CHAPTER 3.D

NATURAL RESOURCES

C. TEXT CONTINUES – PART 2

D. FUTURE CONDITIONS WITHOUT THE PROPOSED ACTION

The likely continued improvements to water quality without the application of mosquito adulticides, discussed in Chapter 3.F, "Water Quality," should result in improvements in habitat quality for the plankton, invertebrates, and fish of the New York Harbor system, including the Hudson Estuary, Raritan Bay, East River, and Jamaica Bay. For example, the multi-year CSO Abatement Program will result in water quality improvements to the tidal basins of Jamaica Bay which will eventually result in higher dissolved oxygen and other water quality improvements. These improvements should enable continued utilization of these tidal basins by aquatic organisms, and could possibly result in an increase in the biodiversity of the aquatic communities. The improvement in water quality of these tidal basins discharging to Jamaica Bay will also result in improved water quality in the Bay since the basins are the only source of freshwater to the system. This should enhance the habitat quality of the Bay and may result in increased utilization by aquatic organisms.

The water quality improvements that will result from the implementation of the water quality management plans on Staten Island, such as those developed for Lemon Creek and Wolfe's Pond will result in improved aquatic habitat in the Lemon Creek system, Wolfe's Pond and Acme Pond, and the other waterbodies of Staten Island. This should enable continued utilization of these waters by aquatic organisms, possibly increasing the biodiversity of the aquatic communities.

Improvements in water quality and increased utilization by aquatic organisms may also result in increased use of these areas by waterfowl and raptors such as osprey that feed on fish. The current management activities of the natural resources found in the City's parklands and natural resources will continue without the application of mosquito adulticides. The resources found within these areas should at a minimum remain in their current condition and may improve with the continued application of the existing park management plans and the development of new management plans for other parkland areas. The National Park Service is continuously developing and implementing habitat improvement measures for the Gateway National Recreational Area. The improvements of parklands enacted by the City, and the habitat improvements enacted by the National Park Service, should allow for continued utilization of the habitats found within New York City, perhaps resulting in increased utilization by mobile animals such as birds, and mobile insects such as bees, butterflies, moths, and dragonflies and in increased suitability of the habitat for less mobile organisms such as reptiles, amphibians, and small mammals.

The City will also continue its *Routine Surveillance and Control Program (Routine Program)* without the application of mosquito adulticides. This Program is presented in a Negative Declaration (CEQR Number 00DOH001Y) issued by the New York City Department of Health on April 12, 2000, and prepared in accordance with the New York State Environmental Quality Review Act (SEQRA) and the Rules of Procedure for CEQR. The *Routine Program* includes the following components, none of which will have a significant adverse effect on the environment, as described in the Negative Declaration.

- Education programs for City agencies, medical professionals, and the public on vector-borne diseases, risks, and measures to reduce exposure.
- Surveillance of mosquito-borne diseases among humans, mosquito habitats and mosquito trapping, and animals (infection and/or illness in domestic animals and wild birds, as well as sentinel chicken surveillance flocks).

- Control activities such as eliminating potential mosquito-breeding sites, testing for the presence of mosquito larvae at suspected or historical breeding sites, the application of larvicides in potential mosquito breeding grounds such as stormdrains/catch basins, sewage treatment plants, and stagnant water, and the use of larvivorous fish in waters that are contained and do not have uncontrolled discharges to natural aquatic systems, such as sewage treatment plants.

The City assessed the potential environmental effects of the following larvicides in the Negative Declaration:

- Methoprene (insect growth regulator)—Altosid XR Briquets, Altosid Briquets, Altosid Liquid Larvicide, and Altosid XR-G Granules. Methoprene targets mosquito larvae in aquatic habitats but may also be toxic to other invertebrates. Methoprene mimics the action of an insect growth regulation hormone. When applied as an insecticide, it interferes with the normal maturation process that enables the pupa to develop into an adult. Because of this potential to affect non-target organisms, methoprene will only be applied to systems (sewers and catchbasins) that do not discharge to surface waters or groundwater. Methoprene is practically non-toxic to humans and other mammals. It is slightly toxic to birds, and slightly to moderately toxic to fish, and very highly toxic to some species of freshwater, estuarine, and marine invertebrates. Methoprene degrades rapidly in water and soil through microbial action and photolysis, and does not leach to groundwater. When applied at the rates recommended for mosquito control, methoprene has been found to affect aquatic stages of other dipterans, but population reductions have between temporary. Methoprene has been found to affect amphibians at levels higher than applied for mosquito control.
- *Bacillus sphaericus* (*Bs*) (naturally occurring soil bacterium)—Vectolex CG, and Vectolex WDG. These bacterial products target mosquito larvae. Bs produces a toxin when its spores and crystals are ingested by the mosquito larvae. Symptoms (tremors and sluggishness) appear within 30 minutes to 1 hour, with mortality usually 48 hours after exposure. Culex species appear to be the mosquitoes most susceptible to Bs, and Bs has been found to exhibit longer periods of larvicidal activity than Bacillus thuringiensis isrealensis (Bti) against certain species of mosquitoes, especially in habitats with high organic content. In fact, viable infective spores have been retrieved several months after introduction into larval habitats, suggesting possible recycling of this bacterium once applied for mosquito control. Bs has not been found to be toxic to non-target invertebrates, other animals, and humans.
- *Bacillus thuringiensis isrealensis* (naturally occurring soil bacterium)—Vectobac. This bacterium targets mosquito, blackfly, and midge larvae. Bti produces a toxin, in the form of crystalline bodies, during spore formation. The crystals are released from the spores in the mosquito gut after being consumed by the larvae. Mortality can occur within a few hours to a few weeks. The Bti toxin only binds to receptor cells present in the guts of insects, and has been found to be practically non-toxic to humans and animals.

These larvicides are registered with USEPA and NYSDEC for use against mosquitoes, and were selected by the City because of their anticipated effectiveness and minimal impacts to the environment. The Negative Declaration, found at www.ci.nyc.ny.us/html/doh.html/epi/wnvnd.html, provides a detailed description of these larvicides. They will be applied to catchbasins, sewage treatment (if larvivorous fish appear to be ineffective), freshwater ponds and lakes, and wetlands as necessary, as described below. All larvicides will be applied by hand and/or backpack. Wheeled or tracked vehicles will not be used to treat vegetated areas of tidal or freshwater wetlands. Truck or aerial application will be used where access for hand or backpack spraying is limited.

- Catchbasins—In 2000, the City applied larvicides in approximately 135,000 street storm drains (catchbasins) in which standing water develops, and approximately 30,000 storm drains which are located in New York City parks, storm drains on Rikers Island, and storm drains located along highways. The City has two basic types of catch basins—those that drain into sewers, and those that allow the water to seep into the ground. Altosid (methoprene) briquets (effective for up to 150 days) and Altosid granules were applied to non-seepage catch basins (approximately 122,0000 Citywide). All other catch basins, those with known seepage and those where the type of seepage is not known, received an application of VectoLex; some received additional applications of VectoLex or Vectobac.
- Water Pollution Control Plants (WPCPs)—NYCDEP initiated a control plan using larvivorous fish (Gambusia) and evaluated the application of fat-head minnows at their facilities in 2000. NYCDEP added fish where larvae were found at the 14 WPCPs as needed. Larvicides were to be added as necessary based on surveillance results.
- Freshwater Ponds/Lakes—Many ponds under the control of NYCDPR contain fish that already provide biological control for mosquitoes. NYCDPR also cleaned the edges of ponds within City parks to minimize the potential for mosquito breeding. Where surveillance data indicated a need biological larvicides were applied. No form of methoprene was applied to freshwater ponds or lakes.
- Saltwater, Tidal, Freshwater Wetlands, and other Mosquito Breeding Areas—NYSDEC supplied the City with maps of tidal and freshwater wetland areas, and NYCDPR identified areas adjacent to tidal marshes where mosquito breeding is likely. Many of the City's freshwater wetlands are located on Staten Island, which contains more than 2,000 wetland acres represented by Mariner's Marsh, Graniteville Swamp, and Goethals Bridge Pond. Other large freshwater wetlands are found in Alley Pond Park in Queens, and the wetlands associated with Van Cortlandt Lake in Van Cortlandt Park, the Bronx. Tidal wetlands are found scattered along the City's 500 miles of tidal waterfront. The largest areas of tidal wetlands occur in Jamaica Bay, with other locations along the inlets and coves in northern Queens, and southeastern Bronx, such as Udall's cove, Alley Pond Park, and the mouths of the Bronx and Hutchinson Rivers. New York City contains 15 designated significant coastal fish and wildlife habitats, and 7 wildlife refuges and sanctuaries, some of which overlap the wetland areas. All of these areas are considered sensitive natural resources and no extended release methoprene was proposed for application in 2000. Only VectoLex and Vectobac were proposed, with liquid methoprene on a site by site basis only as necessary and only after additional information was provided to NYSDEC for each location. Any locations that were inaccessible from the ground were to receive aerial application.

As presented in the *Negative Declaration*, Bti targets mosquito larvae. Midges also appear to be affected but are less susceptible than mosquitoes. Therefore, minimal impacts are anticipated to midges from Bti application. Bs targets mosquito larvae, and studies on a wide range of non-target invertebrates have suggested little effect on other groups of invertebrates. Therefore, minimal impacts are anticipated to non-target invertebrates from the application of Bs. Methoprene is an insect growth regulator and has been extensively studied with respect to potential effects to non-target organisms. As presented in the Negative Declaration, methoprene is not highly toxic to birds, mammals, or fish and should not result in adverse effects to these groups because of the low concentrations used, rapid dissipation, and degradation. Methoprene has been found to affect non-target dipterans closely related to mosquitoes, but the population effects have been found to be temporary. Because methoprene affects the ability of the pupa to develop into the adult, it does not affect the use of the mosquito larva as a food supply. Fish do appear to bioconcentrate methoprene but adverse impacts to fish or fish predators have not been documented. Amphibians appear to be sensitive to concentrations of

methoprene higher than that used for mosquito control, but potential impacts should be minimized by limiting the use of extended release methoprene in or near tidal and freshwater wetlands.

E. PROBABLE IMPACTS OF THE PROPOSED ACTION

ECOLOGICAL RISK ASSESSMENT

The ecological risk assessment is organized in two tiers. Tier I is the screening-level assessment. The purpose of the screening-level assessment is to focus the overall ecological risk assessment process by eliminating from consideration those possibilities that do not have the potential for resulting in adverse effects on plants or animals from the Proposed Action. Therefore, if by applying worst-case conservative assumptions to the screening-level (Tier I) analysis, the results show no potential adverse impacts for a particular stressor (e.g., active ingredient) or pathway, then those stressors or pathways can be eliminated from further assessment. If the Tier I assessment does identify a potential adverse effect for a particular stressor or pathway, then a detailed second tier (Tier II), or focused assessment, would be performed to evaluate these effects under less conservative conditions and assumptions. The Tier II risk assessment results are then used in conjunction with empirical results from monitoring and other field investigations to evaluate the potential adverse impacts on natural resources within each of the Representative Areas.

Screening-Level Ecological Risk Assessment—Tier I

Using a set of generalized and conservative (worst-case) conditions that are described below, the Tier I risk assessment assists in separating the adulticides into two groups.

- Those that do not have the potential to result in adverse impacts on the habitats or terrestrial and aquatic biota within the City under worst-case conditions and assumptions, and therefore do not need to be evaluated further.
- Those that may or may not have the potential to result in adverse impacts on the habitats or terrestrial and aquatic biota found within the City and therefore, require further examination.

Active ingredients following a particular pathway that do not pose adverse impacts on biota under worst case conditions are not considered likely to impact these resources, and therefore, do not need to be examined further. It is the active ingredients that may or may not have the potential to pose an unacceptable adverse impacts on natural resources that will be examined in greater detail in the Tier II evaluation.

This portion of the EIS summarizes the methods and results of the Tier I evaluation—Appendix 3.D-1 "Ecological Risk Assessment," contains the complete Tier I evaluation. The methods for the Tier I assessment generally follow USEPA guidance for ecological risk assessments (USEPA, 1998). Using conceptual models, or exposure scenarios, the potential risk to terrestrial and aquatic organisms from exposure via direct contact to the adulticide spray was evaluated, as was the risk to terrestrial and aquatic organisms from indirect exposure to the adulticide through the food chain. The following sections summarize the Tier I analysis.

Conservative (Worst-Case) Assumptions for the Screening-Level (Tier I) Analysis

The Tier I analysis used three types of worst-case assumptions:

- The most sensitive biota exposed to the adulticide;
- The highest or maximum exposure concentration of the adulticide expected to occur on land and in surface waters; and

- The highest bioconcentration factor (quotient of the concentration of the chemical in an organism's tissues divided by the concentration in the surrounding water) for the adulticides through the aquatic and terrestrial food chain.

These worst-case conditions are described below.

Biota Exposed to the Adulticides

In order to evaluate the potential effect of the adulticides on plants and animals, the Tier I assessment used the results of tests that had been previously conducted on terrestrial and aquatic organisms. These tests typically look at the acute or chronic effect of an adulticide on a number of individuals from a particular species under specific test conditions. For aquatic species the toxicity tests are often conducted on the most sensitive life stages—larvae and juveniles. Types of effects reported for adulticides may include mortality, decreases in weight gain, decreases in reproduction, production of deformities, and other conditions.

These test results are used as, or used to calculate, the benchmark values—the reference points to which the predicted concentrations of the adulticide applications on land and water from the Proposed Action are compared. Appendix 3.D-1, "Ecological Risk Assessment," discusses the data sources used for the benchmark values. The biological groups evaluated included algae, crustaceans, insects (terrestrial and aquatic larvae), mollusks, fish, amphibians, birds, and mammals. These sensitive tested species are considered surrogates for untested sensitive species that might occur in the Representative Areas.

Maximum Exposure Concentration

The adulticides evaluated in this document are those registered and approved by USEPA and the New York State to control adult mosquitoes. These adulticides can be applied from the air by airplane or helicopter or on the ground by trucks or backpack sprayers. The methods used to release the adulticide to air or ground and the rate at which the adulticide is released (amount of adulticide per land area) are specified or recommended on product labels, and are intended to cause mortality to adult mosquitoes (the target population) from one application (acute exposure). As a group, these adulticides are designed to be more toxic to insects than to birds or mammals. Therefore, when applied as directed, they are expected to cause mortality to other insects (non-target insects) as well as adult mosquitoes, but are not expected to cause mortality to warm-blooded animals.

Because these adulticides degrade relatively quickly in the environment, the worst-case chronic effect to animals was assumed to be the continual presence of the adulticide in the environment following a single application. This case does not occur in nature, but may be used to represent the results of repeated applications.

The maximum exposure concentration was developed based on the adulticide characteristics and the exposure characteristics, as described below.

Active Ingredient Characteristics

Appendix 3.D-1, "Ecological Risk Assessment," presents detailed information on the chemical and physical characteristics of the active ingredients evaluated in this document, as well as the degradation or dissipation of the active ingredient in different media within the natural environment (soil, water, and air), designated as a half-life (the time for half of the amount applied to degrade or dissipate from the system). These data and the data sources are presented in Appendix 3.D-1, "Ecological Risk Assessment," and are summarized in Chapter 3.A, "Framework of Analysis." These data are often used in the Tier II analysis, when evaluating selected exposure scenarios under less

conservative conditions than those used in the Tier I analysis (i.e., Tier I did not consider factors such as half life, partitioning coefficients, etc.).

Exposure Concentration (Characteristics)

In order to evaluate the risk to biota, the concentration of the adulticide in different media, such as soil, vegetation, or water, that results from one or more applications must be estimated. This estimate, called the exposure concentration, would depend on the amount of adulticide that reaches the ground or water in a particular area, and the dissipation of the adulticide from that media. Because the adulticides evaluated in this document would be applied to control adult mosquitoes, they would typically be sprayed in the mid- to late-summer and early autumn when the adult mosquitoes are most active. Spraying can occur as a single event or as multiple events. The adulticides must be sprayed as a fine mist of droplets (within a specified size range) to increase the amount of time the adulticide is in the air and therefore in contact with flying mosquitoes and reduce the amount of adulticide that reaches the ground. To quantify potential exposures to adulticides, dispersion modeling is used to predict the concentrations and deposition levels of the adulticides' active ingredients in air and on surfaces following an application. (See Chapter 3.A, "Framework of the Analysis," for a detailed discussion on the dispersion modeling assumptions and results.) The screening-level (Tier I) analysis conservatively assumes that the adulticides are released (aerial application or ground application) at the maximum labeled rate presented in Appendix 3.D-1, "Ecological Risk Assessment" (Table A-2, "Adulticide Application Rates") in a single application that reaches the ground or water surface with no reduction in the concentration of the adulticide. The adulticide is then assumed to stay in the environment and not degrade or dissipate. In this way, the adulticide concentration represents a chronic exposure that can then be evaluated against the chronic benchmark values. The effect that this assumption of a single application may have on the screening-level (Tier I) analysis is discussed in Appendix 3.D-1, "Ecological Risk Assessment," in the section called "Hazard Quotients and Uncertainty Factors." The Detailed, or Tier II analysis, as described later in this chapter, examines the potential effect of multiple applications, and less conservative assumptions regarding degradation and dissipation.

Spraying is assumed to occur at night, a common application practice for these adulticides. Appendix 3.D-1, "Ecological Risk Assessment," presents the chemical characteristics and half-lives for the six active ingredients in different media. Although these active ingredients degrade in the environment, no degradation was assumed for the Tier I (Screening-Level) analysis. Additionally, all of the adulticide active ingredients that reach a water surface were assumed to be available in the water column, with no partitioning to the sediment, even though, as described in Chapter 3.F, "Water Quality," the active ingredients in pyrethroid adulticides—sumithrin, resmethrin and permethrin—partition to soil and sediment particles, which reduces the amount available in the water.

For the Tier I analysis, the application is assumed to occur anywhere in the City and does not specifically describe any of the Representative Areas.

Bioconcentration through the Food Chain

As a conservative estimate of the potential for the adulticide active ingredients to be transported through the food chain, the Tier I analysis used the maximum bioconcentration factors found in the literature to estimate transport to fish-eating birds (e.g., ospreys) and mammals (e.g., raccoons), and USEPA-approved methods to estimate residues on plant material (e.g., seeds or leaves) that is then eaten by birds and mammals. This is very conservative because the active ingredients used for adult mosquito control degrade in the environment and in fish. As such, the chance that fish-eating birds or mammals could feed on contaminated fish, at the sprayed concentration and maximum

bioaccumulation rates, over an extended time period, is extremely small. How this conservative selection of bioconcentration factors may affect the Tier I analysis is discussed in Appendix 3.D-1, "Ecological Risk Assessment," in the section called "Hazard Quotients and Uncertainty Factors."

The following conservative assumptions are made for food chain exposure:

- All food consumed comes from the sprayed areas;
- All food items have the full loading of active ingredient described by bioconcentration factors or other measures; and
- The carnivores do not migrate, or move to other areas.

Hazard Quotients and Uncertainty Factors

The ecological risk assessment evaluates the risk to animals exposed to the active ingredient by calculating a hazard quotient (HQ) (the estimated exposure concentration divided by the toxicological benchmark). An HQ less than one suggests little risk to the receptor examined. In calculating the HQ, the toxicological benchmark concentration or dose should be the chronic. No-Observed-Adverse-Effects-Level (NOAEL) (USEPA, 1996). When this benchmark is unavailable, other benchmarks taken from available data are used and an uncertainty factor is calculated (Duke and Taggart, 2000). Data that are generally available include results from laboratory studies that most often report the concentration required to kill 50 percent of the test organisms (LC50), or concentrations that can produce other observable adverse effects, such as reduced reproductive ability (Lowest-Observed-Adverse-Effect-Level [LOAEL]). Since these concentrations should be considerably higher than those that would result in no observable effects, the uncertainty factors need to be fairly large.

The uncertainty factors used for the Tier I assessment are as follows:

- LC50/EC50 to chronic NOAEL—uncertainty factor of 50 (Calabrese and Baldwin 1993);
- LOAEL to NOAEL—uncertainty factor of 10 (Calabrese and Baldwin, 1993; USEPA, 1993); and
- Endangered species and pets—uncertainty factor of 10 (Calabrese and Baldwin, 1993).

Appendix 3.D-1, "Ecological Risk Assessment," provides a comprehensive discussion of uncertainty factors and calculation of the HQ.

Potential Receptors in the Ecosystem

The sensitive species selected as the potential receptors for evaluation in the screening-level (Tier I) assessment were those that best met the three principal criteria for selecting assessment endpoints in an ecological risk assessment:

- Ecological relevance of the species or habitat—those that help sustain the structure, function, and biodiversity of an ecosystem or its components by serving as food, providing habitat, promoting regeneration of critical resources, or reflecting the structure of the community;
- Susceptibility to one or more of the active ingredients; and
- Relevance to natural resource management goals for the New York City region.

All of the habitats discussed in Section B, "Existing Conditions," of this chapter are considered ecologically relevant communities in New York City.

The literature-based toxicity assessment described in Appendix 3.D-1, "Ecological Risk Assessment," evaluated the potential for the adulticide active ingredients to cause ecological effects based on

existing information on their mode of action and effect on groups of organisms. The adulticides evaluated in this document can be organized into groups with different modes of action and kinds of effects to organisms. A detailed discussion of these effects is presented in Chapter 3.C, "Public Health," and is also provided in Appendix 3.D-1, "Ecological Risk Assessment."

Because the literature-based toxicity assessment suggests that the aquatic communities (fish and invertebrates with some amphibial life stages, and the birds and mammals that feed on these organisms) are most susceptible to the adulticides included in this evaluation, organisms that live in aquatic habitats such as streams, ponds, and wetlands were considered potentially sensitive receptors at the screening level. As discussed in Chapter 3F, "Water Quality," streams, ponds, and wetlands with little base flow or flushing action to dilute adulticides that may be entering in surface runoff or stormwater flow are most susceptible to potential water quality impacts from these adulticides. Although the potential for bioaccumulation may be low, birds (such as osprey, herons, and egrets) and mammals (such as raccoons) that feed in these waterbodies or wetlands are also considered potentially sensitive receptors.

The proposed adulticides are designed to kill insects, therefore both terrestrial and aquatic insects have the potential to be affected and are considered sensitive receptors. Insects that have an aquatic larval stage and a terrestrial stage can be exposed in both aquatic and terrestrial habitats.

Exposure Scenarios

The exposure scenarios evaluated for the Tier I screening-level risk assessment each identify a potential source, one or more exposure pathways, and one or more receptors (a receptor is the population upon which a stressor—something that has the potential to cause adverse effects on people or natural resource species—may act) (see Figure 3.D-7). Five exposure scenarios were evaluated for the Tier I (Screening-Level) assessment:

- Terrestrial Receptors with Direct Exposure;
- Terrestrial Receptors Exposed Through the Terrestrial-Based Food Chain;
- Aquatic Receptors in Pond Exposed to Drift;
- Aquatic Receptors in Wetlands Exposed to Runoff; and
- Terrestrial Receptors Exposed Through the Aquatic-Based Food Chain.

The primary source of active ingredients for all five scenarios is the spraying of adulticides by the City. The following sections provide an overview of these scenarios and the assessment of risk to the receptors evaluated within each of them.

Screening Level (Tier I) Risk Assessment—Terrestrial Habitats

Terrestrial Receptors with Direct Exposure

In terrestrial habitats, mosquitoes, non-target terrestrial insects such as bees, butterflies, moths, and other non-target terrestrial organisms and plants will be directly exposed to the spray. Possible direct exposure routes for terrestrial organisms include dermal absorption, inhalation, and consumption of food, water, and soil that have been contaminated by the adulticide. For terrestrial habitats, the adulticides are assumed to be applied to the ground surface at the maximum labeled rate for each application technique (aerial, truck, backpack) listed in Appendix 3.D-1, "Ecological Risk Assessment," with no degradation of the adulticide.

Birds and mammals have been shown to be resistant to direct dermal effects of adulticides evaluated in this document—birds and mammals are protected from direct dermal exposure by feathers or fur,

respectively. For this reason, the direct exposure to mammals and birds through the dermal route was eliminated from the screening-level assessment conceptual model. In addition to natural resource species, risks to pets drinking water from puddles after spraying is also assessed.

Exposure Concentrations

Inhalation. Exposure by inhalation is of short duration, and although it may produce irritation, inhalation at the concentrations and durations used for mosquito control has not been shown to cause acute mortality to mammals and birds. The Tier I assessment sought, nevertheless, to evaluate the potential risk to mammals and birds from inhalation. To determine the exposure concentration for the evaluation of inhalation in mammals and birds, all adulticides were conservatively assumed to be sprayed by truck, resulting in higher concentrations on the ground than would be expected from aerial spraying. Table 3.D-37 presents the maximum air-modeled concentration for each of the active ingredients being analyzed in this EIS.

Table 3.D-37
Estimated Acute (Short-Term) Airborne Active Ingredient Exposure Concentration for Inhalation of Adulticides by Non-Target Animals

Active Ingredient	Label Application Rate (lb/acre)	Airborne Concentration	
		µg/m^3	mg/L
Sumithrin	0.0036	3.80	0.0000038
Permethrin	0.0210	22.1	0.0000221
Resmethrin	0.0070	7.38	0.00000738
Malathion	0.0540	57.1	0.0000569
Naled	0.0200	18.4	0.0000211
Piperonyl butoxide (PBO)	0.0210	22.1	0.0000221

Acute exposure of birds through inhalation will be expressed in terms of the amount of active ingredient that a bird inhales after spraying. Acute exposure is assumed to be a one-time event that occurs during any spraying or after each of multiple sprayings. Chronic exposure, which will occur over a mosquito season, will be expressed as the average amount of active ingredient that a bird inhales per day over the mosquito-spraying season.

The analysis is based on truck spraying at the recommended application rate. The resulting concentrations in air are derived from spray drift modeling. Birds are assumed to be perched in trees along the spraying truck's route. To be conservative, the maximum reasonable airborne concentration from the modeling is used (105.42 µg/m^3 at an application rate of 0.1 lb/ac), and it occurs 25 feet from the truck under stable atmospheric stability conditions. The air concentration is based on a worst-case wind speed of 2 mph (2.93 ft/sec or 0.89 m/sec), which would result in a relatively short exposure to a bird in a leafless tree. For trees in full leaf, which would occur during the mosquito-spraying season, air velocities would be close to zero in the tree canopy, and the active ingredients would be expected to persist in the air for some time and diminish primarily due to settling. For this analysis, exposure is assumed to result from the active ingredients persisting for one hour at the maximum concentration. The resulting exposure should be conservative because some proportion of the pesticide drifting into the tree should settle on the leaves and not be available for inhalation.

As in the assessment of exposure due to preening, the birds are assumed to be quail or quail-sized (189.9 g). An inhalation rate for quail is 0.11 cubic meters/day (derived for females in summer).

Acute exposure ranges from about 0.018 µg/bird for sumithrin to about 0.26 µg/bird for malathion. (Table 3.D-38)

Table 3.D-38
Acute and Chronic Exposures for Birds Exposed to Pesticides Use to Control the Spread of West Nile Virus.

Active Ingredient	Acute Exposure per Application (µg/bird)	Chronic Exposure for Ten Applications in 90 Days (µg/bird-day)
Sumithrin	0.0173943	0.001933
Permethrin	0.22709225	0.025232
Resmethrin	0.03382225	0.003758
Malathion	1.1113025	0.123478
Naled	0.483175	0.053686
PBO	0.0210	0.011274

Chronic exposure is expressed in terms of the average amount inhaled per day. For inhalation, the pesticide settles out of the air or is carried away or diluted, and does not accumulate due to multiple applications. Assuming a repeat application schedule involving 10 applications in 90 days, the chronic amount inhaled is 10 times the acute amount and the average rate per day is the chronic amount inhaled divided by 90 days (Table 3.D-38).

Ingestion. In addition to risk from inhalation, direct exposure to birds from the deposition of the active ingredients on feathers was evaluated because of the potential of the adulticide to be ingested by the bird through the preening process. Bobwhite quail is the species used to estimate both acute and chronic exposure by this route because it is the species for which the most toxicological data are available.

For acute exposure, the adulticide was assumed to coat the bird at the labeled application rate, and all of the adulticide coating the bird is assumed to be ingested in one dose as the bird preens itself.

For chronic exposure, birds are assumed to be exposed to adulticides ten times over three months. The chronic exposure is calculated as an average concentration in food over the total 90-day exposure period.

The acute and chronic exposure doses for birds exposed to the adulticide active ingredients are presented in Table 3.D-39. Appendix 3.D-1, "Ecological Risk Assessment," provides a detailed discussion on how the acute and chronic exposures from preening were calculated.

Dogs or cats can be exposed to pesticides by drinking from puddles when rain occurs during or after spraying. This assessment addresses the risks of such behavior. Dogs have been used as toxicological test species and are therefore selected as the representative pet species.

The puddle is assumed to be derived from runoff. Concentrations of active ingredients in runoff are those estimated in runoff to wetlands for the Tier I analysis. Acute exposures are expressed in terms of quantity of chemical per kg of individual exposed. The water ingestion rates for male and female foxes (USEPA 1993) are 0.084 and 0.086 g/g individual per day, and an average of 0.085 g/g per day is assumed for dogs. Since one ml of water weighs about one gram, the exposure dose (mg active ingredient/kg dog) is found as the product of the concentration (mg/L) and the water ingestion rate (g/g). Assuming that puddles last two days, a two-day acute dose is twice the one-day dose.

Table 3.D-39
Estimated Exposure Doses for Birds Exposed to
Adulticide Active Ingredients Through Ingestion (Preening)

Active Ingredient	Acute Dose (mg/kg body wt.)	Chronic Dose (average ppm in food over 90 days)
Malathion	4.72	8.07
Naled	2.45	4.20
Permethrin	0.349	0.597
Resmethrin	0.132	0.226
Sumithrin	0.0680	0.116
PBO	0.3967	0.678

Chronic exposures are expressed in terms of average concentration (parts per million [ppm]) of the chemical in water ingested. Chronic exposure will assume multiple applications (10 applications over 90 days). Dogs are assumed to drink exclusively from puddles for two days after each application. Concentrations of adulticide active ingredients in the puddles are the concentrations calculated for runoff.

Direct Contact to Non-Target Insects. Since bees, primarily honey bees, are the only insect required to be evaluated as part of adulticide registration, most of the toxicological data that meet USEPA protocols for insects were conducted on bees. The USEPA toxicity data are only for honey bee acute (short-term) contact toxicity tests. According to the test guidelines (USEPA Office of Prevention, Pesticides and Toxic Substances [OPPTS] guideline OPPTS 850.3020), these tests are intended to meet testing requirements under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Tests under FIFRA are generally used to register pesticides. Typically, bioassay test species are chosen because they are relatively easy to obtain and can withstand laboratory conditions without unacceptable levels of mortality or adverse other effects. Test bees can be obtained from colonies maintained by laboratories or from commercial apiaries. During holding and testing, they can be fed sugar/water solutions. They can be immobilized with CO_2 or N_2 in order to administer test substances. Honey bees are large enough that doses can be applied with microapplicators or other methods that help insure accurate dosing. A honey bee test for acute (short-term, 24-hour) effects due to exposure to pesticide residue on foliage is also available (guideline OPPTS 850.3030). Because many pesticides are applied as part of agriculture and bees can be beneficial for many crops, the honey bee is also a relevant species for examination. Tests of other terrestrial insect species are typically not performed with the honey bee tests during registration.

The active ingredient is assumed to be absorbed through the bee's body surface which is assumed to be coated at the maximum labeled application rate (lb active ingredient/acre). The exposure concentrations are presented as the field application rate (pounds of active ingredient per acre), or the amount applied directly to the bee (µg per bee). The latter is calculated using the label application rate and assumptions on the exposed area on a hypothetical honey bee. Table 3.D-40 includes the estimated exposure doses for bees from aerial and ground application of the active ingredients.

Toxicity Data

Inhalation. Toxicological benchmark concentrations for inhalation are available for mammals and birds. The mammal benchmark concentrations are derived from standard tests on rats used to assess human health risks of adulticide exposure. Test durations are three months, during which rats are exposed daily. Results are expressed as LOEL, LOAEL, No-Observed-Effects-Levels (NOEL), and

Table 3.D-40
Estimated Exposure Concentrations and Bee Doses Due to Aerial and Ground Application of Adult Mosquito Adulticides

		Surface Water Concentration mg/L (ppm)		Food Chain Concentrations mg/kg (ppm)			
Active Ingredient	**Application Rate lb/acre**	**Pond**	**Runoff**	**Grass**	**Seeds**	**Fruit**	**Bee Dose µg/bee**
Aerial Application							
Sumithrin	0.0036	0.0004	0.0636	0.864	0.043	0.025	2.85
Permethrin	0.0234	0.0027	0.0413	5.616	0.281	0.164	18.56
Resmethrin	0.0070	0.0008	0.1236	1.680	0.084	0.049	5.55
Malathion	0.2300	0.0258	4.0603	55.200	2.760	1.610	182
Naled	0.1000	0.0112	1.7654	24.00	1.200	0.700	79.3
PBO	0.0210	0.0024	0.3707	5.040	0.252	0.147	16.6
Ground Application							
Sumithrin	0.0036	0.0004	0.0636	0.864	0.043	0.025	2.85
Permethrin	0.0210	0.0024	0.3707	5.040	0.252	0.147	16.6
Resmethrin	0.0070	0.0008	0.1236	1.680	0.084	0.049	5.55
Malathion	0.0540	0.0061	0.9533	12.960	0.648	0.378	42.8
Naled	0.0200	0.0022	0.3531	4.800	0.240	0.140	15.9
PBO	0.0210	0.0024	0.3707	5.040	0.252	0.147	16.6

NOAEL. Adverse effects are those that might effect survival and health of the organisms. Where available, NOELS or NOAELs, the highest dose to which an animal can be exposed without experiencing a toxic response, are used as end point, or benchmark concentrations. It is assumed that any dose below the NOAEL can be safely tolerated by the animal for a period of time corresponding to the duration of exposure in the study. For assessing the inhalation effects on birds, toxicological endpoints for acute food concentrations (Table 3.D-41) and chronic doses (Table 3.D-42) are available for use as benchmarks for all of the active ingredients. Data were obtained primarily from the USEPA's "Toxicity One Liners" database through Freedom of Information Act (FOIA) requests. Table 3.D-43 presents the inhalation benchmark values for mammals (rats).

Benchmark values are converted to acute and chronic inhalation doses under the assumption that the amount of active ingredient per bird that elicits a response through ingestion will elicit the same response when exposure is through inhalation. To account for uncertainty in this assumption, an uncertainty factor is applied in risk characterization. The acute inhalation benchmark dose is calculated from the ingestion, and the chronic inhalation benchmark dose is calculated from the chronic concentration of active ingredient in food. Quail are assumed to eat 0.07775 g food / g bird per day.

Ingestion. As mentioned above, direct exposure to birds from the deposition of the adulticide on feathers was evaluated because of the potential of the adulticide to be ingested by the bird through the preening process. Toxicological dose endpoints, or benchmarks, for acute exposure to birds are available for all of the adulticide active ingredients, although the species tested may differ. The endpoints are represented by the Lethal Dose (LD50), that is, the concentration that result in death of one half of the test organisms, and are expressed in terms of milligrams of active ingredient per kilogram body weight (mg/kg). These tests are typically performed with a single dose of the test substance followed by a two-week observation period. In some instances, the toxicological benchmark

Table 3.D-41
Toxicological Acute End Point Doses (mg/kg body weight)
for Birds Directly Exposed to Adulticide Active Ingredients

Active Ingredient	Biol. Group	Common Name	Species Name	Study Duration	End Point	End Point (mg/kg)	Source
Sumithrin	Birds	Bobwhite quail	*Colinus virginianus*	14 d	LD50	2510	USEPA OPP
Permethrin	Birds	Starling	*Sturnus vulgaris*	N.R.	LD50	42,706	USEPA OPP
Resmethrin	Birds	California quail	*Callipepla californica*	14 d	LD50	> 2000	USEPA OPP
Malathion	Birds	Ring-neck pheasant	*Phasianus colchicus*	14 d	LD50	167	USEPA OPP
Naled	Birds	Canada goose	*Branta Canadensis*	14 d	LD50	36.9	USEPA OPP
PBO	Birds	Bobwhite quail	*Colinus virginianus*	14 d	LD50	> 2250	USEPA OPP

Notes:
USEPA OPP = USEPA Office of Pesticide Programs (OPP), Toxicity One Liners database.
N.R. Not recorded.

is represented as a dose of the active ingredient in food per unit body weight of the test organism. These values, which represent the acute exposure to birds from preening, are presented in Table 3.D-41. Endpoints for chronic exposure of birds are also available for all of the active ingredients. The endpoints are the Lowest-Observable-Effects-Concentrations (LOECs) for either effects on reproduction after 20 to 24 weeks or dietary effects (sumithrin) after shorter-term (8-day) exposure. These endpoints are represented as the concentration in food with no reference to the body weight of the test organism. Table 3.D-42 presented the chronic direct exposure benchmark for birds exposed to mosquito adulticides. Both acute and chronic toxicological endpoint concentrations are available for assessing the risks to pets drinking from puddles (Table 3.D-42).

Direct Contact to Non-Target Insects. As mentioned above, insects represent a sensitive receptor group with the potential for adverse effects. For non-aquatic insects and life stages, toxicological endpoint concentrations meeting USEPA protocols were found only for bees, and the most commonly tested species is the honeybee. Therefore, the screening level assessment of direct exposure to non-target insects used the benchmark values for bees. Of the results reported, only experiments where the amount of adulticide per bee was reported show defined toxicological endpoints.

Table 3.D-44 presents toxicological data available for bees with respect to the adulticides evaluated in this document.

The numbers below are HQs that represent the results of initial calculations to evaluate the potential significant adverse impact to terrestrial receptors from exposure of reference doses. These HQs, and ones that appear in later section, are the result of calculating worst-case exposure and dosage concentrations, which can be used to conservatively assess the acute or chronic levels from dosage amounts.

Table 3.D-42
Toxicological Chronic End Point Concentrations in Food for Birds and Mammals Exposed to Adulticide Active Ingredients

Active Ingredient	Major Taxon	Common Name	Species Name	Study Duration	End Point	End Point Conc. (ppm)	Source
Sumithrin	Birds	Bobwhite quail	*Colinus virginianus*	8 days	LC50	> 5,620	USEPA OPP
	Mammals	Rat	N.G.	2 gen.	NOEL	1,000	USEPA OPP
Permethrin	Birds	Mallard duck	*Anas platyrhynchos*	20 wks	NOEC	125	USEPA OPP
		Bobwhite quail	*Colinus virginianus*	20 wks	NOEC	125	USEPA OPP
	Mammals	Rat	N.G.	2 yr	LOEC	500	IRIS
Resmethrin	Birds	Mallard duck	*Anas platyrhynchos*	22 wks	NOEC	60	USEPA OPP
		Bobwhite quail	*Coturnix coturnix japonica*	22 wks	NOEC	60	USEPA OPP
	Mammals	Rat	N.G.	3 gen.	LOEC	500	IRIS
Malathion	Birds	Bobwhite quail	*Colinus virginianus*	21 wks	NOEC	110	USEPA OPP
	Mammals	Rat	N.G.	N.G.	NOEC	100	FED RED
Naled	Birds	Bobwhite quail	*Colinus virginianus*	22 wks	NOEC	< 130	USEPA OPP
	Mammals	Rat	N.G.	2 gen.	LOEC	40	IRIS
PBO	Birds	Mallard	*Anas platyrhynchos*	22 wks	NOEC	300	USEPA OPP
	Birds	Bobwhite quail	*Colinus virginianus*	24 wks	NOEC	300	USEPA OPP
	Mammals	Rat	N.G.	2 gen.	NOEC	1,000	USEPA OPP

Notes: FED RED Environmental Risk Assessment for Malathion Reregistration Eligibility Document
USEPA OPP, Toxicity One Liners database
N.G. Not Given

Table 3.D-43
Toxicological End Point Concentrations for Mammals Exposed by Inhalation

Active Ingredient	Common Name	Study Duration	End Point	End Point Concentration (mg/L)	Source
Sumithrin	Rat	3 months (90 days)	NOAEL	0.291	USEPA 2000
Permethrin	Rat	3 months (90 days)	NOEL	0.250	USEPA 2000
Resmethrin	Rat	3 months (90 days)	LOEL	0.100	USEPA 2000
Malathion	Rat	3 months (90 days)	LOAEL	0.100	USEPA 1997
Naled	Rat	3 months (90 days)	NOAEL	0.00023	USEPA 1998
PBO	Rat	3 months (90 days)	NOEL	0.074	USEPA 2000

Table 3.D-44
Toxicological End Points for Bees Exposed
Through Direct Contact to Adulticide Active Ingredients

Active Ingredient	Common Name	Species Name	Study Duration	End Point	Toxicological End Point	Units	Source
Permethrin	Alkali bee	*Nomia melanderi*	24 hr	LD50	< 0.06	lb/ac	USEPA OPP
	Leafcutter bee	*Megachile rotundata*	24 hr	LD50	< 0.06	lb/ac	USEPA OPP
	Honey bee	*Apis mellifera*	72 hr	LD50	< 0.2	lb/ac	USEPA OPP
	Honey bee	*Apis mellifera*	48 hr	LD50	0.024	µg/bee	USEPA OPP
Resmethrin	Honey bee	*Apis mellifera*	48 hr	LD50	0.063	µg/bee	USEPA OPP
Malathion	Honey bee	*Apis mellifera*	8 hr	LD50	< 1.6	lb/ac	USEPA OPP
	Honey bee	*Apis mellifera*	48 hr	LD50	0.2	µg/bee	USEPA OPP
Naled	No data						
PBO	Honey bee	*Apis mellifera*	48 hr	LD50	> 11	µg/bee	USEPA OPP

Risk Characterization for Terrestrial Receptors with Direct Exposure

Inhalation. The HQs for mammals (represented by rats) exposed to adulticides through inhalation of air containing spray are all well below 1.0 (see Appendix 3.D-1, "Ecological Risk Assessment"): 0.000013 for sumithrin, 0.000089 for permethrin, 0.000738 for resmethrin, 0.005693 for malathion, 0.091670 for naled, and 0.00030 for PBO. These results indicate that there is little impact to non-target mammals from inhalation of air containing adulticides. For pets, an additional uncertainty factor of 10 was applied to the wildlife mammal HQ, which still resulted in an HQ less then 1.0 for all of the adulticides: 0.0001 for sumithrin, 0.0009 for permethrin, 0.0074 for resmethrin, 0.0569 for malathion, 0.9167 for naled, and 0.0030 for PBO. These results indicate that, there is little risk of impact to pets from inhalation of the active ingredients.

All HQs for birds were well below 1.0 for both acute and chronic exposure scenarios (see Table 3.D-45). These results indicate that there is no potential adverse impacts on birds from inhalation of the active ingredients. In calculating the HQs, an uncertainty factor of 10 is applied to express the uncertainty of deriving benchmark doses for inhalation based on test endpoints from ingestion experiments.

Ingestion. For birds exposed to adulticides by preening, the HQs were all below 1.0 (see Appendix, 3.D-1, "Ecological Risk Assessment") for both acute and chronic exposures. The HQs were: 0.00027 (acute) and 0.00019 (chronic) for sumithrin, 0.000082 (acute) and 0.0039 (chronic) for permethrin, 0.00066 (acute) and 0.0031 (chronic) for resmethrin, 0.28 (acute) and 0.059 (chronic) for malathion, 0.66 (acute) and 0.026 (chronic) for naled, and 0.00017 (acute) and 0.0018 (chronic) for PBO. This indicates that there are no potential adverse impacts on birds exposed to the adulticides through preening.

Table 3.D-45
Hazard Quotients Including Uncertainty Factors for Birds Exposed to Active Ingredients

Active Ingredient	Uncertainty Factor	Acute	Chronic
Sumithrin	10	0.0000004	0.0000002
Permethrin	10	0.0000003	0.0001367
Resmethrin	10	0.0000009	0.0000424
Malathion	10	0.0003504	0.0007603
Naled	10	0.0006895	0.0002797
PBO	10	0.0000024	0.0000255

Pets exposed to adulticide active ingredients when drinking from puddles are characterized by calculated HQs (Table 3.D-46). In calculating the HQs, uncertainty factors are applied. Besides the factors for extrapolating between test results, an additional uncertainty factor of 10 is applied if the test species is different from that of the species under consideration, in this case, dogs. This uncertainty factor is applied with the same rationale as the uncertainty factor of 10 used for rare and endangered species: where effects on an individual rather than a population are important. The additional uncertainty factor is used to account for the differences in sensitivity among individuals in the potentially exposed population. Even with the addition of the uncertainty factor, all HQs are well below 1.0.

Table 3.D-46
Hazard Quotients for Pets Exposed to Adulticide Active Ingredients

Chemical	UF for Pets	HQ (Acute)	HQ (Chronic)
Sumithrin	10	0.000022	0.000141
Permethrin	10	0.000035	0.001648
Resmethrin	10	0.000047	0.000549
Malathion	10	0.006752	0.021184
Naled	10	0.008222	0.019615
PBO	10	0.054803	0.000824

Direct Contact to Non-Target Insects. Table 3.D-47 presents the HQs for bees directly exposed to the adulticides. All of the HQs were greater than 1.0 for permethrin, resmethrin, malathion, and PBO, suggesting a potential effect to bees that will be evaluated in the Tier II assessment. The HQ for bees also suggests the potential for adverse effects to other non-target terrestrial insects. No HQ could be calculated for naled and sumithrin because toxicological benchmarks for bees were unavailable—these two adulticides will be evaluated in Tier II with respect to bees.

Terrestrial Receptors Exposed Through the Terrestrial-Based Food Chain

Because consumption of the adulticide through water is typically less than through food, only consumption of adulticide contaminated food was included in the Tier I analysis. For the terrestrial-based food chain, the route of adulticide exposure by ingestion starts with the deposition of the adulticide on grass, seeds, and insects, which are then consumed by birds, mammals, and invertebrates. The Tier I

Table 3.D-47
Hazard Quotients and Uncertainty Factors (UF)
for Bees Exposed to Adult Mosquito Adulticides

Active ingredient	Receptor Common Name	UF	Hazard Quotient		Note
			Aerial Spray	Ground Spray	
Sumithrin	No data		—	—	—
Permethrin	**Alkali bee**	50	**> 20**	**> 18**	A
	Leafcutter bee	50	**> 20**	**> 18**	A
	Honey bee	50	**> 6**	**> 5.5**	A
	Honey bee	50	**40,000**	**34,500**	B
Resmethrin	**Honey bee**	50	**4,400**	**4,400**	B
Malathion	**Honey bee**	50	**> 7**	**> 1.5**	A
	Honey bee	50	**45,500**	**10,500**	B
Naled	No data		—	—	—
PBO	**Honey bee**	50	**13,000**	**13,000**	B

Notes: Bolding indicates hazard quotients exceed 1.0
A Based on exposure in lb/ac
B Based on exposure in ?g/bee

assessment examined two routes for consumption: birds consuming grass, seeds, or insects; and mammals consuming grass or insects.

Exposure Concentrations

The concentration of adulticides on grass, seeds, and fruit are estimated using USEPA food-chain (Kenaga) nomogram that predicts the maximum residue level on six categories of plants or plant parts (Fletcher et al. 1994) following different application rates of chemicals. The estimated concentrations of the six adulticides presented earlier in Table 3.D-40 range from 0.025 mg/kg (ppm) for sumithrin on fruit from aerial or ground spraying, to 55.2 mg/kg for malathion in grass with aerial exposure.

Toxicity Data

Table 3.D-42 presented selected toxicological benchmarks in terms of concentration of adulticide in food for birds and mammals. The toxicological benchmarks presented in Table 3.D-42 range over at least two orders of magnitude from 40 ppm for rats fed naled to greater than 5,620 ppm for birds fed sumithrin.

Risk Characterization for Terrestrial Receptors Exposed Through the Terrestrial-Based Food Chain

Table 3.D-48 presents the HQs calculated for terrestrial organisms exposed through the terrestrial-based food chain. Only naled had HQs greater than 1.0, in the case of a rat consuming grass that had been exposed to an aerial application (HQ of 6.0), and in the case of a rat consuming grass that had been exposed to a ground application of the adulticide (HQ of 1.2). The potential impacts of naled to terrestrial receptors through the terrestrial food chain will be discussed further in Tier II. The Tier I analysis indicates no potential adverse impacts on terrestrial organisms through the terrestrial-based food chain for the remaining active ingredients tested.

Table 3.D-48
Hazard Quotients for Species Exposed Through the Terrestrial Food Chain to Adult Mosquito Adulticides

Adulticides	Common Name	Uncertainty Factor	Aerial Application			Ground Application		
			Grass	Seeds	Fruit	Grass	Seeds	Fruit
Sumithrin	Bobwhite quail	50	0.0077	0.00038	0.00022	0.0077	0.00038	0.00022
	Rat	1	0.00086	0.000043	0.000025	0.00086	0.000043	0.000025
Permethrin	Mallard duck	1	0.045	0.0027	0.0013	0.040	0.0020	0.0012
	Rat	10	0.11	0.0055	0.0033	0.10	0.0050	0.0029
Resmethrin	Mallard duck	1	0.028	0.0014	0.00082	0.028	0.0014	0.00082
	Rat	10	0.034	0.0017	0.00098	0.034	0.0017	0.00098
Malathion	Bobwhite quail	1	0.50	0.025	0.015	0.12	0.0059	0.0034
	Rat	1	0.55	0.027	0.016	0.13	0.0065	0.0038
Naled	Bobwhite quail	1	0.18	0.0092	0.0054	0.037	0.0018	0.0011
	Rat	10	6.0	0.30	0.175	1.2	0.060	0.035
PBO	Mallard duck	1	0.017	0.00084	0.00049	0.017	0.00084	0.00049
	Rat	1	0.0050	0.00025	0.00015	0.0050	0.00025	0.00015

Notes: Bolding indicates hazard quotient exceeds 1.0.

Predators that eat warm-blooded organisms (birds and mammals) are not considered in the conceptual model. In New York City, these predators would most likely be represented by raptors, such as peregrine falcons, hawks such as northern harrier and red-tailed hawk, and domestic cats. These adulticides tend to be detoxified and eliminated quickly by mammals, so that food chain accumulations are prevented. Birds are also thought to eliminate these adulticides quickly. For example, malathion is rapidly detoxified and eliminated through the urine, feces, and expired air. Examples of measured malathion half-lives for mammals are eight hours in rats, and two days in cows (EXTOXNET). Some mammals may initially accumulate naled in bone before breaking it down into dichlorvos, which is rapidly metabolized and excreted. Mammals have been reported to break down and almost completely eliminate permethrin from their bodies within twelve days (NPTN). No information is available regarding breakdown or elimination rates of sumithrin by birds and mammals.

Screening Level (Tier I) Risk Assessment—Aquatic Habitats

The sources of adulticide to aquatic habitats (ponds, streams, and wetlands) include drift from an application (primary source) and contaminated runoff (secondary source) formed by precipitation that occurs during or following a adulticide application. Therefore, the Tier I assessment evaluated two groups of receptors in aquatic habitats—those exposed to adulticides in drift and those exposed in runoff.

Aquatic Receptors in Pond Exposed to Drift

Exposure Concentration

The receptors examined for this portion of the conceptual model are fish and aquatic invertebrates exposed to water in the pond that receives drift from spraying. The adulticides are presumed to be applied by air (helicopter or fixed-wing aircraft), truck, and backpack spraying at the maximum application rate presented in Appendix 3.D-1, "Ecological Risk Assessment." As a conservative assumption, the adulticide is assumed to fall on the surface of the pond at the full labeled rate with no

drift or degradation, even though direct application to surface water is not a labeled use. Additionally, all of the adulticide that enters the waterbody is assumed to be available in the water column, with no partitioning to the sediment. Large ponds could receive drift, depending on wind conditions. Small ponds may be accidentally sprayed if not readily apparent to the applicators. This scenario of the conceptual model does not include adulticide that enters the pond from runoff. This will be addressed later in the wetland scenario.

The hypothetical pond for assessing exposure is freshwater, has a surface area of 1 hectare (10,000 square meters), an average depth of 1 meter, and a water volume of 10,000 cubic meters. The assumption of surface area does not affect results. The implications of assuming a mean pond depth are discussed in Appendix 3.D-1, "Ecological Risk Assessment," under the section called "Hazard Quotients and Uncertainty Factors." Table 3.D-40 presented the calculated exposure concentrations in the hypothetical pond, using the maximum application rate for aerial and ground application converted from pound of active ingredient per acre to micrograms of active ingredient per square meter ($\mu g/m^2$). The calculated exposure concentrations in the pond range from 0.0004 mg/L (ppm) for sumithrin with aerial or truck application, to 0.0258 mg/L for malathion with aerial application.

Toxicity Data

Fish (embryo, larva, early juvenile, and adult stages), cladoceran arthropods (daphnids), aquatic insect larvae, mollusk larvae (particularly saltwater species), and some algal species are the most common groups of aquatic organisms subject to toxicological testing. Less commonly tested organisms include gammaridean amphipods (fresh and saltwater). The types of effects typically reported for adulticides include mortality (particularly in short-term or acute tests), decreases in weight gain, decreases in reproduction, and production of deformities.

New York State surface water quality standards for the protection of wildlife and for the protection of the survival and propagation of aquatic life contained in 6 NYSCRR Part X Section 703.5 have a standard only for malathion for fresh and saltwater of 0.1 µg/L (ppb), which is used as the chronic benchmark for aquatic receptors. Table 3.D-49 lists the toxicological endpoints for freshwater habitats obtained for the active ingredients reviewed in this document. As discussed previously, where more that one species was tested for a particular group of organisms (crustaceans, aquatic insect larvae, fish, amphibians, mollusks, and algae), the most sensitive species and test was selected as the benchmark. Test results for the cladoceran *Daphnia magna* and fish were available for all for the adulticides.

Risk Characterization for Aquatic Receptors in Ponds Exposed to Drift

HQs with uncertainty factors were calculated for freshwater aquatic species exposed to adulticides from single aerial applications based on toxicological benchmarks (Table 3.D-50), and for malathion based on the New York State surface water quality standard (Table 3.D-51). On the basis of the HQs presented in Table 3.D-50, the three pyrethroids, sumithrin, permethrin, and resmethrin show the potential to adversely effect fish, but only permethrin and resmethrin appear to cause an adverse effect to the crustacean *Daphnia magna*. Sumithrin does not appear to cause an adverse effect to *Daphnia magna.* Permethrin was the only adulticide that had a benchmark value for a mollusk (pond snail), and the HQ was less than one, which suggests no an adverse effect.

The HQs for the two organophosphate adulticides, malathion and naled, exceeded 1.0 for all of the aquatic species used as benchmarks (fish, crustaceans (*Daphnia magna*), and stonefly larvae). On the basis of the HQs, *Daphnia* appears to be the most sensitive species, followed by fish and the other species. The HQs calculated for malathion based on the New York State surface water quality

standards (Table 3.D-51) exceeded 1.0 for fresh and saltwater, suggesting a potential for adverse impacts to aquatic organisms.

The HQs for PBO are less than 1.0 for all species tested in ponds, which does not suggest a potential adverse impacts to aquatic organisms from the application of PBO without a pyrethroid. Because PBO acts as a synergist it is never applied by itself, but no benchmarks were available for the combination of PBO with a pyrethroid.

Aquatic Receptors in Wetlands Exposed to Runoff

Exposure Concentrations

The receptors evaluated for this portion of the conceptual model are mostly fish and aquatic invertebrates exposed to water in a shallow wetland that receives runoff through overland flow or as discharge from storm sewers. The receiving water can be fresh or saline. This scenario assumes that a precipitation event follows spraying, washes the adulticide from the ground surface or from the air, and carries it to storm drains that discharge into the wetland. The precipitation event (0.25 inches, of rain) is assumed to carry all of the adulticide to the wetland. The value of 0.25 inches was chosen to represent the minimum rainfall expected to wash pollutants from surfaces and carry them into storm drains. It is half of the value of 0.5 inches of runoff per acre of impervious land that NYSDEC uses as the first flush that transports most runoff-related water quality contaminants from land, particularly impervious surfaces (NYSDEC TOGS 5.1.10, internet website www.dec.state.ny.us/ website/dow/appndixd.htm). According to NYSDEC (TOGS 5.1.10, Appendix D from General Permit for Construction Activities, Stormwater Management Guidelines for Development) the first flush carries between 70 and 95 percent of the contaminants from contaminated surfaces. Therefore, estimating that all of the adulticide applied is transported to the receiving wetland in the first flush would be a realistic assumption. The 0.25 inches of rain is also smaller than the mean summer rainstorm volume of 0.375 inches for New York City area recorded for the period from 1949 through 1975 (Hydroscience, 1978). It is also less than the estimated Central Park storm unit volume of 0.350 inches recorded from June through August for this same time frame (Hydroscience, 1978). Therefore, assuming 0.25 inches of rain would yield a conservative estimate of the concentration because surface contaminants would have a smaller volume of runoff. The potential impact that this conservative assumption has on the Tier I risk assessment is discussed in Appendix 3.D-1, "Ecological Risk Assessment," under "Hazard Quotients and Uncertainty Factors." The effect of three rainfall events (0.25 inches, 0.375 inches, and 0.5 inches) on HQs is presented in the Tier II assessment.

Although the receiving water is a wetland, this scenario could also apply to a receiving water that was a stormwater management pond, a stream, river, or bay since it is evaluating the potential risk to animals occupying the area at the point of stormwater discharge. These organisms would be exposed to the highest concentration of the adulticide. For the Tier I assessment, the stormwater discharge is assumed to enter the wetland as a slug that displaces the existing standing water at the discharge point, such that the exposure concentration is actually the concentration of the adulticide in the runoff. As was the case for the pond, all of the adulticide is assumed to be available in the water column and none partitioned to sediment or degraded. The estimated concentrations of the six adulticides in the stormwater discharge (Table 3.D-40) range from 0.0636 mg/L (ppm) for sumithrin with aerial and ground application to about 4 mg/L for malathion with aerial application. In reality, the exposure concentration will vary with rainfall; larger amounts of rainfall will result in lower concentrations of the adulticides.

Table 3.D-49
Toxicological End Point Concentrations for Freshwater Aquatic Species Exposed to Mosquito Adulticides.

Adulticide	Biol. Group	Common Name	Species Name	Study Duration	End Point	End Point Conc. (ppm)	Source
Sumithrin	Crustacean	*Daphnia magna*	*Daphnia magna*	48 hr	EC50	> 300	USEPA OPP
	Fish	Bluegill sunfish	*Lepomis macrochirus*	96 hr	LC50	0.0158	USEPA OPP
Permethrin	Crustacea	*Daphnia magna*	*Daphnia magna*	96 hr	EC50	3.9E-05	USEPA OPP
	Aquatic Insect Larvae	Midge, larvae	*Chironomus plumosus*	48 hr	LC50	0.00056	USEPA OPP
	Mollusks	Pond snail	*Lymnaea stagnalis*	48 hr	LC50	< 100	USEPA OPP
	Fish	Fathead minnow	*Pimiphales promelas*	246 d	LOEC	0.0041	USEPA OPP
Resmethrin	Crustacea	*Daphnia magna*	*Daphnia magna*	21 d	LOEC	6.2E-05	USEPA OPP
	Fishes	Rainbow trout	*Oncorhynchus mykiss*	96 hr	LC50	0.00028	USEPA OPP
Malathion	Crustacean	*Daphnia magna*	*Daphnia magna*	21 d	LOEC	0.0001	USEPA OPP
	Aquatic Insect Larvae	Stonefly, naiad	*Isoperla sp.*	96 hr	LC50	0.00069	USEPA OPP
	Fish	Rainbow trout	*Oncorhynchus mykiss*	96 hr	LC50	0.004	USEPA OPP
	Amphibians	Chorus frog, tadpole	*Pseudacris triseriata*	96 hr	LC50	0.2	USEPA OPP
Naled	Crustacea	*Daphnia magna*	*Daphnia magna*	21 d	LOEC	9.8E-05	USEPA OPP
	Aquatic Insect Larvae	Stonefly	*Pteronarcys californica*	96 hr	LC50	0.008	USEPA OPP
	Fish	Fathead minnow	*Pimephales promelas*	35 d	LOEC	< 0.015	USEPA OPP
	Green algae (plant)	Green algae	*Selenastrum capricornutum*	5 d	EC50	0.02	USEPA OPP
PBO	Crustacean	*Daphnia magna*	*Daphnia magna*	21 d	LOEC	0.12	USEPA OPP
	Fishes	Fathead minnow	*Pimiphales promelas*	N.R.	LOEC	0.11	USEPA OPP
	Amphibian	Chorus frog	*Pseudacris triseriata*	96 hr	LC50	0.21	USEPA OPP

Notes: EC50 Effective concentration—the concentration causing a non-lethal effect in 50 percent of the test organisms.
LOEC Lowest Observable Effects concentration—lowest test concentration at which an effect was observed.
LC50 Lethal concentration—concentration causing mortality in 50 percent of the test organisms.
N.R. Not recorded

Table 3.D-50
Hazard Quotients for Freshwater Aquatic Species
Exposed to Single Applications of Adult Mosquito Adulticides.

Adulticide	Receptor Common Name	Uncertainty Factor	Aerial Application Pond	Aerial Application Runoff /Wetlands	Ground Application Pond	Ground Application Runoff/Wetlands
Sumithrin	*Daphnia magna*	50	6.73E-05	0.01	6.73E-05	0.01
	Bluegill sunfish	50	**1.3**	**200**	**1.3**	**200**
Permethrin	***Daphnia magna***	50	**3,375**	**532,000**	**3,020**	**475,250**
	Midge, larvae	50	**235**	**37,050**	**210**	**33,100**
	Pond snail	50	0.0013	0.21	0.0012	0.185
	Fathead minnow	10	**6.5**	**1,010**	**5.7**	**900**
Resmethrin	***Daphnia magna***	10	**130**	**19,930**	**130**	**19930**
	Rainbow trout	50	**140**	**22,050**	**140**	**22,050**
Malathion	***Daphnia magna***	10	**2,570**	**406,000**	**605**	**95,320**
	Stonefly, naiad	50	**1,850**	**294,200**	**438**	**69,050**
	Rainbow trout	50	**320**	**50,750**	**76**	**11,900**
	Chorus frog, tadpole	50	**6.5**	**1,000**	**1.5**	**240**
Naled	***Daphnia magna***	10	**1,140**	**180,130**	**230**	**36,020**
	Stonefly	50	**70**	**11,050**	**14**	**2,200**
	Fathead minnow	10	**7.5**	**1,180**	**15**	**230**
	Green algae	50	**28**	**4,400**	**5.6**	**900**
PBO	***Daphnia magna***	10	0.20	**31**	**0.20**	**31**
	Fathead minnow	10	0.21	**34**	**0.21**	**34**
	Chorus frog	50	0.55	**90**	**0.55**	**90**

Notes: Bolding indicates hazard quotients exceed 1.0.

Table 3.D-51
Malathion[(a)] Hazard Quotients Based on New York State Surface Water Quality Criteria and Estimated Exposure Concentrations for Single Applications of Adult Mosquito Adulticides

Receiving waterbody	Aerial application		Ground application
	Pond	Runoff to wetland	Runoff to wetland
Freshwater	258	4,060	9,533
Saltwater	NA	4,060	9,533

Notes: (a) No New York State surface water criteria for other adulticides.
NA = Not applicable
Bolding indicates hazard quotients exceed 1.0.

Toxicity Data

The toxicological endpoints for a freshwater wetland are the same as those presented in Table 3.D-50. The toxicological endpoints for saltwater (Table 3.D-52) tend to be derived from acute tests with endpoints of either lethal concentrations, concentrations causing a non-lethal effect in 50 percent of the organisms (LC50s) or effective concentrations, concentrations causing a non-lethal effect in 50 percent of the organisms (EC50s). Fish is the only group with test results for all six adulticides.

Risk Characterization for Aquatic Receptors in Wetlands Exposed to Runoff

As presented in Table 3.D-50 and Table 3.D-53, the HQs calculated with uncertainty factors for fresh water, marine and estuarine aquatic organisms exposed to runoff following an aerial or ground application of the adulticides, exceeded 1.0 except for two cases. The two exceptions were for freshwater organisms:

- The crustacean *Daphnia magna* exposed to sumithrin; and
- The pond snail exposed to permethrin.

All biological groups with HQs greater than 1.0 are retained for Tier II analysis.

Because the exposure concentrations for this scenario vary inversely with water depth, and the water depth selected is only 0.25 inches to be conservative, the HQs for this scenario tend to be high. This is consistent with the findings presented in Chapter 3.F, "Water Quality," with respect to patterns observed with respect to the concentration of malathion in streams receiving stormwater runoff, that show a high concentration in streams at the start of a storm event with a decrease in concentration as the storm continues.

Terrestrial Receptors Exposed Through the Aquatic-Based Food Chain

Exposure Concentrations

Fish-eating birds (such as osprey and kingfishers) and mammals (such as raccoons) also have the potential to be exposed to the adulticide in aquatic habitats through ingestion of fish that have bioconcentrated the adulticides, although the potential for bioconcentration is low because these adulticides degrade quickly in the environment as well as in fish. The adulticides examined in this document are broken down by metabolism and are not expected to bioaccumulate in fish. Nevertheless, as a conservative estimate to the fish eating birds and mammal receptors, the Tier I assessment estimated bioconcentration in fish using published bioconcentration factors listed in Appendix 3.D-1, "Ecological Risk Assessment," Table A-3 (Chemical properties table). The bioconcentration factors used in this evaluation were: sumithrin=418, permethrin=715, resmethrin=28,184, malathion=13,

Table 3.D-52
Toxicological End Point Concentrations for Marine and Estuarine Species Exposed to Adult Mosquito Adulticides

Adulticide	Biological Group	Common Name	Species Name	Study Duration	End Point	End Point Concentration (ppm)	Source
Sumithrin	Fish	Rainbow trout	*Oncorhynchus mykiss*	96 hr	LC50	0.0014	USEPA OPP
Permethrin	Crustacean	Stone crab	*Menippe mercenaria*	96 hr	EC50	1.8E-05	USEPA OPP
	Mollusk	Pacific oyster	*Crassostrea gigas*	48 hr	LC50	6.5	USEPA OPP
	Fish	Atlantic salmon	*Salmo salar*	96 hr	LC50	0.0015	USEPA OPP
	Brown algae	Diatom	*Skeletonema costatum*	96 hr	EC50	0.092	USEPA OPP
Resmethrin	Mollusk	Eastern oyster, spat	*Crassostrea virginica*	96 hr	EC50	1.79	USEPA OPP
	Fish	Rainbow trout	*Oncorhynchus mykiss*	96 hr	LC50	0.00028	USEPA OPP
Malathion	Crustacean	Gammarus	*Gammarus fasciatus*	96 hr	LD50	0.0005	USEPA OPP
	Mollusk	Eastern oyster	*Crassostrea virginica*	96 hr	EC50	0.0029	USEPA OPP
	Fish	Sheepshead minnow	*Cyprinodon variegatus*	96 hr	LC50	0.033	USEPA OPP
Naled	Crustacean	Mysid	*Mysidopsis bahia*	96 hr	LC50	0.0088	USEPA OPP
	Mollusk	Eastern oyster	*Crassostrea virginica*	96 hr	EC50	0.091	USEPA OPP
	Fish	Sheepshead minnow	*Cyprinodon variegatus*	96 hr	LC50	1.2	USEPA OPP
	Fish	Rainbow trout	*Oncorhynchus mykiss*	96 hr	LC50	0.16	USEPA OPP
	Brown algae	Marine diatom	*Skeletonema costatum*	6 d	EC50	0.015	USEPA OPP
PBO	Crustacean	Pink shrimp	*Penaeus duorarum*	96 hr	LC50	2.2	USEPA OPP
	Mollusk	Eastern oyster	*Crassostrea virginica*	48 hr	EC50	0.23	USEPA OPP
	Fish	Rainbow trout	*Oncorhynchus mykiss*	90 d	LC50	1.66	USEPA OPP
	Fish	Sheepshead minnow	*Cyprinodon variegatus*	96 hr	LC50	1.8	USEPA OPP

Table 3.D-53
Hazard Quotients for Marine and Estuarine Species Exposed by Runoff to Single Applications of Adult Mosquito Adulticides*

Adulticide	Common Name	Uncertainty Factor	Aerial Application	Ground Application
Sumithrin	**Rainbow trout**	50	**2,250**	**2,250**
Permethrin	**Stone crab**	50	**1,150,000**	**1,000,000**
	Pacific oyster	50	**3.25**	**2.85**
	Atlantic salmon	50	**13,8000**	**12,350**
	Diatom	50	**225**	**200**
Resmethrin	**Eastern oyster, spat**	50	**3.45**	**3.45**
	Rainbow trout	50	**22,050**	**22,050**
Malathion	**Gammarus**	50	**406,000**	**95,300**
	Eastern oyster	50	**70,000**	**16,400**
	Sheepshead minnow	50	**6,150**	**1,450**
Naled	**Mysid**	50	**10,000**	**2,000**
	Eastern oyster	50	**950**	**195**
	Sheepshead minnow	50	**75**	**14.5**
	Rainbow trout	50	**550**	**110**
	Marine diatom	50	**5,850**	**1,200**
PBO	**Pink shrimp**	50	**8.5**	**8.5**
	Eastern oyster	50	**80**	**80**
	Rainbow trout	50	**11**	**11**
	Sheepshead minnow	50	**10.5**	**10.5**

Notes: * Bolding indicates receptors and toxicity quotients with values greater than 1.0.

naled=8.5, and PBO=1,100. As with the other scenarios and receptors, the adulticides are assumed not to break down once applied. Because food is assumed to be the major route of exposure, other routes are ignored.

Toxicity Data

Because no toxicological benchmarks are available for fish-eating birds or mammals, the Tier I analysis used surrogate species. The species and benchmarks used are those presented in Table 3.D-42.

Risk Characterization for Terrestrial Receptors Exposed Through the Aquatic-Based Food Chain

Table 3.D-54 presents the HQs for birds and mammals exposed to the adulticides through the aquatic-based food chain. The HQs for sumithrin and malathion are less than 1.0 for both birds and mammals. This suggests little adverse effect from these two adulticides to birds or mammals that feed on aquatic organisms. The HQs for permethrin and resmethrin are greater than 1.0 for both birds and mammals, for naled for mammals, and for PBO for birds. These HQs suggest a potential for permethrin, resmethrin, naled and PBO to adversely affect birds or mammals feeding on aquatic organisms. Therefore, they were included for further discussion in Tier II.

Table 3.D-54
Hazard Quotients and Uncertainty Factors for Receptors Exposed to Adult Mosquito Adulticides Through Aquatic Food Chains

Adulticide	Birds		Mammals	
	Uncertainty Factor	Hazard Quotient	Uncertainty Factor	Hazard Quotient
Sumithrin	50	0.24	1	0.03
Permethrin	1	**4.75**	10	**12**
Resmethrin	1	**16**	10	**19**
Malathion	1	0.48	1	0.53
Naled	1	0.12	10	**3.75**
PBO	1	**1.4**	1	0.41

Notes: Bolding indicates hazard quotients exceed 1.0.

No potential adverse impacts on predators such as raptors that may consume mammals or birds are expected. In general, mammals and birds break down all of the adulticides fairly rapidly, so that concentrations in these organisms at the time of their consumption would be expected to be less than those for aquatic organisms such as fish. Therefore, no adverse effects on raptors or other predators consuming mammals or birds are expected to occur.

Detailed Risk Assessment—Tier II

The Tier I screening-level assessment used available toxicity data and conservative assumptions to eliminate certain receptors that were not shown to be adversely impacted from the Proposed Action. The Tier I analysis also identified those stressors and pathways which would require additional investigation to determine potential adverse impacts. The Tier II assessment examines these potential impacts using a method tailored to meet the specific circumstances around each pathway.

The following sections present a summary of the Tier II risk assessment. Appendix 3.D-1, "Ecological Risk Assessment," presents the full Tier II assessment. The assessment evaluates the risks identified in Tier I within the same conceptual models (scenarios) as Tier I but combines the two food chain scenarios into one.

- Terrestrial Receptors With Direct Exposure;
- Aquatic Receptors in Ponds Exposed to Drift;
- Aquatic Receptors in Wetlands Exposed to Runoff;
- Terrestrial Receptors Exposed Through the Food Chain.

Terrestrial Receptors with Direct Exposure

The Tier I identified a potential adverse impacts to non-target insects, represented by bees, exposed to all adult mosquito adulticides evaluated in this document. The screening-level (Tier 1) HQs calculated for bees exposed to the adulticides in Tier I are high. Because toxicological data for other terrestrial insects are generally not available, the bees act as the surrogate for other terrestrial non-target insects. Therefore, the results of the Tier I assessment suggest that other non-target insects such as butterflies, dragonflies, and damselflies, may also be adversely affected by the spray drift. To assess the risks to endangered or threatened insect species such as the Arogos skipper recorded for Staten Island, the HQs for bees were multiplied by an uncertainty factor of 10. The adulticides

evaluated in this document have been developed to control mosquitoes. They are nonspecific and have the potential to affect any insect that comes in direct contact with them.

However, the high HQs calculated for bees may indicate a greater sensitivity to an adulticide by other non-target terrestrial insects than may actually occur in the environment. First of all, the adulticide dosage or concentration tested on the bees is applied directly to the bee through a micropatch. An insect walking on a surface that has been sprayed with adulticides may have a lower exposure dose because the surface area of the feet is small. This insect would receive a lower dose than those used to calculate the HQ in Tier I, and therefore, may have a lower potential for adverse effects. Additionally, some activity patterns, behaviors, or habitat preferences will serve to protect some insects. For example, some insects live underground during some portion of the lifecycle and would have less exposure to adulticides on the ground. Insects such as some butterflies and dragonflies that rest under vegetation or structures at night would have less chance of being directly exposed to the adulticide sprayed at night than ones resting on the surface. Any insect that actively avoids areas that have been sprayed would have a lower exposure and therefore less chance of being adversely affected.

Aquatic Receptors in Ponds Exposed to Drift

The results of the Tier I assessment indicated a need to further evaluate the risks to aquatic resources in ponds exposed to adulticide drift. The Tier I assessment used conservative assumptions in evaluating the risk to aquatic organisms in ponds. The adulticide was assumed to be applied directly to the pond and therefore did not take into account:

- Any reductions in adulticide drift that may occur because of tall vegetation such as trees around the pond;
- Reductions in the adulticide concentration with increasing distance from the spray truck; or
- Partitioning of the adulticide to the sediment.

To better assess the risk from the adulticides to aquatic organisms, the Tier II risk assessment modified the conceptual model for this scenario as follows:

- The hypothetical pond was changed to five of the ponds located within the respresentative areas: Central Park's Turtle Pond and The Lake within the Upper East Side Representative Area; Van Cortlandt Lake within the Jerome Park/Van Cortlandt Park South Representative Area; and Wolfe's Pond and Acme Pond within the Lemon Creek/Wolfe's Pond Park Representative Area. Table 3.D-55 presents the information on each pond used as part of the Tier II assessment.
- A truck was assumed to apply adulticide from an average distance from the ponds' edge where a road or paved path was located that was suitable for truck access (Table 3.D-55), moving parallel to the edge of the pond. For each pond, the average distance was calculated by measuring several distances between paved roads and paths and the pond, and then averaging those distances over 100 feet (the miminum setback requirement for ponds used during the summer of 2000) .
- A distance-weighted average depostion rate of active ingredient (milligram (mg)) per square meter was calculated for each pond (Table 3.D-55), using the methods described in Appendix 3.D-1, "Ecological Risk Assessment."
- Concentrations of the active ingredients in the pond were calculated with and without partitioning to sediments, as described in Appendix 3.D-1, "Ecological Risk Assessment." Table 3.D-55 presents the percent organic material for each pond used to estimate partitioning to the sediment. Resmethrin and sumithrin have the highest tendancy to

partition to organic carbon compounds, followed by permethrin, malathion, naled, and PBO.

- Active ingredients are assumed to mix to a depth of 1 inch (2.5 cm) in the sediments of all five ponds.
- The results for Turtle Pond were compared to the results of Tier II assessments performed for other ponds in the Representative Areas. These ponds included: The Lake (Central Park), Van Cortlandt Lake, Wolfe's Pond, and Acme Pond. .

Table 3.D-56 summarizes the results of the analysis and risk characterization for Turtle Pond with and without partitioning. The table indicates that without partitioning, sumithrin and PBO are the only two adulticides with all calculated HQs less than 1.0. This suggests that the application of sumithrin and PBO according to the procedures and setbacks used during the 2000 spraying, should not result in adverse effects to the ponds in New York City that would receive adulticide drift. Permethrin has HQs greater than 1.0 for *Daphnia* and the midge larva, both of which remain greater than 1.0 when partitioning to sediment is taken into account. The permethrin HQs for pond snail and fathead minnow are below 1.0 without partitioning. These results suggest that permethrin may cause adverse effects to crustaceans and insects, but should not adversely effect fish or mollusks. For resmethrin, both HQs are above 1.0 for *Daphnia* and rainbow trout. When partitioning is considered, both of these HQs drop to below 1.0. This suggests that when the fate of the adulticide in the environment is taken into consideration, resmethrin should not cause adverse effects to aquatic animals in the City's ponds because of its tendency to partition to sediment.

Table 3.D-55
Pond Information for the Tier II Assessment

Table 3.D-56
Summary of analysis and risk characterization for Turtle Pond.

However, the pyrethroids under consideration are generally delivered with inert materials that consist of petroleum distillates. As such, some fraction the material drifting onto the pond surface may remain there for a certain period. This would have the effect producing higher HQs at the air/water interface, but lower HQs further down in the water column and in the sediments. Because these active ingredients have a high affinity for organic material, a steady state would be achieved, with a large fraction of the active ingredients partitioning to the sediments.

Malathion HQs with and without partitioning were greater than 1.0 for all of the species except the chorus frog tadpole. This suggests that malathion may have an adverse effect on invertebrates and fish, but should not affect amphibians within the City's ponds. With and without partitioning, the naled *Daphnia* HQs were greater than 1.0. The naled stonefly larva, fathead minnow, and green algae HQs without partitioning were less than 1.0. This suggests that naled has the potential to adversely effect crustaceans, but not aquatic insects, fish, or phytoplankton in the City's ponds. The small differences in the HQs for malathion and naled without and with partitioning reflects the low affinity of these two adulticides for organic carbon.

The results of this analysis indicate that sumithrin and PBO should have little adverse effect to aquatic organisms if applied according to the label with the setback used by the City for the July through September 2000 spraying events, as described in Chapter 3.F, "Water Quality." As discussed in Chapter 3.F, "Water Quality," the water quality samples collected in Turtle Pond following spray events never had concentrations above the 0.5 µg/L PQL (practical quantitation limit). The estimated water concentration of sumithrin without partitioning, 0.000015 ppm (0.015 µg/L), is less than the PQL for the water quality sampling efforts conducted by the City. The estimated water concentration of PBO, 0.000085 ppm (0.085 µg/L), is also less than the water quality sampling PQL.

The HQs for permethrin, malathion, and naled all suggest they have the potential to cause adverse effects to some aquatic organisms even with a setback. Because the estimated concentrations of these adulticides used to calculate the HQs, with and without partitioning, are extremely small, the PQL for the laboratory analysis of a sample from the pond would have to be set much lower than the 0.5 µg/L PQL used by the City to analyze for sumithrin to monitor whether aquatic resources are being protected. The results of the analysis for resmethrin suggest that this adulticide should not result in adverse effects to aquatic organisms with the setbacks used in 2000.

Comparison to Other Ponds in Representative Areas

Figures 3.D-8 through 3.D-13 compare the HQs for five ponds for each of the six active ingredients assuming partitioning has occurred. In general, while the HQ values were variable among the ponds, the conclusions regarding potential risks were similar for all ponds. HQs for all species tested were well below 1.0 for sumithrin, resmethrin, and PBO in all five ponds. HQs for permethrin also indicated low potential risk for mollusks and fish in all five ponds, and for aquatic insect larvae in four of the five ponds. The exception, Turtle Pond, had an HQ just above 1.0 (1.02) for aquatic insects.

Malathion, on the other hand, indicated HQs between 10.0 and 25.0 for crustaceans and aquatic insects, but only had HQs ranging between about 1.8 and 3.0 for fish, in all five ponds. Malathion results indicated low potential risk to amphibians. HQs for naled were also variable, with crustacean HQs ranging from 7.0 to 30.0, and fish and green algae always well below 1.0. HQs for insect larvae exposed to naled were less than 1.0 for Turtle Pond, Van Cortlandt Lake and Wolfe's Pond, and slightly above 1.0 for the Lake and Acme Pond.

In summary, it appears that organisms in pond habitats are at little risk to the pyrethroid active ingredients and PBO, except for crustaceans exposed to permethrin. Organophosphate (naled and malathion) HQs indicated potential risks to crustaceans in all five ponds, but naled exposure did not pose a risk to fish, while exposure to malathion did. Malathion also exhibited a higher potential risk to aquatic insect larvae than did naled. Amphibians were shown not to be at risk from exposure to the two chemicals for which data are available (i.e., malathion and PBO).

Effects of Multiple Applications

HQs were determined for the various active ingredients assuming 10 repeat applications over a two month period. The model assumed that active ingredients were applied by truck at the maximum rates on days 1, 4, 14, 17, 27, 30, 40, 43, 53, 56. The location selected for the evaluation of multiple applications was Turtle Pond. Similar relationships between single and multiple applications would be expected to occur for any of the other ponds, or runoff scenarios. The multiple application analysis determined:

- The maximum HQ observed at any time over the 60-day period. This measure corresponds to a concentration often used to represent acute exposure.
- The maximum 96-hr average HQ. This measure corresponds to concentration and the duration of most laboratory tests for the most sensitive life stages of aquatic organisms.
- The average 90-day HQ. This measure corresponds to the concentration and duration of chronic tests and simulations for measuring long term effects.

Results indicated extremely low HQs for sumithrin for any of the above three measures and indicates little risk to crustaceans and fish with repeated applications (Figure 3.D-14). Low HQs were also observed for PBO for fish, crustaceans and amphibians (Figure 3.D-18).

Multiple applications of permethrin posed little risk to mollusks and fish, while maximum toxicity for crustaceans increased to 21.7 (from an HQ of 14.7 for a single application), and an average 90-day HQ of 5.3 (Figure 3.D-15). The effect of repeated application of permethrin on aquatic insect larvae increased to a maximum HQ of 1.5, but the maximum 96-hr average HQ was 0.9, and the average 90-day HQ was 0.37. The effects of multiple applications of permethrin on aquatic insects is also unlikely to exceed a HQ of 1.0 at the other four ponds, since they all showed HQs less than 0.40 under the single application scenario (Turtle Pond was highest with an HQ of 1.02). Fewer than 10 applications over the 60-day period would also serve to lower the HQs even further.

Although resmethrin applied to Turtle Pond showed little potential for risk under a single application, the multiple application scenario indicated HQs of between 1.0 and 2.0 for crustaceans and fish for the maximum and maximum 96-hr average HQs, respectively (Figure 3.D-16). Since Turtle Pond indicated substantially higher HQ values than for other ponds under the single dose scenario, it is unlikely that HQs for the other ponds would exceed 1.0 under the multiple application scenario. Furthermore, the potential risk to fish and crustaceans could be greatly reduced at Turtle Pond (and other locations if needed) by reducing the frequency of the repeat applications. Figure 3.D-17 indicates that maximum HQs are well below 1.0 for a scenario with 2.0 applications of resmethrin spaced one week apart.

The effects of multiple applications on naled and malathion are illustrated in Figures 3.D-19 and 3.D-20. Results indicate that in all cases, HQs that were greater than 1.0 under a single application remain so under the repeated spray scenario. Similarly, those values that had HQs less than 1.0, remained less than 1.0, despite the multiple applications. Hence, those receptors that were judged not to be at potential risk given under the single application, remain so even with ten repeat applications. Those

already judged to be at potential risk under a single application appear to be at somewhat greater risk with ten repeat applications.

Aquatic Receptors in Wetlands Exposed to Runoff

The Tier I assessment indicated the need to further assess the potential adverse impacts to aquatic resources exposed to adulticides through runoff. The Tier I assessment used conservative assumptions concerning a rainfall amount and assumed that the rainfall would carry all of the adulticide to the wetland. However, when applied according to the labels, these adulticides cannot be sprayed during a rainstorm or when rainfall is imminent. Additionally, rainfalls greater than 0.25 inches will result in lower adulticide concentrations. The Tier I assessment also did not account for partitioning of the adulticides to soils or other surfaces, which would also reduce the concentration of the adulticides in runoff. It also did not consider any dilution that might occur in receiving wetlands or streams. All of these factors should result in lower risks to aquatic organisms than predicted by risk assessment modeling.

Therefore, to better assess the potential adverse impacts from the adulticides on aquatic organisms in the hypothetical wetland, the Tier II risk assessment modified the conceptual model for this scenario as follows:

- Concentrations of the adulticide in the runoff were calculated with partitioning to organic carbon, as described in Appendix 3.D-1, "Ecological Risk Assessment." Resmethrin and sumithrin have the highest tendancy to partition to organic carbon compounds, followed by permethrin, malathion, naled and PBO. The adulticides with the highest affinity for organic carbon would be expected to remain in soil and on asphalt.
- Assumed an area for runoff receiving spray that is 300 feet (91.5 meters) long and 3.28 feet wide (1 meter) (the width does not affect the results). This is the distance over which partitioning is presumed to occur.
- The ground surface consists of three different surfaces, concrete, asphalt, and soil. Three different distributions were assumed for modeling: all concrete (worst-case because concrete has no organic carbon), equal distribution, and all soil (best-case).
- The concentration of the adulticide deposited on the ground in this swath is the application rate.
- There is no dilution of adulticides assumed that might occur in receiving wetlands or streams.
- No reduction in concentration associated with partitioning to wetland sediments or plants is assumed.
- No reduction in concentration associated with light degradation of active ingredients is assumed.

To conservatively assess the potential effects to freshwater aquatic organisms under this modified conceptual model, the most sensitive species from the Tier I assessment were used, as are benchmarks species that occur, or are expected to occur, in the City's wetlands (Table 3.D-57). These additional species are included to be able to relate the results of the assessment to the City's existing natural resources. Protecting the species identified as sensitive to the adulticides and those that occur, or should occur, in the freshwater and estuarine wetlands should protect the aquatic community inhabiting the City's wetlands.

Table 3.D-57
Hazard Quotients for Freshwater Aquatic Species Exposed to Adulticides in Runoff After Considering the Effects Of Partitioning in Three Distributions of Land Surfaces.

Table 3.D-57 also presents the calculated HQs for freshwater organisms for the three land surface distributions. Sumithrin and permethrin were the only adulticides with any HQs less than 1.0. For sumithrin, all of the HQs for crustaceans were less than 1.0 for all three land surface distributions, but was only less than 1.0 for bluegill when the entire land surface is soil. This suggests that the concentration of sumithrin in stormwater runoff over any land surface should not cause an effect to crustaceans. The bluegill HQ for sumithrin exposed to an equal distribution of the three land surfaces is only 1.8. Although this HQ, is greater than 1.0, the potential effect to freshwater organisms should be small for this land surface distribution because of:

- the high uncertainty factor of 50 that was used to calculate the benchmark;
- the relatively short half-life of sumithrin; and
- the potential for partitioning to sediments once the runoff discharges into the wetland.

For permethrin, only the HQs for the pond snail were less than 1.0. This occurred for all three land surface distributions and suggests that permethrin in stormwater runoff should not affect mollusks, but may affect other invertebrates, as well as fish. The results for the remaining adulticides may suggest a potential adverse impact to all groups of freshwater organisms in wetlands no matter what the land surface consists of.

Table 3.D-58 lists the marine and estuarine species benchmarks from the Tier I assessment. As was the case for the freshwater species, these include both the most sensitive and other estuarine or marine species expected to occur in the City's estuarine and marine wetlands.

Table 3.D-58 presents the HQs calculated for marine and estuarine species exposed to adulticides in runoff under the same three land surface distributions as the freshwater scenario. Resmethrin is the only adulticide with a HQ less than 1.0. This occurs for the eastern oyster spat for a land surface distribution that is an equal mix of concrete, asphalt and soil, and then just soil. The equal mix of land covers and just soil provides resmethrin with the greatest opportunity to partition to organic carbon before entering the waterbody. The results of this analysis suggest a potential risk to marine and estuarine species using an area near a stormwater discharge. However, once the adulticide contaminated stormwater reaches the receiving water, the adulticide should dissipate rapidly due to mixing and partitioning to bottom and suspended sediments (something not taken into consideration in the conceptual model), reducing the potential for adverse effects.

The Tier I and Tier II analysis for calculating HQs from runoff to a generalized wetland assumed a conservative rain event of 0.25 inches. The analysis also assumed that organisms would be exposed to the full concentration of active ingredient for 96 hours with no provision for dilution in the receiving waters, or for pesticide degradation. The effects of other storm event scenarios are presented in Table 3.D-59. Storms selected for comparison with the 0.25 inch event are 0.375 inches, the rainfall calculated for an average New York City summer storm event, and a larger rainfall event of 0.50 inches. Findings indicate that larger storms will reduce the HQs, but most would still be large at the point of discharge into the wetland. The risk to fish from sumithrin falls to 1.2 at the average summer storm and below 1.0 for the 0.5 inch storm. Because sumithrin has a very high affinity for organic carbon, and will degrade somewhat after its initial application but prior to being discharged to the wetland, it should pose little risk to fish or crustaceans under any of the three storm event scenarios for the generalized wetland.

Table 3.D-58
Hazard Quotients for Salt Water Aquatic Species Exposed to Adulticides in Runoff After Considering the Effects of Partitioning in Three Distributions of Land Surfaces.

Table 3.D-59
Effect of Rainfall Discharging Directly to a Fresh Water Wetland on Hazard Quotients (HQ) for Aquatic Species.

Tier II Analysis in Selected Representative Areas

The Tier II analysis described above assumes a generalized wetland that receives runoff from a specific rain event of 0.25 inches. It does not consider any dilution that may occur in the receiving wetlands or stream, or estuary, nor does it consider partitioning that may occur to wetland plants or sediments. The following paragraphs extend the analysis to Jamaica Bay and Lemon Creek, two of the Representative Areas.

Application to Jamaica Bay

Because the evaluation of potential effects to marine and estuarine species in waters receiving adulticide-contaminated runoff indicated a potential for adverse effects to these species, a separate analysis for Jamaica Bay (Jamaica Bay and Environs/Paerdegat Basin Representative Area) was deemed necessary. Although the Tier II HQs for runoff to wetlands all exceed 1.0 with the exception of resmethrin for the eastern oyster spat, not all of the adulticides evaluated may result in adverse effects to Jamaica Bay's resources because of partitioning to organic material (carbon) in the sediment and suspended in the water column (partitioning), and dispersion by currents from the point of discharge. Risks at any location in the Bay can be determined only by studying those local conditions at that time, but some generalizations can help understand risks to Jamaica Bay natural resources overall.

Section 2 of this chapter, "Existing Conditions," provides a detailed description of Jamaica Bay and its resources. It is a relatively large waterbody, with a surface area of about 16,000 acres (NYCDEP, 1995) and an average depth of about 12 ft (Riepe and Tanacredi, undated). It is an important habitat within New York City—it is an NYSDEC designated Critical Environmental Area, and a NYSDOS designated Significant Coastal Fish and Wildlife Habitat. Despite the disturbances that have occurred in the bay and its drainage basin as the City has developed around it, the bay presently supports a diverse and valuable aquatic community and provides habitat for numerous waterfowl and shorebirds, mammals, reptiles, and amphibians. In addition to the Bay's value to wildlife, it is a recreational treasure to the residents and visitors of New York City.

As discussed in Section C, "Existing Conditions," the water quality of the bay is impaired. Water, sediment and habitat quality vary within the bay depending on proximity to the CSO, stormwater and other discharges, hydrologic conditions affecting dispersion, and decomposition of contaminants. Sediment contaminants include metals, hydrocarbons, and organic compounds (NYCDEP, 1995).

Approximately 36,700 acres of Brooklyn and Queens drain to the bay through combined sewer overflows (CSOs) and storm sewers. Most of this land area is developed, followed by approximately 700 acres of open space, and 660 acres of closed landfill (NYCDEP, 1995). Most of the stormwater drainage enters the bay through CSOs (approximately 20,000 to 30,000 acres), with a much smaller area immediately next to the bay (1,000 to 2,000 acres) draining to storm sewers that discharge to the bay (Leo 2000). With the exception of the storm sewers at JFK Airport that discharge directly into the bay at Grassy Bay, the majority of the CSOs and storm sewers on the northern shoreline discharge to the tidal basins (such as Thurston, Bergen, Paerdegat, Fresh Creek, Spring Creek, Mill Creek, and Shellbank). The CSOs on the Rockaways discharge to the bay, but the volume from this area is small compared to the other CSO discharges because of the limited land area. The CSOs discharge an average of 44.7 million gallons per day to the bay (O'Brien and Gere, 1993 in NYCDEP, 1995).

Paerdegat Basin within the Jamaica Bay and Environs/Paerdegat Basin Representative Area is representative of the conditions in many of the tidal basins—limited flushing of the basin has resulted in a build up of settled organics from the CSOs at the head of the basin. Degradation of the organics

lowers the dissolved oxygen levels and provides poor habitat for benthic invertebrates and fish, as evidenced by depauperate (falling short of natural development or size) benthic and fish communities of Paerdegat Basin (AKRF, 1993). Similar poor water quality and limited flushing have been reported for other tidal basins such as Mill, East Mill, and Shellbank (NYCDEP, 1995).

Because of the high organic content of the mixed sewage and storm water in the CSOs, much of the adulticides in runoff that enter the combined sewage system would be expected to partition to the organic material and then be transported either to sewage treatment plants, or to the tidal basins through the CSOs during some precipitation events.

Essentially all of the non-tidal flow in Paerdegat Basin and in the other basins is derived from the CSOs and storm sewers, as well as discharge from WPCPs in some basins. These adulticides do degrade in water. Therefore, the tendency for the CSO material to settle out and the distance the adulticide has to travel between the discharge and the mouth of the tidal basins, will provide some time for degradation of the adulticide to occur; reducing the amount of the adulticides that reach the bay, where the most sensitive resources are located.

While the resources within the tidal basins should not be eliminated from concern, a pathway from the source of the stress to sensitive resource species valued for protection (Jamaica Bay) must be established to understand exposure levels and assess potential adverse impacts. Based on the characteristics of the drainage pathways into the bay described above, little of the mosquito adulticides released to protect humans should find a pathway to sensitive resource species in the main body of the bay.

To assess the potential adverse impacts to the aquatic resources of Jamaica Bay, HQs were calculated for marine and estuarine species used in Tier I (Table 3.D-60) for the discharge of stormwater runoff to Jamaica Bay. The assumptions used for this assessment include the following.

- Adulticides are applied by truck at the maximum labeled rate over a quarter of the entire drainage basin of 36,700 acres. A quarter of the entire area was chosen because it is unlikely that the entire watershed would be sprayed at once, and many areas are exempt from spraying based on the setbacks around shorelines and wetlands imposed by NYSDEC for the spraying conducted by the City during the summer of 2000.
- A rainfall event was assumed to occur one day after spraying, and photolysis of the adulticide on exposed surfaces was assumed to occur during the 12 hours of daylignt between the application and the rainfall. Appendix 3.D-1, "Ecological Risk Assessment," presents the photolysis rates in Table A-4. The one day separation between the application and rain was selected because the label instructions direct applicators not to spray during rainfall. Rainfall was assumed to mobilize all of the adulticide reaching the ground that was not degraded by photolysis.
- Adulticides are assumed to partition over a equal mix of concrete, asphalt, and soil over a distance of 300 feet. A mix of surfaces was felt to best describe land use in the Jamaica Bay watershed.
- All applied adulticide was assumed to reach the Bay after taking into consideration degradation from photolysis, and that lost due to partitioning with organic carbon.
- Adulticides were assumed to enter the Bay and to mix completely with the Bay water. Volume of the Bay was calculated from the surface area (16,000 acres) and mean depth (12 feet).

Table 3.D-60
Example Hazard Quotients for Crustaceans, Mollusks, Fish and Other Groups in Jamaica Bay

Adulticide	Biological Group	Common Name	End Point	End Point Concentration (ppm)	UF	HQ
Sumithrin						
	Crustacean	No data				
	Mollusk	No data				
	Fish	Rainbow trout	LC50	0.0014	50	0.015
Permethrin						
	Crustacean	Stone crab	EC50	1.80E-05	50	**21.4**
	Crustacean	Mysid	LC50	1.90E-05	50	**20.3**
	Mollusk	Pacific oyster	LC50	6.5	50	0.000059
	Fish	Atlantic salmon	LC50	0.0015	50	0.26
	Fish	Striped mullet	LC50	0.0055	50	0.070
	Brown algae	Diatom	EC50	0.092	50	0.0042
Resmethrin						
	Crustacean	Pink shrimp	LC50	0.0012	50	0.32
	Mollusk	Eastern oyster, spat	EC50	1.79	50	2.4xE-6
	Fish	Rainbow trout	LC50	0.00028	50	0.015
Malathion						
	Crustacean	Gammarus	LD50	0.0005	50	**37.6**
	Crustacean	Mysid	LC50	0.0022	50	**8.54**
	Mollusk	Eastern oyster	EC50	0.0029	50	**6.48**
	Fish	Sheepshead minnow	LC50	0.033	50	0.57
	Fish	Striped bass	LC50	0.06	50	0.31
Naled						
	Crustacean	Mysid	LC50	0.0088	50	**1.50**
	Mollusk	Eastern oyster	EC50	0.091	50	0.14
	Fish	Sheepshead minnow	LC50	1.2	50	0.011
	Fish	Rainbow trout	LC50	0.16	50	0.082
	Brown algae	Marine diatom	EC50	0.015	50	0.88
Piperonyl Butoxide						
	Crustacean	Pink shrimp	LC50	2.2	50	0.0077
	Mollusk	Eastern oyster	EC50	0.23	50	0.074
	Fish	Rainbow trout	LC50	1.66	50	0.010
	Fish	Sheepshead minnow	LC50	1.8	50	0.0095

Notes: Bolding indicates hazard quotient exceeds 1.0.

- No partitioning to organic carbon in the tidal basins or the main body of the bay was assumed.
- Reductions in toxicity associated with residence time in tidal basins were not considered.

Table 3.D-60 presents the HQs calculated for estuarine and marine species. These species include the most sensitive species identified in Tier I as well as other estuarine/marine species that occur, or are expected to occur in Jamaica Bay. Even under these conservative assumptions, HQs were below 1.0 (Table 3.D-60) for:

- Sumithrin for rainbow trout—suggests fish species may not be affected by runoff containing sumithrin;
- Permethrin for pacific oyster (surrogate for eastern oyster), two fish species, and a diatom—suggests mollusks, fish, and algae may not be affected by stormwater runoff, but crustaceans and fish might have the potential to be affected;
- Resmethrin for eastern oyster spat, shrimp, and rainbow trout—suggests mollusks, crustaceans, and fish may not be affected by stormwater runoff containing resmethrin;
- Naled for eastern oyster, sheepshead minnow, and rainbow trout—suggests that mollusks, fish, and algae may not be affected by runoff contaminated with naled, but crustaceans showed an HQ slightly higher than one;
- Malathion for sheepshead minnow and striped bass results suggest malathion will not affect fish, but may have potential adverse impacts on crustaceans and mollusks; and
- PBO for pink shrimp, eastern oyster, rainbow trout and sheepshead minnow—suggests PBO will not affect invertebrates and fish when discharged to esturine or marine environments in stormwater discharge.

Although the HQs calculated for organisms in Table 3.D-60 were below one for mollusks and fish, the HQs calculated for crustaceans revealed that potential significant adverse impacts are expected to occur to crustaceans from the application of malathion. According to Tanacredi (1995), the common crustaceans that are expected to occur in Jamaica Bay include Rock Barnacles (*Balanus balanoides*), Sand Shrimp (*Crangon septemspinosa*), Common Shore Shrimp (*Palaemonetes vulgaris*), Blue Crab (*Callinectes sapidus*), Spider Crab (*Libinia emarginata*), Fiddler Crad (*Ovalipes ocellatus*), Green Crab (*Carcinus maenas*), Hermit Crab (*Pagurus species*), Mud Crab (*Panopeus herbstii*), Horseshoe Crab (*Limulus polyphemus*), and Sand Flea (*Ochestia platensis*).

Malathion and naled are relatively water soluble and would not be expected to partition heavily to sediments. Both of these adulticides degrade, naled fairly rapidly, so that the exposure concentration and HQs could be lower than calculated under the assumptions presented. Recovery in populations exposed to malathion and naled would be expected to be relatively rapid.

West Nile virus has been documented to result in death to birds and mammals. To some extent, application of the active ingredients to control the spread of the virus in human populations should also protect individuals of the natural populations affected by the virus. The application of the active ingredients, therefore, may simultaneously produce losses to non-target insects and aquatic organisms, but protect certain mammals and birds. The relative risks after considering both adverse and any simultaneous beneficial effects are presently not understood.

Application to Lemon Creek

The analysis for Lemon Creek was intended to provide additional information on potential impacts to aquatic resources in this Representative Area. The analysis extended the Tier II conducted for the

generalized wetland (see above) by considering effects of mixing on concentrations and ultimately HQs in Lemon Creek. Concentrations of the various active ingredients downstream of a discharge point selected at Hylan Boulevard were computed using standard engineering equations for the concentration of a chemical discharged into a flowing stream. These equations are described in Fischer et al., 1979. Assumptions implicit in the equations used are: active ingredient does not degrade in the stream, that the stream contains no additional sources of active ingredient except that entering at Hylan Boulevard, that the stream may be approximated by a rectangular channel, and that the active ingredients are well mixed at the point of introduction to the stream. No provision is made for tidal mixing, uptake by plants, or partitioning to sediments.

The average summer storm rainfall event of 0.375 inches was used. The analysis also assumed that a quarter of the Lemon Creek drainage area was sprayed in any particular event, and that the rain event occurred one day after spraying. Based on land use data, the subbasins used were estimated to consist of approximately two thirds pervious surface, and one third soil and asphalt. Discharge rates for the 1- and 5-year flood events were computed in the Blue Heron, Arbutus Creek, and Lemon Creek/Sandy Brook Watershed Drainage Plans Environmental Impact Statement as 262 and 4,242 cubic feet per second (cfs), respectively. Discharge rates for the 0.375" storm were estimated using a logarithmic ratio between the 24-hour rainfall for a given return period and the discharge for that same return period event as published in the watershed study above. The 24-hour rainfall depths were determined from the widely accepted National Weather Service Publication TP-40 (Hershfield, 1961). The assumption is that rainfall and runoff may both be fitted to logarithmic curves. This assumption is widely accepted to be true in hydraulic engineering and can be seen to apply with the data used here. Using this logarithmic ratio, a rainfall of 0.375", or the average summer storm, should produce about 50 cfs of discharge at Hylan Boulevard.

Estimated flow depths for the discharge channels were taken from the watershed studies listed above (p. 5-19). A depth of 2 feet was assumed, which is consistent with the 3.48-foot depth found for the 1 year storm from the watershed studies. Channel widths were estimated assuming this depth and the 50 cfs flow rate above. Flow velocities, shear velocities, and transverse mixing coefficients were determined using equations in Fischer et al., 1979.

Maximum concentrations at a variety of distances downstream of Hylan Boulevard were computed using Equation 5.7 (Fischer et al., 1979). Once the plume concentration reached the lowest possible concentration allowed by the incoming quantities of water, no further dilution of the active ingredient was allowed. Beyond this point, the active ingredient concentration was set to the minimum concentration. Concentrations decreased to approximately 23 percent of the values discharging from the point of stream entry, after moving downstream for a distance of about 250 feet.

The HQs for organisms that would reside 250 feet downstream of the active ingredient's introduction into the stream are indicated in Table 3.D-61. Sumithrin is the only active ingredient that posed low potential risk to fish and crustaceans. Permethrin was not at risk to mollusks but posed a potential risk to crustaceans and aquatic insects, and possible risk to fish. Malathion and naled posed a high potential risk to aquatic organisms. Resmethrin was at considerably lower risk to crustaceans and fish than observed for the generalized wetland, with HQ values at 2.1 and 2.4, respectively. HQs for PBO ranged between 6.3 and 17.0.

Receptors Exposed Through Food Chains

In Tier I, the HQs for terrestrial organisms exposed through the terrestrial and the aquatic-based food chains were generally less than 1.0, with the exception of grass-eating mammals eating grass that had

Table 3.D-61
Hazard Quotients for Freshwater Aquatic Species Exposed to Active Ingredients in Runoff in Lemon Creek 250 Feet Downstream of Stream Entry

Pesticide	Biological Group	Common Name	HQ
Sumithrin			
	Crustacean	*Daphnia magna*	0.000014
	Fish	Bluegill sunfish	0.28
Permethrin			
	Crustacean	*Daphnia magna*	**1,600**
	Aquatic Insect Larvae	Midge, larvae	**110**
	Mollusks	Pond snail	0.0006
	Fish	Fathead minnow	**3.0**
Resmethrin			
	Crustacean	*Daphnia magna*	**2.1**
	Fish	Rainbow trout	**2.4**
Piperonyl Butoxide			
	Crustacean	*Daphnia magna*	**6.3**
	Fish	Fathead minnow	**6.9**
	Amphibian	Chorus frog	**17**
Naled			
	Crustacean	*Daphnia magna*	**5,600**
	Aquatic Insect Larvae	Stonefly	**380**
	Fish	Fathead minnow	**36**
	Green algae (plant)	Green algae	**140**
Malathion			
	Crustacean	*Daphnia magna*	**6,300**
	Aquatic Insect Larvae	Stonefly, naiad	**4,600**
	Fish	Rainbow trout	**800**
	Amphibians	Chorus frog, tadpole	**14**

Notes: Bold indicates hazard quotient (HQ) exceeds 1.0.

been exposed to naled sprayed by air or truck, and piscivorous mammals exposed to naled, permethrin, and resmethrin; and piscivorous birds exposed to permethrin, resmethrin, and PBO. However, the Tier I analysis used several conservative assumptions that are unlikely to be met under natural conditions. These include:

- Predators would obtain all of their food from the sprayed area. This is unlikely for birds and mammals because they tend to roam over relatively large areas to feed;
- All of the food organisms in the sprayed area would have been exposed to the applied concentration of active ingredient;
- The food organism has bioaccumulated the active ingredient to concentrations achieved at equilibrium; and
- The food organism (e.g., fish) does not break down the active ingredient at all prior to its ingestion by the predator.

Because food chain effects have not been observed for the adulticides in nature, the screening-level HQs were low (i.e., most less than 1.0, all under 20.0), and the assumptions discussed above are

overly conservative, adverse effects to terrestrial receptors through aquatic- or terrestrial-based food chains are considered to be unlikely.

Summary of Ecological Risk Assessment Results

The Tier I ecological risk assessment (Appendix 3.D-1, "Ecological Risk Assessment") identified the pathways where it was apparent there would be no likely potential adverse effects to a number of biological receptors. However, this initial assessment also identified the potential for adverse effects for certain biological groups that needed to be addressed on a more detailed level in the Tier II assessment. The biological groups needing additional evaluation included:

- Terrestrial Receptors (Insects) with Direct Exposure—Non-target beneficial insects exposed to any of the adult mosquito insecticides.
- Aquatic Receptors in Ponds Exposed to Drift—All groups exposed to all adult mosquito adulticides except (a) mollusks exposed to permethrin and (b) crustaceans exposed to sumithrin.
- Aquatic Receptors in Wetlands Exposed to Runoff—In freshwater, all groups exposed to all adult mosquito adulticides except (a) mollusks exposed to permethrin and (b) crustaceans exposed to sumithrin. In saltwater, all groups exposed to all adult mosquito adulticides.
- Receptors Exposed Through Terrestrial-Based Food Chains—There is a slight possibility of adverse effects for grass-eating mammals exposed to permethrin. No potential adverse impacts risks to grass-eating mammals or other wildlife from adulticides was suggested by the Tier I analysis.
- Receptors Exposed Through Aquatic-Based Food Chain Bioaccumulation—There is a slight possibility of adverse effects for mammals exposed to naled, and potential adverse impacts on birds and mammals exposed to permethrin and resmethrin, from consuming fish that have bioconcentrated these adulticides.

The Tier II assessment analyzed these potential adverse impacts within the context of the resources found within the City, further refining the assumptions to represent the existing conditions. The Tier II analysis concluded that there was no potential adverse impact on organisms exposed to the active ingredients through food chain bioaccumulation. While the Tier II assessment concluded that several of the potential adverse impacts identified in Tier I would not result in adverse effects to the City's natural resources, it also concluded that certain exposures in Tier II did have the potential to affect certain natural resources within the City.

The following sections first discuss the field and monitoring studies that have been performed to assess effects of spraying these active ingredients in areas that support natural resources. It is followed by a section on the potential impacts to natural resources in the Representative Areas, which includes identification of potential measures to reduce these effects.

RECENT ADULTICIDING EXPERIENCE—EMPIRICAL STUDIES

A number of field investigations have been performed to assess the effects of the active ingredients on terrestrial and aquatic receptors. The empirical data generated from these studies are extremely useful for impact assessment purposes because they provide a means for evaluating potential adverse impacts on terrestrial and aquatic resources under natural conditions. The Tier I and Tier II risk assessments provide a basis for determining the potential adverse impacts, but studies are performed under controlled laboratory conditions, often for 96-hour periods. Factors such as adulticide breakdown, partitioning of active ingredients onto sediments and other organic and plant material, and

dilution cannot generally be very accurately represented in the risk assessment models. The empirical field data have the advantage of providing a result that integrates the effects of all of these variables. Some of these field studies provide insights and/or recommendations for mitigating losses to biota. These field studies, however, have the limitation of generally being site specific, with conditions specific to the time and place of study not entirely directly applicable to other situations or locations. For this reason, the results of the empirical studies must be interpreted cautiously, but can be used in conjunction with the Tier I and Tier II findings to help assess potential impact of the Proposed Action. Key findings from these empirical and monitoring studies are summarized below.

Terrestrial Receptors With Direct Exposure

In studies of the potential impacts on honey bees in Manatee County, Florida, from applying aerial ULV of naled on four dates (23 June, 9 and 15 July, and 12 August 1999), Zhong (1999) observed that bee mortality would occur once naled residue deposit on the ground was higher than 1000 µg/L. The average bee mortality in hives exposed to naled ranged from 15 to 200 per hive, compared to 2 to 20 for the control hives. Despite the increase in bee mortality between sprayed and unsprayed areas, Zhong did not observe a significant difference in honey production. According to Animal Plant and Health Inspection Service, honey bee colonies can recover following the loss of individuals from adulticides provided there is sufficient time for the bee population to recover before the winter (APHIS, 1999).

Zhong (1999) recommended several measures to reduce honey bee mortality associated with the aerial application of adulticides that would apply to both aerial and ground application methods, for all of the adulticides evaluated in this document:

- Reduce the deposition of the adulticides on the ground by reducing droplet size to less than 30 µm—Zhong (2000) has observed little impact to bees in experiments with naled when fine particles were sprayed using high pressure nozzles because little of the adulticide actually reached the ground.
- Reduce the number of honey bees out in front of the hive (honey bees will fan at the entrance whenever the temperature/humidity combination exceed a threshold) by adding more supers (removable upper stories of a beehive) on top of the hives which keeps the hives cooler.
- Face the hives away from the primary direction of the wind.
- Preserve the height of vegetation around hives—tall vegetation impedes adulticide drift toward the hive and exposed bees.

Onandaga County Health Department (OCHD) in New York evaluated the effect of aerial application of naled (Dibrom) on the Cicero Swamp as part of its mosquito surveillance and control program to limit potential human exposure to the Eastern Equine Encephalitis virus (O'Brien & Gere, 1997). The objective of the study, conducted in 1995 and 1996, was to evaluate the invertebrate community response to a single aerial application (July 1996) on non-target flying insects and soil litter decomposer organisms. The study focused on flying insects because Dibrom is a broad-spectrum adulticide that can affect any flying insect, not just mosquitoes, and because the majority of adult insects are capable of flight.

O'Brien and Gere (1995) as part of the Cicero Swamp studies conducted for OCHD in association with a single aerial application of Dibrom (naled) to control mosquitoes observed that the two most significant factors affecting Dibrom at the swamp were: location within vegetative strata, and the distance from the point of release. The investigators found that the exposed layers (outer layers) of the

forest canopy and open ground areas contained higher concentrations of the adulticide compared to strata that were protected in some way such as the understory plants in the woodland or vegetation under other vegetation. Additionally, the strata closest to the point of adulticide release contained higher concentrations of the adulticide than those further from the point of release.

For the OCHD studies, O'Brien and Gere (1997) evaluated the potential effects of the aerial spray by comparing community indices (similarity, diversity, equitability, and abundance) among the Cicero Swamp sites and selected reference sites, as well as pre- and post-spray at Cicero Swamp. The only index that exhibited a change attributable to the application of the adulticide was abundance. The investigators observed a decline in insect abundance from the pre-treatment sampling event, but also observed a decline (albeit smaller) at the reference wetlands. The insect population demonstrated a rebound within 7 days of spraying—the rebound was greater in the forested swamp than the shrub-scrub habitat. Within 30 days of spraying insect abundance was at the level expected for that time of year. Although the data indicated that insect abundance declined after spraying, the number of insect families did not decline when compared to natural declines observed at the reference sites. The data also did not indicate an observable loss of Diptera families that could be attributed to the spraying. Therefore, the spray did not result in a change in the insect community structure. The leaf litter study found no difference in the active decomposer community at Cicero Swamp before and after spraying, or between Cicero Swamp and the reference sites.

Giles (1970) in a study of the effects of aerial application of malathion on a small forested watershed concluded that malathion had little effect on soil bacteria or fungi. Insects were affected but recovered rapidly. This investigator also concluded that major portions of the insecticide were intercepted by forest vegetation.

Studies examining the effects of ULV malathion, applied at two or more times the application rate for mosquito control, on breeding birds found no effects of the insecticide on the fledging success and weights of nesting birds (blue tits, Pascual, 1994, and in Jensen et al., 1999; sage thrashers and Brewer's sparrows in Howe et al., 1996, and in Jensen et al., 1999). Additionally, the ODHD study of Cicero Swamp indicates that while there may be an initial decline in the number of flying insects, the population rebounds quickly. Ultimately, the extent of the effect will depend on the spatial coverage, duration and frequency of the spray events, and the subsequent loss of insect prey.

Aquatic Receptors in Ponds Exposed to Drift

The Florida Department of Environmental Protection (FDEP) examined the effects of malathion administered as part of the medfly eradication program on benthic macroinvertebrates in the littoral zone (shallow shoreline area) of five lakes in Umatilla, Florida in 1998 (FDEP, 1998, in APHIS 1998b). The results of the FDEP study showed declines in total numbers of benthic organisms collected in four out of five lakes and in species diversity in 3 out of 5 lakes that might be attributable to malathion. While flatworms and oligochaetes appeared to be reduced or eliminated in all lakes sampled, other taxa increased (water fleas), possibly as a result of reduced numbers of predators. APHIS concluded in 1997 that some reports of fish mortality in ponds following spraying could not be attributed only to the effects of malathion, but were most likely due to the combined stress of malathion, low dissolved oxygen, and high water temperature.

The OCHD study of Cicero Swamp (O'Brien & Gere, 1997), while focusing on flying insects, suggests that some of the aquatic lifestages of the flying insects collected (many were dipterans) were able to survive the application of naled and develop into the adult flying stage, contributing to the rebound in flying insects observed within the swamp.

Jensen et al., (1999) assessed the effects of ULV application of permethrin and malathion on nontarget invertebrate populations, caged mosquitoes, and mosquitofish (*Gambusia affinis*) in seasonal wetlands in the Central Valley of California. The effect of the ULV application of permethrin (application rate of approximately 0.0154 pounds of active ingredient per acre, compared to rate evaluated for this document of 0.021 pounds per acre) and malathion by truck was evaluated by using two pairs of treated and control wetlands for each adulticide within the Colusa National Wildlife Refuge. The wetlands ranged in size from 18 hectares (44.4 acres) to 58 hectares (143.2 acres).

Permethrin was not detected in the pre- and post-treatment water samples, but the detection limit was 0.02 ppm (mg/L, or 20 µg/L). This detection limit is much higher than the 0.5 µg/L used by the City for sumithrin and PBO discussed in Chapter 3.F, "Water Quality." Malathion was detected in the post-treatment samples; the detection limit for malathion was 0.006 ppm (mg/L or 6 µg/L). Macroinvertebrate taxa that were abundant in the wetlands evaluated during the permethrin and malathion trials included midges (Chironomidae), damselfly and dragonfly nymphs (Odonata), mayfly nymphs, water boatmen, and snails. Backswimmers (Notonectidae) and beetles were widespread but not as common. Jensen et al. (1999) did not observe a decrease in macroinvertebrate abundance following the application of permethrin and malathion. In fact, some individual taxa exhibited trends of increasing abundance after treatment, as would be expected with continued reproduction or colonization. Survival of mosquito larvae did not appear to be affected by the application of permethrin or malathion. At the same time, all of the caged adult mosquitoes placed in the application area died within 24 hours. All of the caged mosquito fish survived the 7-day post-application period. There was no change in the numbers of night-flying insects that could be attributed to the application of the adulticides. Insects collected included Diptera (flies) (such as Chironomidae, Culicidae, and Tipulidae), Lepidoptera (moths and butterflies), Coleoptera (beetles) and a few Hemiptera (true bugs). The investigators concluded that the lack of detectable mortality of aquatic invertebrates, particularly the mosquito larvae caged at the air-water interface where contamination should have been highest, resulted from low exposure to the insecticides. Adsorption of the adulticides to particles and vegetation (permethrin is lipophilic [has an affinity for fats] and readily adsorbs to plant surfaces and small particles) in the water may reduce the availability to macroinvertebrates and fish. The wetlands had organic particles in the water column and the bottoms were covered with herbaceous vegetation, and had patches of emergent vegetation. The authors suggested that the study results indicated that ULV applications of permethrin and malathion could be conducted near wetlands to control adult mosquitoes without killing fish or substantially reducing the amount of aquatic macroinvertebrates available to foraging wildlife.

Ongoing studies of the impacts from aerial application of ULV naled for adult mosquito control have found reduced mortality in caged fiddler crabs by switching from a conventional flat fan nozzle generating aerosol droplets with a 50 to 60 µm VMD range (80 percent mortality), to a high-pressure hydraulic nozzle with aerosol droplets in the 20 to 30 µm range (0 percent mortality) (Dukes and Zhong, 1999; Dukes, 2000). This suggests the use of methods to ensure that the greatest volume of small droplet sizes will greatly reduce adulticide concentrations reaching the surface waters.

Aquatic Receptors in Wetlands Exposed to Runoff

Water quality monitoring conducted as part of the medfly eradication program in California and Florida have documented elevated concentrations in streams and lakes associated with stormwater discharges from urban areas following an application of malathion (see Chapter 3.F, "Water Quality"). The USEPA (Montague et al., 2000) concluded that malathion is routinely detected in

monitored tributaries and retention ponds near urban areas. Malathion may be more common and at higher levels in urban areas because they are lacking the soil bacteria that degrade malathion. Montague et al. (2000) reported incidents of fish kills associated with malathion application in urban areas, presumably from stormwater discharge. Sticklebacks have been reported as the fish most severely impacted. Waters with little flow volume that received stormwater flow appeared to be the most affected by the malathion application.

Environmental monitoring conducted as part of the medfly eradication program in Florida has concluded that shallow water bodies receiving a large percentage of their volume from runoff originating from impervious surfaces may experience fish kills as a result of malathion application (APHIS, 1998a). The FDEP Surface Water Assessment and Monitoring Program (SWAMP) evaluated the effect of repeated aerial malathion application to two creeks in eastern Hillsborough County (SWAMP, 1997a and b). Both streams drain urban areas, rangeland, and citrus groves, and received repeated applications of malathion directly over the water. It should be noted that setbacks were not mandated in this study. Benthic macroinvertebrate sampling of both creeks one day after spraying suggested the communities were severely impaired in terms of the total number of taxa, the number of good water quality indicator species, and the number of mayfly, stonefly and caddisfly species that indicate the status of the stream health, compared to the results of similar sampling conducted the previous year, while physicochemical readings were within normal ranges. The macroinvertebrate community was extremely depleted and environmentally sensitive species were absent (SWAMP 1997a). Amphipods were impacted the most. Ephemeroptera, Odonata, and Hirudinea and some chronomid abundances were reduced. Oligochates and mollusca did not appear to be affected. SWAMP monitored the macroinvertebrate community following the cessation of spraying for medfly to document the recolonization of the invertebrate fauna of one of the creeks. Malathion during one of the spray events was measured at 37 µg/L, far in excess of the State standard of 0.1 µg/L. Water quality samples collected four or five days after a spray event had malathion concentrations of 0.81 and 0.41 µg/L, still in excess of the State standard. Recolonization of the stream was fairly rapid. The benthic macroinvertebrate community of the creek monitored following the last spray event reached the level indicative of a healthy community for the three indices evaluated 42 days after the last spraying event. The SWAMP researchers recommended that direct spraying of small waterbodies be avoided and that a buffer zone be implemented where possible (SWAMP, 1997b).

The SeaGrant Programs of Connecticut and New York, the National Oceanic and Atmospheric Administration, and the Connecticut Department of Environmental Protection (Connecticut DEP) are currently sponsoring research to address the lobster mortality and disease that has been observed in Long Island Sound. Concerns had been raised by lobster fishermen over the potential effect of spraying for mosquitoes to combat the West Nile virus that occurred in 1999 and whether the active ingredients used in the areas draining to the sound contributed to the observed mortalities. In response to these concerns, lobsters were tested for toxins, but nothing unusual was found. In November 1999, pathologists at the University of Connecticut identified parasitic amoebae or paramoebae, in the nervous tissue of all dead and dying lobsters. While this protozoan was identified as the immediate cause of mortality, it was not known whether it was the primary or secondary agent (Connecticut DEP 1999). According to the Connecticut DEP (Connecticut DEP Sound Outlook Newsletter, February 2001, #6), pathologists at the University of Connecticut believe that a combination of low dissolved oxygen and above-average water temperatures may have stressed the lobsters' immune systems, decreasing their ability to fight the paraboebae infection. The Connecticut DEP further points out that anecdotal data and reports from lobstermen indicate that the lobster mortality may have begun in

western Long Island Sound in 1998, and possibly as early as 1997, prior to the application of mosquito adulticides in New York and Connecticut to combat the West Nile virus (Connecticut DEP Sound Outlook Newsletter, February 2001, #6).

F. POTENTIAL FOR ADVERSE NATURAL RESOURCES IMPACTS IN REPRESENTATIVE AREAS

Potential effects to the City's natural resources may result from:

- The action of the adulticides evaluated in this document on the aquatic and terrestrial animals and plants inhabiting the open spaces within the City, as evaluated in the Tier I and Tier II ecological risk assessments; and
- The activities associated with the adulticide application methods, or non-adulticide related impacts.

The following sections discuss these two groups of potential effects.

TERRESTRIAL RECEPTORS WITH DIRECT EXPOSURE

The risk assessment findings indicate very low potential adverse impacts on mammals, birds or pets through inhalation of the active ingredients. The Tier I analysis also determined extremely low potential adverse impacts on birds exposed to active ingredients by ingestion through preening, or to pets through drinking water from puddles contaminated with pesticides.

The results of the Tier I and Tier II assessments suggest that non-target terrestrial insects such as bees, may be adversely affected by the application of adulticides. These effects will be direct, consisting of loss of individuals due to contact with the adulticides. Potential impacts to bees and other non-target insects can be reduced through the implementation of several measures.

The field studies demonstrated that when spraying mosquito adulticides in Florida, the mosquito control districts typically time the spraying to avoid periods when bees are actively foraging, typically two hours after sunrise to two hours before sunset. Timing the spray events reduces but does not eliminate bee mortality (Opp, 2000). According to Nick Calderone (2000) the active foraging period for bees in New York is about 1 hour before sunrise to about one half-hour after sunset. Bumble bees will forage when the temperatures are cooler, as well as in fog and light rain (Calderone, 2000). Restricting spraying during this active foraging period will help reduce losses of bees and other non-target insects that are active during this period of the day. Additionally, tall vegetation such as trees has been found to decrease the amount of active ingredient drift that reaches a sensitive resource (Montague et al., 2000).

The City's parklands that provide the greatest diversity of habitats and vertical complexity such as the wooded areas and wetlands of Van Cortlandt Park, Bergen Beach and other areas of Gateway National Recreational Area associated with Jamaica Bay, and the unmanaged woodlands of Wolfe's Pond Park should have sufficient populations of insects in areas unaffected by the spray to compensate for the loss of some individuals in the sprayed areas. Insects using areas blocked from the spray by trees, as would be the case in Van Cortlandt, and Wolfe's Pond Park, and even some portions of Soundview Park, even though it has large areas of meadow or grass, should be able to move into areas where individuals were lost from the spray. Additionally, woodlands such as those of Van Cortlandt Park, Wolfe's Pond Park, Bergen Beach, and even the low quality woodlands surrounding Paerdegat Basin, the poor quality ruderal meadow of Soundview Park, and the wetlands of Lemon Creek and the former Flushing Airport site, all provide multiple, interlocking layers of vegetation that will shield some individuals from the spray.

Using the results of the drift modeling presented in Chapter 3.A, "Framework of the Analysis," the concentration of naled that Zhong (1999) calculated necessary to cause bee mortality would occur at approximately 175 feet from a truck spraying the adulticide. At distances greater than 175 feet, mortality to bees would begin to decrease.

As presented in Section C of this chapter, the City provides habitat for a large number of butterfly and moth species. These species may be adversely affected by the application of adulticides through direct exposure. Moth species that are active at night, when the spraying occurs, have a greater chance of being directly exposed and therefore, affected, by the application of adulticides than butterflies that are active during daylight hours. Other invertebrates active at dusk or at night such as katydids (Orthoptera, *Pterophylla camellifolia*), crickets (Orthoptera), and fireflies (Family Lampyridae) and other beetles (Coleoptera), will also have a greater opportunity for being directly affected by the application of adulticides.

Insect species that rest on the surface of plants or structures have the potential to be impacted more than those that rest on the underside of plants, because they have a greater chance of direct exposure to the adulticides. As is the case for bees, applying the adulticides in smaller droplets (less than 30 µm) would decrease the amount of adulticide that actually reaches the ground and comes in contact with resting insects. Other measures that would reduce effects on butterflies and moths would be to document, and then avoid, spraying butterfly gardens and wildflower meadow areas, and to impose a setback of at least 100 feet around these areas to reduce the drift of adulticides.

The concentration of the adulticide reaching the ground decreases with distance from the source, as demonstrated by the results of the drift modeling (see Chapter 3.A, "Framework of the Analysis"), and as documented by the field studies. Therefore, not all areas within one of the City's parks that provide suitable habitat for these invertebrates will receive the same concentration of adulticide, or receive any adulticide at all.

While some insect or other invertebrate individuals in the outer layers of the different habitats may be lost due to the spray, there should be sufficient pools of individuals from other areas within the habitat that were not affected, to compensate for the losses. Insects occupying open low grassy areas with little vegetation to block some of the spray, such as the Great Lawn in Central Park, or the grassy areas of some of the more developed parks such as Canarsie Beach Park or Herman MacNeil Park, would not afford as much protection to insects and other invertebrates on the plants or on the ground. At the same time, the limited habitats found in these areas support fewer species. Individuals from adjacent areas that received less spray should quickly repopulate areas that were affected by the spray.

While some insects will be affected differently depending on their habitat preferences within the various vegetation communities, other non-target insects and other invertebrates that spend some portion of their life-cycle underground (beetles, ants, cicadas, grasshoppers, crickets, millipedes, and centipedes) would be less affected during the subterranean life stage. Insects and other invertebrates that live on or close to the ground should also be less affected than more exposed invertebrates, such as butterflies, because of the protection afforded by herbaceous plants, shrubs, and trees. Non-target insects such as dragonflies and damselflies (Order *Odonata*) that spend a large portion of the time near water should be less affected by the spraying of adulticides than more terrestrial invertebrates, provided the setback requirements are followed and waterbodies are avoided. Direct effects to non-target insects can be reduced the most by minimizing the amount of adulticide that actually reaches the ground (e.g., smaller droplet sizes), and restricting spraying to the night-time hours when fewer insects are active.

Some indirect effects to non-target invertebrates, mammals, birds, reptiles, and amphibians dependent upon insect prey species may occur in those habitats that provide less protection to invertebrates, such as open grassy areas of Central Park's Great Lawn or some of the more open landscaped parks such as Herman MacNeil Park or Carl Shurz Park. As discussed above, the more natural habitat areas should provide sufficient insect prey species. Insectivorous species known to occur in the Representative Areas, and which should occur elsewhere in the City with suitable habitat include:

- Mammals—meadow vole, short-tail shrew, masked shrew, and bats such as the little brown bat and silver-haired bat;
- Birds—examples include fly catchers such as the kingbird, Eastern phoebe, and Eastern wood-pewee, and swallows such as the colony of purple martins at Lemon Creek Park, and tree, northern rough-winged, bank, cliff and barn swallows, as well as other insectivorous birds such as the blue-gray gnatcatcher, and catbird;
- Reptiles—examples include the eastern garter snake, hognose snake, smooth green snake, and the threatened fence lizard recorded for Staten Island;
- Amphibians—examples include redback salamander, spotted salamander, fowler's toad, grey treefrog and spadefoot toad.

With the exception of the bats, most of the mammals, reptiles, and amphibians found within the City dependent upon insect and other invertebrates for food feed close to the ground surface, where fewer invertebrates are likely to be affected. Therefore, these organisms should be able to find sufficient food supplies within their home range—even those with small home ranges such as voles, or with high food requirements such as shrews—to maintain their current populations. While food will be available, reduced numbers of invertebrates may increase the effort expended in finding food. Invertebrate insect predators, such as spiders, that are less mobile are more likely to be adversely affected by a loss of prey species. Although the insectivorous birds are more dependent on flying insects, or those found on the upper surfaces of vegetation, these birds are also more mobile and should be able to find sufficient food supplies by expanding their feeding range up to the point where they are competing with other individuals.

The extent of losses of non-target insects will depend to a large extent on the frequency of the applications, and the duration of time over which the action is performed. Furthermore, if there is insufficient time for the invertebrate population to rebound the habitats may no longer be able to support the same number of birds and some individuals will move to other areas or be lost. Nesting success may decline for species nesting when spraying occurs. However, spraying of adulticides would occur for a limited period of time, and would not start until the mosquito-monitoring program indicates a concern with respect to mosquito-born diseases. Because of the ability of the insect predators to find alternate sources of food, and the limited spray season, it is not expected that these adulticides will have significant adverse impacts on the feeding ability of insectivorous birds, mammals, reptiles, and amphibians using New York City's terrestrial habitats.

AQUATIC RECEPTORS IN PONDS EXPOSED TO DRIFT

The results of the Tier II assessment, which took into account several factors not considered in Tier I, such as adulticide drift, deposition, and partitioning, suggest that the application of sumithrin should not affect aquatic resources in typical New York City ponds, such as Turtle Pond in Central Park, Wolfe's and Acme Ponds in Wolfe's Pond Park, and Van Cortlandt Lake. As presented in Chapter 3.F, "Water Quality," the water quality sampling conducted by the City before and after application of sumithrin with PBO suggests that the application techniques employed by the City minimized the

amount of sumithrin and PBO reaching the City's surface waters. Concentrations of sumithrin and PBO were almost always lower than the PQL, suggesting that these ingredients would not occur in concentrations sufficient to have potential adverse impacts on aquatic organisms. However, the Tier II assessment does indicate that the application of the other adulticides, permethrin, malathion, and naled, may affect certain groups of aquatic organisms but not others. Potential adverse impacts from application of resmethrin are not expected when partitioning of the adulticide is considered.

Permethrin appears to have the potential to affect crustaceans, but not mollusks or fish, and probably not aquatic insects. Resmethrin and the other pyrethroid adulticides should have opportunity to bind to organic carbon given the amount of suspended matter in the water column and silt in the sediment, and are not expected to pose a risk to fish or crustaceans. Malathion does not readily partition to sediment and it appears to have an adverse effect on all groups of aquatic organisms but amphibians. Naled appears to have the potential to affect crustaceans, but not fish, aquatic insects, and phytoplankton, but is known to break down rapidly. Fisher et al. (1993) identified the sorptive interactions between insecticides and sediments as an important indicator of the toxicity of the adulticide in the environment, even for malathion, which does not have a strong affinity for organic carbon.

While toxicological tests demonstrate the toxicological effects of all of the adulticides to organisms exposed in a laboratory setting, the effect on aquatic organisms in the environment will depend on the amount of adulticide that actually enters the aquatic environment, the exposure concentration. While the Tier II assessment took into account certain characteristics, such as decreasing drift concentrations from the truck, it did not account for all routes of dissipation of the adulticide in the environment that may affect the exposure concentration in ponds. These routes include: the partitioning on particles in the water column and bottom sediments, as well as the binding of pyrethroids such as sumithrin, resmethrin, or permethrin with phytoplankton, that would reduce the concentration in the water column. By not considering these factors the analysis probably greatly overestimates the concentration of the adulticides in the water column, thereby overestimating the amount available to aquatic organisms. As demonstrated by the results of the empirical and monitoring studies, information on the effects contained in the scientific literature is not always consistent with results obtained from the Tier II analysis in terms of the effects of adulticides on aquatic organisms in ponds or wetlands.

The results of the Jensen et al. (1999) study suggest the risk to aquatic insects may be overestimated in the Tier II model, possibly due to an overestimate of the exposure concentration. In cases where effects were reported, recovery occurred relatively quickly.

In conclusion, while the ecological risk assessment suggests that permethrin, malathion, and naled have the potential to affect certain groups of aquatic macroinvertebrates and fish, field studies conducted of these adulticides suggest that the actual environmental exposure from direct application for mosquito control may not result in adverse effects in ponds. The conservative assumptions used in the Tier II risk assessment overestimate the exposure concentration in the environment, and therefore the potential adverse impacts on aquatic organisms exposed to drift in ponds. These risk assessment models, based on laboratory studies, are conservative, and do not account for all potential sources of adulticide degradation, many of which cannot be reliably estimated. The larger, deeper lakes in the New York City Representative Areas will be at substantially lower risk than smaller, shallower ones. This points to the need for comprehensive monitoring programs in all sprayed ponds, at PQLs, that can be used for adequately judging hazard potential.

The potential for adverse effects can be reduced by minimizing the amount of adulticide drift contacting the City's ponds and lakes such as the lakes and ponds described within the Representative Areas, Turtle Pond, the Lake, the Reservoir, Van Cortlandt Lake, Acme Pond, and Wolfe's Pond, as

well as wetlands with limited flushing such as those associated with Van Cortlandt Lake, and the Shandler Recreation Area within Van Cortlandt Park. Ponds and lakes such as the Lake in Central Park, Van Cortlandt Lake, Wolfe's and Acme Ponds that are surrounded by tall shrubs and trees that reduce the amount of drift reaching the pond are less likely to be affected by truck application of the adulticide than one with lower vegetation around the pond, such as some of the bank area for Turtle Pond.

Potential effects can be further reduced by minimizing the amount of adulticide entering these waters through methods concerning over-water application and wind speed, such as: using setbacks to reduce the amount of drift entering these waters, abiding by label restrictions and reducing the droplet size to less than 30 µm, thereby decreasing the amount of adulticide reaching the ground.

AQUATIC RECEPTORS IN WETLANDS EXPOSED TO RUNOFF

The results of the Tier II risk assessment suggest that for some adulticides, the type of land cover may affect the concentration of the adulticide discharging to the receiving water. In freshwater wetlands, such as those associated with Van Cortlandt Lake, Lemon Creek, Wolfe's Pond and Acme Pond, and Flushing Airport, as well as other freshwater wetlands in the City that receive stormwater runoff, sumithrin does not appear to cause adverse effects to crustaceans, and should also not pose a risk to fish if given sufficient opportunity to bind with organic carbon. Permethrin appears to have the potential to cause adverse effects to fish, aquatic insects, and crustaceans, but not mollusks, no matter what the land surface is.

For estuarine wetlands receiving runoff from the same three land cover distributions as the freshwater wetlands, resmethrin was the only adulticide with an HQ less than 1.0—for mollusks under an equal land distribution and for all soil. With respect to the pyrethroids, Clark et al. (1989) concluded that crustaceans are more sensitive than fish, and oysters are comparatively insensitive. Eisler (1970) also observed that marine mollusks appear to be more resistant to adulticides than fish. Adverse effects from sumithrin in runoff appear to be less likely in freshwater systems than for estuarine and marine systems. As described in the Tier II assessment and Chapter 3.F, "Water Quality," sumithrin binds tightly to soil particles and sediments, which would reduce its concentration in the water column. The water quality monitoring conducted as part of the Summer 2000 applications of sumithrin and PBO in the City did not measure concentrations of either adulticide greater than the PQL of 0.5 µg/L with the exception of three samples, as described in Chapter 3.F, "Water Quality." Additionally, while the Tier II took partitioning into account with respect to the ground surface, it did not account for any partitioning to organic carbon that would occur within the storm sewers or CSOs, nor did it account for any partitioning in the receiving water or sediments. The Tier II assessment for a hypothetical wetland also did not take into account degradation that might occur to sumithrin or PBO before it enters the waterbody.

This would suggest that the concentration of sumithrin and PBO entering a waterbody in stormwater either through storm sewers or CSOs should be even lower than the estimated exposure concentration evaluated in Tier II that suggested little effects to freshwater systems. Therefore, freshwater systems without much flushing that receive stormwater discharge through storm sewers such as Van Cortlandt Lake, or Acme, or Wolfe's Ponds should not be significantly adversely affected by the application of sumithrin and PBO with the setbacks and other precautions described in Chapter 3.F, "Water Quality." Freshwater systems that are well flushed or have a larger volume of water, such as portions of the Bronx River, or the freshwater portion of Lemon Creek have an even smaller likelihood of being adversely impacted.

The generalized Tier II assessment projected a potential effect from sumithrin to estuarine and marine resources. Again, the Tier II, while it took into account partitioning on the ground surface, did not account for partitioning in the CSOs or storm sewers, or the receiving waters that would reduce the concentration of the adulticide being discharged at the end of the pipe. The Tier II also assumed no dilution or flushing would occur in the receiving waters. With the exception of the wetlands or other receiving waters associated with inland waters within parks such as Van Cortlandt Lake, or Acme , and Wolfe's Ponds, or the tidal basins of Jamaica Bay, most of the waters receiving stormwater runoff through storm sewers or CSOs have a short residence time or large volume of water capable of reducing the concentration of sumithrin or the other adulticides below what would effect aquatic organisms, for the reasons presented in Chapter 3.F, "Water Quality." Discharges to the East River and Harlem River should be quickly flushed because of the short residence times within these waters. Discharges to the Hudson River, Raritan Bay, or anywhere in New York Harbor should also be quickly diluted and flushed. In addition, the large amounts of suspended sediments within the New York Harbor system would tend to bind sumithrin and the other pyrethroids, minimizing the concentrations in the water column still further.

The Tier II assessment conducted a separate analysis of potential effects to Jamaica Bay because estuarine/marine aquatic species appeared to have a potential for being affected by all of the adulticides evaluated. This evaluation suggested that sumithrin does not appear to have an adverse effect on fish, the only group of marine/estuarine organisms with toxicological endpoints for this adulticide. PBO also does not appear to affect aquatic organisms. Permethrin does not appear to have the potential to affect mollusks, fish, or algae, but may adversely affect crustaceans and fish. Resmethrin does not appear to adversely affect crustaceans, mollusks, or fish. Malathion appears to have the potential to adversely affect mollusks and crustaceans, but not fish. Naled only appears to affect crustaceans and brown algae, and does not appear to affect mollusks, fish, or brown algae.

While this assessment assumed some partitioning would occur on the ground surface, it did not assume any partitioning within the CSOs or storm sewers, or the receiving waters, which in the case of Jamaica Bay are primarily the tidal basins. Taking into account partitioning in the Bay would reduce the concentration entering the tidal basins still further for the pyrethroids. Naled and malathion are more water soluble and may not experience as much of a reduction in concentration through partitioning. However, malathion and naled, while they do not partition heavily to sediments, are degraded fairly rapidly such that the concentration in the water discharging from the tidal basins to Jamaica Bay would be lower than what is discharged at the heads of the tidal basins.

As discussed in Chapter 3.F, "Water Quality," it is the two organophosphate adulticides, malathion and naled, that may have the greatest likelihood of reaching New York City's aquatic resources in waters receiving urban stormwater runoff.

The Tier II assessment for Lemon Creek calculated HQs for areas downstream of the point of entry for the adulticide into the creek. At 250 feet downstream of entry, HQs were greatly reduced from those calculated for the generalized wetland, although most were still above one. HQs for crustaceans and fish receiving resmethrin were 2.1 and 2.4, respectively, suggesting a low risk in these organisms if partitioning to sediments would have been considered.

While naled is also water soluble and likely to be transported to aquatic systems in stormwater runoff, it is also rapidly degraded, with a half-life less than 2 days. Please refer to Chapter 3.F, "Water Quality," for additional information on water quality effects for naled.

In summary, wetlands such as those in Jamaica Bay, Lemon Creek, and other surface waters receiving stormwater through the storm sewers, may be affected by the application of permethrin,

resmethrin, malathion, or naled. Sumithrin and resmethrin do not appear to have the potential to cause aquatic effects. The potential for impacts associated with permethrin and resmethrin will be lower than predicted by the risk assessment models due to the characteristics of the aquatic resources and stormwater systems and CSOs within the City. Because the pyrethroids partition to organic matter, the organic matter contained within the CSOs and storm sewers should reduce the concentrations of these adulticides available in the water column. Once discharged to the surface waters, many of the receiving waters such as the East River, New York Harbor, Hudson River, and Harlem River are fairly rapidly flushed and have a sufficient volume to reduce the concentration of these adulticides.

Jamaica Bay is not as well flushed as the rest of the New York Harbor system and certain groups appear to be affected differently by the various adulticides. Mollusks generally appear to be the group least affected, followed by fish, then crustaceans. The City's wetlands that receive some stormwater runoff through storm sewers but are not associated with the New York Harbor system have a greater potential to be affected because they are not well flushed and do not have a large volume of water to reduce the concentration of the adulticide. The organophosphates naled and malathion have a greater potential to affect the aquatic resources because they are more water soluble and do not partition to organic carbon to the same extent as the pyrethroids. However, both should leave the New York Harbor system in the same manner as the pyrethroids in the well-flushed areas of the harbor.

Receptors Exposed Through Food Chains

Tier II assessment evaluated the following potential effects to terrestrial receptors exposed through the terrestrial-based and aquatic-based food chains:

- Mammals eating grass exposed to naled—examples within New York City include eastern cottontail, meadow vole, deermouse, and ground hog;
- Mammals eating fish that have bioconcentrated naled, pemethrin and resmethrin—an example in New York City is the raccoon;
- Birds eating fish that have bioconcentrated permethrin, resmethrin, and PBO—examples in New York City include gulls, terns, black skimmer, herons, egrets, osprey, and eagle.

Given that food chain effects due to these adulticides have not been observed in nature, and the HQs calculated using very conservative assumptions were small, albeit sometimes greater than 1.0, significant adverse effects to these receptors are not expected to occur.

Endangered Species

Section B of this chapter describes the existing conditions, lists and describes the endangered animal and plant species known to occur in New York City, and also identifies which of these species are known to occur in the Representative Areas. The Federally listed species include the piping plover, seabeach amaranth, and Arogos skipper. The piping plover is a shorebird that nests and forages on beaches and dunes the Rockaways, Queens. Direct and indirect impacts to this species should be minimal because the City is not spraying in the beach or dune area. The seabeach amaranth is an endangered plant that occupies the same beach area as the piping plover in the Rockaways. As with the plover, impacts to this plant are expected to be minimal since the City will not be spraying in the beach or dune area. To further minimize potential impacts, the City would maintain a 300-foot no-spray buffer from the landward edge of the dune area.

The Arogos skipper is an endangered butterfly that was observed in the northern portion of Staten Island in the serpentine barrens. While no recent sightings have been reported, any individuals of this species that may be present on Staten Island have the potential to be adversely affected by the

application of the adulticides evaluated in this document. Impacts can be reduced by establishing a 300-foot no-spray buffer around the historical location for this butterfly, and applying the adulticides at night when butterflies are less active.

The Federally and State-listed endangered shortnose sturgeon migrates up the Hudson River but will not be adversely impacted by the application of the adulticides because of the large volume of water in the Hudson River available to dilute the adulticides and the flushing ability of this portion of the river. Similarly, with the exception of occasional occurrences of the Atlantic ridley in Jamaica Bay, the four endangered sea turtles known to occur in the waters surrounding New York City would be present in areas that provide ample opportunities to dilute and flush any adulticides that should enter these waters.

Two other animal species of special concern, the State-listed endangered eastern mud turtle, and State-listed threatened fence lizard are both found on Staten Island. Because the mud turtle is found in shallow, slow-flowing fresh or brackish waters and adjacent upland areas, potential adverse impacts to this species should be small provided the City maintains a 300-foot no-spray setback from the known locations of this species on Staten Island. Adulticides carried in stormwater runoff that may enter the preferred habitat should have sufficient opportunity to degrade or partition to the sediment prior to entering the preferred habitat areas for this species. The fence lizard prefers dry open woodlands and brushland, and has the potential to be affected by the application of the adulticides. Few toxicological data are available on the effects of these adulticides on reptiles; therefore the direct effect on the fence lizard is unknown. Indirect effects from the loss of prey species, primarily ants and beetles, should be minimal since these groups of insects are mostly ground dwellers with less chance of being affected by the adulticides evaluated in this document.

The wetlands bordering Jamaica Bay provide habitat for several plant species of special concern. While little plant toxicological data are available, potential impacts on these wetland or beach species should be reduced by the observance of the City's no-spray setback from wetlands and waterbodies. Jacobs Ladder, an endangered plant, known to occur at Wolfe's Pond Park and Van Cortlandt Park, is an herbaceous species located under fairly mature tree canopies which should minimize contact with the adulticides and the potential for adverse impacts.

The remaining species of special concern are shorebirds such as the terns; wading birds such as the egrets, ibis, herons, and bitterns associated with wetlands and shallow water areas; waterfowl such as the pied-billed grebe, and raptors such as the barn owl, short-eared owl, northern harrier, and peregrine falcon. As presented in the ecological risk assessment contained in the previous sections, direct adverse effects to birds through inhalation, preening, or consumption of contaminated fish are expected to be minimal. Additionally, the City's no-spray setback from waters and wetlands should reduce the amount of adulticides entering the preferred habitat areas for the shorebirds, wading birds, and waterfowl. Indirect effects caused by a loss of prey species should also be small because of the ability of most of these birds to switch to different prey items should one particular prey item become less abundant. Barn owl, short-eared owl, and northern harrier consume small rodents and other small animals that are not expected to be affected by the application of the proposed adulticides and should not be affected by a loss of prey. Peregrine falcons feed on other birds, which are not expected to be affected by the proposed adulticides and therefore should not experience a loss of prey items. Additionally, the high elevation selected by the peregrine falcon for nesting should minimize potential contact with the adulticides applied by truck. Individuals nesting on bridges should likewise have little contact with adulticides applied aerially because of the City's no-spray setback from

waterbodies. No-spray setbacks would be established around peregrine pairs known to be nesting on buildings to further minimize potential effects to this species.

Cumulative Effects from the Application of Adulticides and Larvicides

According to Sid Able of USEPA (2001), the agency has not evaluated the potential cumulative effects on natural resources from the concurrent application of larvicides and adulticides to aquatic habitats. Because of differences in the mode of action between the adulticides evaluated in this EIS and the larvicides that are part of the City's *Routine Program,* the cumulative effects should be limited. The larvicide Bs targets primarily mosquitoes and therefore its application with the adulticides will not result in greater effects on natural resources than the adulticides alone would have. Bti can affect other dipterans along with mosquitoes, which could result in greater impacts on some groups of dipterans when combined with some adulticides. Methoprene has the potential to affect non-target invertebrates. However, because the City is not proposing to use methoprene in ponds, lakes, or wetlands, the cumulative effect of this larvicide with the adulticides should not pose significant additional risk to natural resources.

CUMULATIVE EFFECTS OF ACTIVE INGREDIENTS APPLIED BY CITY WITH BACKGROUND

Little direct information on background levels of active ingredients in New York City ponds or streams are available. The City's post-spray water sampling from the 2000 action (discussed in Chapter 3.F, "Water Quality") did not generally find sumithrin or PBO in the water bodies at concentrations above detection limits. In 1999, the USGS (Philips et al., 1999) collected surface water samples from 3 networks of lakes and reservoirs in upstate New York that are sources of public water supply. The samples were analyzed for 60 insecticides and herbicides, including malathion and permethrin. No insecticides were detected in the samples. While the USGS study is not site specific to New York City, it does point out that even in areas where a significant amount of active ingredients may be used in a variety of products (e.g., malathion in agricultural pest control insectides), concentrations of the active ingredients remained below detection limits in lakes and reservoirs. This finding, combined with the results of the City's monitoring for sumithrin and PBO, suggests that detectable background levels of the adulticides should either not be present, or occur only in very low concentrations. However, monitoring should be performed in waters likely to receive runoff or direct application to help better characterize baseline conditions.

Even if background concentrations in waterbodies such as ponds, wetlands, or Jamaica Bay were equal to the concentrations of the active ingredients predicted to be added under the Proposed Action (highly unlikely), the conclusions reached in this EIS would not be materially changed. In most cases, HQs that were less than 1 would still be less than 1, despite doubling in value. HQs that were greater than 1 would obviously be increased further under this scenario. Monitoring in waterbodies would establish true background levels of these active ingredients. Establishing background levels will be determined as part of a monitoring program for any active ingredient under consideration for future application. For sumithrin and PBO, it appears that background levels were non-detectable in 2000.

POTENTIAL RELATED IMPACTS

The following aspects of the adulticides application process may cause potential effects to the City's natural resource:

- movement of trucks applying the adulticide;
- movement of the aircraft (fixed wing or helicopter) applying adulticide;

- noise from the trucks or the aircraft;
- lights from the truck application or aircraft; and
- other human disturbance associated with the application.

Movement of Trucks Applying the Adulticide

Effects to natural resources associated with the movement of trucks during spraying may include loss of some individual wildlife and birds due to impact with the truck. However, because the trucks move slowly (5 to 20 mph), are noisy, and have headlights, these losses should be small. Other impacts associated with the movement of trucks may be associated with ground disturbance and creation of ruts should the truck leave paved roadways. Because the trucks must maintain a setback from water or wetlands, effects to aquatic resources should be minimal.

Movement of Aircraft Used for Aerial Application

Effects to natural resources associated with the movement of aircraft used in spraying may include loss of some individual birds from impacts with the aircraft. The number of birds aloft during the night should be low during the summer and early fall when spraying is most likely to occur.

Noise from the Truck or Aircraft During Application

Some wildlife and bird individuals will be affected by the noise associated with the truck applicator or the aircraft applicator. These effects may include a change in activity pattern such as cessation of feeding activities or resting, or change in the resting location. However, these effects should be temporary and normal activity patterns should return once the vehicle or aircraft has passed.

Lights From the Truck Application or Aircraft

As with the noise effects, the lights from the truck or aircraft may cause a temporary change in activity pattern such as feeding or resting. However these changes should be temporary and normal activities should return once the vehicle or aircraft has passed.

Other Human Disturbance Associated With the Application

Any other human disturbance associated with the application of adulticides, such as increased human contact during the spraying will be temporary and short-lived and will have minimal effect on wildlife or birds.

G. INERTS

Chapter 3.C, "Public Health," discusses the inert ingredients contained in the adulticides evaluated in this EIS. In most cases the inerts consist of petroleum distillates or white mineral oil. Mineral oil is included in USEPA's list of minimal risk inert ingredients, which include substances that are ubiquitous in nature and not expected to present a hazard to human health or the environment. The amount that would make its way into surface waters in and around New York City should not affect water quality or aquatic organisms. With respect to petroleum distillates, the volume applied in these ULV formulations will be small, and some of the volume applied will volatilize in the atmosphere or on the ground surface before it reaches surface waters through stormwater runoff. For smaller bodies of water, such as Van Cortlandt Pond and the other ponds found within the Representative Areas the concentration of inerts delivered through stormwater should not result in significant adverse impacts to aquatic organisms. The amount of these inerts that would eventually enter larger bodies of water such as Jamaica Bay, Hudson River, or New York Harbor will be small and quickly diluted such that they will not result in significant impacts to aquatic organisms.

H. CONCLUSIONS

This chapter has provided a detailed description of the existing conditions of the natural resources found in New York City and particularly those within the Representative Areas. The habitats and characteristics of these Representative Areas were utilized to assist in the evaluation of the potential City-wide impacts on natural resources from the Proposed Action. Screening level (Tier 1) and focused (Tier II) ecological risk assessment methods were used to assess the potential adverse impacts on biological receptors from the Proposed Action. In addition, assessments were performed to determine the potential impacts from the operations of the mechanical equipment (such as trucks, all-terrain vehicles and aircraft) on natural resources. The risk assessment calculations were weighted with results from empirical studies and best professional judgment, to assess the effects and significance of potential impacts of the various active ingredients on resources found in the Representative Areas (and therefore, in the City), in accordance with guidelines in the *CEQR Technical Manual* for determining significance.

Jamaica Bay is sometimes highlighted when the potential impacts due to runoff of adulticides after a rain event are discussed below. This is necessary, not just because the Jamaica Bay environs are included as one of the Representative Areas, but because Jamaica Bay is extensive in size and provides a flourishing environment for wildlife within the City boundaries. Jamaica Bay is also nearly completely enclosed by land with only a narrow inlet to the Atlantic Ocean (between the Rockaway Peninsula and Brooklyn). Approximately 36,700 acres of Brooklyn and Queens, most of which is fully developed, drain to the Bay through CSOs and storm sewers. Given the combination of these circumstances, some of the potential adverse impacts from the Proposed Action could be greater in Jamaica Bay when compared to other aquatic environments in the City. These impacts could occur if significant portions of the drainage area in Brooklyn and Queens were subject to adulticiding actions, and significant rainfall follows within a short period after the applications, resulting in the transport and discharge of adulticides into Jamaica Bay. While Jamaica Bay is a unique ecosystem and the only Critical Environmental Area in New York City, there may be other inlet bays in New York City (e.g., Little Neck Bay in Northern Queens) that exhibit similar characteristics with respect to limited tidal flushing and large stormwater discharges. These inlet waterbodies may also experience potential significant adverse impacts on crustaceans like those predicted for Jamaica Bay from the runoff of malathion.

No significant adverse impacts are expected from the application equipment, including trucks or aircraft applying adulticides. No significant adverse impacts are expected from the inerts in the adulticides.

ANALYSES WHICH IDENTIFIED TERRESTRIAL AND AQUATIC ORGANISMS WITH NO POTENTIAL FOR ADVERSE IMPACTS

Based on the results of the Tier I and II analyses, the review of empirical studies, and best professional judgment, several pathways were identified where there would be no potential effects on major groups of terrestrial and aquatic organisms. These pathways and biota are summarized below.

All Active Ingredients

- Birds and mammals by direct inhalation of adulticides.
- Birds by ingestion due to preening of adulticides which could have deposited on their feathers.

- Pets by direct inhalation or drinking water from puddles formed by rainfall after application of adulticides.
- Birds and mammals ingesting adulticides indirectly through the terrestrial-based food chain (including feeding on either grass, seeds or insects that could have adulticides deposited on them), and predators such as raptors feeding on mammals which have ingested adulticides.
- Birds and mammals ingesting adulticides indirectly through the aquatic food chain (including raptors feeding on fish that may have accumulated active ingredients from runoff into the water column).
- Organisms in the large water bodies of New York Harbor, including the East River, New York Harbor, Hudson Harlem Rivers, with the exception of Jamaica Bay or other inlet bays with limited tidal flushing and large stormwater discharges.

Organophosphates

Malathion

- Fish from runoff and amphibians via drift in freshwater habitats.

Naled

- Aquatic insect larvae, mollusks, and fish via drift, and crustaceans, brown algae, fish, and mollusks from runoff.

Pyrethroids

Permethrin:

- Aquatic insect larvae, mollusks, and fish, in ponds via drift, and fish and mollusks from runoff.

Resmethrin

- Aquatic organisms in ponds via drift, and crustaceans, fish and mollusks, and species in streams, after consideration of dilution and partitioning to sediments or plant material.

Sumithrin:

- Organisms in pond, wetland, and estuarine habitats from drift or runoff.

PBO

- Organisms in ponds, wetlands, and estuarine habitats from drift or runoff.

ENDANGERED SPECIES

No significant adverse impact is expected to occur for any endangered species known to presently occur in New York City. The Federally listed piping plover and seabeach amaranth occupy beach areas that would not be subject to spraying. The endangered shortnose sturgeon and sea turtles that occasionally occupy the waters of the New York area are not expected to be adversely impacted by application of the active ingredients. The Arogos skipper is an endangered butterfly that was observed in the northern portion of Staten Island in the serpentine barrens. While no recent sightings have been reported, any individuals of this species that may be present on Staten Island have the potential to be adversely affected by the application of the adulticides evaluated in this document. As part of the proposed project, potential impacts will be reduced by establishing a 300-foot no spray buffer around the historical location for this butterfly. Potential impacts to species of special concern would be minimized by observance of the City's no spray setbacks for wetlands and waterbodies.

GROUPS OF TERRESTRIAL AND AQUATIC ORGANISMS WHICH COULD BE ADVERSELY AFFECTED BY THE PROPOSED ACTION

Based on Tier I and II risk assessment calculations, several groups of terrestrial and aquatic organisms were identified for which potential adverse effects could occur. These organisms would be potentially adversely affected by one of three pathways (via drift and deposition onto freshwater ponds, direct contact with airborne adulticides, or runoff of adulticides from rainfall after application). While there may be some adverse effects and losses of individuals as a result of the Proposed Action, these potential adverse effects are for the most part not considered to be significant adverse impacts. However, there is a potential for application of malathion to result in significant adverse impacts to crustaceans in inlet bays, such as Jamaica Bay. Summarized below are the groups of terrestrial and aquatic organisms (and associated pathways) that could potentially be adversely affected by the Proposed Action. This is followed by a discussion supporting the determination for reaching conclusions regarding significant adverse impacts (presented by pathway) and a separate discussion on potential for significant adverse impacts to resources of Jamaica Bay.

All Active Ingredients

- Non-target insects and other terrestrial arthropods from direct contact with airborne adulticides.

Organophosphates

Malathion

- Organisms, including crustaceans and aquatic insect larvae, in pond, wetland and estuarine habitats through deposition of drift or from runoff.

Naled

- Crustaceans in ponds via deposition from drift; aquatic organisms from runoff entering wetlands.

Pyrethroids

Permethrin

- Crustaceans, in ponds via deposition from drift, aquatic organisms from runoff entering wetlands, and crustaceans from runoff to Jamaica Bay or tidal creeks, such as Lemon Creek.

Resmethrin

- Crustaceans and fish from runoff entering wetlands.

Non-Target Insect and Other Arthropod Terrestrial Wildlife Impacts

While there would be individual losses of insects and other arthropods in the areas near the application of adulticides, especially for night flying arthropods, such diminutions of the insect populations immediately during and after the adulticide application are not considered to be signficant adverse impacts. These effects would occur from all active ingredients. Outlined below are the reasons for the determination of no significant adverse impacts.

- The application of adulticides under the Proposed Action would be limited temporally, and would not occur for the full spring, summer and fall periods. Furthermore, it is highly likely that large areas would be exposed to far fewer than the 10 applications per year assumed in the technical analysis of effects of multiple applications, in this EIS.

- The application of adulticides under the Proposed Action would be limited spatially, and would likely be applied at targeted locations rather than the entire City, for any given application date.
- Potential adverse impacts to non-target organisms, primarily arthropods other than mosquitoes, are likely to be limited to those species that fly or are active during the nighttime hours. Nighttime flying insects would likely be exposed to adulticides in the same way in which mosquitoes would be exposed. However, many insects that fly and are active during the day, such as butterflies and bees (i.e., beneficial pollinators of plants), would likely have less exposure, other than potential residues on plants, to adulticide applications. Therefore, it is not expected that such insects which are active in the daytime would be sprayed directly as would nighttime flying insects (e.g., moths). The majority of insects have several generations per year and produce more than 100 offspring (many produce hundreds) per generation. Many insects that live in leaf litter or underground (e.g., beetles) would likely not experience significant adverse impacts from spraying since they would largely be protected by soil and vegetation.
- Arthropod populations from neighboring unsprayed communities would be likely to repopulate neighboring areas that have experienced short-term losses from the application of adulticides. Although short-term losses of individuals in some arthropod populations in spray zones would be expected to occur, the Proposed Action is not expected to conduct consecutive nightly (i.e., repeated) applications in the same area. Furthermore, many vegetated areas will be buffered from the effects of the adulticides and there are a number of no spray zones identifed throughout the City. Since spraying would not occur year round and potentially only a maximum of ten times over a three month period, it would be expected that within a short time, the sprayed area's populations would rebound to levels that occurred prior to spraying. In most areas and years, far fewer than ten applications per year are expected to occur.

While the loss of non-target insects would not be considered to be a significant adverse impact, the NYCDOH did consider the feasibility of conducting monitoring of non-target insects under the Proposed Action. It was determined that monitoring the potential losses of non-targets could not be feasibly conducted in a cost effective manner for the following reasons:

- Data obtained from any localized monitoring programs could not be extrapolated accurately to indicate non-target insect populations on a city-wide basis.
- There are no quantitative baseline data on the numerous non-target insect or other arthropod species inhabiting the City. Thus, quantitative baseline data for each region of the City would need to be collected prior to spraying.
- As discussed in this EIS, the fluctuating life cycles of individual species further complicate attempts to define pre-adulticiding (baseline) or post-adulticiding conditions throughout the City.
- Due to the sensitivity of such species to other environmental conditions and meteorology (e.g., temperature, rainfall), baseline conditions would need to be established over a long period of time (multi-year) in order to better understand the level of fluctuation in such species (both at a population level and presence in various geographic regions of the City).
- The costs for developing these pre- and post-application characterizations would be significant, and beyond the scope of the Proposed Action.

Given the issues raised above, NYCDOH is not attempting to prepare long term baseline inventories of non-target insects and other arthropods city-wide as part of the Proposed Action. However, NYCDOH will continue to work with other agencies (e.g., NYSDEC, NYCDPR) and stay informed

on observations made by local professionals documenting the presence/absence of such species throughout the City, especially endangered species.

Deposition of Drift Into Ponds

Results of the Tier I and Tier II studies indicated that direct drift into ponds would not result in potential adverse impacts on most aquatic organisms. The exceptions were on crustaceans for permethrin and naled, and on crustaceans, insect larvae, and possibly fish for malathion. While the ecological risk assessment studies indicated these possible adverse impacts, results of field studies conducted for assessing effects of permethrin, malathion, and naled, suggest that the actual environmental exposure from direct application for mosquito control may not result in adverse effects in ponds. In the analyses performed for this EIS, the conservative assumptions used in the Tier II risk assessment appear to overestimate the exposure concentration in the environment, and therefore the potential adverse impacts on aquatic organisms exposed to drift in ponds. The risk assessment modeling approach that was employed in this EIS relies on toxicological laboratory studies generally run for 96 hours, and is intended to yield conservative estimates of the potential impacts. The modeling does not account for all potential sources of adulticide degradation (e.g., partitioning on particles in the water column, or binding of pyrethroids with phytoplankton), and such credits are not readily quantifiable. The potential for drift and deposition of adulticides onto ponds would not be expected to have a significant adverse impact to aquatic species in most cases. This finding is supported by the sumithrin and PBO water quality data collected by the City during adulticiding operations undertaken in the year 2000, which generally did not find detectable levels of these active ingredients in ponds following spray events. In cases where losses due to direct deposition could occur (e.g., malathion for fish, crustaceans and aquatic insects), they are not considered to be reflective of a significant adverse impact because of the limited temporal and spatial extent of the potential losses.

Potential Runoff into Streams, Wetlands and Other Waterbodies

The results of the risk assessment calculations and the review of reported monitoring results from other areas of the country indicate that there could be individual losses of aquatic organisms in the waterbodies of New York, due to runoff from rainfall after appliction of adulticides.

With respect to runoff, these potential effects would largely occur (at least to some extent) at and near the point of discharge into a waterbody. In general, the greatest to least potential for adverse effects from runoff for the active ingredients would be malathion, naled, permethrin, resmethrin, PBO, and sumithrin. While there may be some losses of individual non-target organisms as a result of the Proposed Action, these potential adverse impacts are not considered to be reflective of a significant adverse impact because of the limited temporal and spatial extent of the potential losses.

- Field and monitoring studies in other portions of the country have demonstrated losses in fish and benthic invertebrates in streams after the application of malathion. These included studies conducted in concert with medfly eradication programs, which would be expected to result in greater impacts on aquatic species as compared to the Proposed Action. The medfly eradication programs did not always include buffer zones from waterbodies. In such cases, malathion may have been applied in syrup-like droplets or in aerial applications directly over water. This may have resulted in much higher deposition of malathion concentrations into water bodies, as compared to the Proposed Action, which uses ULV application methods and defined buffer zones in the vicinity of waterbodies. In stormwater discharge locations where there is either very low water volume or in immediate areas near the point of discharge, losses of aquatic species can be expected. However, as reported in

other studies referenced in this EIS, recovery of benthic communities has been reported to be relatively rapid following cessation of spraying activities.

- Losses of even large numbers of individuals within a population, do not necessarily translate into population declines or result in significant adverse impacts. Most populations have compensatory mechanisms that allow them to remain stable in the face of mortality imposed by natural and non-natural causes. This concept forms the basis of fishery stock management, where some level of commercial and/or recreational fishing can occur without producing reductions in the stock of the fishery.
- The runoff analyses did not account for the effects of partitioning to plant material or sediments (in either fresh or saltwater wetlands, or tidal basins) or reductions in toxicity associated with residence time in tidal basins. Because the pyrethroids partition to organic matter and are not highly soluble in water, the organic matter contained within the CSOs and storm sewers should reduce the dissolved concentrations of these adulticides in the water column. Therefore, the calculated levels of pyrethroids, such as permithrin, should be much lower in the water column than as calculated in the risk assessment. Once discharged to the surface waters, many of the receiving waters such as the East River, New York Harbor, and Hudson Rivers are fairly rapidly flushed and have a sufficient volume to significantly reduce the concentration of these active ingredients.
- The Proposed Action would not take place year round, but would likely be limited to applications over a three month window. Furthermore, it is likely that fewer than 10 applications per year would be required in any year at the same locations. The limited application schedule and the fact that not all areas are exposed to the active ingredients, should act to minimize potential effects on natural resources and help maintain stable populations. In cases where losses occur, recovery of aquatic communities from adjacent unaffected areas is expected to be relatively rapid following cessation of adulticide applications, especially for short lived species with multiple generations per year.
- The Proposed Action would not result in any major physical disturbance or permanent loss of habitat. Habitat function or migratory habits of species are unlikely to be affected by the Proposed Action.

POTENTIAL SIGNIFICANT ADVERSE IMPACTS FROM THE PROPOSED ACTION

Based on Tier I and II risk assessment calculations, the potential concentrations of malathion (due to runoff if a storm event occurs after application of malathion over a large land area that drains to Jamaica Bay) could be well above the estimated no effect levels for crustaceans in Jamaica Bay. Field monitoring data of measured malathion levels in waterways after application of the adulticide in other parts of the country support the determination that malathion has the potential to become entrained into stormwater and discharged into urban waterbodies. The analyses performed in this study assume that a large coverage of land in Brooklyn and Queens would have malathion applied, and rainfall after the application would result in a large runoff of this active ingredient to Jamaica Bay. Given that Jamaica Bay can receive such large discharges of runoff and has limited mixing with the Ocean, the net result is that calculated malathion concentrations in the water can be well above no effect levels for crustaceans. Crustaceans in Jamaica Bay are largely comprised of barnacles, shrimp, crabs, copepods, sand fleas, and other amphipods. Even though the concentrations of malathion would not persist for a long time in the bay, given that the calculated concentrations of malathion would be over a large area with levels well above the calculated no effect level, it was determined that the application of malathion and runoff from rainfall could result in potential significant adverse impacts on crustaceans in Jamaica Bay, particularly in the shallower, near shore areas. Other inlet bays, such as Little Neck Bay, which receive a significant amount of stormwater runoff and have limited tidal

flushing may also have significant impacts predicted for crustaceans. Waterbodies around New York Harbor would have much higher volumes of water available for dilution. Therefore, predicted significant adverse impacts would be limited to Jamaica Bay and other inlet bays with large stormwater runoff and limited tidal mixing.

As part of the Proposed Action, the NYCDOH will continue to monitor waterbodies before and after any adulticide applications. If malathion is selected in the future, these impacts on Jamaica Bay may be lessened, once completion of the CSO holding tank at Paerdegat Basin is fully constructed (which will reduce the direct discharges into the bay after rainfall). In addition, NYCDOH may elect to apply the active ingredients in smaller droplet sizes (e.g., average mean diameter less than 30 microns), because studies in other parts of the country have shown that smaller droplet sizes substantially reduce the amount of the active ingredient that reaches the ground, and therefore, less would runoff if a rainfall event would occur after the application. Applications by aircraft with smaller droplets would also reduce the potential for runoff into such inlet bays.

I. LITERATURE CITED

Able, K.W., A.L. Studholme and J.P. Manderson. 1995. Habitat quality in the New York/New Jersey Harbor Estuary: An evaluation of pier effects on fishes. Final Report. Hudson River Foundation, New York, NY.

Allee King Rosen and Fleming, Inc. (AKRF). 1993. Draft Environmental Impact Statement for the Paerdegat Basin Water Quality Facility Plan. Prepared for the City of New York Department of Environmental Protection, Bureau of Environmental Engineering.

Allee King Rosen and Fleming, Inc. (AKRF). 1997. College Point Retail Project, Final Environmental Impact Statement, CEQR No. 96-DME-003Q. Prepared for Triangel Equities 20th Avenue LLC, Triangle Equities Whitestone/Linden, LLC, Whitestone Development Partners, LP.

American Heritage College Dictionary, Third Edition. 1997. Houghton Mifflin Company.

Andropogon Associates, Ltd. 1989. Landscape Management and Restoration Program for the Woodlands of Central Park. Phase One Report: Consensus of the Interviews, Key Issues & Initial Program Recommendations. Draft Report for Review and Comment. Prepared by Andropogon Associates, Ltd. 374 Shurs Lane, Philadelphia, PA 19128. Prepared for Central Park Conservancy, The Arsenal Building, Central Park, New York, New York 10021.

Animal and Plant Health Inspection Service (APHIS). 1997. Environmental Monitoring Report: Cooperative Medfly Project, Florida, 1997. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Biotechnology and Scientific Services.

Animal and Plant Health Inspection Service (APHIS). 1998. Environmental Monitoring Report, Cooperative Medfly Project, Bradenton, Florida, 1998. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Operational Support, Prepared by Environmental Monitoring Team.

Animal and Plan Health Inspection Service (APHIS), United States Department of Agriculture, Marketing and Regulatory Programs. 1999. Fruit Fly Cooperative Control Program, Draft Environmental Impact Statement 1999.

Atkinson, M., New York City Parks and Recreation, Natural Resources Group. Undated. Wolfe's Pond Park, Staten Island, New York. A Guide to the Natural Areas.

Baystate Environmental Consultants, Inc. 1985a. Feasibility Study for Lake Restoration Van Cortlandt Lake, Van Cortlandt Park, Final Report. Prepared by Baystate Environmental Consultants, Inc., in association with Storch Associates.

Baystate Environmental Consultants, Inc. 1985b. Diagnostic Study for Lake Restoration Van Cortlandt Lake, Van Cortlandt Park, Final Report. Submitted by Baystate Environmental Consultants in association with Storch Associates.

Berger, R.G., United States Department of Agriculture, Animal and Plant Health Inspection Service (APHIS). Personal communication with Sandra Collins, PBS&J.

Borowski, B. and P. Aitken-Ander. 1991. Sexually dimorphic free-swimming behavior in the amphipod crustacean *Ampelisca abdita*. J. Mar. Biol. Ass. U.K. 71:655-663.

Brosnan, T.M. and M.L. O'Shea. 1995. New York Harbor Water Quality Survey: 1994. New York City Department of Environmental Protection, Marine Sciences Section, Wards Island, NY.

Bull, J., and J. Farrand, J., Jr. 1977. The Audubon Society Field Guide to North American Birds. Alfred A. Knopf, NY.

Butcher, G.S. 1990. Audubon Christmas Bird Counts. Pp. 5-13 in J.R. Souer and S. Droege, eds. Survey designs and statistical methods for the estimation of avian population trends. U.S. Fish Wildl. Serv. Biol. Rep. 90(1).

Calabrese, E.J., and L.A. Baldwin. 1993. Performing ecological risk assessments. Lewis, Chelsea, MI, USA.

Calderone, N., Cornell University. 2000. Personal communication with Sandra Collins, PBS&J.

Cech, R. 1993. A distributional checklist of the Butterflies and Skippers of the New York City Area (50-mile Radius) and Long Island. Editor and member of the New York City Butterfly Club.

Central Park Conservancy. 2000. Central Park Conservancy Internet Website as of July 2000, www.centralparknyc.org

Clark, J.R., L.R. Goodman, P.W. Borthwick, J.M. Patrick, Jr., G.M. Cripe, P.M. Moody, J.C. Moore, and E.M. Lores. 1989. Toxicity of pyrethroids to marine invertebrates and fish: A literature review and test results with sediment-sorbed chemicals. Environ. Toxicol. Chem. 8:393-401.

Coastal (Coastal Environmental Services, Inc.) 1987. Television City Project: Characterization of the Aquatic Ecology of the Site and Assessment of Potential Impacts of the Project on the Aquatic biota. Prepared for Berle, Cass, and Case, New York, New York; McKeown and Franz, Inc., New York, NY; and The Trump Organization, New York, NY.

Columbus State University. 2000. Fence Lizard Information, Columbus State University Internet Website as of 9-29-00, http://oxbow.colstate.edu/lizard.htm

Comstock, Anna Botsford. *Handbook of Nature Study*.

Connecticut Department of Environmental Protection (ConnDEP), Bureau of Natural Resources, Marine Fisheries Office. 1999. Information Regarding the Impact of the 1999 Lobster Mortalities in Long Island Sound.

Consolidated Edison Company of New York, Inc. (Con-Edison). 1982. Environmental impacts associated with the proposed reconversion of the Ravenswood Generating Station to coal-fired operation. Submitted to the US Department of Energy.

Cook, R.P. 1989. And the voice of the grey tree frog was heard again in the land. Park Science, A Resource Management Bulletin, National Park Service, US Department of the Interior 9(3)6-7.

Cook, R.P. and C, Pinnock. 1989. Amphibians, Reptiles, and Mammals of the Jamaica Bay Wildlife Refuge. US Department of the Interior, National Park Service, Gateway National Recreation Area.

Dahlsten, D.L, J.B. Hoy, D.L. Rowney, K.A. Hoelmer, M., Wilson, K.M. Daane, W.A. Weber, L.E. Caltagirone, D.J. Clair, and S. Marcandier. 1985. Effects of malathion bait spray for Mediterranean fruit fly on non-target organisms on urban trees in northern California. Final progress report to California Department of Food and Agriculture, Agreement No. 1781. University of California, Berkeley, CA.

Davis, T.H. Undated. Birds of the Jamaica Bay Wildlife Refuge. US Department of the Interior, National Park Service, Gateway National Recreation Area.

Douglas, Matthew M. 1986. *The Lives of Butterflies*. The University of Michigan.

Dukes, J., H. Zhong. 1999. Aerial Drift Optimizing and Non-target Impact Research. In Public Health Entomology Research and Education Center 1999 Annual Report. John A. Mulrennan, Sr., Public Health Entomology Research and Education Center. Prepared by PHEREC, Dr. John P. Smith Director

Dukes, J., Public Health Entomology Research and Education Center (PHEREC), Florida Agricultural and Mechanical University. 2000. Personal communication with Fred Jacobs, PBS&J.

Ecology and Field Biology, Fourth Edition. 1990. Robert Leo Smith. Harper Collins Publishers.

EcolSciences, Inc. 1992. Vegetation, Wetlands and Wildlife Inventory, Flushing Airport Redevelopment, Queens Borough, New York. Prepared for Allee King Rosen & Fleming, Inc., 117 East 29th Street, New York, New York. Prepared by EcolSciences, Inc., 75 Fleetwood Drive, Suite 250, Rockaway, New Jersey.

EA Engineering, Science, and Technology. 1990. Phase I Feasibility Study of the Aquatic Ecology Along the Hudson River in Manhattan. Final Report. Prepared for New York City Public Development Corporation, New York, NY. Prepared by EA Engineering, Science, and Technology, Newburgh, NY.

EEA, Inc. 1988. Report on Aquatic Studies - Hudson River Center Site. Prepared for the New York City Public Development Corporation, New York, NY. Prepared by EEA, Inc., Garden City, NY.

EEA, Inc. 1994. Environmental subsurface investigation, Flushing Airport, College Point, New York. Prepared for the New York City Economic Development Corporation New York, New York.

EEA, Inc. 1996. The Flushing Airport Wetland Restoration Project, Bioengineering and Ecology. Prepared for New York City Economic Development Corporation. Prepared by EEA, Inc.

Eisler, R. 1970. Latent effects of insecticides to marine molluscs. Hydrobiologica 36:345.Finton, A.D., P.G. Novak, K.J. Schneider, and T.W. Weldy. 2000. Rare species and significant ecological communities of the Counties bordering the Hudson River Estuary north of New York City. Unpublished report prepared for Cornell University Agreement No. 32629-5747 in cooperation with the New York State Department of Environmental Conservation through the Hudson River Estuary Program. 122pp.

Elzinga, Richard J. *Fundamentals of Entomology, Third Edition*. 1987. Prentice-Hall, Inc.

Fisher, S.W., M.J. Lydy, J. Barger, and P.F. Landrum. 1993. Quantitative structure-activity relationships for predicting the toxicity of pesticides in aquatic systems with sediment. Environ Toxico. Chem. 12:1307-1318.

Fletcher, J.S., J.E. Nellessen, and T.G. Pfleeger. 1994. Literature review and evaluation of the USEPA food-chain (Kenaga) nomogram, an instrument for estimating pesticide residues on plants. Environmental Toxicology and Chemistry 13:1383-1391.

Florida Department of Environmental Protection (FDEP). 1998. Biological Assessment of Five Lakes in the Umatilla, Florida Area in Response to Application of Malathion for the Control of the Mediterranean fruitfly (*Ceratilis capaitata*). A report by the Surface Water Assessment and Monitoring Program. Florida Department of Environmental Protection, Central District Office, Orlando. http://www2.dep.state.fl.uys/water/Slerp/bio/biorepts/otherrepts/unmatmedf.pdf).

Franz, D.R., and W.H. Harris. 1988. Seasonal and spatial variability in macrobenthos communities in Jamaica Bay, New York—An Urban Estuary. Estuaries 11 (1):15-28.

Franz, D.R. and J.T. Tanacredi. 1992. Secondary production of the amphipod *Ampelisca abdita* Mills and its importance in the diet of juvenile winter flounder (*Pleuronecteds americanaus)* . Estuaries 15(2):193-203.

Franz, D.R., and J.T. Tanacredi. 1993. Variability in growth and age structure among populations of ribbed mussels, *Geukensia demissa* (Dillwyn)(Bivalvia: Mytilidae), in Jamaica Bay, New York (Gateway NRA).

Gerle, E. and S. Sadove. 1996. An evaluation of natural versus human induced mortality in sea turtles in the New York Bight. Proceedings of the Fifteenth Annual Workshop on Sea Turtle Conservation and Biology. Pp. 96-99. NOAA Technical Memorandum NMFS-SEFSC-387.

Giles, R.H. Jr. 1970. The ecology of a small forested watershed treated with the insecticide malathion. Widl. Monogr. 24:81 pp.

Glassberg, Jeffrey. 1993. *Butterflies through Binoculars, Boston, New York, Washington Region*. Oxford University Press, Inc.

Gillett, J. D. 1971. *The Mosquito*. Doubleday & Company, Inc.

Hazen and Sawyer 1983. Newtown Creek Water Pollution Control Plant. Additional biologic and toxics information. Revised application for modification of the requirements of secondary treatment under Section 301(h) of PL 97-117. Prepared for City of New York, Department of Environmental Protection.

Hazen and Sawyer and Leonard Jackson Associates. 1998. Hydrologic and Hydraulic Analyses, Lemon Creek. Capital Project SE-1 and SE-100, Storm Water and Sanitary Drainage Management Plan, Staten Island, New York. Prepared for New York City Department of Environmental Protection, Bureau of Water and Sewer Operations. Prepared by Hazen and Sawyer, Environmental Engineers and Scientists, and Leonard Jackson Associates, Pomona, New York.

Hershfield, D.M. Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years. U.S. Department of Commerce, Washington, D.C., 1961.

Howe F. P., R.L. Knight, L.C. McEwen, and T.L. George. 1996. Direct and indirect effects of insecticide applications on growth and survival of nestling passerines. Ecol. Appl. 6:1314-1324.

Howells, R.G, and H.M. Grundage III. 1977. Fishes of the Arthur Kill, Proceedings of the Staten Island Institute of Arts and Sciences. Vol 29 (1): 3-5.

Hugo B. Fischer, E. John List, Robert C.Y. Koh, Jorg Imberger, Norman H. Brooks. 1979. Mixing in Inland and Coastal Waters. Academic Press, Inc., New York.

Hydroscience, Inc. 1978. NYC 208 Task Report, Rainfall-Runoff and Statistical Receiving Water Models. PCP Task 225. Submitted to Hazen and Sawyer, Engineers, 360 Lexington Avenue, NY, NY. Prepared by Hydroscience, Inc., 363 Old Hook road, Westwood, NJ.

Ingraham, J., D. Riepe, and G. Tudor. Undated. Butterflies of Jamaica Bay. US Department of the Interior, National Park Service, Gateway national Recreation Area.

"Insecticide Impact of Urban and Suburban Wildlife," Technical Note 57. Watershed Protection Techniques, Vol. 2, No. 1, Fall 1995.

Jensen, T., S.P. Lawler, and D.A. Dritz. 1999. Effects of ultra-low volume pyrethrin, malathion, and permethrin on nontarget invertebrates, sentinel mosquitoes, and mosquitofish in seasonally impounded wetlands. Journal of the American Mosquito Control Association 15(3):330-338.

Leo, W., Hydroqual Inc. 2000. Personal communication with Sandra Collins, PBS&J.

Lively, J.S., Z. Kauffman and E.J. Carpenter. 1983. Phytoplankton ecology of a barrier island estuary: Great South Bay, New York. *Estuarine, Coastal and Shelf Science* 16:51-68. In Lonsdale, D.J. and E.M. Cosper. 1994. Phytoplankton productivity and zooplankton feeding and productivity in the lower Hudson River estuary. Marine Sciences research Center, SUNY. Final report to the Hudson River Foundation. April 1994.

LMS (Lawler, Matusky, and Skelly Engineers). 1980. Report & Photographic Documentation for the Battery Park City Underwater Recolonization Study. Prepared for the New York State Department of Transportation and Parsons, Brinkerhoff, Quade and Douglas.

LMS (Lawler, Matusky & Skelly Engineers). 1984. Westway Mitigation Studies. Phase II - Summer 1983 Data Report. Prepared for New York State Department of Transportation.

Lonsdale, D.J. and E.M. Cosper. 1994. Phytoplankton productivity and zooplankton feeding and productivity in the lower Hudson River estuary. Marine Sciences Research Center, SUNY, Sony Brook, NY. Final Report to the Hudson River Foundation, New York, NY.

Kim, J. 2000. Personal communication from Jeanie Kim, Central Park Conservancy, and Sandra Collins, PBS&J.

Malcolm Pirnie Inc. 1982. Hudson River Estuary Fish Habitat Study. Prepared for the U.S. Army Corps of Engineers, New York District, New York, NY.

Malone, T.C. 1977. Environmental Regulation of Phytoplankton productivity in the lower Hudson River. *Estuarine and Coastal Marine Science* 5:157-171.

Meylan, A. and S. Sadove. 1986. Cold-stunning in Long Island Sound, New York. Marine Turtle Newsletter 37: 7-8.

Montague, B., N. Birchfield, and R. Mahler. (EPA, Office of Prevention, Pesticides and Toxic Substances, Environmental Fate and Effects Division). 2000. EFED RED Chapter for Malathion, PC Code 057701; Case No. 818961 DP Bar Codes: D238903 and D238906.

Morreale, S.J., A.B. Meylan, S.S. Sadove, and E.A. Standora. 1992. Annual occurrence and winter mortality of marine turtles in New York waters. Journal of Herpetology 26(3): 301-308.

Mulla, M.S., and G. Majori, and A.A. Arata. 1979. "Impact of Biological and Chemical Mosquito Control Agents on Non-Target Biota in Aquatic Ecosystems."

Muzio, J.N., and F.N. Rubel. 1993. Gateway National Recreation Area Inventory of Submerged Natural Resources and Review of Key Issues. Kingsborough Community College, The City University of New York. Prepared under National Park Service Grant 2000917.

National Audubon Society. 2000. National Audubon Society Christmas Bird Count, Internet Website as of 19 October 2000 www.birdsource.cornell.edu/cbc.

National Audubon Society Field Guide to the Mid-Atlantic States (New York, Pennsylvania, New Jersey, Maryland, Delaware, West Virginia, Virginia). 1999. Published by Alfred A. Knopf, Inc.

National Audubon Society Field Guide to North American Insects and Spiders. 1980. Published by Alfred A. Knopf, Inc.

Natural Resources Group, City of New York Parks and Recreation. 1987. The Country in the City, New York's Natural Parklands.

Natural Resources Group, City of New York Parks and Recreation. 1990a. A Guide to the Birds of Queens.

Natural Resources Group, City of New York Parks and Recreation. 1990b. Natural Areas Management Plan Van Cortlandt Park, Bronx.

Natural Resources Group, City of New York Parks and Recreation. 1991a. Freshwater Wetlands of New York City.

Natural Resources Group, City of New York Parks and Recreation. 1991b. Staten Island Natural Areas.

Natural Resources Group, City of New York Parks and Recreation. 1992. Wolfe's Pond Park Natural Areas Assessment and Management Plan.

Natural Resources Group, City of New York Parks and Recreation. 1995a. Saltmarshes of New York City.

Natural Resources Group, City of New York Parks and Recreation. 1995b. Forests of New York City.

New Jersey Department of Environmental Protection. 1984. Inventor of the Fishery Resources of the Hudson River from Bayonne to Piermont. Division of Fish, Game, and Wildlife, Marine Fisheries Administration, Nacote Creek Research Station.

New York City Audubon Society. 2000. List of Birds of New York City, New York City Audubon Society Internet Website as of May 2000, www.nycas.org.

NYBirds. 2000. NYBirds Internet Website as of May 2000, http://members.aol.com/nybirds/.

New York City Audubon Society. 2000. Central Park Breeding Birds 1998. NYCAS Internet Website as of 5-25-2000 www.interboro.com/nycaudubon.

New York City Department of Environmental Protection (NYCDEP). 1995. Jamaica Bay Comprehensive Watershed Management Plan, January 1995 Draft Report. New York Natural Heritage Program (NYNHP), New York State Department of Environmental Conservation. 1999. Plant characterization abstract database record for *Amaranthus pumilus*. Latham, NY.

New York City Department of Environmental Protection (NYCDEP). 1998. Blue Heron, Arbutus Creek, and Lemon Creek/Sandy Brook Watershed Drainage Plans, Final Environmental Impact Statement, CEQR No. 97DEP026. Prepared by NY City Department of Environmental Protection with the assistance of AKRF, Inc., Hazen and Sawyer, PC, Hydroqual, Inc., Environmental Concern, Inc., Historical Perspectives, Inc. and Center for Watershed Protection.

New York City Department of Environmental Protection (NYCDEP). 1999a. Final Environmental Impact Statement for the Croton Water Treatment Plant.

New York City Department of Environmental Protection (NYCDEP). 1999b. Wolfe's Pond and Sweet Brook Drainage Plans, Final Environmental Impact Statement, CEQR No. 99DEP006. Prepared by the New York City Department of Environmental Protection with assistance of AKRF, Inc., Hazen and Sawyer, PC, Hydroqual, Inc., Environmental Concern, Inc., Historical Perspectives, Inc. and Center for Watershed Protection.

New York City Department of Environmental Protection (NYCDEP). 2000. DEP News: Employee Profile - Christopher A. Nadareski, Wildlife Biologist. New York City Department of Environmental Protection Internet Website as of 25 October 2000 www.nyc.gov/dep.

New York City Parks and Recreation. 1994. Woodlands, Wetlands, and Wildlife. A Guide to the Natural Areas of New York City Parks. A publication of the Urban Forest and Education Program, City of New York

Parks and Recreation and City Parks Foundation, sponsored by the Lila Wallace-Reader's Digest Fund.

New York Natural Heritage Program (NYNHP), New York State Department of Environmental Conservation, Division of Fish, Wildlife and Marine Resources. 2000a. Correspondence dated 4 May 2000 from Nicholas Conrad, Information Manager, NY Natural Heritage Program to Sandra Collins, PBS&J.

New York Natural Heritage Program (NYNHP), New York State Department of Environmental Conservation, Division of Fish, Wildlife and Marine Resources. 2000b. Correspondence dated 12 June 2000 from Nicholas Conrad, Information Manager, NY Natural Heritage Program to Sandra Collins, PBS&J.

New York State Department of Environmental Conservation (NYSDEC). 1999a. NYSDEC, Endangered Species Unit, Leatherback Fact Sheet as of 13 May 1999, NYSDEC Internet Website www.dec.state.ny.us/website/dfwmr/wildlife/endspec/leatfs.html.

New York State Department of Environmental Conservation (NYSDEC). 1999b. NYSDEC, Endangered Species Unit, Reptile Species Summaries as of 11 May 1999, NYSDEC Internet Website www.dec.state.ny.us/website/dfwmr/wildlife/endspec/enspreptile.html.

New York State Department of Environmental Conservation (NYSDEC). 1999c. NYSDEC, Endangered Species Unit, Atlantic Ridley Fact Sheet as of 13 May 1999, NYSDEC Internet Website www.dec.state.ny.us/website/dfwmr/wildlife/endspec/atrifs.html.

New York State Department of Environmental Conservation (NYSDEC). 2000a. Eastern mud turtle fact sheet as of 4-20-2000, NYSDEC Internet Website www.dec.state.ny.us/website/dfwmr/wildlife/endspec/mutufs.html.

New York State Department of Environmental Conservation (NYSDEC). 2000b. Loggerhead sea turtle fact sheet as of 4-20-2000, NYSDEC Internet Website www.dec.state.ny.us/website/dfwmr/wildlife/endspec/loggfs.html.

New York State Department of Environmental Conservation (NYSDEC). 2000c. Green sea turtle fact sheet as of 4-20-2000, NYSDEC Internet Website www.dec.state.ny.us/website/dfwmr/wildlife/endspec/grtufs.html.

New York State Department of Environmental Conservation (NYSDEC). 2000d. Shortnose sturgeon fact sheet as of 4-20-2000, NYSDEC Internet Website www.dec.state.ny.us/website.dfwmr/wildlife/endspec/shnostur.html .

New York State Department of Environmental Conservation (NYSDEC). 2000e. Piping plover fact sheet as of 4-20-2000, NYSDEC Internet Website www.dec.state.ny.us/website.dfwmr/wildlife/endspec/piplfs.html.

New York State Department of Environmental Conservation (NYSDEC). 2000f. Roseate tern fact sheet as of 4-20-2000, NYSDEC Internet Website www.dec.state.ny.us/website/dfwmr/wildlife/ednspec/rotefs.html.

New York State Department of Environmental Conservation (NYSDEC). 2000g. Peregrine falcon fact sheet as of 4-20-2000, NYSDEC Internet Website www.dec.state.ny.us/website/dfwmr/wildlife/endspec/pefafs.html.

New York State Department of Environmental Conservation (NYSDEC). 2000h. Least tern fact sheet as of 4-20-2000, NYSDEC Internet Website www.dec.state.ny.us/website/dfwmr/wildlife/endspec/letefs.html.

New York State Department of Environmental Conservation (NYSDEC). 2000i. Common tern fact sheet as of 4-20-2000, NYSDEC Internet Website www.dec.state.ny.us/website/dfwmr/wildlife/endspec/cotefs.html.

New York State Department of Environmental Conservation (NYSDEC). 2000j. Northern harrier fact sheet as of 4-20-2000, NYSDEC Internet Website www.dec.state.ny.us/website/dfwmr/wildlife/endspec/nohafs.html

North American Butterfly Association. 2000. Recent North American Butterfly sightings, April-July 2000. North American Butterfly Association Internet Website www.naba.org/sightings.html .

Pascual, J.A. 1994. No effects of a forest spraying of malathion on breeding blue tits (*Parus caeruleus*). Environ. Toxicol. Chem. 13:1127-1131.

PBS&J. 1998. Appendix to the Hudson River Park Environmental Impact Statement.

O'Brien and Gere. 1993. Jamaica Bay CSO Facility Plan, Final Report.

O'Brien & Gere. 1995. Determination of effects of aerial applications of Dibrom on non-target organisms in the Cicero Swamp. Draft report submitted to Onondaga County Health Department, Syracuse, New York. Prepared by O'Brien & Gere Engineers, Inc., 50000 Brittonfield Parkway, Syracuse, New York 13221.

O'Brien and Gere. 1997. Study of Effects of Aerial Dibrom Application on Non-Target Organisms in Cicero Swamp. Prepared for the Onondaga County Health Department, Syracuse, New York. Prepared by O'Brien & Gere Engineers, Inc., 50000 Brittonfield Parkway, Syracuse, New York 13221.

Odum. 1983. *Basic Ecology*. Saunders College Publishing.

Opp, B., Lee County Mosquito Control District. 2000. Personal communication with Sandra Collins, PBS&J.

Palmer, Laurence E. and H. Seymour Fowler. *Field Book of Natural History, Second Edition*. 1975. McGraw-Hill Book Company.

Perlmutter, A.. 1971. Ecological studies related to the proposed increase in generating capacity at the Astoria Power Station of Consolidated Edison. Report prepared for Consolidated Edison Company of New York, Inc.

Peterson, W.T., and H.G. Dam. 1986. Hydrography and Plankton of Jamaica Bay, New York. Gateway Institute for Natural Resource Sciences, National Park Service, publication Gate-N-021-III, and Marine Sciences Research Center, State University of New York at Stony Brook, Marine Sciences Research Center Contribution Number 557.

Philips, P.J.., D.A. Eckhardt, M.A. Smith, and L. Rosenmann. 1999. Pesticides and their metabolites in selected surface-water public supplies in New York State, 1999. USGS internet Website as of 4/16/01 http://wwwdnyalb.er.usgs.gov/projects/nypesticides/reports/WRIR00-4…/WRIR00-4119.nt

Princeton Aqua Science. 1985. Winter Survey of the Fauna of Harsimus Cove, Jersey City, New Jersey. Submitted to Dresdner Associates, Jersey City, NJ.

Princeton Aqua Science. 1985. Fall Survey of the Fauna of Harsimus Cove, Jersey City, New Jersey. Submitted to Dresdner Associates, Jersey City, NJ.

Riepe, D. and J.T. Tanacredi, Gateway National Recreational Area. 1988. Managing butterflies in urban environments. Park Science 8(3):19.

Riepe, D. and J.T. Tanacredi. Undated. In the shadow of the World Trade Center—Jamaica Bay, a significant coastal fishery. Underwater Naturalist 17(4):29-30.

Riepe, D., J.T. Tanacredi, T. Sperry, B. Lane, A. Scaglione, and W. Stempler. Undated. Finfish of Jamaica Bay. US Department of the Interior, National Park Service, Gateway National Recreation Area.

Riepe, D. 2000a. Personal communication between Don Riepe, Jamaica Bay Wildlife Refuge, National Park Service, and Sandra Collins, PBS&J, on 3 July 2000.

Riepe, D. 2000b. Personal communication between Don Riepe, Jamaica Bay Wildlife Refuge, National Park Service, and Sandra Collins, PBS&J, on 17 October 2000.

Ringenary, M., T. Savage, and J.T. Tanacredi. 1999. 1999 Water Quality Sampling Program Report. United States Department of the Interior, National Park Service, Gateway National Recreational Area, Division of Natural Resources.

Rimmer, L. 2000. Personal communication between Laura Rimmer, Wave Hill, and Sandra Collins, PBS&J 8 June 2000.

Robinson Research World of Knowledge http://www.robinsonresearch.com/ANIMALS/index.htm.

Rupert, Edward E. and Robert D. Barnes. *Invertebrate Zoology, Sixth Edition*. 1994. Saunders College Publishing.

Scaglione, E. A., J.T. Tanacredi, and K.C. Buckley. 1991. Jamaica Bay Fisheries Survey, 1985-1986, and 1988-1989. US Department of the Interior, National Park Service, Gateway National Recreation Area, Division of Natural Resources and Compliance.

Science News. February 10, 2001, Vol. 159, No. 6, Pages 81-96.

Soil and Rock Instrumentation Division (SRI), Goldberg-Zoino and Associates, Inc. 1989. Lemon Creek Crossing Wetlands Evaluation, Contract Section T-13, West Branch Interceptor Sewer. Prepared for the City of New York Department of Environmental Protection, Bureau of Sewers. Prepared by Soil and Rock Instrumentation Division of Godberg-Zoino and Associates, Inc., Newton Upper Falls, Mass.

Stepien, J.C., T.C. Malone and M.B. Chervin. 1981. Copepod communities in the estuary and coastal plume of the Hudson River. *Estuarine, Coastal ad Shelf Science* 13:185-194.

Stilwell, D.A., US Fish and Wildlife Service (USFWS), US Department of the Interior. Correspondence dated 19 June 2000 from David Stilwell, USFWS, to Sandra Collins, PBS&J.

Storozynski, A. 1989. The Sick Bay. Empire State Report June 1989:33-37.

Surface Water Assessment and Monitoring Program (SWAMP), Florida Department of Environmental Protection (FLDEP). 1997a. Biological Reconnaissance of Baker/Pemberton Watershed: Possible Effects of Aerial Spraying During the Medfly Eradication Program, July 9 and 13, 1997. #97-005

Surface Water Assessment and Monitoring Program (SWAMP), Florida Department of Environmental Protection (FLDEP). 1997b. Recolonization of the Baker/Pemberton Creek Watershed Following the Termination of Aerial Spraying for the Medfly Eradication Program. #97-006.

Tanacredi, John T. PhD. 1995. *Gateway, A Visitor's Companion*. Stackpole Books.

The Common Insects of North America. 1972. Lester A. Swan and Charles S. Papp. Harper & Row, Publishers.

The Green Encyclopedia. Franck and Brownstone.

Tudor, G., D. Riepe, and S. Walter. 2000. Moths of Jamaica Bay Wildlife Refuge, A provisional checklist. Internet Website as of 17 October 2000 www.hmana.org/jbwr.

U.S. Army Corps of Engineers and U.S. Department of Transportation, Federal Highway Administration Region I. 1984. Final Supplemental Environmental Impact Statement, Westway Highway Project. Volume II, Fisheries Portion.

US Army Corps of Engineers (COE), New York District. 1997. Jamaica Bay Navigational Channels and Shoreline Environmental Surveys, Final Report, Volume 2.

U.S. Environmental Protection Agency. 1993. Wildlife exposure handbook. EPA/600/R-93/187b. Washington, D.C.

U.S. EPA. 1996. Ecological effects test guidelines: OPPTS 850.3020 Honey bee acute contact toxicity. EPA 712-C-96-147 "Public Draft." Office of Prevention, Pesticides and Toxic Substances, Washington, D.C.

U.S. EPA. 1996. Ecological effects test guidelines: OPPTS 850.3020 Honey bee acute contact toxicity. EPA 712-C-96-147 "Public Draft." Office of Prevention, Pesticides and Toxic Substances, Washington, D.C.

U.S. EPA. 1998. Guidelines for ecological risk assessment. EPA/630/R-95/002F. Risk Assessment Forum, Washington, D.C.

US Fish and Wildlife Service (USFWS), US Department of the Interior. 1997. Significant Habitats and Habitat Complexes of the New York Bight Watershed. Southern New England-New York Bight Coastal Ecosystems Program. Charlestown, Rhode Island.

US Fish and Wildlife Service (USFWS), US Department of the Interior. 1999. USFWS Peregrine falcon Fact Sheet, USFWS Internet Website www.fws.gov.

US Fish and Wildlife Service (USFWS), US Department of the Interior. 2000. USFWS Piping plover Atlantic Coast Population Internet Website as of 5-11-2000, http://pipingplover.fws.gov.

Urquhart, Fred A. 1987. The Monarch Butterfly: International Traveler. Nelson-Hall Inc.

Waldbauer, Gilbert. 2000. Millions of Monarchs Bunches of Beetles, How Bugs Find Strength in Numbers. Harvard University Press.

Weldy, T. (2000). Personal communication from Troy Weldy, NY Natural Heritage Program, and Sandra Collins, PBS&J.

Whittaker, Robert H. 1975. *Communities and Ecosystems, Second Edition*. MacMillan Publishing.

Wigglesworth, V.B. 1964. *The Life of Insects*. The World Publishing Company.

Woodhead, P.M. 1991. Inventory and characterization of habitat and fish resources, and assessment of information on toxic effects in the New York-New Jersey Harbor estuary. A report to the New York/New Jersey Harbor estuary Program, concerning work in Tasks .32, 5.1 and 5.3. Marine Services Research Center, State University of New York, Stony Brook, NY.

Woodhead, P.M. and M. McEnroe. 1991. Habitat use by the fish community. A report on Task 5.1 of the new York/New Jersey Harbor Estuary Program. Marine Services Research Center, State University of New York, Stony Brook, NY.

Zhong, H., Public Health Entomology Research and Education Center, Florida Agricultural and Mechanical University. 1999. Naled Impact on Honey bees Research, in PHEREC 1999 Annual Report. Prepared by PHEREC, Dr. John P. Smith Director.

Zhong, H., Public Health Entomology Research and Education Center, Florida Agricultural and Mechanical University. 2000. Personal communication with Dr. Fred Jacobs, PBS&J.

Zion & Breen Associates, Inc. (ZBA) and J.H. Crow Company, Inc. (JHCC), 1987. Study/Schematic Report for Wolfe's Pond Park, Staten Island, New York. Prepared for City of New York, Parks and Recreation. Prepared by Zion & Breen Associates, Inc., Imlaystown, New Jersey, and J.H. Crow Company, Inc., Port Murray, New Jersey. ☞

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