riding, Etc.)
35005	Ornamental Broadleaf Evergreen Trees (All/Unspec)	56020	Zoo Animals (All Or Unspec)
35006	Ornamental Deciduous Trees (All Or Unspec)	58000	Commercial Egg Handling Equipment
35007	Ornamental Conifers (All Or Unspec)	63000	Household Or Domestic Dwellings (All Or Unspec)

Table B-1. Comprehensive List of Chlorpyrifos Sites of Use (Continued)

Site Code	Site Name	Site Code	Site Name
63001	Household Or Domestic Dwellings (Indoor)	67013	Rights-Of-Way (Unspec) (Firelanes, Etc.)
63002	Cracks & Crevices	67015	Fencerows, Hedgerows, Stone Walls (Non-Ag)
63003	Household Or Domestic Dwellings (Outdoor)	67016	Soil Sterilization Of Uncult., Non-Ag Areas
63004	Greenhouses - Domestic Non-Commercial	67502	Apply Directly To Pest: No Site Specified
63005	House Or Domestic Dwelling Indoor Non-Food Area	68000	Wide Area And General In-/Outdoor (All Or Unspec)
63006	Household Or Domestic Dwelling Food Handling Areas	68002	Urban Areas (All Or Unspec) (Residential, Etc.)
63010	Baseboards	68003	Public Buildings And Structures (Vert. Pests)
63012	Wall Voids, Wood (Injection)	68005	Non-Agricultural Areas (Public Health Treatment)
63013	Window Sills	68009	Fencerows (All/Unspec), Hedgerows (All/Unspec)
63014	Door Frames	68502	Mosquito Abatement Districts
63017	Domestic Garden Crops (Non-Commercial)	70000	Commercial Transport Facilities (All Or Unspec)
64000	Wood Or Wood Structure Protection Treatments	70004	Ships, Boat Premises, Etc. (All Or Unspec)
64003	Wood Protection - Finished Wood Products	70026	Railway Trains (All Or Unspec)
64500	Wood Protection Treatments (All Or Unspecified)	70027	Aircraft (All Or Unspec)
64501	Lumber (Seasoned/Unseasoned)	70031	Commercial Transport Facil (Feed/Food-Empty)
64502	Wood Structures: Above Ground & Finished Struct	70032	Commercial Transport Facil (Feed/Food-Full)
64503	Wood Protection: At/Below Ground Level	70502	Commercial Transport Facil (Non Feed/Food-Empty)
64504	Wood Structures: Indoor/Enclosed Areas	70504	Commercial Transport Facil (Non Feed/Food-Unspec)
65026	Sewage Systems (Septic Tanks, Sewers, Etc.)	71000	Food Processing/Handling Plant/Area (All/Unspec)
67000	Uncultivated Non-Ag Areas (All Or Unspec)	71001	Bakeries, Bakery Equipment, Etc.
67002	Recreational Areas, Tennis Courts, Parks, Etc.	71002	Bottling Plants (Includes Beverage Bottles)
67003	Buildings And Structures (Non-Ag Outdoor)	71003	Breweries, Distilleries, Beer Beverage Cases, Etc.
67004	Highway Rights-Of-Way (Roadways, Curbs, Etc.)	71004	Canneries And Frozen Food Plants
67006	Utility Rights-Of-Way, Yards, Substations, Etc.	71006	Feed Mills, Feed Stores, Feed Processing Plants
67008	Sewage Disposal Areas (Municipal And Other)	71008	Meat Processing Plants (Slaughter Houses, Etc.)
67009	Industrial Sites (Lumber Yards, Tank Farms, Etc.)	71010	Wineries, Wine Cellars
67011	Paved Areas, Pre-Paving Applications	71011	Flour Mills, Flour/Grain Elevators, Etc.
67012	Private Roads, Walkways, Lanes, Patios, Etc.	71012	Egg Processing Plants, Egg Breaking Plants

Table B-1. Comprehensive List of Chlorpyrifos Sites of Use (Continued)

Site Code	Site Name	Site Code	Site Name
71019	Beverage Processing Plants, Etc. (All Or Unspec)	76501	Mausoleums
71022	Fish And Sea Food Processing Plants And Equipment	77000	Commercial, Institutional Or Industrial Areas
71033	Food Processing/Handling Plant/Area (Food Area)	77004	Commercial Storages Or Warehouses (All Or Unspec)
71501	Food Processing/Handling Plant/Area (Food Area)	77005	Commercial/Institut./Indust. Bldgs. (Nonfood-Fum.)
71502	Food Processing/Handling Plant/Area (Nonfood Area)	77501	Schools (Indoor) (School Yards Use 67002)
72000	Eating Establishments (All Or Unspec)	77502	Non-Feed/Non-Food Processing Plants
72004	Eating Establishments (Non-Food Areas)	86000	Human Sites (All Or Unspec)
72501	Eating Establishments (Food Handling/Serving Area)	87010	Carpets (Hospital, Commercial, Household)
73000	Food Marketing, Storage & Distribution Facilities	88003	Bathroom Premises (Lavatories, Restrooms, Etc.)
73002	Food Stores, Food Markets, Supermarkets, Etc.	89000	Refuse And Solid Waste Sites (All Or Unspec)
73003	Meat Markets (Fish Markets, Butcher Shops, Etc.)	89003	Garbage Dumps (All Or Unspec)
74000	Hospitals & Related Institutions (All Or Unspec)	90002	Quarantine Use (Federal And/Or State - Unspec)
74008	Hospital Critical Premises	90011	Ant Dens/Hills/Mounds (In/Out-Door) (All/Unsp)
74016	Nursing Homes	90013	Beehives, Bee Colony (Diseased, Nuisance)
74502	Veterinary Hospitals (Veterinary) (All Or Unspec)	90550	Zoos
76000	Morgues, Mortuaries, Funeral Homes (All Or Unspec)	92002	Commercial-Industrial Uses (Combined Site)
76003	Morgues, Mortuaries And Funeral Home Instruments	100003	Landscape Maintenence

Table B-2. Chlorpyrifos Sites of Use - Likely Water Quality Issues

Type	Site Code	Site Name
Water – Sites involving direct release to surface water		
		No active sites
Sewer – Sites involving direct or inevitable release to sewer systems		
	65026	Sewage Systems (Septic Tanks, Sewers, Etc.)
	67008	Sewage Disposal Areas (Municipal And Other)
	87010	Carpets (Hospital, Commercial, Household)
	88003	Bathroom Premises (Lavatories, Restrooms, Etc.)
Large Outdoor Areas		
	67000	Uncultivated Non-Ag Areas (All Or Unspec)
	67004	Highway Rights-Of-Way (Roadways, Curbs, Etc.)
	67006	Utility Rights-Of-Way, Yards, Substations, Etc.
	67012	Private Roads, Walkways, Lanes, Patios, Etc.
	67013	Rights-Of-Way (Unspec) (Firelanes, Etc.)
	67016	Soil Sterilization Of Uncult., Non-Ag Areas
	68000	Wide Area And General In-/Outdoor (All Or Unspec)
	68002	Urban Areas (All Or Unspec) (Residential, Etc.)
	68005	Non-Agricultural Areas (Public Health Treatment)
	68502	Mosquito Abatement Districts
	90002	Quarantine Use (Federal And/Or State - Unspec)
Wood Treatment – Applies to outdoor sites only		
	64000	Wood Or Wood Structure Protection Treatments
	64003	Wood Protection - Finished Wood Products
	64500	Wood Protection Treatments (All Or Unspecified)
	64501	Lumber (Seasoned/Unseasoned)
	64502	Wood Structures: Above Ground & Finished Struct
	97005	Wood Surfaces (Seasoned/Unpainted)
Residential, Commercial & Institutional Structures - Applies to the portions of these sites that are outdoor hard surfaces or indoor areas cleaned with water		
	63000	Household Or Domestic Dwellings (All Or Unspec)
	63003	Household Or Domestic Dwellings (Outdoor)
	67002	Recreational Areas, Tennis Courts, Parks, Etc.
	67003	Buildings And Structures (Non-Ag Outdoor)
	67009	Industrial Sites (Lumber Yards, Tank Farms, Etc.)
	67015	Fencerows, Hedgerows, Stone Walls (Non-Ag)
	68003	Public Buildings And Structures (Vert. Pests)
	68009	Fencerows (All/Unspec), Hedgerows (All/Unspec)
	70000	Commercial Transport Facilities (All Or Unspec)
	70004	Ships, Boat Premises, Etc. (All Or Unspec)

Table B-2. Chlorpyrifos Urban Sites of Use - Likely Water Quality Issues (Continued)

Type	Site Code	Site Name
	70026	Railway Trains (All Or Unspec)
	70027	Aircraft (All Or Unspec)
	70031	Commercial Transport Facil (Feed/Food-Empty)
	70032	Commercial Transport Facil (Feed/Food-Full)
	70502	Commercial Transport Facil (Non Feed/Food-Empty)
	70504	Commercial Transport Facil (Non Feed/Food-Unspec)
	71000	Food Processing/Handling Plant/Area (All/Unspec)
	71001	Bakeries, Bakery Equipment, Etc.
	71002	Bottling Plants (Includes Beverage Bottles)
	71003	Breweries, Distilleries, Beer Beverage Cases, Etc.
	71004	Canneries And Frozen Food Plants
	71006	Feed Mills, Feed Stores, Feed Processing Plants
	71008	Meat Processing Plants (Slaughter Houses, Etc.)
	71010	Wineries, Wine Cellars
	71011	Flour Mills, Flour/Grain Elevators, Etc.
	71012	Egg Processing Plants, Egg Breaking Plants
	71019	Beverage Processing Plants, Etc. (All Or Unspec)
	71022	Fish And Sea Food Processing Plants And Equipment
	71033	Food Processing/Handling Plant/Area (Food Area)
	71501	Food Processing/Handling Plant/Area (Food Area)
	71502	Food Processing/Handling Plant/Area (Nonfood Area)
	72000	Eating Establishments (All Or Unspec)
	72004	Eating Establishments (Non-Food Areas)
	72501	Eating Establishments (Food Handling/Serving Area)
	73000	Food Marketing, Storage & Distribution Facilities
	73002	Food Stores, Food Markets, Supermarkets, Etc.
	73003	Meat Markets (Fish Markets, Butcher Shops, Etc.)
	74000	Hospitals & Related Institutions (All Or Unspec)
	74016	Nursing Homes
	74502	Veterinary Hospitals (Veterinary) (All Or Unspec)
	76000	Morgues, Mortuaries, Funeral Homes (All Or Unspec)
	76501	Mausoleums
	77000	Commercial, Institutional Or Industrial Areas
	77004	Commercial Storages Or Warehouses (All Or Unspec)
	77005	Commercial/Institut./Indust. Bldgs. (Nonfood-Fum.)
	77502	Non-Feed/Non-Food Processing Plants
	92002	Commercial-Industrial Uses (Combined Site)

Table B-3. Chlorpyrifos Urban Sites of Use - Unlikely Water Quality Issues

Type	Site Code	Site Name
Solid Waste		
	89000	Refuse And Solid Waste Sites (All Or Unspec)
	89003	Garbage Dumps (All Or Unspec)
Greenhouses		
	39005	Ornamental Plants - Greenhouse (All Or Unspec)
Animals - Does not include any application to animals that are washed with water		
	56001	Animals (Unspecified)
	56005	Horses (Race, Draft, Show, Riding, Etc.)
	56020	Zoo Animals (All Or Unspec)
	90550	Zoos
Pest Control - For application methods that apply the pesticide into the hive or nest only		
	90011	Ant Dens/Hills/Mounds (In/Out-Door) (All/Unsp)
	90013	Beehives, Bee Colony (Diseased, Nuisance)
Residential, Commercial & Institutional Structures - only for indoor and substructure areas not washed with water; excludes underground injection of termiticides		
	63001	Household Or Domestic Dwellings (Indoor)
	63005	House Or Domestic Dwelling Indoor Non-Food Area
	63012	Wall Voids, Wood (Injection)
	64000	Wood Or Wood Structure Protection Treatments
	64502	Wood Structures: Above Ground & Finished Struct
	64503	Wood Protection: At/Below Ground Level
	64504	Wood Structures: Indoor/Enclosed Areas
	68003	Public Buildings And Structures (Vert. Pests)
	70000	Commercial Transport Facilities (All Or Unspec)
	70031	Commercial Transport Facil (Feed/Food-Empty)
	70032	Commercial Transport Facil (Feed/Food-Full)
	70501	Commercial Transport Facil (Feed/Food-Unspec)
	70502	Commercial Transport Facil (Non Feed/Food-Empty)
	70504	Commercial Transport Facil (Non Feed/Food-Unspec)
	71000	Food Processing/Handling Plant/Area (All/Unspec)
	71001	Bakeries, Bakery Equipment, Etc.
	71002	Bottling Plants (Includes Beverage Bottles)
	71003	Breweries, Distilleries, Beer Beverage Cases, Etc.
	71004	Canneries And Frozen Food Plants
	71006	Feed Mills, Feed Stores, Feed Processing Plants
	71008	Meat Processing Plants (Slaughter Houses, Etc.)
	71010	Wineries, Wine Cellars

Table B-3. Chlorpyrifos Urban Sites of Use - Unlikely Water Quality Issues (Continued)

Type	Site Code	Site Name
	71011	Flour Mills, Flour/Grain Elevators, Etc.
	71012	Egg Processing Plants, Egg Breaking Plants
	71019	Beverage Processing Plants, Etc. (All Or Unspec)
	71021	Cereal Processing Plants (Mills)
	71022	Fish And Sea Food Processing Plants And Equipment
	71034	Food Processing/Handling Plant/Area (Nonfood Are
	71502	Food Processing/Handling Plant/Area (Nonfood Area)
	72000	Eating Establishments (All Or Unspec)
	72004	Eating Establishments (Non-Food Areas)
	73000	Food Marketing, Storage & Distribution Facilities
	73002	Food Stores, Food Markets, Supermarkets, Etc.
	73003	Meat Markets (Fish Markets, Butcher Shops, Etc.)
	74000	Hospitals & Related Institutions (All Or Unspec)
	74016	Nursing Homes
	74502	Veterinary Hospitals (Veterinary) (All Or Unspec)
	76000	Morgues, Mortuaries, Funeral Homes (All Or Unspec)
	76501	Mausoleums
	77000	Commercial, Institutional Or Industrial Areas
	77001	Schools
	77002	Commercial, Institutional Or Industrial Equipment
	77004	Commercial Storages Or Warehouses (All Or Unspec)
	77005	Commercial/Institut./Indust. Bldgs. (Nonfood-Fum.)
	77501	Schools (Indoor) (School Yards Use 67002)
	77502	Non-Feed/Non-Food Processing Plants
	92002	Commercial-Industrial Uses (Combined Site)

Table B-4. Chlorpyrifos Products Registered For Application to Urban Sites Where Discharge to Surface Water is Likely

Product Name and USEPA Registration Number	% Chlorpyrifos	Relevant Site Codes and Names	Notes
Champion Sprayon Crawling Insect Killer (498-133-AA)	0.5	87010 - Carpets (Hospital, Commercial, Household)	
State Formula 401 Ready To Kill With Dursban (1685-94-AA)	0.5	87010 - Carpets (Hospital, Commercial, Household) 88003 - Bathroom Premises (Lavatories, Restrooms, etc.)	
Killmaster II (26693-2-AA)	2	65026 - Sewage Systems (Septic Tanks, Sewers, etc.)	
Insecta (45600-1-AA)	0.86	67008 - Sewage Disposal Areas (Municipal And Other)	
Dursban ME20 Microencapsulated Insecticide (62719-88-ZA)	20	65026 - Sewage Systems (Septic Tanks, Sewers, etc.)	Label allows carpet and bathroom uses, but neither of these sites is recorded in the DPR Product/Label database
Insecta For Manholes (45600-1-ZB)	0.86	67008 - Sewage Disposal Areas (Municipal And Other)	
Super-IG Insecticide All-Purpose Transp. (59920-1-AA)	0.9	65026 - Sewage Systems (Septic Tanks, Sewers, etc.)	"Sewage systems" use "inactive" but remains on label
Super-IG Insecticide Latex Coating LC (59920-2-AA)	0.9	65026 - Sewage Systems (Septic Tanks, Sewers, etc.)	
Empire 20 (62719-88-ZB)	20	65026 - Sewage Systems (Septic Tanks, Sewers, etc.)	"Sewage systems" use "inactive" but remains on label. Label allows carpet and bathroom uses, but neither of these sites is recorded in the DPR Product/Label database
Prescription Treatment Brand Duration (499-419-ZA)	20	67008 - Sewage Disposal Areas (Municipal And Other)	
Ultracide (45600-1-AA-6)	0.86	67008 - Sewage Disposal Areas (Municipal And Other)	
Unicorn Dursban Spray Insecticide (28293-99-ZA)	0.5	87010 - Carpets (Hospital, Commercial, Household)	

APPENDIX C. DIAZINON AND CHLORPYRIFOS PRODUCT FORMULATIONS

Information in this Appendix:

C.1 Water Quality Evaluation of Diazinon and Chlorpyrifos Formulations

For each formulation, the introduction and analyses below are general in nature and include examples of product types that do not exist for diazinon and chlorpyrifos. This material is included to increase the clarity of the material for readers who are not pesticide experts and to broaden the usefulness of the analysis. While this analysis considers only those pesticide formulations that are used for diazinon and chlorpyrifos products, the information can be generally applied to other insecticides with similar solubility characteristics.

Emulsifiable Concentrate. Emulsifiable concentrates are common liquid formulations with active ingredients that are insoluble in water. The addition of an "emulsifier" (a detergent-like substance) allows the pesticide to mix with water. This mixture is called an emulsion. The primary inert ingredients in a pesticide product formulated as an emulsifiable concentrate are an emulsifier and one or more petroleum-based solvents.

Application: ECs usually need to be diluted prior to application. Mixing and application involves equipment that must be cleaned after use. Solvents in emulsifiable concentrates may cause rubber or plastic hoses, gaskets, and pump parts and surfaces in containers and application equipment to deteriorate, increasing the possibility of leaks or spills.

Product characteristics: The typical relatively high active ingredient concentration in emulsifiable concentrates makes it easy to apply an incorrect amount of the pesticide through mixing or calibration errors; it also makes spills, misuse and dumping a particular concern. After application, the emulsifier will remain on the application site along with the active ingredient (the length of time this will occur depends on environmental fate processes for both materials); under such conditions it is possible that the emulsifier could enhance the dissolution and transport of the active ingredient in water.

Aqueous (Liquid) Concentrate. Aqueous concentrates are pesticide concentrate solutions where the primary solvent is water.

Application: Like emulsifiable concentrates, aqueous concentrates need to be diluted prior to application and they require mixing equipment and application equipment.

Product characteristics: Like emulsifiable concentrates, they are solutions that contain relatively high active ingredient concentrations that make spills, misuse, and dumping a particular concern. For pesticides like diazinon and chlorpyrifos, creating aqueous concentrates requires the use of surfactants and similar compounds to facilitate dissolution of the otherwise relatively insoluble active ingredient in water. After application, these same ingredients may enhance dissolution of the active ingredient into water like rain or storm water runoff.

Solution/Liquid (Ready-To-Use). Some pesticide active ingredients dissolve readily in a liquid solvent, such as water or a petroleum-based solvent. When mixed with the solvent, they form a solution that will not settle out or separate. Formulations of these pesticides usually contain the active ingredient, the solvent, and one or more other ingredients.

Application: Because they are ready to use, such formulations do not require mixing and may or may not require application equipment, depending on the

product container design. Solvents other than water may cause rubber or plastic hoses, gaskets, and pump parts and surfaces in containers and application equipment to deteriorate, increasing the possibility of leaks or spills.
Product characteristics: If the solvent is water, the possibility exists that ingredients used to facilitate product formulation will also enhance dissolution of the active ingredient after application in water like rain or storm water runoff.

Dust/Powder. Dusts are formulations of pesticides on dry particles that are applied dry. Dusts typically contain a very fine dry inert carrier made from a material like talc, chalk, clay, nut hulls, or volcanic ash. According to the University of Nebraska, although dusts were formerly widely used, fewer dust formulations are currently being produced due to safety concerns and the availability of alternative formulations that are easier to handle (University of Nebraska, undated). Currently, dust formulations are most often found in gardening products, and in products for applications in cracks and crevices, for spot treatments, for seed treatments, in products used to control lice, fleas, and other parasites on pets and livestock.

Application: Dust formulations typically do not require mixing. While equipment is used, it is not generally washed with water. The fine nature of dust and the type of application equipment used makes it difficult for applicators to keep the product on target.
Product characteristics: Because of their small particle sizes, dust residues are easily transported away from the application site by air movement or water.

Wettable Powder. Wettable powders, one of the most widely used pesticide formulations, are pesticides formulated on a dry particle (like clay) that contain ingredients (wetting agents) that allow the particles to mix with water. The resulting mixture is referred to as a suspension. During use, agitation is often required to keep the pesticide evenly suspended in the solution.

Application: Like other concentrated products, wettable powders must be mixed and they require application equipment. Some WPs are sold in water-soluble bags that eliminate the need for measuring equipment.
Product characteristics: By design, wettable powders mix easily with water. While this characteristic is intended to facilitate application of products in aqueous solutions (rather than in solvents), the design of the powder to dissolve easily in water may facilitate environmental transport of the applied powders in storm water runoff. The importance of this effect depends on the environmental longevity of the particle and wetting agents, the environmental degradation of the active ingredient, and the relationship of applications to rainfall events. WPs also contain relatively high concentrations of active ingredient, making spills, misuse, and dumping a concern. Like dusts, wettable powders have small particle sizes, so their residues may be readily transported away from the application site (unless formulated with ingredients called “stickers” that prevent such transport).

Suspension. A Suspension is a wettable powder mixed into solution.

Application: Similar to wettable powders; however, some products may not require mixing prior to application.
Product characteristics: Same as wettable powders.

Flowable Concentrate. In flowable concentrates, finely ground solid active ingredients are mixed with a liquid, along with inert ingredients, to form a suspension. Typically, flowable formulations are used for pesticides that are insoluble solids.

Application: Flowables are mixed with water for application. They require the use of application equipment that is generally cleaned after use.
Product characteristics: Similar to wettable powders, except that post-application re-solubilization in water would depend on whether the flowable formulation contains ingredients to enhance dissolution in water.

Granular/Flake. Granules are small pesticide-containing pellets that generally look like kitty litter. To create the granules, dry pesticide formulations can be mixed onto a granule carrier or liquids may be impregnated into a granule carrier. Carriers are composed of materials like clay, ground corncob, or walnut hulls. The active ingredient either coats the outside of the granules or is absorbed into them. Granules are beginning to fall out of favor with regulatory agencies because they may be hazardous to non-target species, especially birds that mistakenly feed on them.

Application: Granules have the advantage of being ready to use (no mixing needed) and easy to handle.
Product characteristics: Granules may have slow-release properties or coatings that cause them to break down more slowly than wettable powders or emulsifiable concentrates. Some granular formulations do not release active ingredient until the granule encounters moisture. Some granules are formulated on low-density materials that readily float on water—these granules can float off application sites with rain or when "watered in" (a common label instruction).

Gel/Paste/Cream. Gels, pastes, and creams are formulations used in baits. A bait is formulated as an active ingredient mixed with food or another attractive substance. Baits may be used both indoors and outdoors. Baits are generally—but not always—designed to contain the active ingredient in a structure that is designed to prevent or limit the pesticide's contact with water.

Application: Baits have several advantages—they are ready to use (no mixing or application equipment is typically required) and their use does not entail covering large areas with pesticides (because the pest goes to the bait).
Product characteristics: Because they are often containerized, environmental exposure of the pesticide is low.

Pellet/Tablet/Cake/Briquet. Most pellet formulations are very similar to granular formulations, however, for pellets, all particles are the same weight and shape. Pellets, tablets, cakes and briquets are also common bait formulations that are used without containers.

Application: Same as for Gel/Paste/Cream formulations.
Product characteristics: Similar to Gel/Paste/Cream formulations, except that products are typically not containerized, which means that they may be exposed to the environment during use.

Impregnated Material. Pesticides may be impregnated into materials used in commercial products to provide pesticidal properties to the product or to form a source for long-term release of the pesticide. Impregnation may occur through means as simple as soaking a material in a solution of the pesticide. Examples include pet flea collars, mildew-resistant shower curtains and carpets, and biocidal cutting boards.

Application: Generally, no mixing or application equipment is required.
Product characteristics: Although the product is a long-term source for release of the active ingredient, impregnation limits the exposed surface area and release

rate of the pesticide, and the size of impregnated products generally precludes transport of the product itself to surface water.

Paint/Coating. Paints are specialty pesticide products. Pesticides may be formulated as additives for ordinary paint, or as an ingredient in a pesticide-containing paint product. Some products are clear coatings intended solely for pest control; however, some products serve the same function as ordinary paint while providing pesticidal properties to the painted surface. Because air quality regulations limit the use of oil-based paints, products are increasingly latex (water-based) formulations.

Application: Paint application may involve more application equipment and more potential for release at the time of application than any other type of pesticide application. Application of ordinary paints involves cleanup activities well known as a source of water quality concerns—it is likely that typical applications of pesticide paints are no different. Cleaning of brushes, rollers, paint trays, mixers, sprayers, and waste paint are of particular concern.

Product characteristics: When paints cure, a coating with properties very different from the properties of the liquid paint is generally formed. Such coatings effectively impregnate the pesticide active ingredient into the surface of the painted object.

Microencapsulated. Microencapsulated formulations are particles of pesticides (liquid or dry) surrounded by a plastic coating (*e.g.*, a tiny not very stable plastic bead).

Application: The formulated product is generally mixed with a liquid (usually water) and applied as a spray. Some microencapsulated products are ready-to-use products sold in spray containers.

Product characteristics: Once applied, the capsule slowly releases the pesticide. After application, capsules have sufficient structural integrity to be transported by bees away from the application site (North Carolina State University, 1999); this suggests that both capsule units and active ingredient may be able to be washed off application sites by water.

Pressurized Liquid/Spray/Fogger. These formulations contain one or more active ingredients and a solvent, such as dimethylether, hydrocarbons, or nitrogen (a gas that can act as a solvent under pressure). Typically these are aerosol sprays. For ready-to-use aerosols, the pesticide is driven through a fine opening by an inert gas under pressure, creating fine droplets.

Application: Sprays are difficult to confine to the target site or pest.

Product characteristics: No identified issues.

Table C-1. List of Inert Ingredients Found to be Present in Diazinon Products (Not Comprehensive)*

Ingredient	Product Type	Use	Notes
Isobutane	Aerosol	Aerosol propellant	
Propane	Aerosol	Aerosol propellant	
Carrier (unnamed)	Powder	Carrier	
Paper	Granule	Carrier	
Crystalline silica	Granule and Powder	Carrier/ Contaminant	Component of clay and talc.
Calcium silicate	Powder	Carrier?	Chemically, this is typically a mix of calcium oxide and silicon dioxide; can be synthetic or from natural minerals; prevents caking of powders.
Magnesium carbonate	Granule	Carrier?	Sold as fine powder to serves as carrier and rheological agent (to improve flow of material).
Dispersing agent (unnamed)	Powder	Dispersant	Prevents the clumping and settling of undissolved particles in suspensions.
Sodium sulfite	Powder	Dispersant/ Contaminant	According to MSDS, contaminant in an unnamed dispersing agent.
Xanthan gum	Liquid	Emulsion stabilizer?	In microencapsulated product. Complex branched heteropolysaccharide. Used commercially as binder, emulsion stabilizer, and viscosity controlling agent.
Calcium carbonate	Granule	Filler?	Also used as a paper coating, may enter the product with paper in the formulation; might also adjust pH, but not easy to use for this purpose due to its solubility properties.
Floral rose perfume	Liquid	Fragrance	
Capsules of crosslinked polyamide-polyurea	Liquid	Microencapsulation ?	Probably serves as the release coating for the microencapsulated product.
Polyvinyl alcohol	Liquid	Microencapsulation ?	Probably serves as a temporary binder or release coating for microencapsulated product.
Buffering agent (unnamed)	Powder	pH adjustment	
Phosphoric acid	Liquid	pH adjustment	

Table C-1. List of Inert Ingredients Found to be Present in Diazinon Products (Not Comprehensive, Continued)

Ingredient	Product Type	Use	Notes
Sodium hydroxide	Liquid	pH adjustment	
1,2-Benziothiazolin-3-one	Liquid	Preservative	Proxel GXL, sold as a 20% solution in dipropylene glycol, preservative for aqueous phase of solutions.
5-chloro-2-methyl-4-isothiazolin-3-one	Liquid	Preservative	Legend MK; recommended for used in products containing Xanthan gum.
Diethylenetriamine hydrochloride	Liquid	Solution stabilizer?	Reacts with epoxides, may be used to stabilize water-based solutions.
Ethylenediamine hydrochloride	Liquid	Solution stabilizer?	Reacts with epoxides, may be used to stabilize water-based solutions.
Aromatic petroleum hydrocarbon	Liquid	Solvent	Also called "aromatic hydrocarbon blend"; generic name for solvent.
Cumene	Liquid	Solvent	
Hydrotreated light petroleum distillates	Aerosol	Solvent	
Paraffinic petroleum distillate (white mineral oil)	Liquid	Solvent	
Water	Liquid	Solvent	
Xylenes	Liquid	Solvent	
1,2,4-Trimethylbenzene	Liquid	Solvent/ Contaminant	Contaminant in naphtha (hydrocarbon solvent).
Ethylbenzene	Liquid	Solvent/ Contaminant	
Surfactant (unnamed)	Powder	Surfactant	

Note: pH adjusters can also assist with solubilization of chemicals in aqueous or semi-aqueous solutions by changing the ionic state of the compound (*e.g.*, ionizing carboxylic acids).

*This list is based on a compilation of available information regarding inert ingredients in diazinon products. A comprehensive list of diazinon product inert ingredients is not available.

Source: ingredients listed in USEPA Freedom of Information Act response letters, manufacturer material safety data sheets, Cox, 1999; Cox, 2000. Use information and notes the product of TDC Environmental analysis, which made significant use of information from vendors of the listed ingredients available on the Internet.

Table C-2. List of Inert Ingredients Found to be Present in Chlorpyrifos Products (Not Comprehensive)*

Ingredient	Product Type	Use	Notes
Sweetener (unnamed)	Bait	Attractant (bait)	
Vegetable-based, food-grade material	Bait	Attractant (bait)	
Binder (unnamed)	Bait	Binder	
Epoxidized linseed oil	Liquid	Binder, drying oil	A drying oil that oxidizes when exposed to air to form a film.
Clay	Granules	Carrier	
Corn cob	Granules	Carrier	
Kaolin clay	Powder	Carrier	Sometimes called "Kaolinite" clay.
Paper	Granules	Carrier	
Talc	Powder	Carrier	
Calcium silicate	Powder and granules	Carrier?	Chemically, this is typically a mix of calcium oxide and silicon dioxide. It can be synthetic or from natural minerals. It prevents caking of powders.
Amorphous silica	Powder	Carrier/contaminant	Component of clay.
Crystalline silica	Powder	Carrier/contaminant	Component of clay.
AF-60 Antifoam	Paint	Defoamer	
Nalco 2303	Paint	Defoamer	
Silicone emulsion antifoam	Liquid	Defoamer	
Dimethicone	Liquid	Defoamer	Silicone; may assist with emulsification.
Lignosulfonic acid, sodium salt	Powder	Dispersant	Prevents the clumping and settling of undissolved particles in suspensions; can also be an emulsifier.
Dodecylbenzenesulfonic acid, calcium salt	Liquid	Emulsifier	Also known as calcium dodecyl benzene sulfonate.
Emulsifier (unnamed)	Liquid	Emulsifier	
Silicone emulsion	Liquid	Emulsifier?	Insufficient information to identify use of the ingredient.
Fragrance	Liquid	Fragrance	
Water soluble ink	Powder	Ink on package	

Table C-2. List of Inert Ingredients Found to be Present in Chlorpyrifos Products (Not Comprehensive, Continued)

Ingredient	Product Type	Use	Notes
Water soluble film	Powder	Package	
Aviloid CT-581	Paint	Paint/?	Unable to find any information on this additive.
Hercules X-158	Paint	Paint/?	Unable to find any information on this additive.
Lovel-27	Paint	Paint/?	Unable to find any information on this additive.
Texanol	Paint	Paint/aids film formation	2,2,4-trimethyl-1,3-pentanediol monoisobutyrate; coalescing aid helps form uniform film as paint dries.
TINT-AYD UL 20-12 Toner Blend	Paint	Paint/color	Colorant for paint, based on an acrylic/siloxane resin.
Tamol 850	Paint	Paint/Dispersant	Sodium salt of polyacrylic acid.
Flexbond 325	Paint	Paint/Durability enhancer	Vinyl acetate-acrylic copolymer, designed as a paint additive; provides paint coating durability.
Wollastonite NYAD 400	Paint	Paint/Filler	A specific calcium silicate used as a filler in paint. Fibrous material somewhat similar to asbestos. Reinforces the paint film, acts as a pH buffer, improves its resistance to weathering, reduces pigment consumption, and acts as a flatting and suspending agent (USGS, Minerals Yearbook, 1999).
Gama Sperse 6451	Paint	Paint/Filler?	Calcium carbonate.
Gama Sperse 80	Paint	Paint/Filler?	Calcium carbonate.
Rhoplex AC-507	Paint	Paint/Latex Resin	Acrylic binder for semi-gloss paints.
Nopcocide N-96	Paint	Paint/Mildew control?	Chlorothalonil, an organochlorine fungicide.
Optiwhite	Paint	Paint/Pigment	Treated kaolin clay.
Ti-pure R-900	Paint	Paint/Pigment	Titanium dioxide pigment.
Zopaque RCL-9	Paint	Paint/Pigment	Titanium dioxide pigment formulated for oil-based paints.
Nuosept 95	Paint	Paint/Preservative	Preservative for water-based paints.
Raybo-60 No-Rust	Paint	Paint/Rust inhibitor	
Ethylene glycol	Paint	Paint/Solvent	
Polypropylene glycol	Paint	Paint/Solvent	"Polyglycol P-1200."

Table C-2. List of Inert Ingredients Found to be Present in Chlorpyrifos Products (Not Comprehensive, Continued)

Ingredient	Product Type	Use	Notes
Bermocoll 451 FQ	Paint	Paint/Viscosity control	Cellulose ether designed to be a paint additive; may also affect a paint's water retention, film formation, settling,dispersion stabilization, and adhesion.
2-amino-2-methyl-1-propanol	Paint	Paint/pH adjustment	Neutralizing amine and corrosion inhibitor, additive used in latex emulsion paints, also called "AMP 95."
Potassium tripolyphosphate	Paint	pH adjustment	Also a buffer.
Preservative (unnamed)	Bait	Preservative	
Quaternium-15 antimicrobial	Liquid	Preservative	Also known as "Dowicil 200"; works in aqueous phase, not affected by surfactants.
1,1,1-trichloroethane	Liquid	Solvent	
Aromatic hydrocarbon	Liquid	Solvent	
Cumene	Liquid	Solvent	
Dipropylene glycol methyl ether	Liquid	Solvent	Co-solvent that facilitates mixing of chlorpyrifos into water-based solutions.
Heavy aromatic solvent naphtha	Liquid	Solvent	
Hydrotreated light petroleum distillates	Liquid	Solvent	
Isobutyl alcohol	Liquid	Solvent	
Isoparaffinic hydrocarbon	Liquid	Solvent	Also "synthetic isoparaffinic."
Isopropanol	Liquid	Solvent	
Light aromatic solvent naphtha	Liquid	Solvent	
Propylene glycol	Liquid	Solvent	
Water	Liquid and Paint	Solvent	Sometimes deionized water is listed.
Xylene range aromatic solvent	Liquid and Paint	Solvent	Sometimes pure solvent, sometimes mixtures called things like "Aromatic 100" and "xylene-range aromatic petroleum solvent".
1,2,4-trimethylbenzene	Liquid	Solvent contaminant	Contaminant in naphtha (hydrocarbon solvent).

Table C-2. List of Inert Ingredients Found to be Present in Chlorpyrifos Products (Not Comprehensive, Continued)

Ingredient	Product Type	Use	Notes
Naphthalene	Liquid	Solvent contaminant	Contaminant in naphtha (hydrocarbon solvent).
Fatty acid methyl ester	Liquid	Solvent?	Biodiesel is a fatty acid methyl ester.
γ-Butyrolactone	Granules	Solvent?	Controlled substance/drug; solvent that is miscible with water, can dissolve polymers.
Dodecylphenol ethoxylate	Liquid	Surfactant	
Polyether polyol	Liquid	Surfactant	
Triton N-101	Paint	Surfactant	Polyoxyethylene branched nonylcyclohexyl ether.
Ethylene oxide-propylene oxide block copolymer	Liquid	Surfactant	Also reduces foaming.
Ethoxylated castor oils	Liquid	Surfactant, nonionic	"36 Mole, 20 Mole, and 40 Mole," "cremophor," "polyoxyethylated" and "polyethoxylated."
Polyalkylene oxide polyol	Liquid	Surfactant?	
Wetting agents (unnamed)	Powder	Surfactant	
Agent 296-74	Liquid	?	Unable to find any information on this additive.
Maskant Aldor #109-255	Liquid	?	Unable to find any information on this additive.
Quarternary [sic] ammonium chloride based aqueous	Liquid	?	Seems to be a description of formulation.
Sodium dibutyl naphthalene	Powder	?	Information appears to be incorrect--not the name of a chemical (but similar to the name of a class of surfactants that are dibutylnaphthalene sulfonate salts and CAS number provided by USEPA is for sodium molybdate.

Note: pH adjusters can also assist with solubilization of chemicals in aqueous or semi-aqueous solutions by changing the ionic state of the compound (*e.g.*, ionizing carboxylic acids).

*This list is based on a compilation of available information regarding inert ingredients in chlorpyrifos products. A comprehensive list of chlorpyrifos product inert ingredients is not available.

Source: ingredients listed in USEPA Freedom of Information Act response letters; manufacturer material safety data sheets; Information Ventures Inc., undated; Cox, 1999; Cox, 2000. Use information and notes the product of TDC Environmental analysis, which made significant use of information from vendors of the listed ingredients available on the Internet.

APPENDIX D. DIAZINON AND CHLORPYRIFOS PRODUCT USE INFORMATION

Information in this Appendix:

Note: About half of the labels reviewed in Table D-1 and a few labels mentioned in Section D.3 were obtained from USEPA and other internet sources where it was impossible to verify whether the label might differ from the California label. Since the most recent label was used in all cases, only California-registered products were reviewed, and no case of a California-specific label for any of these products was identified, the chance that use of these data sources introduced erroneous information is probably small.

D.1 CONSUMER USER AND RETAILER SURVEYS

San Diego Survey

On behalf of the San Diego storm water management program, URS Greiner Woodward Clyde conducted a survey of outdoor insecticide use patterns in San Diego (URS, 2000). The objective of the homeowner survey was to understand how homeowners in San Diego County select, use, and dispose of insecticides. A related retailer telephone survey explored the role that insecticide retailers pay in the selection, use, and disposal of insecticides. The surveys evaluated all outdoor insecticide use, not just usage of diazinon and chlorpyrifos.

The homeowner survey was conducted by mail, with a distribution of 5,000 surveys and a response rate of 23%. The retailer survey involved 58 of the 439 identified pesticide retailers in San Diego County. While the results of the two surveys were relatively consistent, given the small sample size and the design of the surveys, the results provide valuable qualitative information, but not quantitative data about usage.

The table below summarizes locations where homeowners reported applying insecticides. The most common application location was around the foundation of the house (structural pest control), followed by garden (landscaping) applications.

Residential Insecticide Application Locations Reported in San Diego Survey

Location	% Reporting Such Applications
Around foundation of house	48%
In the garden	33%
On trees or shrubs	30%
On a patio or walkway	22%
On the lawn	22%
Inside the house	18%
On the sides or eaves of house	9%

Source: URS Greiner Woodward Clyde, 2000.

Other major findings of the survey were:

- Irrigation. Almost 50% of users report irrigating within 3 days of the application; however, only about 10% irrigated within 24 hours of application.
- Cleanup. Most survey respondents indicated that they cleaned up pesticide application equipment with water. About a third said they put the rinse water on the garden or lawn. Only a few (less than 10%) admitted to allowing cleanup water to drain to the street, sidewalk, driveway, or into a sink. It is unclear where most people actually dispose of cleanup waters.
- Target pests. The most common target pests for residential insecticide use in San Diego are ants and white flies. Other common target pests include aphids, fleas, flies, cockroaches, and worms.
- Time of year. According to store staff, insecticide sales peak in June, with few sales in the winter.

- Retailers. Stores most patronized by consumers were Home Depot (mentioned by 53% of pesticide purchasers), Wal-Mart, Home Base, and K-Mart (all mentioned by 6% or fewer of the surveyed group).
- Products. The survey of stores indicated that the most common pesticide brands included Ortho (mentioned by 76% of respondents), Raid, Spectracide, Safer, Black Flag, Scott's, and Green Light. No brand other than Ortho was mentioned by more than 20% of respondents. The survey did not address product formulations.
- Active ingredients. Popular active ingredients included diazinon, chlorpyrifos, malathion, and Sevin (carbaryl).

Alameda County Survey

In 1997, Alameda County investigated outdoor insecticide use in Alameda County, focusing on diazinon, chlorpyrifos, malathion, and carbaryl (Scanlin and Cooper, 1997). The investigation included a telephone survey of residents, an in-person survey of retail stores, and an evaluation of DPR data on reported use of the four pesticides in Alameda County. The focus of the survey was evaluating usage volumes and application locations; application methods and disposal methods were not addressed.

The telephone survey involved interviews with 644 residents of Castro Valley, a well-studied watershed in Alameda County. While the sample size is statistically significant for the watershed (estimated error less than 4% at a 95% confidence level), it is too small to provide accurate quantitative results for the County as a whole. The retail store survey involved visits to 10 of the 115 pesticide retailers in the County, focusing on the largest retailers. Four stores provided sales data; for the others, interviews with staff and shelf volumes were used to estimate sales.

The table below lists the commonly reported residential insecticide application sites.

Residential Insecticide Application Locations Reported in Alameda County Survey

Location	% Reporting Such Applications
Around building foundations	74%
In the garden	50%
On a patio or walkway	48%
On trees or shrubs	41%
On the lawn	30%

Source: Scanlin, September 1997.

Other major findings of the survey were:

- Target pests. Common target pests for insecticides in Alameda County were ants, fleas, aphids, and spiders. Insecticides were also reported for use on termite and grubs, but at a lower frequency than for the first four pests. Ants were the most common target pests.
- Time of year. According to reports from professional applicators, structural use of both diazinon and chlorpyrifos peaks in the summer, but is relatively steady all

year. Landscape use also peaked in the summer, but exhibited greater summer/winter differences.

- Retailers. The stores with largest amounts of insecticides displayed for sale were Home Depot, Costco, Target, Orchard Supply Hardware, and Home Base.
- Products. Common diazinon and chlorpyrifos brands identified were Ortho, Dexol, Green Thumb, Spectracide, Enforcer, Bug-B-Gon (Ortho), and Lilly Miller. Most diazinon and chlorpyrifos retail products were concentrates (>70%). Granules were the other primary formulation; dusts and ready-to-use diluted products were also identified.
- Active ingredients. Commonly used active ingredients included diazinon (reported used by 32% of respondents), malathion (reported used by 25% of respondents), chlorpyrifos (reported used by 17% of respondents), and carbaryl (17% of respondents). By pounds of active ingredient, diazinon and chlorpyrifos were the most heavily used insecticides in Alameda County. Use of each of these two was more than 20 times the use of malathion or carbaryl.

Palo Alto Survey

In 1996, the City of Palo Alto investigated diazinon sales and use in the Palo Alto, California area (Cooper, 1996). The survey portion of the investigation involved visiting 23 pesticide retail outlets (all identified retailers in the city), interviewing store staff, and inventorying diazinon products available for sale at each store. The major findings of the survey were:

- Target pests. On the basis of the survey of retail store staff, the most common target pests for diazinon are ants, fleas, and grubs.
- Time of year. According to store staff, diazinon product sales peak in the summertime. Some stores only carry diazinon in the spring and summer. Interviewed staff indicated that an exception was the common use of diazinon for winter structural ant control.
- Retailers. Major retailers of diazinon (by active ingredient volume) were Home Depot, Costco and Orchard Supply Hardware (Cooper, 1995-1996).
- Products. The most common brands available for retail sale were Ortho, Lilly Miller, Home Defense, Spectracide, Green Light, Black leaf, Dexol, Green Thumb, and store brands (OSH, Payless, Ace). Commonly available formulations were granules, dusts, concentrates, and ready-to-use diluted products. Granules and emulsifiable concentrates were the most common products.

D.2 LABEL REVIEW: STORE SHELF SURVEY

A product survey and label review was conducted on December 12, 2000. Since the purpose of the review was to obtain information about common products and their uses, the review focused on products available in the 2 stores known to be the major retailers of home use pesticide products in the San Francisco Bay Area (Home Depot and Orchard Supply Hardware).[1]

[1] Product availability (particularly for chlorpyrifos products) may have been affected by agreements with registrants (chlorpyrifos, announced June 8, 2000; diazinon, announced December 5, 2000).

To ensure that a reasonable range of products was included (including products for urban professional applicator use), the in-store review was supplemented by reviewing a random selection of additional labels obtained from manufacturer and USEPA internet sites. Labels for all diazinon and chlorpyrifos products on store shelves were reviewed (13 diazinon and 6 chlorpyrifos products, most available in multiple sizes). Together with labels obtained from the Internet, a total of about 40 diazinon product labels and 20 chlorpyrifos product labels were reviewed in detail.[2] Many product labels contain similar or identical language (whole labels or individual sections). Table D-1 highlights the typical and notable label instructions identified with regards to application sites that involve direct or indirect, but inevitable discharges to surface waters (products listed in Tables A-4 and B-4).

This method for selecting labels to review is based on three assumptions:

- The products available at the two major retailers surveyed on December 12, 2000 are representative of the range of commonly used diazinon and chlorpyrifos products sold throughout the year and throughout California.
- The products sold at these stores in the San Francisco Bay Area are representative of products sold at retail outlets elsewhere in California. (The assumption regards products themselves; uses are anticipated to vary, but such variation in uses should be accounted for on the label directions.)
- Since label review at retailers is less time consuming than other methods of obtaining and reviewing labels, a larger number of labels could be reviewed, providing greater chance of encountering a reasonable range of product labels than would be offered by less time-efficient methods.

Initial findings were consistent with previous surveys:

- The most common brand was Ortho.
- The most common product types were ready to use liquids, liquid concentrates (primarily emulsifiable concentrates), and granules (diazinon only).
- The most common insecticide active ingredients on shelves were diazinon, chlorpyrifos, malathion, and carbaryl.

While the consistency of this survey with previous findings does not ensure that a representative range of labels was reviewed, it suggests that the approach for obtaining labels was valid.

Tables D-2 and D-3 (at the end of this Appendix) provide a summary of the observed product container sizes, formulations, and active ingredient content. Individual containers with the largest amount of active ingredient were liquid concentrates (both diazinon and chlorpyrifos), bags of granules (diazinon) and paint (chlorpyrifos). The concentrates are notable because of their relatively small size, low viscosity, and large amount of active ingredient—spills of such containers in the wrong location (*e.g.,* a gutter) could easily release the entire amount of active ingredient to surface water. Also notable was the presence of a liquid concentrate product (47.5% diazinon) that was labeled for use by professional pest control operators, but was available on an open shelf for retail sale.

[2] Chlorpyrifos products have become increasingly difficult to find, which limited the label review to some extent.

D.3 INTERESTING DIAZINON AND CHLORPYRIFOS PRODUCT LABEL INSTRUCTIONS

Tables D-4 and D-5 (at the end of this Appendix) contain a summary of common and notable label instructions on diazinon and chlorpyrifos products. Additional interesting label instructions are discussed below.

Bands around structures. Both diazinon and chlorpyrifos products called for structural pest control applications in a band around the structure. Where the size of the band was specified it varied from 2 to 10 feet and sometimes (on products that could be so applied) included instructions for applications as high as 3 feet high on the sides of the building. Such instructions were found on granules, dusts, and liquid formulations. None of the instructions mentioned paved areas (as opposed to landscaped areas or bare soil) at all. While the instructions for such applications did not call for "watering in" after application, most products contained such instructions elsewhere on the label for other applications. In general the instructions were sufficiently clear that it is unlikely that users often deliberately irrigate after structural pest control applications.

Lawns (diazinon products). For lawn applications, instructions typically called for watering in the applied pesticide. Commonly, labels called simply for watering after application, and direct the user to "water thoroughly" if the application was to control grubs. Some labels were more specific, directing the user to "water lightly" after application for ants & fleas and to "water thoroughly (at least ¼ inch)" after application for grubs. A few labels had a warning in the lawn care section directing users not to apply diazinon within 75 feet of a water body that may attract waterfowl. Labels commonly warned user not to treat lawns or plants using solution at the higher concentration used to treat around structures for home invading pests.

Lawns (chlorpyrifos products). Products called for treating the entire lawn, specifically cautioning against spot treatment. In contrast to diazinon products, chlorpyrifos products typically directed users not to water for 2-3 days after application. Some labels suggested that users mow the lawn and water it well 1-2 days before treatment. Pesticide runoff has been found to increase when rainfall follows pesticide applications to locations with saturated soils (Evans, 1998).

Other outdoor application locations. Labels for both diazinon and chlorpyrifos product called for applying the pesticide (using a method appropriate to the formulation) to a wide variety of locations other than lawns, other vegetation, and around structures. Typical miscellaneous locations named on diazinon product labels were insect nests, under eaves, near window frames, doorways, carports, picnic sites, outdoor play areas, outside surfaces where insects congregate, walks, firewood piles, garbage cans, tree trunks, and cracks and other places where insects can hide. Chlorpyrifos products had similar broad lists of sites, with more detail regarding applications on wood (*e.g.*, "use in localized areas of wood structures, firewood piles, and stored lumber."

Applications to ornamental vegetation and trees (diazinon products). Labels for such applications typically called for spraying a liquid formulation (usually a diluted concentrate) to wet leaves and branches until dripping.

Indoor Treatments (diazinon products). The D.Z.N. Diazinon 4E label contained relatively typical instructions for indoor treatments in residential or commercial buildings. It instructed users to apply the product as a limited spot or crack and crevice treatment, spraying around water pipes and door frames; on surfaces beneath cabinets, refrigerators, sinks, and stoves; in storage areas; and on other similar floor areas. (Similar products also called for treated edges of carpets and other indoor surface areas.) Spot treatments were not supposed to exceed 20% of the floor area, nor is each individual spot supposed to exceed 2 square feet. In the precaution section (separate from application instructions), the label said not to apply the product to drains or sewers. The instructions did not provide information about floor care after use. It can reasonably be anticipated that wet mopping or wet cleaning of areas treated in the manner described above, followed by discharge of the cleaning solution to the sewer (as is typical practice), could release much of the applied pesticide to the sewer system.

Underground applications (chlorpyrifos products). For structural pest control, chlorpyrifos products typically instructed user to apply the pesticide in trenches around structures (*e.g.*, trenches 6 inches wide, 4 to 12 inches deep), applying a solution of pesticide with a sprinkler can to the base of trench then filling the trench with soil (mixing with treated soil at base of trench). Some product labels said to limit use trench treatment method where there are wells, cisterns, or shallow groundwater. No labels provided limitations on trench treatments intended to protect surface waters. Fence post treatment instructions were similar to trenching treatment instructions, but called for mixing half of the pesticide applied in each hole with the fill soil.

Mixing and application rates. Most liquid concentrate products required mixing. They typically contained application instructions calling for use of odd fractional amounts of the pesticides (*e.g.*, 5 1/3 ounce, 1 ½ teaspoons, 1 ¾ ounce). All required the user to estimate the application area. Some diazinon granule bags did not provide application rates; they only gave spreader settings. It is reasonable to expect tremendous error in measuring the volumes and in estimating application area.

Instructions for cleaning up after use (diazinon products). Diazinon products provided relatively limited instructions for cleanup of equipment after use. Generally the user was directed to clean sprayers thoroughly after use; such directions often specified cleaning with water. No disposal instructions were typically provided for the contaminated water. If the pesticide got on the users' clothes or body, users were directed to wash up and to launder clothes.

Instructions for cleaning up after use (chlorpyrifos products). Chlorpyrifos products often had short cleanup and disposal instructions like those on the Super IQ APT label:

> "Do not contaminate water, food or feed by storage or disposal.
> "Product Disposal: Waste resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.
> "Container Disposal: Triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities."

The label typically provided no guidance about management of the wastewater from rinsing (what not to do is sometimes mentioned in cautions elsewhere on the label). The chlorpyrifos product provided instructions of particular concern from the water quality perspective. Insecta advertised "Easy Water Clean-Up" at the top of the second page of the label. On page 4, the label explained:

> "Attention: Dries quickly and rinses easily with water. Allow to dry for several days before washing. Wash brush, roller, applicator or spraying equipment thoroughly with soap and water after use. As contact between the insect and the treated surface is necessary, any time that the latter becomes coated with dust or dirt, the treated surface should be washed with water in order to re-establish maximum possible contact."

Often, labels called for wrapping the pesticide container in paper prior to putting it in the trash. Often there was no mention as to whether containers disposed of into the trash should be empty.

Cautions. Both diazinon and chlorpyrifos products generally provided some cautions for users. Cautions were always separate from application instructions. Typical cautions included:

- avoid runoff;
- use "properly calibrated" hose end sprayer;
- don't treat structures with cisterns or wells;
- don't treat water saturated or frozen soil;
- don't treat in conditions where runoff movement from the treatment area is likely;
- clean up spills to protect wildlife;
- don't pour the product or rinse water down any drain;
- don't contaminate water when disposing of wash water or waste;
- don't apply while raining.

No product had all of the above cautions and most products only had a few of the statements related to water.

A few products had language specifically intended to educate users about surface water issues. For example, some diazinon product labels contain the following language in the "Environmental Hazards" section of the label:

> "Keep out of lakes, streams, ponds, tidal marshes, and estuaries. For terrestrial uses, do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Drift and runoff may be hazardous to aquatic organisms in neighboring areas. Shrimp and crab may be killed at application rates recommended on this label. Do not apply where fish, shrimp, crab, and other aquatic life are important resources."
>
> "Do not contaminate water by cleaning of equipment or disposal of equipment washwaters."

Other products addressed surface water issues in the "Storage and Disposal" section of the label:

> "Pesticide wastes are toxic. To avoid harming aquatic organisms in rivers and other surface waters, do no pour the concentrate, spray mixture, or rinse water into sanitary drains (for example, toilets, floor drains, and sinks) or into storm water sewers (for example, street drains). Improper disposal of excess pesticide, spray mixture, or rinsate is a violation of Federal law. If pesticide, spray mixture or rinsate cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance."

Sometimes this language was not completely consistent with application instructions regarding sites of use (*e.g.*, drainage systems), which were provided elsewhere and which are probably the focus of the applicator's attention.

Table D-1. Label Instructions for Diazinon and Chlorpyrifos Applications To Urban Sites Where Discharge To Surface Water Is Likely

Site of Use	Typical or Notable Application Instructions
Drainage systems (65013)	Most products registered for this use (diazinon products only) have instructions identical to or similar to the following: "Ditch Banks, Roadsides, Wasteland, Noncrop Areas, Barrier Strips: "Grasshoppers: Spray 31/44-1 pt. Per acre in water (minimum of 1 gal. Of water per acre) for aerial applications or a minimum of 5 gals. Of water per acre for ground applications or in oil (a minimum of 1 gal. Of oil per acre) when insects first appear, preferably in the nymphal stage. Thorough coverage of the foliage is essential."
Bathroom premises (lavatories, restrooms, etc.) (88003)	For bathrooms, the label for diazinon-containing Terand Roach & Ant Killer says to "direct spray into moist places, and around sinks, bath tubs, drains, laundry tubs, pipes through walls and floors." The D.Z.N. product label has similar instructions. The chlorpyrifos products contain no specifics with regards to bathroom applications—the user is simply directed to spray the products on surfaces.
Carpets (hospital, commercial, household) (87010)	On the D.Z.N. Diazinon 4E label, the user is directed to apply a 0.5% spray in spot applications along baseboards and edges of carpeting, under carpeting, rugs, and furniture, but is cautioned to avoid excessive wetting of carpets, floor coverings, or unfinished materials because they may be damaged. The Terand Roach & Ant Killer label directs the user to spray the underside of the carpet. One chlorpyrifos product (Dursban ME 20) calls for covering the carpet with the pesticide: "Brown dog ticks: Thoroughly apply the spray to infested areas such as cracks and crevices and along baseboards, windows and door frames and other areas of floor and floor coverings where these pests may be present. Non-carpeted flooring should only be treated with spot applications as necessary. Spots are defined as areas not to exceed two square feet." "Carpet beetles: Thoroughly apply the spray to rugs and carpets, along baseboards and edges of carpeting, under carpeting, rugs, and furniture, in closets and on shelving, and wherever else these insects are seen or suspected." "Fleas: Thoroughly apply a fine-particle broadcast spray to infested areas, such as rugs and carpets." Some chlorpyrifos products registered for carpet treatment have label language limiting treatment to carpet edges, underneath carpets and under furniture.
Sewage systems (septic tanks, sewers, etc.) (65026), sewage disposal areas (municipal and other) (67008)	Two types of sewer-related uses were noted for chlorpyrifos products: (1) applications into drains (apparently inside premises being treated, called "floor drains" on some labels) and (2) application in sewer manholes. For building drain uses, labels did not provide specific instructions other than to apply (usually by spraying) the pesticide directly into the drain. The instructions on the Insecta label are typical for sewer manhole uses—it directs users as follows: "Treatment of sewer manholes: (For control of roaches). Apply product on manhole walls. Product may be applied via coarse spray using conventional airless spray equipment or by applying with suitable brush or roller…..Do not discharge spray or unused material directly into sewer system. Do not apply product within 36 hours of predicted heavy rainfall." Super IQ APT and Super IQ LC have instructions nearly identical to the above, with the addition of instructions to "[a]pply product on underside of manhole lids and manhole walls" and to "[a]pply no more than 48 ounces (3 pints) of product to each manhole. The Dursban ME 20 label directs users to avoid application directly to drainage water. Killmaster II directs uses to apply: "a coarse low pressure (20 PSI or less) spray in 8" to 10" bands at the sewer base, midway, and upper rim flange and to the entire underside of the manhole cover. The maximum amount of Killmaster II that can be applied to each manhole shall not exceed 16 ounces (one pint). As in all other situations, the applications should be effective for a minimum of 12 months."

Table D-2. Amount of Active Ingredient in Typical Containers of Common Diazinon Products

Formulation	Diazinon Concentration (%)	Container Size	Specific Gravity (g/ml, for liquids)*	Amount of Active Ingredient in Container (grams)
Granules	2	1 pound	n/a	9.1
	5	20 pound	n/a	454.0
Liquids	22.4	16 fluid ounce	1.053	111.7
	25	32 fluid ounce	0.94	222.6
	25	128 fluid ounce	0.94	890.4
	47.5	32 fluid ounce	0.93	418.4
Ready-to-use liquids	0.075	24 fluid ounce	1.003	0.5
	0.5	128 fluid ounce	1	18.9
Dusts	5	1 pound	n/a	22.7
Aerosols	0.5	15 fluid ounce	0.954	2.1
Paint Additive	87	5 fluid ounce	1.117	143.8

*Sources for specific gravity: MSDSs for products with the same concentration (used the MSDS for the product observed on shelf where possible). For paint additive, assumed density same as 100% diazinon.
n/a – Not applicable
Source: Product labels and TDC Environmental calculations.

Table D-3. Amount of Active Ingredient in Typical Containers of Common Chlorpyrifos Products

Formulation	Chlorpyrifos Concentration (%)	Container Size	Specific Gravity (g/ml, for liquids)*	Amount of Active Ingredient in Container (grams)
Granules	1	10 pound	n/a	45.4
Liquids	4.38	32 fluid ounce	8.46 lb/gal	42.1
	12.6	32 fluid ounce	7.4 lb/gal	105.8
Ready-to-use liquids	0.5	24 fluid ounce	1.017	3.6
	0.5	128 fluid ounce	1.017	19.3
Dusts	1	1 pound	n/a	4.5
Aerosols	0.25	17 fluid ounce	0.865	1.1
Paint (clear coating)	0.9	640 fluid ounce	1	170.5

*Sources for specific gravity: MSDSs for products with the same concentration (used the MSDS for the product observed on shelf where possible). For paint, assumed density of water (latex paint). For chlorpyrifos aerosol, used density of a different but similar aerosol product (could not obtain density of the product seen).
Source: Product labels and TDC Environmental calculations.

Table D-4. Typical Diazinon Product Outdoor Application Instructions

Location	% Diazinon	Amount product	Amount Diazinon (grams)	Area covered (square feet)	Diazinon Per 1000 sq. ft (grams)	Frequency
Band around home	2	8 oz granules	4.5	100.	45.4	
Band around home, 2 feet wide	5	1 lb granules	22.7	500	45.4	At 3 week intervals (no maximum)
Band around home	5	3.2 oz granules	4.5	100	45.4	Repeat at 3 week intervals if necessary
Band around home	22.4	2 fl oz	13.96	300.	46.5	
Band around home, 5 feet wide plus 2 feet high on house	25	8 fl oz	62.34	1200 (170 lineal ft.)	51.9	Repeat as needed
Band around home, 5 feet wide plus 2-3 feet high on house	47.5	3 oz		Not provided		Makes 3 gallons solution
Lawn	2	1 lb granules	9.1	200.	45.4	
Lawn	3.2	14.35 lb granules	208.5	5000	41.7	6 week intervals
Lawn	3.34	3 lb granules	45.5	1000	45.5	
Lawn	3.33	3 lb granules	45.4	1000	45.4	Limit application area to 15,000 sq. ft.
Lawn	5	2 lb granules	45.4	1000	45.4	In 3 weeks, up to 4 times per year
Lawn	22.4	1.5 tsp	1.75	42	41.6	
Lawn	25	3 fl oz	23.38	500	46.8	Repeat as needed
Vegetables	25	1 fl oz	7.79	1050	7.4	Up to 5 treatments every 7-10 days
Flowers, shrubs, trees, vegetables	22.4	2 tsp		Not provided		
Fruit trees & berries	25	1 fl oz	7.79	375	20.8	5 times per year
Nut trees	25	1 fl oz	7.79	250.	31.2	1-3 times per year
Vegetables and trees	0.075	As needed		Not provided		3 to 5 times per season, 7-10 to 14 days apart
Paint additive	87	5 oz		Not provided		5 gallons paint

Source: Product labels and TDC Environmental calculations.

Table D-5. Typical Chlorpyrifos Product Outdoor Application Instructions

Location	% Chlorpyrifos	Amount product	Amount Chlorpyrifos (grams)	Area covered	Chlorpyrifos Per 1000 sq. ft. (grams)	Chlorpyrifos Per 100 Lineal Feet (grams)	Frequency
Fence post hole	12.6	5.33 fl oz	17.6	1 hole	n/a	176.3	
Trenching for structural pest control	12.6	32 fl oz	105.8	30 lineal feet	n/a	352.8	
Trenching for structural pest control	12.6	5.33 fl oz	17.6	2.5 lineal feet	n/a	705.1	
Band around home, 6-10 feet wide plus 2-3 feet high on house	12.6	1.75 fl oz	5.8	500 sq. ft.	11.6	n/a	
Band around home, 5-10 feet wide plus 2-3 feet high on house	4.38	4 fl oz	5.3	500 sq. ft.	10.5	n/a	
Band around home	1	1 lb dust	4.5	72 lineal feet	n/a	6.3	
Lawn	12.6	6.5 fl oz	21.5	500 sq. ft.	43.0	n/a	
Lawn	12.6	1 fl oz	3.3	75 sq. ft.	44.1	n/a	Every 4-6 weeks
Lawn	12.6	2 tsp	1.1	100 sq. ft.	11.0	n/a	Every 4-6 weeks
Lawn	12.6	13 fl oz	43.0	1000 sq. ft.	43.0	n/a	Every 4-6 weeks
Lawn	12.6	3.5 fl oz	11.6	1000 sq. ft.	11.6	n/a	Every 4-6 weeks
Lawn	4.38	3 fl oz	3.9	500 sq. ft.	7.9	n/a	Monthly, late spring through late summer
Lawn	4.38	1.5 tsp	0.3	30 sq. ft.	11.0	n/a	Every 4-6 weeks
Lawn	4.38	4 fl oz	5.3	500 sq. ft.	10.5	n/a	Every 4-6 weeks

Source: Product labels and TDC Environmental calculations.

APPENDIX E. FAULT TREE ANALYSIS

Information in this Appendix:

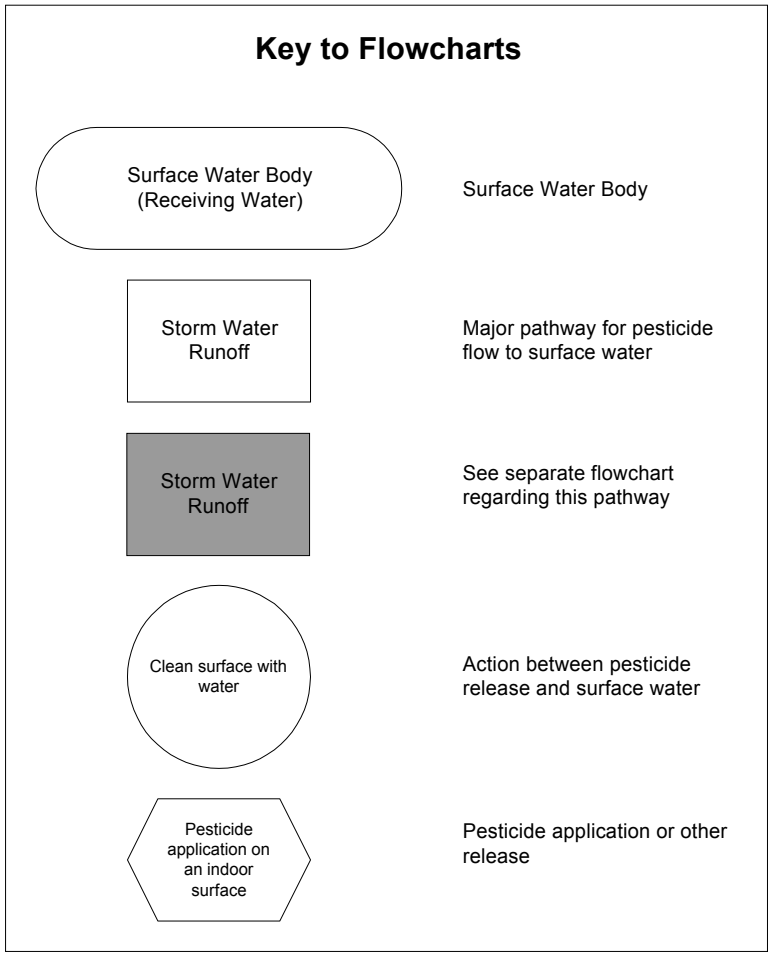


Figure E-1. Pathways for Urban Pesticide Release to Surface Waters

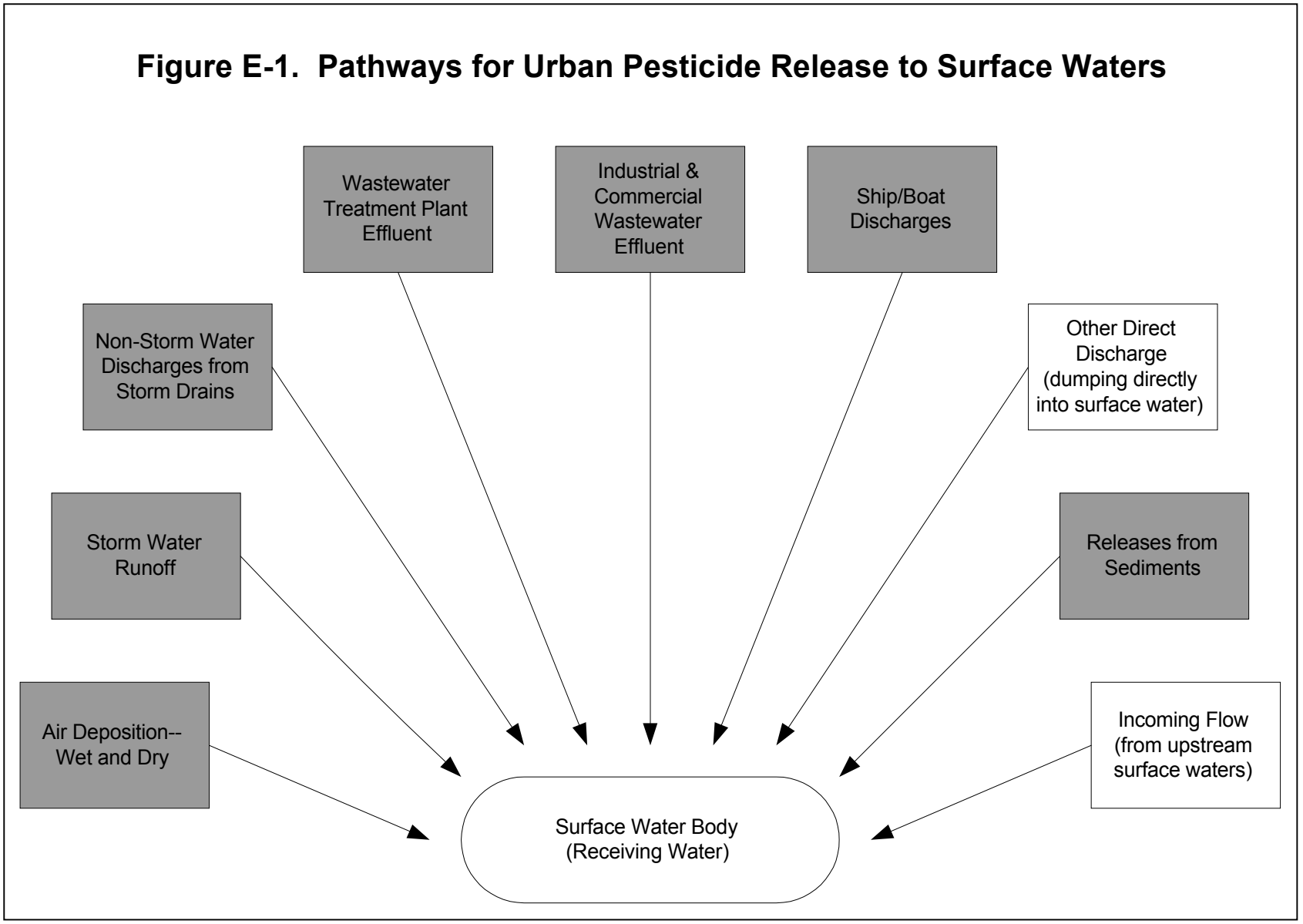


Figure E-2. Urban Sources for Air Deposited Pesticides

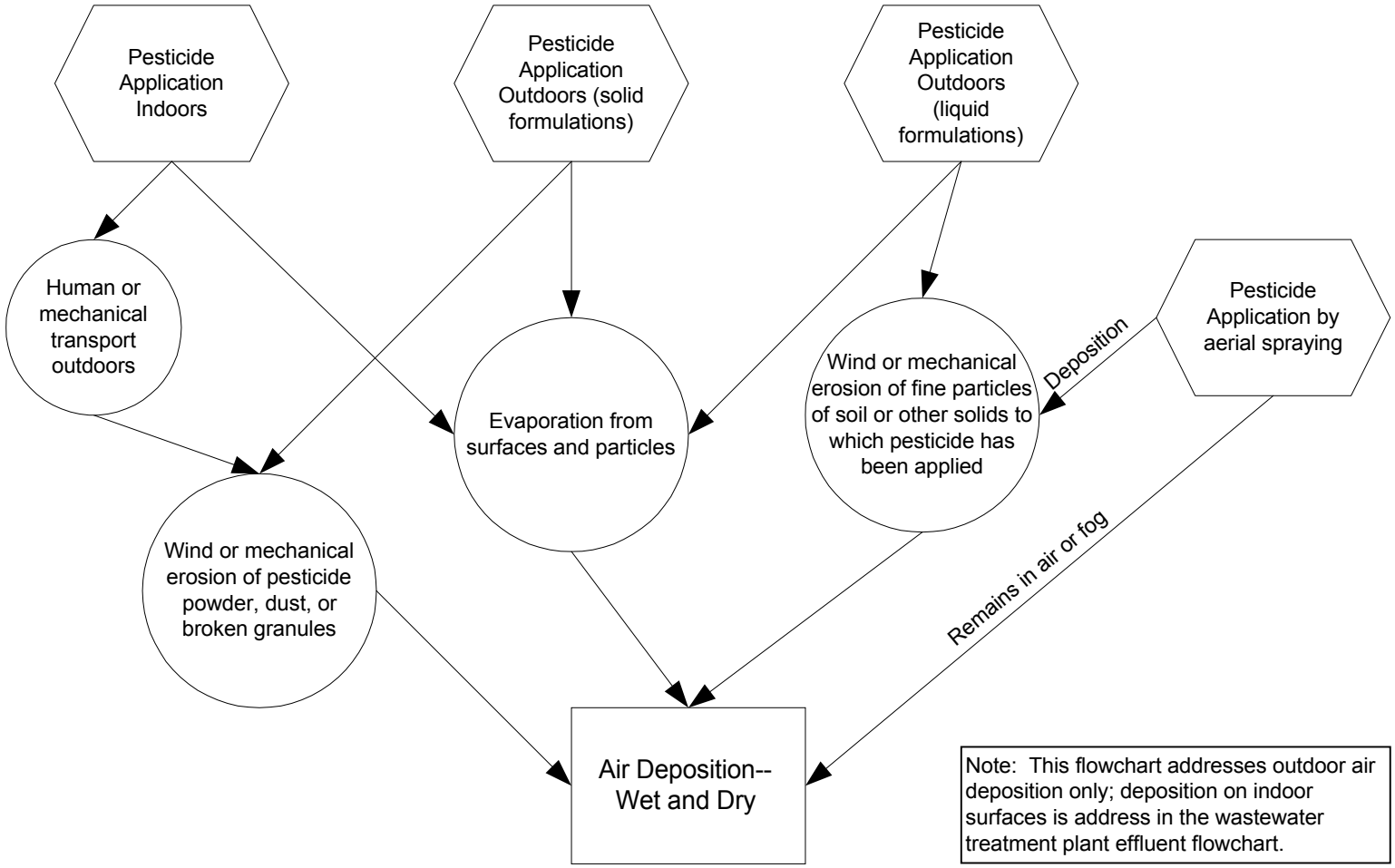


Figure E-3. Sources for Pesticides in Urban Storm Water Runoff

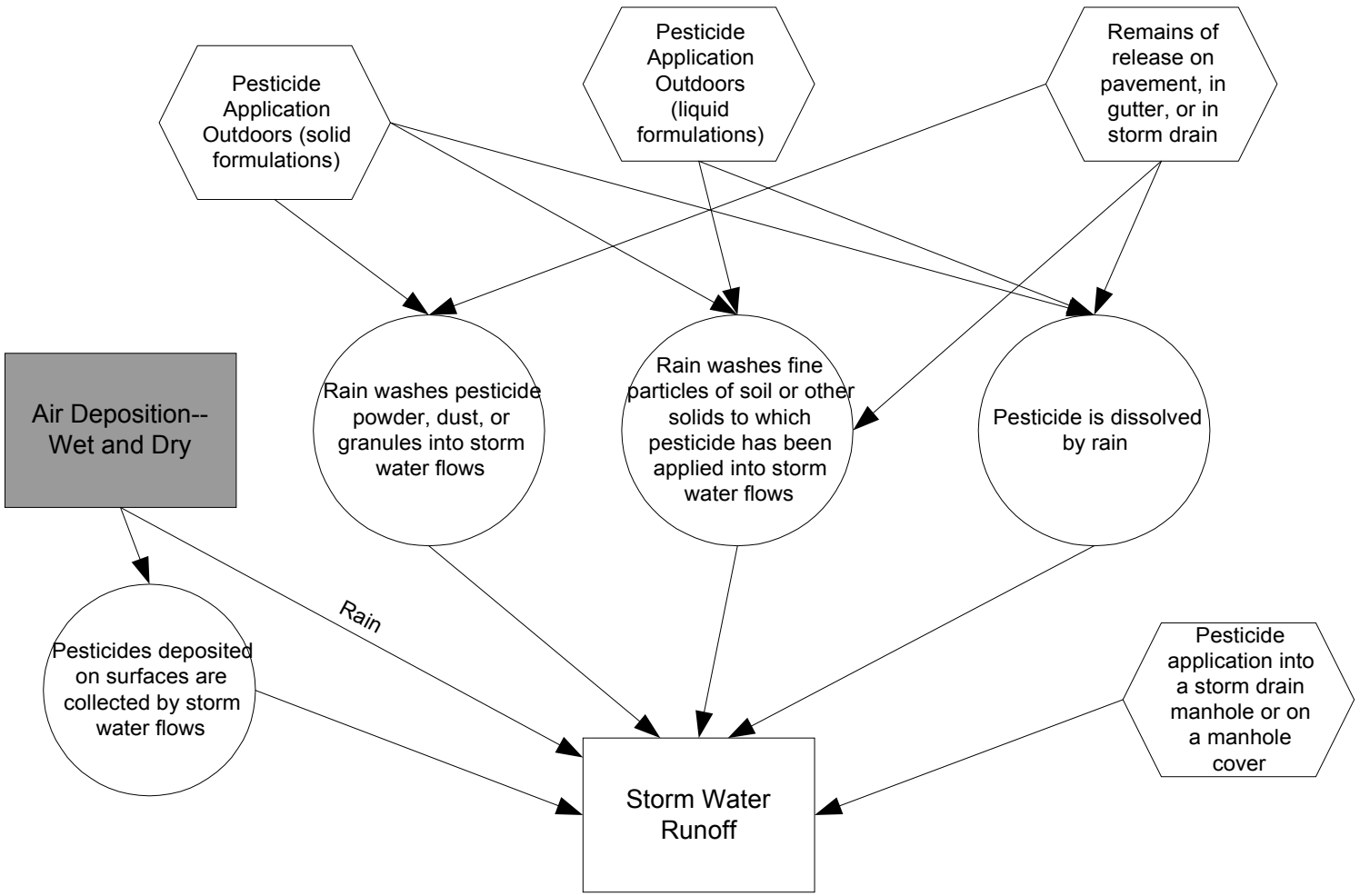


Figure E-4. Pesticides Sources in Non-Storm Water Storm Drain Discharges

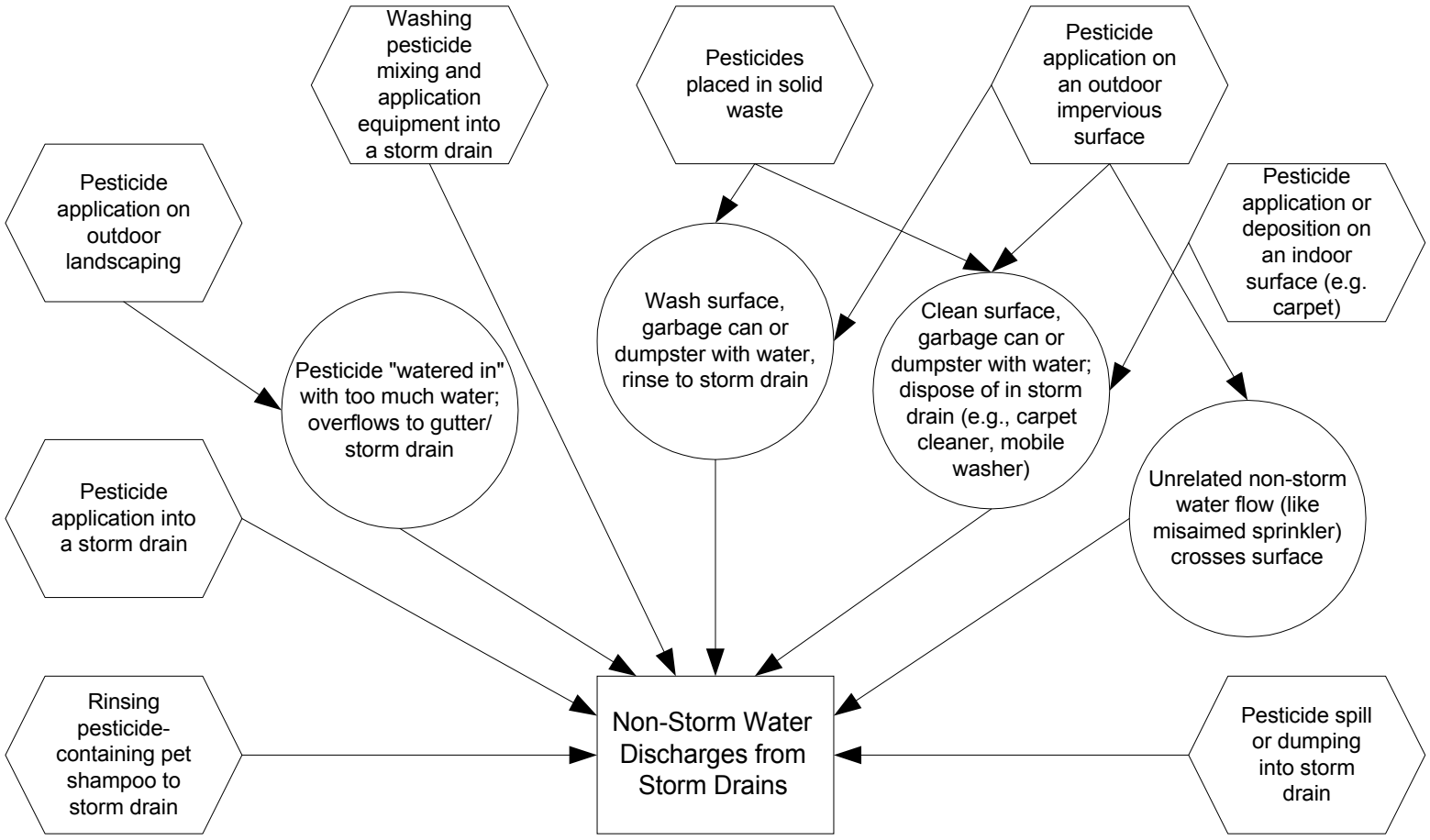


Figure E-5. Sources for Pesticides in Wastewater Treatment Plant Effluent

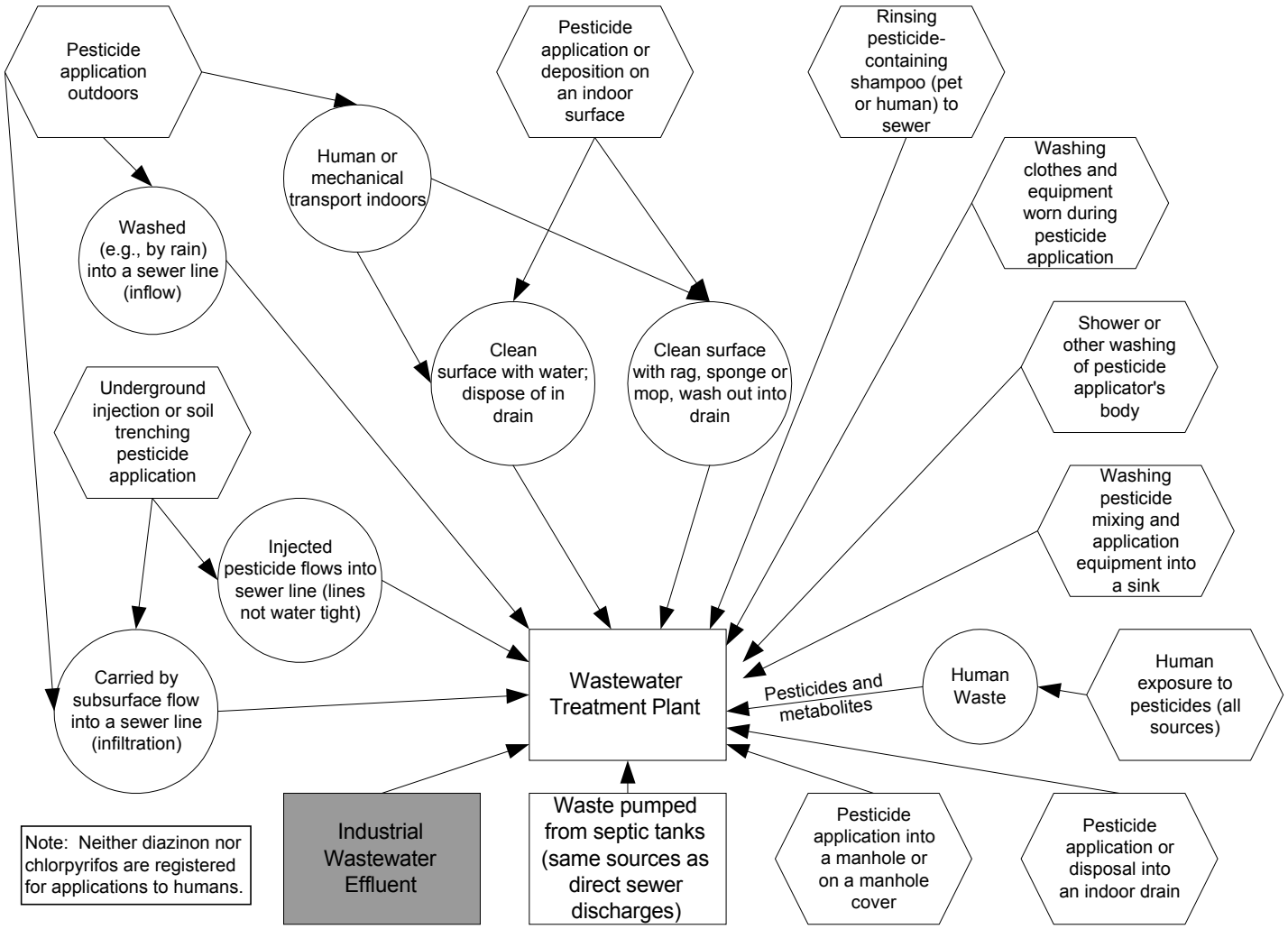


Figure E-6. Sources for Pesticides in Industrial & Commercial Wastewater Effluent

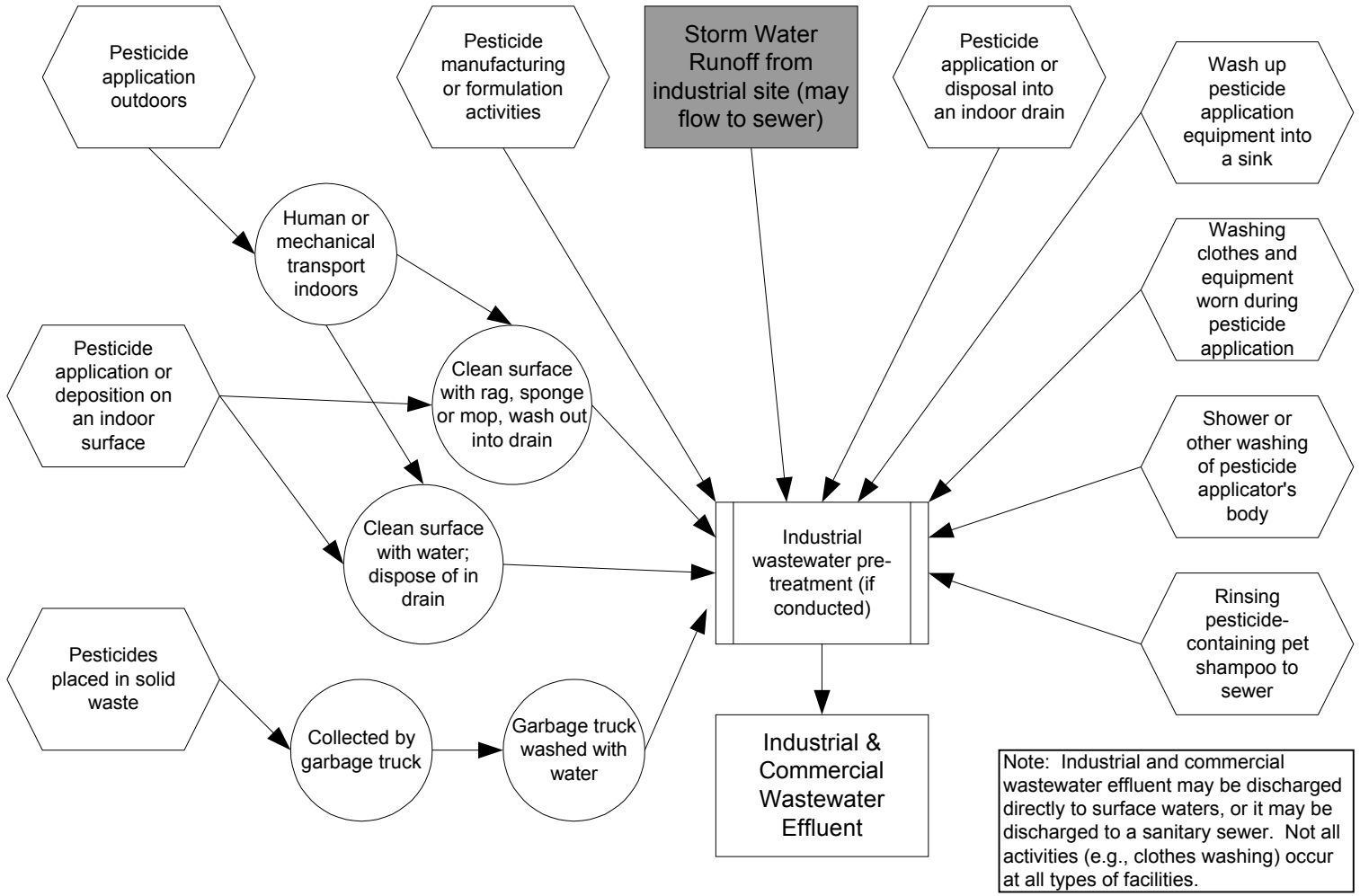


Figure E-7. Sources for Pesticides in Ship/Boat Discharges

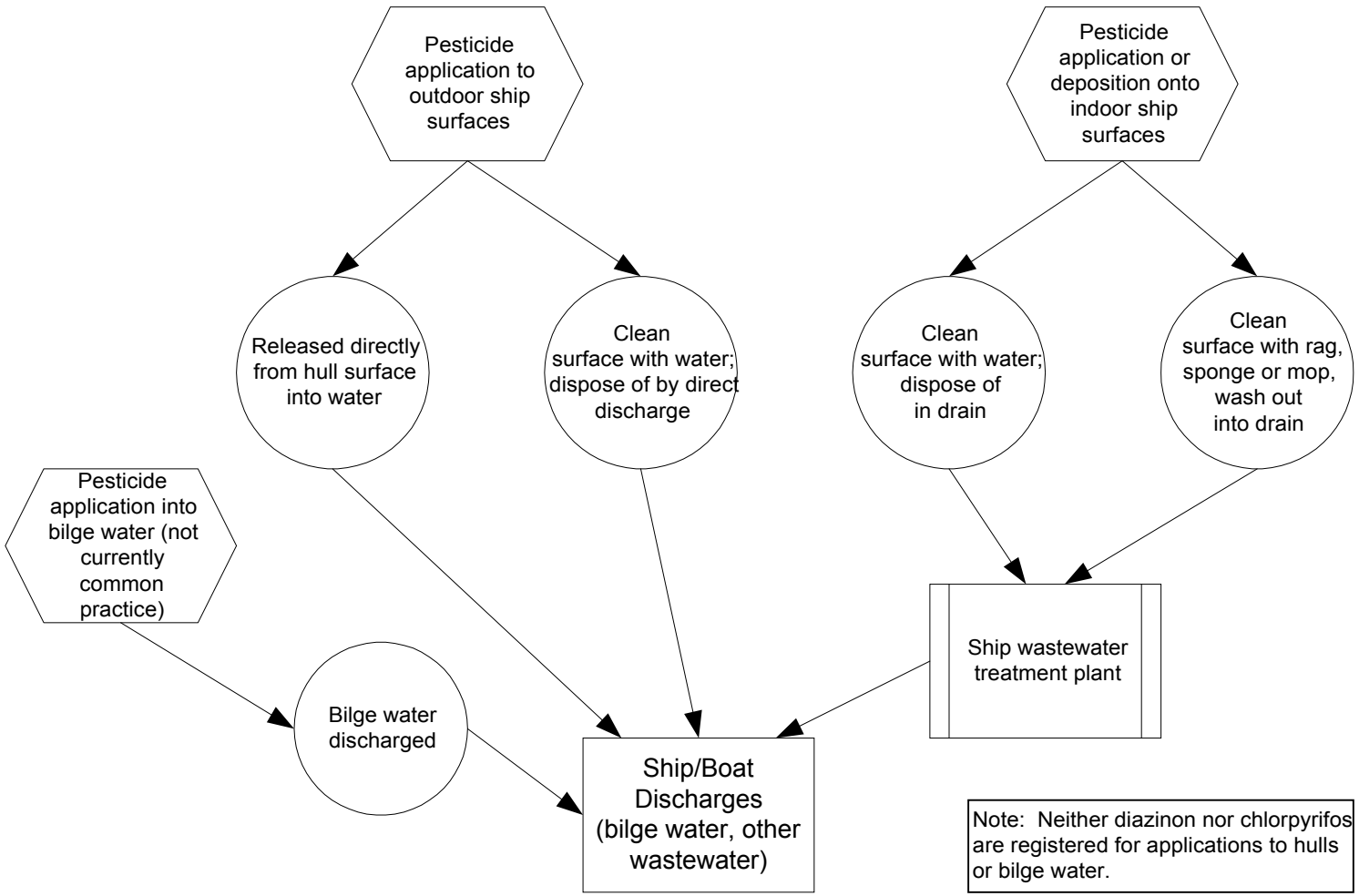
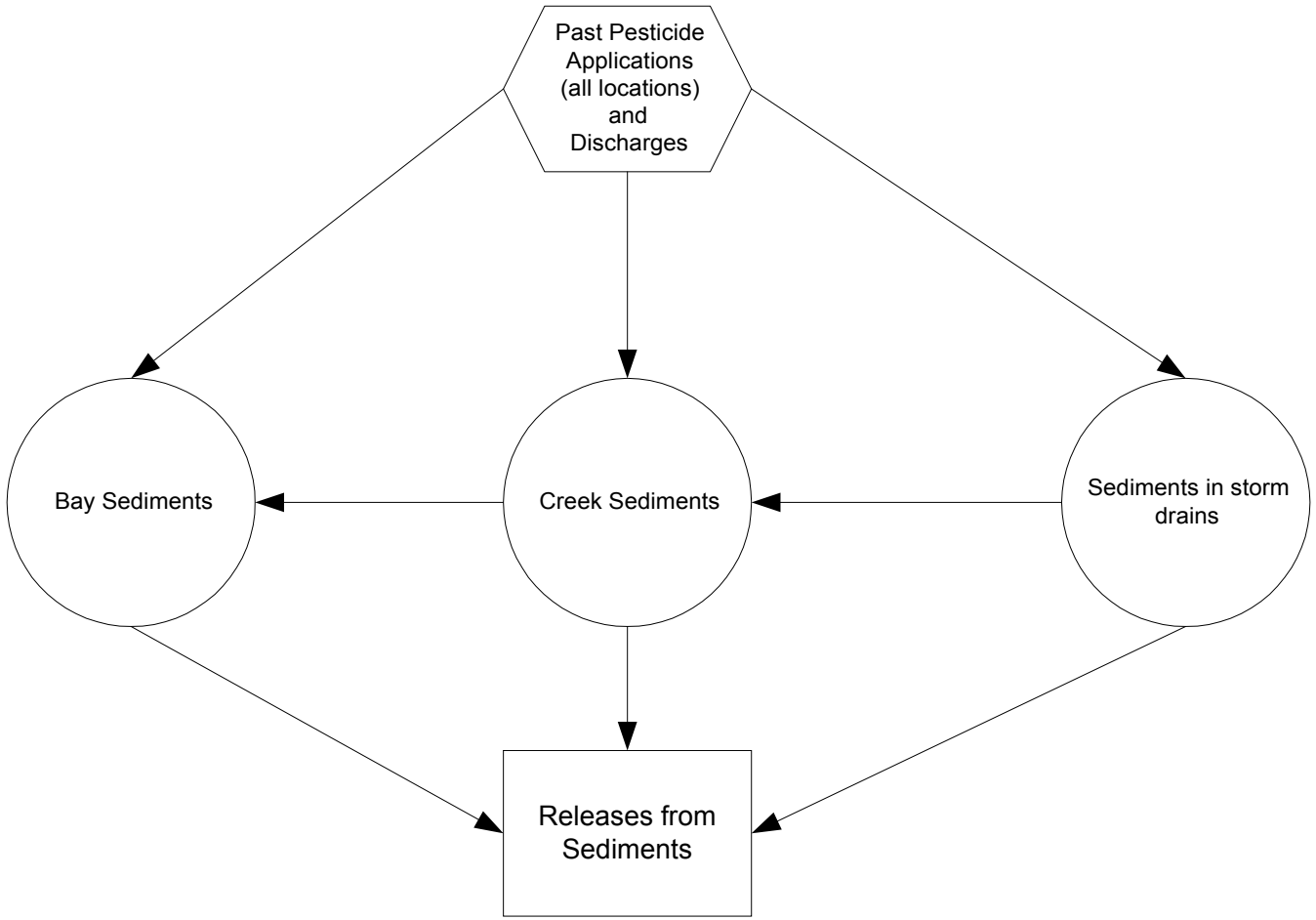


Figure E-8. Sources for Pesticides in Releases from Sediments into Surface Waters



APPENDIX F. EVENT TREE ANALYSIS

Information in this Appendix:

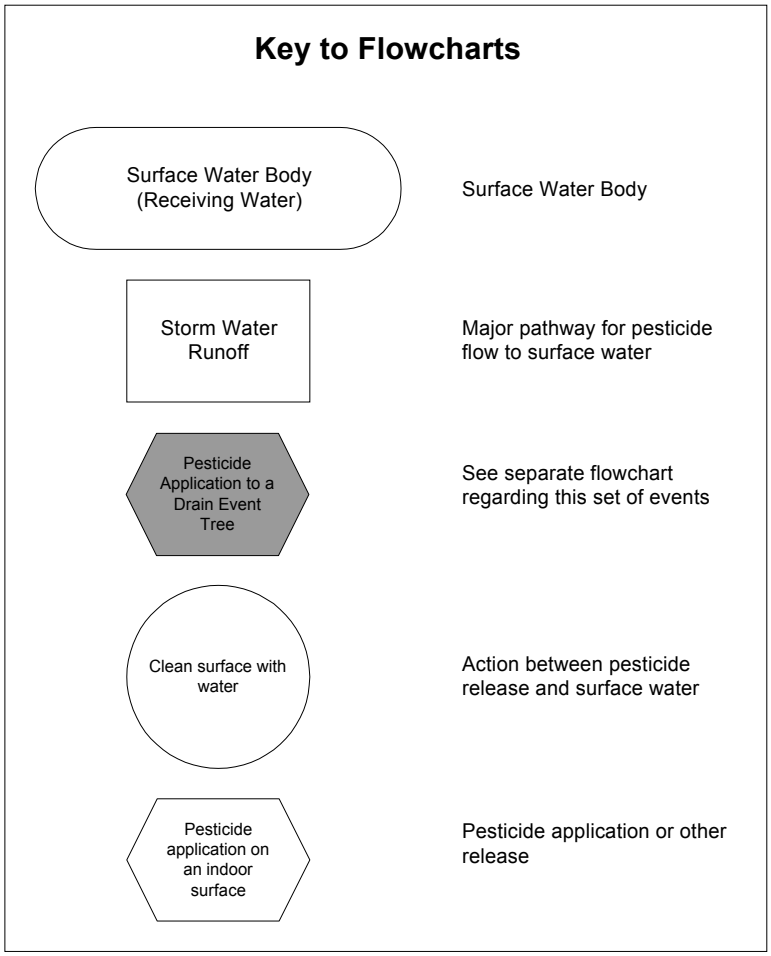


Figure F-1. Major Pathways from Common Urban Diazinon and Chlorpyrifos Uses to Surface Waters

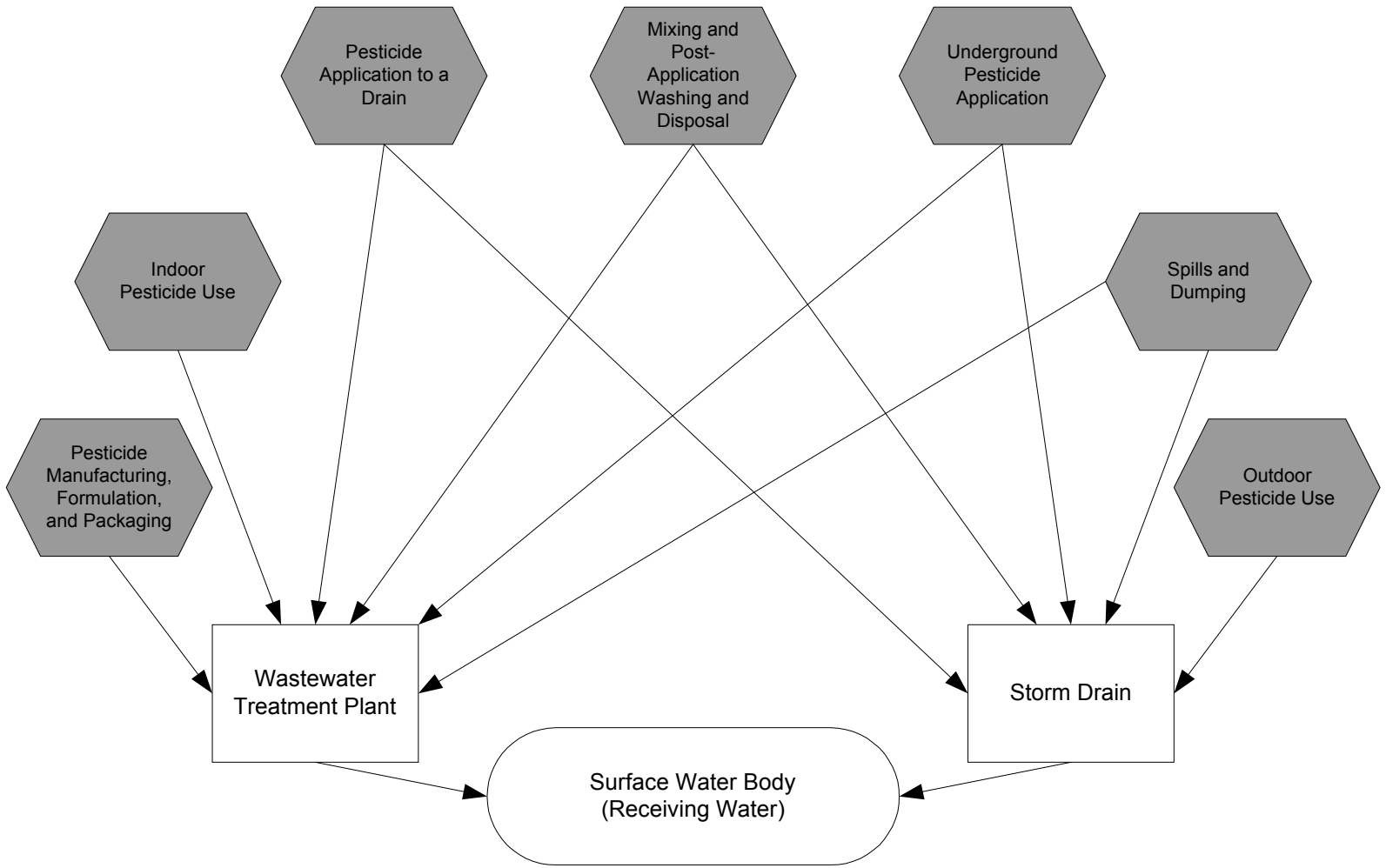


Figure F-2. Outdoor Pesticide Use

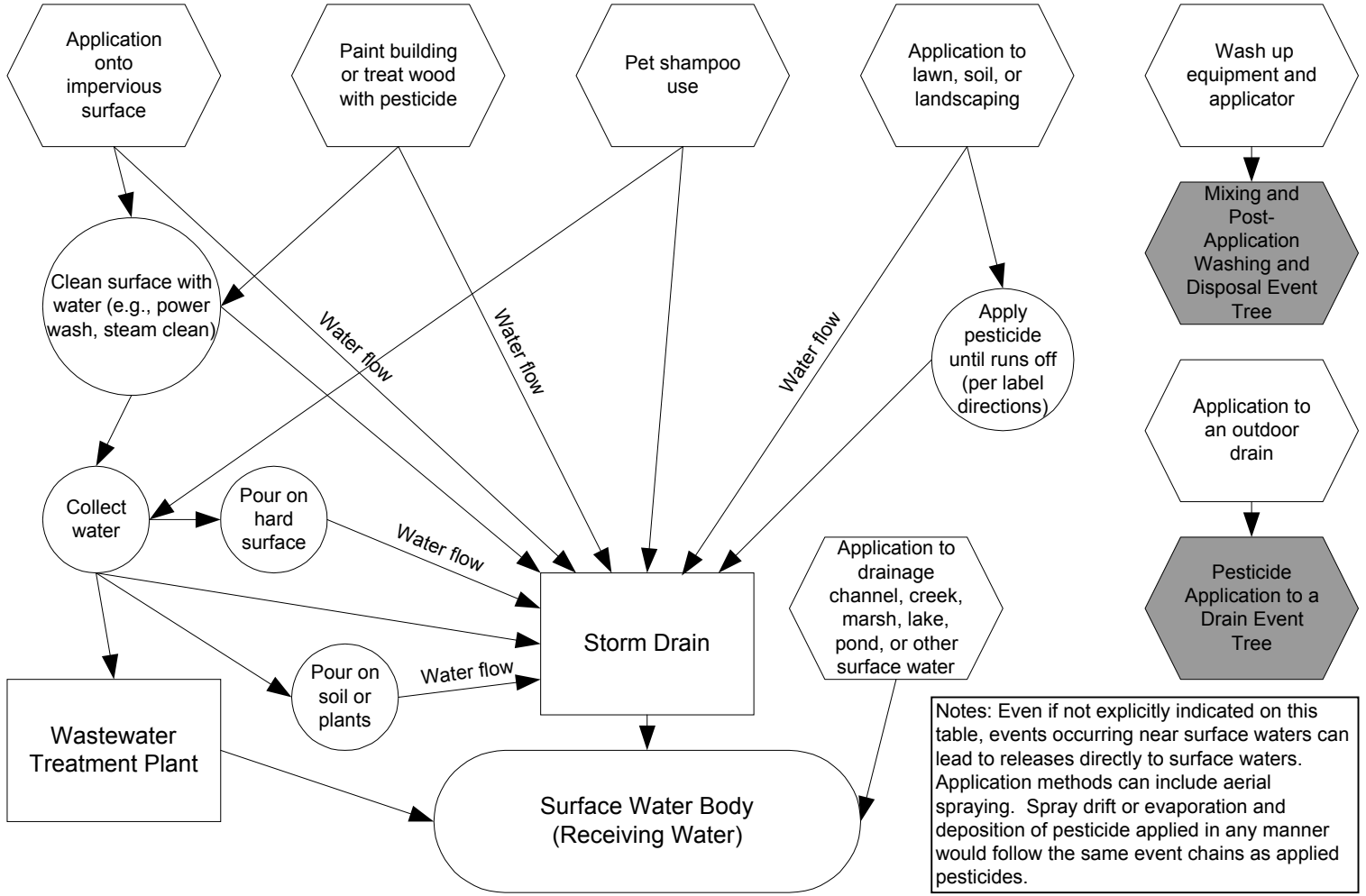


Figure F-3. Spills and Dumping

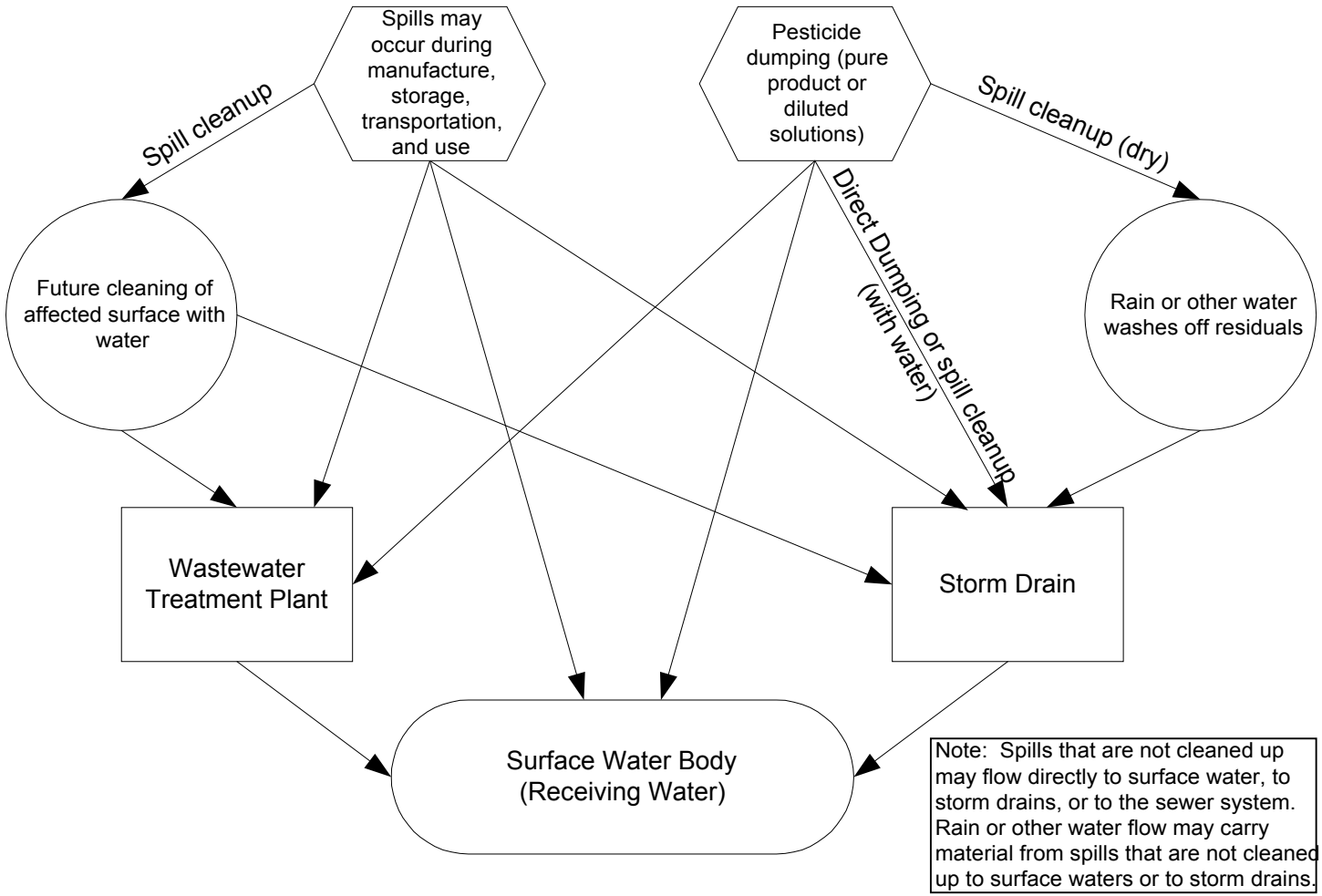


Figure F-4. Underground Pesticide Application

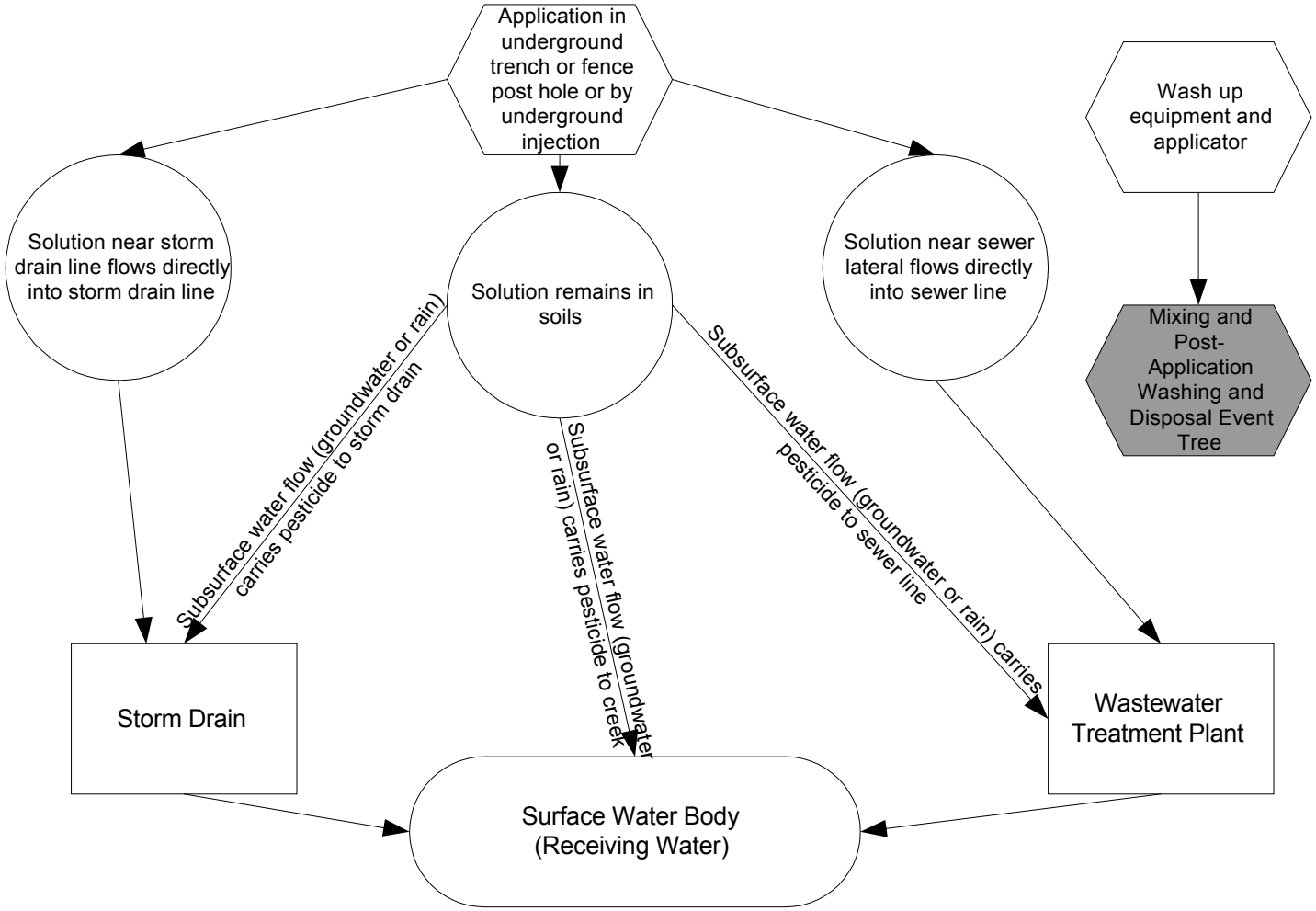


Figure F-5. Mixing and Post-Application Washing and Disposal

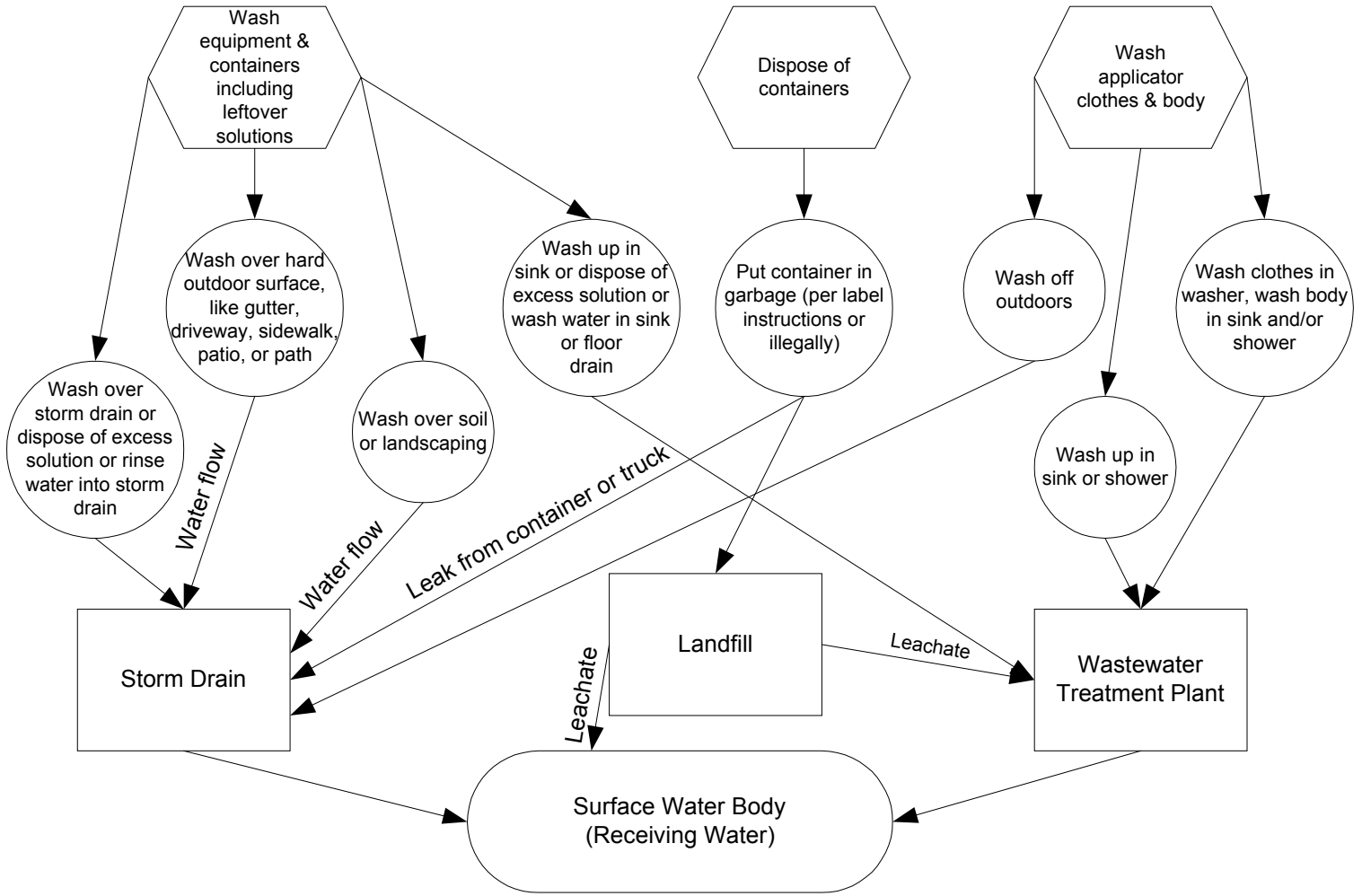


Figure F-6. Pesticide Application to a Drain

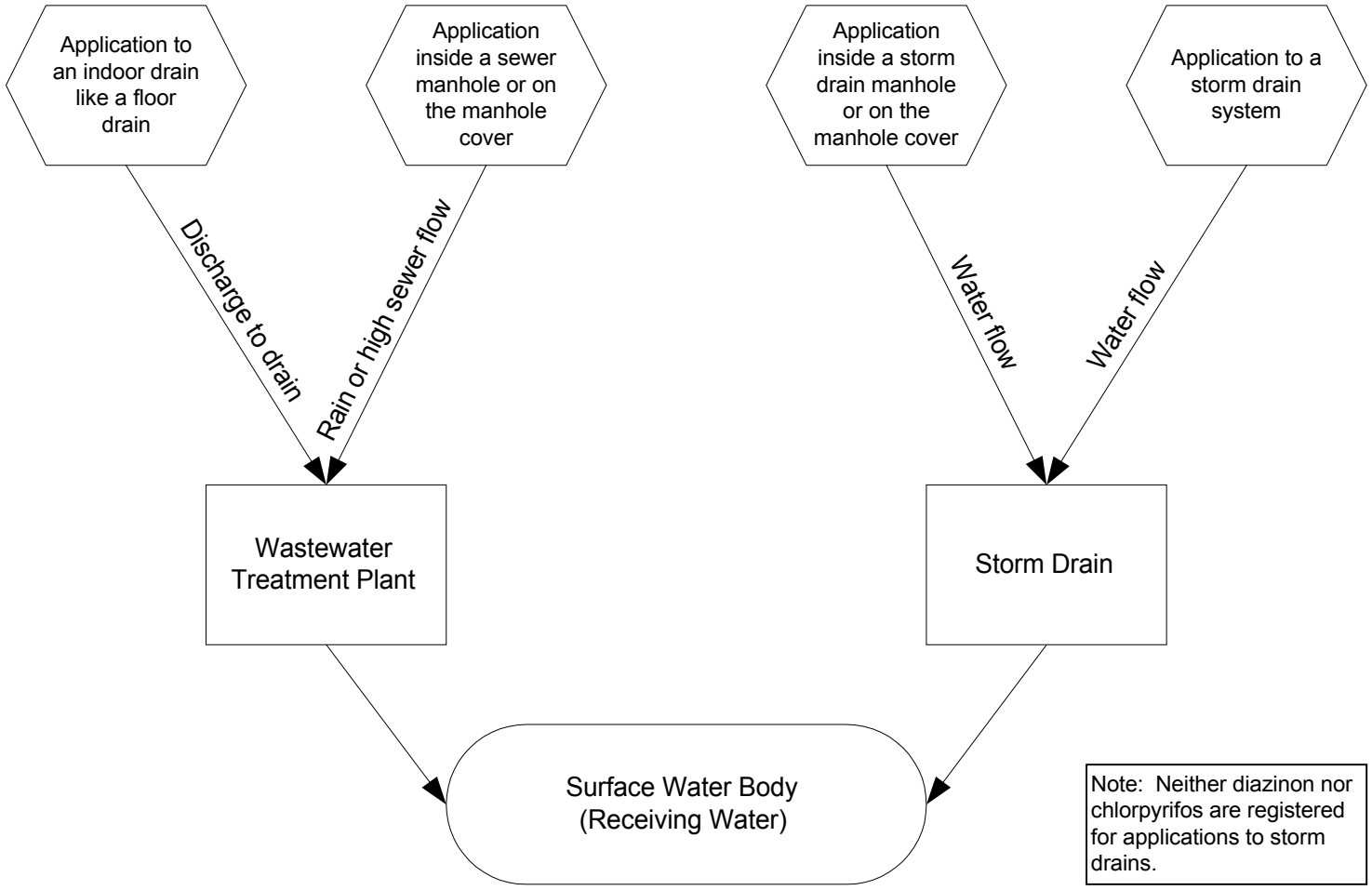


Figure F-7. Indoor Pesticide Use

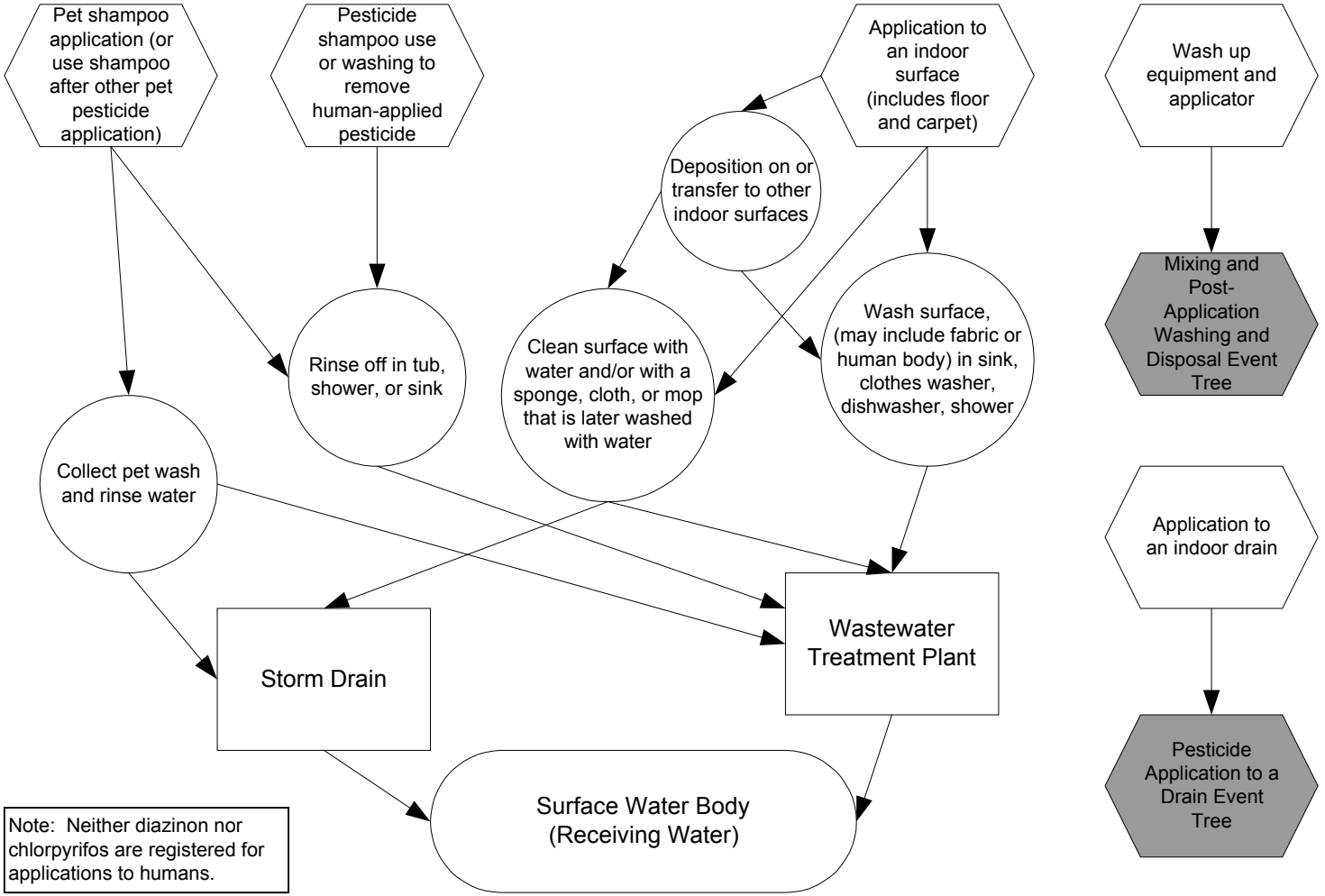
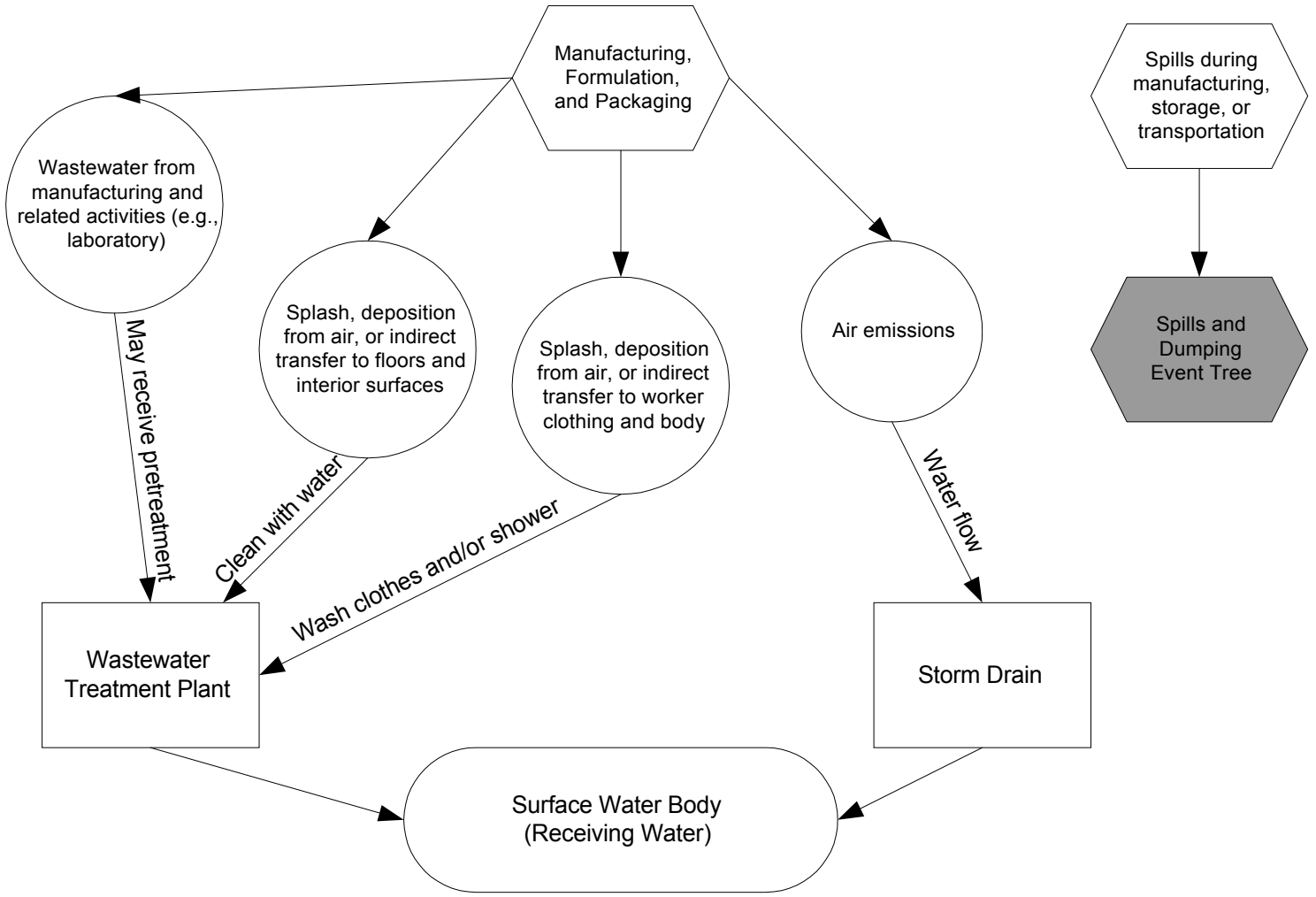


Figure F-8. Pesticide Manufacturing, Formulation, and Packaging



APPENDIX G. WHAT IF? ANALYSIS

Information in this Appendix:

Table G-1. Sites of Use Categorization

Landscape applications

Code	Name
29510	Nurseries (All Or Unspec)
31000	Ornamental Herbaceous Plants (All Or Unspec)
31003	Ornamental Herbaceous Flowering Plants (All/Un)
31004	Ornamental Herbaceous Foliage Plants (All/Un)
31005	Ornamental Bulb, Corm, Rhizome Plants (All/Unspec)
31011	African Daisy/Gazania/Gazania Longiscara
31012	African Violets/Saintpaulia
31013	Ageratum/Flossflower/Pussy-Foot
31017	Alyssum (Gold-Dust; Goldentuft)
31034	Begonia (Fiberous & Tuberous Rooted)
31046	Cacti (Family Cactaceae)
31057	Carnation
31058	Celosia
31065	Chrysanthemum (Mum)
31071	Coleus
31095	Echinopsis (Cactus); Echinopsis Spp.
31106	Garden Balsam/Balsam; Impatiens Balsamina
31108	Geranium
31111	Gladiolus
31117	Gypsophila (Baby's Breath)
31122	Hoya (Variegated Hoya, Indian Rope Plant)
31127	Jade Plant
31136	Maranta
31137	Marigold
31149	Pansies
31154	Petunias
31161	Marigold, Pot
31170	Sage, Ornamental/Scarlet; Salvia Spp.
31190	Sedum, Stonecrop
31191	Strawflower
31206	Verbena
31213	Zinnia
31228	Lily, Canna (Canna) (Canna Hybrids)
31267	Snakeplant; Sansevieria Trifasciata Prain.
31284	Primrose
31297	Succulents (All Or Unspecified)
31306	Velvetplant, Java Velvetleaf
31340	Arrowhead (Sagittaria Spp.)
31418	Aluminum Plant; Pilea Candierei
31450	Spider Plant; Chlorophytum Comosum
32000	Ornamental Plants (Herb. & Woody) (All Or Unspec)
32002	Ornamental Vines (Herb. & Woody) (All Or Unspec.)
32004	Ornamental Plants (Deciduous) (All Or Unspec)
32005	Ornamental Evergreens (All Or Unspec)
32501	Gardens (Ornamental, Flower, Rock, Shrub, Etc.)
33005	Ornamental Grasses, Northern
33007	Turf, Golf Course (Fairways, Greens, Rough)
33008	Ornamental Turf (All Or Unspec)
33009	Ornamental Ground Covers (All Or Unspec)
33010	Ornamental Lawns, Lawns (All Or Unspec)
33011	Ornamental Grasses
33028	Dichondra (Ground Cover)
33044	Vinca (Ground Cover) (Periwinkle, Myrtle)
33112	Ivy (All Or Unspec) (Ground Cover)
33125	Sedum (Ground Cover) (Stonecrop)
33128	Gazania (Ground Cover)
34000	Ornamental Shrubs (All Or Unspec) (Woody/Herb.)
34006	Ornamental Broadleaf Evergreen Shrubs
34007	Ornamental Deciduous Shrubs
34018	Aralia (Aralia Spp.)
34022	Azalea (Rhododendron Species)
34031	Boxwood (Box Tree) (Buxus Spp.)
34036	Camellia
34053	Euonymous
34055	Feijoa (Pineapple Guava) (Feijoa Spp.)
34058	Pyracantha (Firethorn)
34063	Gardenia
34070	Holly (Yaupon) (Inkberry) (Ilex Spp.)
34072	Honeysuckle (Lonicera Spp.)
34076	Ivy (Hedera)
34083	Lantana (Shrub Verbena) (Lantana Spp.)
34087	Leucothoe; Leucothoe Spp.
34088	Ligustrum (Privet) (Ligustrum Spp.)
34089	Lilac
34100	Heavenly Bamboo (Sacred Bamboo); Nandina Domestica
34102	Oleander (Nerium Spp.)
34106	Pachysandra (Pachysandra Spp.)
34109	Vinca (Photinia)
34113	Pittosporum
34118	Rhododendron (Species/Hybrids/Cultivars) (Azalea)
34120	Rose
34130	Spirea (Spiraea Spp.)
34134	Lilac (Syringa) (Syringa Spp.)
35000	Ornamental And/Or Shade Trees (All Or Unspec)
35005	Ornamental Broadleaf Evergreen Trees (All/Unspec)
35006	Ornamental Deciduous Trees (All Or Unspec)
35007	Ornamental Conifers (All Or Unspec)
35008	Ornamental Flowering Trees (Fruit, Nut, Etc.)
35028	Birch (Betula Spp.)
35043	Dogwood (Ornamental)
35044	Douglas-Fir (Pseudotsuga Spp.)
35049	Elm; Ulnus Spp.
35051	Fir (True Firs) (Abies Spp.)
35056	Crabapple, Flowering (Ornamental); Malus=Pyrus Spp
35057	Dogwood, Flowering; Cornus Florida
35060	Plum, Flowering (Ornamental); Prunus Spp.
35070	Honeylocust (Gleditsia Spp.)
35073	Juniper; Juniperus Spp.
35077	Locust
35083	Maple; Acer Spp.
35084	Cypress, Monterey (Cupressus Spp.)
35093	Oak (Quercus Spp.)
35097	Palm; Family Palmae
35098	Pine; Pinus Spp.
35099	Podocarpus; Podocarpus Spp.
35101	Poplar (Populus Spp.)
35116	Spruce
35119	Sycamore (Planetree) (Buttonwood) (Plantus Spp.)
35128	Willow (Salix Spp.)
35130	Yew (Taxus Species)
35136	Mimosa
39000	Ornamental Nonflowering Plants (All Or Unspec)

Table G-1. Sites of Use Categorization (Continued)

Landscape applications (continued)

Code	Name
39001	Ornamental Ferns (All Or Unspec)
39003	Ornamental Nurseries (Stock, Crops, Etc.)
39005	Ornamental Plants - Greenhouse (All Or Unspec)
40000	Soil Application (Ag-Crop, Orn-Plant Situations)
40005	Soil Application, Preplant-Indoor(Greenhouse,Etc.)
40006	Mulch (Including Mulching Straw, Hay, Paper)
40008	Soil Application, Preplant-Outdoor (Seedbeds,Etc.)
40501	Soil Application, (Houseplant Potting Soil)
40502	Soil Beneath Host Plants
40503	Soil Amendment (Ph, Mineral, Texture Adjustment)
61015	Greenhouses (In Use)
63004	Greenhouses - Domestic Non-Commercial
63017	Domestic Garden Crops (Non-Commercial)
67002	Recreational Areas, Tennis Courts, Parks, Etc.
67502	Apply Directly To Pest: No Site Specified
90011	Ant Dens/Hills/Mounds (In/Out-Door) (All/Unsp)
90013	Beehives, Bee Colony (Diseased, Nuisance)
100003	Landscape Maintenence

Structure-related pest control
(Indoor applications at these sites are also considered in the Indoor Application section)

Code	Name
44000	Proc. Or Manuf. Non-Food Prod. (All Or Unspec)
46000	Storage Areas & Processing Equipment (All/Unspec)
46026	Storage Areas - Empty (All Or Unspec)
46027	Storage Areas - Full (All Or Unspec)
46028	Feed/Food Storage Areas - Empty
46029	Feed/Food Storage Areas - Full
46031	Non Feed/Food Storage Areas - Full
46501	Storage Areas (Unspecified)
46502	Feed/Food Storage Areas (Unspecified)
46503	Non Feed/Food Storage Areas (Unspecified)
58000	Commercial Egg Handling Equipment
63000	Household Or Domestic Dwellings (All Or Unspec)
63002	Cracks & Crevices
63003	Household Or Domestic Dwellings (Outdoor)
64000	Wood Or Wood Structure Protection Treatments
64003	Wood Protection - Finished Wood Products
64500	Wood Protection Treatments (All Or Unspecified)
64501	Lumber (Seasoned/Unseasoned)
64502	Wood Structures: Above Ground & Finished Struct
64503	Wood Protection: At/Below Ground Level
64504	Wood Structures: Indoor/Enclosed Areas
67003	Buildings And Structures (Non-Ag Outdoor)
67009	Industrial Sites (Lumber Yards, Tank Farms, Etc.)
68003	Public Buildings And Structures (Vert. Pests)
70000	Commercial Transport Facilities (All Or Unspec)
70004	Ships, Boat Premises, Etc. (All Or Unspec)
70026	Railway Trains (All Or Unspec)
70027	Aircraft (All Or Unspec)
70031	Commercial Transport Facil (Feed/Food-Empty)
70032	Commercial Transport Facil (Feed/Food-Full)
70502	Commercial Transport Facil (Non Feed/Food-Empty)
70504	Commercial Transport Facil (Non Feed/Food-Unsp)
71000	Food Processing/Handling Plant/Area (All/Unspec)
71001	Bakeries, Bakery Equipment, Etc.
71002	Bottling Plants (Includes Beverage Bottles)
71003	Breweries, Distilleries, Beer Beverage Cases, Etc.
71004	Canneries And Frozen Food Plants
71006	Feed Mills, Feed Stores, Feed Processing Plants
71008	Meat Processing Plants (Slaughter Houses, Etc.)
71010	Wineries, Wine Cellars
71011	Flour Mills, Flour/Grain Elevators, Etc.
71012	Egg Processing Plants, Egg Breaking Plants
71019	Beverage Processing Plants, Etc. (All Or Unspec)
71022	Fish And Sea Food Processing Plants And Equipment
71033	Food Processing/Handling Plant/Area (Food Area)
71501	Food Processing/Handling Plant/Area (Food Area)
71502	Food Processing/Handling Plant/Area (Nonfood Area)
72000	Eating Establishments (All Or Unspec)
72004	Eating Establishments (Non-Food Areas)
72006	Eating Establishments (Equipment & Utensils)
72501	Eating Establishments (Food Handling/Serving Area)
73000	Food Marketing, Storage & Distribution Facilities
73002	Food Stores, Food Markets, Supermarkets, Etc.
73003	Meat Markets (Fish Markets, Butcher Shops, Etc.)
74000	Hospitals & Related Institutions (All Or Unspec)
74008	Hospital Critical Premises
74016	Nursing Homes
74501	Hospital Critical & Semi-Critical Items (Combined)
74502	Veterinary Hospitals (Veterinary) (All Or Unspec)
76000	Morgues, Mortuaries, Funeral Homes (All Or Unspec)
76003	Morgues, Mortuaries And Funeral Home Instruments
76501	Mausoleums
77000	Commercial, Institutional Or Industrial Areas
77004	Commercial Storages Or Warehouses (All Or Unspec)
77005	Commercial/Institut./Indust. Bldgs. (Nonfood-Fum.)
77501	Schools (Indoor) (School Yards Use 67002)
77502	Non-Feed/Non-Food Processing Plants
89001	Refuse And Solid Waste Containers
90002	Quarantine Use (Federal And/Or State - Unspec)
90550	Zoos
92002	Commercial-Industrial Uses (Combined Site)
92502	Commercial - Industrial Uses (Combined Site)

Table G-1. Sites of Use Categorization (Continued)

Other outdoor applications

Code	Name
67000	Uncultivated Non-Ag Areas (All Or Unspec)
67004	Highway Rights-Of-Way (Roadways, Curbs, Etc.)
67006	Utility Rights-Of-Way, Yards, Substations, Etc.
67011	Paved Areas, Pre-Paving Applications
67012	Private Roads, Walkways, Lanes, Patios, Etc.
67013	Rights-Of-Way (Unspec) (Firelanes, Etc.)
67015	Fencerows, Hedgerows, Stone Walls (Non-Ag)
67016	Soil Sterilization Of Uncult., Non-Ag Areas
67501	Wasteland(s) (Distinct From Pasture/Rangeland)
68000	Wide Area And General In-/Outdoor (All Or Unspec)
68002	Urban Areas (All Or Unspec) (Residential, Etc.)
68005	Non-Agricultural Areas (Public Health Treatment)
68009	Fencerows (All/Unspec), Hedgerows (All/Unspec)
68502	Mosquito Abatement Districts
89000	Refuse And Solid Waste Sites (All Or Unspec)
89003	Garbage Dumps (All Or Unspec)

Indoor applications

Code	Name
32010	House Plants
63001	Household Or Domestic Dwellings (Indoor)
63005	House Or Domestic Dwelling Indoor Non-Food Area
63006	Household Or Domestic Dwelling Food Handling Areas
63010	Baseboards
63012	Wall Voids, Wood (Injection)
63013	Window Sills
63014	Door Frames
67502	Apply Directly To Pest: No Site Specified
86000	Human Sites (All Or Unspec)
87010	Carpets (Hospital, Commercial, Household)
88003	Bathroom Premises (Lavatories, Restrooms, Etc.)
90011	Ant Dens/Hills/Mounds (In/Out-Door) (All/Unsp)

Applications to pets

Code	Name
54000	Pets (All Or Unspec)
54002	Cats (All Or Unspec) (Pet)
54003	Dogs (All Or Unspec) (Pet)
56001	Animals (Unspecified)
56005	Horses (Race, Draft, Show, Riding, Etc.)
56020	Zoo Animals (All Or Unspec)
92501	Pets And Domestic Animals (Combined Site)

Sewer applications

Code	Name
65013	Drainage Systems (All Or Unspec)
65026	Sewage Systems (Septic Tanks, Sewers, Etc.)
67008	Sewage Disposal Areas (Municipal And Other)

Table G-2. What If? Analysis—Landscape Applications

Application Sites	How Pesticide May Be Released	Event Needed for Release to Surface Water	Primary Pathway to Surface Water	Master Scenario
Landscape Maintenance - General	One of the two most common urban uses of diazinon and chlorpyrifos. See the analysis of specific landscape maintenance and related activities below.	See below	See below	Plant or soil release
Lawn/turf	May be applied as a solution, in dusts, or as a granular formulation (sometimes combined with fertilizers). Under normal conditions, pesticide applied to lawns would only be carried off site by rain. Over watering leading to runoff is, however, a common occurrence, both on residential and commercial lawns and on managed turf at parks and golf courses (where runoff often flows directly to surface waters). Depending on the target pest, instructions often call for watering after application (lightly or thoroughly, varies depending on target pest). If over watering occurs to implement this instruction, flows may carry the newly applied pesticide to surface waters. Pre-watering (sometimes called for on the label) or watering in followed by rain while the ground is still saturated has been shown to increase pesticide runoff.	Rain, over watering, or other water flow	Storm drain	Plant or soil release
Ornamental vegetation treatment--Flowers, shrubs, trees, etc.; nurseries; domestic garden crops; vegetables; soil, mulch, and soil amendment applications	Typically pesticides are applied to the vegetation itself or to the soil surrounding the plants. Under normal conditions, pesticide applied to ornamental vegetation would only be carried off from the plants and surrounding soil by rain. Over watering of surrounding soil may also carry pesticides off-site (such over watering is not as common as it is for lawns). Instructions sometimes call for spraying to wet leaves and branches until dripping or applying until runoff. In such cases, if the vegetation is above paved surfaces (*e.g.*, walkways, driveways, patios), the pesticide would quickly reach the paved surface, where rain or water-based cleaning could carry the pesticide to a storm drain. Other, more minor transport pathways are possible (*e.g.*, pruning of treated vegetation that is sent to a landfill or is composted; picking treated fruit and washing in a sink). (Note: see Structural pest control analyses for applications to impervious surfaces at nurseries or in gardens.)	Rain, over watering, or other water flow	Storm drain	Plant or soil release

Table G-2. What If? Analysis—Landscape Applications (Continued)

Application Sites	How Pesticide May Be Released	Event Needed for Release to Surface Water	Primary Pathway to Surface Water	Master Scenario
Insect nests and hives; application directly to pest - no site specified	Treatments generally involve drenching the nest itself with a pesticide. While such nests (ant colonies or wasp, bee, or yellow jacket nests) typically are in soil areas, where rain would be needed to carry applied pesticides to storm drains. Nests or pests may occur immediately adjacent to surface waters (for example, on creek banks)--in such cases, subsurface flow could carry applied pesticides to surface waters. Applications often involve higher pesticide concentrations than are used for landscaping or agricultural sites.	Rain or other water flow	Storm drain or direct drainage to surface waters	Plant or soil release
Fence post hole	Typical application instructions call for mixing a relatively high-strength pesticide solution and then using that solution to treat the base of the post hole and the soil used to refill the hole around the post. While some of the treated soil will be on the surface and then exposed to runoff, most will be below the surface, where it would only be subject to subsurface flows. Such flows may, however, be a concern due to the relatively large amount of pesticide typically applied in each hole, particularly when holes are near surface water (*e.g.*, a fence along a creek bank).	Rain or other water flow	Storm drain or direct drainage to surface waters	Undergrou nd release
Greenhouses	Typically applied to plants inside greenhouses. Since greenhouses are not exposed to rain and do not typically have sewer connections, releases are unlikely. Pathways for release include transfer on plant material when removed from the greenhouse, and subsurface flow of irrigation water.	Subsurface water flow	Storm drain or direct drainage to surface waters	Undergrou nd release
Recreational areas, tennis courts, parks, outdoor play areas, picnic sites, etc.	Same as for lawn/turf (see above) and for near-building pavement (see Structural Pest Control analysis).			Plant or soil release; Outdoor impervious surface release

Table G-3. What If? Analysis—Structural Pest Control Applications

Application Sites	How Pesticide May Be Released	Event Needed for Release to Surface Water	Primary Pathway to Surface Water	Master Scenario
Structural Pest Control - General	The most common reported urban use of diazinon and chlorpyrifos. This analysis considers residential, industrial, and commercial structures. A list of specific urban structural (or similar) sites of use (indoor and outdoor) is attached. See the analysis of specific structural pest control and related activities below.	See below	See below	See below
Around foundation of building	Treatments around the outside of structures are very common in California. They normally involve use of relatively high pesticide application rates. Sometimes called the "band around the home" application or an application to stop "home invading pests." Instructions typically call for applying the pesticide in a band up to 10 feet from the wall of the structure, and (for spray applications) sprayed 2-3 feet up the walls of the structure. Since everything around the structure is treated, treated areas may include pavement, ornamental vegetation, and lawns. None of the labels reviewed called for "watering in" the pesticide, so the most likely release would be from rain or use of water to wash treated surfaces (*e.g.*, hosing down paths and driveways).	Rain, washing with water, or other water flow	Storm drain	Outdoor impervious surface release; Plant or soil release
Application to pavement and other outdoor hard surfaces, including patios, walkways, porches, driveways, and the sides or eaves of a building	Labels often suggest applications on "locations where insects congregate" on or near buildings. Applications to paved surfaces generally do not involve direct discharge to a drain, but rain or water used to wash treated surfaces (*e.g.*, hosing down paths and patios) can carry the applied pesticide to storm drains.	Rain, washing with water, or other water flow	Storm drain	Outdoor impervious surface release

Table G-3. What If? Analysis—Structural Pest Control Applications (Continued)

Application Sites	How Pesticide May Be Released	Event Needed for Release to Surface Water	Primary Pathway to Surface Water	Master Scenario
Outdoor crack and crevice treatment	Commonly, such applications occur on concrete paths, sidewalks, patios, and gutters. While such applications are similar to those described above, applications to gutters are of special concern, as non-stormwater flows (*e.g.*, water from washing a car, flow from sprinklers draining to street) can carry the pesticide to a storm drain soon after application, even when application is made on a dry day.	Rain, washing with water, or other water flow	Storm drain	Outdoor impervious surface release
Paints and stains	Products include pre-formulated paints and coatings, and additives for paints, coatings, and wood treatment. When applied on outdoor surfaces like buildings, fences, and decks, the pesticide can be washed off by rain or by cleaning with water (*e.g.*, pressure washing). Pesticide-containing product may drip onto surfaces near the treatment area, from which it can be washed by rain or cleanup water.	Rain, washing with water, or other water flow	Storm drain	Outdoor impervious surface release
Garbage cans	Like other outdoor surfaces discussed above (disposal of pesticides in garbage cans is discussed in the Cleanup section).	Rain or other water flow	Storm drain	Outdoor impervious surface release
Wood or wood structure protection treatments--including lumber, unfinished wood, seasoned wood, finished wood, and firewood	When applied on wood, pesticide can be washed off by rain or by cleaning with water (*e.g.*, pressure washing). Pesticide-containing product is likely to drip onto surface near the treatment area, from which it can be washed by rain or cleanup water. Runoff of treatment residues from wood treatment facilities is of particular concern, since it may release pesticides left from numerous treatments.	Rain, washing with water, or other water flow	Storm drain	Outdoor impervious surface release

Table G-3. What If? Analysis—Structural Pest Control Applications (Continued)

Application Sites	How Pesticide May Be Released	Event Needed for Release to Surface Water	Primary Pathway to Surface Water	Master Scenario
Underground injection under structures	Pesticide solutions may flow beneath the surface into storm drain or sewer lines. Such flows are most likely to encounter sewer laterals and underground pipes that connect gutters to storm drainage systems (common on commercial structures). During the rainy season, elevated water tables or subsurface water flows could similarly transport the pesticide. If underground injection occurs in areas exposed to rain, erosion could expose treated areas and subsequently release the pesticide in storm water runoff.	None or water flow from in saturated soils	Sewer or Storm Drain	Underground release
Trenching for structural pest control	Post-construction treatments of soil under and adjacent to buildings involve the highest application rates of any application of diazinon and chlorpyrifos. Such applications may occur during the rainy season. Subsurface flows may transport the applied pesticide off site--this is of particular concern for treatments near surface waters (*e.g.*, structures near creeks).	Rain or other water flow	Storm drain or direct drainage to surface waters	Underground release
Pre-construction termiticide treatments; paved areas, pre-paving applications	Pre-construction treatments of soil under buildings involve the highest application rates of any application of diazinon and chlorpyrifos. Such applications may occur during the rainy season. Pre-construction treatments involve the largest application area (under an entire foundation or roadway). While treated soil is exposed, the pesticide may be carried by rain into storm drains. After construction, subsurface flows may also transport the applied pesticide off site--this is of particular concern for treatments near surface waters (*e.g.*, structures near creeks).	Rain or other water flow	Storm drain or direct drainage to surface waters	Plant or soil release; Underground release

Table G-4. What If? Analysis—Other Outdoor Applications

Application Sites	How Pesticide May Be Released	Event Needed for Release to Surface Water	Primary Pathway to Surface Water	Master Scenario
Aquatic area/water areas	Directly to the surface water body	None	Direct application	Direct release to surface water
Storm drains (public or private drains or drainage systems in pipes)	Application is made inside storm drain, where it can flow directly to surface waters without treatment. If the pesticide solution flow stops before it reaches the storm drain outlet, future rain can wash off the applied pesticide and carry it to surface waters.	None, rain or other water flow	Storm drain	Storm drain release
Drainage systems	This site sounds like storm drains, but appears (based on label reviews) to mean surface water drainage channels. Such applications involve direct application to water surfaces and applications to channel slopes and adjoining areas. In cases where application is not made directly to water, rain and/or increased flows in the drainage channel (which elevate the water level) can carry pesticides into the water.	None, rain or other water flow	Direct application	Direct release to surface water
Rights-of-way (fire lanes, etc.); fencerows, hedgerows, stone walls (non-agricultural); uncultivated non-agricultural areas; soil sterilization of uncultivated, non-agricultural areas; wasteland(s) (distinct from pasture/rangeland); and utility rights-of-way, yards, substations, etc.	Most of these sites are likely to be covered with vegetation or soil; some may be hard surfaces (walls) or pavement; some may drain directly to storm drains. The primary concern for such applications is the relatively large area that may be treated, potentially providing the opportunity for treatment of a significant area within a surface water body watershed (*e.g.*, the watershed of a creek). Applications are unlikely to involve a direct discharge to surface waters, but such is possible in situations where a creek or drainage channel is part of the site.	Rain	Storm drain (most likely) or direct application	Plant or soil release; Outdoor impervious surface release; Direct release to surface water

Table G-4. What If? Analysis—Other Outdoor Applications (Continued)

Application Sites	How Pesticide May Be Released	Event Needed for Release to Surface Water	Primary Pathway to Surface Water	Master Scenario
Highway rights-of-way (roadways, curbs, etc.); private roads, walkways, lanes, patios, etc.	Application may be made to pavement or to adjoining soil or vegetation. The primary concern for such applications is the relatively large area that may be treated, potentially providing the opportunity for treatment of a significant area within a surface water body watershed (*e.g.*, the watershed of a creek). In general, rain would be needed to carry applied pesticide to surface water.	Rain	Storm drain	Plant or soil release; Outdoor impervious surface release
Wide area; urban area; and non-agricultural area (public health treatment); mosquito abatement districts	These sites are apparently for uses like fogger adult mosquitocide applications in marshes, which may be conducted by mosquito abatement districts or public health departments, and aerial spraying of urban areas for pests like fruit flies. Pesticide may be released directly to the surface water body (*e.g.*, marsh) or indirectly from all locations where the pesticide was applied in rain water (or in other water flows like wash waters). Other than direct application to surface waters, the primary concern for such applications is the relatively large area that may be treated, potentially providing the opportunity for treatment of a significant area within a surface water body watershed (*e.g.*, the watershed of a creek). With fogger and similar applications, spray drift may carry pesticides to surface waters even if the pesticide is not intentionally applied on surface waters. Fogger and aerial spraying applications are also likely to cause volatile pesticides (like diazinon) to be incorporated into rain water itself.	None, rain or other water flow	Direct application or storm drain	Plant or soil release; Outdoor impervious surface release; Direct release to surface water
Refuse and solid waste sites; garbage dumps (all or unspecified)	Pesticides may be applied at solid waste transfer stations, at other solid waste facilities (*e.g.*, compost facilities), and at landfills. Releases may occur directly from treated material that is sent off-site for re-use (*e.g.*, compost) or indirectly from the landfill in the landfill's leachate, which is typically discharged to surface water after some sort of treatment (considered akin to, but not typically the same as sewage treatment).	None, rain or other water flow	Storm drain or leachate discharge	Plants or soil release; Sewer release

Table G-5. What If? Analysis—Indoor Applications

Application Sites	How Pesticide May Be Released	Event Needed for Release to Surface Water	Primary Pathway to Surface Water	Master Scenario
Inside residential, commercial, or industrial buildings (such as office buildings, schools, hotels, warehouses, and factories)	Indoor applications may involve direct discharges to sewers (if applied in drains) or indirect discharges, which occur when a treated area (or an area where a pesticide deposits from air) is later cleaned with water or with items (sponges, rags, mops) that are later washed with water. Common application sites and those of special interest for water quality are considered below.	Direct discharge or washing with water	Sewer	Indoor release
Indoor floor drain	Pesticides are applied inside a floor drain to control insects that congregate at the drain. To the extent that the pesticide does not immediately flow to the sewer, it can be carried to the sewer the next time the floor drain is used (*e.g.*, to dispose of mop water or to receive overflow water from sinks or appliances in the room.	None or another discharge to the same drain	Sewer	Sewer release
Carpets (hospital, commercial, household)	Pesticides applied to carpet can be removed when the carpet is cleaned with water (steam cleaning or wet shampooing). When the cleaning solution is discharged, the pesticide is carried away with it. Typically, such solutions are discharged to the sewer, but storm drain discharge of carpet cleaning solutions is an ongoing problem. Pesticides may also be removed by vacuum cleaning, which would transfer them to the trash (see disposal of pesticides in trash analysis). Transfer pathways include transfer to home occupants and their clothing--transferred pesticides would be discharged to the sewer during bathing and clothes washing.	Washing with water	Sewer (most likely) and storm drain	Indoor release
Cracks, crevices, baseboards, edges of carpet, and other surfaces	When the surface is cleaned, the pesticides may be transferred into water or onto items that are later washed with water. Pesticides may also be transferred by vacuum cleaning and other more minor pathways (see Carpets analysis).	Washing with water	Sewer	Indoor release
Bathrooms	If application is made to the inside surfaces of sinks, tubs, toilets, or showers, then pesticide can immediately be discharged to the sewer. If application is made to other bathroom surfaces, the pesticide would be released to surface water when that surface is cleaned with a water-based solution or a tool like a sponge, cloth, or mop that is later washed with water.	None or wash water.	Sewer	Indoor release; Sewer release

Table G-6. What If? Analysis—Pet Applications

Pet Applications	How Pesticide May Be Released	Event Needed for Release to Surface Water	Primary Pathway to Surface Water	Master Scenario
Pet shampoo use	Possible pesticide sources include pesticide in pet shampoo (flea shampoo) and pesticides in pet fur from direct treatment of pet. Releases occur when the pet is rinsed. If pet is bathed in a tub or shower, or if the pet washing and rinse water is dumped into an indoor drain, the pesticide will be discharged to the sewer. If the pet washing occurs outdoors, or pet wash and rinse water is dumped outdoors, it could be directly discharged to a storm drain, or the pesticide could flow to a storm drain when it rains.	None, rain, or other water flow	Sewer or Storm Drain	Sewer release; Plant or soil release; Outdoor impervious surface release
Application to pets (excluding shampoos); horses; zoo animals	Pesticides applied directly to pets can be transferred to surface water when the pet is washed (see pet shampooing analysis). Other more minor transfer pathways include transfer to people and their clothing--transferred pesticides would be discharged to the sewer during hand washing, bathing, and clothes washing (see the Pesticide Cleanup analyses).	None	Sewer	Sewer release

Table G-7. What If? Analysis—Sewer Applications

Application Sites	How Pesticide May Be Released	Event Needed for Release to Surface Water	Primary Pathway to Surface Water	Master Scenario
Sewage disposal areas (municipal and other)	Application may be to treatment tanks, to other treatment facilities, or to other locations at a sewage treatment plant site. Indoor uses would involve direct discharge to sewage system upon use, or later release when the area is washed with water (the primary cleaning practice for sewage treatment plant facilities). Storm drainage at most sewage treatment plants is to the sewer system, so pesticides applied outdoors would be likely to be released to the sewer when it rains or when the outdoor area is washed with water.	None, rain, or other water flow	Sewer (most likely) or Storm Drain	Sewer release
Sewage systems (septic tanks, sewers, etc.)	Common application locations include the insides of manhole covers and nearby piping, both of which would immediately discharge some or all of the applied pesticide to the sewer. (Sewer line applications are common for other pesticides, but not for diazinon and chlorpyrifos). Rain would, via sewer inflow, carry pesticides applied in the manhole vicinity into the sewer. While some portion of a pesticide applied to septic tanks would remain in the leach field, the remainder would be carried to the sewage treatment plant when the tank is cleaned and cleanout wastes are hauled to the sewage treatment plant by septage services. Some pesticides in septic tank leach fields could flow into surface waters or storm drains if the leach field is not properly designed or operated (a common problem).	None, rain, or other water flow	Sewer	Sewer release; Underground release

Table G-8. What If? Analysis—Mixing and Post-Application Cleanup

Activity	How Pesticide May Be Released	Event Needed for Release to Surface Water	Primary Pathway to Surface Water	Master Scenario
Mixing and cleanup waste management at residential and professional applicator locations	Various specific cleanup activities, including activities in accordance with label directions and reasonably anticipated misuse and dumping are considered below. In general, activities conducted by professionals are anticipated to be more in accord with label directions and other legal requirements, but would involve much larger pesticide quantities than would cleanup activities at an individual residential site.	None, rain, or other water flow	Sewer or storm drain	See below
Cleanup application equipment and solutions in a sink	Washing equipment, pouring out concentrate or unused solution, dumping powder or granules, and washing applicator's hands and body may release pesticide into a sink that drains to the sewer. Cleanup from painting/coating may release especially large amounts of active ingredient, since people tend to clean up paint-laden brushes and equipment directly into the drain.	None	Sewer	Sewer release
Cleanup application equipment and solutions on the garden or lawn	Washing equipment, pouring out concentrate or unused solution, dumping powder or granules, and other cleanup activities may release pesticides to soil or landscaping. Such pesticide may be transported by ensuing rain to surface waters.	Rain or other water flow	Storm drain	Plant or soil release
Cleanup application equipment and solutions in or draining to the street, sidewalk, driveway, gutter, or storm drain	Washing equipment, pouring out concentrate or unused solution, dumping powder or granules, and washing down a mixing area may release pesticides to paved surfaces, to gutters, and to storm drains.	None, rain, or other water flow	Storm drain	Outdoor impervious surface release; Storm drain release
Cleanup pesticide on clothes worn during pesticide handling and application	In a clothes washer, the pesticide is transferred to the wash and rinse water, which then drain to the sewer	None	Sewer	Sewer release

Table G-8. What If? Analysis—Mixing and Post-Application Cleanup (Continued)

Cleanup Activity	How Pesticide May Be Released	Event Needed for Release to Surface Water	Primary Pathway to Surface Water	Master Scenario
Cleanup pesticide on human body	Bathing or showering releases the pesticide to the sewer system	None	Sewer	Sewer release
Pesticides placed in solid waste	Pesticides may reach the trash by illegal disposal, by following label directions (which often call for wrapping the container and putting it into the trash) or by disposal of cleanup wastes (*e.g.*, paint trays and newspaper used to "paint out" brushes used for a pesticide-containing paint, vacuum cleaner bags after use vacuuming a treated carpet or floor). Releases may then occur directly from the garbage container (if it leaks), from the truck (if it leaks), or indirectly, from the landfill in the landfill's leachate, which is typically discharged to surface water (considered akin to, but not typically the same as sewage treatment).	None, rain, or other water flow	Treated landfill leachate or storm drain	Outdoor impervious surface release; Sewer release

Table G-9. What If? Analysis—Accidents

Accident	How Pesticide May Be Released	Event Needed for Release to Surface Water	Primary Pathway to Surface Water	Master Scenario
Drop/puncture/overfill /knock over pesticide container; container mechanical failure (due to container defect or external conditions like heat/sun); leaks in application equipment; splashing or spraying during handling	Pesticide concentrate, powder, granules, or solution may be released wherever pesticides are stored, mixed, transported, or used (see analysis of releases from all application sites). For water quality, the major difference between controlled use and uncontrolled releases of this sort is the quantity of material that is potentially released in one location, and the ability of a large spill to quickly reach a drain (sewer or storm drain). In most cases, spills would be cleaned up; however, efficacy of cleanup in some locations (*e.g.*, on soil, on semi-permeable pavement like asphalt) may not be high, leaving a potentially meaningful amount of the pesticide on a surface that may in the future be exposed to water.	None, rain, or other water flow	Sewer or storm drain	All scenarios
Earthquake	An earthquake could cause stored containers to fall over and to release pesticides (see the Drop/puncture etc. analysis above). The important differences with the above analysis are that a larger quantity of pesticide could be released, that mixing of different pesticides could occur, and that the most likely release location would be in a pesticide manufacturing or storage area.	None, rain, or other water flow	Sewer or storm drain	All scenarios
Flood	In the event of a flood, pesticides may be released by mechanical failure of storage containers, swamping of mixing and manufacturing facilities, and wash off of previously applied pesticides. Floodwaters themselves are surface waters, so any release is immediate. While the large quantity of floodwater flow provides some dilution, the large flows also cause releases of relatively large quantities of pesticides at one time.	None	Directly to surface waters	Direct release to surface water
Power failure at Manufacturer or PCO	Equipment should be designed to contain pesticides in the event of a power failure; however, it is possible that human error would allow a pesticide to flow to a drain inside a manufacturing facility or a PCO's premises in the event of a power failure.	None	Sewer	Indoor release; Sewer release

Table G-9. What If? Analysis—Accidents (Continued)

Accident	How Pesticide May Be Released	Event Needed for Release to Surface Water	Primary Pathway to Surface Water	Master Scenario
Fire	A fire at a pesticide handling facility could cause equipment or container failure that could then release pesticides. Like an earthquake, a fire has the potential to release multiple containers and multiple pesticides at once, and the most likely release locations are in pesticide manufacturing and storage areas. With a fire, any water used for fire suppression (or water used to wash down fire suppression form) could at once provide a pathway to carry released pesticides to drains. During and after the fire, pesticides emitted to the air (if not destroyed by combustion) would deposit on surfaces in the surrounding area, where they could be exposed to water.	None	Sewer or storm drain	Sewer release; Storm drain release; (all scenarios possible)
Vehicle accident (due to human error or mechanical failure on pesticide transporting vehicle)	Vehicle accidents may release pesticides wherever pesticides are transported in vehicles. Because pesticides and mixed pesticide solutions are considered hazardous materials, certain limited protections are required; however, these protections do not in many cases prevent container breakage (*e.g.*, single-walled containers are allowed, and pesticide containers do not need to meet the stringent DOT requirements applicable to hazardous waste transport containers). Once released, a pesticide being transported on a road is all too likely to flow to a storm drain and/or a sewer utility access point if a liquid product, or to be spread across both pavement and unpaved roadside areas if a powder or granular product. Even with rail transport, releases may quickly reach surface water if they occur near water bodies. Cleanup efficacy is also an issue. The major issue is the relatively large quantity of a pesticide that may be released during a transportation vehicle accident.	None, rain, or other water flow	Storm drain or directly to surface waters	Outdoor impervious surface release; Storm drain release; Direct release to surface water; Sewer release; Plant or soil release