APPENDIX C

IPMP Guidance Manual

Midpeninsula Regional Open Space District

Integrated Pest Management Program Guidance Manual

September 2014

PREPARED FOR:
Midpeninsula Regional
Open Space District
330 Distel Circle
Los Altos, CA 94022

Midpeninsula Regional Open Space District

Integrated Pest Management Program
Guidance Manual

PREPARED FOR:
Midpeninsula Regional Open Space District
330 Distel Circle
Los Altos, CA 94022

PREPARED BY:
May & Associates, Inc.,
Shelterbelt Builders, Inc.
and
Ascent Environmental, Inc.
455 Capital Mall, Suite 300
Sacramento, CA 95814

September 2014

TABLE OF CONTENTS

Appendices

Tables

Exhibits

This page intentionally left blank.

ACRONYMS AND ABBREVIATIONS

BAEDN	Bay Area Early Detection Network
Cal-IPC	California Invasive Plant Council
CDFA	California Department of Food and Agriculture
CDFW	California Department of Fish and Wildlife (formerly Department of Fish and Game)
CEQA	California Environmental Quality Act
District	Midpeninsula Regional Open Space District
EDRR	Early Detection and Rapid Response
GGNRA	Golden Gate National Recreation Area
IPM	Integrated Pest Management
MSDS	Material Safety Data Sheets
OSP	Open Space Preserve
PCA	Pest Control Advisor
PCR	Pest Control Recommendation
PPE	Personal Protective Equipment
PSIS	Pesticide Safety Information Series leaflets
QAC	Qualified Applicator’s Certificate
QAL	Qualified Applicator’s License
SPCA	Structural Pest Control Applicator
SPCO	Structural Pest Control Operator
SOD	Sudden Oak Death
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service

This page intentionally left blank.

1 OVERVIEW

Integrated Pest Management (IPM) is a process of efficiently managing pests while protecting human health and environmental quality. With this Guidance Manual, the Midpeninsula Regional Open Space District (District) is adopting a comprehensive IPM approach throughout all of its preserves, other properties, and associated buildings and facilities. The District's definition of IPM and its IPM Policy are described in Chapter 2.

The IPM Policy and this Guidance Manual will be considered by the Board of Directors for adoption. Once adopted, the Guidance Manual will be updated as needed. The Guidance Manual is intended to have a ten-year planning timeframe. The Guidance Manual is split into two main sections: chapters that deal with program-wide processes (Chapters 1-5), and chapters that guide individual pest management decisions (Chapters 6-10).

The IPM Coordinator and the IPM Coordination Team will play key roles in reviewing pest management projects for consistency with the Guidance Manual and overseeing licensing, training, and safety (Chapter 3) in carrying out the IPM Program. Other processes undertaken by the IPM Coordinator or staff throughout the year include planning, notification, and monitoring of the projects(Chapters 3 and 4). The Guidance Manual primarily emphasizes the review, prioritization and approval of pest management activities through the development of an Annual IPM Work Plan (Chapter 3). Any new pest management activities not originally included in the Annual IPM Work Plan will be reviewed on an individual basis throughout the year.

An Annual IPM Report will summarize the work completed in the year (Chapter 3), evaluate the program's progress in meeting overall goals, and recommend any modifications (Chapter 4).

To adopt a comprehensive IPM program, especially one that emphasizes prevention and monitoring, there are certain tasks that are too large to implement all at once. Therefore, an IPM Implementation Plan will be developed in the first year of the program (Chapter 5).

The most important decisions regarding IPM are made when individual projects are designed. This Guidance Manual identifies specific approaches to pest management including: preventative and maintenance measures; damage assessment procedures; tolerance levels and thresholds for action; and treatment options. Within the District, situations that trigger the need for pest control fall into five distinct pest management categories. Chapters 6 through 10 guide specific pest management decisions in these five major categories of work:

- Buildings (Chapter 6),
- Recreational facilities (Chapter 7),
- Fuel managment areas (Chapter 8),
- Rangelands and agriculture properties (Chapter 9), and
- Natural areas (Chapter 10).

Human health, environmental quality, and effective and efficient management of District property is a concern across all categories. Pests and treatment options are somewhat unique in each of the five work categories because each category represents not only a different purpose under the District's mission, but also a different type of environment. In general, the first three categories represent conditions that have been altered to a greater degree for human purposes, are more frequently occupied or visited by humans, and where the District has greater concerns for human safety. The later two categories are in a more natural state, and environmental quality is of great importance.

1.1 THE IPM APPROACH

This IPM program emphasizes pest prevention as a first approach, followed by actions to discourage or reduce pest populations from reaching levels where active control may be required. Tolerance levels are described to help staff determine when pest populations have reached levels where active pest control should be considered. A wide array of physical (e.g., separation of the pest from the public), biological (e.g., bio-control agents), and cultural (e.g., education and human behavior modification) actions are provided before chemical treatments can be considered. Pest treatment options are provided, including the most effective and least environmentally harmful options by pest type. Monitoring and adaptive management principles, both on the project level and on the program level, are provided to help ensure improvements in efficiency and effectiveness of pest control over time.

Certain vegetation management projects are primarily undertaken to meet legal requirements (e.g., defensible space regarding wildfire protection) or District-adopted specifications (e.g., clearance adjacent to trails and roads for hikers, bicyclists, equestrians and vehicles), and these types of projects are undertaken on a routine basis at the same locations primarily by mechanical methods without the need to conduct detailed analysis or monitoring of the appropriate treatment method every time.

1.2 QUICK REFERENCE TO THE IPM GUIDANCE MANUAL BY PEST TYPES

The following provides a quick cross-reference by types of pests to specific sections in the Guidance Manual.

- **Rodents, insects or other animals in buildings and vehicles** –Chapter 6 Section 6.7.2, Nuisance Animals in Buildings.
- **Rattlesnakes or stinging insects outside and near people** –Chapter 7, Section 7.7.2 Nuisance Animals Near Recreational Facilities.
- **Invasive animals in natural areas or rangelands** – Chapter 10, Section 10.10.1 Invasive Animals In Natural Areas (cross –referenced in Chapter 9, Section 9.9.1- Invasive Animals in Rangelands).
- **Vegetation encroaching on trails, roads, parking lots and other outside recreational facilities** – Chapter 7, Section 7.7.3 Vegetation Management of Trails and Other Recreational Facilities (cross referenced in Chapter 8, Section 8.7.3, Maintaining Vegetation along Trails for Fire Safety).
- **Landscaping around buildings** – Chapter 7, Section 7.4.2 Retrofit.
- **Flammable vegetation in designated fuel management areas** – Chapter 8, Section 8.6 Treatment Options.
- **Weeds on rangelands or in agriculture fields** – Chapter 9, Section 9.9.5 Weeds in Agricultural Fields and 9.9.2, Invasive Plants in Rangelands (Cross Referenced to Chapter 10, Section 10.8.2 Invasive Plants)
- **Invasive plants in natural areas** – Chapter 10, Section 10.8.2 Invasive Plants.
- **Forest diseases** - Chapter 10, Section 10.8.3 Forest Diseases.

2 IPM DEFINITION AND POLICY

2.1 DEFINING IPM AND PESTS

IPM is a long-term, science-based, decision-making system that uses a specific methodology to manage damage from pests. The District defines pests in its Resource Management Policies as "Animals or plants that proliferate beyond natural control and interfere with the natural processes which would otherwise occur on open space lands," and target pests as "Plant or animal species that have a negative impact on other organisms or the surrounding environment and are targeted for treatment." This IPM Guidance Manual addresses plant, animal and disease pests that occur on District properties including preserves and buildings or on lands otherwise managed by the District.

IPM requires monitoring site conditions before, during, and after treatment to determine if objectives are being met and if methods need to be revised. IPM can be used for many types of pests and situations, including invasive species control, control of structural and agricultural pests, and control of other nuisance species (e.g., rattlesnakes and stinging insects). This methodology includes the following elements:

- Correctly identify the pest and understand its life cycle.
- Determine the extent of the problem or infestation.
- Evaluate the site conditions.
- Establish the tolerance level for control actions.
- Utilize the least harmful suite of treatment methods to control the pest at the most vulnerable stages of its life cycle.
- Monitor pest populations and effectiveness of treatment methods.

IPM requires knowledge of the biology of pests, the available techniques for controlling them, and an understanding of the secondary effects of the control techniques (e.g., soil erosion, pesticide drift, and bioaccumulation). Control of a pest is only undertaken once a "tolerance level" has been exceeded. A tolerance level, also referred to in IPM systems as a "tolerance threshold," is the level below which pests can be present without causing substantial economic damage, degradation of intended uses or human enjoyment of facilities, disturbance of natural processes, or unacceptable human health risks.

The effectiveness, safety, and efficiency of control methods are important considerations as they apply to the specific site conditions and life history of the target pest. IPM requires monitoring site conditions before, during, and after treatment to determine if objectives are being met and if methods need to be revised. IPM requires that non-chemical methods be considered in addition to chemical methods (i.e., pesticides, herbicides, insecticides).

Pesticides is a broad term defined by the Food and Agricultural Organization of the United Nations as

> "…a substance or mixture of substances intended for preventing, destroying or controlling any pest, including vectors of human or animal disease, and unwanted species of plants or animals …"

Pesticides include ***insecticides*** (substances intended to control insect pests), ***rodenticides*** (substances intended to control rodents), ***herbicides*** (substances intended to control plant pests), and ***fungicides*** *(*substances intended to control fungi). Pesticides often include ***surfactants*** or ***adjuvants*** that are substances intended to adhere and spread pesticides on a surface, typically an insect's exoskeleton, a plant's leaf, or dry soil.

If the use of chemical methods is determined to be necessary to meet a pest control objective, the potential for harm to workers and the public is carefully considered, as are effects on the environment, and then the least harmful and most effective, efficient, and target-specific method is chosen.

IPM was originally developed in the 1960s for agricultural pests and then urban landscapes. Somewhat different approaches are needed when implementing an IPM approach on natural lands. For purposes of managing pests on District land, IPM is:

- An adaptive process that takes into account new science, technology, and understanding of pests and their environment.
- A program to ensure judicious use of pesticides. It is not necessarily intended to eliminate pesticide use; however, well-developed, science-based IPM programs typically reduce pesticide use per acre over time because they employ a wider array of pest management techniques (i.e., physical, biological, and cultural pest control as well as chemical control) that are more effective at eliminating pest issues.
- A decision-making system that adapts to changing conditions. Control methods are determined based on the pest and site-specific conditions, and methods are not universally applied to all pest problems or work categories.

2.2 IPM POLICY

The District's proposed IPM Policy, once adopted, will guide staff in defining, preventing, and managing pests on District lands. The IPM goal, policies, and implementation measures were reviewed initially in 2013, and will be considered for adoption by the Board of Directors concurrently with this Guidance Manual.

2.2.1 GOAL (PROPOSED)

Goal IPM- Control pests by consistent implementation of IPM principles to protect and restore the natural environment and provide for human safety and enjoyment while visiting and working on District lands.

2.2.2 POLICIES (PROPOSED)

Policy IPM-1 Develop specific pest management strategies and priorities that address each of the five work categories.

1. Manage pests in buildings to support existing uses, while also protecting human health and surrounding natural resources.

2. Manage pests and potential human interactions in recreational facilities to minimize conflict, ensure visitor safety and enjoyment, and protect the surrounding natural resources.

3. Manage pests in fuel management areas to reduce risk to human life and property, while also protecting natural resources.

4. Manage pests in rangelands and on agricultural properties to support existing uses, while also protecting human health and surrounding natural resources.

5. Manage invasive species in natural areas and set priorities for their control based on the potential risk to sensitive native species and loss of native biodiversity.

Policy IPM-2 Take appropriate actions to prevent the introduction of new pest species to District preserves, especially new invasive plants in natural areas, rangelands, and agricultural properties.

Policy IPM-3 Manage pests using the procedures outlined in the following eight implementation measures.

1. Develop and implement tolerance levels for pests within each of the Work Categories to determine when to undertake pest control (refer to Chapters 6 through 10 in this Guidance Manual).

2. Identify the pest, determine its life cycle and disruptive potential, and identify relevant site conditions prior to implementing a pest control activity. Review pest control objectives for consistency with other site goals and with established tolerance levels that must be exceeded before pest control is undertaken (refer to Chapters 6 through 10 in this Guidance Manual).

3. Choose site-specific strategies and times of treatment that provide the best combination of protecting preserve resources, human health, and non-target organisms and that are efficient and cost effective in controlling the target pest. Wherever feasible, direct the control method narrowly at the most vulnerable point in the target organism’s life cycle to avoid broad impacts (refer to Chapters 6 through 10 in this Guidance Manual).

4. Monitor results and modify control methods over time as site conditions and treatment techniques change and as needed to obtain an effective level of control (refer to Chapters 6 through 10 in this Guidance Manual).

5. Use the least harmful method(s) to control identified pests. Where the use of pesticides is necessary, apply according to the label using all safety precautions and take all measures needed to protect the environment, the health and safety of visitors, employees, neighbors, and the surrounding natural areas including water and soil resources (refer to Chapters 6 through 10 in this Guidance Manual).

6. Plan for repeat treatments as indicated by the pest’s regenerative capabilities.

7. Coordinate and cooperate with adjacent landowners, neighbors, and other responsible agencies to control pests and limit secondary effects.

8. If eradication of a pest from a distinct location is not feasible, apply measures to achieve containment, sustained control, slow down a pest’s rate of spread, or minimize pest damage.

Policy IPM-4 Monitor pest occurrences and results of control actions and use adaptive management to improve results.

Policy IPM-5 Develop and implement a Guidance Manual to standardize pest management and IPM procedures across all District lands.

This page intentionally left blank.

3 THE IPM PROGRAM

This Chapter describes the IPM Program, including roles and responsibilities, management systems, and organizational processes that will be used to implement IPM on District lands. To illustrate this, refer to Exhibit 3-1 for a diagram of the decision-making process to be used by staff when implementing IPM in various work situations.

3.1 ROLES AND RESPONSIBILITIES

This section describes roles and responsibilities for implementing the IPM program. The Board of Directors is responsible for approving the IPM Policy. The General Manager is responsible for ensuring the implementation of the IPM Policy through District managers and supervisors who train all staff on the IPM Guidance Manual and guide its implementation within the departments.

3.1.1 IPM COORDINATION TEAM

The District will establish an IPM Coordination Team. The team will be made up of District staff working with the advice of technical pest control experts. At a minimum, the team will include one staff representative from each of the field offices, the Natural Resources Department, the Real Property Department, and the Volunteer Program. As necessary, the IPM Coordination Team will consult with the Rangeland Ecologist regarding rangeland and agricultural practices and properties, and with the Planning Department regarding long-range plans and construction and maintenance of capital projects.

The IPM Coordination Team is responsible for the following:

- review and approve an Annual Work Plan that is consistent with this Guidance Manual, feasible and within the District's projected staff and budget capabilities, and balances the District's pest management and other responsibilities while providing consistency from year-to-year so that effective progress can be made on multi-year projects;
- provide expertise and staff assistance to complete tasks in the IPM Implementation Plan to ensure that the District's approach to IPM principles and processes are continually improved;
- review and approve Individual Pest Management Plans throughout the year that were not included in the Annual Work Plan;
- assess the IPM program for safety and effectiveness on an annual basis or whenever urgent changes are indicated;
- develop, periodically review, and recommend changes to the District's List of Approved Pesticides (Section 3.7 and Appendix A) for initial approval by the General Manager; additions to the District's List of Approved Pesticides will be brought to the Planning and Natural Resources Committee before approval by the full Board of Directors.
- investigate lower risk/least hazardous alternatives to current practices described in this Guidance Manual, and make recommendations for revising or updating District procedures as described herein;
- review the Annual IPM Report to ensure that it accurately represents pest management work completed in the year and that any recommendations for change are consistent with the District's adopted IPM Policy; and
- oversee and peer review of the IPM Coordinator position.

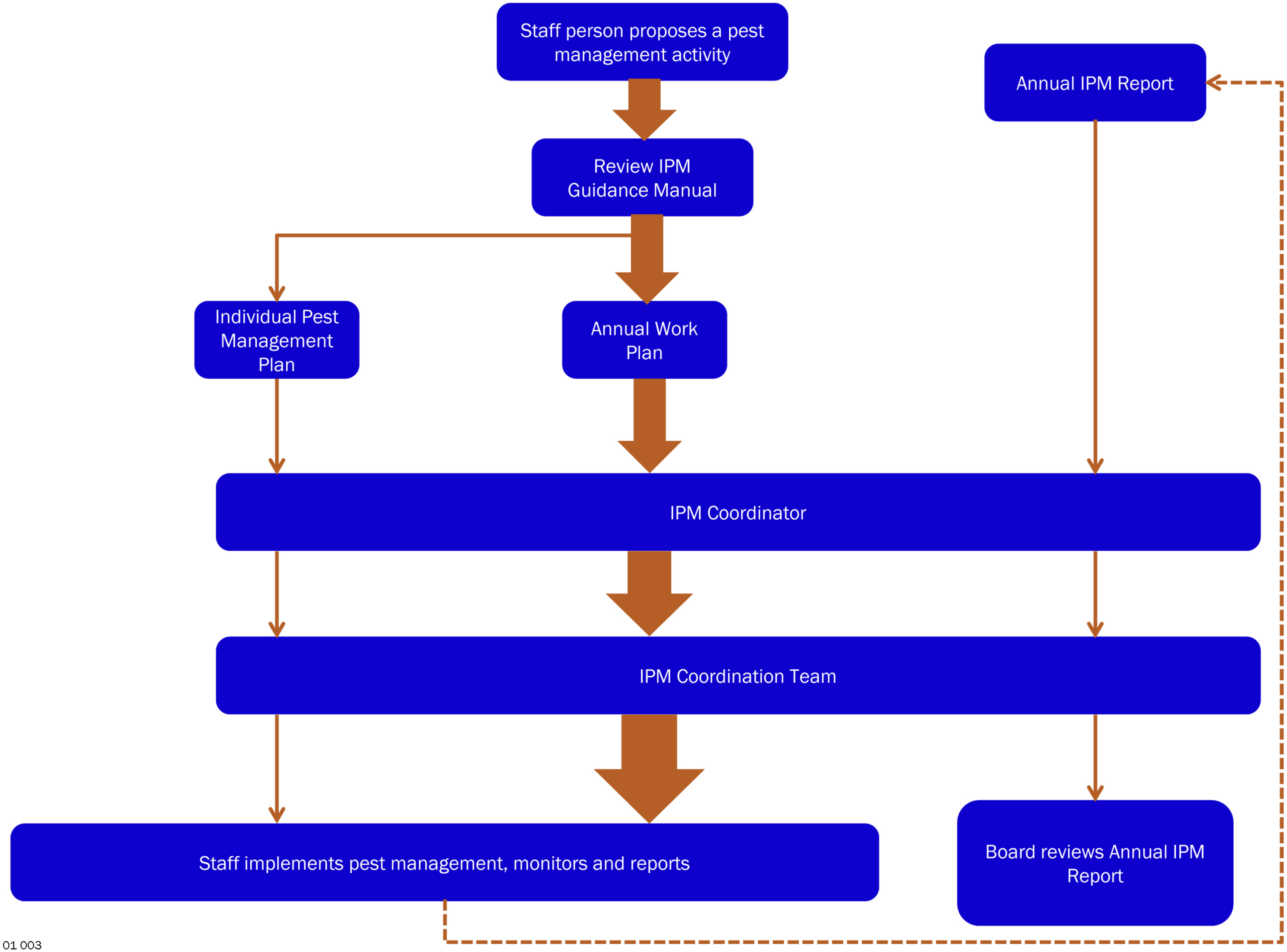


Exhibit 3-1

Flow Chart of the District's IPM Decision-Making Process

IPM COORDINATOR

The IPM Coordinator will have day-to-day oversight of the integrated pest management practices at the District, including the following:

- prepare the Annual Work Plan and Annual IPM Report for review by the IPM Coordination Team;
- coordinate the meetings and tasks of the IPM Coordination Team;
- coordinate staff, contractor, and volunteer IPM training;
- coordinate/implement the pesticide safety program;
- educate and respond to the public;
- prepare other required reports, such as pesticide use reports to the County Agricultural Commissioner; and
- undertake, tasks required by the IPM Implementation Plan with assistance from the IPM Coordination Team, other staff and contractors or consultants.

The IPM Coordinator will report directly to the Natural Resources Manager who will have the overall responsibility for ensuring that the program guidelines are followed. The District will hire an IPM Coordinator who will need to have experience with pests in natural settings such as invasive plants and animals, insects, and pathogens; and will need to have or gain experience with pest management in agricultural crops, rangelands, forests, park facilities (such as non-crop lawn and landscape areas), rights-of-way, and aquatic environments. The IPM Coordinator will have either a PCA, QAC, or QAL certification, or will obtain one or more of these certifications within 2 years of hire date.

The IPM Coordinator must keep records of all pesticide recommendations for a minimum of two years. Recommendations may be site-specific or programmatic (cover multiple sites within the same property or preserve). Each written recommendation must include the following information:

- category, active ingredient, pesticide formulation (i.e., brand name or common name) and dosage of each pesticide to be used;
- identity of each pest to be controlled by a name of common usage;
- property owner and location on the property that will be treated;
- description of commodity, crop, or site to be treated. This includes specific crops (i.e., wine grapes) or descriptions of non-crop sites such as roadsides, habitat restoration sites, forests, etc.;
- suggested schedule, time, or conditions for the pesticide application or other control method;
- any warnings of the possibility of damages by the pesticide application that reasonably should have been known by the agricultural pest control adviser to exist;
- signature and address of the person making the recommendation, the date, and the name of the business such person represents;
- total acreage or units to be treated;
- concentration and volume per acre or other units;
- worker reentry interval, if one has been established; pre-harvest or pre-slaughter interval; and label restrictions on use or disposition of the treated commodity, by-products or treated area;
- criteria used for determining the need for the recommended treatment (tolerance level or tolerance threshold); and
- certification that alternatives and mitigation measures that would substantially lessen any significant adverse impact on the environment have been considered and, if feasible, adopted.

STRUCTURAL PEST CONTROL OPERATOR

The District will designate an employee with an active California Structural Pest Control Operator (Operator) license, or will retain the services of a licensed Branch I (fumigation), II (General Pest), or III (Wood Destroying Pest and Organisms) Structural Pest Control Operator as needed. The Operator will be responsible for reviewing the Annual Work Plan, Individual Pest Management Plans, and developing guidelines for the control of pests in all buildings within the District. Operator guidelines will be forwarded to the IPM Coordinator for a consistency review with the IPM program before implementation.

In the event the District engages the services of a structural pest management company to operate in this capacity, the company will be required to comply with all applicable provisions of the state of California's Department of Consumer Affairs Structural Pest Control Act dated October 2013 (available online at http://www.pestboard.ca.gov/pestlaw/pestact.pdf). The District will require proof of company registration and proof of the companies' qualifying Operators license information before engaging in a contract. The company should be licensed in the applicable Branch of the work being performed (as specified above). The District will monitor the work being done by the company to ensure quality workmanship and compliance with the District's IPM program.

QUALIFIED APPLICATOR

Pesticides will be applied in all areas except buildings by or under the supervision of a California licensed Qualified Applicator (QAC/QAL) who will be licensed in categories relevant to the type of pest control work. The QAC/QAL will be responsible for pesticide use records, work hours, and compliance with the Annual IPM Work Plan, Individual Pest Management Plans, and pesticide labels. Qualified applicators may include District field staff, contractors, and farmer/rancher tenants. Non-QAC or QAL certified District staff can apply pesticides, but only under direct supervision of the QAC or QAL and after completing the District's annual pesticide safety training (Section 3.6).

All contract pest control applicators, the IPM Coordinator, and designated field supervisors must have a valid California QAC or QAL license in one or more of the following categories:

- Residential, industrial, institutional (A);
- Landscape maintenance (B);
- Right-of-way (C);
- Plant agriculture (D);
- Aquatic (F); and/or
- Forestry (E)

Field supervisors who hold a QAC/QAL license or another certified trainer must train all staff who apply and handle pesticides on an annual basis as described in the Training section below (see Section 3.6).

3.1.2 STRUCTURAL PEST CONTROL APPLICATOR

Household and structural pesticides will be applied under the supervision of a California licensed Branch I, II, or III Structural Pest Control Applicator (SPCA). SPCA's will be responsible for pesticide use records, work hours, and compliance with written recommendations in the approved Annual Work Plan, Individual Pest Management Plans, and compliance with pesticide labeling instructions. SPCA's may include a combination of District field staff and contractors. No unlicensed staff, contractors, volunteers, or tenants will perform structural or household pest control except for the limited use of District approved ant/roach bait stations.

Structural pesticide applications made on District property by an outside vendor will be by a registered structural pest control company in accordance with the state of California's Structural Pest Control Act dated October 2013. Structural pesticide applications made by District staff will be carried out by trained applicators under the supervision of the IPM Coordinator or designated field supervisors. All applications on District property will be made in compliance with the Annual Work Plan, Individual Pest Management Plans, and pesticide labeling instructions. No untrained staff, volunteers, or tenants will make structural pesticide applications.

3.2 DECISION-MAKING AND RECORD-KEEPING

This section describes the procedures that the District will follow to make decisions and track pest management throughout its lands and departments. The primary process by which pest management decisions will be made and evaluated is through an Annual IPM Work Plan. Pesticide use record-keeping completed by each department will be kept by the IPM Coordinator, who will be responsible for consolidating this information into the Annual IPM Report, as described below.

3.2.1 DEVELOPMENT OF THE ANNUAL IPM WORK PLAN

The IPM Coordinator and the IPM Coordination Team will prepare an Annual IPM Work Plan each year that describes planned pest control projects in the upcoming year. Working through department supervisors, staff will provide the IPM Coordinator with a standardized spreadsheet or similar summary form describing upcoming pest control for the following basic types of activities:

- Routine minor pest control actions;
- Ongoing pest control projects; and
- New pest control projects.

Using this staff information, the Annual IPM Work Plan will be prepared by the IPM Coordinator, then reviewed and approved by the IPM Coordination Team. Information in the Annual IPM Work Plan will also be used to inform the Annual IPM Report (described below in Section 3.4.1).

The Annual IPM Work Plan will include the following basic information:

- Summary (e.g., Excel spreadsheet) of routine minor and ongoing pest control projects;
- Detailed descriptions of new pest control projects;
- Projected amounts of pest control in the next year (acres, hours, acres treated per gallon, total gallons used); and
- Any new approaches to be implemented as a result of the adaptive management review in the Annual IPM Report of the preceding year.

These types of pest control activities are described in more detail below. Refer to Appendix B for sample forms.

INDIVIDUAL PEST MANAGEMENT PLANS

If a project is proposed during the year which was not included in the Annual Work Plan, then a description of the project will be prepared for review and approval by the IPM Coordinator and the IPM Coordination Team. Examples of when individual pest management plans might be required are when new properties are acquired or new pests of high priority are discovered in the course of a year.

3.2.2 ROUTINE MINOR PEST CONTROL

Routine minor pest control activities include maintenance activities that generally utilize the same pest control methods at the same site from year to year. These are primarily non-chemical methods such as brush cutting of trails and mowing/discing for fuel management, but also include minor use of pesticides in cut-stump or spot-spraying application at recreational facilities and fuel management areas, the use of approved insecticide baits in buildings, or wasp spray for stinging insects in trails or bathrooms.

Staff will provide a brief projection of routine minor pest control activities in spreadsheet or similar format.

3.2.3 ONGOING PEST CONTROL PROJECTS

Ongoing pest control projects are existing projects that are expected to have an end date (even if it is takes ten years) such as treatment of brush on rangelands or French broom on natural lands. Because these are ongoing projects, they will have already been surveyed for site conditions, a multiple-year strategy will have been developed. Tracking and monitoring of these ongoing projects will be important to determine if treatment is effective and at what stage treatment methods should be adjusted (such as switching from herbicide to pulling when the density of invasive weeds has substantially decreased). Ongoing pest control projects will be summarized in the Annual Work Plan and tracked for staffing, costs, and adaptive management (effectiveness of selected pest control) purposes.

Staff will provide a projection of ongoing pest control projects in a spreadsheet or similar format and will specifically note any changes that are to be made to specific ongoing projects in the upcoming year (e.g. change in treatment method, change in level of effort, requirements for periodic pre-treatment surveys).

3.2.4 NEW PEST CONTROL PROJECTS

New pest control projects will receive a more detailed review and assessment by the IPM Coordinator and IPM Coordination Team. Staff will prepare a description of newly proposed projects and will specifically note how the recommended treatment is consistent with the IPM Guidance Manual, best management practices and mitigation measures.

Staff proposing new pest control actions will provide the following information:

- name and purpose of the proposed pest control activity;
- location (i.e., preserve name, building or trail name, or location including map where appropriate);
- pest identification and the population size, location, life cycle, and density;
- a brief assessment of damage caused by the pest, including the perceived threshold for action (e.g., severity of the infestation/amount and type of damage);
- site conditions including the presence of aquatic areas, rare species, steep slopes, access and other environmental conditions that are relevant to the effectiveness of pest control and avoidance of environmental impact;
- a description of prevention, options that were considered/previously implemented before the active pest control project was proposed;
- proposed pest treatment options (e.g., grazing, brushing, mowing, herbicide application) and amount of each type of treatment (e.g., acres to be treated), project duration, project timing, performance standards, and remedial actions;
- proposed labor force (staff, contractor, volunteers or special groups) projected labor hours or special materials or equipment required, and direct costs for the next year.

If new pest control projects are determined outside of the Annual IPM Work Plan, then an Individual Pest Management Plan will likewise be prepared and reviewed and approved by the IPM Coordinator.

3.3 PRIORITIZATION

One of the most difficult aspects of implementing an IPM program is to develop a consistent, transparent, and replicable decision-making and prioritization system that allows the District, or any other organization, to make informed decisions about which pest control projects out of many potential ones will be funded. The decision-making process must be flexible, so that staff can adjust workloads from year-to year while still resulting in consistent IPM decisions across departments and staff. The prioritization approaches developed by the Golden Gate National Recreation Area and Marin County Open Space District were examined for their advantages and disadvantages since these two organizations are similar in size and mission to the District, and manage diverse resources, interest groups, and stakeholder groups.

A prioritization system is most useful in determining relative importance of closely related pest management activities. For example, a prioritization system can help staff compare the benefits of treating yellow starthistle in two pastures, one of which is newly invaded with weeds, the other which is an ongoing treatment site. Another example would be comparison of treatment of a newly-discovered invasive plant population with treatment of an established population of French broom that is located in a sensitive habitat. The District will use the prioritization system for IPM on rangeland, agricultural lands, and natural lands.

The District will not use the prioritization system for pest control in buildings, recreational facilities, or fuel management because these routine activities are a relatively fixed, constant priority for the District and are primarily undertaken to meet legal requirements (e.g., defensible space for wildfire protection) or District-adopted specifications (e.g., fuel management clearance adjacent to trails and roads for hikers, bicyclists, equestrians and vehicles), or to protect human health in or the structural integrity of a building. Although there is little flexibility in whether to manage pests associated with these routine activities, there is flexibility in deciding what treatment methods to use and how to conduct them.

The prioritization system will be used mostly when the IPM Coordination Team meets to finalize the Annual IPM Work Plan. This process should be coordinated with the overall staffing, budgeting and objectives of the agency and departments for the year.

Projects will be given a score within each category depending on how well it addresses the most important criteria (at top of each list) and/or the number of criteria within that category (Table 3-1). The score within each category will be within 0 through 3 points with 3 indicating a higher score. The category scores will be totaled at the bottom of the table to provide an overall project priority score.

Table 3-1 Sample Project Ranking System	
Category and Criteria	**Ranking** (Assign a score of 0,1,2, or 3 to each of the 5 categories using the criteria shown in each category 0 =does not apply, 1 minimally meets criteria to 3=meets all or most criteria)
1. Safe ◢ Low level of risk (exposure) to human health, the environment and non-target organisms for anticipated result. ◢ Nonchemical method provides acceptable level of pest control especially for structures frequently occupied by humans.	
2. Prevents and Controls Most Destructive Pests ◢ Prevents new populations of pest. ◢ Activity is early detection of and rapid response to small populations of a new pest species or new occurrences of known pests. ◢ Pest has been ranked as or is otherwise known to be highly invasive or destructive. ◢ Continues, or completes an ongoing District pest control project or action. ◢ Reduces, contains, or eliminates a target pest species. ◢ Enhances or encourages natural predation or natural systemic control of pests.	
3. Protects Biodiversity ◢ Results in protection or enhancement of native biodiversity especially for special-status species or sensitive plant communities such as wetlands, serpentine grasslands, and coastal prairies. ◢ Contributes to the long-term preservation of natural resources and functioning ecosystems. ◢ Reduces spread of plant pathogens that have the potential for large-scale and long-term ecological change such as with Sudden Oak Death. ◢ Reduces risk of vegetation converting to less native biological diversity ◢ Improves rangeland or natural area health or otherwise provides for ecological resiliency in light of future climate change and wildfire cycles.	
4. Provides for Public Engagement ◢ Has significant public interest and support particularly from collaborating organizations or neighbors. ◢ Provides for increased volunteer and/or stewardship opportunities/participation in IPM program. ◢ Increases public understanding and support of IPM program	
5. Feasible and Effective ◢ Can be accomplished with existing staffing and funding. ◢ Project readiness (i.e., project can be accomplished within projected timeline, including permitting and environmental compliance). ◢ High level of anticipated outcome for the staffing and funding (cost/benefit). ◢ Selected technique has been shown to be effective in controlling target pest under relevant site conditions within 5 years. ◢ Integrates with existing District programs, including grazing leases and approved agricultural land uses. ◢ Reduces overall maintenance costs.	
TOTAL PROJECT SCORE (Add scores in each of the 5 categories to get a total scope for the project. Range from 0=low priority to 15=high priority)	

3.4 REPORTING

3.4.1 ANNUAL IPM REPORT

The District will prepare an Annual IPM Report each year that describes past pest control activities (both chemical and non-chemical) on District Lands. The draft Annual IPM Report will be prepared by the IPM Coordinator and reviewed by the IPM Coordination Team. Once approved by the IPM Coordination Team, the final report will be presented to the General Manager for initial approval. The report will then be forwarded to the Board of Directors for review, and where necessary, approval (e.g., changes to the List of Approved Pesticides).

At a minimum, the Annual IPM Report will include the following basic information:

- A summary of pest problems that the District has encountered during the year, and a comparison to past years.
- A summary of District pest control treatments, presented by type of control (e.g., mowing, herbicide use). Wherever possible, a comparison of units treated (e.g., acres, square feet, linear feet or miles) in the current year and previous years will be provided for comparison purposes. A cost per acre will be provided for major pest control treatment types.
- A qualitative assessment of effectiveness of the District's pest control program, and suggestions for increasing future effectiveness (see Chapter 4 for additional details).
- A summary of pesticide use, presented by category (e.g., herbicide, insecticide), active ingredient (e.g., glyphosate, imazapyr) or pesticide formulation (e.g., Roundup ProMax™).
- A brief summary of public notifications and public inquiries about IPM on District lands;
- Assessment of compliance with the Guidance Manual including:
  - An evaluation of the effectiveness of any changes in practices that were implemented in the past 12 months.
  - A description of any experimental pest control projects (test studies) and the results, including a cost/benefits analysis.
  - Suggested changes to the IPM program or the Guidance Manual's pest control practices proposed for adoption within the next 12 months including:
    - Any substitute pesticides to replace phased out pesticides (additions to the List of Approved Pesticides).
    - Any proposed alternative pesticides (additions to the List of Approved Pesticides) or pest control methods proposed for adoption.

3.4.2 PESTICIDE REPORTING

As required by regulations of the California Department of Pesticide Regulation (California Code of Regulations, Title 3, Division 6), the IPM Coordinator will report all pesticide use on a monthly basis to the County Agriculture Departments (San Mateo, Santa Clara and Santa Cruz Counties); will prepare, or obtain Pest Control Recommendations from a licensed Pest Control Advisor on an annual basis; will renew the District's Operator Identification with the County Agriculture Departments; and will most likely require designated field supervisors to obtain either a Qualified Applicator License or a Qualified Applicator Certificate. The IPM Coordinator will also collect monthly pesticide reporting from its contractors who apply pesticides on District lands (See Section 3.4.3).

3.4.3 CONTRACTOR REPORTING

The District will ensure that all pest control contractors working on District lands comply with the Guidance Manual, including restricting use of pesticides to products on the District's List of Approved Pesticides (Appendix A). As required by regulations of the California Department of Pesticide Regulation (California Code of Regulations, Title 3, Division 6), contractors will report all pesticide use on a monthly basis to the County Agriculture Departments (San Mateo, Santa Clara and Santa Cruz Counties); will obtain Pest Control Recommendations from a licensed Pest Control Advisor (either from the District's IPM Coordinator or from an independent PCA); will renew its Operator Identification with the County Agriculture Departments; and require Contractor's field supervisors to obtain either a Qualified Applicator License or a Qualified Applicator Certificate. The Contractor will provide copies of its reports to the IPM Coordinator.

Contractors who trap certain pest animal species must also obtain and comply with predation permit requirements from CDFW to record the species, pounds captured, and final destination of the animals (to prove that the species were not transported live or re-released elsewhere in California).

3.5 TRAINING AND SAFETY

3.5.1 TRAINING

The IPM Coordinator is responsible for coordinating staff training across departments, and for overseeing safety procedures. In general, three types of trainings will be provided:

- Pest identification training (for staff involved in pest control), and
- Annual pesticide safety training (for staff that use/apply pesticides).

PEST IDENTIFICATION TRAINING

The pest identification training will be prepared by District staff, with assistance from the IPM Coordinator, then provided to staff, particularly those who work in natural areas, rangelands, and agricultural properties. This training will most likely be provided on an as needed basis (as determined by the IPM Coordinator and department supervisors).

Pest identification training will include procedures for identifying and reporting pest sightings. Color photographs of several life stages (e.g., seedling, flowering, fruiting stages or larval and adult stages), a brief description and life history of each pest, associated habitat types, map of where the pest is found on District preserves and summary of best management practices for working in and around infested areas will be covered in this training. It may take several years to comprehensively develop information and train staff on all pests in District preserves. The District's Invasive Plant Control Notebook already contains information on approximately 150 invasive plants of the region and is already used as a key training and identification tool by the staff; it will be expanded to include other types of pests.

ANNUAL PESTICIDE SAFETY TRAINING

The annual pesticide safety training is intended to help supervisors, managers, and other staff involved in pest control application become familiar with non-chemical pest control actions; limit exposure and risk associated with the use of pesticides; and understand Best Management Practices for environmental protection. The District's Annual Pesticide Safety Training will also describe regulatory requirements of the California Department of Pesticide Regulation's pesticide application requirements and CDFW's wildlife handling procedures.

The annual pesticide safety training will be performed by the IPM Coordinator (if a licensed PCA QAL and/or QAC), or a PCA-, QAL/QAC-licensed contractor who is familiar with District resources, pest management issues, and staff work procedures.

The annual Pesticide safety training must include the following:

- Pesticide product labeling format and meaning of information, such as precautionary statements about human health hazards.
- Hazards of pesticides (acute, chronic, delayed, and sensitization effects) identified in pesticide product labeling, Material Safety Data Sheets (MSDS), or Pesticide Safety Information Series (PSIS) leaflets.
- Pesticide safety requirements and procedures in regulation, PSIS leaflets, MSDS.
- Engineering controls (closed systems, enclosed cabs) for handling, transporting, storing, and disposing of pesticides.
- Environmental concerns (drift, runoff, and endangered species best management practices to reduce risks to sensitive natural resources).
- Routes by which pesticides can enter the body.
- Common signs/symptoms and emergency first aid for pesticide exposure.
- How to obtain emergency medical care.
- Routine and emergency decontamination procedures, including spill cleanup and the need to thoroughly shower with soap and warm water after the exposure period.
- Use and care of any required personal protective equipment.
- Prevention, recognition, and first aid for heat-related illness.
- Notification requirements.

Records of annual training will be retained by the IPM Coordinator or the District’s Training and Safety Specialist and will be kept for two years in a location accessible to employees. Training records must indicate the topics covered during training, the materials used for training, the name and qualifications of the trainer, and the signature and date of all employees who received the training.

3.5.2 SAFETY

SAFETY PROCEDURES FOR HERBICIDE APPLICATION

Section 17.005 of the District’s Operations Maintenance Manual provides guidelines to the staff for safely handling and applying pesticides. Upon adoption of the IPM Guidance Manual, those procedures will be updated to be consistent with the IPM Guidance Manual and will be subsequently included herein.

3.6 LIST OF APPROVED PESTICIDES

A List of Approved Pesticides was developed specifically for use on District lands. Refer to Table 1.1 in Appendix A for the complete list of approved pesticides, as well as detailed toxicological analysis and results presented for each pesticide. This list presents pesticides by ***category*** (e.g., herbicide, insecticide); ***active ingredient*** (e.g., glyphosate, imazapyr); and ***pesticide formulation*** (e.g., Roundup ProMax™) (sometimes referred to as brand name or common name).

This list of pesticides is intended only for use on the pests, environment, and microclimates of properties and buildings managed by the District, and would not be used on other lands without additional analysis. Each product on this list has been (and new proposed products would be):

- screened for human toxicology, ecological toxicity environmental fate and transport, and proven efficacy against target pests;
- reviewed annually by the District's IPM Coordinator and IPM Coordination Team;
- reviewed and approved by the Board of Directors;
- presented for public comments at public hearings; and
- included in the environmental documentation and public notification procedures that are being prepared for the IPM Program (i.e., the list is adopted as part of environmental review and approval process).

This list encompasses mostly products already in use by the District, as well as a few new pest control products. Products on this list were reviewed for human and environmental safety, and efficacy on the District's target pest species. Additional details about the District's screening process are provided below.

3.6.1 PESTICIDE SCREENING PROCESS

The District, using toxicologists, its IPM Coordinator and IPM Coordination Team and other licensed experts, has or will screen proposed pesticides by the following three steps:

1. Conduct a toxicological analysis of each pesticide under consideration (Appendix A).
2. Assess the risk to the human health and safety of workers and visitors on District lands, as well as the risk to the environment from proposed pesticide use.
3. Review the List of Approved Pesticides and associated background materials, then reject, modify, or adopt the list for use by District staff, contractors and tenants.

3.6.2 UPDATING THE LIST OF APPROVED PESTICIDES

The List of Approved Pesticides is intended to change over time as the science of pest control advances and more effective, safer, and less harmful pesticides are developed; as manufacturers update, discontinue, or substitute products; and as the District's target pests change over time. The process for updating the List of Approved Pesticides is as follows:

- ***Product Substitutions.*** When manufacturers substitute a product or change a product name or formulation, but when the active ingredient stays the same, the new product can be substituted for the old product on the List of Approved Pesticides. In general, this type of change to the list would not trigger a change in condition or result in the need for additional environmental documentation. Therefore, this change typically will require a simple update to the List of Approved Pesticides (Table 1.1- Appendix A). Additional environmental review would only be required if the change results in a substantive change in human health exposure, environmental fate, or toxicity.
- ***Product Eliminations.*** In instances where products on the list are no longer available from the manufacturer, are found to be ineffective against the District's target pests, or if new risks are discovered that were not previously evaluated by the District (see Appendix A), a product may be eliminated from the List of

Approved Pesticides. This type of change requires an update to the List of Approved Pesticides (Table 1.1-Appendix A), but does not require additional environmental review.

- ***Product Additions***. In instances where new products with new active ingredients are found to be safer, more effective, and/or less costly than products on the on the List of Approved Pesticides, the District may elect to add new pesticides. This type of change typically requires additional toxicological review, and depending on the results, may also require additional environmental review.

For simple substitutions and elimination of products from the List of Approved Pesticides, the IPM Coordinator will, as necessary seek the advice of technical experts and independent Pest Control Advisors; keep the IPM Coordination Team informed; and include such changes in the Annual IPM Report.

In instances where new pesticide formulations (products) are being recommended for addition to the List of Approved Pesticides, the IPM Coordinator will, with assistance from technical experts such as independent PCAs, conduct the same analysis on the proposed new pesticide formulation as was conducted on the approved pesticide formulation (Appendix A). All new pesticide formulations (products) under consideration will be evaluated using the same standards for human and environmental safety, and efficacy on the District's target pest species.

Based on the results, the IPM Coordinator will then present the findings to the IPM Coordination Team, along with a recommendation to add or eliminate the new pesticide formulation from consideration. The IPM Coordinator can also recommend a test study to provide additional information. Based on the information provided by the IPM Coordinator, the IPM Coordination Team will advance the new pesticide formulation (product) plus any required environmental review for consideration by the Board of Directors for approval, request additional information, or eliminate the new pesticide formulation from consideration. If the IPM Coordination Team recommends advancement, the IPM Coordinator will provide pertinent information about the new pesticide formulation, including a description of why the new pesticide formulation is being considered, risk, efficacy, cost, application standards and limitations for use, results of test studies (where available), and environmental review to the Board of Directors for consideration. Approval of all new pesticide formulations is the responsibility of the Board of Directors. If approved, the new pesticide formulations will be added to the List of Approved Pesticides.

In the event of an emergency situation, such as a human health disease outbreak, pesticides that are not included on the List of Approved Pesticides may be used for short periods of time. In these unusual situations the District will comply with required regulatory procedures, then will evaluate the emergency response pesticide use and determine if its IPM program needs to be modified to accommodate similar future emergencies.

3.7 NOTIFICATION

The District has developed notification procedures for use of pesticides (Section 17.006 of the District's Maintenance Operations Manual will be updated accordingly). District procedures are summarized below.

Prior, during, and after the application of a pesticide (including herbicides, insecticides, or other types of pesticides) on District preserves, employees or contractors will post signs at the treatment area notifying the public, employees and contractors of the District's use of pesticide. Posting periods designated below are the minimum requirements; signs may be posted earlier and left in place for longer periods of time if it serves a public purpose or if it provides staff flexibility in accessing remote locations.

- For pesticide application in outdoor areas of all District-owned preserves and in buildings which are not occupied or are rarely visited (e.g. pump houses), signs will be posted at the treatment areas 24 hours before the start of treatment until 72 hours after the end of treatment. Signs stating "Pesticide Use Notification" will be placed at each end of the outdoor treatment area and any intersecting trails.

- For urgent application of pesticides to control stinging insects, signs will be posted at the treatment area 72 hours after the end of treatment but no pre-treatment posting is required.
- For pesticide application in occupied buildings such as visitor centers, offices and residences, notification will be provided to building occupants (employees, visitors, residents) 24 hours before the start of treatment by email, letters or telephone calls. Additionally, for buildings which might be visited by more than just a single family, signs stating "Pesticide Use Notification" will be placed at the entrances to the building 24 hours before the start of treatment until 72 hours after the end of treatment. The use of approved insecticidal baits in tamper-proof containers will require notification 24 hours before the start of treatment by email, letters or telephone calls, but will not require posting of signs.
- The information contained in the pesticide application signs will include: product name, EPA registration number, target pest, preserve name and/or building, date and time of application, and contact person with telephone number. The contact person will usually be the IPM Coordinator.
- On lands that the District manages but does not own (e.g., Rancho San Antonio County Park), the District will provide notification of pesticide use in the same manner and applying the same actions as it does with its properties, unless the contracting agencies have adopted more restrictive management standards. In those cases, the more restrictive management standards would be implemented by the District.
- In the event of an immediate public safety concern, notification will occur at the time of treatment but pre-posting may not be possible.

All contractors and lessees need to also notify District before application on any property, and comply with requirements for notification and posting of signs described above.

At the discretion of the District staff and depending on the site conditions, neighboring land owners will be notified if the District is conducting pest management near a property line.

At the discretion of the District staff, pest management activities that do not require pesticides (e.g., mowing, discing) may or may not be posted, depending on the level of visitor use and the potential for conflicts between site uses and planned pest management actions. Additional notification may also be provided in emails, newsletters, and public meetings, depending on the level of public safety concerns, public interest, and the size and duration of the planned pest control action.

4 ASSESSING THE IPM PROGRAM AND UPDATING THE GUIDANCE MANUAL

This chapter describes procedures for assessing the effectiveness of the IPM program as a whole using adaptive management, and the process for updating the Guidance Manual.

Adaptive management is a tool that allows natural resource managers to make good decisions and effective action plans based on limited information, and provides a means of reducing uncertainty over time through assessing the results of an action and changing subsequent actions (The Nature Conservancy 2007). Adaptive management is often described as “learning by doing.” Given the types and rates of change observed on District preserves resulting from global, regional, and local factors (many of which are beyond the District’s control), adaptive management is an important tool to help the District implement IPM in the face of change and uncertainty.

Adaptive management encompasses the following steps: establishing assessment criteria, collecting information, evaluating the program, and undertaking program modifications to make the program safer, more effective, and efficient.

4.1 CRITERIA TO ASSESS THE IPM PROGRAM

These criteria are intended to quantitatively and qualitatively measure and evaluate changes in the District’s IPM program over time:

- **Compliance with the Guidance Manual and List of Approved Pesticides.** The Guidance Manual’s procedures are designed to select the least harmful pest control methods. When chemical control is selected, the Guidance Manual requires the selection of the least harmful effective pesticides (through the review and approval process).
- **Demonstrated use of lower pesticide worker health/exposure classifications in buildings and recreational structures** (as measured by totaling use of pesticides using the U.S. EPA Classifications I, II, III, and IV).
- **Reduction of pesticide use in buildings** (i.e., in areas where human use levels are high and the potential for human exposure to pesticides is greater than in other areas). The District will seek to comprehensively oversee all pesticide use in and around District buildings, including use by tenants, which is expected to result in an overall reduction of pesticide use in buildings, and in particular, eliminate use of pesticides not appropriate for use around human occupants or visitors, or which can inadvertently escape into the surrounding wildland environment. Pesticide use in buildings will be measured in units of product used per treatment area (each building), or by units of product used per total square footage for District buildings.
- **Reduction in per-acre herbicide use at individual sites in natural areas over time.** The District will seek a reduction in per-acre usage of herbicides over time at individual sites, but acknowledges that in some instances, use will initially increase, followed by a reduction in herbicide use when the pest is eliminated or reduced. As an example, as new properties are acquired or new invasive plant infestations are discovered, overall herbicide use may initially go up, however, they are anticipated to drop over time as pests are controlled or eliminated at such sites.
- **Preservation of biodiversity and natural resource values** in natural areas, rangelands, and agricultural properties. District staff will provide an annual qualitative assessment of natural resources conditions of IPM projects in natural areas, rangelands, and agricultural properties in the Annual IPM Report.
- **Provide a brief summary of public notifications and responses to inquiries from the public.** District staff will provide a summary of public notifications in the Annual IPM Report. The District will also record public

inquiries made by telephone or in person regarding the IPM program, and will briefly summarize inquiries and its responses to such inquiries on an annual basis.

- **Provide an annual summary of public participation in pest control.** The public is seen as an integral part of the success of the IPM program. In particular, volunteers who assist with invasive plant identification and control are a valuable asset to the IPM program. The District will tally volunteer hours spent on invasive plant control, and where possible will identify future activities for volunteers, and/or new ways that the public can participate in the IPM process.
- **Provide an annual summary of staff training, public outreach, and educational activities related to IPM**. The District will summarize staff trainings, public outreach efforts, and educational outreach efforts such as working with tenants to use appropriate pesticides in structures and rangeland/agricultural areas.

4.2 TRACKING THE PROGRAM

Using the criteria described above, District staff will monitor pest control projects, and tally quantitative and qualitative results on an annual basis.

- Each Department will report pesticide use (quantities of each pesticide product per toxicity classification) to the IPM Coordinator, as described in Chapter 3. The IPM Coordinator will present results in the Annual IPM Report.
- District staff will regularly update the District’s pest database, including a summary of District pests of concern, pest control activities, acres treated, and geographic (mapping information) on treatment locations. The IPM Coordinator will use this information to prepare an annual assessment of units of herbicides per acres treated, as well as non-chemical treatments of pests. The IPM Coordinator will present results in the Annual IPM Report.
- The IPM Coordinator will qualitatively describe the condition of natural areas and managed landscape areas, identifying problem pests or areas requiring further investigation or treatment. The IPM Coordinator will present results in the Annual IPM Report
- The volunteer coordinators will tally volunteer hours spent on invasive plant control and provide this information to the IPM Coordinator.
- The IPM Coordinator will track and record public inquiries, questions, comments, and concerns about the IPM program.

4.3 PROGRAM EVALUATION

Using the information described above, the IPM Coordinator, with input from District staff, will evaluate the IPM Program as a whole on the basis of:

- ***Safety*** (i.e., did the IPM program reduce risks and help ensure the safety of people and the environment?);
- ***Effectiveness*** (i.e., were pests controlled or eliminated in a cost effective and safe manner?); and
- ***Purpose*** (i.e., are District buildings; recreational facilities; and agricultural lands, rangelands, and natural areas functioning as intended?).

The results of the evaluation will be presented in the Annual IPM Report. The Annual IPM Report will be presented to the IPM Coordination Team for review and approval. Using the monitoring protocol described above in Section 4.1, the IPM Coordination Team will assess the effectiveness of the IPM Program, and recommend changes to the program intended to increase effectiveness and efficiency of pest control activities.

The final Annual IPM Report, which will include the IPM Coordination Team recommendations, will then be submitted to the General Manager for initial approval and to the Board of Directors for review and acceptance, including any changes to the Approved Pesticide List.

4.4 PROGRAM MODIFICATIONS

The Annual IPM Report, as approved by the General Manager and accepted/approved by the Board of Directors will be the basis for making changes to the Guidance Manual, including modification of any IPM procedures or changes to the List of Approved Pesticides.

Each year following Board of Directors review of the Annual IPM Report, the IPM Coordinator will implement recommended changes to the Guidance Manual and IPM program.

4.5 UPDATING THE IPM GUIDANCE MANUAL

This Guidance Manual is intended to be a "living document," in which minor changes that do not trigger additional environmental effects can be made without needing to complete additional environmental analysis. The document will be updated approximately every ten years, and as necessary, supplemental CEQA and other environmental analysis will also be prepared in the interim. The IPM Coordinator and IPM Coordination Team will review proposed changes to determine if they would result in changes to adopted IPM Policy and guidance procedures (see Section 4.3 above). This review will include assessment of changes to the lists of target pest species, pest control methods, and pesticide use trends.

When changes to the Guidance Manual are required, the IPM Coordinator will initiate a review process to determine whether the proposed changes are minor (as defined under the CEQA approval process for the project as not resulting in substantial new information or new significant environmental impacts). If the changes are confirmed to be minor, these changes can be addressed through the IPM Coordination Team review and approval process (described above). Examples of minor changes that would not likely trigger a new environmental review include process updates and simple product substitutions for products on the District's List of Approved Pesticides (see Section 3.7.2).

This page intentionally left blank.

5 IPM PROGRAM IMPLEMENTATION

An IPM Implementation Plan will be developed in the first year of the program. The purpose of the Implementation Plan is to systematically develop larger tasks (i.e., prevention and monitoring) and integrate them into the Annual IPM Work Plan over a five-year period. Major tasks to be included the IPM Implementation Plan in the first year include:

- designate an IPM Coordinator and an IPM Coordination Team;
- develop an Annual Work Plan;
- develop a comprehensive pest database including forms to allow staff to record and report pests and pesticide use to the IPM Coordinator in a streamlined fashion;
- develop and implement training and safety programs to ensure IPM as described in the Guidance Manual is properly implemented by staff;
- assess, and as necessary modify, the Guidance Manual (adaptive management) in the Annual IPM Report to the Board of Directors.

In future years, the following additional steps would be taken to further implement the IPMP:

- test and revise a priority system to rank pest control projects on natural areas, rangelands, and agricultural lands;
- work with tenants to consistently apply IPM practices around people and in natural surroundings;
- develop an early detection rapid response program and related landscape-level monitoring program for all District lands; and
- participate in regional pest management research and monitoring efforts to keep up on the most recent innovations in pest control science, pest control methods, and pests that are detected near District preserves but may not yet be problemmatic on District lands.

This page intentionally left blank.

6 IPM IN BUILDINGS

6.1 DEFINITION AND PURPOSE

District properties include over 182 buildings, including an administrative office in a city, three field offices, a nature center, residences, and numerous outbuildings such as barns, sheds, and water tanks in the preserves. Certain animals and plants may be incompatible with human use of these structures or may harm the building itself. For example, rodents, ants, and similar structural pest species are typically controlled in buildings when their population numbers may result in structural damage or health risks to humans. Management of pests in buildings is estimated to occur in 103 of the total buildings and it may be conducted by District staff or by residential, commercial or agricultural/rangeland tenants at some level almost every year. For purposes of this management category, rodent infestation of vehicles that are parked for extended periods of time on District preserves (reported by staff to happen regularly in ranger and crew trucks) will be treated similarly to rodent infestations of buildings.

For the purposes of this manual, structural pests include common insects, plants and animals that routinely occupy the open interiors and immediate exteriors of buildings. Structural pests that live within the soil and wood components of these structures such as termites, wood boring beetles, and wood decaying fungi are not included in the IPM program and will be addressed by the District on a case-by-case basis.

The purpose of pest control in District buildings is to manage pests for human health and safety, and to preserve the intended uses of the building structure. Most structural pests only become problematic when there are extra resources readily available (food, water, shelter) in and around the structure. Many of these types of outbreaks can be managed with cultural control options such as changing human behavior (e.g., securing garbage, cleaning up food) or engineered control options within structures (e.g., sealing up entrance area, securing garbage disposal areas).

6.2 TYPES OF PESTS

This chapter is organized by pest, although many general concepts apply throughout. Organisms of all kinds, whether vertebrate or invertebrate, are living creatures with specific biological needs and behavioral preferences. They all require food, water, safety and a point of entry to become a structural pest. Cutting off access to any one of these resources can often be sufficient to prevent or reduce a structural pest problem. The prevention methods discussed below aim to reduce the conditions that support structural pests.

6.2.1 STRUCTURAL PESTS

Structural pests include insect, plant, fungi and animal pests that damage occupied buildings and other structures, or pests that are a health threat to humans working in, living in, or visiting the buildings. Nuisance insects and wildlife pests in buildings addressed within the District's IPMP include ants, cockroaches, flies, mice, rats, skunks, opossums, raccoons, and bats. These pests may be present throughout District lands, but they may only be incompatible with planned District uses when their proximity or behavior conflict with human uses in buildings. Some structural pests can only survive in a human-modified environment (e.g., German cockroaches) versus others that are only opportunistic visitors from nearby wildlands (e.g., deer mice).

The definition of a structural pest can be highly variable between individuals and groups of people based on the perception of damage versus any true damage to structures. Care must be exercised when defining tolerance levels for each pest species. One must consider the actual damage potential of the organism, the cultural acceptance of the organism to humans who may have to live and work nearby, and any broader environmental consequences to the natural environment. For example, deer mice may be tolerated if they occupy the exteriors of human-occupied buildings, but once they penetrate the structure and begin to occupy building interiors, they become unacceptable pests. The traditional approach to structural pest control is modified in the District's IPM program because District structures are located in natural areas. Native species (e.g., deer mice) that can move freely between the inside (pest) environment and outside (native/natural) environment must be treated in a manner that achieves control of the pest without compromising the natural resources around the structure. The District's structural IPM decision-making must always balance health and human safety concerns with District's goal of protection of natural resources.

Structural IPM focuses on first modifying the behavior of humans or the structure of our environment to moderate or eliminate pest problems. The District can use familiar planning and building tools to engineer pests out of conflict areas such as structures through the use of physical barriers, materials selection, and site modifications. Tolerance levels for this category of pests take into consideration the risks of economic damage along with the fact that these species will inevitably occur in the built environment.

6.3 PEST IDENTIFICATION

Structural pests are generally identified when routine building inspections are conducted by IPM professionals, but are also commonly identified by the building occupants themselves. Because buildings are much more intensively utilized than the District's surrounding natural areas, structural pests can usually be identified relatively quickly before major infestations become problematic. Visual inspections will focus on identifying conditions where excess food, shelter, and access can support pests (e.g., the break room); signs of pest damage or entry (e.g., holes in the building exterior); or on observations of the pest itself.

Some District buildings could benefit from routine inspections from IPM professionals who have specialized training to find structural pests and their associated damage. Professionals may utilize special monitoring traps for specific organisms to monitor the population thresholds of common pest species (e.g., "sticky" bait traps for ants). These types of monitoring devices are useful in scenarios where the presence of the pest is inevitable, and the pest population must be maintained at an acceptable tolerance level. Other buildings and structures that are less intensively utilized will rely on the observations of the District's employees, tenants, and visitors to identify pests.

Employees, tenants, and visitors will have clear communication pathways to the IPM Coordinator to report structural pest presence and damage in a timely manner. Structural pest problems will be reported to the IPM Coordinator at any time during the year via telephone, email or meetings, in an Individual Pest Management Plan, or as part of Annual IPM Reporting. The IPM Coordinator can help problem-solve structural pest situations by providing the following types of assistance:

- assist with determining pest control treatment threshold levels,
- provide recommendations for building or human use modifications to reduce pest problems below threshold levels,
- review Individual Pest Management Plan and facilitate their implementation by staff or tenants, and/or
- recommend professional assistance such as use of a structural pest control advisor or structural pest control operator to actively control pests.

6.4 PREVENTIVE AND GENERAL MAINTENANCE ACTIVITIES

Modern IPM programs for buildings rely on prevention (i.e., building design and human behavior modification) as the primary structural pest control treatment options to eliminate pest problems. Active pest control is used only as a last resort. Because humans occupy a highly engineered environment, use of such control options as physical barriers, materials selection, and site modifications provide the primary means to eliminate pest from buildings and other structures without the need to use pesticides or other lethal control.

If structural pest control in vacant structures is expensive, time-consuming, or otherwise damaging to the surrounding natural environment, demolition of the buildings will be considered as part of the Annual IPM Report (See Chapter 3, section 3.4 Reporting). Demolition activities will be subject to separate permitting processes through respective County planning departments. Modern IPM programs for buildings rely on prevention (i.e., building design and human behavior modification) as the primary structural pest control treatment options) to eliminate pest problems. Therefore, a discussion of preventive and general maintenance activities is summarized below.

6.4.1 PREVENTION

Preventing insects and wildlife pests in buildings include general guidelines that promote pest-resistant materials, block common access points to buildings, and promote the modifications of common structures to repel rather than attract common pests. These guidelines may include landscape design practices that can be incorporated at District facilities in natural areas. For example, defensible space around structures should not be planted with dense ground covers and/or climbing vines like ivy that could attract structural pests such as mice and skunks.

Pests need a place to live – or harborage; most prefer a hidden space where they will not be disturbed. Preventing access to hidden spaces can, therefore, assist pest management efforts: cracks, crevices, gaps, holes, loose structural elements, and dense vegetation can all act to hide small pest organisms. In some cases, the materials present in District structures can create a potential harborage, such as when rigid foam insulation - a material that is known to attract termites - is used on the outside of foundations.

Incorporating some preventive measures will be simple, while others (like discontinuing the use of rigid foam insulation) may directly conflict with building codes and other design goals for the structure. Generally, the inclusion of standard pest prevention practices during the building design and construction or retrofit phase can dramatically reduce pest problems in the future while still fulfilling all the requirements for modern building codes. For example, proper placement of exterior lighting can significantly reduce the attraction of night flying insects into the building. Eliminating ledges under roof eaves can discourage pigeons and swallows from taking up residence. Planting and maintaining landscaping so that it does not touch building walls can help reduce the transmission of pests inside the structure. All of these retrofit, design, and construction practices can help prevent the establishment of pests in District structures, thereby reducing the need for pest management.

6.4.2 RETROFIT

Architects, planners, and engineers have only recently begun to consider pest control and building maintenance in the design of new structures and within the retrofitting of existing structures. New local green building ordinances and elective building rating systems now incorporate methods for enhancing modern buildings to be more energy efficient and less toxic beyond modern building codes. Reducing the need for toxic pesticides to control structural pests is especially feasible because much of their damage can be prevented by improved design.

Designing pests out of new and existing structures may include structural materials selection and the addition of non-structural components to reduce building access or utilization by pest species. Design guidelines are now available from the International Code Council/San Francisco Department of the Environment (Geiger and Cox 2012). Much of the focus of these guidelines is on the building envelope and the building interface with soil and landscaping. This allows buildings to repel ground-dwelling insects and rodents and significantly reduce their access to the building interior. Other more general guidelines promote pest-resistant materials, block common access points to buildings, and promote the modifications of common structures to repel rather than attract common pests. These guidelines include landscape design practices that can be incorporated at District facilities in natural areas. For example, defensible space around structures should not be planted with dense ground covers and/or climbing vines like ivy that could attract structural pests such as mice and skunks. Maintenance practices that can reduce structural pest impacts are summarized in Table 6-1.

Table 6-1 Maintenance Practices to Prevent and Reduce Structural Pests
Minimize moisture. Moisture in and near structures can provide harborage for insect pests such as termites, wood-boring beetles, cockroaches, flies, carpenter ants, silverfish, and millipedes. Utilize the following procedures to minimize building moisture during construction or general maintenance and repairs: ◢ Check for proper ventilation of crawl spaces; add vapor barriers in crawl spaces. ◢ Ensure appropriate slopes and drainage next to structures. ◢ Downspouts and gutters should discharge at least one foot away from walls; splash guards, rain barrels, or gutter extensions may be added to reduce accumulation of moisture near structural walls. ◢ Ensure that landscape irrigation does not introduce moisture to foundations – use drip irrigation and position sprinklers to avoid structures.
Maintain landscaping next to structures. ◢ Prune vines, shrubs, and trees at least six feet away from roofs and exterior walls, as rodents can use these for access into buildings and shelter next to foundations. ◢ Remove and avoid planting Algerian or English ivy, star jasmine, or honeysuckle vines, which provide shelter and food sources for rats and other urban pests. Remove and avoid planting bamboo, cherry laurel, fig, pine, and roses near buildings, which encourage scale, aphid, and ant populations. ◢ Clear landscaping away from vent openings to crawlspaces to prevent moisture buildup. ◢ Remove plants and wood mulch within several inches of foundations to minimize ants and other nests. A gravel strip around foundations at least two feet wide and 0.5 feet deep of one-inch gravel or larger discourages rodent burrowing and other insect nesting. ◢ Select plants that attract beneficial insects such as parasitic wasp, native bees, and ladybugs.
Move stored materials away from structures. ◢ Store compost and trash bins away from structures, as these can attract rodents, insects, and other nuisance pests. ◢ Store woodpiles and debris away from structures to prevent rodent, beetle, and termite infestation.
Seal off openings. ◢ Inspect openings to crawlspaces and other ventilation features to ensure screens are intact. ◢ Inspect, maintain, and use elastomeric sealant, polyurethane foam, and weather-stripping to seal all small cracks in structures, around countertops and windows, pipe breaks, and areas where pipes enter walls. Use stainless steel wool and mesh and fire block foam to re-seal larger openings in buildings and below decks. ◢ Add door sweeps or high density pest brushes to seal gaps greater than ¼” below doors.
Block access for rodents to climb pipes and gutters. ◢ In areas with Norway rats or other rodent issues, various items can be installed to prevent the rodents from climbing downspouts and pipes, including flap valves or screens in downspouts, 12”-diameter downward-facing cones or 18”-diameter discs, or a 12” band of glossy paint on exterior vertical pipes.
Add bird exclusion materials to lighting and other horizontal surfaces. ◢ Bird spikes, wires, netting, or similar materials should be installed prevent birds from roosting or nesting on structures or on light poles.
Reduce or move exterior lighting. Exterior lighting may encourage insects to gather near doors and windows. ◢ Timers and motion detectors can be installed to minimize unnecessary lighting. ◢ Use reflected light instead of direct light to illuminate entryways, as insects are more attracted to direct light. ◢ Use yellow (sodium) bulbs to reduce insect attraction in exterior areas.

Table 6-1 Maintenance Practices to Prevent and Reduce Structural Pests
Exclude rodents from refuse and recycling areas. ◢ Enclose refuse and recycling areas with metal, concrete, or similar materials to prevent wildlife from climbing, burrowing, or chewing into the enclosure. Do not plant ivy around the enclosure. ◢ Use refuse containers that are heavy duty, rust resistant, rat and damage resistant, and equipped with tight-fitting lids.
Notes: Recommendations selected from Pest Prevention By Design: Authoritative guidelines for designing pests out of structures (Geiger and Cox 2012).

In the same way that buildings can be re-engineered to resist and prevent pests, so can appropriate planning. Architectural standards have long dictated how buildings should be situated in an environment for appropriate function and appeal. In the same way that a subdivision of straw houses is not appropriate for high fire risk areas, appropriate site planning and design can also reduce future pest problems. Better planning for lighting, storage, building use and landscaping around existing buildings can all contribute to fewer pest problems in and around District structures. District staff should assess how existing buildings are being used and how they are arranged together and within the landscape to maximize the reduction of future pest management.

Pest impacts to wooden structures often result from the introduction of moisture. Subterranean termites, carpenter ants, most wood boring beetles, and fungal rots only impact wood that is already impacted by moisture. Maintaining structures so they remain dry at all times, especially in the high humidity of the Santa Cruz Mountains and Central Coast, will reduce the potential for pest outbreaks in the structure. Maintenance of older structures should focus on keeping the building envelope functional to minimize leaks and moisture accumulation.

Other general maintenance practices in and near structures involve general cleanliness and vigilance in preventing access to resources that encourage pests. For example, equipment that attracts rodents or provides harborage should not be left in natural areas for long periods of time. Landscape maintenance should focus on elimination of vegetation touching the building envelope, or reduction or elimination of the types of landscaping that are known to provide harborage for structural pests.

6.4.3 SANITATION AND MAINTENANCE

Many pest species are present because of improper handling and storage of food and food waste, or improperly cleaning up food scraps and dishes. Uncovered garbage containers, both inside and adjacent to buildings can attract rats and other pests. Storing native plant seeds in paper envelopes rather than hard sealed plastic containers may encourage mice to take up residence in storage areas. All of these types of pest attractants can be eliminated with human behavioral modification as a prevention method. Optimally managing human behavior can drastically reduce or even completely eliminate the need for pesticide products in District structures and landscapes.

Recommendations for structural pest prevention measures to be implemented by District staff and volunteers in food and waste storage areas are listed below. If behaviors cannot be easily modified, hire a janitor or cleaning service for common area cleaning.

ADDITIONAL RESIDENTIAL/OFFICE UNIT PREVENTION STRATEGIES

The following additional measures may be applied in District residential and office buildings:

- train staff, including building occupants and janitorial staff on safe food and trash handling procedures;
- store all food and food wastes in sealed containers;
- in communal spaces, provide extra containers, sealed cabinets, or a refrigerator for temporary food storage;

- do not allow food waste to remain in open areas overnight;
- regularly clean dishes, floors and counter tops;
- use sealed garbage cans, or alternatively place them on a crawling insect-proof platform;
- rinse out cans and bottles before they are placed in a recycling bin; and
- do not leave pet food out overnight.

INDUSTRIAL UNIT PREVENTION STRATEGIES

The following types of additional measures may be applied in District storage buildings, livestock structures such as corrals, and for District projects utilizing contractors and outside construction materials such as fill dirt or erosion control materials:

- Train staff about proper storage of work supplies in non-occupied buildings.
  - Store all pet food, animal grains, and other consumable agricultural supplies in sealed containers (metal/plastic).
  - Store plant seeds used for habitat restoration and landscaping in sealed containers.
- Monitor landscaping and rooted plant materials for pests, and treat as necessary to prevent pest outbreaks.
- Position attractive harborage areas, such as rock piles, soil storage piles, hay and erosion control materials away from buildings.
- Control food waste in contractor work areas, outbuildings, storage areas and other non-occupied structures. Provide sealed garbage containers in or near such areas to prevent inadvertent disposal.
- Reduce, monitor, and where possible eliminate use and import of natural materials that could introduce pests onto District lands, such as reducing use of offsite fill (soil, gravel, and rock) and livestock feeds (hay) that may contain weed seeds. Where possible, include requirements to utilize onsite fill, require balanced cut and fill projects on District lands, and require use of certified weed-free erosion control materials for construction projects on District lands.

6.5 DAMAGE ASSESSMENT

Determine what, if any, damage to the structure is present. If there is no structural damage, but a pest is present that is in conflict with human use or enjoyment of the structure, determine the tolerance level for each pest species to determine if control is warranted. To the extent possible, quantify the damage (square feet affected or number of occurrences) and qualitatively describe the perceived damage in its context. As an example, a staff person could estimate the square footage of a building affected by ants and evaluate if the ants are always present at observed levels or if the incident is just a temporary outbreak.

6.6 TOLERANCE LEVELS/THRESHOLD FOR ACTION

Tolerance levels vary greatly for structural pests depending on the true or perceived impact of the pest to the structure or human experience. Some species, such as cockroaches, are unwelcome guests but present no real damage to either people or structures. Other species, such as woodrats, can seem more acceptable because they are attractive native animals but they can also carry deadly, incurable human diseases. The District's IPM approach for structural pest species begins with establishing human and structural tolerance levels that balance human safety, enjoyment, and comfort within the build environment with the ability to conserve natural resources and cost/benefit assessment.

Human safety and enjoyment is the primary metric for establishing tolerance levels in structures. Although structural pests can be both native, protected species, and non-native invasive species, staff and visitor safety is paramount in regulating treatment actions. Tolerance levels will consider conservation goals and impacts to the larger surrounding natural system in determining treatment actions.

6.6.1 MANAGEMENT THRESHOLDS FOR STRUCTURAL INSECT PESTS

Refer to Table 6-2 for establishing management thresholds and treatment options for nuisance insects in buildings.

Table 6-2 Management Thresholds and Treatment Options for Nuisance Insects in Buildings

<table>
<tr><th>Pest Category</th><th>Management Threshold
(Population Size/Conditions)</th><th>Treatment</th></tr>
<tr><td rowspan="3">Ants</td><td>Colonies near structures and occasional trails indoors</td><td>Use a combination of the following:
◢ Clean up ant trails with soapy water or sticky lint rollers.
◢ Ensure all food sources are in sealed containers.
◢ Fill entry points with caulk, silicone, or expanding foam.</td></tr>
<tr><td>Heavy invasion, more than occasional seasonal nuisance</td><td>Use a combination of the following:
◢ Inject diatomaceous earth dust into cracks before sealing if there are multiple entry points.
◢ Use Boric acid bait
◢ Use Fipronil bait as last resort (extreme infestations, fast control)</td></tr>
<tr><td>Homopteran insect populations on plants (aphids, etc.) that support ants invading structures</td><td>Use a combination of the following:
◢ Prune vegetation that supports ants and/or Homopteran insects away from structures.
◢ Control Homopteran insects by dusting the infested vegetation with diatomaceous earth
◢ treat the infested vegetation with a soap and water solution.</td></tr>
<tr><td rowspan="2">Cockroaches</td><td>Occasional presence indoors in low numbers</td><td>Use a combination of the following:
◢ Fill entry points with caulk, silicone, or expanding foam.
◢ Ensure all food and water is unavailable.</td></tr>
<tr><td>Heavy invasion, more than occasional seasonal nuisance</td><td>Use a combination of tools and alternate to avoid resistance:
◢ Inject diatomaceous earth dust into cracks before sealing if there are multiple entry points.
◢ Use Boric acid dust in walls, cracks, and other inaccessible areas.
◢ Use baits:
  ▰ Hydropene
  ▰ Indoxacarb bait
  ▰ Fipronil bait as last resort</td></tr>
<tr><td>Flies</td><td>Heavy invasion, more than occasional individual nuisance indoors or in picnic areas</td><td>Use a combination of the following:
◢ Fill entry points with caulk, silicone, or expanding foam
◢ Install Sticky fly traps indoors
◢ Install Baited electric traps outdoors
◢ Remove food and breeding sources</td></tr>
</table>

6.6.2 STRUCTURAL WILDLIFE PESTS

Refer to Table 6-3 for establishing management thresholds and treatment options for wildlife nuisance pests in buildings.

Table 6-3 Management Thresholds and Treatment Options for Nuisance Wildlife in Buildings

Pest Category	Management Threshold (population size/conditions)	Treatment
Mice & rats	Occasional presence indoors in low numbers (< 10 individuals)	Use a combination of the following tools and alternate to avoid resistance: ◢ Snap traps 6 feet apart for initial population control and maintenance. Prebait up to several weeks for rats. ◢ Box traps for mice – inspect daily. ◢ Glue boards – supplemental control.
	Moderate to Heavy infestation (> 10 individuals of house mice, Norway or roof rats ONLY) AND infestations posing risk to human health that do not respond to preventative and non-chemical methods	Use a combination of the tools and alternate to avoid resistance: ◢ Tools listed above for occasional presence ◢ Cholecalciferol – During instances when human health and safety are in jeopardy
	Moderate to Heavy infestation ((> 10 individuals) of Dusky-footed woodrats	Use exclusion methods to prevent entry of native rats into structures.
Skunks, opossums & raccoons	Individual animals invading structures	Implement trapping. Animals must be released or euthanized immediately. Relocation requires a permit from CDFW.
Feral Pets	Aggressive animals or resident populations that cause nuisance or impede resource protection goals	Implement live trapping with city or county animal control departments or animal shelters.
Bats	Roosting in structures that allows access to human-occupied rooms	Use a combination of the following: ◢ Implement strategic exclusion. ◢ Block entry to spaces where roosting causes conflict with human health and safety.

6.7 ACTIVE PEST CONTROL TREATMENT OPTIONS

When thorough prevention measures have been undertaken and human health and safety dictates, District staff may determine active pest control is required in buildings. The basic steps for planning active pest control in buildings include:

- Identification of a potential pest problem by trained professionals, staff, or tenants;
- Inspections to establish pest activity and treatment options;
- Identifying a preferred pest control approach;

- Implementing the selected pest control;
- Monitoring the results of pest control; and
- Reviewing results to inform and improve future pest control actions (adaptive management).

Some pest management options include:

- Indoor monitoring/trapping stations (non-chemical options such as snap traps and glue traps are preferred over other chemical control options);
- Natural pest controls (e.g., diatomaceous earth);
- Other active IPM controls (as described above in Tables 6.6.1 and 6.6.2).

Where pesticide use is determined to be the only viable treatment option to address the specific infestation of concern, selection of least harmful products is required. Only pesticides on the District's List of Approved Pesticides (Table 1.1, Appendix A) may be utilized. As an example, structural pest infestation that poses an immediate threat to human health or public safety would exceed District tolerance levels and warrant use of pesticides if non-chemical control could not protect the public. The chemical control options presented in this Chapter represent the least harmful, most efficient treatment methods for controlling structural pests. For example, a wasp nest in a public restroom may require use of a pyrethroid wasp spray to immediately eliminate the hazard of wasp injury to visitors. The inclusion of a variety of pest treatment method options in the IPM program allows the District to respond with the necessary tools based on actual risk to the District, its visitors, workers, structures, and lands.

6.7.1 INSECTS

Structural insects found on District lands include ants, cockroaches, flies, and wasps. As described above, these species can be deterred from establishing in District structures through design, maintenance, and behavioral modifications. However, some structural and nuisance pests may exceed tolerance levels for their presence in buildings. The following section discusses treatment methods for populations that exceed tolerance levels.

The presence of insects in buildings is very unappealing to most facility users. Their occurrence tends to suggest unsanitary conditions or deferred maintenance. Though these insect species usually do not pose a threat of direct harm to humans, their presence is almost always deemed to be unacceptable in our homes and landscapes. In the absence of immediate public health and safety risks, prevention and physical controls are the first treatment methods implemented in an IPM program, and these methods typically provide the most long-term effective control. Sanitation and cleanliness are the most effective methods for preventing and managing these insect pests. Chemical treatment methods are generally only used if the other methods prove inadequate to bring the insect pest population to within tolerance levels.

IPM strategies for common insect pests must utilize a spectrum of different control techniques to avoid problems with pesticide resistance. For example, both Argentine ants and German cockroaches have developed resistance to a number of common pesticides. For this reason, no single treatment or product can be recommended for complete control. All products that have chemical modes of action – both natural and synthetic – can promote resistance if used indiscriminately. All chemical products must only be used in the most appropriate and effective manner and in parallel for consistent results.

ANTS

The most common nuisance ant species in District structures is the Argentine ant (*Iridomyrmex humilis*). The Argentine ant is a non-native species from South America that likely arrived in California in the early 1900s and quickly spread throughout the state's citrus growing regions. Argentine ants have largely replaced native ant species in the urban environments that they have invaded (Holway 1998). Although the species is usually considered a nuisance pest in structures, the Argentine ant has eliminated nearly all native ant species in natural areas as well. Other native insects and some populations of native birds, lizards, and salamanders may have been similarly affected by the Argentine ant (Randall 2011). Many native plants rely on insect pollination and insect-related seed dispersal; the loss of native insects resulting from the invasion of the Argentine ant has most likely also reduced native plant seed production, dispersal and other mutualistic relationships between insects and their host plants (Gomez 2003, Nygard 2008).

Argentine ants have four life stages: egg, larva, pupa (cocoon), and adult. They are social insects that live in organized colonies where different adults have specialized duties and where numerous queens and workers mix freely among spatially separated nests. Unlike native ants, Argentine ants mix freely between colonies without any intraspecific competition and thus are capable of reaching unnaturally high population densities compared to native ant species (Silverman 2008). For this reason, eradication of Argentine ant populations is impossible; if a sub-colony collapses, other nearby queens will shift to fill the void. Argentine ants are omnivorous, preferring high protein sources until those resources are exhausted and then shifting to plant and nectar based resources. They are especially fond of honeydew produced by Homopteren insects (e.g., aphids, scale) and the pest problems of each of these species in gardens and structures are often linked.

PEST MANAGEMENT STRATEGIES FOR ANTS

Prevention

- Clean all kitchen and food storage surfaces regularly; sweep and vacuum kitchen floors daily. Shared-use appliances such as sinks, microwaves, and vending machines should be cleaned regularly to eliminate spills.

- Store all food properly. Argentine ants are especially small creatures that can easily crawl along the threads of a screw-top jar and enter the container if there is no silicone or rubber seal on the lid. Store all food in containers with tight fitting lids, or in the refrigerator or freezer.

- Rinse recycling waste if it is temporarily stored in open bins. Alternatively, store all waste in containers with tight fitting lids/seals or place open bins on insect-proof bases (e.g., AntserTM) and always line trash bins with plastic bags. Regularly take out the garbage to an outside storage area/dumpster.

- Do not leave pet food in open bowls overnight. Wash pet food bowls after the pet is done eating.

- Inspect potted plants for ant nests regularly. If ant nests are found, remove the potted plant. If potted plants become a frequent harborage for ant nests, use ant-proof platforms (e.g., AntserTM) or use a double saucer system (inside saucer – water – outside saucer – soapy water) for all inside/outside potted plants. Flooding the pot for several days can treat ant-infested potted plants.

- Inspect landscaping for aphids, scale, and other honeydew producing insects. If found, treat plants for insect pests, and manage ants in a coordinated effort to eliminate both problems.

Physical Control

- Clean up ant trails when they are found with soapy water or sticky lint rollers. Note the location the ants were headed and the location where they were coming from. Clean-up whatever was attracting the ants, if possible.
- Use caulking, silicone, or expanding foam to fill cracks, holes, or other entry points where ant trails originate. If multiple entry points are suspected, inject diatomaceous earth dust into cracks before sealing.
- Prune outside vegetation that is touching the structure if it supports ants, aphids, or scale. Some species, such as Citrus, are especially susceptible to sucking Homopteran insects that in turn attract ants. Consider replacing these species of plants with others that do not attract Homopteran pests. Treat infested

vegetation by spraying with soapy water or insecticidal soap sprays, dusting with diatomaceous earth, or physically removing insects.

Chemical Control

Chemical control of ants includes two options: 1) direct control using sprays for instant, but temporary knockdown of individual ants and the treatment of Homopteran pests that attract ants, and 2) baits for colony control. Sweet liquid baits are useful throughout the year because adult Argentine ants only feed on sugary liquids. High protein baits are generally only useful to treat colonies during the periods of the year when they are actively expanding because such solid food is typically used by the ants to feed larvae. Baiting is generally a slower process than direct control but it has a much greater long term impact on controlling the entire local colony. Baits are taken back to feed larvae and shared with other adults and queens so they potentially can eliminate the entire colony rather than just a few individuals. Modern baits are designed to be extremely host-specific compared to generalist insect sprays. Baits target the pest directly, rather than being applied to the environment. Never use direct control (spray) around a bait station, as the spray will impede the bait's ability to attract the insects. Baits will only be used indoors in tamper-proof stations.

For the control of insects, multiple baits with different modes of action are recommended to prevent local populations from developing resistance to the pesticides. Every structural insect management program should include a few products to use in rotation to prevent resistance.

- **Insecticidal Soap Spray.** Insecticidal soaps are specially designed mixes of fatty acids that are made to penetrate an insect's covering and dissolve its cell membranes causing dehydration and mortality. Generally, the soaps are formulated to not dissolve plant cell membranes so are safe to apply directly to plants. Insecticidal soaps are not effective on all insects, but soft bodied insects, such as Homopterans, are highly susceptible. When used for ant control, soaps are most effective in controlling the Homopteran insects on plants that attract and sustain ant colonies.
- **Boric Acid Bait.** Boric acid is a naturally occurring compound found in many fruits and vegetables, but at concentrated doses it can be an effective stomach poison for insects. Baits use low concentrations of boric acid – sodium tetraborate decahydrate – in the range of 0.5 – 5% to allow for ants to ingest the bait and take it back to the colony to share with other workers before there is a lethal effect. Higher concentrations risk killing the individual before it has time to take the bait back to the colony. Studies show that the lowest concentrations (<1%) are optimum for Argentine ant preference (Klotz 2000).
- **Fipronil.** Fipronil is a broad-spectrum insecticide common in household cockroach/ant baits and flea sprays for pets. When used as an ant bait, it is toxic to insects through ingestion where it blocks chloride channels in the central nervous system; resulting in excess neuronal stimulation and death of the target insect pest. It has higher binding affinity in insect receptor sites versus mammalian receptors so it is considered highly selective for insects and safe to use in human environments (Jackson et al. 2009). It is considered one of the most effective baits for colony control of Argentine ants in situations when boric acid-based baits are less effective (Hooper-Bui and Rust 2000; Mathieson et al. 2012). Fipronil is relatively quick-acting compared to other natural pesticides. It should be used as a last-resort option when extremely high populations of ants must be controlled quickly. Only small amounts of bait are necessary to control ants compared to knockdown sprays, which must be applied more widely in the environment to be effective. Small amounts of fipronil will be used as a last-resort option when extremely high populations of ants must be controlled quickly.
- **Diatomaceous Earth.** Diatomaceous earth (DE) is a silica-based, naturally occurring mineral product that works as a generalist insect pesticide. It is composed of the fossilized silica cases of marine diatoms that have been mined from ancient marine sediments. The dusts are considered non-toxic although care should be taken to not inhale large amounts of dust during application as all mineral and wood dusts are considered hazardous in extremely large amounts. Food-grade DE is available to mix directly in human and pet foods to manage pests that occur in bulk food storage. DE works by mechanically abrading an insect's

exoskeleton that leads to dehydration and eventual death of the insect. DE is non-selective so it must be used only in specific areas where the target pests travel. The dusts are not eaten – so must be applied in areas where they will make contact with the bodies of insect pests. For ant control, it is often applied to cracks and crevices and may also be used in conjunction with caulks and foams to fill problem areas.

COCKROACHES

One of the most common structural nuisance insect pests in North America is the cockroach (Olkowski et al. 1991). Though rarely carrying disease or causing major economic damage to our structures, it is typically considered unacceptable in our homes and workplaces; triggering psychological distress, embarrassment, and general feelings of disgust. Cockroaches do consume human foodstuffs and wastes, and can contaminate them with saliva and excrement. In some cases, they carry disease and may be linked to increased asthma rates (CDC 2013a).

Cockroaches are scavengers of plant materials; as a result, they prefer carbohydrates over fats and proteins. They consume any human food or food waste that contains significant carbohydrates in addition to materials such as pastes, glues, and soaps. Most common cockroach species can only exist in high humidity and high temperature environments such as those present in human structures.

Several different species of cockroaches occur as pests in Northern California and each has separate behaviors and habitat preferences that dictate different types of pest management. The non-native German cockroach is the most common pest species in the counties in which the District is located. The German cockroach (*Blatella germanica*) is the smallest and most widely spread pest cockroach in North America. It has three life stages: egg, nymph, and adult. German cockroaches prefer dark, warm, and humid hiding places and they are common in basements, kitchens, and bathrooms. They are thigmotactic, meaning they prefer to rest in small cracks where their stomach and back touches surfaces during most of the day, so regular inspection of crack areas can sometimes aid in cockroach detection in buildings. Unlike ants, they are solitary insects but since preferred habitats are rare in buildings, it is common to find large numbers of cockroaches hiding in the same general areas.

German cockroaches are ubiquitous in human environments that occur in temperate climates so complete pest eradication is almost never achievable. Cockroaches regularly disperse in cartons, boxes and other containers coming to and from grocery stores, warehouses, flower shops, and other shipments, and are thus are likely to always be present in human environments. Strategies such as sealing exterior cracks/holes in buildings and strict sanitation measures both inside and out of buildings will help maintain their populations at nearly indiscernible levels which should be sufficient for most District properties.

PEST MANAGEMENT STRATEGIES FOR COCKROACHES

Prevention

- Clean all kitchen and food storage surfaces regularly; sweep and vacuum kitchen floors daily. Shared-use appliances such as sinks, microwaves, and vending machines should be cleaned regularly to eliminate spills.
- Store all food properly. Store all food in containers with tight-fitting lids, or in the refrigerator or freezer.
- Rinse recycling waste if it is temporarily stored in open bins. Alternatively, store all waste in containers with tight fitting lids/seals or place open bins on insect-proof bases (AntserTM bases) and always line trash bins with plastic bags. Regularly take out the garbage to an outside storage area/dumpster.
- Do not leave pet food in open bowls overnight. Wash pet food bowls after the pet is done eating.
- Ensure all exterior windows that open have insect screens to prevent roaches from gaining entry into structures.

Physical Control

- Use caulking, silicone, or expanding foam to fill cracks, holes, or other entry points where cockroaches are known to hide or enter structures. If multiple entry points are suspected, inject diatomaceous earth dust into cracks before sealing.
- If hiding places are unknown, use a sticky-trap monitoring program to determine where in the building roaches are hiding.

Chemical Control

Only baits in tamper-proof stations will be used indoors.

- **Diatomaceous Earth.** Diatomaceous earth (DE) is a silica-based, naturally occurring mineral product that works as a generalist insect pesticide. It is composed of the fossilized silica cases of marine diatoms that have been mined from ancient marine sediments. The dusts are considered non-toxic although care should be taken to not inhale large amounts of dust during application as all mineral and wood dusts are considered hazardous in extremely large amounts. Food-grade DE is available to mix directly in human and pet foods to manage pests that occur in bulk food storage. DE works by mechanically abrading an insect's exoskeleton that leads to dehydration and eventual death of the insect. DE is non-selective so it must be used only in specific areas where the target pests travel. The dusts are not eaten – so must be applied in areas where they will make contact with the bodies of insect pests. For cockroach control, they are often applied to cracks and crevices and may also be used in conjunction with caulks and foams to fill problem areas.
- **Boric Acid Dusts.** Boric acid is a naturally occurring compound found in many fruits and vegetables, but in concentrated doses, can be an effective stomach poison for insects. Boric acid dusts are highly effective for cockroach control when applied to cracks and crevices where cockroaches are known to occur. The dusts (when kept dry) have a long service life and provide control for many years after application. They are practically non-detectible to cockroaches, so unlike many other chemical products that cockroaches can detect and avoid, they offer one of the more effective methods for cockroach control (Gore and Schel, 2004). Since they have such a long service life, they are effectively applied inside building walls, plenum (false) ceilings, crawlspaces and other relatively inaccessible areas where cockroaches can occur. Boric acid dusts are relatively slow acting compounds that take up to 10 to 15 days to achieve effective elimination of problem insects so they should generally be used in compliment with a baiting program to achieve full control of cockroach outbreaks.
- **Hydroprene.** Hydroprene is a synthetic insect growth regulator (IGR) that mimics juvenile insect hormones to regulate insect pest populations. Although they do not poison an insect directly to cause a lethal effect, they do interrupt the development cycle of juvenile cockroaches so they do not ever reach a reproductive stage. This mode of action can be important to reducing adult populations by preventing young insects from reaching adulthood and breeding in a long term control strategy. For this same reason, hydroprene is considered highly specific to insect pests and has low toxicity for birds and mammals, species that do not possess these same types of growth hormones. IGRs are not an ideal stand-alone control, but they are effective when used in combination with other methods to reduce populations of troublesome insects.
- **Fipronil insecticidal baits.** Fipronil is a relatively recently developed, broad-spectrum insecticide common in household cockroach/ant baits and flea sprays for pets. When used as cockroach bait, it is toxic to insects through ingestion where it blocks chloride channels in the central nervous system. This results in excess neuronal stimulation and death of the target insect pest. It has higher binding affinity in insect receptor sites versus mammalian receptors so it is considered highly selective for insects and safe to use in human environments (Jackson et al. 2009). Fipronil is relatively quick acting compared to other natural pesticides. It should be used as a last-resort option when extremely high populations of cockroaches must be controlled quickly. As it is insecticidal bait, only small amounts of bait are necessary to control cockroaches effectively compared to knockdown sprays that must be applied much more widely in the environment.

- **Indoxacarb insecticidal baits.** Indoxacarb is a synthetic, non-systemic insecticide effective on chewing and sucking insects. When used as cockroach bait, it is toxic to insects through ingestion where it blocks sodium channels in the central nervous system resulting in paralysis and elimination of the target insect pest. Iit replaces more hazardous organophosphate insecticides while still providing a fast acting, quick knockdown pest control option. Indoxacarb is a quick acting insecticide and offers exceptional German cockroach control potential. In laboratory conditions, small amounts of gel baits can provide several generations of control when the product is re-consumed through feces, regurgitates, and through bodily contact from the primary exposed individual cockroach (Buczkowski et.al, 2008). This product is recommended for last-resort options in challenging cockroach pest control scenarios.

FLIES

Flying insect pests such as flies can be problematic inside buildings. In our region, the most common pest fly species, also referred to as filth flies, are common house, stable, and greenbottle flies (Calliphoridae and Muscidae families). Common houseflies and greenbottle flies tend to be the most problematic groups of filth flies that cause pest problems in buildings and other public spaces. The presence of filth flies is generally indicative of unsanitary conditions, which makes them undesirable. They can also carry disease pathogens to humans through feces and regurgitation.

Pest flies breed in animal wastes and decaying organic material from which they can pick up bacteria and viruses that may cause human diseases. In addition, adult stable flies feed on mammalian (livestock) blood and can offer a painful bite. All flies undergo complete metamorphosis with egg, larva, pupa, and adult stages in their development. The female fly deposits her eggs in animal waste or moist organic material where the larvae, or “maggots,” complete their development, feeding on wastes until they pupate in a dry location.

PEST MANAGEMENT STRATEGIES FOR FILTH FLIES

Prevention

- Clean all kitchen and food storage surfaces regularly; sweep and vacuum kitchen floors daily. Shared use items such as sinks, microwaves, and vending machines should be cleaned regularly to eliminate spills.
- Store all food properly. Store all food in containers with tight fitting lids, or in the refrigerator or freezer.
- Rinse recycling waste if it is temporarily stored in open bins. Alternatively, store all waste in containers with tight fitting lids/seals or place open bins on insect-proof bases (AntserTM bases) and always line trash bins with plastic bags. Regularly take out the garbage to an outside storage area/dumpster.
- Ensure outside garbage cans and dumpsters have tight-fitting lids to prevent flies from completing their life-cycles in waste cans.
- If garbage cans do not have tight fitting lids, use cedar sawdust to layer over wet/organic waste in the trash bins to prevent flies from accessing food waste.
- Clean trash bins regularly with pressure washer or soap/water to ensure no thick layers of organic wastes build up in the bottom of cans.
- Ensure all exterior windows that open have tight-fitting insect screens to prevent flies from gaining entry from outside.
- For stables and other livestock areas, remove animal wastes on a regular basis and dispose in sealed containers or in managed compost piles.

Physical Control

- Use caulking, silicone, or expanding foam to fill cracks, holes, or other entry points in building exteriors where flies can gain entry.

- In problem areas, use sticky fly traps (ribbons) to capture excess adult flies and remove them from building interiors.
- Use baited electric traps for problem outside areas such as picnic grounds, barns, or livestock areas.

Chemical Control

In most residential and commercial situations, pesticides are not needed or recommended for control of flies, as they are not effective. Sanitation methods along with screens to keep flies out of buildings should be sufficient for nuisance fly control outside of agricultural facilities with livestock. Fly traps and strips used in problem trash areas may be effective in reducing the number of adult flies if proper sanitation practices are followed.

6.7.2 STRUCTURAL WILDLIFE

Structural wildlife is a diverse group of native and non-native mammals and reptiles that are especially tolerant, and even attracted to human behaviors and structures. This group includes common urban pests such as house mice and roof rats as well as native forest dwellers such as woodrats, deer mice, skunks, raccoons, bats, and rattlesnakes. House mice, roof, and Norway rats typically invade urban structures. More rural, natural areas may be invaded by deer mice and woodrats. Some species (house mice, woodrats) can be controlled relatively easily in single structures as they typically set-up single, temporary colonies in human structures. Others (roof and Norway rats) can be especially challenging since they have much larger, regional populations that interconnect. In all cases, the presence of increased shelter or food availability derived from the human world attracts these animals to buildings, including residential buildings, offices and landscaped area where they can be problematic.

District structures have the potential to be invaded by numerous species of rodents – some of which are native species that are naturally occurring in the natural areas surrounding District structures, while others are typical urban pests. Because many of the District properties occur in natural areas, the natural populations of these pest species can reinvade and repopulate the treated areas. Most native wildlife species that are common structural pests are classified as non-game animals in California’s Fish & Game Code and can be controlled with any method at any time they are found to be injuring human property. Some wildlife species have special protections and additional regulations covering their management such as game species (e.g., grey squirrels, deer), furbearers (e.g., skunks, raccoons) and threatened and endangered species (e.g., California red-legged frogs).

The following sections present pest management information by species.

HOUSE AND DEER MICE

The house mouse (*Mus musculus*) and deer mouse (*Peromyscus* sp.) are both small rodents that readily invade human structures in search of shelter and food. The house mouse is a widespread species that has been linked to human culture for over 1,000 years (Timm 1994). It is now found on every continent except Antarctica. Deer mice are native to California and most other parts of North America. They are common in nearly every habitat in their range – from deserts to forests and also in urban and suburban areas that interface with natural areas.

Both types of mice are omnivorous but generally prefer grain, seeds, and nuts. Both are nocturnal, have similar reproductive traits and reside in nests composed of fibrous materials. All mice species that are considered pests are capable of extremely high reproductive rates anytime during the year, making control difficult. House mice are rather plain looking versus deer mice that have light/dark fur color schemes, white feet, large eyes, and large ears.

Mouse damage includes the consumption of human foods, building nests in human structures, defecation, physical gnawing, damage to paper, clothing and other textiles and the vectoring of disease. House mice are known to carry salmonellosis, leptospirosis, and a variety of other diseases but transmission to humans is rare.

Deer mice, on the other hand, frequently carry Hantavirus – which has been linked to several human deaths in California in the last decade.

PEST MANAGEMENT STRATEGIES FOR MICE

Prevention

- Ensure outside garbage cans and dumpsters have tight-fitting lids to prevent mice from foraging on human food waste. This is especially important in public gathering areas in parks and open spaces. Cans with domed lids and self-closing, hinged lids are preferred in these outside areas.
- Clean all kitchen and food storage surfaces regularly; sweep and vacuum kitchen floors daily. Shared use items such as sinks, microwaves, and vending machines should be cleaned regularly to eliminate spills.
- Store all food properly, in containers with tight fitting lids, or in the refrigerator or freezer.
- Store native seeds, hay, and other vegetation-based materials that can attract mice properly in sealed containers or designated sealed storage facilities.
- Do not leave pet food in open bowls overnight. Wash pet food bowls immediately after feeding.

Habitat Modification

- Use silicone caulking and stainless steel/bronze mesh to plug/fill cracks and holes greater than ¼” in the exterior of building where mice could gain entry. Focus especially on utility penetrations, as mice are known to travel along pipes/wires. Avoid using carbon steel wools and expandable foams that degrade quickly and require repeat maintenance.
- Ensure all exterior windows that open have tight-fitting insect screens to prevent mice from gaining entry from the outside when windows are opened.
- Use galvanized sheet metal to create climbing barriers and exclude mice from travelling up vertical posts where necessary (pet cages/food storage tables/etc.).
- Mouse-proof storage facilities and seasonal buildings after visitor season ends to reduce possible nesting areas.

Physical Control

- **Snap Traps.** Basic hardware store mouse traps offer one of the most effective means for mouse population control when executed with enough preparation, time, and effort. When uncontrolled mouse populations are present, snap traps can be used to “knockdown” large populations and then maintained to keep the population under control. Mice generally travel very short distances throughout their life – space traps approximately every six feet where mice are active. Time must be invested in determining where mice are active and then setting traps in appropriate locations. Pre-baiting will help prevent trap shyness and allow for the operator to test appropriate baits. Only highly desired baits should be used in the actual trapping program. Most mice species are not as trap shy as roof and Norway rats.
- **Box Traps.** Several types of box traps are available that are capable of trapping multiple individual mice per trapping event. These traps operate on the principal that mice are attracted to small openings and are naturally inquisitive. These traps are most successful for house mouse control. Traps should be inspected on a daily basis so live trapped mice can be humanely dispatched.
- **Glue Boards.** Glue or sticky boards are effective for supplementing other trapping methods in challenging areas. Glue boards work especially well in established runways where other traps cannot be easily placed. If a trapping program fails to trap all individuals that then become trap shy, glue boards are an alternative method that can capture the remaining rogue individuals. Traps should be inspected on a daily basis so live trapped mice can be humanely dispatched. Glue boards will be used indoors only to prevent incidental catch of other wildlife.

Chemical Control
Chemical control of mice should not be considered except under very unusual (human health and safety considerations). In the unlikely event that chemical control of mice is deemed necessary, Refer to the Chemical Control section for rats, below.

ROOF, NORWAY, AND WOOD RATS

Roof rat (*Rattus rattus*), Norway rat (*Rattus norvegicus*), and Dusky-footed woodrat (*Neotoma fuscipes*) are medium sized rodents that readily invade human structures in search of shelter and food. With the exception of the native woodrat, rats represent some of the most challenging pest rodents to control in urban environments (Marsh 1994). Roof and Norway rats can be present in very large numbers in urban areas. Their home ranges are much larger than those of mice so effective treatment is challenging and may require treatment of more than a single structure. Both the roof and Norway rat are a widespread pest species that have co-evolved with humans for thousands of years.

Dusky-footed woodrats are native California mammals that are occasionally considered pests when they invade structures from nearby wildlands. All woodrats found on District lands are the San Francisco Dusky-footed woodrat (*Neotoma fuscipes annectens*) which is a CDFW Species of Special Concern. Control of woodrats, as with all native species, should first focus on prevention instead of physical or chemical control.

Like cockroaches, rats trigger general feelings of disgust in humans as they are thought to be representative of dirty living conditions and squalor. They do bite, and many people in the U.S. suffer from rat bites each year. Rats are known to carry diseases that can be transmitted to humans. The majority of actual rat damage in the United States is due to structural damages caused by burrowing (Norway rats), defecation and contamination of food products, textiles and living spaces (Norway/roof/wood rats), and damage to agricultural crops and landscaping (roof rats). Woodrats typically build elaborate nests in wildland areas, but can also be nuisance pests in structures where they make nests and cache food. Woodrats also are the only species of rat known to carry Hantavirus and Arena virus in North America, both of which can be deadly to humans (Salmon and Gorenzal, 1994).

PEST MANAGEMENT STRATEGIES FOR RATS

Prevention
- Ensure outside garbage cans and dumpsters have tight-fitting lids to prevent rats from foraging on human food waste. This is especially important in public gathering areas in parks and open spaces. Cans with domed lids and self-closing, hinged lids are preferred in these outside areas.
- Clean all kitchen and food storage surfaces regularly; sweep and vacuum kitchen floors daily. Shared use items such as sinks, microwaves, and vending machines should be cleaned regularly to eliminate spills.
- Store all food properly, in containers with tight fitting lids, or in the refrigerator or freezer.
- Do not leave pet food in open bowls overnight. Wash pet food bowls immediately after feeding.

Habitat Modification
- Inspect building exterior for possible rodent entryways. Especially inspect attics for signs of rat occupation and openings or gaps between the structure and roofs or foundations. Use silicone caulking and stainless steel/bronze mesh to plug/fill cracks and holes greater than ½” in the exterior of building where rats could gain entry. Focus especially on areas where utilities enter the buildings, as rats are known to travel along pipes/wires. Avoid using carbon steel wools and expandable foams that degrade quickly and require repeated maintenance.
- Ensure all exterior windows that open have tight-fitting insect screens to prevent rats from gaining entry from the outside when windows are opened.

- Use galvanized sheet metal to create climbing barriers and exclude rats from travelling up vertical posts where necessary (e.g., utility poles, pet cages, food storage areas, tables).
- Rodent-proof storage facilities and seasonal buildings after visitor use season ends to reduce possible nesting areas.
- If they appear to be a constant source of infestation, woodrat nests within 100 feet of buildings will be moved after consultation with the California Department of Fish and Wildlife.

Physical Control

- **Snap Traps.** Basic hardware store rat traps offer one of the most effective means for rat population control in small structures with small rodent populations. Where large rat populations are present, snap traps can be used to "knock down" the population size in conjunction with other management techniques (prevention, habitat modification) to keep the population under control. Time must be invested in determining where rats are active and then setting traps in appropriate locations. Roof and Norway rats are inherently wary of new objects in their environment, including rat traps. Pre-baiting is essential to allow rats to associate rat traps with feeding stations, a process that may take several weeks. Only after rats have become used to traps should the trapping portion of the control effort move forward.
- **Glue Boards.** Glue or sticky boards are effective for supplementing other trapping methods in challenging areas. Glue boards work especially well in established rat pathways of travel where other traps cannot be easily placed. If a trapping program fails to trap all individuals that then become trap shy, glue boards are an alternative method that can capture the remaining rogue individuals. Glue boards will only be used indoors and will be checked daily.

Chemical Control

The District is aware of the potential for secondary effects of rodenticide use in and near natural lands on native wildlife species, and is committed to strictly regulating rodenticide uses on its lands to the full extent possible. The District intends to use all non-chemical control options before selecting rodenticides as a treatment option, except in instances where rodent infestations are determined to present a public health issue. The District goal is to reduce all rodenticide use on its lands over time to the full extent possible, while still protecting human health. The following section carefully lays out the effects and limitations of each type of rodenticide product, and provides guidance for District staff selection of the least toxic effective treatment option in the event that chemical control of rodents must be utilized.

Primary versus Secondary Poisoning. Non-target poisoning is divided into two scenarios: 1) a non-target animal intercepts the bait – referred to as "primary exposure"; and 2) a non-target animal ingests a prey species that has been exposed to the toxicant – referred to as "secondary exposure." Rodenticides typically have high degrees of mammalian toxicity compared to other types of pesticides so it is important to control how these compounds are presented to target rodent pests. Acute toxicant baits can attract non-target mammals and birds so these baits must be presented in environments where only rodents have a chance of encountering them. Sealed box bait stations are now common for nearly all rodent baits used in structures to prevent pets and people from encountering the baits. Bait stations are usually designed for urban environments and they offer little protection to stronger wildlife species such as raccoons, badgers and bears that can easily open them (Erickson 2004). To better protect non-target wildlife species in the urban-wildlife interface, custom protective devices can be installed to shield bait stations from non-target wildlife species. Because predators generally prefer to catch and eat live prey, acute toxicants (the products that work quickly on the target animal resulting in a quick mortality) rarely cause secondary exposures to predators and scavengers.

Acute Rodenticide – Cholecalciferol (Vitamin D3). Cholecalciferol is a natural form of Vitamin D that is industrially synthesized from lanolin (sheep's wool) to produce human dietary supplements and rodent poison. In very high doses, it causes mobilization of calcium from the bone matrix to blood plasma, causing hypercalcemia and death. It is especially toxic to rodents and a single dose of toxicant acts as an acute poison. It is the only current rodenticide in California labeled for organic food production (OMRI 2013). Cholecalciferol is considered a novel mode of action for rodenticides and can be used in urban areas where rodents have developed resistance to other anticoagulants (Marshall 1984). It is considered a low risk for secondary poisoning in wildlife but can be a hazard to non-target pets that directly consume the bait. Rodenticides will only be used inside in tamper-proof anchored containers.

SKUNKS, OPOSSUMS, AND RACCOONS

Skunks, opossums, and raccoons are native mammals that have the potential to take residence in District structures as unwelcome guests. All these species are exceptionally common on District lands and generally will not bother humans. On rare occasions, they may invade trash cans, open kitchens, or den under and within structures. CDFW regulates these species as nongame or furbearer animals so they all may be controlled without permits if found causing agricultural damage or nuisance problems.

PEST MANAGEMENT STRATEGIES FOR SKUNKS, OPOSSUMS AND RACCOONS

Prevention

- Ensure outside garbage cans and dumpsters have tight-fitting lids to prevent foraging on human wastes. This is especially important in public gathering areas in parks and open spaces. Cans with domed lids and self-closing, hinged lids are preferred in these outside areas.
- Clean all kitchen and food storage surfaces regularly; sweep and vacuum kitchen floors daily. Shared use items such as sinks, microwaves, and vending machines should be cleaned regularly to eliminate spills.
- Do not leave pet food in open bowls overnight. Wash pet food bowls immediately after feeding.

Habitat Modification

- Use stainless steel/bronze mesh or welded wire to plug/fill cracks and holes in the exterior of building where large animals could gain entry.
- For larger openings, such as under decks and porches, fully enclose with plywood, concrete or wire mesh to prevent animals from making dens under structures. If animals are already denning in the areas, use one-way, hinged doors to allow them out but preventing them from returning. Confirm there are no juvenile animals in the den before using one-way doors.
- For raccoons in challenging areas, a single electrified strand of wire elevated eight inches from the ground can be used to deter them entering the area.

Physical Control

- **Box and Cage Traps.** All skunks, opossum, and raccoons are easily trapped with live box or cage traps. Trap design varies but solid wall traps are preferred for skunks to shield the trapper from skunk spray during the control operation. The use of live trapping methods ensures that non-target animals can be released unharmed. Current CDFW trapping regulations requires that trapped animals are either released immediately or euthanized, live animals may not be relocated without a permit from CDFW.

Chemical Control

Currently there are no toxicants or fertility control agents available in California for these species.

BATS

Bats are California's only flying mammal. There are a wide variety of bats (more than 16 species in all) that inhabit all habitats in the Bay Area; some are solitary and others colonial. All California bat species are insectivorous and they provide an ecologically valuable service of consuming vast quantities of insect pests such as mosquitos (Gannon 2003). Though they generally benefit humans greatly, bats secretive nature, nocturnal habits, coarse appearance, ability to fly, and habitation near humans have contributed to folklore, superstition, fear and ultimately persecution.

Some species of colonial bats can become structural pests when they establish colonies in homes or other human structures. Some species prefer dark open spaces, such as attics and basements and others prefer small cracks/crevices, such as between roof tiles/shingles or behind shutters (Greenhall and Frantz, 1994). One human structure can actually support a wide diversity of bat species. Though many bat species are tolerant of humans, many humans are not tolerant of bats.

Common damages caused by bats are noise coming from bat roosts, smells coming from their urine and guano, potential disease such as rabies and histoplasmosis, and discomfort anytime their presence is too close to humans in structures (CDFW 2008). Most bat damage can be mitigated with prevention and habitat modification techniques to make human structures less inviting or completely exclude bat roosting.

PREVENTION AND HABITAT MODIFICATION

- Carefully assess where bats are entering structures and modify the building to exclude future entry. Since bats are extremely small, fly and can squeeze into very small spaces, assessing bat entry points can be a tedious and challenging exercise. Evaluate spaces during day/nighttime hours; use smoke pens, and infrared cameras to assist in detecting breeches to the building envelope. Consult bat exclusion specialists for challenging structural projects.
- Install flashing, screening or netting in obvious roof/gable areas where bats can roost.
- Caulk cracks in masonry, especially chimneys.
- Use one-way trap doors to allow bats to escape roost areas after exclusionary methods are completed.

TRAPPING

- Trapping is not recommended as its more time consuming and less effective than strategic exclusion as discussed above.

CHEMICAL CONTROL

- Currently there are no toxicants or fertility control agents available in California for these species.

6.7.3 FERAL DOMESTIC PETS

Domestic pets such as feral cats and stray dogs can sometimes become structural pests. Uncontrolled feral domestic pets, unlike most wildlife, are often highly habituated to humans and therefore much more likely to come in very close contact with District staff, tenants, visitors and livestock (Information Services 2012). These close encounters can lead to increased chances of physical injury, disease transmission, contamination of District facilities and injury to tenant livestock.

Cats and dogs are generally considered private personal property when ownership can be established through collars, registration tags, microchips, tattoos, brands or other proof of ownership. Pets without identification can be considered free roaming, uncontrolled private property or feral (wild) animals. In California, both state and local laws govern domestic animal damage control under Fish & Game, agriculture codes and local ordinances. District staff consult local city and county ordinances and animal control departments when conducting any domestic animal control actions.

PREVENTION AND HABITAT MODIFICATION

- Feral domestic pets are often relics of old structures/settlements. If the District inherits older buildings/infrastructure, consider demolition or wildlife exclusion retrofitting so the structures can no longer support animals.
- Control of excessive rodent populations in structures can also help control feral cat populations.
- Ensure outside garbage cans and dumpsters have tight-fitting lids to prevent foraging on human food waste. This is especially important in public gathering areas in parks and open spaces. Cans with domed lids and self-closing, hinged lids are preferred in these outside areas.
- Ensure District staff and tenants have properly placed any bird feeders or bird nest boxes such that they do not also serve as cat feeding stations.
- Prohibit staff and tenants from feeding feral domestic pets on District property. Develop education programs to encourage the public not to feed wildlife or feral animals on District property.

TRAPPING

- Live trapping is effective to capture problem cats but generally ineffective for dogs in California (Fitzwater 1994, Green 2012). Because feral domestic pets may be private property, District staff conducts all trapping in conjunction with local animal control departments and/or animal shelters.

This page intentionally left blank.

7 IPM FOR RECREATIONAL FACILITIES

7.1 DEFINITION AND PURPOSE

Human use is typically concentrated on preserves at the recreational facilities provided by the District. Recreational facilities within District preserves currently include approximately 479 miles of access road and trails as well as associated infrastructure (i.e., bridges, culverts, drainage ditches, parking lots, gates, stiles, bathrooms), picnic areas, one campground, off-leash dog zones, managed turf and landscaped recreation areas, pond viewing and dam areas, and Deer Hollow Farm).

Nuisance pests in and around recreational facilities include plants, insects and wildlife that can temporarily affect the District's visitor experience in a negative manner. Sometimes nuisance pests at recreational facilities become problematic when there are extra resources readily available (e.g., food, water, shelter) and therefore can be managed with physical control options (e.g., controlling food-trash in picnic and camping areas).

The purpose of pest control in and around recreational facilities is to manage pests for human enjoyment of the the natural and scenic qualities of the preserves while also minimizing human exposure to pests. The maintenance of vegetation alongside roads and trails and the control of stinging or biting insects or reptiles at recreational facilities must incorporate protection of the surrounding natural resources as a primary consideration. Unlike buildings, recreational facilities are almost always located in natural (undeveloped) areas, therefore, pest control solutions must also consider protection of the surrounding natural resources as a primary consideration.

7.2 TYPE OF PESTS

7.2.1 NUISANCE PESTS IN RECREATIONAL FACILITIES

Nuisance pests include native and naturalized plants, insects and wildlife that are present throughout the region and are generally compatible with the District's mission and goals. Conflict only occurs when these species become overabundant or exceptionally close to staff and visitors. For example, native social wasps in outside areas would normally be tolerated, but a wasp nest in a public bathroom would be considered an unacceptable risk to visitor health and enjoyment of District lands.

The determination of a nuisance pest can be quite variable depending on the tolerance of staff or the visitor to any real or perceived harm. Care must be exercised when defining tolerance levels for each pest species. One must consider the actual damage potential of the organism versus the cultural acceptance to the risk that the organism poses. For example, poison oak is an important native plant that occurs throughout District lands and is quite common along trails. Educating the public about the effects of poison oak exposure to humans (dermatitis) is the first option to reducing perceived risk of exposure to this pest. When visitors complain about incidences of poison oak exposure, District staff must consider the context of the poison oak exposure risk. At trailheads, campgrounds, and other areas where potential for frequent visitor interactions is high, staff may elect to routinely control poison oak. In contrast, infrequent brushing and/or installation of educational signs may be appropriate for poison oak at remote, backcountry trails that are rarely visited. The District's recreational facility IPM decision-making must always balance health and human safety concerns with the District's goals to protect natural resources.

7.3 PEST IDENTIFICATION

Nuisance pests are generally identified by chance encounters by District staff, tenants and visitors. Because recreational facilities have more intensive utilization than the District's surrounding natural areas, nuisance pests can usually be identified relatively quickly before the problem reaches levels where active pest management is required. Routine inspections of recreational facilities should focus on identifying conditions where visitor use levels are high, and where conditions can result in excess food, shelter, and access that support pest problems.

Many nuisance pests can be anticipated and their management scheduled based on an understanding of their biology and behavior. For example, some types of native vegetation growth outwards onto roads and trails in search of light and space can be anticipated and preventative treatment (brushing) can be scheduled on an annual or periodic basis. District staff can identify problem areas with excess vegetation along trails each year, and schedule abatement accordingly. Other pests may present themselves randomly and/or rarely. For example, a rattlesnake denning along a trailside is a relatively infrequent occurrence. These infrequent pest problems are usually best reported when the staff and/or visitors encounter them.

7.4 PREVENTION AND RETROFIT

Nuisance pest control in recreational facilities focuses on first modifying the behavior of humans or the structure of our environment to reduce or eliminate the problem. The District's IPM program relies on cultural pest control practices, such as product design or retrofit and behavior modification as the primary pest control treatments, with active chemical or lethal controls used only as a last resort.

This section describes general operational procedures intended to prevent or minimize the need for pest control in recreational facilities. The District will undertake some or all of the following to help prevent pest infestation from reaching action thresholds:

- staff training,
- public education regarding identification and avoidance of naturally-occurring nuisance pests,
- structural changes intended to pest-proof recreational facilities,
- general sanitation and maintenance actions,
- landscape maintenance, and
- waste management procedures.

District procedures for these preventative actions are described in more detail below.

7.4.1 PREVENTION

Many pest outbreaks can be managed with cultural control options such as changing human behavior (e.g., promoting removal of food-related trash, installing educational signs promoting human avoidance of naturally occurring pests, temporary closures of facilities during periods pests are most likely to be present to physically separate visitors and pests) and engineered control options within our recreational facilities (e.g., securing garbage cans, managing vegetation around heavily used recreational facilities, sealing off buildings and structures). Many open space and park districts throughout the nation have dramatically reduced human-wildlife encounters by simply making food and garbage unavailable with wildlife-proof garbage cans (Decker et al. 2008, Herrero et al. 2005). This simple, single engineering solution reduces wildlife habituation to humans, ultimately reducing human conflicts with stinging insects, raccoons, skunks, coyotes and other naturally-occurring nuisance pest species.

Feeding wildlife can significantly increase nuisance wildlife problems in the District. Using postings and other educational materials in District picnic areas, parking lots and trailheads can help inform the public that feeding wildlife ultimately causes them great harm. Postings should emphasize that passive feeding (i.e., poor sanitation) is as detrimental to wildlife as active feeding, and that visitors should remove their food-related trash at the end of their visit. Educational postings for conservation related topics are best supported by both active and passive enforcement, or otherwise tend to be ineffective (Baruch-Mordo et al. 2011).

Recreational facilities pest problems are often temporary in nature. Rattlesnakes and skunks may temporarily occupy a facility, but otherwise remain unseen by visitors. Instead of actively managing the pest itself, the District can install educational signs promoting human avoidance of naturally occurring pests, or the facility can be temporarily closed (for buildings and other facilities) or rerouted (for trails) so District staff or visitors remain safe during time periods when pests are most likely to occur.

7.4.2 RETROFIT

The District will train staff to regularly assess and manage the areas within recreational facilities that are known to attract pests. Some examples of such areas include:

- storage areas for tools, seeds and plant materials, food, research supplies,
- waste management areas: trash cans, trash compactors, dumpsters, etc.,
- drainage areas,
- plumbing (faulty plumbing such as leaky pipes can support pests),
- entryways and windows (ensure tight seals to prevent pest entry),
- landscaped areas, especially immediately adjacent to buildings,
- storage areas (such as woodpiles) located next to buildings.

District supervisors should regularly inspect such areas and provide additional training or educational materials to encourage staff to keep such areas clean and pest free. In addition, for buildings used for storage of equipment and vegetation materials such as seed, hay or livestock feeds, and all other materials that could attract rodents will be sealed in plastic or metal containers with tight fitting lids. Actions to prevent or reduce nuisance pests in recreational facilities include:

- Train staff about proper storage of work supplies in non-occupied buildings.
  - Store all pet food, animal grains, hay, and other consumable agricultural supplies in sealed containers metal/plastic containers.
  - Store plant seeds used for habitat restoration and landscaping in sealed containers.
- Position attractive harborage areas, such as rock piles, soil storage piles, hay and erosion control materials away from recreational facilities.
- Control food waste in contractor work areas, outbuildings, storage areas and other non-occupied recreational facilities. Provide sealed garbage containers in or near such areas to prevent inadvertent disposal.
- Reduce, monitor, and where possible eliminate use and import of natural materials that could introduce pests onto District lands, such as reducing use of offsite fill (soil, gravel, and rock) and livestock feeds (hay) that may contain weed seeds. Where possible, include requirements to utilize onsite fill, require balanced cut and fill projects on District lands, and require use of certified weed-free erosion control materials for construction projects on District lands.

In addition, landscaping around recreational facilities can harbor pests. Maintenance staff should prune back or remove dense vegetation such as ivy and any landscape vegetation that touches buildings, providing a physical pathway for pests such as ants to access the building. In addition, maintenance of healthy landscapes through proper fertilization, watering, pruning and aeration is also thought to reduce potential for pests to reach problematic levels.

Landscape design and good landscape maintenance practices can discourage pests and encourage healthy plantings that may resist pest establishment. Some options for pest prevention and reduction in landscaped areas include:

- appropriate cleaning and maintenance of tools and equipment;
- selection of new landscape design intended to discourage landscape pest species;
- replacement of older landscaping design when it is found to harbor pests (e.g., dense vegetation such as ivy near buildings);
- monitoring of landscaping plants for secondary pests (such as aphids or scale), and treatment as necessary to prevent nuisance pest outbreaks (such as ants).
- ensuring new planting materials are clean of pests and disease;
- selection of pest-resistant plants for landscape maintenance projects;
- positioning planting sites away from buildings;
- proper irrigation design, proper watering practices.

In the event of a pest outbreak in landscaped areas, choose least environmentally disruptive and harmful, effective treatments for landscape pest species.

7.4.1 TIMED MAINTENANCE

Many nuisance pests can be managed through preventative treatments based on an understanding of their biology and behavior. This is especially true for the District's routine maintenance needs for horticultural landscaping and native vegetation along gates, stiles, trails and access roads. Native vegetation grows vigorously after being cut because of plant hormone responses and changes in the availability of soil nutrients (Par and Way, 1988). Vegetation types that are regularly mowed with mechanical equipment have predictable regrowth times that can be measured and incorporated into routine District maintenance schedules. To prevent road and trailside vegetation from becoming a nuisance pest, mechanical brushing can be scheduled for specific times of year to abate the hazard before it becomes a problem. Roadside brushing also serves as secondary control for other nuisance insect and wildlife species. The reduction of cover near trails reduces the chances that visitors and staff will encounter ticks and rattlesnakes.

Some native perennial vegetation (e.g., poison oak or stinging nettles) is less tolerated by humans than other types of native vegetation. The presence of such vegetation may not be appropriate for some trailside locations that have high visitation rates. These special circumstances require the use of more complex management tools for perennial plants such as chemical control. Refer to vegetation management options presented for perennial plants, as detailed in Chapter 10, Section 10.8 for such special circumstances.

7.4.2 PLANT HEALTH CARE

Many nuisance pests in horticultural landscaping and turf (e.g., as mildews, rusts, aphids, whiteflies) can be controlled with routine and proper horticultural practices. Proper watering, fertilization, and cutting/pruning can insure horticultural plants have sufficient resources to grow well without providing support to fungal, insect and mammalian pests. Horticultural plants that are especially susceptible to nuisance landscaping pests should be considered for replacement with more suitable varieties. Often pests can be 'designed' out of the landscape by choosing more appropriate species or varieties for a specific location.

7.5 DAMAGE ASSESSMENT

Determine what, if any, damage to recreational facilities or the visitors using them is present. If there is no damage to a recreational facility, but a nuisance pest is present that is in conflict with human use or enjoyment of the structure, determine the tolerance level for each nuisance pest species to determine if control is warranted. To the extent possible, quantify the damage (square feet or number of occurrences affected) and qualitatively describe the perceived damage in its context.

7.6 TOLERANCE LEVELS/THRESHOLD FOR ACTION

Recreational facility IPM focuses on modifying the structure of the environment to balance nuisance pest conflicts with visitor needs. In recreational facility pest management, often small retrofits or facility modification can reduce risk of exposure, or manage the pest population down to acceptable tolerance levels.

Tolerance levels vary greatly for nuisance pests in recreational facilities. Most nuisance pest species are native species that are compatible with the District's goals for conservation. The District's IPM approach for nuisance pest species begins with establishing tolerance levels that balance human safety, enjoyment, and comfort within visitor facilities with the ability to conserve natural resources, meet regulatory requirements and cost/benefit assessment. Human safety and enjoyment is the primary metric for establishing tolerance levels in visitor facilities. Staff and visitor safety is paramount in regulating treatment actions for nuisance pests. Tolerance levels will consider conservation goals and impacts to the larger surrounding natural system in determining treatment actions.

Refer to Table 7-1 below for management thresholds, and possible treatment options for nuisance pests in and near recreational facilities, presented by pest category.

Table 7-1 Management Thresholds and Treatment Options for Nuisance Insect, Animal, and Plant Pests in Recreational Facilities

Pest Category	Management Threshold (Population Size/Conditions)	Treatment
Mosquitoes	Detection of pest at levels at levels that could cause human health problems, populations causing visitor discomfort or as required by local regulatory agencies.	Use a combination of the following: ◢ Inspect areas in vicinity of problem area for standing water and other potential mosquito breeding sites. Where possible, repair or drain /eliminate potential breeding habitats ◢ Educate visitors about mosquitos and human health risks by posting temporary signs in problem areas ◢ Protect workers by requiring use of protective clothing when working in affected areas ◢ Use BTI discs in water troughs ◢ For ongoing pest issues, contact a local county Mosquito and Vector Control District to schedule treatment (District to comply with legal requirements to control mosquitos for human health and safety).

Table 7-1 Management Thresholds and Treatment Options for Nuisance Insect, Animal, and Plant Pests in Recreational Facilities

Pest Category	Management Threshold (Population Size/Conditions)	Treatment
Social Wasps	Populations causing conflict with humans near structures or other high use visitor areas	Use a combination of the following: ◢ Remove or enclose attractants in well-sealed containers (trash cans, etc.) ◢ Use baited non-toxic water traps (late winter and early spring) ◢ Use non-toxic lure traps set approximately 200 feet apart.
	Nests determined to pose immediate threat to human safety	Use a combination of the following: ◢ Physically remove problem nests with water jets or by digging ◢ Use Pyrethrin aerosol spray to target individual nests.
Ticks	Detection of multiple individual in work areas or offices, tick populations causing visitor discomfort.	Use a combination of the following: ◢ Remove and destroy individual ticks. ◢ (See also preventative trail maintenance for native vegetation below.)
Rattlesnakes	Individuals within structures or recreational facilities where contact with humans is likely	Use a combination of the following: ◢ Trap and relocate (obtain appropriate permits from CDFW). ◢ Block access to structures and remove hiding places adjacent to structures and high public use areas.
Native vegetation along trails and roads (poison oak, stinging or scratching plants, brush)	Conditions could cause severe discomfort or health hazards to visitors, volunteers, and staff, or vegetation that is blocking emergency access.	Follow District guidelines for trail clearing in various habitats and slopes. ◢ Mow and prune buffers along trails and roads to reduce direct contact by visitors. ◢ Herbicide use on perennial species only if permanent control is needed.

7.7 TREATMENT OPTIONS

In recreational facilities, pest tolerance levels are based on ensuring the health and enjoyment of visitors, in addition to human health and safety requirements, by following the District adopted details and specifications for trail and other recreational facilities.

When the presence of pests in recreational facilities is determined to require action, pest prevention actions the District may consider in recreational facilities include:

- Reducing the attractiveness of the recreational facilities areas to pests. For example, remove rock and brush piles that are attractive to snakes; seal small burrows and holes that attract ground-dwelling pests; regularly remove food debris that can attract wildlife (e.g., skunks, ravens).
- Educating the public about interactions with wild creatures such as snakes and ticks, and providing suggestions for avoiding unpleasant or dangerous interactions. Support this action with proactive enforcement.
- Sealing up entrances in and near recreational facilities to discourage pest occupation (e.g., screening air vents to bathrooms, screening in overhangs to prevent pests from entering the facility).
- Cutting back unwanted brush such as poison oak along trailheads and high use trails to reduce potential for visitor interaction.
- Mowing high grasses along heavily used trails where ticks tend to congregate.

Pest management options for nuisance pests in and around recreational facilities are the same for insect and wildlife pests in buildings that is described above in Chapter 6. The following section describes additional nuisance pests that are not covered in Chapter 6.

Where pesticide use is determined to be the only viable treatment option to address the specific infestation of concern in and around recreational facilities, selection of least harmful products is required. In these limited instances, only pesticides on the District's List of Approved Pesticides (Table 1.1, Appendix A) may be utilized.

The chemical control options presented in this Chapter represent the least harmful, most efficient treatment methods for controlling structural pests. For example, a wasp nest in a public restroom may require use of a pyrethroid wasp spray to immediately eliminate the hazard of wasp injury to visitors. The inclusion of a variety of pest treatment method options in the IPM program allows the District to respond with the necessary tools based on actual risk to the District, its visitors, workers, structures, and lands.

7.7.1 STINGING INSECTS

MOSQUITOES

Mosquitoes are a family of small, midge-like flies in the *Culicidae* family. Most mosquitoes are considered a pest species because they consume blood from vertebrates, including humans and can transmit diseases and cause uncomfortable dermatitis. Mosquitoes go through four life stages: egg, larva, pupa, and adult. The first three life stages are largely aquatic and last approximately 14 days. Control of wet areas, including stagnant standing rain water, stock ponds, and even ponded water from leaky pipes is therefore an effective control strategy for controlling this pest species. The females of many, but not all species of mosquitoes consume blood during a portion of their life cycle. In feeding on blood, some species of mosquitos can transmit extremely harmful human and livestock diseases, such as West Nile virus and Malaria. Therefore, pest control focuses on elimination of stagnant water and wet area habitats, and on control of adults' population numbers where a health concern is detected.

Although mosquitos are members of the ecosystems of natural areas, the threat of mosquito bites makes them unwelcome in and near buildings and recreational facilities. Mosquitos are generally only considered pests when their population numbers are incompatible with human health and safety, at which point the District will contact the appropriate county Mosquito and Vector Control District. The county Mosquito and Vector Control District is the agency responsible for monitoring disease outbreaks, and implementing necessary pest control for human health and safety.

PEST MANAGEMENT STRATEGIES FOR MOSQUITOES

Prevention

In addition to actions taken by local county Mosquito and Vector Control District to detect and control mosquito populations in natural areas, the District can also implement many non-chemical, cultural control methods to prevent infestation or reduce the number of adult mosquitoes that come into contact with workers and visitors. Depending on the situation, the most important usually include:

- source reduction (e.g., removing stagnant water around), and
- education (e.g., posting public information signs to inform visitors about mosquitos and human health risks).

Physical Control

- Install and maintain window screening in recreational buildings.

- Train staff to protect themselves from exposure by wearing long-sleeved clothing, tucking pant legs into socks and/or taping pant cuffs close to the body.

Chemical Control

The District places *Bti* disks (*Bacillus thuringiensis israelensis*) in watering troughs throughout the preserves to control mosquitoes. *Bti* is a specific type of bacteria that prevent mosquito larvae from developing.

Where other forms of chemical control are determined to be the only viable treatment option to address the specific infestation of concern in and around recreational facilities, the District will contact the appropriate county Mosquito and Vector Control District for assistance and will comply with legal requirements to control mosquitos for human health and safety).

SOCIAL WASPS

Social wasps are a large group of native stinging insects that include yellow jackets, hornets, and mud daubers. Wasps' yellow and black color schemes and social behavior are shared with distantly related bees. Like bees, wasps are an important group of native insects that perform valuable ecological functions in our natural world (Hinkle et al. 2002). Most of the species in this group are generalist insect predators that are essential in their natural environments to aid in decomposition, control populations of other insects, and some even pollinate flowers like bees. Although wasps are important members of the ecosystems of natural areas, the threat of wasp stings makes them unwelcome intruders in and near buildings and recreational facilities. Social wasps are generally only considered pests when their nests are located in areas where they are incompatible with human use. For example, when social wasps nest under the eaves of buildings or alongside trails, they can sometimes exhibit aggressive protective behaviors that can threaten humans with painful and sometimes dangerous stings. Where multiple stinging incidents occur, District staff will consider control of wasp nests.

Wasps belong to a large group of insects in the family *Hymenoptera* that includes ants, bees, and wasps. Many genera and species within *Hymenoptera* are difficult to tell apart as they share similar body shapes and color schemes. Because many of these *Hymenopteran* insects have protective stings and bites, even some other species outside the family like flies have adapted their body styles to mimic wasps. For this reason, staff must be careful to properly identify the pest to species to ensure that it is an actual nuisance pest species that can sting, rather than a similarly shaped or colored harmless species.

Like bees, wasps are social organisms that live together in colonies where individuals have specialized roles. Queens emerge from hibernation each spring to build nests and start larger colonies composed of workers. Pupae are raised in cell-like structures within paper or mud nests that are tended by workers and queens. Different species build different types of nests – from small mud structures that are attached to ledges to aerial and underground paper-type nests. Different species also have different foraging habits. Some prefer hunting for carrion and sweet liquids while others prefer hunting live prey. The species that forage for carrion and sweet liquids are often the most problematic individuals that disturb picnickers.

PEST MANAGEMENT STRATEGIES FOR SOCIAL WASPS

Prevention

- Ensure outside garbage cans and dumpsters have tight-fitting lids to prevent wasps from foraging on human food wastes. This is especially important in public picnic and gathering areas in parks and open spaces. Cans with domed lids and self-closing, hinged lids are preferred in these outside areas.
- Periodically clean the hinged-lids of garbage and recycling bins so spilled sweet liquids do not attract wasps to picnic areas.

- Ensure all exterior windows that open have tight-fitting insect screens to prevent wasps from gaining entry from the outside when windows are opened.
- If concessionaires sell soft drinks and other sweet liquids on District properties, require drinks to be sold with straws and tight fitting lids to prevent wasps from entering drinking containers while in use.

Physical Control

- Install baited non-toxic water traps in late winter and early spring to reduce queens in problem areas where wasps are known to be regularly problematic.
- Install pesticide-free lure traps set approximately 200 feet apart in outside problem areas where human/wasp conflicts are known to occur (e.g., picnic areas, outside amphitheaters). Place traps between the center of human activity and natural areas in an attempt to attract wasps away from humans instead of attracting more wasps to human areas.
- Physically remove problem wasp nests with water jets or by digging them out of underground locations. Ensure pest control workers wear protective beekeeper suits to reduce the potential for dangerous stings.

Chemical Control

- **Pyrethrin Aerosol Sprays.** Pyrethrin-type aerosol sprays containing d-trans allethrin and phenothrin are only recommended where immediate threats exist to human health and safety. These aerosol sprays are extremely effective at immediately eliminating single, problem wasp nests that threaten District staff or visitors. The pyrethrin-type sprays work as a contact neuro-poison that results in near immediate mortality of any insect (Jackson 2011). The sprays offer a relatively safe and effective means for park ranger and maintenance workers responding to immediate threats of wasp nests. Contact pyrethrins are completely non-selective, so care must be taken to target only the pest wasp and not to impact other beneficial insects. Contact sprays do not offer population-level control for wasps; diligent sanitation and early seasonal queen trapping are the only known methods to effectively reduce populations of stinging wasps in open landscapes.

7.7.2 TICKS

The western black-legged tick (*Ixodes pacificus*) is a native arachnid (i.e., spider relative) that is very common in grasslands, scrub, and woodlands throughout District lands. Black-legged ticks are common parasites of native mammals such as deer, but they can also be problematic parasites of District visitors and staff. To complete their life cycles, ticks must feed on blood and for this reason can also be dangerous vectors that can transmit blood-borne diseases such as Rocky Mountain spotted fever, Lyme disease, and tularemia (CDC 2013b). Ticks are an important part of the natural environment and are present on District lands in abundance. Due to their prevalence in naturally occurring deer populations that move through District lands, eradication of ticks in natural areas is impossible; however, some level of preventative control may be warranted in high visitor use areas in and around recreational facilities and buildings. Ticks can be especially problematic indoors where field staff work and store clothing; staff returning from field work can unknowingly introduce ticks into buildings where they can be transmitted to unsuspecting office workers.

PEST MANAGEMENT STRATEGIES FOR TICKS

Prevention

- In high visitor use areas, regularly cut or mow alongside trails and picnic areas to reduce the chance of visitors and staff picking up ticks. Ticks often summit tall grass blades and shrub branches to “catch” or brush against a passing animal. Keeping vegetation cut low and pruned reduces the opportunities for ticks to utilize this strategy in areas with high pedestrian use.
- Post tick educational materials in District offices and at major trailheads and parking areas.

- Regularly vacuum carpeted areas where District employees work.
- Ensure all exterior windows that open have tight-fitting insect screens to prevent ticks from gaining entry from outside when windows are opened.

Physical Control

- Install carbon dioxide traps daily to collect ticks in field offices where field staff regularly begin and end field days. This may be especially effective in staff changing rooms where field clothes are shed, changed, and stored.
- Train staff to protect themselves from exposure by wearing light colored long-sleeved clothing, tucking pant legs into socks and/or taping pant cuffs close to the body; performing regular inspections of clothing and exposed areas such as the head and neck; and showering or bathing and inspecting their bodies as soon as possible upon completion of work.
- Post educational signs with the information above to help inform visitors of tick prevention and detection strategies they can employ before and after using recreational facilities.
- As ticks are found, remove and destroy individuals.

Chemical Control

No chemical control strategies are recommended for ticks.

7.7.3 NUISANCE ANIMALS

RATTLESNAKES

Rattlesnakes are the only type of venomous snake found in California. They are native to California and are considered to be important predators that help keep rodent populations under control. Rattlesnakes are generally extremely wary of humans and tend to shy away from human activities. They are not aggressive towards humans unless cornered, surprised, or stepped-on. Occasionally, they can be considered nuisance pests when they find themselves too close to recreational facilities, occupied buildings, or other areas where human encounters are likely. Though important to the natural world, the threat of rattlesnake bites makes them unwelcome pests in certain portions of District lands.

PEST MANAGEMENT STRATEGIES FOR RATTLESNAKES

Prevention

- District field staff can protect themselves from rattlesnake bites during workdays by wearing high-top leather boots and snake-resistant chaps or gaiters. Snake gaiters are also useful in preventing the dispersal of non-native weed seeds, since weed seeds usually do not penetrate the gaiters.
- Educational materials can warn visitors about rattlesnake hazards and suggest preventative actions such as wearing protective clothing, as described above for District field staff.

Habitat Modification

- Eliminate hiding places for snakes by trailheads and parking areas with brushing, removing rock and brush piles near busy human use areas especially those with children, and filling cracks and holes in publicly accessible buildings. Use stainless steel/bronze mesh or welded wire to plug/fill cracks and holes in the exterior of buildings where snakes could gain entry.

- Where rattlesnake sightings are common, manage recreational facilities during the spring and summer months to reduce suitable habitat, and especially eliminate hiding places for snakes (e.g., brushing trailheads and parking areas, removing rock and brush piles, managing localized prey populations near known snake problem area, filling cracks and holes in public accessible buildings).

Physical Control

- **Tongs and Funnel Traps.** In certain areas (especially in structures and recreational facilities where humans gather and there is potential for snakebites), the District may elect to capture and relocate, or eliminate single problem snakes.

  - Using snake tongs, snake hooks or shovels, capture and relocate or eliminate problem rattlesnakes. Captured rattlesnakes can be placed in a secure container for relocation in the preserve to suitable habitat away from people. Occasionally, because of site conditions or the urgency of the situation, a staff member or tenant may need to kill a rattlesnake with a shovel.
  - Funnel traps can be used to collect problem snakes. Traps must be checked daily to ensure that non-target wildlife is not trapped accidentally.

Chemical Control

Currently there are no toxicants or fertility control agents available in California for rattlesnakes.

OTHER NATIVE AND DOMESTIC MAMMALS

See discussion of skunks, raccoons, opossum, and feral cats/dogs in Chapter 6 above.

7.7.4 VEGETATION MANAGEMENT OF TRAILS AND OTHER RECREATIONAL FACILITIES

The majority of IPM activity associated with recreational facilities is annual brushing (i.e., pruning of vegetation along roads and trails) which keeps them open for vehicular, horse, bicycle and human foot traffic, and furthermore provides a buffer area to separate humans from pests like ticks, rattlesnakes and poison oak. The District maintains guidelines for road and trail brushing that prescribe different treatments for different vegetation types and slope conditions (District 2013). Mowers and saws may be used by District staff to maintain grass and shrubs near roads and trails in short stature, limb up overhanging tree branches, and remove dead or decadent vegetation. Wider strips of brushing occur along certain roads to provide access for emergency vehicles.

The following section outlines typical vegetation management actions conducted in right of way areas on District lands.

PEST MANAGEMENT STRATEGIES FOR VEGETATION RIGHTS-OF-WAY

Prevention

- Prepare an annual treatment schedule for maintaining designated trail and roadside rights-of way based on use and vegetation types. Mechanically mow and brush annually to prevent nuisance vegetation from impeding roads and trails.

Habitat Modification

- Where possible, pave trailheads, parking lots or other heavily used right-of-ways to reduce annual maintenance needs.
- Eliminate roads, trails, or other rights-of-ways that are determined to be redundant or not necessary.

Physical Control

Manual/mechanical control treatment options include maintenance of existing recreational facilities within District preserves via brushing and/or mowing:

- *Road and trail brushing*. Mechanical mowing is used to prevent nuisance vegetation from impeding roads and trails. Vegetation along approximately 600 miles of trails and roads is cut back to maintain an open corridor for trail and road use. This work is primarily mechanical work done with brushcutters (a.k.a. weed-whips), hedgers, chainsaws, poles saws, chippers, and tractor-operated mowers (mowing decks either pulled by a tractor or attached to the tractor as part of an articulated arm). All roads are mowed one to four times per year depending on the rainfall/vegetation growth in any one year. Most trails are mowed or brushcut on an annual basis; some trails may need to be brushed up to four times a year if there is a lot of rain and it is a trail heavily used by the public. Some more remote trails may not be brushed every year.

- *Parking lots, gates, and stiles*. On an annual basis, a strip of land around 13 parking lots and 213 gates and stiles in the preserves are sprayed to maintain an open area for parking and visibility. A few of the locations are brushcut or mowed instead if they are large grassy areas or if there is water too close to allow spraying. Islands in the middle of parking lots or parking lots with narrow grassy edges are mowed.

- *Miscellaneous recreational areas.* A few miscellaneous recreational areas are mowed one to five times a year with a tractor pulling a mowing deck. This includes a model airplane field and three meadow areas along Rogue Valley Trail maintained at Rancho San Antonio Open Space Preserve (OSP), the picnic table area at the top of Anniversary Trail on Windy Hill OSP, and the hang gliding take off and landing areas at the top and bottom of Spring Ridge Trail of Windy Hill OSP. In addition, special events occur in the preserves each year (i.e.,Volunteer Recognition Event, summer camps, and other public gatherings) that require mowing of grassy areas. At Deer Hollow Farm in Rancho San Antonio OSP, pastures, animal pens and the Ohlone village are mowed four to five times per year with a tractor mower or brushcutters.

- *Campsite*. The Black Mountain campsite is mowed once a year to provide a comfortable camping experience and to reduce the risk of wildfire encroaching either into or out of the campground.

- *Pond Viewing Areas and Dams*. At some ponds, aquatic and terrestrial vegetation is managed at viewing areas and on dams. Windows of cattails and other tall wetland vegetation are removed in small select areas to allow public viewing of these water bodies. The California Division of Dam Safety requires all woody material be removed and tall herbaceous vegetation be cut on both faces of certain pond dams to improve visibility to see possible failure hazards. Vegetation on the water side of the dam is clipped with mowers and brush cutters; vegetation on the dry side of the dam is controlled with mowers and selective use of herbicides to maintain a light grassy vegetation cover. Woody vegetation is cut in pond spillway to prevent blockage of water flow. Duckweed or azola (aquatic fern) skimming has been done, with limited success, to control these plants from covering the entire surface of some ponds. Downed trees that have fallen in a pond can require removal for aesthetic or other management reasons.

- *Streambed Alteration*. The District follows conditions of an annual routine maintenance Streambed Alteration Agreement from CDFW for manual/mechanical vegetation management activities located within CDFW’s jurisdiction.

- *Hazard and downed trees*. An estimated 50 to 150 hazard and downed trees are limbed or removed every year with chainsaws, pole saws and chippers because they are blocking roads, trails and parking lots or are otherwise hazardous to visitors, staff, tenants or contractors They may be alive or dead. Stumps of live trees may be treated with herbicide to prevent re-growth.

Chemical Control

Chemical control is typically not used for right-of-way clearing unless perennial plants require permanent treatment. For example, some problem vegetation, such as poison oak, can be eliminated from specific locations with spot application of herbicides.

- **Glyphosate,** the active ingredient in Roundup Custom™ (previously sold as Aquamaster™), is a broad-spectrum non-selective systemic herbicide used to control a wide variety of plants, including annual broadleaf weeds, grasses, perennials, and woody plants. It is absorbed through foliage and translocated to growing points. Glyphosate's mode of action is to inhibit an enzyme involved in the synthesis of aromatic amino acids, making it effective on all herbaceous and woody growing plants. It is a rather slow-acting herbicide with symptoms typically appearing with a week, including yellowing and stunting a young leaves and growing points, however it may take up to several weeks for a plant to die.
- **Imazpyr,** the active ingredient in Polaris™ (previously sold as Habitat™), is a non-selective herbicide used to control a broad range of weeds including grasses, broadleaf herbs, woody plants, riparian plants, and emergent aquatic species. Imazapyr has a similar mode of action as glyphosate but acts on a different suite of essential amino acids. Imazapyr is absorbed by leaves and roots, and moves to growing points; it disrupts protein synthesis and interferes with cell growth and DNA synthesis, plants die as a result of AHS inhibition. To be effective on aquatic plants, the majority of plant parts must be accessible above the waterline. Imazapyr can be useful for difficult-to-control species when glyphosate is less effective, and with much lower application rates.

This page intentionally left blank.

8 IPM FOR FUEL MANAGEMENT

8.1 DEFINITION AND PURPOSE

This management category addresses IPM as it affects staff selection of options for required and ongoing maintenance of fuel management activities. Fuel management is the practice of removing or modifying vegetation to reduce the risk of wildfire ignitions, rates of wildfire spread, and fire intensity.

The District aims to manage fuels in a context that supports the maximum safety to adjacent human communities while also allowing fire as a natural process to maintain native species diversity on its preserves. The wildland urban interface (WUI) is the meeting point between wildland vegetation (i.e., fuels) and structures. The WUI warrants fuel management consideration because it is the area where there is the most threat of damage to human life and property. Other important areas to control flammable vegetation on District lands include access roads on and adjacent to District lands that are necessary for emergency access.

Fuel management is the practice of removing or modifying vegetation to reduce wildfire ignitions, rate of fire spread, and fire intensity. Changing the continuity of the vegetation, and reducing its volume are the two primary actions in fuel management. Preventative treatment actions may include temporary trail or equipment closures during fire season.

This chapter is not intended to replace a Fuel Management Plan, nor does it present the full range of fire risk management options available on District preserves.

No new major fuel breaks or fuel management activities on District lands would be implemented as part of the IPMP. The use of prescribed burns to restore natural conditions in preserves would also not be permitted as an option under the proposed IPMP. The IPMP would provide guidance to District staff in selecting the safest, least toxic, and most effective options to maintain existing fuel management activities. Consistent with current activities on District lands, the District's fuel management activities would first consider health, human safety, and regulatory requirements for local and state fire codes, and then balance these requirements with the District's goals to protect natural resources. For example, defensible space around structures is required and regulated under the Uniform Building Code, Uniform Fire Code, Public Resources Code Section 4291/4119, and County and City municipal codes and ordinances).

8.2 TYPE OF PESTS

In the context of IPM, vegetation at the WUI and vegetation around structures that could contribute to large, uncontrolled wildfires is considered a potential "pest" that may warrant control, depending on site-specific circumstances.

8.3 PEST IDENTIFICATION

Vegetation may be considered a pest where it becomes overabundant, decadent or exceptionally close to facilities, structures, and communities that people inhabit and use. At the same time, fire is a natural component of many common plant communities in the District and helps to maintain species diversity of native grasslands, shrublands, and forests.

8.4 MANAGING PLANT COMMUNITIES FOR FIRE SAFETY

The District is faced with the difficult task of protecting the natural values in their OSPs while also protecting the adjacent metropolitan and rural communities of San Mateo, Santa Clara, and Santa Cruz counties from catastrophic wildfires. These goals are sometimes mutually beneficial and they are sometimes mutually exclusive. Frequent, intense wildfires can be destructive to native plants, wildlife, and people. Conversely, our attempts to reduce or eliminate wildfire can also be destructive and this may have significant impacts on biodiversity (Keeley 2006). Use of fuel breaks and other fuel management techniques that disturb large areas can significantly change the composition of native vegetation or eliminate species altogether and help to spread and establish invasive weeds throughout natural areas.

In a natural burn cycle in shrublands and forests, recovering vegetation is less susceptible to repeat fires for several years after the initial burn (Minnich 2001, Pyne et.al, 1996). The lush new growth of resprouting species is supported by existing deep root systems that help reduce the plants' flammability by maintaining high moisture content in the above-ground growth. Shrub and tree species are also generally separated by bare ground or short statured annual forbs that will not carry a fire over the larger landscape. Once invasive annuals are introduced into this natural scenario, the dynamics change dramatically. The increased abundance of these annual grasses and forbs in turn support increased ignition potential almost immediately following the initial burn (Whisenant 1990). This in turn drives an even more increased fire frequency until shrubs and trees are completely eliminated from the system altogether, leaving only weedy annual grasslands in their wake. This has been described as a "grass-fire cycle" (D'Antonio and Vitousek 1992).

Fuel management is a complex process that must balance the needs of human communities with natural resource goals. It is unrealistic to think that natural vegetation communities can be managed to create fire-safe, wildfire resilient vegetation that also supports high natural biodiversity (Zedler 1995). Given that the District's lands are all fire prone, the best option for managing fire risk is to focus active management in the wildland-urban interface where fire safety is needed most – adjacent to human communities. Because early successional landscapes contain less biomass and are more resistant to fire, targeted management of plant succession in early-successional brushlands and woodlands can be an effective fire management strategy.

8.5 PREVENTION

Preventive treatment actions include temporary trail closures or adjustment in equipment use during some high fire hazard conditions. In addition, the following actions may also be considered to prevent vegetation from becoming a fire risk:

- Focus fuel management activities in WUI areas adjacent to neighborhood communities, structures, and other at-risk assets.
- Work with local fire organizations to amplify results by encouraging neighbors to also manage adjoining properties for fire (reduce fuel loads) within the WUI.
- Conduct visitor and neighbor outreach and education about wildfire dangers on and near District preserves.
- Eliminate any redundant, unnecessary, or high maintenance roads and trails that are determined to be not necessary on individual District preserves.
- Continue to control flammable invasive plants such as French broom in established fuel management areas. Encourage the establishment of native plant communities (which are more resistant to wildfires than invasive plants such as French broom).

The following management approach is recommended to help promote high diversity natural vegetation communities that are relatively fire safe.

- Focus vegetation biomass reduction on non-native vegetation and avoid damaging native grasses, and mature shrublands and forests wherever possible. Where active treatment is needed, seek to break the vertical fuel ladder connection between the ground and the canopy layer, and create some horizontal physical separation between plants where possible. Prioritize projects where invasive plant removal alone can result in fire-safe landscapes.
- Implement fuel management projects with low impact tools and methods such as hand cutting and pruning rather than vegetation removal or soil disturbance with hand methods or machines. Although managing woody plant communities can reduce fuel volume, increased disturbance resulting from the active management can counteract the process by promoting the establishment of invasive plants and reducing native plant diversity (Lavin et al. 2013, Keeley 2002). Hand cutting and pruning is not feasible on a large scale because it takes too long across large areas and can result in injuries to staff doing this kind of work over extended periods of time.
- Prioritize leaving forest duff and organic soil layers undisturbed in all fuel management actions.
- Avoid removing/thinning the canopy layer in mature, established forests and woodlands to maximize shading (thereby promoting shade and related increased moisture under the canopy level) and increase resistance to non-native plant invasion.

8.6 TOLERANCE LEVELS

Consistent with current activities on District lands, the District's tolerance for vegetation that poses a fire risk would first consider health, human safety, and regulatory requirements for local and state fire codes, and then balance these requirements with the District's goals to protect natural resources. For example, defensible space around structures is required and regulated under the Uniform Building Code, Uniform Fire Code, Public Resources Code Section 4291/4119, and County and City municipal codes and ordinances).

Refer to Table 8-1 for management thresholds, and potential treatment options for fuel management presented by type of vegetation.

Table 8-1 Management Thresholds and Treatment Options for Wildfire Management Pests

Pest Category	Management Threshold (Population Size/Conditions)	Treatment
Grasslands	Site-specific management needs are determined based on proximity to developed areas that could be damaged by fire, proximity of ignition sources, current fuel loads within the site, and weather conditions.	Annual mowing in summer to reduce fuel loads, especially near likely ignition sources (trails, roads, recreational facilities, and parking lots).
Shrublands (coastal scrub, chaparral)		Thin brush and mow tall grasses to reduce fuel loads and break fuel ladders. In shrublands, increase spacing between shrub clusters.
Forests		Limb up trees to a height of 8 to10 feet, thin brush, and mow tall grasses to reduce fuel loads and break fuel ladders.
Agricultural Landscapes		Mowing and brush thinning along roads that could provide ignition sources for adjacent natural areas. Discing along borders of agricultural and rangeland properties to ensure fires do not spread beyond different management units. Conservation grazing reduces fuel loads.

8.7 TREATMENT OPTIONS

8.7.1 PHYSICAL CONTROL

- Use tractor, truck, and hand mowers to cut or disc vegetation along roads, trails and borders.
- Limb up trees to a height of 8 to 10 feet, thin brush, and mow tall grasses to reduce fuel loads and break fuel ladders in high risk fire areas.
- Target control of invasive species such as French broom that are known to form dense, highly flammable brush stands.
- If they appear to be a wildland fire hazard, woodrat nests within 100 feet of buildings will be moved after consultation with the California Department of Fish and Wildlife. Refer to treatment options under the Buildings section.

Additional details on physical control options are provided below, presented by the type of work that staff routinely conduct on District preserves.

DISC LINES

Disc lines are a type of mechanical fuel treatment that utilize an agricultural cultivator attachment for a tractor to cut and overturn many parallel small trenches in the soil 6 to 12 inches deep. A disc line is typically placed along the perimeter of undeveloped land, ranches, and roadways. The District would continue to maintain 31 miles of disc lines on its land annually as required by local fire agencies. Occasional trimming of overhanging branches with a chainsaw or pole pruner would also be undertaken along disc lines where needed to allow passage of the tractor. Brush encroaching into disc lines is removed with chainsaws, boom flails, and mowing or masticator equipment. Discing is only practical in grassland vegetation types that do not contain many woody shrub or tree species. The intent of discing is to create small swaths of barren soil that do not support fuel or conduct fire. This technique has limited applications in reducing fire risk in natural areas because the soil disturbance associated with this technique is known to encourage establishment of invasive plants such as invasive annual plants, often exacerbating the fuel load problem. Disc lines are more temporary than shaded fuel breaks (described below), but offer the advantage of being a rougher surface that is less prone to soil erosion (Amphion Environmental 1995). Discing requires annual maintenance to be effective, and once cultivation modifies native soil, must be done in perpetuity to manage invasive weeds thereafter.

SHADED FUEL BREAKS

Shaded fuel breaks is a forest management strategy that requires selective thinning and removal of the more flammable understory vegetation while leaving the majority of larger, more fire tolerant tree species in place. On District lands, a shaded fuel break is maintained along Monte Bello Road in Monte Bello OSP. Maintenance of the fuel break along the road includes annual mowing in grasslands adjacent to the road, clearance of brush and all dead vegetation, and removal of ladder fuels to the canopy in forested areas. Manual and mechanical tools used for these activities include tractors, brushcutters, chainsaws, chippers, masticators, and/or a JAWZ implement.

CLEARING AROUND BUILDINGS

Manual and mechanical clearing of flammable vegetation to provide defensible space occurs on an annual basis around an estimated 117 structures by District staff or by residential, commercial or agricultural/rangeland tenants. This work consists of manual and/or tractor mowing, brushcutting, chainsaw work, pole pruning, chipping, masticator and spraying depending on the site conditions and generally occurs within 100 feet of the structures although some jurisdictions require clearing within 30 feet of a property boundary or other additional precautions. The District developed Defensible Space Clearing Guidelines that it adheres by (refer to Appendix C of this EIR). The required amount of clearance for defensible space can vary depending on the Fire District jurisdiction that a parcel falls within. Implementation of the proposed IPMP would not result in any changes to the District's Wildfire Management Policy (District 2012, 76-84) or defensible space requirements (District, local, or state) on or adjacent to District lands. As needed to control fire risk, staff should consult local authorities to update and improve preserve-specific guidelines for clearing around buildings.

EMERGENCY HELICOPTER LANDING ZONES

Emergency helicopter zones are maintained annually or bi-annually via mowing with a tractor or brushcutter at 39 locations on District lands. As needed, encroaching brush is mechanically removed using a chainsaw or JAWZ implement.

TRAIL AND ROAD BRUSHING

Trail and road brushing is an activity undertaken to facilitate visitor recreation and safety. Refer to discussion above, IPM For Recreational Facilities, for a more detailed discussion of mechanical and manual treatments used to maintain trails and roads.

DRIVEWAYS

- Driveways to residences and other key structures receive additional treatment for ingress and egress in a fire emergency. Vegetation would be maintained to minimize flame length:
  - Within 10 feet of the road edge where flames are predicted to be 0-8 feet in length (generally grassy locations and in oak woodlands)
  - Within 30 feet of the road edge where flames are predicted to be over 8 feet in length (generally brushy locations and where understory shrubs are developed in woodlands)

Occasionally, controlling invasive plants as described in the Natural Areas section below also provide fire management benefits by removing dense, highly flammable brush stands such as French broom.

8.7.2 CHEMICAL CONTROL

Chemical control is used for fuel management directly adjacent to structures as required and in some high risk fire areas where perennial plants are not responding to manual or mechanical treatments and require permanent treatment. Chemical control treatment options for fuel management include:

- **Glyphosate,** the active ingredient in Roundup CustomTM (previously sold as AquamasterTM), is a broad-spectrum non-selective systemic herbicide used to control a wide variety of plants, including annual broadleaf weeds, grasses, perennials, and woody plants. It is absorbed through foliage and translocated to growing points. Glyphosate's mode of action is to inhibit an enzyme involved in the synthesis of aromatic amino acids, making it effective on all herbaceous and woody growing plants. It is a rather slow-acting herbicide with symptoms appearing with a week, including yellowing and stunting a young leaves and growing points, however it may take up to several weeks for a plant to die.
- **Imazapyr,** the active ingredient in Polaris™ (previously sold as Habitat™), is a non-selective herbicide used to control a broad range of weeds including grasses, broadleaf herbs, woody plants, riparian plants, and emergent aquatic species. Imazapyr has a similar mode of action as glyphosate but acts on a different suite of essential amino acids. Imazapyr is absorbed by leaves and roots, and moves to growing points; it disrupts protein synthesis and interferes with cell growth and DNA synthesis, plants die as a result of AHS inhibition. To be effective on aquatic plants, the majority of plant parts must be accessible above the waterline.

Imazapyr can be useful for difficult-to-control species when glyphosate is less effective, and with much lower application rates.

Chemical options should be applied in the following situations:

- *WUI Areas and Defensible Space.* To meet legal requirements (District, local, and/or state) for defensible space, flammable vegetation may be spot sprayed annually within the inner 30 feet of land surrounding a structure with glyphosphate in addition to mowing within this area. Trees or large shrubs that require removal within the inner 30 feet of defensible space are typically treated by cut-stump method with glyphosphate to permanently remove them from this high hazard zone. For example, some native resprouting brush species that are also known to be flammable, such as coyote brush and chamise, can be eliminated from proximity to buildings with cut-stump or spot spraying. Spraying around buildings further avoids having to run a brushcutter blade against or around buildings, fences, pipes, rocks, and other obstacles that can be a fire hazard by causing sparks.
- *Disc lines*. Although brush encroaching into disc lines is primarily removed with chainsaws (as discussed above), more stubborn woody plants may require treatment with herbicides by cut-stump method with glyphosphate or imazapyr).
- *Shaded fuel breaks*. Use of glyphosphate in a cut-stump method is used to maintain fuel breaks that contain decadent woody vegetation.

9 IPM FOR RANGELANDS AND AGRICULTURAL PROPERTIES

9.1 DEFINITION AND PURPOSE

Some District lands encompass rangelands, crop fields, and orchards that are actively managed as grazing or agricultural operations. Rangeland and agriculture activities on District preserves are primarily managed by lessees who typically operate under a Rangeland Management Plan or Agricultural Management Plan that is attached to their lease. These site-specific management plans guide the rangeland and agricultural activities to ensure compatibility with natural resource protection and low-intensity public recreation.

This IPMP does not replace the requirements of the individual range or agricultural management plans, nor does it present the full range of agricultural or range management options. Rather, it seeks to provide staff with tools that are consistent with IPM principles to select the safest, least harmful, and most effective treatment options for rangeland and agricultural pests.

9.2 RANGELANDS

IPM in rangelands focuses on maintaining land uses (e.g., grazing) while also managing for the long-term functioning and stability of high value natural resources (e.g., grasslands, creeks) that surround the rangelands and agriculture. This requires landscape level monitoring to determine when pests such as agricultural pests and invasive plants are present in sufficient numbers to reduce the intended land uses or quality of the managed habitats.

The District established a Conservation Grazing Program in February 2007 with the goal of managing District land with livestock grazing that is protective of natural resources, compatible with public access, maintaining or enhancing the diversity of native plant and animal communities, managing vegetation fuel for fire protection, helping to sustain the local agricultural economy, and preserve or foster appreciation for the region’s rural agricultural heritage.

By 2015, a total of 10 properties, totaling over 10,800 acres, is projected to be managed with livestock grazing. Stocking rates and either year-round or seasonal grazing are prescribed for each property based on site-specific factors such as soil fertility, terrain, plant composition, water availability, and available infrastructure. Typical vegetation pests on rangelands include thistles, Harding and velvet grass, poison hemlock and encroaching brush.

The IPM Coordinator is responsible for reviewing Rangeland Management Plans and periodically reviewing existing rangeland practices to make sure they are implemented using current IPM practices outlined herein, and, if pesticides are used, follow the District’s list of approved pesticides.

9.2.1 TYPES OF RANGELAND PESTS

Typical pests on rangelands include weeds poisonous to livestock or otherwise detrimental to productive pastures, primarily invasive thistles, Harding and velvet grass, poison hemlock and encroaching brush.

9.2.2 PEST IDENTIFICATION IN RANGELANDS

Because the extent of grassland communities on District lands are so large and interconnected with leased rangeland properties, rangeland pests are inherently difficult to detect. The District will assess a subset of grasslands in and adjacent to leased rangelands on a routine basis to detect problem pests (most commonly to be conducted during a lease renewal or establishment of a new lease). Monitoring rangelands should focus on:

- Sites most likely for pests to invade (e.g., corrals and areas around water troughs and feed stations);
- High value areas (e.g., grassland areas that support special-status species).
- Map pests of concern, record in the District's Pest Database, and evaluate.

9.2.3 TOLERANCE LEVELS IN RANGELANDS

Determining tolerance levels for pests in grazing lands is largely done by the grazing lessee, in consultation with District staff and rangeland experts. Active pest management would only occur where the lessee determines that tolerance level for a pest is exceeded- for example, where livestock forage quality is severely reduced, resulting in a loss of livestock production value. In some limited instances, the District may assess leased grazing land pests and determine a tolerance level, for example, when the presence of the pest is a target invasive species or particularly if it threatens the persistence of a special-status species or other high value area. Refer to Table 9-1 for an overview of management thresholds and treatment options available for use on District rangelands.

Table 9-1 Management Thresholds and Treatment Options for Rangeland Pests

Pest Category	Management Threshold (Population Size/Conditions)	Treatment
Grasslands	Site-specific management needs are determined by lessee and District in Rangeland Management Plans based on assessment of rangeland condition, type of livestock to be used, and stocking rates/seasons of use. District to work with individual rangeland lessees when rangeland forage values decrease such that stocking rates decline, and or when lessees identify pests that warrant control.	Lessee to monitor forage values in grasslands. In coordination with District, lessee responsible for detection, District notification, and control of rangeland pests such as French broom and invasive thistles that lower value of forage and grassland habitat.
Shrublands (coastal scrub, chaparral)		Lessee to monitor brush encroachment in grasslands. Lessee to work with District to thin brush in grasslands when brush encroachment significantly reduces value of forage and grassland habitat. In shrublands, increase spacing between shrub clusters.

9.3 AGRICULTURAL FARMS AND FIELDS

The purpose of IPM in on agricultural properties is to manage pests to maintain the specific land uses (e.g., crop production), while also providing natural resource protection and visitor access. Agricultural pests that may be encountered include weeds, pathogens and insects in croplands; and rodents in farm fields and buildings.

Two District properties contain agriculture fields. The Lobitos Ridge property consists of two crop fields containing flowers and vegetables on seven acres of Purisima Creek Redwoods OSP and the Madonna Creek Ranch property consists of 27 acres on Miramontes OSP on which a tenant cultivates dry farmed hay as well as smaller irrigated areas for pumpkins and other truck crops.

A draft Agriculture Production Plan has been prepared for the Lobitos property and includes the IPM approach on District agriculture properties. It requires that best management practices (BMPs) as defined by the University of California Cooperative Extension Service and the USDA Natural Resources Conservation Service for farm production be followed, and specifically, that IPM techniques, as defined by the crop specific University of California Cooperative Extension Service are employed along with BMPs. Methods for control of weeds on the site can be by mowing, grazing, flaming or the use of an approved herbicide.

Lessees operate a Christmas tree farm and chestnut orchard at Skyline Ridge OSP and a vineyard at Picchetti OSP. A historic fruit orchard is maintained by District staff and volunteers on the Stevens Canyon property. The City of Mountain View operates an educational farm located in the Rancho San Antonio OSP that offers classes and camps for thousands of schoolchildren in farm, garden, native peoples and history.

The IPM Coordinator is responsible for reviewing existing Agricultural Production Plans and periodically reviewing existing agricultural practices to make they are implemented using current IPM practices outlined herein and, if pesticides are used, follow the District's list of approved pesticides. As new agricultural lands are acquired, District staff will help draft new Agricultural Production Plans that follow the procedures outlined in this Guidance Manual.

9.3.1 TYPES OF AGRICULTURAL PESTS

Insect management in field crops is very specific to the type of crop grown. Because the District has few properties that currently support row crops, agriculture insect pest management for agricultural fields is not covered under the IPMP but would be covered in future Agriculture Management Plans and incorporated into the IPMP.

9.3.2 REGULATED AGRICULTURAL PESTS

Though the definition of a 'pest' can depend on perspective and location, some species are regulated as various types of pests by state and federal laws. Plants classified as 'Noxious' are regulated by the California Department of Food and Agriculture (CDFA) and the United States Department of Agriculture (USDA). Wildlife species classified as 'Injurious' are regulated by the CDFW and United States Fish and Wildlife Service (USFWS). Other species that transmit diseases may be regulated by local, state, or federal health departments. Regulated pests pose a risk to the environment, public health, or economic resources. Many times the acceptable IPM tolerance level of regulated pests is zero, so that any detected individual initiates a management action. These are species that the District has a legal responsibility to control per state and federal laws and regulations though control is often conducted by other agencies.

9.3.3 PEST IDENTIFICATION IN AGRICULTURAL FARMS AND FIELDS

Due to the limited number of agricultural lands on District property, pest identification is the responsibility of the lessee, who is to report significant pest infestations to the District. Once pests are reported, they should be mapped and recorded in the District's Pest Database, and evaluated for their impacts to the surrounding natural areas.

9.3.4 TOLERANCE LEVELS IN AGRICULTURAL FARMS AND FIELDS

Active pest management would only occur where tolerance levels are exceeded- for example, where agricultural crop production is greatly reduced, or where the presence of the pest threatens the persistence of a special-status species occurring in adjacent areas. Refer to Table 9-2 for an overview of management thresholds and treatment options available for use on District rangelands.

Table 9-2 Management Thresholds and Treatment Options for Agricultural Pests

Pest Category	Management Threshold (Population Size/Conditions)	Treatment
Agricultural Insect Pests	Site-specific management needs to be determined by lessee and District in individual Agricultural Management Plans based on assessment of farm and field conditions, type of crops, and anticipated crop yields. District to work with individual rangeland lessees when crop yields decrease such that economic damage or environmental damage warrant control.	Lessee to monitor insect damage of crops. Agriculture insect pest management to be addressed in future Agriculture Management Plans. Staff and tenants to consult crop-specific IPM guidebooks published by University of California Davis - http://www.ipm.ucdavis.edu for both organic and conventional crop production and include pest management actions in the Agricultural Management Plan for individual parcels.
Rodents and Other Nuisance Pests in Agricultural Areas		Lessee to monitor rodent damage. In coordination with District, lessee responsible for detection, District notification, and control of problem rodents in farm buildings or crop fields using procedures in the Buildings section above (Chapter 6).
Invasive Plants in Agricultural farms and fields		**Cultural Control Options:** ◢ Crop Rotation ◢ Cover Crops and Smother Crops ◢ Late-Season Planting ◢ Planting Rates and Crop Density ◢ Water and Nutrient Management ◢ Crop Variety Selection ◢ Covering/soil Sterilization ◢ Mulching ◢ Soil Sterilization **Physical Control Options:** ◢ Mowing ◢ Pulling ◢ Green Flaming, ◢ Mulching ◢ Use Of Weedmats ◢ Hoeing ◢ Discing ◢ Cultivating with tractor implements **Chemical Control Options:** ◢ To be determined by lessee and District in Agricultural Management Plans. Staff and tenants to consult crop-specific IPM guidebooks published by University of California Davis - http://www.ipm.ucdavis.edu for both organic and conventional crop production and include pest management actions in the Agricultural Management Plan for individual parcels.

9.4 PREVENTION

Using existing Rangeland Management Plans and Agricultural Management Plans, the District will work with lessees to encourage management practices that prevent the establishment of pest species. Prevention strategies for District lands in agricultural production may include:

- During development of new Agricultural Management Plans, encourage lessees to keep lands healthy through soil management, proper irrigation, and by providing sufficient habitat (refugia) for natural insect pest predators (natural enemies) in and near crop production areas.
- During development of new Agricultural Management Plans, and as practical, incorporate good stewardship practices such as rotational cropping, integrating annuals into perennial crops (such as Christmas tree farms), implementing no-till cropping, and, where possible, promoting organic farming practices to reduce annual disturbance and increase farm biodiversity (Coll 2004).
- During acquisition planning for new preserve lands, encourage landscape mosaics (i.e., plan for a mixture of natural and agricultural or grazing lands) to help maintain natural pest predator populations.
- During lease renewal periods, monitor pest invasions at the edges of agricultural and grazing lands, especially in and near roads, trails, and fuel breaks. Determine if tolerance thresholds are exceeded (both in and adjacent to leased lands), and develop pest control requirements accordingly in the new lease requirements.
- During preparation of new Rangeland Management Plans and lease renewals, monitor livestock feeding locations, corrals, watering troughs and livestock feeding for pests. Consider rotational grazing, changing livestock stocking rates and/or requiring different types of grazing animals to prevent spread of pests and to promote healthy, diverse grassland areas.

9.5 TREATMENT OPTIONS

Working with lessees, the District will determine a site-specific solution that meets the needs of the lessee, maintains natural resource values and District lands, and addresses the identified pest issue. The general steps involved in implementing IPM in rangelands and agricultural properties are similar, but not identical to those described for buildings and natural areas, and generally include the actions described below.

9.5.1 STRUCTURAL PEST CONTROL

MECHNICAL CONTROL OPTIONS

Mechanical control treatment options for rangeland and agricultural properties on District lands include:

- *Rodents*. For rodents in farm buildings or crop fields, refer to the procedures for controlling rodents under the Buildings section above (Chapter 6).

CHEMICAL CONTROL OPTIONS

Chemical control treatment options for rangeland and agricultural properties on District lands include:

- *Rodents*. For rodents in farm buildings or crop fields, refer to the procedures for controlling rodents under the Buildings (Chapter 6) and Natural Areas sections (Chapter 10), respectively.

9.5.2 INVASIVE INSECTS

Because the District has few properties that currently support row crops, agriculture insect pest management for agricultural fields is not covered under the IPMP. If new pesticides are proposed for agricultural insects, they will be evaluated, included in future Agriculture Management Plans, an environmental review will be conducted, and the IPMP will be revised to include the new pesticide, new treatment method and any required precautions. Staff and tenants should consult crop-specific IPM guidebooks published by University of California Davis - http://www.ipm.ucdavis.edu for both organic and conventional crop production and include pest management actions in the Agricultural Management Plan for individual parcels.

9.5.3 INVASIVE PLANTS

RANGELAND CONTROL OPTIONS

Consistent with existent management plans, grazing and agricultural lessees are allowed to control pests through grazing, mowing, pulling and careful application of District-approved herbicides. Brush, commonly the native coyote brush, limits the available forage for livestock, reduces grassland habitat areas and creates an increased wildfire fuel load. Grazing tenants typically treat brush encroachment with herbicide and then use a tractor and drag bar to break up dead vegetation for the following season.

Manual/mechanical control treatment options for invasive plants on rangelands include:

- ***Mow/Cut.*** A brushcutter, disc, brushrake or other motorized cutting machine would be selected for mowing of weeds and cutting of brush based on the size of the infestation. Most species would require repeated cutting throughout the growing season (generally late spring through mid-summer) or they could re-sprout from their base and continue to grow, flower, and produce seed. Mowing would be carefully timed according to the phenology of each plant species to minimize the amount of re-sprouting and to avoid spreading ripe seed. Mowing is a temporary measure that controls reproductive spread and can eventually reduce populations of annual plants, but other subsequent treatments (e.g., pulling, herbicide) would be necessary to eradicate perennial plants. Mowing cannot be used on steep slopes or in locations with desirable native plants unless the timing of the mowing can be selected to affect only target plants.

- **Grazing Regime Modifications.** Invasive plants can also be partially or fully controlled using carefully timed grazing rotation, and or/ manipulating the types and seasons of grazing livestock (for example, using goats instead of cattle to forage on invasive thistle species in spring before seed set). As described in Chapter 8, Possible actions to be considered include:
  - changing types of livestock to include browsing livestock that eat shrubs (e.g., goats);
  - installing physical barriers (cross fencing);
  - controlling brush through hand or mechanical treatments;
  - applying pesticides in a specific location (e.g., directly onto individual plants or small patches of brush); or
  - implementing a combination of mowing, foliar spraying, and hand removal (for very large brush encroachments).

- **Chemical Control Treatment Options.** Any of the herbicides approved under the IPM Program may be used to treat weeds on rangelands or agricultural fields if cultural or mechanical methods are not effective. Glyphosate will likely be the primary herbicide used on thistles and brush on rangelands, and for weeds in agriculture fields and orchards.

AGRICULTURAL FARM AND FIELD CONTROL OPTIONS

Cultural weed control includes crop rotations, water and nutrient management, late-season planting, and cover/smothering crops (Smith 2000, Gunsolus et al. 2010). Cultural methods are the first line of defense in weed management and primary tools for organic crop production. Manual/mechanical control treatment options for invasive plants on agricultural lands include the following cultural, mechanical, and manual weed control options:

- **Crop Rotation.** Diversifying a rotation is one of the most effective tools against weeds. Over time, routine planting and cultivation dates will select for weeds that are adapted to these strategies. Varying crops by different planting date or growing perennial crops in rotation with row crops can prevent weeds from adapting to the planting regimen.

- **Cover Crops and Smother Crops.** Offseason cover crops and smother crops are effective strategies to outcompete weeds. Cover crops occupy vacant space in an ordinarily fallow field and displace weeds that would otherwise occupy the space. Some species also have allelopathic effects on weeds.

  Smother crops are vigorously-growing crops that growers use to suppress weeds. Generally, a smother crop is not harvested, but plowed down instead. The primary risk in using smother crops is that their effectiveness in weed control may be inconsistent and unpredictable or they may become weeds themselves.

  Late-Season Planting. Delayed planting past the traditional planting times is an option in weed management, but depending on growing season and crop, may also reduce crop yields. Later season planting allows crop seedlings to bypass the competitive flush of weed seedlings and also allows for additional time for mechanical weed control operations.

- **Planting Rates and Crop Density.** Increasing the planting rate is another common strategy for weed management. Higher crop densities can lead to greater competitiveness against weeds. In addition, higher planting rates can compensate for crop losses that occur during mechanical weed control operations.

- **Water and Nutrient Management.** Effective water and nutrient management can ensure crops benefit from farming practices rather than weeds. Switching to drip irrigation from flood or broadcast styles, monitoring nutrient requirements instead of blanket fertilization, timing compost applications, and burying irrigation pipe may all help to reduce weed problems.

- **Crop Variety Selection**. Selecting the proper variety of a specific crop that is best adapted for local conditions can reduce the resources necessary for production and consequently reduce weed management problems. If the crop is better adapted to local conditions than the weed, the site will favor the crop over the weed.

- **Mechanical weed control.** Mechanical weed control is the most widely used weed control method for agriculture fields and can occur before, during, and after the crop is planted. This method includes primary tillage, row crop cultivating tillage, use of mulches (i.e., plastic sheeting, straw, wood chips, and sawdust), and/or soil sterilization techniques that use heat to kill weeds and weed seeds in soil. Passive sterilization uses clear plastic tarps to foster the germination of weeds under the tarp and then exposes the seedlings to hostile growing conditions and they perish and active sterilization uses extremely high temperature steam to eliminate weed seeds and bulbs with direct contact. Both processes are expensive and require specialized equipment and/or high labor output.

- **Primary Tillage.** Primary tillage is the initial step in seedbed preparation. It incorporates residues from the previous crop and can incorporate compost, manures, and other nutrients. It buries some weed seeds so deeply they cannot germinate, but it also brings other seeds to the surface allowing them greater opportunity for germination. Tillage is best combined with a forced germination program, where multiple tillage and watering events are coupled to force the germination of weeds and then eliminate them. The timing of primary tillage will encourage different weed species to predominate so the farmer must time the actions to correspond with the primary weed targets.

  A fundamental aspect to consider in seed bed preparation is the concept of providing the crop with an "even start." An even start means controlling weeds that germinate before the crop germinates. Once seed bed preparation is complete, the crop must be planted as soon as possible because if crop planting is delayed, weeds can germinate and get a head start on the crop.

- **Cultivation.** Row crop cultivating tillage is performed after the crop is planted. Cultivation kills weeds by digging them out, burying them, breaking them apart, or drying them out. In addition to controlling weeds, cultivation can break up soil crusting and thus can increase crop emergence, water infiltration, mineralization of nutrients, and soil aeration during the growing cycle.

  A short window of time usually exists for timely use of cultivation. Weeds that emerge before or with the crop are the most critical to eliminate. Weeds that emerge after crop emergence will have less negative impact on yield, but may still contribute to the weed seed bank for problems in future years. When it comes to weeds that emerge with the crop, it is best to be proactive, rather than reactive. Waiting until weeds are noticeable will limit the control options.

- **Mulches**. Mulch is any artificial or natural soil cover. Plastic sheeting, straw, wood chips, and sawdust are all common types of mulches for crop production. Mulches work by eliminating light availability to small weeds. The larger the weed, the deeper the mulch needs to be for effective control. Mulches have the added benefit of also conserving soil moisture and reducing soil erosion. Many organic types of mulch ultimately decompose into necessary plant nutrients for the following growing season.

- **Sterilization**. Soil sterilization uses heat to kill weeds and weed seeds in soil. Two types are common in agriculture, 1) passive soil sterilization with clear plastic tarps and 2) active soil sterilization with injected steam. Passive sterilization uses clear plastic tarps to foster the germination of weeds under the tarp and then exposes the seedlings to hostile growing conditions and they perish. Active sterilization uses extremely high temperature steam to eliminate weed seeds and bulbs with direct contact. Both processes are expensive and require specialized equipment and/or high labor output.

- **Manual weed treatment.** Specific manual weed treatment methods allowed under the Lobitos Agricultural Management plan are mowing, pulling, flaming, mowing, mulching, weedmats, and hoeing.

10 IPM IN NATURAL LANDS

10.1 DEFINITION AND PURPOSE

Natural areas make up the majority of District lands, and typically experience minimal levels of human use. The purpose of IPM in natural areas is to preserve and restore natural resources while also maintaining safe and enjoyable human access for visitors and staff.

IPM in the District's natural areas focuses primarily on the control of pests that threaten the long-term viability of natural resources on District preserves. Pests that are commonly encountered on natural areas include invasive plants and invasive animals, including regulated species (i.e., plants and wildlife that are regulated under state and federal law or CDFW Code, and feral pets. The District spends the majority of its IPM management efforts in natural areas on control of invasive plants.

- **Invasive plants** are implicated in many natural resource and conservation problems and are considered by most land managers to be a threat to their resource management goals. When transplanted to a foreign landscape, invasive plants leave behind their associated predators, prey, and diseases that previously helped to balanced their growth and abundance. In addition, many invasive plants have inherent biological traits that allow them to rapidly reproduce and colonize new areas faster than the native plants of the invaded habitat. Some of these invasive plants become problematic because of abundance – they displace native species by outcompeting them for space and resources (CA Coastal Conservancy 2003, San Mateo County 1983, State of Washington 2003). Some invasive plants can alter ecosystem processes, such as reducing or changing seasonal food sources for wildlife, hydrological patterns, fire regimes, or soil chemistry (Keeley 2006, D'Antonio 1992, Vitousek and Walker 1989).

  The California Department of Food and Agriculture designates a plant species as a noxious weed if they find it to be "troublesome, aggressive, intrusive, detrimental, or destructive to agriculture, silviculture, or important native species, and difficult to control or eradicate" (CDFA 2014). The Department designates a rating for each noxious weed species based on the present distribution of the pest within the state and the likelihood that eradication or control efforts will be successful. The ratings are not laws, but are policy guidelines that indicate the appropriate actions to take against pests. The District works closely with the Agricultural Commissioners for San Mateo and Santa Clara Counties to address state-designated noxious weeds on preserves. The California Invasive Plant Council maintains an Invasive Plant Inventory that rates the threat of non-native plant species by evaluating their ecological impacts, invasive potential and ecological distribution (Cal-IPC 2014). The Bay Area Early Detection Network along with the San Mateo County Weed Management Area and the Santa Clara County Weed Management Area set regional priorities for eradication of invasive plants in the San Francisco Bay Area, particularly those for which early action could substantially reduce future risk (Cal-IPC 2009). District staff members are active with these organizations and further apply local knowledge to evaluate the invasive risk of existing and new non-native plants found on District preserves and to determine the best responses.

- **Invasive animals** pose another threat to natural areas. Escaped/released domestic animals and other non-native wildlife species can thrive in the favorable climate of the San Francisco peninsula. Once established in a preserve, they compete for valuable resources and disturb the sensitive balance of natural food webs. Bullfrogs and wild pigs are examples of invasive introduced animals found in District preserves that physically displace or consume the native plants and wildlife that normally inhabit natural areas, or otherwise alter natural processes.

Wild (feral) pigs are an example of an invasive wildlife species with obvious impact on District lands. They have been widespread in the central coast of California since about 1970, reproduce rapidly, dig up meadows and wetlands, and carry diseases that can affect people and livestock. They eat acorns, bulbs, and roots in soil, and are difficult to control. Feral pigs were abundant in the South Skyline region in the 1990s. The District has been trapping feral pigs since 2000 and has substantially reduced their population and damage from their rooting.

The management of invasive species may sometimes involve eradication (i.e., the removal of all of the pest species, typically only achievable for new invasive species and small populations of pests), but more common natural area management methods involve incremental reduction of pest numbers (control), removal of individuals that have the greatest impact on critical resources, or the exclusion of a pest species from a defined sensitive area (containment). Programs to control invasive plant and animal species often require a long-term commitment. With many invasive species, short-term lapses in active management can negate years of expensive control programs.

First steps in all invasive species management focus on preventing the establishment of any new pest populations. Prevention or detection actions can minimize many invasive species problems in the future, reducing the need for more active management and costly treatment methods. In the future, the pest prevention tactics identified below will be based on minimizing dispersal or reacting quickly to new invasions through anticipation and surveillance.

10.2 REGULATORY BACKGROUND

Invasive species are regulated to some extent by state and federal laws. The USDA, CDFA, USFWS, and CDFW all regulate the importation, sale, transportation, and control of designated invasive species.

10.2.1 REGULATED WILDLIFE

Under the Lacey Act, the Secretary of the Interior is authorized to regulate the importation and transport of species, including offspring and eggs, determined to be injurious to the health and welfare of humans, the interests of agriculture, horticulture or forestry, and the welfare and survival of wildlife resources. Wild mammals, birds, fish, mollusks, crustaceans, amphibians, and reptiles are the only organisms that can be added to the injurious wildlife list. The current 2013 list includes 236 species, many of which are kept as pets around the world (USFWS 2013). All species listed as injurious may not be imported or transported between states or any United States territory without a permit issued by the USFWS. No injurious species of wildlife are currently known to occur on District lands. The importation of any live amphibians from outside the United States (such as bullfrogs imported from China) has been petitioned by environmental groups for inclusion on the list to prevent the importation of the chytrid fungal pathogen. The USFWS is still reviewing the petition to list exotic amphibians as injurious wildlife.

10.2.2 REGULATED PLANTS

Some species of invasive plants are regulated as noxious weeds by the CDFA and USDA. Because the two agencies work cooperatively, California’s classification scheme is representative of both federal and state regulations. CDFA currently lists 251 invasive plant species as noxious weeds (CDFA 2013a). Control actions are determined by a ranking system based on a species’ threat to economic or environmental resources. The following is California’s ranking system for invasive pest plant species:

- **Class A Noxious Weed** – A pest of known economic or environmental detriment which is either not known to be established in California or has limited distribution that allows for the possibility of eradication or successful containment. A-rated pests are prohibited from entering the state because, by virtue of their rating, they have been placed on the Plant Health and Pest Prevention Services Director's list of organisms "detrimental to agriculture" in accordance with the FAC Sections 5261 and 6461. The only exception is for organisms accompanied by a CDFA or USDA live organism permit for contained exhibit or research purposes. If found entering or established in the state, A-rated pests are subject to state (or commissioner when acting as a state agent) enforced action involving eradication, quarantine regulation, containment, rejection, or other holding action.

- **Class B Noxious Weed** – A pest of known economic or environmental detriment that, if present in California, has a limited distribution. B-rated pests are eligible to enter the state if the receiving county has agreed to accept them. If found in the state, they are subject to state endorsed holding action and eradication only to provide for containment, as when found in a nursery. At the discretion of the individual county agricultural commissioner they are subject to eradication, containment, suppression, control, or other holding action.
- **Class C Noxious Weed** – A pest of known economic or environmental detriment that, if present in California, is usually widespread. C-rated organisms are eligible to enter the state as long as the commodities with which they are associated conform to pest cleanliness standards when found in nursery stock shipments. If found in the state, they are subject to regulations designed to retard spread or to suppress at the discretion of the individual county agricultural commissioner. There is no state enforced action other than providing for pest cleanliness.
- **Class Q Noxious Weed** – An organism or disorder suspected to be of economic or environmental detriment, but whose status is uncertain because of incomplete identification or inadequate information.

10.3 TYPE OF PESTS

Pests in natural areas include invasive plants and invasive animals. This section presents an overview of IPM practices presented by for each type of pest.

Traditional IPM concepts can be difficult to apply to invasive species. The ecosystems invaded by these species normally do not support the same predators and parasites that may regulate the species populations in its native range, so simply facilitating increased natural controls may not be effective. Modern IPM strategies for invasive species emphasize use of standardized decision-making processes supported by science-based understanding of invasive species biology and ecological interactions with their host environment. Tolerance levels may vary greatly for invasive species; invasive species impacts range in severity and extent, and some species may be so widespread or complexly woven into their host environment that control is not technically or economically feasible. Monitoring is a critical part of the District's IPM program; prevention and early detection/eradication strategies can be implemented to prevent new invasive species pest problems before they become unmanageable.

Programs to control invasive plant and animal species require long-term commitment. With many invasive species, short-term lapses in management activity may negate years of expensive control programs. IPM is considered an integral part of a strategy to efficiently and effectively control invasive species on District lands.

10.3.1 INVASIVE ANIMALS IN NATURAL LANDS

Invasive animal management in natural areas focuses on first modifying the behavior of humans or the habitat of natural areas to moderate or eliminate invasive animal pest problems. After these prevention actions are exhausted, invasive animal populations will be managed to a defined tolerance level. Tolerance levels focus reducing the pest population down to a level that does not cause substantial harm to the natural resource; does not cause severe economic harm; and/or does not cause disruption of natural processes or severe displacement of native species. The District's goal is to maintain the long-term stability and resiliency of its natural areas.

State regulations concerning invasive animals are complex. Some invasive animals in California are regulated for sport and commercial purposes (e.g., feral pigs and bull frogs), others expressly prohibited (e.g., northern pike fish) and others are currently unregulated (e.g., snapping turtles and parrots). Some invasive wildlife species can be difficult to manage where adjacent landowners manage the same species for sport or profit. The District prioritizes specific invasive animals for management that have the greatest potential to impact natural areas. Some regulated game species (e.g., feral pigs) must be controlled under special permits obtained from the CDFW.

10.3.2 INVASIVE PLANTS IN NATURAL LANDS

The District has identified numerous species of invasive plant species present on District lands; 75 invasive plants were observed in a study conducted in 2004 (see Table 10-1 below). The following section presents IPM strategies for these target invasive plant species, organized by general life history (i.e., annual and biennial, perennial, aquatic plants). Because there is a great diversity of invasive plant species managed on District lands, specific treatments and management strategies must also take into account the life history traits of each species in the context of its specific environment – the details of which cannot be outlined in a single document. Ultimately, land managers, biologists, and pest control professionals must develop site-specific management for individual projects and species, using the information provided in this manual and the District Invasive Plant Control Handbook as guides. The District's goal is to maintain the long-term stability and resiliency of its natural areas.

10.4 PEST IDENTIFICATION

Pest identification for invasive plants and wildlife can be readily undertaken using existing District resources such as invasive plant identification materials, and field guides. Staff should identify the pest to species, and then investigate its life history and life cycle, and document the distribution, density, population size and population structure (i.e., percentage of each population in immature, adult, and reproductive stages) within the natural areas. Use the target pest list presented in Table 10-1 above as a starting point of identifying pests that currently occur on District lands. New pest species may invade District lands over time: if the pest is not listed in Table 10-1, staff should then do basic web searches to determine if the pest is regulated by statute, by which agency it is regulated, or determine if it is an unregulated pest on District lands.

Table 10-1 Invasive Plant Species Documented as Present on the District Lands

Scientific Name	Common Name	Life Form	Cal-IPC Invasive Status (2014)	CDFA Rating (2014)
Acacia baileyana	cootamundra wattle	Tree	Watchlist	
Acacia dealbata	silver wattle	Tree or shrub	Moderate	
Acacia melanoxylon	blackwood acacia	Tree	Limited	
Aegilops cylindrica	jointed goatgrass	Annual herb	Watchlist	B
Aegilops triuncialis	barbed goatgrass	Annual herb	High	B
Ailanthus altissima	tree of heaven	Tree	Moderate	C
Arundo donax	giant reed	Perennial herb	High	B
Asphodelus fistulosus	asphodel, onion weed	Perennial herb	Moderate–ALERT	B
Brachypodium sylvaticum	slender false brome	Perennial herb	Moderate–ALERT	A
Brassica (nigra?)	mustard	Annual herb	Moderate	
Carduus pycnocephalus	Italian thistle	Annual herb	Moderate	C
Carthamus lanatus	woolly distaff thistle	Annual herb	Moderate	B
Centaurea calcitrapa	purple star-thistle	Annual or Perennial herb	Moderate	B

Table 10-1 Invasive Plant Species Documented as Present on the District Lands

Scientific Name	Common Name	Life Form	Cal-IPC Invasive Status (2014)	CDFA Rating (2014)
Centaurea melitensis	tocolate, Malta star-thistle	Annual herb	Moderate	C
Centaurea solstitialis	yellow star-thistle	Annual herb	High	C
Centaurea stoebe ssp. *micranthus*	spotted knapweed	Perennial herb	High	A
Cirsium vulgare	bull thistle	Biennial herb	Moderate	C
Conium maculatum	poison hemlock	Biennial herb	Moderate	
Cortaderia jubata	Jubata grass	Perennial herb	High	B
Cortaderia selloana	pampas grass	Perennial herb	High	
Cotoneaster spp.	cotoneaster	Shrub	Moderate (several species)	
Cynara cardunculus	artichoke thistle	Perennial herb	Moderate	B
Cytisus scoparius	Scotch broom	Shrub	High	C
Dactylis glomerata	orchard grass	Perennial herb	Limited	
Delairea odorata	Cape ivy	Perennial herb	High	B
Dipsacus sativus	teasel	Biennial herb	Moderate	
Dittrichia graveolens	stinkweed	Annual herb	Moderate	
Elymus caput-medusae	Medusa head grass	Annual herb	High	C
Ehrharta calycina	Perennial velt grass	Perennial herb	High	
Ehrharta erecta	Erect velt grass	Perennial herb	Moderate	
Eucalyptus camaldulensis	red river gum	Tree	Limited	
Eucalyptus globulus	blue gum	Tree	Moderate	
Euphorbia oblongata	Oblong spurge	Perennial herb	Limited	
Foeniculum vulgare	fennel	Perennial herb	High	
Genista monspessulana	French broom	Shrub	High	C
Hedera helix	English ivy	Woody vine	High	
Helminthotheca (Picris) echioides	bristly ox-tongue	Annual or biennial herb	Limited	
Hesperocyperis (Cupressus) macrocarpa	Monterey cypress	Tree	Moderate (when outside native range)	
Hypericum perforatum	Klamath weed	Perennial herb	Moderate	C
Lathyrus latifolius	sweet pea	Perennial herb	Watchlist	
Ligustrum lucidum	glossy privet	Tree or shrub	Watchlist	
Lythrum salicaria	purple loosestrife	Perennial herb	High	B
Marrubium vulgare	horehound	Perennial herb	Limited	
Mentha pulegium	pennyroyal	Perennial herb	Moderate	
Mesembryanthemum crystallinum	crystalline iceplant	Annual herb	Moderate–ALERT	
Myosotis (latifolia?)	forget-me-not	Perennial herb	Limited	
Nerium oleander	oleander	Tree	Watchlist	
Olea europaea	olive	Tree or shrub	Limited	
Oxalis pes-caprae	Bermuda buttercup	Perennial herb	Moderate	
Phalaris aquatica	Harding grass	Perennial herb	Moderate	
Pinus radiata	Monterey pine	Tree	Limited (when outside native range)	
Robinia pseudoacacia	black locust	Tree	Limited	
Rubus armeniacus (discolor)	Himalayan blackberry	Shrub	High	
Senecio minimus (Erechtites minima)	coastal burnweed	Annual or perennial herb	Moderate	
Silybum marianum	milk thistle	Annual or biennial herb	Limited	

Table 10-1 Invasive Plant Species Documented as Present on the District Lands

Scientific Name	Common Name	Life Form	Cal-IPC Invasive Status (2014)	CDFA Rating (2014)
Spartium junceum	Spanish broom	Shrub	High	C
Stipa mileacea var. *mileacea* *(Piptatherum miliaceum)*	Smilo grass	Perennial herb	Limited	
Ulex europaeus	gorse	Shrub	High	B
Verbascum (thapsus?)	mullein	Biennial herb	Limited	
Vinca major	periwinkle	Perennial herb	Moderate	
Zantedeschia aethiopica	calla lily	Perennial herb	Limited	

Notes: Species documented during 2004 study (District/Shelterbelt Builders Inc. 2004).
CalIPC Invasive Status Definitions:

- High- Species with severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. Most are widely distributed ecologically.
- Moderate- ALERT – Species on an active Cal-IPC watch list as a species suspected to causing severe impacts (may be moved to High status). These species have substantial and apparent-but generally not severe-ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal, though establishment is generally dependent upon ecological disturbance. Ecological amplitude and distribution may range from limited to widespread.
- Moderate – See above---same as above but not on active Cal-IPC Watch list
- Limited –Species that are invasive, but that ecological impacts are minor on a statewide level or there was not enough information to justify a higher score. Their reproductive biology and other attributes result in low to moderate rates of invasiveness. Ecological amplitude and distribution are generally limited, but these species may be locally persistent and problematic.
- Watch List - - On a list of species that require further evaluation and monitoring to determine impact.

CDFA Rating Definitions:

- A = A pest of known economic or environmental detriment and is either not known to be established in California or it is present in a limited distribution that allows for the possibility of eradication or successful containment. A-rated pests are prohibited from entering the state because, by virtue of their rating, they have been placed on the of Plant Health and Pest Prevention Services Director's list of organisms "detrimental to agriculture" in accordance with the FAC Sections 5261 and 6461. The only exception is for organisms accompanied by an approved CDFA or USDA live organism permit for contained exhibit or research purposes. If found entering or established in the state, A-rated pests are subject to state (or commissioner when acting as a state agent) enforced action involving eradication, quarantine regulation, containment, rejection, or other holding action.
- B – A pest of known economic or environmental detriment and, if present in California, it is of limited distribution. B-rated pests are eligible to enter the state if the receiving county has agreed to accept them. If found in the state, they are subject to state endorsed holding action and eradication only to provide for containment, as when found in a nursery. At the discretion of the individual county agricultural commissioner they are subject to eradication, containment, suppression, control, or other holding action.
- C - A pest of known economic or environmental detriment and, if present in California, it is usually widespread. C-rated organisms are eligible to enter the state as long as the commodities with which they are associated conform to pest cleanliness standards when found in nursery stock shipments. If found in the state, they are subject to regulations designed to retard spread or to suppress at the discretion of the individual county agricultural commissioner. There is no state enforced action other than providing for pest cleanliness.

10.5 PREVENTION

IPM in natural areas focuses first on preventative actions. Preventative actions include modifying human behavior and land use practices to minimize conditions that favor invasive plant infestation and establishment. When combined with landscape-level invasive plant monitoring and early detection/rapid response methods, this approach ensures that invasive plants can be managed when they are small, rather than large populations.

Many invasive plants establish themselves in ruderal or disturbed areas, for example, freshly graded, flooded, or mechanically cleared land, while others exploit more subtle disturbance areas, such as edges of trails and roads or overgrazed rangelands. Management of these species can often be accomplished by implementing better land use practices. Landscape management changes such as restoring natural processes (e.g., fire and flooding), reducing stocking rates/utilize rotational grazing on rangelands, increasing biodiversity in croplands or altering forestry practices on timber tracts, can reduce invasive species populations to a level where active management is not required (Jackson et al. 2007). Other invasive species can invade stable, intact landscapes. These competitive species usually require active management to achieve effective control.

Seeds, insects, pets, and pathogens from anywhere in the world can easily arrive on District lands via numerous sources. The District's mission includes providing recreational access to 60,000 acres of public open space, so visitors are one of many sources of potential new pest infestations. For example, a nature-loving tourist may take a plane from another region of the world with a climate similar to California's, and visit one of the District's properties for a hike, inadvertently introducing seeds from invasive species on their hiking boots.

Agricultural pest prevention programs have been implemented by governments throughout the world, with point-of-entry and trade distribution inspections, insect trap monitoring, and nursery certification. In California, more than 30 million vehicles are monitored annually at California agricultural inspection stations when entering the state (CDFA 2013b). From these inspection stations, tens of thousands of prohibited materials are intercepted and seized annually which include a wide variety of agricultural pest species. Similar inspection systems are in place in many international ports of entry throughout the state, including airports, ports, and border crossings. Only more recently have regional entities and local governments begun to develop similar programs for species of local interest. These programs face many challenges in locations where defined borders where effective monitoring can occur do not exist. There is no clear regulatory oversight for local programs, and there is little funding and staffing available. The most successful examples of local control programs have so far been limited to the management of aquatic pest species of restricted distribution (e.g., California's quagga/zebra mussel quarantines using boating restrictions in recreational waterways) (California State Parks 2013).

Although the District may have limited opportunities to restrict the flow of invasive species into its preserves from world trade and tourism, prevention is possible at smaller scales. Project-specific best management practices and improved planning can help prevent inadvertent species introductions by requiring staff training on new invasive species that could invade District lands; inspection of outside materials, equipment and vehicles; and requiring staff ad contractors to only use clean materials equipment and vehicles on District lands. These best management practices intended to prevent introduction or establishment of new invasive species should be incorporated into the construction and maintenance of facilities, road maintenance, fire prevention, firefighting, and routine tool maintenance. Table 10-2 identifies specific preventative actions to reduce the potential to introduce and spread invasive species to District lands. Likewise, District visitors can be trained to identify, look for and report new invasive species that can invade District lands. Educational materials and boot cleaning stations at key entrance points can help prevent inadvertent introductions, or catch them early. And finally, managing lands in a manner that monitors and reduces areas of soil disturbance, reduces unnecessary and redundant trails and roads, and helps promote larger, intact areas of undeveloped natural areas can also make District lands more resilient to new invasive species invasions.

Table 10-2 Best Management Practices to Prevent Invasive Species Introductions (Recommendations selected from Cal-IPC)
Sanitation and Prevention of Contamination - All personnel working in infested areas will take appropriate precautions to not carry or spread weed seed or SOD-associated spores outside of the infested area. Such precautions will consist of, as necessary based on site conditions, cleaning of soil and plant materials from tools, equipment, shoes, clothing, or vehicles before entering or leaving the site.
All staff, contractors, and volunteer crew leaders will be properly trained to prevent spreading weeds and pests to other sites.
District staff will appropriately maintain facilities where tools, equipment, and vehicles are stored free from invasive plants.
District staff will inspect rental equipment and project materials (especially soil, rock, erosion control material, and seed) to confirm as much possible that they are free of invasive plant material before their use at a worksite.
Suitable onsite disposal areas will be identified to prevent the spread of weed seeds.

Table 10-2 Best Management Practices to Prevent Invasive Species Introductions (Recommendations selected from Cal-IPC)
Invasive plant material will be rendered nonviable when being retained onsite. Staff will desiccate or decompose plant material until it is nonviable (partially decomposed, very slimy, or brittle). Depending on the type of plant, disposed plant material can be left out in the open as long as roots are not in contact with moist soil, or can be covered with a tarp to prevent material from blowing or washing away.
Monitor all sites where invasive plant material is disposed onsite and treat any newly emerged invasive plants.
When transporting invasive plant material offsite for disposal, the plant material will be contained in enclosed bins, heavy-duty bags, or a securely covered truck bed. All vehicles used to transport invasive plant material will be cleaned after each use.

10.5.1 EARLY DETECTION/RAPID RESPONSE

Preventing the introduction of invasive species is the first line of defense against invasions. However, even the best prevention practices will not stop all invasive species introductions. Early Detection and Rapid Response (EDRR) programs increase the likelihood that invasions will be addressed successfully while the population size and extent are not beyond that which can be contained and eradicated on both practical and economic scales. According to the 2005 California State Noxious Weed Plan, “early detection is the single most important element in successful and economical eradication of new weeds before they become permanently established in new localities” (CDFA 2005).

An EDRR Program is a formalized monitoring program that utilizes active and passive land surveillance as a method to discover and identify new invasive species or their symptoms before they become widely established. This can be accomplished with 1) active detection, 2) passive detection, and 3) syndromic surveillance as defined by the National Invasive Species Working Group (National Invasive Species Counsel 2003, 2008).

- **Active Detection.** Active detection programs have structure, staffing, and dedicated funding to accomplish land surveillance (landscape-level invasive plant monitoring). Dedicated staff, volunteers, or contractors under a specific set of goals may run these programs. Active detection programs for invasive species often have limited resources so it is important to be focused on high-priority targets, such as high-risk locations, high-value resources, important pathways, and populations and species of concern.
- **Passive Detection.** Passive detection programs have more limited goals and structure that are embedded into existing programs and activities. These programs fortuitously detect invasive species as staff, volunteers, or contractors conduct other activities and may or may not have specific training or funding for the detection of invasive species.

Syndromic Surveillance. Syndromic surveillance uses the analysis of other resource management problems to detect invasive species indirectly through their direct damage or other ecosystem disruption. Detecting the damage associated with invasive species may be the first indication of a new invasion. This is often the case with invasive pathogens and parasites that are difficult to detect. Regardless of which detection system is selected for use by the District, EDRR efforts should include the following objectives:

- identify potential threats in time to allow control or mitigation measures to be taken;
- detect new invasive species in time to allow efficient and safe eradication or control decisions to be made;
- respond to invasions effectively to prevent the spread and permanent establishment of invasive species;
- provide adequate and timely information to decision-makers, the public, and to partner agencies concerned about the status of invasive species within an area; andadaptively implement detection and early response strategies over time.

The District currently does not have a well-developed EDRR program, or dedicated staff or contractors to implement such a program on a comprehensive basis. Some aspects of an EDRR program are implemented as District staff work on other projects.

DETECTION STRATEGIES

New invasive species may arrive in the District through sudden, unpredictable pathways (e.g., boots on a traveler) and more constant, predictable pathways (e.g., roads, trails, and/or horticultural escapees from neighboring properties). District lands are scattered throughout the San Francisco Peninsula, adjacent to urban development, rural private residences and hobby farms, and production agricultural landscapes including rangelands, dairies, commercial nurseries, and row and cereal crops. Each of these lands uses account for some possible introductions of invasive species along preserve borders, roads, trails, and easements.

The most efficient way to prevent routine introductions of invasive species into District lands is to use vigilant patrol and monitoring protocols along District boundaries that interface with urban and agricultural landscapes. Trails, roads, and waterways intersecting District lands are the most likely routes of invasion for new species. Many of these common pathways have been confirmed by previous District mapping and planning work (District 2004). Refer to Chapter 5, IPM Program Implementation, for more information on how the District intends to implement this action during IPM Program implementation.

MODELING INVASION PATHWAYS

The District maintains approximately 142 miles of single-track trail, 444 miles of road, and has a geographic border (not including adjacent District parcels) totaling 397 miles. Not all of these trails, roads, and edges have the same potential to introduce new invasive species into District properties. Locations within the District that receive the most intense impacts from disturbance, visitation, utility maintenance, and neighboring land use are the most likely sources for new species introductions. Simple models can be used on a local preserve level to analyze probable pathways for key invasive species the District may expect to encounter. The District can identify routine and sporadic activities that have a high probability of introducing invasive species and also the types of species anticipated.

Refer to Chapter 5, IPM Program Implementation, for more information on how the District intends to address EDRR during the IPM Program implementation. Table 10-3 defines a ranking system for the District to identify activities on preserves that are most likely to promote invasive species introductions. Table 10-4 provides a summary of known occurrences of novel invasive species (i.e., current targets of early detection programs that are considered likely to invade and impact California ecosystems if allowed to establish), and is intended to be a "Watch List" for use by the District in raising awareness of new invasive plants that may be found in the future on District lands. By understanding both the activities that promote invasions and the candidate species for likely invasion, the District can more successfully plan for prevention, detection, and control activities.

Table 10-3 Ranking of Most Likely Pathways of Invasive Species Introductions (Identification of Areas and Activities to Prioritize for Early Detection Monitoring)

Ranking of vectors' Probability to Import/Distribute Invasive Plants	
1	Heavy equipment from outside District
2	Top soil importation for construction
3	Sand or gravel for road construction
4	Work activities along rights-of-way external to District (e.g., PG&E, CalWater)
5	Work activities of District employees or contractors

Table 10-3 Ranking of Most Likely Pathways of Invasive Species Introductions (Identification of Areas and Activities to Prioritize for Early Detection Monitoring)

6	Grazing lessees/livestock grazing
7	Visitor vehicle traffic
8	Wind
9	Visitors hiking
10	Wildlife
11	Water
Prioritization of Specific Areas for Monitoring Based on Suitability for Invasion and Volume of New Plant Material (Seeds, etc.) likely to be Introduced	
Very high priority	
1	Construction/maintenance areas
2	Buildings, houses at the urban interface
3	Paved areas (e.g., roads/parking lots/trailheads)
4	Landscaped areas
5	Disturbance from human intervention (e.g., emergency fuel breaks during fire fires)
6	Trails
7	Areas of high visitor use
8	Utilities (e.g., cell towers, powerline corridors)
9	Pastures/agricultural areas
Medium priority	
10	District offices, structures
11	Riparian areas
12	Natural disturbances with no human intervention (e.g., fire, rockfall)
Low priority	
16	Off-trail wilderness areas

Source: adapted from Gerlach et al. 2001

Table 10-4 Invasive Plant Watch List: Invasive Plants that are Known to be Problematic near District Lands (for use in Early Detection and Rapid Response Efforts)

Scientific Name	Common Name	Species Reported (X) to Occur in:			
		District	San Mateo County	Santa Clara County	Santa Cruz County
Plants					
Acacia paradoxa	Kangaroo thorn		X	X	X
Acaena novae-zelandiae	Biddy biddy				X
Achnatherum brachychaetum	Puna needle grass				
Acroptilon repens	Russian knapweed			X	X
Aegilops cylindrica	Jointed goatgrass	X	X	X	
Aegilops triuncialis	Barbed Goatgrass	X	X	X	X
Ambrosia trifida	Giant ragweed				

Table 10-4 Invasive Plant Watch List: Invasive Plants that are Known to be Problematic near District Lands (for use in Early Detection and Rapid Response Efforts)

Scientific Name	Common Name	Species Reported (X) to Occur in:			
		District	San Mateo County	Santa Clara County	Santa Cruz County
Araujia sericifera	Bladderflower		X	X	X
Arctotheca calendula	Cape weed		X		X
Arrhenatherum elatius	Tall oatgrass		X	X	X
Asparagus asparagoides	African asparagus fern			X	X
Asphodelus fistulosus	Onionweed				
Brachypodium sylvaticum	Slender false brome	X	X	X	
Buddleja davidii	Butterfly bush		X	X	
Carduus acanthoides	Spiny plumeless thistle				
Carex pendula	Hanging sedge	X	X		
Carthamus leucocaulos	White stemmed distaff thistle				
Centaurea diffusa	Diffuse knapweed			X	
Centaurea iberica	Iberian knapweed			X	
Centaurea stoebe ssp. micranthos	Spotted knapweed	X		X	
Centaurea sulphurea	Sicilian starthistle			X	X
Cestrum parqui	Chilean Jessamine				
Chondrilla juncea	Skeleton weed		X	X	
Cirsium undulatum	Wavy leaved thistle				
Coprosma repens	Creeping mirrorplant		X		X
Crupina vulgaris	Bearded creeper				
Cuscuta japonica	Japanese dodder				
Cytisus striatus	Portuguese broom		X		X
Dittrichia graveolens	Stinkweed	X	X	X	X
Echium plantagineum	Salvation echium				
Elymus caput-medusae	Medusa head grass	X	X	X	X
Ehrharta calycina	Perennial velt grass				X
Ehrharta erecta	Erect velt grass	X	X		X
Euphorbia esula	Leafy spurge				
Euphorbia oblongata	Oblong spurge	X	X	X	X
Euphorbia terracina	Geraldton carnation weed				
Fallopia japonica	Japanese knotweed			X	X
Festuca pratensis	Meadow fescue			X	X
Gazania linearis	Gazania	X	X	X	
Gunnera tinctoria	Chilean gunnera				
Halimodendron halodendron	Russian salt tree				
Helichrysum petiolare	Licorice plant				
Hypericum canariense	Canary Island St John’s Wort		X		X
Isatis tinctoria	Dyers woad				
Lepidium appelianum	Hairy whitetop	X	X	X	
Lepidium campestre	Field pepper grass		X		

Table 10-4 Invasive Plant Watch List: Invasive Plants that are Known to be Problematic near District Lands (for use in Early Detection and Rapid Response Efforts)

Scientific Name	Common Name	Species Reported (X) to Occur in:			
		District	San Mateo County	Santa Clara County	Santa Cruz County
Ligustrum lucidum	Glossy privet				
Ligustrum ovalifolium	California privet		X		
Limonium ramosissimum	Algerian sealavender		X	X	
Linaria genistifolia ssp. dalmatica	Dalmatian toadflax		X		X
Linaria vulgaris	Butter and eggs			X	
Lonicera japonica	Japanese honeysuckle		X		X
Lythrum salicaria	Purple loosestrife		X		X
Nassella formicarum	Andean tussockgrass				
Nassella tenuissima	Finestem needlegrass		X	X	X
Oenothera sinuosa	Wavy-leaved gaura		X	X	X
Oenothera xenogaura	Drummond’s gaura		X		X
Onopordum acanthium	Scotch cottonthistle				
Onopordum Illyricum	Illyrian thistle			X	
Paspalum urvillei	Vasey’s grass	X		X	
Persicaria wallichii	Himalayan knotweed				X
Polygonum aubertii	Bukhara fleeceflower				
Pyracantha coccinea	Scarlet firethorn				
Pyracantha crenulata	Nepalese firethorn				
Ricinus communis	Castor bean		X	X	X
Rubus laciniatus	Cut leaved blackberry				
Rumex dentatus	Toothed dock				
Rytidosperma penicillatum	Purple awned Wallaby Grass		X	X	X
Saccharum ravennae	Ravennagrass				
Sapium sebiferum	Chinese tallowtree				
Scolymus hispanicus	Golden thistle		X	X	
Senecio jacobaea	Tansy ragwort				X
Senna multiglandulosa	Glandular cassia			X	
Sesbania punicea	Rattlebox			X	
Solanum carolinense	Carolina horse nettle				
Solanum rostratum	Buffalo berry				X
Spartina alterniflora	Salt water cord grass				
Spartina densiflora	Dense flowered cord grass		X		
Spartina patens	Salt meadow cord grass				

Notes: Species list and occurrences compiled from the Bay Area Early Detection Network (BAEDN) Priority Weeds and CalFlora (2013), District Weed List. Records of occurrence shown below may be extirpated, but indicate some likelihood of current or future occurrence on District properties.

STAFF TRAINING

Early detection monitoring can be accomplished by staff, volunteers, park patrons, or contractors. The utilization of existing natural resource management and maintenance staff and volunteers provides the best value for the District. With limited training, existing staff resources can be utilized and repurposed for early detection monitoring at minimal additional cost although it will not be a comprehensive effort. Refer to Chapter 3, Section 3.6 for a more detailed description of planned IPM trainings.

In a world with millions of species, detecting a new arrival can sometimes be a challenge since very few people have adequate training to identify foreign and unfamiliar species. However, there is potential to train staff and volunteers familiar with District habitats to notice and report when species are found that appear unusual or out-of-place. In addition to new invasive species, other resource management targets such as rare plants and animals may also be discovered through this type of observation.

The following techniques should be implemented to support an effective early detection program:

- Develop a simple invasive species identification guide for use by laypeople. Include invasive species currently known to occur in District preserves (Table 10-2), as well as “Watch List” species known to occur in the regions (Table 10-4). The identification guide should include photographs (several life stages), life cycle, and associated habitats. As funding and staffing allow, update this identification guide over time to ensure its usefulness in EDRR efforts. The IPM Coordinator will coordinate regularly with local agencies who track and monitor invasive plants in the region, such as California State Parks, San Mateo/Santa Clara Weed Management Areas, and BAEDN.
- Train permanent and seasonal Rangers, Open Space Technicians, volunteers, and contractors in using electronic and/or paper weed mapping methods. Practice data collection with staff and volunteers so data recording and processing is consistent. Start with basic paper mapping methods, which can be suitably accurate, easier, and cheaper to manage than digital systems. Enter this information into the District’ Pest Database.
- Develop simple workflows that incorporate all District departments/staff that perform pest control. Develop a methodology to receive and organize weed mapping information so none is lost or forgotten. Consider ways to incorporate this information into existing forms or maps to keep things simple and reduce paperwork.
- Produce and post baseline weed maps for each preserve at field offices so staff can stay informed about current populations and make updates in real-time directly on maps.
- Ensure that data collection methods are relevant to partner organizations such as California State Parks, San Mateo/Santa Clara Weed Management Areas, and BAEDN so the information can be shared with other cooperating agencies.
- If using volunteers, support a specialized group of committed individuals that receive training for invasive species identification and mapping activities. Ensure the goals for use of volunteers in this capacity are clear and that the resulting data generated by the volunteers is useful to District staff.

RAPID RESPONSE STRATEGIES

Small infestations of invasive species generally offer the greatest number of treatment method options for successful eradication. Many times, hand removal of individuals is the control method with the greatest selectivity and cost effectiveness with the least amount of indirect impacts. Individual specimens or small patches identified incidentally or during regular monitoring can often be immediately removed. For vegetation removal, hand digging, cutting, or pulling are all examples of selective hand removal. For vertebrate species, hand removal usually means trapping or shooting. Small-scale removal is most effective on newly-established and small populations with limited distributions.

Pesticides may also be an efficient treatment method for rapid response actions. In some cases, a specific pesticide may be identified to abate an immediate invasive species hazard when it is found. Pesticides may be especially effective for species where hand removal actions are impractical (e.g., steep cliffs) or where hand or mechanical removal methods would risk spread of the species (e.g., where plants that can spread from broken root fragments). It is critical that herbicides be on the List of Approved Pesticides (Appendix A) so there is no delay because of the approval process for implementing a rapid response.

In all cases, the District will map the occurrence before control, and then revisit the control site several times to ensure full control was achieved. Eradication may require multiple visits in a year, or possibly multiple years of monitoring and treatment.

10.6 DAMAGE ASSESSMENT

Staff will determine what, if any damage to the natural area and its natural resource values has resulted from the presence of the pest species. To the extent possible, quantify the damage (in acres, square feet or numbers of occurrences affected) and qualitatively describe the perceived damage in its context. As an example, a staff person could determine that a certain percentage of the District's native perennial grassland acres are infested with yellow star-thistle, a target pest species, resulting in displacement native species and degradation of a large percentage of the natural resources on District lands. Ultimately, the District's goal is to maintain the long-term stability and resiliency of its natural areas, therefore damage assessments must consider the long term effects of the pest infestation.

10.7 TOLERANCE LEVELS/THRESHOLD FOR ACTION

Tolerance levels vary greatly for invasive species; some species have much greater impacts on the environment than others, or they may be so completely mixed with native species such that control methods would result in unacceptable damage to native habitats or rare species, or simply be technologically impossible. The District's IPM approach for invasive species begins with establishing site-specific conservation goals, leading to a determination of the targeted actions with which specific individuals or populations can be managed to achieve the stated goals.

Tolerance levels and treatment methods for invasive species are based on the potential of the invasive species to degrade wildlife habitat and other natural resource values such that the long-term stability and resiliency of its natural areas are compromised. To do so, staff must consider worker health and safety, visitor safety, and the technical feasibility of meaningful control (i.e., a cost/benefits analysis). Because many of the District's invasive species populations are present across multiple preserves or present throughout the entire region, scale is an important variable in determining the feasibility and need for control and the selection of a treatment method. Unlike pest management in structural landscapes, invasive species tolerance levels must factor in the scale at which a management tool is both appropriate and effective. Treatments such as hand removal may have minimal negative unintended impacts when a few individuals are removed, but substantially greater impacts (e.g., soil erosion or damage to non-target species, injury to staff) when the same treatment is applied to large areas. Similarly, the control of large populations of invasive plants using mechanical control methods can be cost prohibitive, impractical, and dangerous. The population size and habitat conditions for which each management technique is useful and appropriate is discussed for each section below. Tolerance levels not only differ by species, but also location and spatial scales. All treatment method selections will balance the net negative impacts to the natural environment, safety of the public, District workers and contractors, and the visitor experience.

Establishing tolerance level for insipient and widespread invasive plants in common, widespread natural communities (e.g., yellow star-thistle in annual grasslands or French broom in oak woodlands) will be established on a case-by case basis by comparing the anticipated benefit against the cost and potential for success of the target invasive control efforts. As an example, tolerance levels for French broom in oak woodlands will be determined based on the total amount of infested areas within total oak woodlands on the subject preserve. As a general rule of thumb, the tolerance level for invasive plants will be exceeded where infestations exceed more than 10 percent of the total amount of a sensitive vegetation type, or 25 percent of the total amount of a common vegetation type. When tolerance levels are exceeded, District staff will then assess if active control is feasible by conducting a quick cost/benefit analysis. If staff determines that control is technically feasible and can be accomplished using existing staff and budgeting parameters, an Individual Pest Plan will be prepared (Chapter 3). If however, available pest control options are not likely to be successful, staff may elect not to implement active pest control.

For federal and state listed species, certain protections are required under the state and federal Endangered Species Acts, and tolerance levels will be linked to compliance with the ESA's. For wetlands, tolerance levels are linked to federal regulations under the federal Section 404 Clean Water Act and to state regulations as described in Section 401 Clean Water Act and in the Porter-Cologne Act. For natural communities, tolerance levels will be related to degree of rarity in the region (as indicated by experts such as the state California Natural Diversity Database, California Native Plant Society, and local experts); the relative rarity of the community on District lands; the technical and cost feasibility of the pest to be controlled; and the sensitivity of the natural community to pest damage.

Following procedures outlined in this Chapter, District staff will qualitatively and quantitatively determine the degree of pest damage to the natural resource, then determine if action is warranted.

10.8 TREATMENT OPTIONS

When all other options for preventing or actively reducing pest population levels to below specified tolerance levels have been exhausted, District staff will determine treatment options. Because natural area pest control (typically control of invasive plants) is one of the most expensive and time-consuming aspects of District preserve management, special attention will be given to selecting proven, technically feasible, and cost-efficient least environmentally disruptive and harmful pest control solutions. Refer to Chapter 3 for project prioritization procedures intended to maximize the effectiveness and efficiency of District pest control actions.

Staff will evaluate pests in natural areas as follows:

- Pests will be treated (eradicated or controlled) when their presence could directly threaten the health and safety of visitors and staff.
- For pest infestations that are affecting listed species, pest species will be treated to comply with state and federal Endangered Species Acts, and tolerance levels will be linked to compliance with the ESA's.
- For pests in wetlands, pest species will be treated to comply with the Federal Section 404 Clean Water Act, and state wetland regulations as described in Section 401 Clean Water Act and in the Porter-Cologne Act.
- Pest species may be considered for treatment (eradicated, controlled, or contained) if and when District staff determines that their presence is likely to result in the loss of the long-term stability and resiliency of the natural areas as a whole.
- Pest species may be considered for treatment (eradicated, controlled, or contained) if and when District staff determines that the pest could displace or degrade individual natural resources (e.g., where the presence of an invasive species is displacing a rare plant or animal population).
  - For natural communities, tolerance levels will be related to the sensitivity of the natural community to pest damage and the degree of rarity of the individual natural community in the region (as indicated by

experts such as the state California Natural Diversity Database, California Native Plant Society, and local experts)

- For native species, tolerance levels will be related to the sensitivity of the individual species to pest damage and the relative rarity of the individual species in the region or on District preserves. (Note: rarity to be determined by experts such as the state California Natural Diversity Database, California Native Plant Society, and local experts)

- Pest species may not receive treatment when their presence is not likely to result in the loss or severe displacement or degradation of natural resources and/or when treatment is considered technically infeasible, unsafe, or harmful to the environment.

If the target pest exceeds specified tolerance levels, the District will begin to investigate pest control options. This includes the following general steps involved in pest control planning:

- delineate a project area;
- determine pest control objectives;
- identify any dispersal routes or mechanisms that may have helped the pest enter or spread onto District lands;
- identify a range of possible pest control options using information presented below;
- select a preferred pest control approach;
- prepare an Individual Pest Management Plan (if necessary- see Chapter 3);
- implement the selected pest control approach; and
- using adaptive management, monitor, report (see Chapter 3) and adjust the selected pest control approach to achieve project objectives.

10.8.1 INVASIVE ANIMALS IN NATURAL AREAS

NON-NATIVE FISH

Known species of non-native fish in the District include black bass (*Micropterus* sp.), sunfish (*Lepomis* sp.), catfish (*Ameiurus/Ictalurus* sp.) and mosquitofish (*Gambusia* sp.) (Anderson 2013). These species are generally found in man-made stock ponds and reservoirs but some also occur in natural sag ponds. The District does not actively manage non-native fish in man-made water bodies unless the water body also supports protected native species such as the California red-legged frog. In special cases where protected species are present, ponds are typically drained for sufficient time to eliminate all non-native fish species and then refilled. As most nonnative fish species are managed as game fish by the CDFW, special permits are typically obtained for their control.

BULLFROGS

The American bullfrog (*Rana [Lithobates] catesbeiana*) is a large, brilliant green amphibian that is native to eastern North America. Its natural range does not extend west of the Rocky Mountains and Great Plains but it is an increasingly common invasive animal in the western United States. Bullfrogs are sold throughout the world as food, pets, fish bait, and for educational purposes. They sometimes become unwanted pets or escape from frog farms and grocery stores, and as a result have readily established themselves in all suitable habitats throughout California.

Bullfrogs are classified by the CDFW as a game amphibian and are regulated by state fishing regulations. As a game amphibian, commercial and sport collection is permitted with commercial and sport fishing licenses, but individuals cannot be controlled as an invasive species unless they are specifically utilized for a purpose (i.e., wanton waste is prohibited by statute). State fishing regulations do not include any depredation conditions, so all bullfrog control efforts and programs require a specific Memorandum of Understanding or Special Permit from the CDFW (Kasteen, pers. comm., 2013).

American bullfrogs are most problematic in the District because they directly affect the federally Threatened California red-legged frog (*Rana draytonii*) (Lawler et al. 1999). In habitats where they exist together, large, overwintering bullfrog tadpoles can compete with California Red-Legged Frog tadpoles or even consume them directly. Adult bullfrogs consume California red-legged frogs in all forms (i.e., as tadpoles, metamorphs, or as adult frogs), in addition to other native wildlife species such as newts, salamanders, garter snakes, birds, and bats. Their voracious appetites have been implicated in the declines of many North American amphibian species.

In addition to competition and predation, bullfrogs spread chytrid fungus – a lethal skin disease known as chytridmycosis that impacts many of California's native amphibians (Schloegel et al. 2009). Chytrid fungus is a non-native fungal pathogen from Asia that has spread to decimate amphibian populations all over the world. Because bullfrogs are domestically raised for food and educational purposes worldwide, many that are imported to California each year carry the chytrid fungus from unregulated foreign frog farms. As these individual frogs are accidentally or intentionally released into the wild, they help to spread the fungal disease throughout native amphibian populations.

PEST MANAGEMENT STRATEGIES FOR BULLFROGS

Prevention and control of American Bullfrogs is discussed below. Tolerance levels and treatment methods are also outlined in Table 10-5.

Prevention

- **Education.** Education can be an important tool for the District in preventing captive frogs from being intentionally released onto District lands. Some people feel ethically motivated to release captive pets and food animals back into natural environments for humane reasons or when they no longer wish to care for them. Public outreach and judiciously placed educational materials such as signs and brochures in District preserves with wetlands may be a useful strategy to curb intentional releases of animals.
- **Fencing.** Exclusionary fencing to keep bullfrogs from entering non-infested wetlands is a temporary tool for use while other control methods are applied concurrently. Fencing is not considered a long-term solution because it disrupts movement of other wildlife, can entrap non-target wildlife species, and may disrupt the natural processes of the wetlands. Exclusionary fences are useful during pond draining to limit the potential for dispersal of bullfrogs out of the treatment area. Exclusionary fencing may also be used in conjunction with funnel traps to collect bullfrogs as they attempt to disperse from drying ponds.

Physical Control

- **Gigging or shooting.** Gigging or shooting American bullfrogs (a pest species not native to California) are two methods that are implemented with small caliber air rifles and lead-free ammunition to eliminate individual adult bullfrogs. Gigging is the targeted spearing of fish or frogs with barbed tines mounted on a long pole. Both gigging and shooting are effective and humane methods for selective removal of target adult bullfrogs. However, this treatment method alone will rarely eradicate bullfrogs from the target area because only a portion of adults are usually found, and it does not control eggs or larval stages. Some studies have indicated that adult metamorph removal (i.e., removal of immature bullfrogs) is the most economical removal method for population suppression (Govindarajulu 2005). Egg masses can also be collected to remove additional life stages at the appropriate time of year.
- **Trapping.** Submerged funnel traps and floating cage traps can be used to control different life stages of American bullfrogs. Funnel traps designed for catching baitfish can be used to live capture bullfrog tadpoles. Floating cage traps have been successfully used to catch adult frogs. Trap designs for bullfrog removal are relatively recent and mainly rely on modifying Australian cane toad traps. Methods designed to trap multiple

life stages of frogs in parallel have proven to be effective for bullfrog management (Snow and Witmer 2011). Though trapping is a recently-developed treatment method for bullfrogs, it may be effective especially where other sensitive amphibian species are present to which impacts must be avoided.

- **Electrical currents.** Use of electrical currents (electroshocking) to temporary disable frogs in netting and gigging operations have proved to be effective in some control programs (Orchard 2011). 12v DC electroshockers that are typically used in fisheries management are mounted either on small boats or on backpacks, then the electroshock current applied to the surface of the wetland. This treatment is non-specific, and will affect all aquatic species within the range of the electroshocking 'wand'. Electroshocking is not lethal, rather it shocks and lifts the affected individuals to the surface where they can be netted or otherwise collected. This treatment method, therefore, must be followed by another treatment method such as hand removal or gigging. Even with follow-up control of individuals found by electroshocking, this treatment method alone will rarely eradicate bullfrogs from the target area because only a portion of adults are usually found, and it does not control eggs or larval stages.
- **Habitat Manipulation.** Pond draining is one of the most common methods used for bullfrog control in California, especially in projects where protected species may be present such as the native California red-legged frog. American bullfrogs need a perennial water source to complete their lifestyle. In contrast, California red-legged frogs only need water during their breeding cycle. The USFWS California Red-legged frog Recovery Plan and others recommend draining ponds that contain both bullfrog and California red-legged frog species every other year to reduce the habitat suitability for bullfrogs (Grey 2009). Type conversion of permanent stock ponds to ephemeral wetlands can also reduce bullfrog populations across a landscape scale.
- **Exclusionary Fencing.** The District may install exclusionary fencing to keep bullfrogs from entering non-infested wetlands as a temporary preventive tool for use while other control methods are applied concurrently. Fencing is not considered a long-term solution because it disrupts movement of other wildlife, can entrap non-target wildlife species, and may disrupt the natural processes of the wetlands. Exclusionary fences are useful during pond draining to limit the potential for dispersal of bullfrogs out of the treatment area. Exclusionary fencing may also be used in conjunction with funnel traps (described below) to collect bullfrogs as they attempt to disperse from drying ponds.

Chemical Control

No toxicants or fertility control treatments are registered for use in controlling bullfrogs in California (Table 10-5).

Table 10-5 Treatment Methods for American Bullfrogs

Pest Category	Treatment Method Thresholds	Timing	Treatment	Treatment Constraints
American Bullfrogs	Incipient: < 25 individuals	Adults present in breeding ponds (February-July)	Hand removal of adults; gigging, shooting adults and metamorphs, egg mass collection	Small populations - accessible water bodies only
	Medium - Expanding Population	Adults and juveniles present in breeding ponds (February-August)	Funnel and cage trapping, exclusionary fencing	Requires combined trapping of tadpoles and adults
	Large - established populations in managed ponds	Adults present in breeding ponds (April-October)	Pond draining with exclusionary fencing	Not possible in wetlands or where other natural resource may be damaged by draining
	Large - established populations in wetland areas that cannot be drained	Adults present in breeding ponds and wetlands (April-October)	Electroshocking with boats and nets exclusionary fencing	

OTHER NON-NATIVE AMPHIBIANS AND REPTILES

Several species of non-native turtles are known to occur in District ponds and water bodies. These species are common food items for Bay Area ethnic communities and/or pet species. The red-eared slider (*Trachemys scripta elegans*) is the most common species known to occur within the District and an eastern snapping turtle (*Chelydra serpentina serpentina*) has been documented in at least one District pond. Red-eared sliders are managed as game fish species and snapping turtles are a restricted species in California. The District does not actively manage red-eared sliders unless the water body also supports protected, native species such as California red-legged frogs. The District will attempt to trap non-native turtles and remove them in compliance with CDFW when they share habitat with protected, native species. The District will attempt to trap restricted amphibian and reptile species in compliance with CDFW. Traps are designed specific to the target species and meant to capture the turtles without harm. Traps are checked daily for release and documentation of any native species and removal of any non-native species. A qualified biologist determines if any native species are present in the trapping area and consults with CDFW and USFWS if special status species are present. A qualified biologist complies with CDFW recommendations for restricted species since they are illegal to possess in California without a special permit. In special cases, ponds are drained for sufficient time to collect and eliminate non-native amphibian species (in compliance with CDFW Code) and then refilled. See information on pond draining presented above for bullfrogs.

FERAL PIGS

Feral pigs (*Sus scofra*) are one of the most destructive wildlife species in California and continue to expand their range throughout the entire United States. Feral domestic and wild Eurasian pigs are not native to North America but have been introduced in multiple events. These wild pigs have hybridized to become unique, abundant invasive pests in California, and they are thought to be one of the most prolific large mammals on earth (West et al. 2009).

Any pig living unassisted in the wild in California is classified as a game animal by current CDFW Code, which regulates the sport harvest of game animals in California. Pigs have extremely generous allowable methods of sport take, and can be harvested year-round in unlimited quantities with a hunting license and valid pig tag. Because they are also regulated as an agricultural pest in California by the USDA – APHIS Wildlife Damage Control Services and the CDFA, their management is often regulated by depredation permits from the CDFW. These permits can be obtained by private growers, ranchers, or other land owners and public agencies when proof of economic damage can be documented to the CDFW.

Pigs are mammals that are capable of extremely high reproductive rates when environmental conditions are favorable. In California's Coast Ranges, they can reach high populations densities because of cool weather, year-round access to water, and food (including acorns, a favored food source) through the winter months. Their invasive potential is largely because of their ability to quickly increase population size; they reach sexual maturity at young ages, females can have multiple litters each year, and natural mortality rates are generally low with few native predators. They can also disperse over large distances to invade new habitats and so cannot be managed effectively on a local basis.

Pigs cause damage to California agriculture and native fish and wildlife. Their destructive rooting behavior is visible in many natural areas. Rooting increases erosion and soil sedimentation, decreases water quality, directly reduces native plant species (e.g., ingestion of tubers, acorns), and promotes the establishment of non-native and invasive plants in disturbed soils (Seward et al. 2004, Kotanen 1995). They also create competition for food resources that would normally be consumed by native wildlife (especially winter acorns), spread disease to wildlife, and consume ground nesting birds, reptiles, amphibians and small mammals (The Nature Conservancy 2009, Barrett 1982). Wild pigs are also estimated to cause $1.5 billion of crop damage annually through the direct consumption and damage to crops, transmission of disease to livestock, and other damages to property and agricultural infrastructure (USDA 2009). The District has in the past conducted feral pig predation under a CDFW permit.

PEST MANAGEMENT STRATEGIES FOR FERAL AND WILD PIGS

Under the direction of the California Department of Fish and Wildlife, the District has developed a management program to capture feral pigs using baited traps and humane termination (shooting). As part of the program, the District coordinates with other regional land management agencies that are controlling feral pig populations. Since 2000, over 300 feral pigs have been dispatched and pig rooting, damage, and sightings have substantially decreased. Prevention and control of feral and wild pigs is discussed below. Tolerance levels and treatment methods are also outlined in Table 10-6.

Table 10-6 Treatment Methods for Feral and Wild Pigs

Pest Category	Treatment Method Threshold	Timing	Treatment	Treatment Constraints
Feral & Wild Pigs	Incipient: < 2 individuals	Year-round	Shooting incidentally observed individuals	Not possible in heavy visitor use areas
	Medium to large populations	Year-round	Cage and corral trapping program	

Prevention

- **Fencing.** Exclusion of pigs with pig-proof fencing can be effective in preventing high value areas from being invaded by pigs. Fencing must be maintained annually to be effective. Pig-proof fencing is usually very expensive to install and maintain and also has the possibility of restricting the movement of native animal species. It is an effective strategy for protecting extremely high value natural areas, agricultural lands, or archeological sites in small areas.

Physical Control

- **Shooting.** Shooting (either hunting or professional depredation) is the most common method for feral pig control throughout California (CDFW 2013). Though state sport hunting is regulated in such a way to offer some control of pig populations, there can still be a population increase above target levels because pigs often change their behaviors to avoid hunting pressure. Permitted depredation hunting with the assistance of tracking dogs or using nighttime vision aids and thermal imaging can increase the effectiveness of managing populations. Shooting methods should only employ lead-free, copper-based ammunition to reduce non-target mortality to pig carcass scavengers. Shooting has limited public appeal in and near recreational facilities and may not be a practical option for the District.
- **Trapping.** Trapping is the most effective means for regulating wild pig populations on a small landscape scale, although it must be done in perpetuity to maintain low population numbers. Cage- or corral-type traps are the most commonly used trap design in California. Snares have been found to be highly successful in Hawaii and Texas. Cage traps function by attracting single or multiple pigs into traps with bait through a one-way or guillotine trap door. Since pigs have large home ranges and they can disperse over large landscapes, effective trapping must focus on areas pigs are actively using. This requires the trapper to scout large landscapes or use a network of camera-traps to identify locations where pigs are actively travelling and feeding. Pre-baiting increases the effectiveness of live-catch traps. Trapping requires great effort and costs are typically high, but it is currently one of the most effective available methods for population control. All cage trap and snaring methods must be permitted through the CDFW on a project-by-project basis.

Chemical Control

- **Toxicants.** No toxicants are currently registered for the control of pigs, although some are in development for Federal registration through the EPA (Lapidge 2012).
- **Contraception.** Currently, no immuno-contraceptives are registered for use on wild pigs although some are in development. The Wildlife Society considers wild pig contraception controls to be impractical in the field (Fagerstone 2002), so they are likely not a viable treatment method for managing feral pigs on District lands.

FERAL PETS

As with non-native turtles, domestic animals are sometimes released by preserve visitors, or wander into preserves on their own. Some people feel ethically motivated to release captive pets and food animals back into natural environments for humane reasons or when they no longer wish to care for them. As a result, domestic cats, dogs, rabbits and other species end up living in preserves, and utilizing native rodents, plants, and insects for food.

Prevention

- **Education.** Education can be an important tool for the District in preventing pets from being intentionally released onto District lands. Public outreach and judiciously placed educational materials such as signs and brochures in District preserves may be a useful strategy to curb intentional releases of animals.

Live Capture

Utilize catch pole or otherwise trap dogs, cats, turtles, rabbits and other domesticated animals found escaped or released in the preserves and return them to their owners or turn them over to local animal control departments or animal shelters.

10.8.2 INSECT PESTS IN NATURAL AREAS

In general, insects are considered a natural component of the District's natural areas and do not warrant control. In some limited circumstances, such as restoration of a native habitat through active planting, short term insect control may be warranted (for example, to control stinging insects or Argentine ants within a specified area during clearing or planting to protect worker or volunteer safety, plant health, and promote native insect pollination). For information regarding control of insect pests in natural areas, refer to the Buildings section (Chapter 6).

10.8.3 INVASIVE PLANTS

The selection of physical control, chemical control, or other treatment methods for the District's target invasive plant species on over 60,000 acres of terrestrial and aquatic habitats in natural areas, various rangelands, and agricultural properties is an extremely complex task. This document is only intended to summarize generalized options for simplified management scenarios, and to provide decision-making tools for the thoughtful implementation of an IPM strategy. Staff who are selecting a project-level IPM strategy must take into account site-specific conditions, detailed life history information for a target invasive plant, project history, an understanding of the native vegetation where these plants occur, the impacts of the target plant, and the feasibility for safe and effective long-term control. Maintaining pest levels below a desired tolerance level will ultimately rely on several integrated methods for various stages of the project; rarely will a single method, pesticide or otherwise, suffice to achieve long-term success.

ANNUAL AND BIENNIAL INVASIVE PLANTS

Annual plants live for one growing season and germinate from seed. Only the dormant seed bridges the gap between one generation and the next. Biennial plants have a similar life history except they can live for several growing seasons before flowering and death. After germination, many species develop into prostrate (i.e., ground-hugging) basal rosettes. This growth form allows the plant to suppress germination of other plants near its root zone to maximize the solar energy reaching its leaves. After a critical amount of energy is collected and stored in the basal rosette form, the plant initiates its final growth stage and elongates or 'bolts' to produce a flowering stalk. Environmental cues that initiate bolting, flowering, and seed production include changes in day length, light and temperature, soil moisture and other stresses to the plant (Lanini 2002).

Many annual plants, both native and non-native, are considered 'weedy' because they have generalist rather than specialist life history traits. Annuals may be self-fertile or require pollination, or may utilize a combination of both pollination strategies. Often, invasive plants are highly successful because they produce many viable seeds with or without specialized pollination. In contrast, many native plants rely on specific native pollinators such as solitary native bees and cannot compete with the volume of seed production of invasive plants. Since annuals rely entirely on seed production for survival, the most successful invasive annual plants typically produce tremendous amounts of seeds each year. Many invasive (and native) species also have specialized seed coats that aid in seed dormancy in the soil, allowing the seed bank of a plant to persist in the soil for many years. Seed dormancy allows the plant to germinate only when environmental conditions ideal for growth are present and allows for seedling emergence over several decades instead of just one or a few years. The extended germination period of some invasive species can be problematic for control efforts, as follow-up treatments for new seedlings may be required for many years.

Within District lands there are two main growing seasons for annual and biennial invasive plants: referred to as early season and late season. Early season annuals and biennials germinate, flower, and seed between November and June, while late season annuals and biennials germinate, flower, and seed between February and August. Common annual invasive plants that the District currently manages include yellow star-thistle (*Centaurea solstitialis*), wooly distaff thistle (*Carthamus lanatus*), and Italian thistle (*Carduus pycnocephalus*). Biennials include purple star-thistle (*Centaurea calcitrapa*) and poison hemlock (*Conium maculatum*).

PERENNIAL INVASIVE PLANTS

Perennial plants persist for many growing seasons and have a great diversity of growth strategies. Perennials include ferns, bulbs, herbaceous plants, woody shrubs, and trees. Herbaceous perennial plants typically go dormant, die back, and or lose their leaves each winter and regrow from the root system the following spring. Evergreen perennial plants retain their above-ground stems and leaves throughout their life, except sometimes in cases of extreme stress (e.g., drought). Deciduous perennial plants retain their aboveground stems but lose their leaves seasonally when they are not actively growing. Trees and shrubs are perennial plants with woody stems, and can be either evergreen or deciduous.

Understanding the biology and reproduction method of perennials is essential to developing effective control strategies. Perennial plants can have multiple reproduction methods, including seeds, re-growing from vegetation fragments, or resprouting or colonizing from roots. In some cases species may use a combination of all these reproductive strategies for successful establishment and expansion. Perennial plants can spread vegetatively from many different portions of the plant (e.g., from runners, tubers or bulbs, root fragments) depending on species. Preventing seed production in perennial invasive species that rely exclusively on seeds for regeneration can deplete the existing seed bank, (as with annuals), but this strategy does not address the parent population which must also be controlled. Control of perennial plants often focuses on removal of the roots or other underground storage tissues, where energy reserves are stored. However, this treatment method may result in ground disturbance and/or soil erosion that must also be mitigated or avoided.

Pest Management Strategies for Invasive Plants

Prevention and control of invasive plants is discussed below. Tolerance levels and treatment methods are also outlined in Tables 10-7 (Annual Plants) 10-8 (Perennial Plants), and 10-9 (Aquatic Plants).

Prevention

- Develop and implement an employee and contractor prevention training program; include invasive plant identification and cleaning protocols for clothing, tools, and vehicles.
- Inspect recreational facilities (e.g., parking lots, trails, visitor centers) that experience high visitor use often during target invasive plant flowering and seed production times. Treat any detected target invasive plant populations to prevent spread from the facility into the preserves.
- Establish and maintain cleaning and prevention facilities (e.g., boot cleaning stations) and post educational materials in parking lots and trailheads to encourage visitors to clean their boots, socks, pants, etc. before entering District lands.
- If target invasive plants have already begun to flower and set seed before management, consider manual control methods (e.g., cutting and bagging the flower/seed heads) intended to reduce the amount of new seed released. This type of active management is only feasible for small populations.
- Prevent the spread of plant fragments (roots, stems) of certain perennial species that can produce new plants from these plant fragments during soil disturbing activities such as trail and road maintenance.

Physical Control

Physical control of invasive plants includes actions that physically remove plants in part or in their entirely, including (but not limited to) hand pulling using weed wrenches, shovel; mechanical control using brushcutters, chainsaws, mowers and similar equipment; and other types of control to remove plants such as green flaming (i.e.,use of a propane torch on emergent seedlings), or grazing the plant using livestock. These types of controls are described in more detail below.

Table 10-7 Treatment Thresholds and Methods for Annual and Biennial Invasive Plants

Pest Category	Treatment Method Thresholds	Phenology	Timing	Treatment	Treatment Constraints - Assets
Annual/ Biennial Invasive Plants	Incipient/small: < 100 individuals	Basal rosette or bolting before seed production	February - May	Manual (Hand removal)	Use for small infestations only; worker hazards may occur when applied at larger scales
	Small to medium: < 5 acres	Bolt stage – flowering	March - June	Cutting (Mowing)	Not effective on most species - especially not biennials; to be used for suppression/containment goals only
	Small to medium: < 5 acres	Early seedling - from germination to appearance of first true leaves	November - January	Propane Torch (Green Flaming)	Narrow timing window; only appropriate for sparse vegetation with low ignition potential. Usually applied during rain events to reduce wildfire risk.
	Medium to large: > 5 acres	Seedling to pre-flowering grasses	December - April	Herbicide: clethodim	Highly selective to monocots only; rate selective for annual grasses only
		Seedling stage through late flowering/bud stage	December - April	Herbicide: glyphosate	Spot treatments; non-selective
		Pre-germination to flowering stage	November - July	Herbicide: imazapyr (pre/post emergent)	Spot treatments where residual control of seedlings is desired; non-selective
	Large: > 5 acres	Pre-germination to dicot seedling stage	December - February	Herbicide: aminopyralid (pre/post emergent)	Moderately selective for specific dicot plant families only; promotes grass and unaffected dicot species
		Later dicot seedling stages – bolting	January - March	Herbicide: clopyralid (pre/post emergent)	Highly selective for specific dicot plant families only; promotes grass and unaffected dicot species
		Bolt stage – flowering	March - June	Grazing	Effective on only some species; effectiveness varies by stock type, grazing season, grazing rotation and intensity

Table 10-8 Treatment Thresholds and Methods for Perennial Invasive Plants

Pest Category	Treatment Method Thresholds	Phenology	Timing	Treatment	Treatment Constraints - Assets
Perennial Invasive Plants	Incipient/small: < 100 individuals	Herbaceous perennials - seedling to mature	Any time	Manual (Hand removal)	Use for small infestations only; worker hazards may occur when applied at larger scales
	Incipient/small: woody plants with trunk diameter < 2”	Woody plants/trees - Seedling to mature	Any time	Manual (Digging - Leveraged Pulling)	Use for small infestations only; worker hazards may occur when applied at larger scales
	Small to medium: < 5 acres	Flowering to bud stage	December - July	Cutting (Mowing)	Not effective on most species; for suppression/containment/pre-treatment goals only
	Small to medium: < 5 acres	Early seedling - from germination to appearance of first true leaves	November - January	Propane Torch (Green Flaming)	Narrow timing window; only appropriate for bare ground areas with no ignition potential
	Medium to large: > 5 acres	Seedling to pre-flowering grasses	December - April	Herbicide: clethodim	Highly selective to monocots
		Seedling stage OR late flowering/bud stage	December - July	Herbicide: glyphosate	Spot treatments; non-selective
		Seedling or actively growing	December - June	Herbicide: aminopyralid (pre/post emergent)	Moderately selective for specific dicot plant families only; good for difficult to control vines/brambles
		Seedling or actively growing	December - June	Herbicide: clopyralid (pre/post emergent)	Highly selective for specific dicot plant families only; good for difficult to control vines/brambles
		Pre-germination to flowering stage	November - October	Herbicide: imazapyr	Spot treatments where residual control of seedlings is desired or difficult to control species; non-selective
	Trees > 6” stump diameter	Actively growing, post-flowering	Anytime	Herbicide: glyphosate	Spot treatments; non-selective
		Actively growing, post-flowering	Anytime	Herbicide: imazapyr	Spot treatments where residual control of seedlings is desired or difficult to control species; non-selective; basal bark treatments
		Conifers – mature	Anytime	Cutting	Hand methods time consuming; mechanical harvesters for large areas > 10 acres

- Pulling of individual plants by hand before flowering and seed development. Given the stout taproot of many annuals and biennials, it is best to undertake hand removal after regular periods of rain when the soil is moist and the entire taproot can be easily removed. Grasp the plant at the base and pull straight up. Leaving the portion of the root deeper than a quarter to a half inch below the surface is usually acceptable for annual species as they are not likely to re-sprout from a remaining root fragment. Digging tools can also be used to loosen the root out of the soil, however, limit the amount of soil disturbance as much as possible.
- Cutting plants below the root crown with a pick or shovel before flowering or seed set (to be applied only to crown-sprouting plant species). Perennial invasive plants with large amounts of vegetative material are often be easier to control once the mass of above-ground vegetation is cut to near-ground level (e.g., large perennial grasses and shrubs) to improve access to the root system. For plants that can regenerate from underground root fragments, root and/or stem material would be carefully collected, then disposed of in compost or garbage offsite or completely covered (composted, solarized) onsite to prevent it from re-establishing onsite.
- Mowing of late season annuals/biennials when a very small percentage of plants are beginning to flower. Mow as close to the ground as is safe (hitting rocks with mowing equipment may cause sparks and risk start a fire). Follow-up mowing may be required at four- to six-week intervals. Mowing early season annuals/biennials, or mowing late season annuals/biennials too early will likely result in resprouting and formation of multiple flowering stalks during bolting (thereby increasing seed production).
- Green flaming of young seedlings with a hot propane flame immediately following germination. This method is typically applied in early winter, during or immediately after a rain event to reduce potential for wildfires. Green, referred to in this report as “green flaming” is only effective on some species of non-fire adapted herbaceous and shrub species (dicots), and it is not effective on grasses (monocots).
- Selective grazing to remove or suppress some species when grazing is timed for periods when the plants are both palatable to the selected type of livestock (e.g., goats for brush, cattle or sheep for grasses) and susceptible to grazing effects (i.e., when plants are very young and do not have substantial underground energy reserves built up to support re-sprouting).
- Hand removal of small insipient populations of perennial invasive plants. Hand-removal of mature plant parts would be accomplished using a weed wrench, or by digging up individual plants, including as much of the root system as possible. Multiple re-treatments would be required for the control of most invasive perennials, because their root systems are often large and challenging to pull manually and many species have regenerating roots, stolons, and rhizomes that can break off during the removal effort and regrow. Digging can also promote soil disturbance, a secondary effect that can promote the germination of new seedlings in disturbed soils areas.
- Burning to reduce greenwaste. After large stands of broom are pulled, the green plants would be stacked in piles no greater than six feet by six feet to dry out. The piles would be located on mineral soils with a 4-inch by 12-foot wide trench to catch debris and would not be located under the drip line of trees. Brush piles would be burned during the wet season on days that the Bay Area Air Quality Management District (BAAQMD) designates as “open burn status” and the piles would be monitored to ensure that all combustible material is consumed before leaving the site. Notification Form C for Hazard Reduction Fires would be filed with the BAAQMD, and all conditions of Hazard Reduction Fires per BAAQMD regulations would be followed.
- Use of tractor-mounted implements. Jawz is a hydraulic implement mounted onto an excavator or other tractor. Opposing jaws pinch the stalk of the plant and the arm of the excavator pulls the plant out by its roots and then drops it in a pile for future burning, chipping, or composting. The use of Jawz would be limited in steep terrain and areas where there is excessive soil. Removal of coyote brush is the most common species that Jawz are used for on District lands.
- Use of a masticator for brushing. A masticator is a high-rotation drum with fixed teeth mounted on the hydraulic arm of an excavator that pulverizes vegetation. A masticator would be used for structure brushing, road brushing, parking lot brushing, fuel breaks, and brush removal in grasslands. The masticator would cut

vegetation ranging from grass to 6-inch diameter trees and can reach up to 22 feet horizontally. Masticators leave behind mulch and pieces of shattered wood up to approximately 12 inches long and can require, depending on vegetation, follow-up use of chainsaws by field staff. Use of a masticator would be limited by terrain and soil moisture (i.e.,soft ground). A masticator would be used less than four miles per year.

- Hairy weevil biocontrol insects for yellow starthistle. Release of approximately 20,000 hairy weevils (*Eustenopus villosus)* on approximately 800 acres per year at Fremont Older, Monte Bello, Rancho San Antonio, Russian Ridge, Skyline Ridge and St. Joseph's Hill and possibly biocontrol at other preserves in the future. This form of biocontrol is intended to control seed production of yellow starthistle. Selected areas are typically heavily infested with yellow starthistle, and other forms of control were determined to be infeasible due to site access limitations, labor costs or staffing safety issues. In these instances, biocontrol is intended to keep the infestations from spreading or becoming denser, until such time as other methods can be utilized.

Chemical Control

Chemical control of annual and biennial weeds includes two strategies to treat different life stages: 1) post-emergent (i.e., direct application of herbicide to eliminate the plant), and 2) pre-emergent (i.e., treatment to prevent the germination of seeds). Herbicides are also classified as either selective or non-selective. Selective herbicides control plants in specific plant families or life stages, while allowing other plants to survive uninjured. Utilizing selective herbicides can be a powerful tool in balancing active management with protecting desirable, native vegetation types. Non-selective herbicides and application methods injure all plant species that are directly exposed to treatment, so should be directed only to the target species. Selectivity may be based on the chemistry of the herbicide, but can change with the timing of the application.

- **Aminopyralid,** the active ingredient in Milestone™, is a selective herbicide used to control broadleaf invasive plants, especially sunflower and bean plant families. Milestone™ is an EPA Reduced-Risk pesticide product that is considered to have low exposure risks associated with wildlife and humans, especially in natural areas where exposure levels will be of short duration and low total exposure rates (Appendix A). Plants in the nightshade, bean, rose, and sunflower families are particularly sensitive to this herbicide. However, grasses are not affected by the herbicide when used after grass seed germination, making it an attractive IPM option for annual plant control in grasslands. Aminopyralid controls plants by disrupting the normal hormone balance, targeting auxins, and causing uncontrolled growth in susceptible plants. Symptoms of effective aminopyralid application include bending and twisting of stems and petioles, swelling at nodes, stem elongation, leaf curling, chlorosis (yellowing) of growing points, and plant mortality within three to five weeks. Aminopyralid persists in the soil and is absorbed by plant roots, and thus prevents germination of new seeds after an initial treatment. It can be used before an invasive plant species germinates in a known population area, or well after seedlings emerge, making it a nimble tool for invasive species plant control.
- **Clopyralid,** the active ingredient in Transline™, is a selective herbicide used to control broadleaf invasive plants, especially thistles and clovers, and woody leguminous plants. Plants in the nightshade, bean, and sunflower families are particularly sensitive to this herbicide. Grasses are not affected by it, making it an attractive IPM option for annual invasive plant control of these susceptible broadleaf plants in grasslands. Clopyralid is a growth regulator, is rapidly transported through plants primarily through the phloem and accumulates in growing points. It is absorbed into the plant by leaves, stems, and roots. Symptoms of effective clopyralid application include bending and twisting of stems and petioles, swelling at nodes, stem elongation, leaf curling, chlorosis (yellowing) of growing points, and plant mortality within three to five weeks. Clopyralid can travel through soil and should not be used where soils have very rapid permeability, such as loamy sand to sand. Transline™ is very similar to Milestone™ but it is more selective (i.e., active on a narrower list of susceptible plant families). It is useful in controlling invasive thistles and legumes on rangelands, so is used in situations when the less-selective Milestone™ could impact desirable native plants.

Transline™ is also generally more effective than Milestone™ on later plant growth stages so it is a valuable backup for Milestone in certain conditions.

- **Glyphosate,** the active ingredient in both Roundup ProMax™ and Roundup Custom™ (formerly sold as Aquamaster™), is a non-selective herbicide used to control a wide variety of plants, including annual broadleaf plants, grasses, perennials, and woody invasive plants. It is absorbed through foliage and moves throughout the plant's growing points. Glyphosate's mode of action is to inhibit an enzyme involved in the synthesis of aromatic amino acids, making it effective on all herbaceous and woody growing plants, but not effective as a pre-emergent herbicide. It is a rather slow-acting herbicide with symptoms appearing within about a week, including yellowing and stunting of young leaves and growing points, however it may take up to two weeks for complete plant mortality. Young, actively growing plants are most susceptible to glyphosate treatments when applied during warm weather. Perennial woody plants are best treated in the late summer or fall when plants are moving carbohydrates into their underground storage tissues. Glyphosate is the most commonly used herbicide in invasive plant control in natural areas, and herbicide resistance is a growing problem in some annual species (Monsanto 2008).

  Roundup ProMax™ contains a surfactant (i.e., a substance that adhere pesticides to plant leaves) that enhances the absorption of glyphosate on treated leaves so it is considered by herbicide applicators to be an efficient product to mix and apply. Roundup Custom™ contains only glyphosate dissolved in water with no surfactant, and is thus recommended for use on plants in aquatic, riparian, and other sensitive habitats. It is often mixed with an appropriately labeled surfactant to enhance the spread, adhesion, and penetration to the target plant, thereby increasing effectiveness of the entire mixture.

- **Imazapyr,** the active ingredient in Stalker™ and Polaris™ /Habitat™, is a non-selective herbicide used to control a broad range of invasive plants including grasses, broadleaf herbs, woody plants, riparian plants, and emergent aquatic species. Imazapyr has a similar mode of action as glyphosate but acts on a different suite of essential amino acids. Imazapyr is absorbed by leaves and roots, and moves to growing points; it disrupts protein synthesis and interferes with cell growth and DNA synthesis, causing plant mortality. Unlike glyphosate, imazaypyr has pre- and post-emergent effects. It also has moderate soil persistence, which can be useful for difficult-to-control species for which glyphosate is less effective or when parallel treatments of the parent population and seedlings are desired.
- **Clethodim,** the active ingredient in Envoy Plus™, is a selective herbicide that provides post-emergent control of grasses. It does not affect broadleaf plants or sedges and has no uptake through roots or pre-emergent effect. Clethodim is a lipid-synthesis regulating herbicide that impacts chemical pathways that are only present in some monocots (e.g., grasses). Clethodim is most effective on young grasses, especially annuals, and thus is recommended for early season application only. Grass-specific herbicides are highly effective tools for problem invasive grasses that grow in complex native vegetation. They are effective tools for the elimination of annual and perennial grasses in broadleaf (dicot) dominated environments or in eliminating annual grasses from some perennial grassland systems.

AQUATIC INVASIVE PLANTS

Aquatic invasive plants, like terrestrial invasive plants, can arrive on District preserves from a variety of sources including migrating birds, animals, and humans or they are already present on properties that the District purchases. Often, a small seed or plant fragment stuck to a duck's foot or canoe paddle is all that is necessary to expose a wetland habitat to a new invasive aquatic species. Aquatic invasive plants are divided into two major groups; 1) emergent invasive plants and 2) submerged invasive plants. Each group requires a different control strategy. Emergent invasive plants, in general, are rooted in soil below shallow water from one inch to 24 inches deep, and extend leaves above the water surface at least seasonally; or they can grow in neighboring upland areas as long as their roots can easily reach the water table (Anderson 2002). Some emergent invasive plants are actually floating plants that need no soil contact. Submerged invasive plants are those that grow on the bottom of lakes, rivers, and streams and do not need exposure to the air to complete their life cycles.

Aquatic invasive plants can compromise both fish and wildlife habitat, promote flooding, provide breeding habitat for mosquitoes, and can impede or slow the distribution of water in irrigation canals/ditches (Thunberg 1992). All aquatic invasive plant control requires specialized expertise and equipment to effectively manage the target pest. Submerged invasive plants are especially difficult to control and often require specialty floating equipment and boats to access the plants.

Native aquatic plants can require management as well to maintain navigational, recreational and agricultural uses of water bodies. Native vegetation in ponds and other static water bodies decomposes to naturally fill-in to a point where they eventually cease to be water bodies. At times, the District manages water bodies to support aquatic wildlife and agriculture that requires occasional maintenance. Plants and sediments are mechanically removed to increase shoreline areas and sustain open water habitats.

Pest Management Strategies for Aquatic Invasive Plants

Prevention and control of aquatic invasive plants is discussed below. Tolerance levels and treatment methods are also outlined in Table 10-9.

Table 10-9 Treatment Thresholds and Methods for Aquatic Invasive Plants

Treatment Method Thresholds	Phenology	Timing	Treatment	Treatment Constraints - Assets
Incipient/small: < 10 individuals	Emergent perennials - seedling to mature	Varies by species	Manual (Hand removal)	Small amounts only; worker hazards at larger scales
Small to medium: < 5 acres	Emergent perennials - mature	Varies by species	Cutting (Mowing)	Not effective on most species; for suppression/containment/pre-treatment goals only
Small to medium: < 5 acres	All stages	Varies by species	Pond draining, pond skimming	Non-selective. Can be combined with aquatic animal control.
Large: > 5 acres	Floating perennials - mature	Varies by species	Harvesting	Requires specialized aquatic weed control machines

Prevention

- Develop and implement an employee and contractor training program; include aquatic invasive plant identification and cleaning protocols for clothing, tools, vehicles, and boats.
- Inspect recreational facilities that contain aquatic features often during target invasive plant flowering and seed production times. Treat any detected target invasive plant populations to prevent spread into District lands.
- Prevent the spread of plant fragments (roots, stems) of certain species that can produce new plants in irrigation ditches, canals, and streams.

Physical Control

- Pulling aquatic plants is similar to pulling terrestrial weeds, and requires removing the entire plant, including leaves, stems, and roots, and disposing of the material away from the shoreline. In wetlands and shallow water less than three feet deep, no special tools are required. Deeper water may require SCUBA divers equipped with mesh bags to collect plant fragments as they work. Additional precautions are required for staff working in aquatic locations to protect both the habitat and the staff.
- Specialized equipment can be used to excavate or 'harvest' floating or submerged aquatic vegetation. Generally these types of control efforts seek to clear waterways for adequate water flow or boat access

rather than completely eliminate the problem plant. They can be effective tools for the removal of biomass from flood control channels and navigable waterways.

- Pond draining may be implemented for small water bodies to eliminate invasive aquatic plants and invasive animals such as bullfrogs concurrently. Some plants have propagules that can remain viable during dry periods, so this method is only effective on some aquatic plant species. All projects that temporarily divert water and discharge sediment may require permits from regulatory agencies, and may require additional monitoring and reporting.

Chemical Control

Some of the herbicides included in the IPMP include those that are formulated for use in and near aquatic habitats (Roundup Custom™ for example, which can also be used with an added surfactant). The District on rare occasions may need to use chemical treatments within or very near to aquatic habitats including treatments in seasonal wetlands (during the dry season) to control pest species (e.g., to remove slender false brome or cattails). In these situations, the District would use herbicides suitable for aquatic habitats. The aquatic formulations for selected herbicides in the IPMP would most often be used in upland habitats within the District. These formulations are useful in upland areas for certain pest species because the surfactants included in the formulation provide increased adhesion to selected target plant species than the non-aquatic formulations and are, therefore, more effective at providing the desired control of the pest species.

- Roundup Custom™ contains only glyphosate dissolved in water with no surfactant, and is thus recommended for use on plants in aquatic, riparian, and other sensitive habitats.

- Imazapyr, the active ingredient in Stalker™ and Polaris™ /Habitat™, a non-selective herbicide used to control a broad range of invasive plants including grasses, broadleaf herbs, woody plants, riparian plants, and emergent aquatic species.

10.8.4 FOREST DISEASES

At present, the District manages forests primarily for ecological and recreational values (rather than for timber value), therefore management actions are focused on maintaining the long-term stability and resiliency of forests to disruptive changes such as climate change and forest diseases. The threshold for active management of forest diseases and invasive species focuses on the level of damage from a forest disease that could result in a substantial alteration in the forest species composition, extent, or density.

SUDDEN OAK DEATH

Sudden oak death (SOD) is plant disease caused by an exotic water mold (*Phytophthora ramorum*) that has been implicated in native oak and tanoak deaths throughout coastal California and Oregon (CA Oak Mortality Taskforce 2013). The disease often results in mortality of certain species of oaks, mainly tanoak (*Notholithocarpus densiflorus*), coast live oak (*Quercus agrifolia*), black oak (*Quercus kelloggii*), and canyon live oak (*Quercus chrysolepis*) but can also cause twig and foliar disease symptoms in many other native plant species. The wholesale loss of oak tree species in coastal forests can cause major ecosystem disruptions, especially because so many native species depend on oaks and their fall acorn masts. Sick and dying trees also greatly increase the wildfire risk in native coastal forests dominated by oaks.

It is still uncertain how the invasive forest pathogen *Phytophthora ramorum* causing sudden oak death (SOD) will impact the native forests and woodlands of the greater Bay Area. Methods such as selective removal of California bay laurel trees (known to harbor the pathogen), pesticide applications, and promoting conifers over hardwoods have all been proposed for local and landscape scale management of the SOD pathogen (Filipe 2012). The SOD pathogen is extremely difficult to detect until advanced infection and symptoms are visible in individual plants. Because this pathogen is a water mold, it can move great distances through the landscape using wind (e.g., windborne transport of spores) or through water (e.g., transport of spores in waterways and through fog drip) making management very difficult at any scale (Filipe and Cobb 2012). The landscape scale management of high value forested areas (e.g., selective removal of diseased trees, selective removal of host plants such as California bay laurel, replanting conifers and other disease-resistant tees) may be one of the few ways to slow the spread of the disease. District staff should consult the California Oak Mortality Task Force (http://www.suddenoakdeath.org) for the most recent information on effective control of SOD.

PEST MANAGEMENT STRATEGIES FOR SUDDEN OAK DEATH

At present, the District monitors and manages SOD on Rancho San Antonio, Monte Bello, El Corte de Madera Creek, Los Trancos, Russian Ridge, Skyline Ridge, Long Ridge and Saratoga Gap OSPs. It is unclear if the vegetation composition shift is a temporary phenomenon, or a more permanent result of the disease infestations. Because the long-term effect of the disease on California's forests are unknown, the District is working with the California Oak Mortality Task Force to further study and monitor the impacts of the disease on District lands. In 2006, the District adopted a ten-year Sudden Oak Death plan to map oak trees on District Preserves that are potentially resistant to the SOD pathogen, treat a selected number of specimen oak trees, and establish collaborative funding for SOD research to help guide land management decisions.

The following list outlines general steps that District staff will follow when managing SOD infestations:

- Track the effects of SOD disease (mapping dead oaks as staffing and budgeting permit), and share this information with the California Oak Mortality Task Force (www.suddenoakdeath.org) as staffing and funding allow.
- Removal of California bay trees or their branches within 15 feet of the trunks of high value oaks. Ongoing research at the District and other locations in the state are evaluating whether bay removal is effective for managing larger stands or forests infested with SOD or to prevent or slow down the spread of SOD. This option is costly and requires regular maintenance and monitoring and, therefore, is implemented in limited areas.
- For individual high value oaks such as very large mature oaks near picnic facilities, consider spot treatment of individual oaks with pest control sprays (e.g., Agri-Fos™) intended to reduce potential for SOD infection. Due to high cost, this option should not be applied on a landscape level.

This page intentionally left blank.

11 GLOSSARY

Active management — Physical actions intended to manage natural resources or built facilities for a desired outcome. Active management may include physical control (hand, mechanical control), or chemical control of pests or manipulation of their habitats. For example, mowing yellow star-thistle to remove it from an infested rangeland would be considered active management. In contrast, ***passive management*** includes design and cultural practices intended to change human behavior or the physical environmental in a manner that discourages pests from occurring. For example, installing boot cleaning stations, or requiring ranchers to inspect feed for yellow star-thistle seeds would be considered passive management.

Allelopathy/Allelopathic effect — The suppression of growth of one plant species by another because of the release of toxic substances. The effect of suppressing the growth around a plant resulting from the release of toxic substances.

Auxin — A class of substances that in minute amounts regulate or modify the growth of plants, especially root formation, bud growth, and fruit and leaf drop.

Basal rosette — A cluster of leaves spreading outward from the base of a low-growing plant. In thistles, such as yellow star-thistle, a basal rosette forms just before the plant bolts (i.e., sends up a main stem on which flowers are produced). Often, the timing of pest control treatment of plants is recommended for the "basal rosette stage."

Bolt stage — A plant developmental stage during which a young plant sends up a main stem on which flowers are produced. The timing of pest control treatment of plants is often recommended for either just before or just after "bolt stage"

Broadleaf — Plants possessing broad (as opposed to needlelike or grass-like) leaves. Most of the trees and shrubs on District preserves are broadleaves. Pest control treatments prescribe different treatments for broadleaf plants than for grasses, sedges, and needle-bearing trees such as pine trees.

Chlorosis — A condition in which leaves produce insufficient chlorophyll. As chlorophyll is responsible for the green color of leaves, chlorotic leaves are pale, yellow, or yellow-white. The affected plant has little or no ability to manufacture carbohydrates through photosynthesis and typically dies. Some pest control of plants induces chlorosis, thereby eliminating the pest plant's ability to survive and reproduce.

Containment — A pest control strategy that focuses on establishing a pest-free area (e.g., a mowed or cleared area around a well-established population of invasive plants), and ensuring, through active management, that the target pest does not move past the defined area into the surrounding (pest free) areas. Containment is typically used when eradication of a target pest is no longer considered a viable an option.

Control — A pest control strategy that focuses on reducing the number, amount, or extent of a pest over time to achieve a defined tolerance level. Control may result in full eradication of a pest, or reduction in the pest such that is no longer causes economic or environmental damage, or human health concerns.

Dicot — Dicotyledons, (also known as dicots), are a group of flowering plants whose seed typically produce two embryonic leaves or cotyledons when first germinating. Pest control techniques often prescribe different treatment for dicot plants than for ***monocots*** (i.e., grasses, sedges and bulbaceous plants that only produce one embryonic leaf)

Eradicate — A pest control strategy that focuses on eliminating all members of a target pest population.

Gigging — A pest control method typically used to kill bullfrogs, fish, and other aquatic pests whereby the animal is speared with a trident or spear while in water.

Herbicide — A pesticide (see definition below) intended for preventing, destroying, or controlling plant pests.

Herbivory — A type of predation typically used to describe the consuming of plants by animals. Herbivory has an impact on the health, structure, and diversity of natural plant communities. For example, low level herbivory can remove aging roots and leaves, allowing new growth of young roots and shoots resulting in healthy plant growth. At high levels, herbivory can damage plants, changing the composition, and reducing the quality of the natural plant community.

Homopteran Insect — A suborder of insects, including cicadas, aphids, and scale insects, having wings of a uniform texture held over the back at rest

Hypercalcemia — An abnormally high level of calcium in the blood. In pest control, hypercalcemia is usually associated with rodenticide use.

Injurious — The term "injurious wildlife" refers to a defined list of species identified in either the federal Lacey Act (18 U.S.C. 42) or related implementing regulations (50 CFR 16). The U.S. Fish and Wildlife Service Office of Law Enforcement plays a role in preventing the introduction of invasive species into the U.S. through the enforcement of the Lacey Act which makes it illegal in the United States to import injurious wildlife, or transport such wildlife between states without a permit. Species are placed on the list when they are determined to be injurious to: human beings; the interests of agriculture, horticulture, forestry, or wildlife; or wildlife resources in the U.S.

Insecticide — A pesticide (see definition below) intended for preventing, destroying or controlling insect pests.

Insipient (invasive population) — A population (usually referring to an invasive plant) that is small, but is beginning to reproduce and become established in a location or a region.

Metamorph (amphibian) — A major change in the form or structure of some animals or insects that happens as the animal or insect becomes an adult. For amphibians, a metamorph refers to the stage of development between larval and adult. For example, the stage between a tadpole and adult frog. Some pest control techniques recommend treatment timing before or after the metamorph stage.

Monocot — Monocotyledons, (also known as monocots), are a group of plants whose seed typically produce only one embryonic leaves or cotyledon when first germinating (e.g., grasses, sedges and bulbaceous plants). Pest control techniques often prescribe different treatment for monocot plants than for dicots (i.e., plants that produce two embryonic leaves when first germinating, such as flowering plants)

Non-Native Species — An introduced, alien, exotic, non-indigenous, or non-native species. Includes species living outside their native distributional range, which have arrived there by human activity, either deliberate or accidental. Some introduced species are damaging to the ecosystem they are introduced into, others have no negative effect and can, in fact, be beneficial as an alternative to pesticides in agriculture for example. Refer to the definition of pest and invasive species (below) to differentiate non-native species that cause harm from other non-native species.

Noxious weeds — A plant species that has been designated by country, state, provincial, or national agricultural authority as one that is injurious to agricultural and/or horticultural crops, natural habitats and/or ecosystems, and/or humans or livestock. These weeds are typically agricultural pests, though many also have impacts on natural areas. Many noxious weeds have come to new regions and countries through contaminated shipments of feed and crop seeds or intentional introductions such as ornamental plants for horticultural use.

Pest Species — Insects, animals, or plant species that are incompatible with the District's goal of protecting and restoring the natural environment, and with providing opportunities to enjoy and learn about the natural environment. Several categories of pest species are defined below:

- **Invasive species** are animal or plant species that invade and dominate sufficiently large areas, causing a reduction in biodiversity. They proliferate in the absence of natural control and interfere with the natural processes that would otherwise occur in natural areas. Once established, invasive species can become difficult to manage and can eliminate native species or otherwise alter the ecosystem. Invasive species are targeted in natural areas and rangelands. Invasive species can alter ecosystem processes by changing biotic ecosystem characteristics (such as plant community composition, structure, and interactions; trophic relationships; and genetic integrity) and abiotic characteristics and processes (such as fire regimes, erosion, sedimentation, hydrological regimes, nutrient, and mineral conditions, and light availability).
- **Structural and agricultural pests** include insect, plant, and animal pests that damage occupied buildings, formal landscapes, or agricultural crops, or pests that are a health threat to humans working in, living in, or visiting the buildings. Examples of structural pests include termites, ants, rodents, and stinging insects in buildings, and weeds in formal landscaped areas. Examples of agricultural pests include insects, weeds, and burrowing mammals such as moles and voles that damage crops. Structural and agricultural pests are targeted in buildings, recreational facilities, and agricultural properties.
- **Nuisance pest species** include species that commonly occur on District lands, such as stinging insects, but whose presence can be incompatible when their proximity or behavior conflict with human use of buildings and recreational facilities in the preserves. For example, hornets that locate their ground nests in trails must be removed if they are stinging hikers and horses using the trail. Branches and other types of vegetation must be trimmed back from trails, parking lots, picnic tables, and benches to allow safe visitor use. Similarly, vegetation must be cut back from the sides of roads to keep them open for patrol, maintenance, and emergency vehicles. Problem pest species are targeted in areas with focused visitor use.

Pesticide — A substance or mixture of substances intended for preventing, destroying or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals causing harm during or otherwise interfering with the production, processing, storage, transport or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs, or substances which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies. Pesticide is a broad term that encompasses:

- ***Herbicides*** (substances intended to control plant pests),
- ***Insecticides*** (substances intended to control insect pests),
- ***Rodenticides*** (substances intended to control rodent pests),
- ***Other Substances,*** such as ***Fungicides*** (substances intended to fungus pests) and ***Surfactants*** (substances that adhere pesticides to surfaces such as plant leaves) and other substances often used with other pesticides to increase treatment results.

Phloem — The living tissue in plants that carries soluble organic material made during photosynthesis -in particular, sucrose, to all parts of the plant where it is used for growth and reproduction. Many pest control treatments focus on disrupting the phloem through mechanical or chemical means, thereby disrupting the flow of nutrients to the plants, causing plant death.

Pre-bait — A substance used to attract pests (e.g., rodents or other animals) to a feeding site as a preliminary step to use of a rodenticide or other pesticide to control the target pest.

Propagule — Any vegetative portions of a plant, such as a bud, stolon, root, tuber, rhizome, or other offshoot, that aids in the dispersal of the species and from which a new plant may grow. In pest control, follow-up treatments for invasive plants often focus on prevention and control of propagules after the initial mature plants are treated.

Rhizome — A modified subterranean stem of a plant that is usually found underground from which a new plant may grow. Plants often send out roots and shoots from these modified stems, resulting in vegetative (asexual) reproduction of a plant. In pest control, follow-up treatments for invasive plants often focus on prevention and control of rhizomes after the initial mature plants are treated.

Root Crown — The junction between the root and shoot portion of a plant. Crown sprouting is the ability of a plant to regenerate its shoot system after destruction of the above –ground portions of the plant. Crown sprouting plants typically have extensive root systems in which they store nutrients allowing them to survive after damage to the above-ground parts of the plant. In pest control, follow-up treatments for crown-sprouting plant species often focus on control of resprouting vegetation after the initial mature plants are treated.

Shooting — A plant that sends up shoots (new growth) from the underground portions of the plant. In pest control, recommended treatments are often timed for when invasive plants are actively 'shooting' or sending up new growth.

Seed Bank — In natural systems, the natural storage of seeds, often dormant, within the soil below the parent plant. In invasive plant control, treatment often focus on long-term management of plants that sprout from the seed bank, often years after the initial removal of mature invasive plants.

Stolon — A prostrate plant stem, at or just below the surface of the ground, that produces new plants from buds at its tips or nodes. In pest control, treatments for plants that produce stolons often focus on removal of existing stolons, and retreatment of new plants produced from any remaining stolons.

Taproot — A large, somewhat straight to tapering plant root that grows downward that forms a center from which other roots sprout laterally. The taproot system contrasts with fibrous root system, which typically have with many branched roots. Pest control of invasive plants often focuses on removal of the entire taproot to kill the target invasive plant.

Tolerance Levels — The level at which pests can be present without disturbing or disrupting natural processes, causing economic damage, degrading intended uses or human enjoyment of built facilities, or resulting

12 REFERENCES

Chapters 1 through 5 - IPM Program References

Elzinga, Carly L, Daniel W. Salzer and John W. Willoby. 1998 (July). *Measuring and Monitoring Plant Populations*. Published by the Bureau of Land Management, U.S. Department of the Interior.

The Nature Conservancy. 2007 (February). *Conservation Action Planning: Developing Strategies, Taking Action, and Measuring Success at Any Scale*.

U.S. Environmental Protection Agency, 1998. *Guidelines for Ecological Risk.* Available online: http://www.epa.gov/raf/publications/guidelines-ecological-risk-assessment.htm

Chapters 6 and 7 - IPM in Buildings and Recreational Facilities

Baruch-Mordo, S., S.W. Breck, K.R. Wilson, J. Broderick. 2011. The carrot or the stick? Evaluation of education and enforcement as management tools for human-wildlife conflicts. *PLoS One*: 6(1). E15681.

Buczkowski, G., C.W. Scherer, and G.W. Bennett. 2008. Horizontal transfer of bait in the German cockroach: Indoxacarb causes secondary and tertiary mortality. *J Econ Entomol*. 101 (3): 894-901.

California Department of Fish and Wildlife. 2008. *Trapping License Examination Reference Guide*.

CDC. *See* Center for Disease Control and Prevention.

CDFW. *See* California Department of Fish and Wildlife.

Center for Disease Control and Prevention. 2013a. Asthma Fact Sheet. http://www.cdc.gov/asthma/triggers.html.

______. 2013b. Tickborne Diseases of the United State: A Reference Manual for Health Care Providers. U.S. Dept. of Health and Human Services. http://www.cdc.gov/ticks/.

Decker, Dan, H.W. Hudenko, B. Siemer, P. Curtis, Cornell University, J. Major, L Berchielli. Living with Wildlife on the Rural-Urban Interface. 2008. Cornell University Research & Policy Brief Series, Published Issue 31, Sept 2009.

District. *See* Midpeninsula Regional Open Space District.

EPA. *See* U.S. Environmental Protection Agency

Erickson, W., and D. Urban. 2004. Potential risks of nine rodenticides to birds and non-target mammals: a comparative approach. U.S. EPA Office of Pesticide Programs, Washington DC.

Fitzwater, W.D. 1994. House Cats. In: Prevention and Control of Wildlife Damage. Ed: S.E. Hygnstrom, R.M. Timm, G.E. Larson. University of Nebraska – Lincoln. 2 vols. http://digitalcommons.unl.edu/icwdmhandbook/.

Gannon, W.L. 2003. Bats. In: Wild Mammals of North America – Biology, Conservation and Management. Ed. Feldhamer, J.A., B.C. Thompson, J.A. Chapman. Johns Hopkins University Press.

Geiger, C., and C. Cox. 2012. *Pest Prevention By Design: Authoritative guidelines for designing pests out of Structures*. San Francisco Department of the Environment and International Code Council. http://www.sfenvironment.org/sites/default/files/fliers/files/final_ppbd_guidelines_12-5-12.pdf.

Gomez, C., P. Pons, and J.M. Bas. 2003. Effects of the Argentine ant *Linepithema humile* on seed dispersal and seedling emergence of *Rhamnus alaternus*. Ecography. 26(4): 532-538.

Gore, J.C., and C. Schal. 2004. Laboratory evaluation of boric acid-sugar solutions as baits for management of German cockroach infestations. Journal of Economic Entomology 97(2): 581-587.

Green G. S., P.S. Gipson. 1994. Feral dogs. In: Prevention and Control of Wildlife Damage. Ed: S.E. Hygnstrom, R.M. Timm, G.E. Larson. University of Nebraska – Lincoln. 2 vols. http://digitalcommons.unl.edu/icwdmhandbook/.

Greenhall A. M., S.C. Frantz. 1994. Bats. In: Prevention and Control of Wildlife Damage. Ed: S.E. Hygnstrom, R.M. Timm, G.E. Larson. University of Nebraska – Lincoln. 2 vols. http://digitalcommons.unl.edu/icwdmhandbook/.

Herrero, S., T. Smith, T.D. DeBruyn, T.D. Gunther, C.A. Matt. 2005. From the field: brown bear habitation to people – safety, risks, and benefits. Wildlife Society Bul. 33(1): 362-373.

Hildreth, A.M., S.M. Vantassel, S.E. Hygnstrom. 2010. Feral cats and their management. University of Nebraska-Lincoln Extension. http://www.ianrpubs.unl.edu/epublic/live/ec1781/build/ec1781.pdf.

Hinkle, N.C., J. Klotz, D. Silva, V. Lazaneo. 2002. Household and structural pests. In: California Master Gardener Handbook. Ed. D.R. Pittenger. University of California Agriculture and Natural Resources Publication No. 3382. Oakland, CA.

Holway, D.A. 1998. Effect of Argentine ants invasions on ground-dwelling arthropods in Northern California riparian woodlands. Oecologia. 116: 252-258.

Hooper-Bui, L.M., and M.K. Rust. 2000. Oral toxicity of abamecitin, boric acid, fipronil, and hydramethylnon to laboratory colonies of Argentine ants (*Hymenoptera: Formicidae*). Journal of Economic Entomology 93(3): 858-64.

Information Services Division, Armed Forces Pest Management Board. 2012. Integrated management of stray animals on military installations. Pest Management Board Website – http://www.afpmb.org/sites/default/files/pubs/techguides/tg37.pdf

Jackson, D., C.B. Cornell, B. Luukinen, K. Buhl, D. Stone. 2009. Fipronil Technical Fact Sheet; National Pesticide.

Jackson, D., B. Luukinen, J. Gervais, K. Buhl, and D. Stone. 2011. d-Phenothrin Technical Fact Sheet; National.

Klotz, J.H., L. Greenberg, C. Amrhein, M.K. Rust. 2000. Toxicity and repellency of borate-sucrose water baits to Argentine ants (*Hymenoptera: Formicidae*). Journal of Economic Entomology 93(4): 1256-1258.

Midpeninsula Regional Open Space District. 2013. Vegetation and Biodiversity Management Plan. Administrative Draft dated April 13, 2013. May & Associates, Inc.

Marsh, R.E. 1994. Roof and Norway rats. In: Prevention and Control of Wildlife Damage. Ed: S.E. Hygnstrom, R.M. Timm, G.E. Larson. University of Nebraska – Lincoln. 2 vols. http://digitalcommons.unl.edu/icwdmhandbook/.

Marshall, E.F. 1984. Cholecalciferol: a unique toxicant for rodent control. Proceedings of the 11th Vertebrate Pest Conference. Paper 22. http://digitalcommons.unl.edu/vpc11/22.

Mathieson, M., R. Toft, and P.J. Lester. 2012. Influence of toxic bait type and starvation on worker and queen mortality in laboratory colonies of Argentine ant (Hymenoptera: Formicidae). Journal of Economic Entomology 105(4): 1139-44.

Nygard, J.P., N.J. Sanders, E.F. Connor. 2008. The effects of the invasive Argentine ant (*Linepithema humile*) and the native ant *Prenolepis imparis* on the structure of insect herbivore communities on willow trees (*Salix lasiolepsis*). Ecological Entomology. 33: 789-795.

Olkowski, W., S. Daar, and H. Olkowski. 1991. Common Sense Pest Control. Tauton Press. Newtown, CT.

OMRI – Organic Materials Review Institute. 2013 Generic Materials List. http://www.omri.org/omri-lists.

Oregon State University Extension Services - Information Center. http://npic.orst.edu/factsheets/fiptech.pdf.

Parr, T.W., J.M. Way. 1988. Management of roadside vegetation: long-term effects of cutting. J. Applied Eco. 25(3): 1073-1087.

Randall, J.M., K.R. Faulkner, C. Boser, C. Cory, P. Power, L.A. Vermeer, and L. Lozier. 2011. Argentine ants on Santa Cruz Island, California: conservation issues and management options. In: Island Invasives: eradication and management. IUCN. Switzerland.

Salmon, T.P., and W.P. Gorenzel. 1994. Woodrats. In: Prevention and Control of Wildlife Damage. Ed: S.E. Hygnstrom, R.M. Timm, and G.E. Larson. University of Nebraska – Lincoln. 2 vols. http://digitalcommons.unl.edu/icwdmhandbook/.

Silverman, J., R.J. Brightwell. 2008. The Argentine ant: challenges in managing an invasive unicolonial pest. Annual Review of Entomology 53: 231-252.

Timm, R.M. 1994. House Mice. In: Prevention and Control of Wildlife Damage. Ed: S.E. Hygnstrom, R.M. Timm, G.E. Larson. University of Nebraska – Lincoln. 2 vols. http://digitalcommons.unl.edu/icwdmhandbook/.

Timm, R.M., and W.E. Howard. 1994. White-footed and deer mice. In: Prevention and Control of Wildlife Damage. Ed: S.E. Hygnstrom, R.M. Timm, G.E. Larson. University of Nebraska – Lincoln. 2 vols. http://digitalcommons.unl.edu/icwdmhandbook/.

U.S. Environmental Protection Agency. 2000. *New Pesticide Fact Sheet - Indoxacarb*; U.S. Environmental Protection Agency, Office of Prevention, Pesticides and Toxic Substances, Office of Pesticide Programs, U.S. Government Printing Office Washington, DC. pp 1-10.

Chapter 8 - IPM in Fuel Modification Areas

D'Antonio, C. M., and P. M. Vitousek. 1992. Biological invasions by exotic grasses, the grass/fire cycle and global change. Annual Review of Ecology and Systematics 23: 63-87.

Keeley, J.E. 2002. Fire and invasive species in Mediterranean-climate ecosystems of California. Pages 81-94 in K.E.M. Galley and T.P. Wilson (eds.). Proceedings of the Invasive Species Workshop: The Role of Fire in the Control and Spread of Invasive Species. Fire Conference 2000: The First National Congress on Fire Ecology, Prevention and Management. Miscellaneous Publication No. 11, Tall Timbers Research Station, Tallahassee, Fl.

Keeley, J.E. 2006. Fire management impacts on invasive plants in the Western United States. Conservation Biology 20(2): 375-384.

Lavin, M., T.J. Brummer, L.J. Rew. 2013. Physical disturbance shapes vascular plant diversity more profoundly than fire in the sagebrush steppe of southeastern Idaho, USA. Ecol. Evol. 3(6): 1626-1641.

Minnich, R.A. 2001. An integrated model for two fire regimes. Conservation Biology 15(6): 1549-1553.

Prestemon, J.P., T.J. Hawbreaker, M. Bowden, J. Carpenter, M.T. Brooks, K.L. Abt, R. Sutphen, S. Scranton. 2013. Wildfire ignitions: a review of the science and recommendations for empirical modeling. USDA Forest Service. Gen. Tech. Report SRS-171. Southern Research Station.

Pyne, S. J., P.L. Andrews, R.D. Laven. 1996. Introduction to wildland fire, 2nd ed. John Wiley and Sons. NY, NY.

Spies, T.A., and J.F. Franklin. 1991. The structure of natural young, mature and old-growth Douglas-fir forests in Oregon and Washington. In: Wildlife and Vegetation of Unmanaged Douglas-Fir Forests. U.S. Department of Agriculture, Forest Service. Pacific Northwest Research Station Gen. Tech. Report PNW-GTR-285. Portland, OR.

Whisenant, Steven G. 1990. Changing fire frequencies on Idaho's Snake River Plains: ecological and management implications. In: McArthur, E. Durant; Romney, Evan M.; Smith, Stanley D.; Tueller, Paul T., compilers. Proceedings--symposium on cheatgrass invasion, shrub die-off, and other aspects of shrub biology and management; 1989 April 5-7; Las Vegas, NV. Gen. Tech. Rep. INT-276. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 4-10.

Zedler, P. H. 1995. Fire frequency in southern California shrublands: biological effects and management options. Pages 101-112 in J. E. Keeley and T. L. Scott, (eds.) Brushfires in California: ecology and management. International Association of Wildland Fire, Fairfield, Washington, USA.

Chapter 9 - IPM in Agricultural Properties and Rangelands

Altieri, M.A., G.M. Gurr, and S.D. Wratten. 2004. Genetic engineering and ecological engineering: a clash of paradigms or scope for synergy. In: Ecological Engineering for Pest Management. CSIRO, pp. 133-142.

Anderson, E.W. 1967. Grazing systems as methods of managing the range resource. Proc. 20th Ann. Mtg. Am. Soc. Range Management: Seattle, WA.

Austin, M.P., R.H. Groves, L.M.F. Fresco, P.E. Kaye. 1985. Relative growth of six thistle species along a nutrient gradient with multispecies competition. Journal of Ecology 73: 667-684.

Bianchi, F.J, C.J.H. Booij, T. Tscharntke. 2006. Sustainable pest regulation in agricultural landscapes: a review on landscape composition, biodiversity and natural pest control. Proc. R. Soc B. 273. 1715-1727.

Coll, M. 2004. Precision agriculture approaches in support of ecological engineering for pest management. In: Ecological Engineering for Pest Management. CSIRO. pp. 133-142.

Gelbard, J.L., and J. Belnap. 2003. Roads as conduits for exotic plant invasions in a semiarid landscape. *Conservation Biology* 17: 420-432.

Grace, B.S., R.D.B. Whalley, A.W. Sheppard, B.M. Sindel. 2002. Managing saffron thistle in pastures with strategic grazing. *Rangeland Journal* 24(2): 313-325.

Gunsolus, J., D. Wyse, K. Moncada, C. Fernholz. 2010. Weed management. IN: Risk Management Guide for Organic Producers. University of Minnesota.

Gurr, G.M., S.L. Scarratt, S.D. Wratten, L. Berndt, N. Irvin. 2004. Effects of agroforestry systems on the ecology and management of insect pest populations. In: Ecological Engineering for Pest Management. *CSIRO*. pp. 133-142.

Hastings, J.D., K. Branting, and J. Lockwood. 1996. A multi-paradigm reasoning system for rangeland management. *Computers and Electronics in Agriculture* 16(1): 47-67.

Higley, L.F. 2009. Economic Decision Rules for IPM. In: Integrated Pest Management: Concepts, Tactics, Strategies and Case Studies. Ed: B.E. Radcliffe, W.D. Hutchison, R.E. Cancelado. Cambridge University Press. 529 pp.

Jackson, L.E. U. Pascual, T. Hodgkin. 2007. Utilizing and conserving agrobiodiversity in agricultural landscapes. Agricultural, Ecosystems and Environment. 121: 196-210.

Kogan, M. 1998. Integrated Pest Management: Historical perspectives and contemporary development. Annu. Rev. Entomol. 43:243-70.

Lewis, W.J., J.C. van Lenteren, S.C. Phatak, and J.H. Tumlinson. 1997. A total system approach to sustainable pest management. Proceedings of the National Academy of Sciences 94(23): 12243-12248.

Matson, P.A., W.J. Parton, A.G. Power, M.J. Swift. 1997. Agricultural intensification and ecosystem properties. Science 277: 504-509.

Nicholls, C.I., and M.A. Altieri. 2004. Precision agriculture approaches in support of ecological engineering for pest management. In: Ecological Engineering for Pest Management. *CSIRO*. pp. 133-142.

Onsager, Jerome A. and USDA, Agricultural Research Service. 1987. Integrated Pest Management on Rangeland: State of the Art in the Sagebrush Ecosystem. All U.S. Government Documents (Utah Regional Depository). Paper 511. http://digitalcommons.usu.edu/govdocs/511.

Onsager, Jerome A., editor. 1987. Integrated Pest Management: State-of-the-Art in the Sagebrush. Pyne, S. J., Andrews, P. L., and Laven, R. D. 1996. Introduction to Wildland Fire. John Wiley and Sons; New York, NY. 769 pp.

Pedigo, L.P., M.E. Rice. 2006. Entomology and Pest Management, 5th Ed. Prentice Hall. Columbus, OH. 747 pp.

Smith, R. W.T. Lanini, M. Gaskell, J. Mitchell, S.T. Koike, C. Fouche. 2000. Weed management for organic crops. Organic Vegetable Production in California Series. Pub. 7250. Vegetable Research and Information Center. UC Davis.

Stern, V.M., R.F. Smith, R. van den Bosch, and K.S. Hagen. 1959. The integrated control concept. Hilgardia 29: 81-101.

Chapter 10 - IPM for Natural Areas

Anderson, L.W.J. 2002. Aquatic Vegetation Management. In: Principals of Weed Control. California Weed Science Society.

Anderson, J. 2013. District Staff. Personal communication.

Barrett, R.H. 1982. Habitat preferences of feral hogs, deer, and cattle on a Sierra Foothill Range. *Journal of Range Management* 35(3): 342-346.

Calflora: Information on California plants for education, research and conservation [web application]. 2013. Berkeley, California: The Calflora Database [a non-profit organization]. http://www.calflora.org/

California Coastal Conservancy. 2003. Final Programmatic Environmental Impact Statement/Environmental Impact Report, San Francisco Estuary Invasive Spartina Project: Spartina Control Program.

California Department of Fish and Wildlife. 2013. *Wild Pig Management Program*.

California Department of Food and Agriculture. 2005. *California Noxious and Invasive Weed Action Plan*.

______. 2013a. *Noxious Weed List*.

______. 2013b. *CA Border Protection Station Program Summary*.

California Invasive Plant Council. 2013a. Calweed Mapper Program.

______. 2013b. California Invasive Plant Inventory. http://www.cal-ipc.org/ip/inventory/.

California Oak Mortality Task Force. 2013. (http://www.suddenoakdeath.org). Database search referenced 2013.

California State Parks, Division of Boating and Waterways. 2013. Quagga and Zebra Mussel Program.

Cal-IPC. *See* California Invasive Plant Council.

CDFA. *See* California Department of Food and Agriculture.

CDFW. *See* California Department of Fish and Wildlife.

D'Antonio, C. M., and P. M. Vitousek. 1992. Biological invasions by exotic grasses, the grass/fire cycle and global change. Annual Review of Ecology and Systematics 23: 63-87.

District. *See* Midpeninsula Regional Open Space District.

Fagerstone, K.A., M.A. Coffey, P.D. Curtis, R.A. Dolbeer, G.J Killian, L.A. Miller, and L.M.Wilmot. 2002. Wildlife fertility control. Wildl. Soc. Tech. Rev. 02-2, 29 pp.

Filipe, J.A.N., R.C. Cobb, M. Salmon, D.M. Rizzo, and C.A. Gilligan. 2012. Management of Phytophthora ramorum in plot and landscape scales for disease control, tanoak conservation, and forest regeneration – insights from epidemiological and ecosystem models. Proceedings of the Sudden Oak Death Fifth Science Symposium.

Filipe, J.A.N., R.C. Cobb, R.K. Meentemeyer, C.A. Lee, Y.S. Valachovic, et al. 2012. Landscape epidemiology and control of pathogens with cryptic and long-distance dispersal: sudden oak death in northern California forests. PLoS Comput Biol. 8(1): e1002328. doi: 10.1371/journal.pcbi.1002328.

Gerlach, J.D., P. Moore, D.M. Lubin, B. Johnson, G. Roy, P. Whitmarsh, D.M. Graber, and J.E. Keeley. 2001. Exotic species threat assessment and management prioritization for Sequoia-Kings and Yosemite National Parks. USGS Western Ecological Research Center.

Govindarajulu, P., R. Altwegg, and B.R. Anholt. 2005. Matrix model investigation of invasive species control: *Bullfrogs on Vancouver Island, Ecological Applications* 15(6): 2161-2170.

Kasteen, T. 2013 (August 1). Regional Biologist, CDFW, personal communication.

Keeley, J.E. 2006. Fire management impacts on invasive plants in the Western United States. *Conservation Biology* 20(2): 375-384.

Kotanen, P.M. 1995. Responses of vegetation to a changing regime of disturbance: effects of feral pigs in a Californian coastal prairie. *Ecography* 18: 190-199.

Lanini, W.T., J.M. DiTomaso, R.F. Norris. 2002. Weed Biology and Ecology. In: Principals of Weed Control. CA Weed Science Society.

Lapidge, S., J. Wishart, L. Staples, K. Fagerstone, T.Campbell, J. Eisemann. 2012. Development of a Feral Swine Toxic Bait (Hog-Gone®) and Bait Hopper (Hog-Hopper™) in Australia and the USA. Proceedings of the 14th Wildlife Damage Management Conference. Nebraska City, NE.

Lawler, S.P., D.Dritz, T. Strange, and M. Holyoak. 1999. Effects of introduced mosquitofish and bullfrogs on the threatened California red-legged frog. *Conservation Biology* 13(3): 613-622.

Midpeninsula Regional Open Space District. 2004. The Status and Management of Invasive Plants on the Midpeninsula Regional Open Space District. Shelterbelt Builders Inc.

______. 2013. Vegetation and Biodiversity Management Plan. Administrative Draft dated April 13, 2013. May & Associates, Inc.

Monsanto. 2008. Management Guide for Mare's tail. http://www.weedresistancemanagement.com.

National Invasive Species Council. 2003. General Guidelines for the Establishment and Evaluation of Invasive Species Early Detection and Rapid Response Systems. Version 1. 16 pp

National Invasive Species Council. 2008 (amended 2012). *2008-2012 National Invasive Species Management Plan*. 35 pp.

Orchard, S.A. 2011. Removal of the American bullfrog *Rana (Lithobates) catesbeiana* from a pond and a lake on Vancouver Island, British Columbia, Canada. In: *Island Invasives: Eradication and Management*. IUCN. Switzerland. pp. 217-221.

San Mateo County. 1983. *San Bruno Mountain Habitat Conservation Plan*.

Schloegel, L.M., A.M. Picco, A.M. Kilpatrick, A.J. Davies, A.D. Hyatt. 2009. Magnitude of the U.S. trade in amphibians and presence of *Batrachochytrium dendrobatidis* and *ranavirus* infection in imported North American bullfrogs *(Rana catesbeiana).* Biological Conservation. 142. 1420-1426.

Seward, N. W., VerCauteren, K.C., Witmer, G. W., Engeman, R. M. 2004. Feral swine impacts on agriculture and the environment. *Sheep & Goat Research Journal*. Paper 12

Snow, N.P., G.W. Witmer. 2011. A field evaluation of a trap for invasive American bullfrogs. *Pacific Conservation Biology* 17: 285-291.

State of Washington. 2003. Washington State Sage Grouse Recovery Plan. Washington State Fish & Wildlife Service.

The Nature Conservancy. 2009. An assessment of the known and potential impacts of feral pigs *(Sus scofra)* in and near San Diego County with management recommendations. Conservation Biology Institute.

Thunberg, E.M., C.N. Pearson, and J.W. Milon. 1992. Residential flood control of benefits of aquatic plant control. *Journal of Aquatic Plant Management* 30: 66-70.

United States Department of Agriculture (USDA). 2009. Feral swine: damage and disease threats. Animal and Plant Health Inspection Service Program Aid No. 2086.

United States Fish and Wildlife Service (USFWS). 2013. Injurious Species List. http://www.fws.gov/injuriouswildlife/pdf_files/Current_Listed_IW.pdf.

Vitousek, P.M., L.R. Walker. 1989. Biological invasion by *Myrica faya* in Hawaii: plant demography, nitrogen fixation, ecosystem effects. *Eco. Mon*. 59. 247-65.

West, B.C., A.L. Cooper, J.B. Armstrong. 2009. Managing wild pigs: a technical guide. *Human-Wildlife Interactions Monograph*. 1:1 - 55.

Appendix A

Pesticide Technical Background Information

Appendix A

Pesticide Technical Background Information

Cardno ENTRIX

Shaping the Future

Table of Contents

This page intentionally left blank.

1 Introduction

The Midpeninsula Regional Open Space District (District) undertakes weed and vector management activities to control noxious and invasive weeds and mobile vectors such as mosquitoes, wasps, hornets, Argentine ants, cockroaches, rats, mice, and certain wildlife (e.g., skunks, raccoons, opossum) that are a nuisance or risk to human and ecological health on District lands.

Because of the importance of providing needed weed and vector control without causing undue adverse impacts to human and ecological health, the District intends to implement a modified Integrated Pest Management (IPM) Program that embodies the use of the most effective, least toxic, suite of treatment options.

IPM is an adaptive strategy developed and utilized to manage insect, weed, and pathogen pest species in production agriculture and urban landscaping environments. Using modified, but similar, IPM strategies to manage wild lands is a relatively new approach and has only been undertaken by a small number of land management agencies. The District intends to evaluate, recommend, and implement weed and vector management in an effective and least toxic manner using currently available and defensible new pest control approaches. The District intends to become a leader in this new application of IPM philosophy and implementation for District wild lands.

While this cutting edge approach to land management can provide safer, more effective approaches to controlling unwanted vegetative and pest vectors, it is essential to understand the physical and chemical characteristics, relative toxicity, and possible adverse impacts to non-target receptors (i.e., humans, domestic pets, non-target wildlife and vegetation) of any pesticides that may be used. The technical background presented in this appendix will provide the necessary information for each pesticide considered for use in the District's IPM to provide the following results when chemical methods are necessary to meet a pest control objective:

> Providing the most effective treatment of unwanted vectors while achieving the most appropriate and least toxic safe application techniques.

> Reducing the potential for human and non-target animal exposure to chemicals.

> Reducing the potential adverse impacts to humans, animals and non-target vegetation.

> Reducing the potential for human and non-target animal discomfort or injury from applications and from exposure to non-vegetative vectors.

This technical background appendix addresses these objectives for the pesticides being considered to support the IPM approach for the District. In order to comprehensively evaluate the potential safety of the selected pesticides, each candidate chemical (active ingredient or product) is reviewed and evaluated for its reported fate and transport in the environment (summarized for quick reference in Table 1.1) and toxicity to humans and non-target wildlife and vegetation (summarized in tables at the end beginning of each pesticide category section). The evaluations are grouped by the general categories of herbicide, fungicide, rodenticide, insecticide, and several chemicals incorporated as additives (surfactants and "inert" ingredients).

Table 1-1 Summary of Pesticides under Consideration for use by the District

The tables below provide a general overview of the characteristics of each of the pesticides used or being considered by the district. Each category in the table is supplemented in greater detail in tables included in sections four and five. This table is intended for a "quick look" evaluation of the potential effects and toxicity to humans, wildlife, and some physiochemical characteristics of each.

Herbicides- General term for Pesticides developed specifically to target unwanted vegetation

Product and Manufacturer	***Mode of Action***	***Purpose***	***Toxicity Rank- Humans***	***Toxicology Non-Target and Wildlife***	***Solubility and Half Life water***	***Persistence and Half-life soils***	***Food Web Issues?***	***Safe to Children?***	***MSDS Flags and Cautions***
Glyphosate – *Roundup Custom, Roundup ProMax* (Monsanto)	Amino acid synthesis inhibitor	Nonselective post-emergent broad-spectrum ***weed control***	Low- No evidence of carcinogenicity, neurotoxicity, immunotoxicity. Possible reproductive toxicity very large doses	Practically non-toxic to birds and aquatic invertebrates Surfactants may have toxicity to amphibians	High water solubility	Moderate Persistence Binds to soil Strong soil adsorption Binds to soils and sediment	Since *glyphosate* does not bioaccumulate in fish or other animals it is not likely to have impacts on the ecological *food chain*	Very low toxicity to children unless direct consumption of large amounts of chemical.	Practically non-toxic. No known heal hazard.
Aminopyralid *Milestone* Dow Agro	Auxin growth hormone mimic	post-emergent broad-spectrum ***weed control***	Low toxicity to humans. No evidence of carcinogenicity, neurotoxicity, immunotoxicity, or reproductive or developmental toxicity	Practically non-toxic to birds, fish, aquatic invertebrates amphibians, and honey bees.	Non-persistent in water and soil. Breaks down rapidly in water. Half life is about 0.6 days due to photolysis.	Very low persistence with aerobic half life of avg 103 days.	Due to its low persistence and rapid excretion in animals it is not likely to impact food chain uptake.	Very low toxicity to children unless direct consumption of large amounts of chemical.	Practically non-toxic. No real health hazard.
Clopyralid *Transline* Dow Agro	Auxin growth hormone mimic	Selective ***broadleaf weed control***	Low toxicity. Neurotoxicity caused by acute poisoning. No evidence of carcinogenicity, immunotoxicity, or reproductive or developmental toxicity	Practically non-toxic to birds, fish, aquatic invertebrate and honey bees	Degrades rapidly in water. Half-life @ 9-22 days	Low likelihood of leaching to ground water. Binds to soils. Half life @40 days.	Very little potential for bioaccumulation or food web impact.	Very low toxicity to children unless direct consumption of large amounts of chemical.	Practically non-toxic. No real health hazard.

Table 1-1 Summary of Pesticides under Consideration for use by the District

The tables below provide a general overview of the characteristics of each of the pesticides used or being considered by the district. Each category in the table is supplemented in greater detail in tables included in sections four and five. This table is intended for a "quick look" evaluation of the potential effects and toxicity to humans, wildlife, and some physiochemical characteristics of each.

Herbicides- General term for Pesticides developed specifically to target unwanted vegetation

Product and Manufacturer	*Mode of Action*	*Purpose*	*Toxicity Rank-Humans*	*Toxicology Non-Target and Wildlife*	*Solubility and Half Life water*	*Persistence and Half-life soils*	*Food Web Issues?*	*Safe to Children?*	*MSDS Flags and Cautions*
Imazapyr *Polaris* (Nufarm) *Stalker* (BASF)	Amino acid synthesis inhibitor	Nonselective pre-and post-emergent broad-spectrum weed control	Low toxicity. No evidence of carcinogenicity, neurotoxicity, immunotoxicity, or reproductive or developmental toxicity	Practically non-toxic to birds, fish, aquatic invertebrates and honey bees	Soluble in water and degraded quickly via photolysis. ½ life @3-8 days.	Moderate potential for soil leaching to groundwater. Moderate soil adsorption.	Rapidly excreted and little potential for bioaccumulation or food web impact.	Very low toxicity to children unless direct consumption of large amounts of chemical.	Practically non-toxic. No real health hazard
Clethodim *Envoy Plus* (Valent)	Fatty acid synthesis inhibitor	Selective post-emergent grass weed control	Low toxicity. No evidence of carcinogenicity, neurotoxicity, immunotoxicity, or reproductive or developmental toxicity	Slightly toxic to birds, fish, and aquatic invertebrates, practically non-toxic to honey bees	Insoluble in water. ½ life in water @128 days	Short half-life in soil, and unlikely to leach in ground water. ½ life in soil @1-2 days. @128days in sediment.	No apparent uptake via food web issues. Approved for applications to edible food crops.	Very low toxicity to children unless direct consumption of large amounts of chemical.	Practically non-toxic. No real health hazard

1.1 Review and Evaluation Process

Data encompassing the available acute and chronic toxicity of the various active ingredients to numerous mammalian, avian, fish, aquatic invertebrate, and non-target insect species are included herein. In many cases, manufacturers do not include or disclose the proprietary additional ingredients in a product. The product approved for use is tested as the label indicates. Acute data are derived from experiments in which the target organisms are exposed to a single dose/concentration of a compound, and the endpoint, usually survival, is measured 48 or 96 hours post-exposure. Chronic data are derived from experiments in which the experimental organisms are exposed to multiple doses of a compound over an extended period of time, ranging from weeks to months depending on the organism and endpoint of interest (e.g., development, reproduction, carcinogenicity).

1.1.1 Calculations, Uncertainty, Conservatism, and Extrapolations in Toxicity Data

The toxicity of a pesticide (i.e., herbicides, rodenticides, fungicides, and insecticides) is determined by the documented adverse laboratory and field effects to target and non-target organisms that occur after an exposure to that compound. Thus, the key to potential adverse (toxic) effects is the nature of the exposure to the compound, which is based on the specific amount of the compound that reaches an organism's target tissues (i.e., the dose). Several other factors are involved in an exposure, such as the duration of time over which the dose is received, the target tissue or physiological function affected, and the sensitivity of the organism of interest to the compound.

The toxicity of pesticides are generally measured in controlled laboratory or field studies in which the test organisms are exposed to contaminated food or doses of a test substance at several concentrations. Most regulatory studies are designed to evaluate toxic responses based on tiered increases of dose and to determine at what dose the onset of an adverse physiological or behavioral effect occurs. Toxicity studies commonly evaluate the Lethal Dose or LC_{50}, the dose/concentration that causes mortality in 50% of the test population and the: no observed adverse effect level NOAEL); or the lowest concentration that causes a measured adverse effect (LOAEL). Many toxicity tests, laboratory organisms are not provided alternative food sources, and as a result, these laboratory tests are not particularly representative of realistic exposures in the environment. Furthermore, effects in laboratory species many not adequately represent effects in environmentally relevant species due to genetic, physiological, and behavioral differences. For many pesticides, the suite of tests required for approval of a compound includes other types of exposure, such as dermal, inhalation, and dietary. All of these laboratory data are combined to develop the pesticide product label recommendations and restrictions, incorporating several "safety" factors to provide acceptable use of each product. As a result of the extensive use of safety factors, surrogate test species, and unrealistic exposures to the laboratory animals, the pesticide data available for evaluation of potential adverse impacts for these compounds are subject to uncertainty and conservatism in actual potential effects.

Numerous biological, chemical, and physical parameters that are not apparent in laboratory tests affect the behavior of a compound in the environment and its potential toxicity. The chemistry, and particularly the fate and transport of a compound, must be considered to estimate likely potential exposure. The fate and transport of a compound is determined by the physical and chemical properties of the compound itself and the environment into which it is released. Thus, the following characteristics of a compound are considered when estimating potential adverse effects: 1) its half-life in various environmental media (e.g., sediment, water, air), including its photolytic half-life; 2) lipid and water solubility; 3) adsorption to sediments and plants; and 4) volatilization. Environmental factors that affect fate and transport processes include temperature, rainfall, wind, sunlight, water turbidity, and water and soil acidity (pH). Each of these parameters can markedly influence the potential exposure to a pesticide by modifying its characteristics in the environmental media.

A certain level of exposure to a compound is necessary for potential toxic effects to occur, but an exposure does not, in itself, imply that adverse effects will occur. The potential toxicity of a pesticide can be reduced or mitigated by limiting or modifying the conditions of potential exposure to ensure that resulting doses are less than an amount that may result in adverse effects. The important characteristics of a pesticide are considered before and during any pesticide application by the District, which employs numerous best management practices (BMPs) to minimize the potential for unwanted adverse impacts to non-target species. The culmination of all this information, and its relation to the specific application considered, provides a proven foundation for assuring the most effective, yet relatively safe, use of pesticides when treatment is determined to be needed.

1.1.2 Toxicity Designations

The results of laboratory tests are reported as the highest dose that does not cause any adverse effects (No Observed Adverse Effects) and the dose where adverse effects first appear (Lowest Observed Adverse Effects, LOAEL) and the dose that results in mortality to 50% mortality (LC_{50}). **Figure 1**.

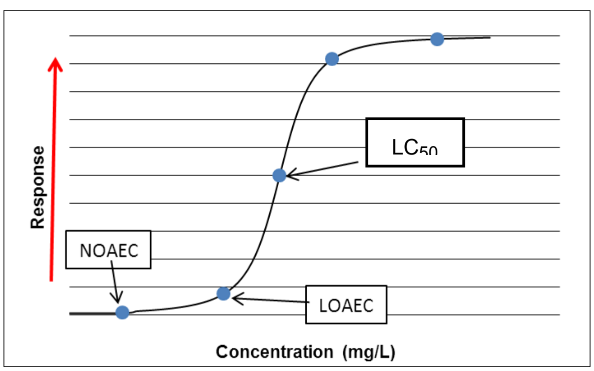


Figure 1. Relative doses reported in laboratory toxicity studies.(Generalized Sigmoidal Concentration-Curve).

1.1.3 Evaluation of Potential Human Health Impact

The information provided for each of the selected pesticides supports a defense of very low risk or "no significant adverse effects (NSAE)" on humans. Assessments include information about the ingredients reported in the Material Safety Data Sheet (MSDS), pesticide registration documents, and peer-reviewed scientific literature. Review of the pesticide formulations, label recommendations, and application procedures is used to evaluate their potential likelihood for exposure, toxicity, and bioaccumulation. For each pesticide evaluated, information herein includes the physiochemical characteristics of the product, including absorption, metabolism, and elimination, and any other specific reported evidence of acute and chronic effects including reproductive, developmental, or carcinogenic effects.

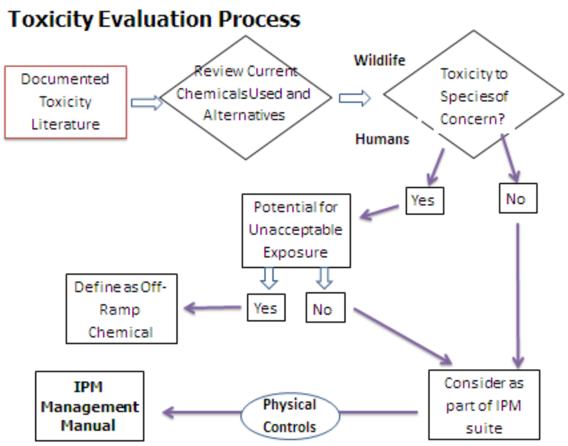
1.1.4 Evaluation of Potential Ecological Impact

Successful application of the IPM approach depends on defensible assessment of the hazards for each of the current reported application scenarios and an evaluation of the possible impacts to representative non-target wildlife (avian, aquatic vertebrate and invertebrate, amphibian, and bee species) and vegetation. This evaluation includes information relevant to the ultimate environmental fate and transport of active and certain "inert" ingredients (when available) as well as review and evaluation of the current toxicity literature (available field and laboratory studies) relevant to non-target ecological receptors impacts and the potential for increased exposure due to food web uptake and accumulation in higher trophic level animals or in vegetation (bioconcentration, bioaccumulation, or biomagnification).

The following use, efficacy, environmental fate and transport, water pollution potential, and toxicity information of the chemicals of interest for the District's IPM is based on available, documented, and validated government and peer-reviewed experiments and reports.

1.1.5 Ranking of Pesticide Toxicity

Pesticides are evaluated using documented toxicity and adverse effects to humans and animals (Figure 3) and sorted to develop the most effective, yet safe pesticides for use in specific application scenarios.



in IPM applications.

After determination of the toxicity of each pesticide of interest using the process in Figure 3, the toxicity information is used to rank each pesticide according to its potential to cause adverse effects in non-target organisms. The four levels (1-4) of relative toxicity (USEPA) for each general category of species is included in Table 1.2 below.

Each of the pesticides included in this review have been evaluated by USEPA and state agencies and the toxicity results are included in the several tables associated with each category of pesticide. Each pesticide has been ranked for target and non-target toxicity, potential bioaccumulation, food web transfer, and several physio/chemical characteristics, including half-life, solubility, and other parameters that may affect total exposure over time.

1.1.6 Toxicity Interactions and Alterations.

The toxicity of a pesticide is dependent on the concentration of active ingredients and the timing and duration of the exposure. The length of time that a pesticide persists after application is measured as its ½ life in water and/or soil. Although many earlier pesticides, primarily organochlorines like DDT and other highly toxic chemicals were shown to persist in media for months and even years. However, the current pesticides available for pest control have substantially shorter ½ lives and often remain for only a few days. However, when treating to impact a critical pest life stage, it may be necessary to use a more toxic product that does not last long in the environment. However, for the less toxic pesticides it is often best to utilize separate but successive applications to cover the pest's likely activity cycle.

Pesticide applications are based on two general chemical and physical properties of the pesticide intended for use in the control of specific pests. Efficacy (relative toxicity to the pest) and the persistence of the product in the treated area are evaluated and considered to provide the most effective treatment scenarios resulting in the least unwanted side effects.

Pesticide toxicity in laboratory tests is not always translated to the laboratory effects in actual use scenarios because laboratory tests generally utilize unrealistic exposures to an active ingredient without any possible alternative sources or exposures.

In some cases, it is preferable to use several very low application doses over time to make sure the target pests are adequately controlled. This increases the likelihood that the pesticide will be effective and any side effects (non-target effects) will be alleviated or minimized.

For those applications where it is critical to significantly eradicate a specific life stage, larger doses may be used with very specific focus rather than widespread applications.

In both of these application scenarios, care is taken using documented Best Management Practices and experienced applicators to select the appropriate timing and doses to achieve control of unwanted pest vectors.

Experienced and trained pesticide applicators, using the proper choice and doses of target-specific chemicals, can provide effective pest control with minimal to no unwanted side effects or impacts to non-target species or the environment.

Table 1.2. USEPA Categories Used to Rank Pesticide Toxicity

Route of Exposure	I: High Toxicity	II: Moderate Toxicity	III: Low Toxicity	IV: Very Low Toxicity
Acute Oral LD50	≤50 mg/kg	50-500 mg/kg	500 – 5000 mg/kg	>5000 mg/kg
Acute Dermal LD50	≤200 mg/kg	200 – 2000 mg/kg	2000 – 5000 mg/kg	>5000 mg/kg
Acute Inhalation LC50	≤0.05 mg/L	0.05 - 0.5 mg/L	0.5 - 2 mg/L	>2 mg/L
Primary Eye Irritation	Corrosive (irreversible destruction of ocular tissue) or corneal involvement or irritation persisting for more than 21 days	Corneal involvement or irritation clearing in 8-21 days	Corneal involvement or irritation clearing in 7 days or less	Minimal effects clearing in less than 24 h
Primary Skin Irritation	Corrosive (tissue destruction into the dermis and/or scarring)	Severe irritation at 72 h (severe erythema or edema)	Moderate irritation at 72 h (moderate erythema)	Mild or slight irritation (no irritation or slight erythema)

This page intentionally left blank.

2 Herbicides

Table 2-1 Human Toxicity Summary of Herbicide Active Ingredients

Active Ingredient	Mammalian Oral LD50 (mg/kg)[A]	Mammalian Dermal LD50 (mg/kg)[B]	Mammalian Inhalation LC50 (mg/L)[A]	USEPA Toxicity Rating	Carcinogenic	Reproductive or Developmentally Toxic	Neurotoxic	Immunotoxic	Endocrine Disruption
Glyphosate	>4,320 (technical); ≥5,000 (salts)	≥2,000 (tech); ≥5,000 (salts)	≥4.43 (tech); >1.3 (salts)	Oral, dermal, inhalation (III)	No	No	No	No	In human cell lines at very high doses
Aminopyralid	>5,000	>5,000	>5.79	Oral, dermal, inhalation (IV)	No	No	No	No	No
Clopyralid	>5,000	>5,000	>3.0	Oral, dermal, inhalation (III)	No (may contain hexachlorobenzene – potential human carcinogen)	No	Yes	No	No
Imazapyr	>5,000	>2,000	>1.3	Oral, dermal, inhalation (IV)	No	No	No	No	No
Clethodim	>5,000	>5,000	>3.9	Oral, dermal, inhalation (IV)	No (Envoy contains naphthalene – potential human carcinogen)	No	No	No	NA

Table 2-2 Ecotoxicity Summary of Herbicide Active Ingredients

Active Ingredient	Mammalian Oral LD50 (mg/kg)[A]	Mammalian Dermal LD50 (mg/kg)[B]	Mammalian Inhalation LC50 (mg/L)[A]	Avian LD50 (mg/kg)[C]	Fish LC50 (mg/L)[D]	Aquatic Invert EC50 (mg/L)[E]	Honeybee LD50 (µg/bee)	Other Receptors
Glyphosate	>4,320 (technical); ≥5,000 (salts)	≥2,000 (tech); ≥5,000 (salts)	≥4.43 (tech); >1.3 (salts)	>2,000	140 (tech); 1.3 to >1,000 (salts)	55 to 780	>100	Frog LC50 >17.9 mg/L; 1-yr dog NOAEL = 500 mg/kg/day
Aminopyralid	>5,000	>5,000	>5.79	>2,250	>100	>98.6	Contact >100; Oral >117	Northern leopard frog 96-h LC50 > 95.2 mg/L
Clopyralid	>5,000	>5,000	>3.0	>1,645	103-125	225	>100	Dog NOAEL = 100 mg/kg/day
Imazapyr	>5,000	>2,000	>1.3	>2,150	>100	>1,000	>100	1-yr dog NOAEL = 250 mg/kg/day
Clethodim	>5,000	>5,000	>3.9	>2,000	67-120	>120	>100	NA

A. Unless otherwise specified, values are for rats.

B. Unless otherwise specified, values are for rabbits.

C. Unless otherwise specified, values are for mallard duck or bobwhite quail.

D. Unless otherwise specified, values are for rainbow trout or bluegill sunfish.

E. Values are for Daphnia or similar species.

2.1 Glyphosate

GLYPHOSATE

Formulations: Roundup ProMax; Roundup Custom (previously Aquamaster)

> Human Toxicity: Low toxicity. Skin and eye irritation possible. No evidence of carcinogenicity, neurotoxicity, immunotoxicity, or toxicity. Reproductive toxicity at very high doses.

> Ecological Toxicity: Technical grade is practically non-toxic to birds, fish and aquatic invertebrates. POAE surfactant used in some formulations causes toxicity to amphibians.

> Water Pollution Potential: Moderate persistence in the environment. High water solubility, but strongly adsorbs to soil. Sometimes found in surface and ground water in locations of high use.

> Other Considerations: Glyphosate resistance has been documented in areas of high use.

2.1.1 Basic Use Information

> Products: *Roundup ProMax, Roundup Custom (previously Aquamaster)*

> Typical target pests: Grasses, Brush, Vines, Thistles, unwanted woody plants, Spurges

> Application rates:

General Weed Management: Grasses, Brush, Vines, Thistles

Material	Rate per 100 gal	Rate per gal (handheld)	Volume/acre
Adjust buffer	½ - 4 pints	To be used if water has pH >7	
Roundup ProMax*	0.4 – 1.5 gal	0.5 – 2 oz.	Spot spray – variable rate
Dye (as necessary)	0.25 gal (1 qt)	0.25 oz.	

*Do not exceed maximum use rate of 7 quarts (8 lbs acid) of product per acre per year.

Cut Stump: *Acacia, Baccharis, Cytisus, Eucalyptus, Genista, Ilex, Spartium*

Material	Rate per 100 gal	Rate per gal (handheld)	Volume/acre
Roundup ProMax*	50 gal	64 oz.	Cut stump variable rate
Dye (as necessary)	1 qt	0.25 oz.	

*Do not exceed maximum rate of 7 quarts (8 lbs acid) per acre per year – especially when treating dense stands of cut stumps.

Sponge/Wick: Grasses, Brush, Vines, Thistles

Material	Rate per 100 gal	Rate per gal (handheld)	Volume/acre
Roundup ProMax*	25-50 gal	32-64 oz.	Wiper/Sponge variable rate
Dye (as necessary)	1 qt	0.25 oz.	

*Do not exceed maximum rate of 7 quarts (8 lbs acid) per acre per year – especially when treating dense stands of vegetation.

Waxy Leaves: Spurges – *Euphorbia oblongata* and Vines

Material	Rate per 100 gal	Rate per gal (handheld)	Volume/acre
Roundup Custom	1.5 gal	2 oz.	Spot spray – variable rate
Liberate NIS	2 qt.	0.6 oz.	
Dye (as necessary)	0.25 gal (1 qt)	0.3 oz.	

***Do not exceed maximum use rate of 8 quarts (8 lbs. acid) of this product per acre per year.

Glyphosate [N-(phosphonomethyl)glycine] is a nonselective, post-emergent, and systemic herbicide registered for use in agricultural and nonagricultural areas. It is applied to a variety of food crops and agricultural drainage, sewage, and irrigation systems. There are several formulations of glyphosate, including an acid, monoammonium salt, diammonium salt, isopropylamine salt, potassium salt, sodium salt, and trimethylsulfonium or trimesium salt. It is highly effective for the control of weeds and invasive species. Glyphosate is a plant growth regulator that functions by targeting the plant-specific shikimic acid pathway, inhibiting the synthesis of the enzyme 5-enolpyruvylshikimic acid-3-phosphate synthase, leading to reductions in aromatic amino acids necessary for plant protein synthesis and growth (Miller et al., 2010). Glyphosate is not effective on submerged or mostly submerged foliage and therefore is only applied to control emergent foliage (Schuette, 1998; Siemering, 2005).

2.1.2 Exposure Considerations

Glyphosate is a broad spectrum, non-selective herbicide used by the District as the active ingredient in Roundup ProMax and Roundup Custom (previously named Aquamaster) to control invasive weeds including grasses, brush, vines, and thistles via foliar sprays or direct wipe/sponge onto the weeds. Both are used only in specific instances where other pest control methods such as hand pulling or mowing of weeds are not safe or effective options. These spray techniques involve highly localized and focused applications applied to specific, delineated areas with an emphasis on care and control of overspray or off-spray. They are applied at low pressure (30-70 psi) by hand held wands or guns only when wind is between 2-7 mph to reduce drift and never when there is a 40% or greater forecast of rain within 24 h of a planned application. The low and high rate foliar applications of both formulations are 0.5% v/v and 1.5% v/v, respectively, and the low and high rate wipe/sponge treatment rates are 25 and 50% v/v, respectively. Both formulations are also used for treatment of unwanted woody shrubs and trees. To reduce run-off and non-target exposure, they are applied (25% v/v) directly onto the inside (avoiding the exterior bark) of a woody stem/stump immediately following stump cutting and under the same restrictions as those for foliar applications using approved and BMP spray techniques.

Application sites are prohibited within defined critical habitats for the red-legged frog. For other rare plant and wildlife species, Applications may occur in certain conditions. A qualified biologist that can identify all rare plant and wildlife species present within the application area will supervise all applications of the pesticide to ensure non-target specie are not effected. Application is also restricted around water and wetlands. A buffer of at least 15 ft or greater from aquatic systems is typically implemented during Roundup ProMax use, as it contains the surfactant POAE. Roundup Custom does not contain this surfactant and is approved for use in/near aquatic systems. It is used in conjunction with the nonionic soybean-based surfactant Liberate NIS (discussed in sections 6.2 and 6.3).

2.1.3 Human Toxicity

The shikimic acid pathway is specific to plants and some microorganisms; therefore, glyphosate has very low acute toxicity to mammals. The USEPA classifies glyphosate as Category III for oral and dermal toxicity. The oral LD50 for technical grade glyphosate for rats is >4,320 mg/kg; the oral LD50 for the isopropylamine salt in rats is ≥5,000 mg/kg; and the oral LD50 for the ammonium salt in rats is 4,613 mg/kg (USEPA, 1993b). The dermal LD50 for technical grade glyphosate in rabbits is ≥2,000 mg/kg (USEPA, 1993b), and the dermal LD50 for rabbits is ≥5,000 mg/kg for both salts (Miller et al., 2010). The LC50 for technical grade glyphosate in rats is ≥4.43 mg/L based on a 4-hr, nose-only inhalation study (USEPA, 1993b); the 4-hr LC50 for rats exposed to the isopropylamine salt is >1.3 mg/L air; and the LC50 for rats exposed to the ammonium salt is >1.9 mg/L in a whole-body exposure (Miller et al., 2010).

No chronic adverse effects were observed in beagles exposed to daily doses of 500 mg/kg for one year. Glyphosate has not been shown to be carcinogenic or mutagenic (USEPA, 1993b). The USEPA has classified glyphosate in Group E –

evidence of non-carcinogenicity in humans. Developmental LOAELs range from 1,500-3,500 mg/kg/day in rats. Neither glyphosate nor its major metabolite aminomethylphosphonic acid (AMPA) bioaccumulate in animal tissue. Glyphosate is poorly biotransformed in rats and is excreted mostly unchanged in the feces and urine; 97.5% of the administered dose was excreted in the urine and feces of rats (Williams et al., 2000). The USEPA's Office of Pesticide Programs Reference Dose (RfD) Peer Review Committee has recommended that the RfD for glyphosate be established at 2 mg/kg/day.

Despite the documented scientific research used to evaluate the toxicity to dozens of species required by USEPA to register pesticides, public concern about the toxicity to mammals have been raised about the long-term safety of glyphosate. Only extremely high doses, far beyond any potential exposure that would be seen in actual application have been associated with adverse effects to mammalian sytems. In one study, forced ingestion of high doses of glyphosate was shown to alter the respiratory and hepatic systems of rats and caused damage to reproductive functions and fetal development (Clair et al., 2012). In another study, male rats fed a diet containing 25,000 and 50,000 mg/kg (unrealistically high doses of up to 25% of their total body weight) of 99% pure glyphosate for 13 weeks had significant reductions in sperm concentrations. Female rats in the 50,000 mg/kg group had slightly longer estrus cycles than the control group (Chan and Mahler, 1992). Each of these studies elicitied toxic effects only after unrealistically high doses of glyphosate

2.1.4 <u>Ecological Toxicity</u>

In toxicological studies, Glyphosate is practically nontoxic to birds. The oral LD50 for bobwhite quail is >2,000 mg/kg, and the 8-day sub-acute dietary LC50 is >4,640 ppm for mallard ducks and bobwhite quail. Glyphosate is also practically nontoxic to freshwater fish, and it is not expected to bioaccumulate. The 48-h LC50 for technical grade glyphosate is 140 mg/L for bluegill sunfish, 140 mg/L for rainbow trout, and 97 mg/L for fathead minnow (USEPA, 1993b). Formulations of the isopropylamine salt range from practically non-toxic to moderately toxic to fish (96-h LC50s range from 1.3 to >1,000 mg/L for various formulations). Technical grade glyphosate is practically nontoxic to slightly toxic to freshwater invertebrates with 48-hr LC50s ranging from 55 to 780 mg/L, and the isopropylamine salt ranges from practically non-toxic to moderately toxic. The 96-h LC50 for technical grade glyphosate is >17.9 mg a.e./L (the highest dose tested) in green frog (Howe et al., 2004). However, based on surrogate species information (primarily avian), USEPA has made a "may affect" or "likely to adversely affect" determination for the endangered California Red-legged Frog following chronic exposure to glyphosate at application rates of 3.84-7.5 lb a.e./acre and above (certain crops, forestry, areas with impervious surfaces and rights of way) (USEPA, 2008b). It is listed as "may affect but is not likely to adversely affect" endangered and threatened salmonids (Patterson, 2004). Glyphosate is practically nontoxic to honey bees. The acute oral and contact LD50 is >100 µg/bee (USEPA, 1993b).

Polyethoxylated tallowamine (POEA) is a surfactant used in some glyphosate formulations, including some Roundup mixtures. Several studies have indicated that the toxicity observed in tadpoles of various frog species exposed to different Roundup mixtures is due to this surfactant and not glyphosate itself; calculated LC50s for certain Roundup mixtures are an order of magnitude or more lower than technical glyphosate or formulations that do not contain POEA (Howe et al., 2004; Mann and Bidwell, 1999; Relyea, 2005). POAE has also been shown to be highly toxic to aquatic invertebrates and fish, and glyphosate formulations containing POAE are also more toxic than those without the surfactant (Brausch and Smith, 2007; Giesy et al., 2000). Roundup Custom, which is approved for use near and in water sources, is a formulation of glyphosate dissolved in water and does not contain POAE.

2.1.5 <u>Physical Properties/Environmental Fate and Transport</u>

The vapor pressure of glyphosate is very low, making it nonvolatile. It tends to partition to water rather than air. It is highly water-soluble. Glyphosate dissipates from surface water by partitioning into sediment. It is stable to hydrolysis and photodegradation in water and soil, and it is degraded primarily by microbial degradation in both water and sediment (Barrett and McBride, 2005; Newton et al., 1994). The major metabolite of glyphosate is AMPA. Degradation of AMPA is generally slower than that of glyphosate because AMPA likely adsorbs more strongly to soil particles and because it may be less likely to permeate the cell walls or membranes of soil organisms (Schuette, 1998). AMPA exhibits similar or less toxicity than the original parent glyphosate (Borggaard and Gimsing, 2008).

In soil, glyphosate is resistant to chemical degradation, is stable to sunlight, is relatively non-leaching, and has a low tendency to runoff (except as adsorbed to colloidal matter and sediment). It is relatively immobile in most soil environments and does not move vertically below the 6 inch soil layer. Glyphosate's primary route of decomposition in the environment is through microbial degradation in soil (t ½ = 8-25 days). The herbicide is inactivated and biodegraded by soil microbes at rates of degradation related to microbial activity in the soil and factors that affect this activity. The biological degradation process is carried out under both aerobic and anaerobic conditions (Schuette, 1998; USEPA, 1993b).

2.1.6 Water Pollution Potential

Glyphosate is very soluble in water; however, due to its strong soil adsorptive characteristics, limited amounts of glyphosate have been found in surface water as a result of runoff (Borggaard and Gimsing, 2008; Vereecken, 2005). Glyphosate has been detected in surface waters in areas of very high Roundup use, such as the Midwest, but at levels lower than the California drinking water standard for the compound (<0.7 mg/L). Glyphosate dissipates quickly in ponds and streams to below detection limit in 3-14 days (Schuette, 1998).

2.2 Aminopyralid

AMINOPYRALID

Formulations: Milestone

> Human Toxicity: Low toxicity. No evidence of carcinogenicity, neurotoxicity, immunotoxicity, or reproductive/developmental toxicity.

> Ecological Toxicity: Practically non-toxic to birds, fish, aquatic invertebrates, amphibians, and honey bees.

> Water Pollution Potential: Likely to be non-persistent in the environment. Highly photolabile in water.

2.2.1 Basic Use Information

> Products: *Milestone*

> Typical target pests: Thistles; Sweet Pea; Cape ivy.

> Application rates:

Material	Rate per acre	Rate per 1000 sq. ft	Volume/acre
Milestone*	3-7 oz.	Lo: 2 ml or 0.07 fl. oz. Hi: 4.8 ml or 0.16 fl. oz.	Variable - Applicator responsible to calibrate equipment for proper application rate
Liberate NIS	Variable per acre (0.5% v/v)	Variable	
Dye (as necessary)	Variable	Variable	

* Do not exceed maximum rate of 7 oz. (0.11 lb acid) of product per acre during a single growing season or 14 oz. (0.22 lb acid) per acre where no more than 50% of the acre is treated by spot spraying.

Aminopyralid (4-amino-3,6-dichloropyridine-2-carboxylic acid) is a pyridine carboxylic acid herbicide that provides systemic post-emergence broad-spectrum control of a number of noxious and invasive annual, biennial, and perennial weeds, as well as agronomic broadleaf weeds (USEPA, 2005). Aminopyralid is an auxin growth hormone mimic, affecting cell wall plasticity and nucleic acid metabolism. It has been classified as a low risk herbicide, meaning that USEPA has concluded that the use of aminopyralid as a replacement for other herbicides will decrease the risk to some non-target species (Syracuse Environmental Research Associates, 2007). Its manufacturer, Dow AgroSciences, indicates that aminopyralid is intended as an alternative to picloram, 2,4-D, dicamba, monosodium methanearsonate (MSMA), and metsulfuron methyl (Jachetta et al., 2004; Syracuse Environmental Research Associates, 2007).

2.2.2 Exposure Considerations

Aminopyralid, the active ingredient in Milestone, is used to control invasive broadleaf weeds including thistles, and sweet pea. It is selective for broadleaf plants and does not harm grasses if used after germination. It is not used when wind speeds are greater than 7 mph or when the chance of rain is 40% or greater within 24 h of the planned application. Milestone is used at a rate of 3 oz/acre for pre-emergent applications in winter and early spring and at 5 oz/acre for post-emergent applications. A special high rate of 14 oz/acre is used for spot treatment of cape ivy vines in riparian zone tree canopies during winter. It is used in conjunction with the nonionic surfactant Liberate NIS (discussed in sections 6.2 and 6.3).

Application sites are not within defined critical habitats for the red-legged frog; however, a qualified biologist that can identify all rare plant and wildlife species present within the application area will supervise all applications of the pesticide. It is not to be applied directly to water, and it is used only with a 15 ft or greater buffer between aquatic systems and application sites.

2.2.3 Human Toxicity

Due to the relative newness of aminopyralid, the only acute toxicity studies for the compound are those that were conducted as part of the initial USEPA registration process. Based on these studies, the USEPA has classified aminopyralid as having low acute oral, dermal, and inhalation toxicity (all Category IV). The oral and dermal LC50s for Milestone in rats are both >5,000 mg/kg, and the inhalation LC50 is >5.79 mg/L (USEPA, 2005). Chronic rat neurotoxicity studies and two generation reproductive studies have indicated NOAELs >1,000 mg/kg/day for both endpoints (USEPA, 2005).

The mechanism of toxicity to mammals has not yet been well-characterized. The most typical response of rats to aminopyralid appears to be cecal enlargement after prolonged oral exposure; however, the toxicological significance of this response is unclear (Syracuse Environmental Research Associates, 2007). Aminopyralid is rapidly excreted after exposure, likely by the well-characterized active transport mechanism via the kidneys seen after ingestion of similar herbicides such as picloram. Aminopyralid has not been shown to cause cancer, neurotoxicity, immunotoxicity, teratogenesis, reproductive effects, genotoxicity or mutagenicity in laboratory studies (Dow AgroSciences, 2006; Syracuse Environmental Research Associates, 2007). Due to its low toxicity, an acute RfD for aminopyralid is not required by the USEPA. The chronic RfD for aminopyralid is 0.5 mg/kg bw/day.

2.2.4 Ecological Toxicity

Aminopyralid is practically non-toxic to birds, fish, aquatic invertebrates, amphibians, and honey bees on an acute basis (Dow AgroSciences, 2006; USEPA, 2005). The acute LD50 for bobwhite quail is >2,250 mg/kg, and the dietary 5-day LC50s in bobwhite quail and mallard duck are >5,556 mg/kg diet and >5496 mg/kg diet, respectively. The 96-h LC50s for rainbow trout and bluegill sunfish are > 100 mg/L, and the 96-h LC50 for sheepshead minnow is >120 mg/L. The log KOW is <3 and thus aminopyralid is not expected to bioaccumulate in fish tissues. The 48-h LC50 in *Daphnia magna* is >98.6 mg/L; the 48-h EC50 for

Eastern oyster is >89 mg/L; and the 96-h LC50 for mysid is >100 mg/L. A single acute toxicity study has been performed for amphibians, and there was no indication that aminopyralid was toxic to northern leopard frog tadpoles (LC50 >95.2 mg/L) (Henry et al., 2003; Syracuse Environmental Research Associates, 2007). Aminopyralid is also practically non-toxic to honey bees with acute contact and oral LD50s of >100 µg/bee and >117 µg/bee, respectively. There are no known acute or chronic risks to non-target endangered or non-endangered fish, birds, wild mammals, terrestrial and aquatic invertebrates, algae, or aquatic plants (USEPA, 2005).

2.2.5 Physical Properties/Environmental Fate and Transport

Aminopyralid is essentially nonvolatile. In aquatic systems, it is highly photolabile. It is stable to direct hydrolysis, stable in anaerobic sediment-water systems, and weakly sorbs to soil. It is likely to be non-persistent and relatively immobile in the field with minimal leaching below the 15 to 30 cm soil depth. Under aerobic conditions, degradation results in the production of CO_2, ammonia, and non-extractable residues (USEPA, 2005). Aminopyralid is labile to photolysis at the soil surface but this process occurs at a much slower rate than it does in water (t ½ = 72 days in soil vs. 0.6 days in water).

2.2.6 Water Pollution Potential

Aminopyralid is quickly degraded via photolysis in aquatic systems (t ½ = 0.6 days), while degradation in the absence of photolysis occurs under aerobic conditions at a much slower rate (t ½ = 462-990 days). It has a low potential for groundwater contamination.

2.3 Clopyralid

CLOPYRALID

Formulations: Transline

- Human Toxicity: Generally low toxicity. Neurotoxicity caused by acute poisoning. No evidence of carcinogenicity, immunotoxicity, or reproductive/developmental toxicity.
- Ecological Toxicity: Practically non-toxic to birds, fish, aquatic invertebrates, and honey bees.
- Water Pollution Potential: Degraded rapidly in water. Low potential for leaching.
- Other Considerations: Very stable in compost piles, and thus is no longer used for lawn and garden applications in California and Washington.

2.3.1 Basic Use Information

- Products: *Transline*
- Typical target pests: Thistles; Clover
- Application rates:

Material	Low volume/acre	High volume/acre
Transline	10 oz. – winter rate on seedlings and pre-emergent plants	20 oz.- spring rate on basal rosettes, bolt stage

Clopyralid is a selective herbicide used for broadleaf noxious weed control. It is structurally similar to aminopyralid, which has an extra amino group, and it is also an auxin hormone mimic, causing abnormal growth that impairs proper nutrient transport throughout the plant. It is highly selective for terrestrial plants and appears to be relatively non-toxic to aquatic plants (Syracuse Environmental Research Associates, 2004).

2.3.2 Exposure Considerations

Clopyralid is the active ingredient in Transline. It is used to control broadleaf weeds such as thistle and clover. Similar to aminopyralid, it is selective for broadleaf plants and is not harmful to grasses when use post seed germination: however, it appears to be even more selective and effective than aminopyralid on post-emergent plants. It is applied at 10 oz/acre in the winter to pre-emergent invasive weeds and seedlings and at 20 oz/acre in the spring during the bolt (flowering) stage of unwanted plants. It is not used when wind speeds are greater than 7 mph or when the chance of rain is 40% or greater within 24 h of the planned application. It is used only with a 15 ft or greater buffer between aquatic systems and application sites.

2.3.3 Human Toxicity

Clopyralid is listed as a Category III compound for oral, dermal, and inhalation toxicity. The oral and dermal mammalian LD50s are both >5,000 mg/kg, and the mammalian inhalation LC50 is >1.3 mg/L. It is not metabolized extensively; 79-96% of parent clopyralid is excreted in rat urine (t ½ = 3 h) (Syracuse Environmental Research Associates, 2004). The NOEL in dogs is 100 mg/kg/day. Clinical signs of acute clopyralid poisoning include neurotoxicity, manifested as ataxia, tremors, convulsions, and weakness. Chronic studies in rats, mice, and dogs have noted general decreases in body weight and increases in liver and kidney weight, which are commonly observed in chronic toxicity studies and can indicate either an adaptive or toxic response. The USEPA OPP has established an acute RfD of 0.75 mg/kg/day and a chronic RfD of 0.15 mg/kg/day for clopyralid. The USEPA classifies clopyralid as a Group E human carcinogen (no evidence of carcinogenicity) because chronic studies in rats, mice, and dogs have shown no indication of carcinogenicity. However, technical grade clopyralid contains low levels of hexachlorobenzene (<2.5 ppm), which is classified as a potential human carcinogen (Syracuse Environmental Research Associates, 2004).

2.3.4 Ecological Toxicity

Clopyralid is practically non-toxic to slightly toxic to birds. The oral LD50 in mallard duck is >1,645 mg/kg. The dietary LC50 for both pure clopyralid and the monoethanolamine salt of clopyralid is >4,460 ppm in both bobwhite quail and mallard duck. Clopyralid is also practically non-toxic to fish and aquatic invertebrates. The 96-h LC50 in bluegill is 125 mg/L, and the LC50 in rainbow trout is 103 mg/L for technical grade clopyralid. The monoethanolamine salts are even less toxic to fish, with LC50s ranging from 700-1,645 mg a.e./L. There is no indication that clopyralid bioaccumulates in fish. The LC50 in Daphnia is 225 mg/L. In a chronic Daphnia reproduction study, the NOAEL was found to be 23.1 mg a.e./L (Syracuse Environmental Research Associates, 2004). Clopyralid is also practically non-toxic to honey bees; the contact LD50 is >100 µg/bee. Clopyralid residues are highly toxic to non-target broadleaf plants.

2.3.5 Physical Properties/Environmental Fate and Transport

Clopyralid is relatively nonvolatile and highly water soluble. It is stable to both hydrolysis and photolysis in aqueous systems but is degraded rapidly. It is degraded in soil primarily through microbial activity (t ½ = 40 days), and carbon dioxide is the major breakdown product (USDOE). It is very stable under anaerobic conditions. It is mobile and does not bind tightly to soil. Clopyralid is very stable in compost piles, and thus is no longer used for lawn and garden applications in California and Washington (California Department of Pesticide Regulation, 2004).

2.3.6 Water Pollution Potential

Clopyralid is very water soluble and is also degraded rapidly in water (t ½ = 9-22 days). Various monitoring studies have determined that the potential for leaching is very low due to its rapid degradation; only 0.1-0.6% of applied clopyralid was lost through leaching in various studies (Marin Municipal Water District Vegetation Management Plan, 2010; Syracuse Environmental Research Associates, 2004).

2.4 Imazapyr

IMAZAPYR

Formulations: Polaris, Stalker

> Human Toxicity: Low toxicity. No evidence of carcinogenicity, neurotoxicity, immunotoxicity, or reproductive/developmental toxicity.

> Ecological Toxicity: Practically non-toxic to birds, fish, aquatic invertebrates, and honey bees.

> Water Pollution Potential: Soluble in water and degraded quickly via photolysis. Moderate potential for leaching into groundwater.

> Other Considerations: Can be applied in areas where glyphosate is ineffective or not approved for use.

2.4.1 Basic Use Information

> Products: *Polaris, Stalker*

> Typical target pests: Grasses, Scotch broom.

Material	Low rate foliar	High rate foliar	Cut stump	Volume/acre
Polaris	0.5% v/v - spot treatment of annual wetland, non-crop weeds	1.5 – 5% v/v spot and low volume treatment of perennial wetland, non-crop weeds	10 % v/v	Variable

Material	Cut stump	Volume/acre
Stalker	10 -12 % v/v	Variable

Imazapyr is a systemic, nonselective, pre- and post-emergent herbicide used for the control of a broad range of terrestrial and aquatic weeds. It controls plant growth by preventing the synthesis of branched-chain amino acids. Imazapyr is applied either as an acid or as the isopropylamine salt and is approved for use on grasses, commercial and residential sites, and water bodies.

2.4.2 Exposure Considerations

Imazapyr is a broad-spectrum, non-selective herbicide that is used to control unwanted grasses, woody plants, and riparian plants. It is effective on both pre- and post-emergent (before and after sprouting) plants and can be used when glyphosate treatment is not efficacious or when multiple growth stages of a plant are present in the same location. It is the active ingredient in Stalker and Polaris commercial formulations. Polaris is used in low volume applications or spot treatments of perennial weeds at 1.5-5% v/v and a low foliar rate of 0.5% v/v for spot treatments of annual wetland and non-crop weeds. It is not used when wind speeds are greater than 7 mph or when the chance of rain is 40% or greater within 24 h of the planned application. Imazapyr is approved for use in and near aquatic systems. However, if suitable habitat for any endangered species is found, and if imazapyr use has the potential to affect the species, coordination with the California Department of Fish and Game, the U.S. Fish and Wildlife Service, and/or National Marine Fisheries shall occur before weed treatment activities may be conducted within this buffer or activities shall be canceled in this area. It is efficacious against aquatic plants when most of the plant is not submerged and can be used in lieu of glyphosate in aquatic systems. Polaris and

Stalker are both used as treatments on stumps immediately following tree cutting at 10% v/v.

2.4.3 Human Toxicity

Imazapyr exhibits low acute toxicity to mammals via oral (Category IV), dermal (Category III), and inhalation (Category II) exposure. The oral LD50 for rats is >5,000 mg/kg; dermal LD50 for rabbits is >2,000 mg/kg; and the inhalation LC50 for rats is >1.3 mg/L. The formulations used by the District are Category III for oral, dermal, and inhalation toxicity. Imazapyr is classified as a Group E chemical, with no evidence of carcinogenicity, and is not mutagenic (USDOE-Bonneville Power Administration, 2000). A NOAEL of 250 mg/kg/day (the highest dose tested) was identified in a one-year dog feeding study, indicating that imazapyr has very low chronic toxicity to mammals. The USEPA has determined that the risk to humans of dietary and incidental exposure is below the level of concern (USEPA, 2006).

2.4.4 Ecological Toxicity

Imazapyr is practically nontoxic to birds, fish, Daphnia, and honey bees. The oral LD50 is >2,150 mg/kg for mallard duck and bobwhite quail. The 96-hr LC50 is >100 mg/L for rainbow trout and bluegill sunfish, and the 48-hr LC50 for Daphnia magna is >1,000 mg/L. The LD50 for honey bees is >100 µg/bee (USDOE-Bonneville Power Administration, 2000). Imazapyr is not expected to bioaccumulate in aquatic organisms because it exists as an anion at typical environmental pH (USEPA, 2006). Although there are no risks of concern to terrestrial birds, mammals, bees or aquatic invertebrates and fish, imazapyr does pose an ecological risk to non-target terrestrial and aquatic vascular plants, which can be reduced by applications that minimize spray drift and limitations on spraying near certain water bodies (USEPA, 2006).

2.4.5 Physical Properties/Environmental Fate and Transport

Imazapyr is an ionic, organic acid that is nonvolatile and is both moderately persistent and mobile in soil. Commercial formulations contain either imazapyr acid or the imazapyr isopropylamine salt, both of which are dissolved in a water solution. Imazapyr is mainly in ionic form at typical environmental pH levels, and the behavior of the acid and salt forms are similar. Upon direct application, or indirect release into surface water, imazapyr is degraded by photolysis, with a half-life of approximately 3 to 5 days in surface water. It is essentially stable to hydrolysis, aerobic and anaerobic soil degradation, and aerobic and anaerobic aquatic metabolism. In soil, it is degraded primarily by microbial activity, and has a moderate soil adsorption coefficient.

2.4.6 Water Pollution Potential

Imazapyr is soluble in water and is quickly degraded by photolysis (t ½ = 3-8 days). There is moderate potential for leaching into groundwater (USDOE-Bonneville Power Administration, 2000)

2.5 Clethodim

CLETHODIM

Formulations: Envoy Plus

- Human Toxicity: Low toxicity. No evidence of carcinogenicity, neurotoxicity, immunotoxicity, or reproductive/developmental toxicity.
- Ecological Toxicity: Slightly toxic to birds, fish, and aquatic invertebrates. Practically non-toxic to honey bees.
- Water Pollution Potential: Insoluble in water. Very short half-life in soil, and unlikely to leach in ground water.
- Other Considerations: Envoy contains small amounts of naphthalene, which is listed as a Group 2B (possibly carcinogenic) compound by the USEPA and a carcinogen under California Proposition 65.

2.5.1 Basic Use Information

> Products: *Envoy Plus*

> Typical target pests: Annual and perennial grasses.

> Application rates:

Material	Low volume/acre	High volume/acre
Envoy Plus	16 oz. – early/mid season annual grasses – spot and broadcast in non-crop areas	32 oz. – early/mid season annual grasses – spot and broadcast in non-crop areas

Clethodim is a selective, post-emergence herbicide used for the control of annual and perennial grass weeds. It functions by inhibiting fatty acid synthesis in plants.

2.5.2 Exposure Considerations

Clethodim is the active ingredient in Envoy Plus and is highly selective for post-emergent grass control. It is not toxic to broadleaf or pre-emergent plants, and it is therefore highly effective in controlling invasive grasses that grow within broadleaf habitats and in eradicating annual unwanted grasses from perennial grasslands. It is used in early to mid season spot and broadcast applications at a high rate of 32 oz/acre on perennial grasses and a low rate of 16 oz/acre on annual grasses.

2.5.3 Human Toxicity

Clethodim is listed as Category IV for oral, dermal, and inhalation toxicity. The mammalian oral and dermal LD50s are both >5,000 mg/kg, and the acute inhalation LC50 is >3.9 mg/L. It is a Category III eye irritant and skin irritant and is a dermal sensitizer (USEPA, 1995). Chronic toxicity has been shown to increase liver weights and anemia in rats. There is no evidence of reproductive toxicity or carcinogenicity for pure clethodim. However, Envoy contains small amounts of naphthalene, which is listed as a Group 2B (possibly carcinogenic) compound by the USEPA and a carcinogen under California Proposition 65 (Valent, 2006).

2.5.4 Ecological Toxicity

Clethodim is reported as practically nontoxic to slightly toxic to birds; the bobwhite quail LD50 is >2,000 mg/kg. In longer term reproductive studies, the NOAEL in quail was found to be 300 ppm while in mallard ducks it is 1,000 ppm. Clethodim is slightly toxic to fish and aquatic invertebrates. The 96-h LC50 of Envoy Plus in bluegill is 120 mg/L; the 96-h LC50 in rainbow trout is 67 mg/L; and the 48-h LC50 in Daphnia is >120 mg/L. It does not bioaccumulate in fish. Clethodim is practically non-toxic to honey bees (LD50 >100 µg/bee) (USEPA, 1990b, 1995).

2.5.5 Physical Properties/Environmental Fate and Transport

Clethodim is relatively nonvolatile. In soil, it is non-persistent, mobile, and weakly binds to soil particles. It is broken down in soil through primarily aerobic processes (t ½ = 1-2.6 days). Its degradation under anaerobic conditions is slow in both water (t ½ = 128 days) and sediment (t ½ = 214 days).

2.5.6 Water Pollution Potential

Clethodim is not soluble in water. Because it is has a very short half-life in soil (1-3 days), it is unlikely to leach into and contaminate ground water sources (USEPA, 1990a).

3 Fungicide

Table 3-1 Human Toxicity Summary of Fungicide Active Ingredient

Active Ingredient	Mammalian Oral LD50 (mg/kg)[A]	Mammalian Dermal LD50 (mg/kg)[B]	Mammalian Inhalation LC50 (mg/L)[A]	USEPA Toxicity Rating	Carcinogenic	Reproductive or Developmental Toxicity	Neurotoxic	Immunotoxic	Endocrine Disruption
Potassium salts of phosphorus acid	>5,000	>5,000	> 2.06	Oral and dermal (III), inhalation (IV)	No	NA	NA	NA	NA

Table 3-2 Ecotoxicity Summary of Fungicide Active Ingredients

Active Ingredient	Mammalian Oral LD50 (mg/kg)[A]	Mammalian Dermal LD50 (mg/kg)[B]	Mammalian Inhalation LC50 (mg/L)[A]	Avian LD50 (mg/kg)[C]	Fish LC50 (mg/L)[D]	Aquatic Invert EC50 (mg/L)[E]	Honeybee LD50 (µg/bee)	Other Receptors
Potassium salts of phosphorus acid	>5,000	>5,000	> 2.06	>1,060	>544.6	>544.6	>13.3	NA

A. Unless otherwise specified, values are for rats.

B. Unless otherwise specified, values are for rabbits.

C. Unless otherwise specified, values are for mallard duck or bobwhite quail.

D. Unless otherwise specified, values are for rainbow trout or bluegill sunfish.

E. Values are for Daphnia or similar species.

3.1 Potassium salts of phosphorus acid

POTASSIUM SALTS OF PHOSPHORUS ACID

Formulations: Agri-Fos

> Human Toxicity: Low toxicity. No evidence of carcinogenicity, neurotoxicity, immunotoxicity, or reproductive/developmental toxicity.

> Ecological Toxicity: Practically non-toxic to birds, fish, and freshwater invertebrates. Toxic to bees.

> Water Pollution Potential: High water solubility, but unlikely to contaminate water due to use practices.

> Other Considerations: Formulation is used via injection or directed spray in targeted applications, reducing exposure and risk to non-target species.

3.1.1 Basic Use Information

- Products: *Agri-Fos*
- Typical target pests: *Phytophthora ramorum,* cause of sudden oak death
- Application rates:

Material	Basal bark treatment
Agri-Fos	49 % v/v

Potassium salts of phosphorus acid are the active ingredient of Agri-Fos, a fungicide that is used to help prevent infection, or increase infection resistance by the oomycete plant pathogen *Phytophthora ramorum*, which causes sudden oak death. The fungicide functions by inhibiting oxidative phosphorylation in the fungus, and some evidence suggests that phosphorous acid has the indirect effect of stimulating the plants natural defense response against pathogens. Agri-Fos is applied via injection in the oak bark or by a localized spray onto the bark. When applied by spray, it is used with the organosilicone surfactant Pentra-bark.

3.1.2 Exposure Considerations

Potassium salts of phosphorus acid are the active ingredient in the fungicide Agri-Fos, which is used to prevent sudden oak death. It is applied directly to the bark of forest trees at a 49% v/v application rate. The surfactant Pentra-bark is used with Agri-Fos to increase the uptake of the fungicide by the tree, thereby increasing its efficacy and decreasing its potential to impact non-target species. The basal bark application method also decreases the potential for drift, deposition in water, and exposure to non-targets because the fungicide is sprayed directly onto the bark and quickly taken up by the tree.

3.1.3 Human Toxicity

Potassium salts of phosphorus acid are Category III for oral and dermal toxicity and Category IV for inhalation (USEPA, 1998). The mammalian oral and dermal LD50s are both >5,000 mg/kg, and the inhalation LC50 is >2.06 mg/L. Potassium salts are Category III eye irritants. They are not dermal sensitizers. There is no evidence of genotoxicity. Further, because there are no food uses associated with these compounds, dietary risk is minimal (Health Canada, 2012).

3.1.4 Ecological Toxicity

Potassium salts of phosphorus acid are practically non-toxic to birds, fish, and freshwater invertebrates. The acute LD50 in bobwhite quail is >1,060 mg/kg, and the 8-day dietary LC50 in mallard ducks is >5,000 ppm (734.2 mg a.i./kg bw/day). For rainbow trout and *Daphnia magna*, the LC50 is >544.6 mg/L. These compounds are highly water soluble and are not expected to bioaccumulate in fish. The LD50 for honey bees is >13.3 µg a.i./bee (Health Canada, 2012).

3.1.5 Physical Properties/Environmental Fate and Transport

Little information regarding the environmental fate and transport of potassium salts of phosphorus acid or Agri-Fos exist. They will produce phosphite ions when in contact with water, and these phosphite ions can be directly taken up by plant roots, slowly transform to phosphate, or bind with other substances in the soil. Microbial transformation in soil is likely to be very slow.

3.1.6 Water Pollution Potential

Potassium salts are very water soluble. Due to the directed application of Agri-Fos, introduction into the water or soil environment is unlikely, and thus, the water pollution potential of this compound is negligible (USEPA, 1998).

This page intentionally left blank.

4 Rodenticides

Table 4-1 Human Toxicity Summary of Rodenticide Active Ingredient

Active Ingredient	Mammalian Oral LD50 (mg/kg)[A]	Mammalian Dermal LD50 (mg/kg)[B]	Mammalian Inhalation LC50 (mg/L)[A]	USEPA Toxicity Rating	Carcinogenic	Reproductive or Developmental Toxicity	Neurotoxic	Immunotoxic	Endocrine Disruption
Cholecalciferol	43.6	2,000	NA	NA	No	No	No	No	No

Table 4-2 Ecotoxicity Summary of Rodenticide Active Ingredient

Active Ingredient	Mammalian Oral LD50 (mg/kg)[A]	Mammalian Dermal LD50 (mg/kg)[B]	Mammalian Inhalation LC50 (mg/L)[A]	Avian LD50 (mg/kg)[C]	Fish LC50 (mg/L)[D]	Aquatic Invert EC50 (mg/L)[E]	Honeybee LD50 (µg/bee)	Other Receptors
Cholecalciferol	43.6	2,000	NA	2,000	NA	NA	NA	Dog oral LD50 = 88 mg/kg

A. Unless otherwise specified, values are for rats.
B. Unless otherwise specified, values are for rabbits.
C. Unless otherwise specified, values are for mallard duck or bobwhite quail.
D. Unless otherwise specified, values are for rainbow trout or bluegill sunfish.
E. Values are for Daphnia or similar species.

4.1 Cholecalciferol

CHOLECALCIFEROL

Formulations: NA

> Human Toxicity: High acute toxicity to mammals.

> Ecological Toxicity: Moderate toxicity to avian species. Lower risk of secondary poisoning to non-target birds.. Generally toxic to rodents with one ingestion.

> Water Pollution Potential: Unlikely to enter aquatic systems due to use of tamper-resistant bait stations.

> Other Considerations: Use of anchored tamper-resistant bait stations minimizes risk to non-target wildlife, domestic pets, or children.

4.1.1 Basic Use Information

> Products: *Cholecalciferol (Vitamin D_3) Quintox, Rampage, Hypekill*

> Typical target pests: Rats, mice

> Application rates:

Material	Rate
Cholecalciferol	0.075% in bait

Cholecalciferol is used to control Norway rats (*Rattus norvegicus*), roof rats (*Rattus rattus*), and several species of mice, including house mice (*Mus musculus*), and field mice (*Peromyscus spp.*) in and around homes, industrial buildings, and similar man-made structures. Formulation types include pellets and blocks. Cholecalciferol is a sterol (vitamin D3) and its ingestion results in hypercalcemia from mobilization of calcium from bone matrix into blood plasma leading to metastatic calcification of soft tissues (USEPA, 2011).

4.1.2 Exposure Considerations

Cholecalciferol is the active ingredient (commonly 0.075%) of rodent baits and is applied using tamper-resistant bait stations. The use of bait stations offers protection to non-target organisms, particularly birds, because loose pellets are not available to other animals that might attempt to consume the bait. These bait stations are designed to stop access to the bait by other animals and small children. They are anchored at treatment locations (e.g., by wires or stakes) to ensure that they cannot be dragged away by non-target wildlife, domestic pets, or children. Bait placements must be inside or within 50 or 100 feet of buildings (distance dependent upon particular product formulation). The amount of bait used in each bait station varies depending upon the target pest.

4.1.3 Human Toxicity

Cholecalciferol is acutely toxic to target rodents. The oral LD50 for cholecalciferol is 42.5 for mice, 43.6 mg/kg for rats, and 88 mg ai/kg for dogs (Marshall, 1984). However, subsequent studies have indicated that the dog LD50 may be much lower (USEPA, 2004). In rats and mice fed 0.075% cholecalciferol, 100% mortality occurred within 3 to 6 days and was found to be efficacious in warfarin-resistant rats. The dermal LD50 of the finished bait product (0.075% cholecalciferol) is 2,000 mg/kg for rabbits (Marshall, 1984).

The parent compound and metabolites are fat soluble and stored in adipose tissue. Enterohepatic recirculation of cholecalciferol and metabolites occurs. After a massive intake of cholecalciferol, excess calcifediol is produced in the liver. Because of their high lipid solubility, cholecalciferol and its metabolites are eliminated from the body very slowly (primarily through bile and feces). Two mechanisms occur with consumption of large doses of cholecalciferol. First, more calcium is absorbed from the intestines. Second, cholecalciferol metabolites stimulate phosphorus transfer from bone to plasma. The increased plasma calcium concentrations result in vomiting, lethargy, and muscle weakness. Specific organ effects include acute renal tubular necrosis, gastrointestinal stasis, gastric acid secretion, decreased skeletal muscle responsiveness, and decreased neural tissue responsiveness. The increase in plasma calcium causes soft tissue mineralization resulting in loss of functionality of kidneys, cardiac muscle, etc. (Morrow, 2001).

4.1.4 Ecological Toxicity

Cholecalciferol is considered of lower hazard to avian species compared to other rodenticides. The oral LD50 for mallard ducks >2,000 mg/kg (30% a.i.), equating to >600 mg/kg, and the mallard and northern bobwhite dietary LC50 are 1190 and 528 ppm, respectively (Marshall, 1984; USEPA, 2004). The USEPA has made an effects determination of “may affect, and likely to adversely affect” for the endangered salt marsh harvest mouse based on risk of consuming the compound via bait blocks (USEPA, 2011). In the only secondary avian toxicity study available for cholecalciferol, two turkey vultures and one red-tailed hawk were offered rats or mice fed for 1-day with 0.075% a.i. bait, and no adverse effects were observed in the birds (Marsh and Koehler, 1991). When cholecalciferol-poisoned prey were offered to dogs and cats for five days, no death occurred in either species and while some signs of toxicosis were observed in the dogs, these symptoms were reversible after exposure and all animals recovered (Eason et al., 2000).

4.1.5 Physical Properties/Environmental Fate and Transport

No environmental fate and transport data for cholecalciferol have been submitted to USEPA. Based on physical/chemical properties of the compound, it is expected to be nonvolatile, essentially insoluble in water, and immobile in soil (USEPA, 2011). Information on biotic and abiotic degradation is not available.

4.1.6 Water Pollution Potential

Because cholecalciferol is used in tamper-resistant bait stations, it is unlikely to enter aquatic environments via runoff or spray drift. Thus, the water pollution potential of cholecalciferol is negligible.

This page intentionally left blank.

5 Insecticides

Table 5-1 Human Toxicity Summary of Insecticide Active Ingredients

Active Ingredient	Mammalian Oral LD50 (mg/kg)[A]	Mammalian Dermal LD50 (mg/kg)[B]	Mammalian Inhalation LC50 (mg/L)[A]	USEPA Toxicity Rating	Carcinogenic	Reproductive or Developmental Toxicity	Neurotoxic	Immunotoxic	Endocrine Disruption
d-trans allethrin	860	11,332	NA	NA	No	No	Yes	No	No
Phenothrin	>5,000	>2,000	>2.1	Oral and inhalation (IV), dermal (III)	No	No	Yes	No	No
Indoxacarb	<1,000	>5,000 (rat)	>5.5	Oral (II), dermal and inhalation (IV)	No	No	No	No	No
Hydroprene	>5,000	>5,000	>5.2	Oral (IV), dermal and inhalation (III)	Not enough data to classify	No	No	NA	NA
Fipronil	97	>2,000 (rat); 354 (rabbit)	0.390 – 0.682	Oral and inhalation (II), dermal (III)	Possible human carcinogen	Yes (reproductive)	Yes	NA	NA
Sodium tetraborate decahydrate (borax)	>5,000 (Prescription ant bait)	>5,000 (Prescription ant bait)	>0.16 (boric acid)	Oral and dermal (III)	No	Yes, at high doses (reproductive)	NA	NA	NA
Diatomaceous earth	>5,000	>2,000	> 0.859	Oral (IV), dermal (III), inhalation (II)	NA	NA	NA	NA	NA

Table 5-2 Ecotoxicity Summary of Insecticide Active Ingredients

Active Ingredient	Mammalian Oral LD50 (mg/kg)[A]	Mammalian Dermal LD50 (mg/kg)[B]	Mammalian Inhalation LC50 (mg/L)[A]	Avian LD50 (mg/kg)[C]	Fish LC50 (mg/L)[D]	Aquatic Invert EC50 (mg/L)[E]	Honeybee LD50 (µg/bee)	Other Receptors
d-trans allethrin	860	11,332	NA	>5,620 (8-day dietary)	0.0094 (coho salmon) to 0.027 (channel catfish)	NA	Contact – 3.4; Oral – 4.6 to 9.1	2-yr Dog dietary NOEL = 50 mg/kg/day
Phenothrin	>5,000	>2,000	>2.1	>5,000 (dietary)	0.0158 to 0.0942 (inland silverside)	0.000025 (mysid) - .0044	NA, likely toxic	NA
Indoxacarb	<1,000	>5,000 (rat)	>5.5	98	0.65	0.0542 (mysid) – 2.94	Contact - 0.18; Oral - practically non-toxic	90-d Dog LOAEL = 19 mg/kg/day
Hydroprene	>5,000	>5,000	>5.2	NA	>100	NA	Adult - 1000; larval - 0.1	3-month rat LOAEL = 250 mg/kg/day
Fipronil	97	>2,000 (rat); 354 (rabbit)	0.390 – 0.682	11.3; 31 (pheasant)	0.083 to 0.246	0.020 (LOAEL)	Highly toxic	NA
Sodium tetraborate decahydrate (borax)	>5,000 (Prescription ant bait)	>5,000 (Prescription ant bait)	>0.16 (boric acid)	>2,510 (boric acid)	41; 12,000 (mosquito fish)	133 (boron)	100 (boron)	Frog LC50 = 414 to 529 mg borax/L
Diatomaceous earth	>5,000	>2,000	> 0.859	Practically nontoxic	Practically nontoxic	Practically nontoxic	NA	NA

A. Unless otherwise specified, values are for rats.

B. Unless otherwise specified, values are for rabbits.

C. Unless otherwise specified, values are for mallard duck or bobwhite quail.

D. Unless otherwise specified, values are for rainbow trout or bluegill sunfish.

E. Values are for Daphnia or similar species.

5.1 D-trans allethrin

D-TRANS ALLETHRIN

Formulations: Wasp-Freeze

> Human Toxicity: Low toxicity. Dermal and eye irritation possible. Neurotoxicity caused by acute poisoning. No evidence of carcinogenicity, immunotoxicity, or reproductive/developmental toxicity.

> Ecological Toxicity: Practically non-toxic to birds. Highly toxic to fish and aquatic invertebrates.

> Water Pollution Potential: Rapidly degraded in the environment and not likely to leach into groundwater.

> Other Considerations: Not used in/near aquatic systems due to high fish and aquatic invertebrate toxicity.

5.1.1 Basic Use Information

> Products: *Wasp-Freeze*

> Typical target pests: Wasps

> Application rates:

Material	Formulation	Rate
Wasp-Freeze	0.10% a.i.	One 17.5 oz ready to use spray can/wasp nest

Allethrins are first generation or Type I synthetic pyrethroids that contain three asymmetric carbons and, thus, eight potential isomers; however, four isomers are present in the greatest concentrations in product formulations. One of the stereoisomers, d trans of the d isomer (d-trans allethrin), is recognized as being the most insecticidally active and toxicologically important, and it is the active ingredient (along with phenothrin, discussed below) in Wasp-freeze. Pyrethroids bind to neuronal voltage-gated sodium channels, preventing them from closing; this persistent activation of the channels then leads to paralysis.

5.1.2 Exposure Considerations

D-trans allethrin and phenothrin (discussed below) are the active ingredients in Wasp-Freeze. Each compound is approximately 0.1% of the pesticide formulation. Wasp-freeze is a ready-to-use formulation in a 17.5 oz spray can. The pesticide is applied by hand directly onto the nests of unwanted wasps, hornets, or bees. Because pyrethroids are highly toxic to fish, Wasp-Freeze is not applied to water; the District maintains a 15 ft or great buffer between aquatic systems and application areas. It is not used when wind speeds are greater than 7 mph or when the chance of rain is 40% or greater within 24 h of the planned application.

5.1.3 Human Toxicity

The toxicity of allethrin varies with the amounts of different isomers present. The LD50 of d-trans allethrin in rats is 860 mg/kg, and the dermal LD50 in rabbits is 11,332 mg/kg. Dermal exposure results in itching, burning, tingling, and numbness. Large doses by any route can cause physical symptoms such as nausea, vomiting, diarrhea, tremors, convulsions, and coma. A chronic dosage of 50 mg/kg/day for two years produced no detectable effect in dogs. Allethrins are not known to cause reproductive, teratogenic, mutagenic, carcinogenic, or endocrine disrupting effects in mammals (EXTOXNET, 1993; World Health Organization, 2002).

5.1.4 Ecological Toxicity

D-trans allethrin is practically nontoxic to birds, but it is highly toxic to fish and invertebrates. The 8-day acute dietary LC50 in bobwhite quails and mallards is >5,620 ppm. The LC50 for fish ranges from 9.4 (coho salmon) to 27 µg/L (channel catfish). The bioaccumulation potential of allethrin is unknown. The LD50 of allethrin to honey bees is 3.4 µg/bee via contact and 4.6-9.1 µg/bee via ingestion (World Health Organization, 2002).

5.1.5 Physical Properties/Environmental Fate and Transport

Allethrins were the first pyrethroids developed, and they are incredibly photolabile (USEPA, 2009). The photolysis half-life is 8-19 hours (WHO, 1989; World Health Organization, 2002). It is stable to hydrolysis at a neutral pH (t ½ = 500 days) but not at pH 9 (t ½ = 4.3 days) (World Health Organization, 2002).

5.1.6 Water Pollution Potential

D-trans allethrin is not soluble in water and is expected to adhere moderately to soil containing organic matter. It rapidly degrades in the environment and is not expected to leach into and contaminate ground water.

5.2 Phenothrin

PHENOTHRIN

Formulations: Wasp-Freeze

- Human Toxicity: Low toxicity. Dermal and eye irritation possible. Neurotoxicity caused by acute poisoning. No evidence of carcinogenicity, immunotoxicity, or reproductive/developmental toxicity.
- Ecological Toxicity: Practically non-toxic to birds. Highly toxic to fish and aquatic invertebrates.
- Water Pollution Potential: Rapidly degraded in the environment and not likely to leach into groundwater.
- Other Considerations: Not used in/near aquatic systems due to high fish and aquatic invertebrate toxicity.

5.2.1 Basic Use Information

- Products: *Wasp-Freeze*
- Typical target pests: Wasps
- Application rates:

Material	Formulation	Rate
Wasp-Freeze	0.10% a.i.	One 17.5 oz ready to use spray can/wasp nest

Phenothrin is a first generation, or Type I, pyrethroid that is the active ingredient (along with d-trans allethrin, discussed above) in Wasp-freeze. It has been registered by the EPA since 1976. It functions in the same manner as d-trans allethrin, causing a persistent opening of neuronal sodium channels, leading to paralysis and death.

5.2.2 Exposure Considerations

Phenothrin and d-trans allethrin (discussed above) are the active ingredients in Wasp-Freeze. Each compound is approximately 0.1% of the pesticide formulation. Wasp-freeze is a ready-to-use formulation in a 17.5 oz spray can. The pesticide is applied by hand directly onto the nests of unwanted wasps, hornets, or bees. Because pyrethroids are highly toxic to fish, Wasp-Freeze is not applied to water; the District maintains a 15 ft or great buffer between aquatic systems and application areas. It is not used when wind speeds are greater than 7 mph or when the chance of rain is 40% or greater within 24 h of the planned application.

5.2.3 Human Toxicity

Phenothrin exhibits low acute toxicity by oral (Category IV), dermal (Category III), and inhalation (Category IV) exposure routes, and it is a mild eye irritant (Category III). The rat oral LC50 is >5,000 mg/kg; the dermal LC50 is >2,000 mg/kg; and the inhalation LC50 is >2.1 mg/L (USEPA, 2008a).

Neurotoxic effects were observed in developmental toxicity studies but not observed in other acute, chronic, and subchronic toxicity studies done in rats and dogs up to the highest dose of 20,000 mg/kg/day. In rats, decreased parental weight gain and decreased weight gain during lactation of pups was observed in animals exposed to 150 mg/kg/day for up to 6 months (USEPA, 2008a).

5.2.4 Ecological Toxicity

Phenothrin is practically nontoxic to avian species. The LC50 for avian dietary toxicity is above 5,000 ppm (USEPA, 2008a). Phenothrin is highly toxic to freshwater, estuarine, and marine fish. LC50s range from 15.8 - 18.3 µg/L for freshwater fish and from 38.3 - 94.2 µg/L for estuarine and marine fish. The chronic NOAEL in fish is 1.1 µg/L. It is also very highly toxic to freshwater invertebrates. The EC50 for freshwater invertebrates is 4.4 µg/L. The lowest LC50 for phenothrin is 0.025 µg/L, based on a 96-h mysid test (SWRCB, 2012). Chronic data for phenothrin show adverse reproductive effects for freshwater invertebrates at a NOAEL of 0.47 µg/L. Estuarine invertebrates are even more sensitive than freshwater invertebrates, with an EC50 of 0.025 µg/L. Chronic effects to estuarine and marine invertebrates are expected based on the chronic reproductive toxicity to freshwater invertebrates and the acute effects to estuarine and marine invertebrates (USEPA, 2008a). Exposure to phenothrin in terrestrial non-target listed or non-listed species mammals is not expected to result in acute or chronic risks.

5.2.5 Physical Properties/Environmental Fate and Transport

Phenothrin has a relatively high affinity for binding to soils, moderate persistence in surface soils, and low water solubility. The major routes of dissipation in the environment are photolysis in water (t ½ = 6.5 days) and aerobic metabolism (t ½ = 36 days in aquatic environments and 18.6-25.8 days in soil). Phenothrin is moderately persistent under aerobic conditions and is persistent under anaerobic conditions (USEPA, 2008a).

5.2.6 Water Pollution Potential

Phenotrhin is likely to remain immobile in soil. It has low leaching potential and is unlikely to cause groundwater contamination (USEPA, 2008a). Phenothrin has a high affinity for sediments or suspended solids in the water column and thus may persist if applied to aquatic systems.

5.3 Indoxacarb

INDOXACARB

Formulations: Advion gel baits

> Human Toxicity: Low toxicity. Eye irritation possible. No evidence of neurotoxicity, carcinogenicity, immunotoxicity, or reproductive/developmental toxicity.

> Ecological Toxicity: Moderately toxic to birds. Moderately to highly toxic to fish and aquatic invertebrates.

> Water Pollution Potential: Rapidly degraded in the environment and not likely to leach into groundwater.

> Other Considerations: Designated as a low risk pesticide. Potential for exposure to non-target species is very low due to use of the pesticide in contained bait stations.

5.3.1 Basic Use Information

> Products: *Advion gel baits*

> Typical target pests: Cockroaches, ants.

> Application rates:

Material	Formulation	Low rate	High rate
Advion gel baits	0.60% a.i	0.5 g bait/10 linear feet	0.5 g bait/2 linear feet

Indoxacarb is proposed for use on structural pests such as ants and cockroaches. It possesses both larvicidal and ovicidal activity. It functions by blocking sodium channels, leading to impaired nerve function, paralysis, and ultimately death of lepidopteran pests (California Department of Pesticide Regulation, 2006; USEPA, 2000). It must be metabolized to elicit its toxicity. Indoxacarb is considered an organophosphate replacement (USEPA, 2000). Formulations often contain indoxacarb and its R-enantiomer.

5.3.2 Exposure Considerations

Indoxacarb is the active ingredient of Advion gel bait, which is applied indoors to cracks and crevices, along and inside access points to treat cockroach infestations. The baits contain 0.6% indoxacarb. For heavy cockroach infestations, 0.5 g bait/2 linear feet is applied, and for lighter infestations, 0.5 g bat/10 linear feet is used. These baits are not used near aquatic systems (>15 ft buffer) or where surface water may be present.

5.3.3 Human Toxicity

Indoxacarb is classified as a Category II oral toxicant; the rat acute oral LD50 is <1,000 mg/kg, with large variation in toxicity between male and female rats (843 and 179 mg/kg, respectively). It is a Category IV dermal and inhalation toxicant; the rat dermal LD50 is >5,000 mg/kg and the inhalation LC50 is >5.5 mg/L. It is a moderate eye irritant (Category III). In a 90-day oral toxicity study in dogs, the LOAEL was determined to be 19 mg/kg/day based on impacts to various blood parameters. There is no evidence that indoxacarb is carcinogenic or mutagenic (California Department of Pesticide Regulation, 2006; USEPA, 2000).

5.3.4 Ecological Toxicity

Indoxacarb is moderately toxic to birds. The LD50 in bobwhite quail is 98 mg/kg, and the subacute 5-day LC50 in bobwhite quail is 808 mg/kg in the diet. It is moderately to very acutely toxic to freshwater, estuarine, and marine fish. The LC50s for rainbow trout, carp, and channel catfish are 0.65, 1.02, and 0.29 mg/L, respectively. It is moderately to very highly acutely toxic to freshwater, estuarine, and marine invertebrates. The acute LC50s in *Daphnia carinata* and *Daphnia magna* are 2.94 and 0.60 mg/L, respectively. The LC50 in Eastern oyster is 0.203 mg/L, and the LC50 in mysid shrimp is 0.0542 mg/L. Chronic toxicities range from 0.003 to 0.25 mg/L for fish and invertebrates (California Department of Pesticide Regulation, 2006). Indoxacarb is practically non-toxic to honey bees by dietary intake but is highly toxic by contact (LD50 = 0.18 µg/bee).

5.3.5 Physical Properties/Environmental Fate and Transport

Indoxacarb is relatively non-volatile and has a low vapor pressure. In water, it is degraded primarily via photolysis, and to a lesser extent, hydrolysis (the hydrolysis half-life is about ten times longer than the photolysis half-life of three days). It is stable to photolysis in soil. It is immobile in soil and is also moderately persistent under both aerobic and anaerobic conditions (California Department of Pesticide Regulation, 2006).

5.3.6 Water Pollution Potential

Indoxacarb is degraded quickly in water. The water pollution potential of this active ingredient is negligible as it is used in contained bait stations.

5.4 Hydroprene

HYDROPRENE

Formulations: Gentrol Point source baits

> Human Toxicity: Low toxicity; does not pose acute dietary risk. No evidence of neurotoxicity, carcinogenicity, immunotoxicity. May be developmentally toxic at very high doses.

> Ecological Toxicity: Practically non-toxic to fish, aquatic invertebrates, and adult honey bees. Some toxicity to larval honey bees.

> Water Pollution Potential: Used indoors, so groundwater contamination is unlikely.

> Other Considerations: Only used in directed applications in response to cockroach infestations indoors.

5.4.1 Basic Use Information

- Products: *Gentrol Point source baits*
- Typical target pests: Cockroaches, beetles, moths.
- Application rates:

Material	Formulation	Low rate	High rate
Gentrol Point source baits	91% a.i.	1 bait/75 sq. ft.	2 baits/75 sq. ft.

Hydroprene is an insect growth regulator that functions by mimicking insect juvenile hormones. It is used against cockroaches, beetles, and moths. It is not applied to plants.

5.4.2 Exposure Considerations

Hydroprene is the active ingredient in Gentrol Point source bait, which is used to control cockroaches. The bait stations contain 91% hydroprene. To treat heavy infestations, two bait stations per 75 sq. ft are used, and to treat light infestations, one bait station per 75 sq. ft is used. These bait stations are permitted for use indoors only, so exposure to wildlife in their natural habitat is highly unlikely.

5.4.3 Human Toxicity

Hydroprene is listed as a Category IV oral toxicant and Category III for dermal and inhalation routes of exposure. Based on the available acute toxicity data, the USEPA has determined the hydroprene does not pose any acute dietary risks. The mammalian oral and dermal LD50s are both >5,000 mg/kg, and the inhalation LC50 is >5.2 mg/L. The USEPA has determined that the parental toxicity LOAEL is 7,500 ppm for the rat reproductive toxicity study based on parental weight gain reductions (Federal Register, 1997). The NOEL for pup development was 1,500 ppm. In a three-month feeding study in rats, the LOAEL based on vacuolated ovarian luteal cells in females was 250 mg/kg/day. There is no evidence for genotoxicity or mutagenicity. It is classified as a Group D compound – not classifiable as to human carcinogenicity. Based on chronic rat studies, the Rfd for hydroprene is 0.1 mg/kg/day (Federal Register, 1997).

5.4.4 Ecological Toxicity

There are no data available regarding the toxicity of hydroprene to birds. It is practically non-toxic to fish, with LC50s >100 mg/L. It is practically non-toxic to adult honey bees by oral and contact routes (LD50 >1,000 µg/bee); however, it is highly toxic to larval honey bees (LD50 = 0.1 µg/bee) (Federal Register, 1997).

5.4.5 Physical Properties/Environmental Fate and Transport

There is a paucity of data regarding the environmental fate and transport of hydroprene because it is only used indoors. Hydroprene is insoluble in water, and it is rapidly degraded in soil (t ½ = days) (National Pesticide Information Center, 2001).

5.4.6 Water Pollution Potential

Because hydroprene is only used indoors, the EPA does not anticipate any contamination of drinking water.

5.5 Fipronil

FIPRONIL

Formulations: Maxforce bait stations

> Human Toxicity: Moderate toxicity. No evidence of neurotoxicity or immunotoxicity. Possible human carcinogen.

> Ecological Toxicity: Highly toxic to fish, aquatic invertebrates, bees, and some bird species.

> Water Pollution Potential: Degrades rapidly in water and unlikely to leach from soil.

> Other Considerations: Bait stations are used in response to ant infestations indoors so risk to non-target species is low.

5.5.1 Basic Use Information

> Products: *Maxforce bait stations*

> Typical target pests: Argentine ants

> Application rates:

Material	Formulation	Low rate	High rate
Maxforce bait stations	0.01% a.i.	3 baits/room	6 baits/room

Fipronil is a non-systemic insecticide registered for use to control ants, beetles, cockroaches, fleas, mole crickets, ticks, termites, and other insects in a variety of agricultural and residential uses. It functions by blocking GABA-gated chloride channels in the central nervous systems of pests.

5.5.2 Exposure Considerations

Fipronil, the active ingredient in Maxforce bait stations, is used to control Argentine ants. The bait stations contain 0.01% fipronil. The bait stations are restricted to placement indoors at rates of 3 or 6 baits per room, respectively. Fipronil baits are not used outside and the District does not employ spray applications, so exposure to wildlife is highly unlikely.

5.5.3 Human Toxicity

Fipronil exhibits moderate acute toxicity (Category II) by the oral and inhalation routes in rats. The oral LD50 in rats is 97 mg/kg. The acute oral LD50 of fipronil-desulfinyl in rats is 15 and 18 mg/kg for females and males, respectively. The 4-h inhalation LC50 ranges from 0.390 to 0.682 mg/L in rats. By the dermal route, it is of moderate toxicity in rabbits and low toxicity (Category III) in rats. The dermal LD50 is 354 mg/kg in rabbits and >2,000 mg/kg in rats. It is relatively non-irritating to the skin (Category IV) and eye (Category III) of rabbits and is not a dermal sensitizer. In a one-year chronic rat feeding study, responses included reduced feeding and food conversion efficiency, reduced body weight gain, seizures and seizure-related death, changes in thyroid hormones, increased mass of the liver and thyroid, and kidney effects. It is not mutagenic. However, fipronil has been classified as a Group C, possible human carcinogen, based on increases in thyroid follicular cell tumors in both sexes of the rat. Fipronil does not cause these tumors in mice. Based on chronic rat studies, the chronic Rfd for humans is 0.0002 mg/kg/day (USEPA, 1996).

5.5.4 Ecological Toxicity

Fipronil is highly toxic to some birds. The LD50 in bobwhite quail is 11.3 mg/kg and in pheasants is

31 mg/kg. The five-day dietary LC50 in bobwhite quail is 49 mg/kg in feed. However, it is practically non-toxic to mallard ducks with no documented acute (LC50 >5,000 mg/kg in 8-day dietary study), sub-acute, or chronic effects. It is highly to very highly toxic to marine and freshwater fish. The 96-h LC50 is 0.246 mg/L for rainbow trout, 0.083 mg/L for bluegill sunfish, and 0.130 mg/L for sheepshead minnow. Fipronil-sulfone is three-six times more toxic than the parent compound in fish, and fipronil has been shown to bioconcentrate in fish. Fipronil is highly toxic to freshwater invertebrates. In Daphnia, the 48-h LC50 = 248 μg/L. The LOAEL in Daphnia is 20 μg/L, and fipronil-sulfone and fipronil-desulfinyl are almost seven and two times more toxic, respectively, than parent fipronil. It is highly toxic to honey bees by contact and ingestion when it is applied to plants (USEPA, 1996).

5.5.5 Physical Properties/Environmental Fate and Transport

Fipronil is nonvolatile. It degrades rapidly in water under UV light. The primary photodegradate is fipronil-desulfinyl. Under aerobic conditions in soil, it is subjected to microbial degradation, which results in the production of fipronil-sulfone (USEPA, 1996). It can also be hydrolyzed to form fipronil-amide. These degradates are persistent and immobile in soil (National Pesticide Information Center).

5.5.6 Water Pollution Potential

Fipronil degrades rapidly in water under UV light (t ½ = 3 days). It is not likely to leach from soil into ground or surface water. The fipronil-containing bait stations used by the are used indoors, and thus the water pollution potential is negligible.

5.6 Sodium tetraborate decahydrate (borax)

SODIUM TETRABORATE DECAHYDRATE (BORAX)

Formulations: Prescription Treatment and Terro Ant Killer II

> Human Toxicity: Low toxicity. Eye irritation possible. No evidence of neurotoxicity, carcinogenicity, immunotoxicity, or reproductive/developmental toxicity.

> Ecological Toxicity: Practically nontoxic to slightly toxic birds, fish, and aquatic invertebrates, and it is relatively nontoxic to beneficial insects

> Water Pollution Potential: Naturally present in water.

> Other Considerations: Used in targeted response to ant infestations.

5.6.1 Basic Use Information

- Products: *Prescription Treatment and Terro Ant Killer II*
- Typical target pests: Argentine ants
- Application rates:

Material	Prescription Formulation	Terro Ant Killer Formulation
Borax	1.3% a.i.	5.4% a.i.

Sodium tetraborate decahydrate, also known as borax, was first registered for use as a pesticide by the USEPA in 1948. It is the active ingredient in Prescription Treatment and Terro Ant Killer II. It functions by disrupting the water balance of insects. The USEPA has determined that, because boric acid and its sodium salts are of low toxicity and occur naturally, they should be exempted from the requirement of a tolerance (maximum residue limit) for raw agricultural commodities (USEPA, 1993a). Additionally, relatively small amounts of borax and boric acid are used for pesticide purposes. Because of its minimal usage and low potential toxicity, very little experimental data exist for borax.

5.6.2 Exposure Considerations

Borax is the active ingredient in Prescription Treatment and Terro Ant Killer II baits. Prescription Treatment ant baits contain 1.3% borax and are approved for use both indoors and outdoors. Terro Ant Killer II liquid contains 5.4% borax and can be used indoors and outside near buildings. These products are not used within 15 ft of aquatic systems.

5.6.3 Human Toxicity

Borax is listed as a Category III compound for oral and dermal toxicity and skin irritation. For Prescription ant bait, the rat oral LD50 is >5,000 mg/kg, and the rabbit dermal LD50 is >5,000 mg/kg (BASF, 2009). Terro liquid ant bait has a similar lack of toxicity to mammals: the rat acute oral LD50 is >5,000 mg/kg and the rabbit acute dermal LD50 is > 2,000 mg/kg (Senoret Chemical Company, 2009). It is listed as a Category I eye irritant. The USEPA has classified boric acid as a Group E carcinogen, indicating that there is evidence of noncarcinogenicity to humans (USEPA, 1993a).

5.6.4 Ecological Toxicity

Technical boric acid and borax are reported to be practically nontoxic to slightly toxic birds, fish, and aquatic invertebrates, and it is relatively nontoxic to beneficial insects (USEPA, 1993a). The LD50 for boric acid in bobwhite quail is >2,510 mg/kg. Bluegill appear to be the most sensitive fish to borax, with a 24-h LC50 of 41 mg/L, while mosquito fish are the least sensitive (24-h LC50 = 12,000 mg/L). In *Daphnia magna*, 48-h LC50s range from 133-530 mg boron/L when exposed to boric acid or borate salts. LD50 values for frogs and toads range from 414 to 529 mg borax/L (National Pesticide Information Center).

5.6.5 Physical Properties/Environmental Fate and Transport

Due to the fact that significant amounts of boron are naturally present in soil and water, the fate and transport of borax is not well elucidated. Boron salts also occur naturally in low concentrations in most unpolluted waterways. There is no data to show that borates or boric acid are transformed or degraded in the atmosphere through photolysis or hydrolysis.

5.6.6 Water Pollution Potential

Boron is ubiquitous and naturally present in water. The water pollution potential of borax is negligible.

5.7 Diatomaceous earth

DIATOMACEOUS EARTH

Formulations: NA

> Human Toxicity: Low toxicity. Mild skin and eye irritation possible. No evidence of neurotoxicity, carcinogenicity, immunotoxicity, or reproductive/developmental toxicity.

> Ecological Toxicity: No evidence of toxicity to wildlife.

> Water Pollution Potential: Insoluble in water.

> Other Considerations: This natural compound consists of the fossilized remains of hard shelled algae known as diatoms.

5.7.1 Basic Use Information

> Products: *N/A*

> Typical target pests: All insects

> Application rates:

Material	Use	Rate
Diatomaceous earth	Fill in crack/voids/interior walls, claimed to be non-toxic insecticide and additive.	Various rates

Diatomaceous earth is a natural compound that also functions through disrupting the water balance of insects. It is practically non-toxic to humans and wildlife, and it is not of environmental concern. The USEPA has identified it as a compound to deregulate due to its lack of toxicity.

5.7.2 Exposure Considerations

Diatomaceous earth applied to cracks, interior walls, voids, and bulk food storage to control unwanted insects. It is used at various rates depending on the target nuisance insect and level of infestation. Because it is not selective, it is used in very directed and specific applications. It is not used within 15 ft of aquatic systems.

5.7.3 Human Toxicity

The LD50 in rats is >5,000 mg/kg (Category IV); the dermal LD50 is >2,000 mg/kg (Category III); and the acute inhalation LD50 is > 0.859 mg/L, the highest dose tested in the study (USEPA, 1984). Diatomaceous earth may cause mild eye and skin irritation in some people.

5.7.4 Ecological Toxicity

There is no evidence of toxicity to wildlife exposed to diatomaceous earth.

5.7.5 Physical Properties/Environmental Fate and Transport

Diatomaceous earth is insoluble in water.

5.7.6 Water Pollution Potential

The water pollution potential of this active ingredient is negligible.

6 Adjuvants/Surfactants

Table 6-1 Human Toxicity Summary of Adjuvant/Surfactant Active Ingredients

Active Ingredient	Mammalian Oral LD50 (mg/kg)[A]	Mammalian Dermal LD50 (mg/kg)[B]	Mammalian Inhalation LC50 (mg/L)[A]	USEPA Toxicity Rating	Carcinogenic	Reproductive or Developmental Toxicity	Neurotoxic	Immunotoxic	Endocrine Disruption
Modified Vegetable Oil/Methylated Seed Oil	>5,000 (Competitor)	>5,000 (Competitor)	NA	NA	NA	NA	NA	NA	NA
Lecithin	>5,000 (Liberate)	>2,000 (Liberate)	NA	NA	NA	NA	NA	NA	NA
Alcohol Ethoxylates	600 to >10,000	2,000 to >5,000 (rat)	1.5 – 20.7	NA	No	No	NA	NA	NA
Alkylphenol ethoxylate (APE)	low	low	NA	NA	NA	Yes	NA	NA	Yes

Table 6-2 Ecotoxicity Summary of Adjuvant/Surfactant Active Ingredients

Active Ingredient	Mammalian Oral LD50 (mg/kg)[A]	Mammalian Dermal LD50 (mg/kg)[B]	Mammalian Inhalation LC50 (mg/L)[A]	Avian LD50 (mg/kg)[C]	Fish LC50 (mg/L)[D]	Aquatic Invert EC50 (mg/L)[E]	Honeybee LD50 (µg/bee)	Other Receptors
Modified Vegetable Oil/Methylated Seed Oil	>5,000 (Competitor)	>5,000 (Competitor)	NA	NA	95 (Competitor)	>100 (Competitor)	NA	NA
Lecithin	>5,000 (Liberate)	>2,000 (Liberate)	NA	NA	17.6 (Liberate)	9.3 (Liberate)	NA	NA
Alcohol Ethoxylates	600 to >10,000	2,000 to >5,000 (rat)	1.5 – 20.7	NA	0.25 - 100	0.100 – 100	NA	NA
Alkylphenol ethoxylate (APE)	low	low	NA	NA	0.135 (fathead minnow) – 110 (killifish)	0.18 to 1.5	NA	NA

A. Unless otherwise specified, values are for rats.

B. Unless otherwise specified, values are for rabbits.

C. Unless otherwise specified, values are for mallard duck or bobwhite quail.

D. Unless otherwise specified, values are for rainbow trout or bluegill sunfish.

E. Values are for Daphnia or similar species.

6.1 Modified vegetable/seed oil

MODIFIED VEGETABLE/SEED OIL

Formulations: Competitor MSO

> Human Toxicity: Low toxicity. No evidence of neurotoxicity, carcinogenicity, immunotoxicity, or reproductive/developmental toxicity.

> Ecological Toxicity: Slightly toxic to fish and practically non-toxic to freshwater invertebrates.

> Water Pollution Potential: Biodegradable and insoluble in water.

> Other Considerations: Limited toxicity and fate and transport data are available.

6.1.1 Basic Use Information

> Products: *Competitor MSO*

> Application rates:

Material	Surfactant Low Rate	Surfactant High Rate	Diluent Use	Volume/acre
Competitor MSO	0.5% v/v spot, low volume, and broadcast treatments	1% v/v spot and low volume treatments	90% v/v for stump cut treatments	Variable

Modified vegetable seed oil is one of the active ingredients in Competitor MSO. These oils act as adjuvants to decrease surface tension, increase herbicide uptake, and enhance wetting and spreading. They are used in conjunction with and to help the efficacy of aquatic pesticides.

6.1.2 Exposure Considerations

Competitor MSO is used as a surfactant with other active ingredient herbicides at a high foliar rate of 1% v/v for spot and low volume treatments. It is used at a low foliar rate of 0.5% v/v for spot, low volume, and broadcast treatments. It is also used as a diluent (90% v/v) with other herbicides for cut stump treatments. The same BMPs and precautions utilized for active ingredient herbicides are also utilized for this surfactant.

6.1.3 Human Toxicity

Competitor MSO exhibits very low toxicity to mammals. The rat oral and rabbit dermal LD50 are both >5,000 mg/kg. It is minimally irritating to eyes (Competitor MSO MSDS). It is not listed as a carcinogen.

6.1.4 Ecological Toxicity

Competitor MSO is reported to be slightly toxic to fish; the 96-h LC50 in rainbow trout is 95 mg/L. It is practically non-toxic for freshwater invertebrates, with a 48-h EC50 of >100 mg/L for daphnids (Washington State Department of Agriculture, 2009).

6.1.5 Physical Properties/Environmental Fate and Transport

Very little information exists about the environmental fate and transport of these oils.

6.1.6 Water Pollution Potential

According to the product sheet for Competitor MSO, it is biodegradable and is relatively insoluble in water. Thus, the water pollution potential of this compound is low.

6.2 Lecithin

LECITHIN

Formulations: Liberate NIS

> Human Toxicity: Low toxicity. No evidence of neurotoxicity, carcinogenicity, immunotoxicity, or reproductive/developmental toxicity.

> Ecological Toxicity: Slightly toxic to fish and moderately toxic to freshwater invertebrates.

> Water Pollution Potential: Registered for use near/in water and recognized as safe by the USDA.

> Other Considerations: NA.

6.2.1 Basic Use Information

> Products: *Liberate NIS*

> Application rates:

Material	Low Foliar Rate	High Foliar Rate	Volume/acre
Liberate NIS	0.25% v/v spot, low volume, and broadcast treatments	0.5% v/v spot and low volume treatments	Variable

Lecithin is a general term used to describe yellow-brownish fatty substances occurring in animal and plant tissues. It is often derived from soybeans. It is one of the ingredients in Liberate, a nonionic surfactant, which also contains alcohol ethoxylates, discussed below (Washington State Department of Agriculture, 2009). Liberate is an uptake enhancing surfactant that is used in conjunction with other herbicides and pesticides.

6.2.2 Exposure Considerations

Liberate NIS is used as a surfactant with other active ingredient herbicides at a high foliar rate of 0.5% v/v for spot and low volume treatments. It is used at a low foliar rate of 0.25% v/v for spot, low volume, and broadcast treatments. It is commonly used as a surfactant with Roundup Custom. The same BMPs and precautions utilized for active ingredient herbicides are also utilized for this surfactant.

6.2.3 Human Toxicity

Lecithin is metabolized by mammals and is non-toxic when ingested. It is used as a food additive and is recognized as safe by the USFDA. The acute oral LD50 of Liberate for rats is >5,000 mg/kg, and the acute dermal LD50 in rabbits is >2,000 mg/kg. It is not an eye irritant and not a skin sensitizer. It is not listed as a carcinogen (Liberate MSDS, 2012).

6.2.4 Ecological Toxicity

The 96-h LC50 for Liberate in rainbow trout is 17.6 mg/L (slightly toxic), with a NOAEL of 12.5 mg/L. Liberate is moderately toxic to freshwater invertebrates: the 48-h LC50 for daphnids is 9.3 mg/L, and the NOAEL is 7.5 mg/L (Liberate MSDS, 2012).

6.2.5 Physical Properties/Environmental Fate and Transport

Little is known about the fate of lecithin in the environment (Tu et al., 2001). It is relatively insoluble in water.

6.2.6 Water Pollution Potential

Lecithin is registered for use near/in water, is insoluble in water, and is recognized as safe by the USDA. The water pollution potential of lecithin is negligible.

6.3 Alcohol ethoxylates

ALCOHOL ETHOXYLATES

Formulations: Liberate NIS

> Human Toxicity: Low toxicity. No evidence of neurotoxicity, carcinogenicity, immunotoxicity, or reproductive/developmental toxicity.

> Ecological Toxicity: Slightly toxic to fish and moderately toxic to freshwater invertebrates.

> Water Pollution Potential: Registered for use near/in water and recognized as safe by the USDA.

> Other Considerations: NA.

6.3.1 Basic Use Information

> Products: *Liberate NIS*

> Application rates:

Material	Low Foliar Rate	High Foliar Rate	Volume/acre
Liberate NIS	0.25% v/v spot, low volume, and broadcast treatments	0.5% v/v spot and low volume treatments	Variable

Alcohol ethoxylates are a constituent of Liberate, along with lecithin. They are also commonly used in laundry detergents and household cleaners.

6.3.2 Exposure Considerations

Liberate NIS is used as a surfactant with other active ingredient herbicides at a high foliar rate of 0.5% v/v for spot and low volume treatments. It is used at a low foliar rate of 0.25% v/v for spot, low volume, and broadcast treatments. It is commonly used as a surfactant with Roundup Custom. The same BMPs and precautions utilized for active ingredient herbicides are also utilized for this surfactant.

6.3.3 Human Toxicity

Alcohol ethoxylates exhibit low toxicity to mammals via oral, inhalation, and dermal routes of exposure. Oral LD50 values for rats range from 600 mg/kg to >10,000 mg/kg depending on the structure of the compound. One- to four-hour inhalation LC50 values range from 1.5 to 20.7 mg/L in rats. Acute dermal LD50 values range from 2,000 to >5,000 mg/kg in rats (HERA, 2009). They may be irritating to eyes and skin. There are no data indicating that alcohol ethoxylates are genotoxic, mutagenic, or carcinogenic. They are also not categorized as reproductive or developmental toxicants. See above section for Liberate toxicity information.

6.3.4 Ecological Toxicity

The toxicity of alcohol ethoxylates differs depending on the branching and number of carbons in the specific compound. No toxicity data are available for birds. The 96-h LC50s in fish vary widely, from 0.25 – 100 mg/L (HERA, 2009). EC50s for invertebrates range from 0.1 to 100 mg/L. See above section for Liberate toxicity information.

6.3.5 Physical Properties/Environmental Fate and Transport

Alcohol ethoxylates are readily biodegradable under aerobic and anaerobic conditions. Total measured removal rates in wastewater treatment plants vary from 99.6 to 99.9%. They have low vapor pressure and are relatively nonvolatile. As they increase in carbon number, their water solubility decreases. They are able to sorb to soils. Hydrolysis in water and photolysis in water or soils is unlikely (HERA, 2009).

6.3.6 Water Pollution Potential

Alcohol ethoxylates are permitted for use in/near aquatic systems and are readily biodegradable. Therefore, the water pollution potential of these compounds is low.

6.4 Alkylphenol ethoxylates

ALKYLPHENOL ETHOXYLATES

Formulations: Pentra-bark

> Human Toxicity: Low toxicity. Irritating to skin and eyes. No evidence of neurotoxicity, carcinogenicity, or immunotoxicity. Potential estrogen-mimicking behavior of some congeners.

> Ecological Toxicity: Toxic to fish and aquatic invertebrates.

> Water Pollution Potential: Persistent in sediment and stable to photolysis and hydrolysis.

> Other Considerations: Formulation is used via injection or directed spray in targeted applications, reducing exposure and risk to non-target species.

6.4.1 Basic Use Information

- Products: Pentra-bark
- Application rates:

Material	Basal bark treatment	Volume/acre
Pentra-bark	2.5% v/v oak treatment in forests	Variable

Alkylphenol ethoxylates (APEs) are used as detergents, wetting agents, dispersants, emulsifiers, solubilizers and foaming agents. They are constituents of Pentra-Bark, a nonionic wetting agent, which is used in conjunction with Agri-Fos to prevent sudden oak death. Use of Pentra-Bark with Agri-Fos eliminates the need for aerial applications, reducing exposure to non-target systems.

6.4.2 Exposure Considerations

Alkylphenol ethoxylates are the active ingredients in the surfactant Pentra-bark, which is used with Agri-Fos to increase the uptake of the fungicide by the tree, thereby increasing its efficacy and decreasing its potential to impact non-target species. Pentra-bark is used at a rate of 2.5% v/v. Agri-Fos and Pentra-bark are applied by the basal bark method, which decreases the potential for drift, deposition in water, and exposure to non-targets because the fungicide is sprayed directly onto the bark and quickly taken up by the tree.

6.4.3 Human Toxicity

The toxicity of APEs usually increases as the length of the hydrophobic chain increases. Nonylphenol (NP), a well-studied APE, is of low acute oral and dermal toxicity but is highly irritating and corrosive to the skin and eyes (USEPA, 2010). Concern exists regarding the estrogen-mimicking behaviors of APEs (USEPA, 2010). NP and nonylphenol ethoxylate (NPE) are of particular interest and concern to the public and the EPA. The USEPA (USEPA, 2010) has recently recommended that this suite of chemicals be evaluated further due to their wide-spread use (past and present), persistence, and possible estrogen-mimicking behavior.

6.4.4 Ecological Toxicity

Toxicity of APEs to aquatic organisms increases with alkyl chain length. The 48-h LC50 for APEs in brown trout is 2.7 mg/L, and the 48-h LC50 in Daphnia is 1.5 mg/L (Argese et al., 1994). NP is bioaccumulative and toxic to aquatic organisms.

NPEs, though less toxic than NP, are also highly toxic to fish, aquatic invertebrates, and aquatic plants (USEPA, 2010). The 96-h LC50 of NP in fathead minnow is 0.135 mg/L (Holcombe et al., 1983), and the 48-h LC50 in Daphnia is 0.18 mg/L (Comber et al., 1993).

6.4.5 Physical Properties/Environmental Fate and Transport

Alkylphenol ethoxylates are essentially nonvolatile. They degrade faster in the water column than in sediment. Aerobic conditions further facilitate biotransformation of APE metabolites as compared to anaerobic conditions (Ying et al., 2002). Primary degradation of APEs in the environment generates more persistent shorter chain APEs and alkylphenols (i.e., nonylphenol, octylphenol, and mono- to triethoxylates), some of which may mimic natural hormones and disrupt endocrine function in wildlife and humans (Ying et al., 2002).

6.4.6 Water Pollution Potential

The solubility of APEs decreases with increasing carbon number. They are stable to photolysis and hydrolysis in water, though labile to biodegradation under aerobic conditions (t ½ = 4-24 days). APEs bind strongly to aquatic particles in river and coastal environments and are persistent in sediments. Due to the basal park application of Pentra-bark, the water pollution of this formulation is negligible.

This page intentionally left blank.

7 References

Argese, E., Marcomini, A., Miana, P., Bettiol, C., Perin, G., 1994. Submitochondrial particle response to linear alkylbenzene sufonates, nonylphenol polyethoxylates and their biodegradation derivatives Environmental Toxicology and Chemistry 13, 737-742.

Barrett, K.A., McBride, M.B., 2005. Oxidative degradation of glyphosate and aminomethylphosphonate by manganese oxide. Environmental Science & Technology 39, 9223-9228.

BASF, 2009. Advance Liquid Ant Bait 381B Safety Data Sheet.

Borggaard, O.K., Gimsing, A.L., 2008. Fate of glyphosate in soil and the possibility of leaching to ground and surface waters: a review. Pest Management Science 64, 441-456.

Brandli, D., Reinacher, S., 2012. Herbicides found in human urine. Ithaka 1/2012, 270-272.

Brausch, J.M., Smith, P.N., 2007. Toxicity of three polyethoxylated tallowamine surfactant formulations to laboratory and field collected fairy shrimp, Thamnocephalus platyurus. Arch. Environ. Contam. Toxicol. 52, 217-221.

California Department of Pesticide Regulation, 2004. Determination of the Director Under Assembly Bill 2356: Clopyralid in Compost.

California Department of Pesticide Regulation, 2006. Environmental Fate of Indoxacarb.

Chan, P.C., Mahler, J.F., 1992. NTP technical report on toxicity studies of glyphosate (CAS No. 1071-83-6) administered in dosed feed to F344/N rats and B6C3F1 mice, Toxicity Reports Series. United States Department of Health and Human Services.

Clair, E., Mesange, R., Travert, C., Seralini, G.-E., 2012. A glyphosate-based herbicide induces necrosis and apoptosis in mature rat testicular cells in vitro, and testosterone decrease at lower levels. Toxicology in Vitro 26.

Comber, M.H.I., Williams, T.D., Stewart, K.M., 1993. The effects of nonylphenol on Daphnia magna Water Research 27, 273-276.

Competitor MSO MSDS.

Dow AgroSciences, 2006. Milestone VM Herbicide Material Safety Data Sheet, 3 pgs.

Eason, C.T., Wickstrom, M., Henderson, R., Milne, L., Arthur, D., 2000. Non-target and secondary poisoning risks associated with cholecalciferol. New Zealand Plant Protection 53, 299-304.

EXTOXNET, 1993. Allethrin, in: E.T. Network (Ed.), Ithaca, NY, Pesticide Information Project of Cooperative Extension Offices of Cornell University, Michigan State University, Oregon State University, and University of California at Davis.

Federal Register, 1997. (S)-Hydroprene Biochemical Pest Control Agent; Pesticide Tolerance, in: USEPA (Ed.).

Giesy, J.P., Dobson, S., Solomon, K.R., 2000. Ecotoxicological risk assessment for Roundup (R) Herbicide, in: G.W. Ware (Ed.), Reviews of Environmental Contamination and Toxicology, Vol 167, 35-120.

Health Canada, 2012. Mono- and Di-Potassium Salts of Phosphorus Acid, in: Pest Management Regulatory Agency (Ed.).

Henry, K., McClymont, E., Yaroch, A., al., e., 2003. XDE-750: 96-h Acute Toxicity to Larval Amphibians Using the Northern Leopard Frog, Rana pipiens, as a Biological Model. Project Number: 031030. Unpublished study prepared by The Dow Chemical Co. 34 p. MRID No. 46235816.

HERA, 2009. Human & Environmental Risk Assessment on ingredients of European household cleaning products.

Holcombe, G.W., Phipps, G.L., Fiandt, J.T., 1983. Toxicity of selected priority pollutants to various aquatic organisms Ecotox. Environ. Safe. 7, 400-409.

Howe, C.M., Berrill, M., Pauli, B.D., Helbing, C.C., Werry, K., Veldhoen, N., 2004. Toxicity of glyphosate-based pesticides to four North American frog species. Environmental Toxicology and Chemistry 23, 1928-1938.

Jachetta, J., Havens, P., Dybowski, J., al., e., 2004. Reduced-Risk Pesticide Rationale for Aminopyralid Technical. Project Number: J042004. Unpublished study prepared by Dow AgroSciences LLC. 523 p. MRID No. 46259601.

Liberate MSDS, 2012.

Mann, R.M., Bidwell, J.R., 1999. The toxicity of glyphosate and several glyphosate formulations to four species of southwestern Australian frogs. Arch. Environ. Contam. Toxicol. 36, 193-199.

Marin Municipal Water District Vegetation Management Plan, 2010. Herbicide Risk Assessment

Marsh, R.E., Koehler, A.E., 1991. Potential secondary hazards of cholecalciferol - unpublished report submitted to EPA. Bell Laboratories, Inc., Madison, WI.

Marshall, E.F., 1984. Cholecalciferol: a unique toxicant for rodent control. Proceedings of the 11th Vertebrate Pest Conference Paper 22, 94-98.

Miller, A., Gervais, J.A., Luukinen, B., Buhl, K., Stone, D., 2010. Glyphosate Technical Fact Sheet, in: O.S.U.E.S. National Pesticide Information Center (Ed.).

Morrow, C., 2001. Cholecalciferol poisoning, Toxicology Brief. College of Veterinary Medicine, University of Illinois, Urbana, IL.

National Pesticide Information Center, Boric Acid Technical Fact Sheet.

National Pesticide Information Center, Fipronil Technical Fact Sheet.

National Pesticide Information Center, 2001. Hydroprene General Fact Sheet.

Newton, M., Horner, L.M., Cowell, J.E., White, D.E., Cole, E.C., 1994. Dissipation of glyphosate and aminomethylphosphonic acid in North American forests. Journal of Agricultural and Food Chemistry 42, 1795-1802.

Patterson, M., 2004. Glyphosate Analysis of Risks to Endangered and Threatened Salmon and Steelhead, in: Office of Pesticide Programs (Ed.).

Relyea, R.A., 2005. The lethal impact of roundup on aquatic and terrestrial amphibians. Ecological Applications 15, 1118-1124.

Schuette, J., 1998. Environmental Fate of Glyphosate. Environmental Monitoring and Pest Management, Department of Pesticide Regulation.

Senoret Chemical Company, 2009. Terro Liquid Ant Bait MSDS.

Siemering, G., 2005. Aquatics Herbicides: Overview of Usage, Fate and Transport, Potential Environmental Risk, and Future Recommendations for the Sacramento-San Joaquin Delta and

Central Valley White Paper for the Interagency Ecological Program. FEI Contribution 414. San Francisco Estuary Institute, Oakland, CA.

SWRCB, 2012. Statewide National Pollutant Discharge Elimination System (NPDES) Permit for Biological and Residual Pesticide Discharges to Waters of the United States from Vector Control Applications. Water Quality Order No. 2012-0003-DWQ, General Permit No. CAG 990004 (amending Water Quality Order No. 2011-0002-DWQ). April 3, 2012.

Syracuse Environmental Research Associates, I., 2004. Clopyralid - Human Health and Ecological Risk Assessment - Final Report. Prepared for USDA/Forest Service and National Park Service.

Syracuse Environmental Research Associates, I., 2007. Aminopyralid Human Health and Ecological Risk Assessment - Final Report. Prepared for USDA/Forest Service and National Park Service.

USDOE-Bonneville Power Administration, 2000. Imazapyr herbicide fact sheet. U.S. Department of Energy, Bonneville Power Administration.

USDOE, Clopyralid Herbicide Fact Sheet, in: Bonneville Power Administration (Ed.).

USEPA, 1984. Diatomaceous Earth TSS/IRB Safety Review.

USEPA, 1990a. Clethodim new chemical registration standard, in: P. Office of Prevention, and Toxic Substances (Ed.), Washington, D.C.

USEPA, 1990b. Proposed Registration of a New Pesticide, Clethodim.

USEPA, 1993a. Boric Acid RED Facts.

USEPA, 1993b. Reregistration eligibility decision (RED) glyphosate, Office of Prevention, Pesticides, and Toxic Substances (7508W). EPA 738-R-93-014.

USEPA, 1995. Clethodim Memorandum.

USEPA, 1996. Fipronil New Pesticide Fact Sheet.

USEPA, 1998. Mono- and di-potassium salts of phosphorous acid (076416) Fact sheet.

USEPA, 2000. Indoxacarb Conditional Registration Fact Sheet, in: P. Office of Preventaion, and Toxic Substances (Ed.).

USEPA, 2004. Potential Risks of Nine Rodenticides to Birds and Nontarget Mammals: A Comparative Approach.

USEPA, 2005. Pesticide Fact Sheet: Aminopyralid. 7501C.

USEPA, 2006. Reregistration eligibility decision for imazapyr. List C. Case number 3078., Office of Prevention, Pesticides, and Toxic Substances (7508C). EPA 738-R-06-007/OPP-2005-0495.

USEPA, 2008a. Reregistration Eligibility Decision for d-Phenothrin. List A Case No. 0426, Office of Prevention, Pesticides, and Toxic Substances (7508P).

USEPA, 2008b. Risks of Glyphosate Use to Federally Threatened California Red-legged Frog (Rana aurora draytonii), in: O.o.P.P. Environmental Fate and Effects Division (Ed.), Washington, D.C.

USEPA, 2009. Reregistration Eligibility Decision for Allethrins. List C, Case No. 0437, Office of Prevention, Pesticides, and Toxic Substances (7508P). EPA 738-R-07-001.

USEPA, 2010. Nonylphenol (NP) and nonylphenol ethoxylates (NPEs) action plan RIN 2070-ZA09.

USEPA, 2011. Risks of Chlecalciferol Use to the Federally Endangered Salt Marsh Harvest Mouse (Reithrodontomys raviventris). Pesticide Effects Determinations, PC Code: 202901, CAS Number: 67-97-0. Environmental Fate and Effects Division, Office of Pesticide Programs.

Valent, 2006. Envoy Plus Herbicide MSDS.

Vereecken, H., 2005. Mobility and leaching of glyphosate: a review. Pest Management Science 61, 1139-1151.

Washington State Department of Agriculture, 2009. Summary of aquatic acute toxicity data for spray adjuvants allowed for use on aquatic sites in Washington, revised May 18, 2009 ed. Pesticide Management Division, Olympia, WA.

WHO, 1989. Allethrins, Environmental Health Criteria 87. International Programme on Chemical Safety (IPCS).

Williams, G.M., Kroes, R., Munro, I.C., 2000. Safety evaluation and risk assessment of the herbicide Roundup and its active ingredient, glyphosate, for humans. Regulatory Toxicology and Pharmacology 31, 117-165.

World Health Organization, 2002. WHO Specifications and Evaluations for Public Health Pesticides - d-Allethrin.

Ying, G.-G., Williams, G.M., Kookana, R., 2002. Environmental fate of alkylphenols and alkylphenol ethoxylates--a review. Environ International 28, 215-226.

8 List of Abbreviations/Acronyms/Definition

a.e.	Acid equivalent-The acidic level of a chemical in solution
a.i.	Active ingredient-The primary chemical in a products that is the toxic chemical of concern.
AMPA	Aminomethylphosphonic acid
APE	Alkylphenol ethoxylate
BMP	Best Management Practice- Documented approaches to conducting field applications that have been demonstrated to mimimize any unwanted adverse effects to the environment.
bw	Body weight- The weight of an individual, usually expressed in grams for toxicology rankings to wildlife species impacted or in kilograms for humans.
K_{OW}	Octanol-water partitioning coefficient of an organic compound. A dimensionless concentration ratio whose magnitude expresses the distribution of a compound between equal volumes of n-octanol and water.
LC_{50}	Median lethal concentration. A statistically derived concentration of a substance that can be expected to cause death in 50% of the test animals when administered by the indicated route (oral, dermal, inhalation). Usually expressed as the amount of substance per amount of solution (e.g., mg/L).
LD_{50}	Median lethal dose. A statistically derived concentration of a substance that can be expected to cause death in 50% of test animals when administered by the indicated route (oral, dermal, inhalation). Usually expressed as a weight of substance per unit weight of animal (e.g., mg/kg).
LOAEL	Lowest observed adverse effect level. The lowest dose/concentration of a compound that causes a significant predetermined adverse effect in an experimental population.
µg	Micrograms One thousandth of a gram.
µg/g	Micrograms per gram of substance.
mg/kg bw	Milligrams per kilogram of body weight- General metric used for determining dose.
mg/L	Milligrams per liter-
MSDS	Material safety data sheet- Publlshed documentation of all available information about a chemical, including toxicity to humans and wildlife, known hazards and special conditions required for use.
NOAEL	No observed adverse effect level. The highest dose/concentration of a compound that causes no significant predetermined adverse effects in an experimental population.
NSAE	No significant adverse effects
IPM	Integrated Pest Management- An approach to pest management that combines BMPs, use of appropriate application scenarios, and minimal chemical use to achieve desired pest control.
POAE	Polyethoxylated tallowamine

RfD	Reference dose. The RfD is an estimate of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.
t ½	Half-life. The period of time required for the amount of a substance undergoing decay to decrease by half.
USEPA	United States Environmental Protection Agency

Glossary

Table of USEPA Toxicity Categories

Route of Exposure	I: High Toxicity	II: Moderate Toxicity	III: Low Toxicity	IV: Very Low Toxicity
Acute Oral LD50	≤50 mg/kg	50-500 mg/kg	500 – 5000 mg/kg	>5000 mg/kg
Acute Dermal LD50	≤200 mg/kg	200 – 2000 mg/kg	2000 – 5000 mg/kg	>5000 mg/kg
Acute Inhalation LC50	≤0.05 mg/L	0.05 - 0.5 mg/L	0.5 - 2 mg/L	>2 mg/L
Primary Eye Irritation	Corrosive (irreversible destruction of ocular tissue) or corneal involvement or irritation persisting for more than 21 days	Corneal involvement or irritation clearing in 8-21 days	Corneal involvement or irritation clearing in 7 days or less	Minimal effects clearing in less than 24 h
Primary Skin Irritation	Corrosive (tissue destruction into the dermis and/or scarring)	Severe irritation at 72 h (severe erythema or edema)	Moderate irritation at 72 h (moderate erythema)	Mild or slight irritation (no irritation or slight erythema)

Table of Fate and Transport of Active Ingredients Used by the District

Active Ingredient	Air	Water	Soil
Glyphosate	Nonvolatile	> Very soluble > In aquatic systems, sediment appears to be the major sink for glyphosate residue > Broken down by microbial degradation > Stable to hydrolysis and photolysis > T½ ≈ 8 days	> Strongly adsorbs to soil particles; remains in top 0-6" of soil > Low tendency to leach or runoff > Resistant to chemical degradation and photolysis > Biodegraded by microbes under aerobic (t½ = 1-2 days) and anaerobic conditions (t½ = 8-25 days)
Aminopyralid	Nonvolatile	> Degraded by photolysis; t½ = 0.6 days > Stable to hydrolysis > Susceptible to degradation under aerobic conditions; t ½ = 462-990 days	> Weakly sorbs to soil > Minimal leaching below the 15-30 cm soil depth > Non-persistent > Degraded by photolysis but much more slowly than in water; t ½ = 72 days > Susceptible to degradation under aerobic conditions; t½ = 31-533 days
Clopyralid	Relatively nonvolatile	> Very soluble > Degraded rapidly > Stable to hydrolysis and photolysis > T½ = 9-22 days	> Does not bind tightly to soil; mobile > Primarily degraded by microbes > Low leaching potential > Stable in compost > T½ = 8-250 days
Imazapyr	Nonvolatile	> Degraded by photolysis; t½ = 3-8 days > Stable to hydrolysis > Stable to aerobic and anaerobic aquatic metabolism	> Moderately persistent > Mobile > Primarily degraded by microbes; t ½ = 14-150 days > Stable to hydrolysis > Stable to aerobic and anaerobic degradation > May leach to groundwater
Clethodim	Nonvolatile	> Very persistent	> Non-persistent; t ½ = 3 days > Weakly bound to soil; mobile > Degraded through aerobic processes
Potassium salts of phosphorus acid	na	> Very soluble > Rapidly dissociate to yield hydrogen and phosphite ions	> Microbial transformation is very slow
d-trans allethrin	na	> Insoluble > Degraded rapidly by photolysis; t ½ < 8 h > Stable to hydrolysis	> Adheres moderately to soil containing organic matter

Active Ingredient	Air	Water	Soil
Phenothrin	na	> Low water solubility > Stable to hydrolysis > Degraded rapidly by photolysis; t ½ = 6.5 days > Degraded by aerobic metabolism; t ½ = 36 days	> High affinity for binding to soils and moderate persistence in surface soils > Low leaching potential; relatively immobile > Aerobic metabolism t ½ = 18-26 days
Indoxacarb	Nonvolatile	> Degraded primarily via photolysis; t ½ = 3 days > Relatively stable to hydrolysis at pH 5 and 7; t ½ > 30 days > Susceptible to hydrolysis at pH 9; t ½ = 1 day	> Moderately persistent > Immobile > Degraded under aerobic conditions; t ½ = 4-7 days > Stable to photolysis; t ½ = 139 days
Hydroprene	Nonvolatile	> Insoluble	> Rapidly degraded; t ½ ≈ 3 days
Fipronil	Nonvolatile	> Degrades rapidly under UV; t ½ = 3 days	> Under aerobic conditions, broken down by microbes > Photodegradation t ½ = 34 days > Low potential for leaching
Sodium tetraborate decahydrate (borax)	Nonvolatile	> Soluble	na
Diatomaceous earth	Nonvolatile	> Insoluble	na
Modified Vegetable Oils and Methylated Seed Oil	na	> Insoluble	na
Lecithin	na	> Insoluble	na
Alcohol Ethoxylates	Nonvolatile	> Solubility decreases with increasing carbon > Rapidly biodegraded under aerobic conditions; t ½ = 4-24 h > Stable to hydrolysis and photolysis	> Rapidly biodegraded under aerobic conditions > Stable to hydrolysis and photolysis
Alkylphenol ethoxylates	Nonvolatile	> Degrades faster in water than in soil; t ½ = 4-24 days > Solubility decreases with increasing carbon	> Bind strongly to particulates and are persistent in sediments > Aerobic conditions facilitate biotransformation; t ½ = 4-320 days

This page intentionally left blank.

Appendix B

Forms

Midpeninsula Regional Open Space District
New Pest Control Recommendation

Submitting Person

Date

Preserve

Location

Species

Common Name

Calflora Record Number

Date Last Assessed

Known Site Conditions

- ☐ Access Issues
- ☐ Aquatic Areas (within 15 feet)
- ☐ Preserve Boundary (within 100 feet)
- ☐ Steep Slopes (Erosion Potential)
- ☐ T&E Species (within 30 feet)
- ☐ Other

Site History

Proposed Treatment

Year 1

Work Force ☐ Contractors Hours

☐ Staff Hours

☐ Volunteers PP days or ARMS Hours

Year 2

Work Force ☐ Contractors Hours

☐ Staff Hours

☐ Volunteers PP days or ARMS Hours

Year 3

Work Force ☐ Contractors Hours

☐ Staff Hours

☐ Volunteers PP days or ARMS Hours

ENVIRONMENTAL SITE REVIEW FORM

Biologist ______________________________ Date: ____________________

Preserve ______________________________ Treatment Site ____________________

Photo Filename ______________________________

GIS Filename ______________________________

Target Species ______________________________

Vegetation Type	Grassland		Brush		Wooded		
% Cover - Target Sp	0	0-1	1-5	5-25	25-50	50-75	75-100
Treatment Method	Manual		Mechanical		Chemical		

Sensitive Plant Species	
Sensitive Animal Species	
Cultural Resources	
Aquatic Features	
Erosive Conditions	
SOD Symptoms	

Specific BMPs or other site conditions needs

Work Performed

Date: ______________________ Preserve ______________________

Reporter ______________________ Treatment Site ______________________

% Area Treated ______________________ Target Species ______________________

Person Hours ____________ X ____________ = ____________

# of People | Project Hours | Person-Hours

Herbicide Use

____________ ____________ ____________

Product | Method | Amount of Concentrate (oz)

Post Treatment Survey

Surveyor ______________________

Photo Filename ______________________ Date ____________

Signs of Herbicide Damage (Target)

Signs of Herbicide Damage (Non-target)

New Environmental Issues

Recommendations for next treatment

Additional Comments

Project ID

Safe	
Human Health	
The proposed method is the safest method for workers at that location.	
There are human occupied facilities nearby (trails, parking lots, buildings, school, etc.).	
Environmental Health	
The pest provides habitat for beneficial species.	
Removal method would cause a seed bank flush or erosion issues.	

Prevents and Controls Most Destructive Pests	
Prevent	
The species is listed as a State or Federal noxious weed.	
The species is listed as a Cal-IPC Alert and/or Cal-IPC or District watch list.	
The species' Cal-IPC rating is …	
Control	
This is the only population of the species at the preserve.	

Protects Biodiversity	
The removal will …	
assist in the recovery of a Special Status Species.	
protect a sensitive ecological community (wetlands, serpentine grassland, coastal prairie).	
actively protect against spread of pathogens.	
assist in retaining a bio-diverse community.	
The species is allopathic or can change the soil chemistry.	

Provides for Public Engagement	
The project has significant public interest and/or support.	
The project provides for the participation or education of the public.	

Feasible and Effective	
The project be done with existing staffing and/or funding.	
There is a high level of anticipated outcome (Cost/Benefit)	
The treatment method is considered the most effective.	
The project method will reduce the overall maintenance of the area.	

Comment