National Management Measures to Control Nonpoint Source Pollution from Urban Areas

Management Measure 9: Pollution Prevention

November 2005

MANAGEMENT MEASURE 9
POLLUTION PREVENTION

9.1 Management Measure

Implement pollution prevention and education programs to reduce nonpoint source pollutants generated from the following activities:

- The improper storage, use, and disposal of household chemicals, including automobile fluids, pesticides, paints, solvents, etc.;
- Lawn and garden activities, including the improper application and disposal of lawn and garden care products, and the disposal of leaves and yard trimmings;
- Turf management on golf courses, parks, and recreational areas;
- Commercial activities, including parking lots and gas stations;
- Improper disposal of pet wastes; and
- Activities that generate trash.

9.2 Management Measure Description and Selection

9.2.1 Description

This management measure is intended to prevent or reduce nonpoint source pollutant loadings generated from a variety of activities within urban areas. Everyday activities of citizens, municipal employees, and businesses have the potential to contribute to nonpoint source pollutant loadings. These activities include improper use and disposal of household chemicals, lawn and garden maintenance, turf grass management, operation and maintenance of diesel and gasoline vehicles, illicit discharges to urban runoff conveyances, commercial activities, and improper pet waste disposal. Reducing pollutant generation can decrease adverse water quality impacts from these sources.

The practices presented in this management measure are often referred to as source reduction practices. They are nonstructural in nature (i.e., they do not require infrastructure) and can be used to reduce pollutant generation and maintenance costs. Source control practice costs are typically associated with programmatic expenses such as signage, outreach materials, workshops, and development and enforcement of ordinances. Although agricultural sources are not specifically addressed in this chapter, agricultural sources in an urban or suburban watershed should also be considered when developing a pollution prevention plan (see Management Measure 1 – Program Framework and Objectives). Source controls for agriculture can be found

Getting in Step: A Guide to Effective Outreach in Your Watershed

Getting in Step is a guide published by EPA to provide a summary of useful tools for developing and implementing an effective watershed outreach plan. The manual uses a step-by-step approach to help watershed practitioners address public perceptions, promote management activities, and inform or motivate stakeholders. Getting in Step is divided into three parts, as follows:

- Part I presents the overall framework for developing and implementing an outreach plan. It provides specific information about defining goals and objectives; identifying the target audience; creating, packaging, and distributing the message; and evaluating the outreach plan.
- Part II provides tips and examples for developing and enhancing outreach materials, with emphasis on elements of composition and layout, using artwork and photos, establishing a watershed identity, packaging the watershed message, and estimating costs.
- Part III provides specific tips on working with the news media to gain improved media coverage of water quality issues.

Getting in Step also includes worksheets, graphics for use without permission, and information on additional outreach and education resources. The manual is available for download from http://www.epa.gov/owow/watershed/outreach/documents/getnstep.pdf or by calling Books on Demand at 1-800-521-3042.

in *National Management Measures to Control Nonpoint Source Pollution from Agriculture*, which can be accessed at http://www.epa.gov/owow/nps/agmm/index.html.

9.2.1.1 Household chemicals

Many everyday household chemicals are flammable, combustible, toxic, explosive/reactive, or corrosive. If these chemicals are released into the environment, they can pose long-term threats to human health, wildlife, vegetation, and other environmental resources. Unlike industrial hazardous wastes, not all household chemicals are regulated by federal, state, and local laws. In fact, the Federal Resource Conservation and Recovery Act, which regulates hazardous waste, has a special exemption for "household hazardous wastes" as defined in the act (Kopel, 1998). It is important to note that state and local regulations may be more stringent than federal regulations. The Federal Insecticide, Fungicide, and Rodenticide Act regulates the use and disposal of pesticides, herbicides, and fungicides through labeling. It is important that users of these chemicals follow label instructions carefully, because they provide specific information that help prevent harm to human and environmental health.

The four main avenues for household chemicals to become problem pollutants are through leaks and spills, improper use, improper storage, and improper disposal.

(1) *Leaks and spills*. Chemicals leaking from improperly maintained automobiles and lawn equipment or faulty containers can accumulate on roads, driveways, and lawns and be carried by runoff to receiving water bodies.

(2) *Improper use*. Failure to follow label instructions properly may result in over-application of fertilizers or pesticides and can lead to chemical accumulation in the soil and grass. These chemicals can leach to ground water or be carried by runoff to surface waters.

(3) *Improper storage*. Improper storage of chemicals can lead to spills that can contaminate runoff and ground water or result in dangerous chemical reactions.

(4) *Improper disposal*. It is a common practice for citizens to pour unwanted chemicals, such as detergents, cleansers, or automotive fluids, onto their lawns or driveways or directly down storm drains. Contrary to popular belief, most storm sewers do not connect to wastewater treatment plants—chemicals disposed of this way could be discharged directly to receiving water bodies. Additionally, when chemicals are poured down drains connected to a wastewater treatment plant or septic system, they could interfere with treatment systems by killing the bacteria that metabolize pollutants, causing water discharged from the plants to be contaminated. Ground water is also at risk because runoff can carry these chemicals through the soil to the water table. Product labels describe requirements for proper disposal and should be followed carefully.

(5) *Outdoor car washing*. This activity can result in high loads of nutrients, metals, and hydrocarbons being carried to receiving waters during dry weather conditions when the wash water flows into the storm drain system. According to surveys, 50 to 75 percent of households wash their own cars and 60 percent of those households wash their cars at least once a month (Schueler and Swann, 2000b).

9.2.1.2 Failing septic systems

Approximately one in four American households relies on a septic system to dispose of their wastewater. Septic systems have a failure rate of 5 to 35 percent, depending on soil conditions and other factors. When septic systems fail, the untreated or partially treated wastewater discharges to surface and ground waters. A survey conducted in the Chesapeake Bay watershed found that the average age of septic systems in the area was about 27 years, which is seven years beyond the design life of an unmaintained system. About half the owners indicated that they had not inspected or cleaned out their system in the previous three years. (Schueler and Swann, 2000b).

9.2.1.3 Lawn and garden activities

Lawn care practices are often targeted by watershed managers as contributors of pesticides and nutrients to runoff. A nationwide study by the U.S. Geological Survey (USGS) in 1999 found a high incidence of insecticides and herbicides in urban streams. Insecticides commonly used in homes, gardens, and commercial areas were found more frequently and in higher concentrations in urban streams than in agricultural streams. These concentrations often exceeded guidelines for the protection of aquatic life. Herbicides, such as those used for weed control, were found in 99 percent of sampled streams, but rarely at levels that exceeded guidelines.

A recent summary of the water quality monitoring efforts by USGS's National Water Quality Assessment Program (2004) revealed high concentrations of pesticides, most commonly diazinon, malathion, chlorpyrifos, and carbaryl, in urban waterways; these chemicals were

typically found in higher concentrations in urban streams than in agricultural streams. Although several of these pesticides are used commonly in household applications, findings in Thornton Creek near Seattle suggested that many of the pesticides were from commercial or municipal activities because the chemicals are not readily available on the retail market.

Surveys showed that roughly half of the total diazinon applications in the San Francisco Bay Region were to lawns and landscaped areas. In 1995, 27 percent of urban creeks sampled in the San Francisco Bay Region demonstrated potentially toxic levels of diazinon (Katznelson and Mumley, 1997). Research on diazinon indicates that even proper use, characterized by following label instructions, can result in harmful levels of diazinon in urban streams (Schueler and Swann, 2000d).

While these results alone do not specify the relative contribution of lawn care activities to urban pollution, they do indicate that there is a need for watershed-specific management actions. Many aspects of the risks associated with commonly occurring pesticides in the environment are not yet clearly understood. Drinking water standards have only been established for 10 of the 75 pesticides detected by the USGS National Water Quality Analysis**,** and aquatic life criteria have been developed for only six (Graffy, 1998; USGS, 1999).

Maintaining a healthy lawn might require fertilizers, pesticides, and heavy watering in some areas. Overuse of fertilizers, pesticides, and water can lead to excessive growth, increased pest problems, and environmental damage. In terms of fertilizer inputs, nutrients typically are applied to lawns at about the same rates as for row crops. One study in Marquette, Michigan, indicated that nitrogen and phosphorus concentrations in runoff from lawns were five to 10 times higher than runoff from other land uses (Schueler and Swann, 2000e). Contrary to popular belief, it is possible to achieve a beautifully landscaped yard with judicious use of fertilizers, pesticides, and irrigation. A large body of literature by turf researchers shows that healthy and well-managed turf grass can actually slow runoff and trap pollutants (Beard and Green, 1994; Schueler and Swann, 2000c; USEPA, 1992). The products applied to lawns—fertilizers, pesticides, and herbicides—can pollute runoff if label instructions are not properly followed. Studies on the characteristics of urban lawns have shown that the soils are often compacted, increasing runoff to the point that it is comparable to runoff on some pavements (NCSCS, 2000). Fertilizers contain nitrogen and phosphorus, which become pollutants when runoff carries excess fertilizers into lakes and streams. Excessive nutrients stimulate algae growth that can lead to death and decay of aquatic vegetation due to light and oxygen deprivation.

Lawns also require physical maintenance in the form of mowing, raking, and removing weeds, clippings, and branches. Yard trimmings comprised 12 percent of the total tonnage of municipal solid waste generated in 2000, second only to paper products (USEPA, 2002). Alternative practices can reduce the quantity of yard wastes generated by lawns and enable reuse of yard wastes to extend the capacity of landfills.

9.2.1.4 Commercial activities

Runoff from commercial land uses, such as shopping centers, office parks, and parking lots or garages may contain high hydrocarbon loadings and metal concentrations that are twice those found in the average urban area. These loadings can be attributed to heavy traffic volumes and

large areas of impervious surface on which automotive-related pollutants concentrate (refer to Management Measure 7, Bridges and Highways, for a discussion of automobile-related pollutants). Other commercial uses, such as vehicle maintenance, liquids storage, and equipment storage and maintenance, can also introduce pollutants to runoff.

In most communities, gas stations are designated as a commercial land use and are subject to the same controls as shopping centers and office parks. However, gas stations may generate high concentrations of heavy metals, hydrocarbons, and other automobile-related pollutants. Since gas stations have high potential loadings and pollutant profiles similar to those of industrial sites, good housekeeping controls, such as those used on industrial sites, are recommended.

Restaurants are sometimes considered hot spots for nonpoint source pollution because they generate oils and grease that can contaminate runoff when disposed of improperly. Grease can also clog sanitary sewer laterals if sinks are not equipped with grease traps or interceptors, resulting in sanitary sewer overflows and increased maintenance of sewer lines. Poor housekeeping practices in the outdoor areas of restaurants, such as storing food waste in uncovered or leaky garbage bins and dumpsters or hosing off floor mats in the parking lot, can cause bacteria, detergents, organic matter, and other pollutants to come into contact with runoff.

Municipalities can target pollution prevention campaigns to specific commercial activities that are suspected of contributing to nonpoint source pollution. Typically, these campaigns involve an assessment of commercial facilities to identify the types of waste produced. The campaigns also outline methods to reduce the total amount of pollutants generated on-site and to properly dispose of pollutants. A set of rules and use limitations that a commercial tenant must agree to as a condition of occupying a site can be implemented in commercial covenants, conditions, and restrictions.

9.2.1.5 Pet wastes

When pet waste is not properly disposed of, it can wash into nearby water bodies or be carried by runoff into storm drains. Since most urban storm drains do not connect to treatment facilities, but rather drain directly into lakes and streams, untreated animal waste can become a significant source of runoff pollution. As pet waste decays in a water body, the degradation process uses oxygen and sometimes releases ammonia. Low oxygen levels and the presence of ammonia, combined with warm temperatures, can be toxic to fish and aquatic life. Pet waste also contains nutrients that promote weed and algae growth. Perhaps most importantly, pet waste carries microbes, such as bacteria, viruses, and parasites, that can pose a health risk to humans and wildlife. For example, fatalities in sea otters off the coast of California have been traced to a protozoan, *Toxoplasma gondii*, found in cat feces. *T. gondii* can cause fatal brain infections in otters and muscle cysts in humans (Glausiusz, 2002). Pet waste can be controlled through enforcement of ordinances (e.g., warnings and citations, public education, signage, and disposal containers).

9.2.1.6 Trash

Trash and floating debris in waterways have become significant pollutants, especially near urban areas where a large volume of trash can be generated in a concentrated area. Trash contributes to

visual pollution and detracts from the aesthetic qualities of the landscape. Boaters have complained that trash and debris clog engine intake valves and propellers, resulting in expensive repairs. Finally, municipalities must incur the cost of clean-up efforts to restore water quality.

9.2.2 Management Measure Selection

This management measure was selected to identify ways in which communities can implement practices that bring about behavioral changes to reduce nonpoint source pollutant loading from the sources listed in the management measure. Such activities include public education, proper management of maintained landscapes, source reduction, training and runoff control plans for commercial sources, pet waste management activities, and trash control. Communities can select practices that best fit local priorities and funding. It is important for the watershed manager to note that community acceptance is often the major determinant of whether education and outreach activities and administrative mechanisms such as certification and training requirements are practical and effective solutions.

9.3 Management Practices

9.3.1 Household Chemicals

A host of biodegradable cleaners and other less-toxic chemicals are commercially available. Such alternative products typically contain chemicals that rapidly break down in soil and water into fewer toxic constituents, or they are reusable or recyclable. These include low-phosphate or phosphate-free detergents and water-based products. These alternative products can be used in combination with traditional chemicals as part of an integrated pest management program or for everyday household cleaning. Although there may be instances when it is necessary to use stronger chemicals (for example, to target bacteria), often a simple, milder cleanser will do the job.

Although alternative products are generally less harmful than commercial cleaners, it is still just as important to follow their instructions for proper storage and handling. Alternative products and homemade mixtures should be stored in clean, store-bought containers and properly labeled to avoid confusion with food or drink (USEPA, no date; USEPA and Perdue University, 1997). While some alternative products may claim to be disinfectants, cleaners that are registered as disinfectants must meet EPA testing requirements. The EPA's *Source Reduction Alternatives Around the Home*, which is part of the *Consumer Handbook for Reducing Solid Waste*, provides a brief discussion of alternative cleaning methods as well as proper storage and handling procedures (USEPA, no date).

A 1994 study compared commercial cleaners with various alternative products, including lemon juice, vinegar, ammonia, baking soda, and borax. The study found that commercial cleaners were more effective than the alternatives at both soil removal and microbial reduction. Alternative cleaners were found to achieve soil removal with some additional work. Among the alternative cleaners, borax and ammonia were most effective at soil removal. Vinegar was most effective in reducing microbial contamination. The study recommended sequential use to maximize cleaning effectiveness (USEPA and Purdue University, no date).

The key to preventing household chemicals from entering receiving waters is to educate the public about the importance of taking care when storing and disposing of everyday materials.

The practices discussed below are intended to inform the public on proper procedures for handling and disposing of household chemicals to prevent pollution and to instill a sense of responsibility for their actions and choices as consumers.

9.3.1.1 Educate the public on proper storage and disposal of household chemicals

Watershed managers can produce outreach materials describing methods that citizens should follow to store household chemicals in appropriate containers and storage areas to prevent leaks, spills, accidental ingestion, and fire or explosion hazards. Tips can include covering piles of chemicals that can come into contact with rainfall or runoff; ensuring that containers for volatile, corrosive, or otherwise harmful chemicals are intact; and clearly labeling all containers with the name of the material and proper storage and disposal procedures. Pesticides, herbicides, and fungicides are addressed below in the Pest Management section.

Citizens should also be encouraged to follow the manufacturer's recommendations for disposal of household chemicals. Many communities across the country have implemented programs to collect and safely dispose of these chemicals, such as providing year-round collection facilities or sponsoring what many communities call “household hazardous waste” collection days. Effective outreach programs keep citizens informed about the location and hours of operation of disposal facilities and provide a list of waste products that are accepted.

Recycling of certain household chemicals, especially used oil and batteries, can reduce the amount of potentially harmful materials that enter a landfill. Many municipalities and automotive service stations provide used oil and antifreeze recycling facilities for “do-it-yourselfers” to encourage environmentally sound chemical management. Outreach materials, such as pamphlets and utility bill inserts, can be developed to inform the public of locations and hours of operation of local recycling facilities.

9.3.1.2 Conduct storm drain marking

Storm drain marking involves labeling storm drain inlets with painted or prefabricated messages that warn citizens of the environmental hazards of dumping materials into storm drains. Marking projects are typically conducted by volunteer groups in cooperation with local authorities. The messages can be a simple phrase to remind passersby that the storm drains connect to local water bodies and that dumping pollutes those waters. Some specify which water body the inlet drains to or name the particular river, lake, or bay. Common messages include “No Dumping—Drains to Water Source,” “Drains to River,” and “You Dump it, You Drink it. No Waste Here.” Communities with a large Spanish-speaking population might wish to develop markers in both English and Spanish or use a graphic without text (Davenport, 2003).

9.3.1.3 Encourage responsible car washing practices

Schueler and Swann (2000b) summarized results of several surveys of automobile owners and their car washing behavior. The researchers found that 55 to 70 percent of households wash their own cars, with the remainder taking their cars to commercial car washes. Sixty percent of residents washed their cars at least once a month, and between 70 and 90 percent of residents reported that their car wash water drained directly to the street and presumably into the runoff conveyance system. These results indicate that an appreciable amount of wash water laden with

detergents, dirt, and automotive fluids can wash into the storm drain system or directly into receiving waters in urban areas.

It is preferable for citizens to patronize commercial car washing facilities because they are mandated under the regulatory authority of the NPDES program (see the Introduction for a description of the NPDES program) to treat and/or reuse wash water, whereas residential car washing activities are exempt from requirements under Phase I MS4 permits and Phase II general permits (USEPA, 2003b). If commercial facilities are not available or if residents prefer to wash their cars themselves, they should be encouraged to wash their cars less often, especially in areas with water bodies sensitive to nutrient enrichment. Another practice to reduce the impact of car washing on receiving waters is to wash cars on grass or another permeable surface to filter dirt and detergents (this practice should be avoided in areas that recharge drinking water supplies). Additionally, citizens should use a sponge and bucket to reduce the amount of wash water used and to allow it to be disposed of down a household drain that is connected to the sanitary sewer or septic system. Finally, low-phosphate detergents should be used to minimize the eutrophic effects of wash water in receiving waters.

Community car washes, such as those conducted for fundraisers, are not specifically addressed in Phase II MS4 requirements, but may be a particularly large source of contaminated runoff. Some communities are experimenting with fundraiser registration, practices that block storm drains during community car washes, and the designation of pervious areas for the diversion of runoff. Kitsap County, Washington, uses a patented device called a Bubble Buster to divert water away from storm drains during community car washes (USEPA, 2003b).

9.3.2 Lawn, Garden, and Landscape Activities

Lawns are a significant feature of urban landscapes. This large area of managed landscape has the potential to contribute to urban runoff pollution due to over-fertilization, overwatering, over-application of pesticides, and direct disposal of lawn clippings, leaves, and trimmings. Also, erosion from bare patches of poorly managed lawns contributes sediment to watercourses, and disposal of lawn clippings in landfills can reduce the capacity of these facilities to handle other types of waste. Public education for citizens and municipal crews with respect to pest tolerance and proper handling of fertilizers, pesticides, water, and yard waste can greatly reduce the potential for adverse impacts to waters receiving runoff from lawns. Municipalities and watershed managers should develop an outreach campaign that targets citizens, lawn care businesses, landscapers, and municipal crews. Materials should highlight the following steps to help citizens and lawn care professionals maintain healthy, attractive lawns with less maintenance and fewer chemical inputs:

- Lawn conversion
- Soil building
- Grass selection
- Mowing and thatch management
- Minimal fertilization
- Weed control and tolerance
- Pest management
- Sensible irrigation

While all of the above practices are applicable to both citizens and lawn care professionals, they will differ when implemented due to differences in scale. For example, lawn care services may have multiple employees, carry large quantities of fertilizers and pesticides, and manage vast expanses of turf. Therefore, in addition to the above practices, good housekeeping is particularly important for lawn care professionals, landscapers, and municipal crews. Housekeeping includes implementing materials management and spill prevention plans and conducting employee training (see the Commercial Activities section). In addition, site development considerations for landscaped areas and golf courses should aim to protect local water bodies by avoiding sensitive areas, providing sufficient buffers, and ensuring erosion and sediment control during construction and maintenance activities (Center for Resource Management, 1996). See Management Measure 3—Watershed Protection and Management Measure 8—Construction Site Erosion and Sediment Control for more information about buffers and erosion and sediment control, respectively. Information resources specific to citizens and landscape professionals are provided at the end of this chapter.

Local cooperative extension services can provide assistance with the practices described in this section. State-specific cooperative extension service information is available from the Cooperative State Research, Education, and Extension Service (CSREES) at http://www.csrees.usda.gov/qlinks/partners/state_partners.html. Cooperative extensions are part of a nationwide organization authorized by Congress, and each state has designated a land grant university to administer its cooperative extension. Cooperative extensions conduct applied research and educational outreach such as workshops, conferences, fact sheets, and newsletters. These organizations are an excellent resource for information and assistance with lawn care practices. For example, the Virginia Tech Cooperative Extension Web site, http://www.ext.vt.edu/, maintains the *Database of Fact Sheets on Home Gardening and Insecticides/Pesticides*. The Rutgers University Cooperative Extension publishes fact sheets such as *How to Calculate the Amount of Fertilizer Needed for your Lawn* and *Best Management Practices for Home Lawns* (http://www.rce.rutgers.edu/).

NRCS's Backyard Conservation

USDA's Natural Resources Conservation Service (2000) Web site sponsors a Backyard Conservation Web site (http://www.nrcs.usda.gov/feature/backyard/) that presents technical information and management practices to "increase food and shelter for birds and other wildlife, control soil erosion, reduce sediment in waterways, conserve water and improve water quality, inspire a stewardship ethic, and beautify the landscape." The Web site includes 10 conservation practice standards, such as composting, mulching, nutrient management, pest management, and terracing, which have been modified for use in suburban landscapes.

9.3.2.1 Lawn conversion

Grasses are very water-hungry and labor-intensive landscaping plants when compared to ground cover, flowers, shrubs, and trees. Therefore, to reduce the maintenance requirements of a lawn and address problem areas where turf is difficult to grow, property owners could identify areas where turf grass can be replaced with other types of plantings. These areas include lawn edges, frost pockets, exposed areas, dense shade, steep slopes, and wet, boggy areas. Replacement

vegetation that is best suited to local conditions should be chosen to replace turf. Recommendations for drought-tolerant plants are available from a local extension office. State-specific cooperative extension service information is available from the Cooperative State Research, Education, and Extension Service (CSREES) at http://www.csrees.usda.gov.

9.3.2.2 Soil building

Lawn owners should analyze their soil every one to three years to determine its suitability for supporting a lawn and to identify whether additives are needed or adjustments should be made to optimize growing conditions. Soil characteristics that should be measured include pH, fertility, compaction, texture, and earthworm content. Soil test kits (for pH and fertility) can be purchased inexpensively at a garden center, or samples can be analyzed for free by a local cooperative extension service. Soil tests reveal whether fertilizer or lime is needed, helping to avoid over-fertilization and loss of nutrients. Surveys have indicated that only 10 to 20 percent of citizens test their soil to determine fertilization needs (Schueler and Swann, 2000c).

Prior to planting, sandy and heavy clay soils may be amended by adding organic compost to improve aeration and nutrient-holding capacity. Compacted soil under an established lawn should be aerated to improve the flow of water, fresh air, and nutrients to the system. Aeration is a non-chemical technique that relieves compaction, increases rooting, helps prevent thatch accumulation, incorporates organic matter into the soil surface, and helps prevent damage by insects and disease (Troutman, 2003). Core cultivators, which aerate by pulling small plugs of soil from the lawn, can be found at many local rental agencies (Mugaas, 1999). Soil texture can be determined with a settling test or by squeezing a handful of moistened soil through the fist. If soils prove to be very sandy or very clayey, organic matter such as compost, manure, or grass clippings should be added (USEPA, 1992). While the presence of earthworms is an indicator of healthy soil, the presence of white, healthy roots is the ultimate goal. Rooting can be checked by cutting a four-inch deep slice or plug of turf and soil. Roots should be at least four inches deep, and the tips should be white. Poor root condition may be a result of compacted soils, ineffective watering practices, or poor fertilization (Troutman, 2003). If a lawn does need soil amendments (e.g., an adjustment to pH or aeration to address compaction) a local cooperative extension service can provide the technical guidance necessary to care for the lawn properly (USEPA, 1992). State-specific cooperative extension service information is available from the Cooperative State Research, Education, and Extension Service (CSREES) at http://www.csrees.usda.gov. For more information on soil amendments, see the discussion of Erosion Control Practices in Management Measure 8—Construction Site Erosion, Sediment and Chemical Control.

9.3.2.3 Grass selection

Grass seed is available in a wide range of cultivated varieties, so citizens are able to choose the grass type that grows well in their particular climate, matches site conditions, and is consistent with the property owner's desired level of maintenance. Consideration should be given to seasonal variations in rainfall and temperature. Several grass varieties have been developed with increased resistance to disease and insect damage, which reduces pesticide use. Some turf varieties have high levels of endophytes, a fungus that does not threaten the grass but eradicates common lawn pests such as billbugs, sod webworms, and aphids. Tall fescue, zoysia grass, and Bermuda grass tend to be highly resistant to insects (Audubon Society, 2000). Other varieties

have been selected to be slow growing, which requires less mowing, fertilizer, and water. Care should be taken to select the species and cultivated variety that are best adapted to the site conditions. Selecting the correct variety will result in a healthier lawn that is better able to compete with weeds and resist insects and disease (Bruneau, 2001; USEPA, 1992).

9.3.2.4 Mowing and thatch management

Each turf grass variety has an ideal mowing height range. Turf grasses use water more efficiently and out-compete weeds better when kept at the higher end of the ideal mowing height range. Mowing grass too short decreases rooting and increases the need for frequent watering. Tall turf competes more vigorously against weeds and can usually tolerate more insect and disease pressure (Troutman, 2003). Property owners might need to mow grass more frequently to maintain a minimum healthy height, depending on the type of grass planted and the local climate. Property owners should understand that grass grows at different rates throughout the seasons. As a result, some lawns may need to be mowed every four or five days when they are growing rapidly (Troutman, 2003). Therefore, grass should be mowed only as needed. If excessive thatch (which can prevent nutrients and water from reaching grass roots) has developed, the lawn should be dethatched by raking or using an automated dethatcher, or it could be sprinkled with compost and then aerated. Some grasses are more prone to developing thick layers of thatch than others. A thatch layer less than ½ inch can be beneficial by providing insulation and increasing the turf's resiliency (Mugaas, 1999; Murphy, 1994; USEPA 1992).

To prevent insects and weeds, property owners should mow high and frequently, and keep mower blades sharp to avoid tearing or injuring the grass. Longer grass is exposed to more sunlight, which allows it to develop a deep root system and increases tolerance to drought, insect damage, and disease. Lawns should not be cut shorter than 2½ to 3½ inches because weeds can grow more easily in short grasses. Grass can be cut lower in the spring and fall to stimulate root growth, but not shorter than 1½ inches (Audubon Society, 2000; USEPA, 1992). Table 9.1 lists recommended mowing heights for various types of grasses.

Table 9.1: Mowing heights for various grass types (PCLAA, No Date).

Grass Type	Mowing Height
Kentucky Bluegrass	3.0 in.
Fescues & Ryegrass	3.0 in.
Bent grass	1.0 in.
Bermuda grass	1.0 to 1.5 in.
Zoysia grass	1.0 to 1.5 in.
St. Augustine grass	3.0 in.
Bahia grass	3.0 in.
Centipede grass	1.5 in.

9.3.2.5 Yard waste management

Recent concerns about landfill capacity have prompted a number of states to ban the disposal of yard waste in landfills (Fickes, 2002). Approximately 3,800 yard waste composting programs were operating in the United States during 2000 (USEPA, 2002). Most of these were located in the Northeast, Midwest, and South where landfill capacity is of concern and many states have

Yard Waste Ban

In Syracuse, New York, a 1992 ban on yard waste disposal resulted in 45 percent of households composting yard waste and 55 percent leaving clippings on the lawn. The ban, instituted by the Onondaga County Resource Recovery Agency (OCRRA) in North Syracuse, prohibited grass, leaves, and brush from being disposed of with the trash. OCRRA has run an eight-year, $300,000 public education campaign. OCRAA's outreach program involves home composting workshops; the distribution of flyers, and TV, radio, and newspaper ads with the themes "A Recipe for Compost," "Time for a Trim," and "Keep Your Clippings on the Lawn" (Lalonde, 2000).

instituted yard waste bans. In the West, where landfill capacity is relatively high and no statewide yard waste bans exist, there are only approximately 400 composting programs.

Yard trimmings accounted for nearly half the municipal waste eliminated or diverted through source reduction programs in 2000 (USEPA, 2002). Source reduction has been a successful component of municipal waste management, and is a major reason why landfill capacity at a national level remains relatively constant. In fact, source reduction is estimated to have prevented a 25 percent increase in solid waste in 2000. As of 2000, 34 states had more than 10 years of landfill capacity remaining, 12 had five to 10 years, and two had less than five years of capacity remaining. (USEPA, 2002).

Yard clippings can be managed by reapplying them to lawns, or by composting at home or at community composting facilities. Reapplying clippings to yards, known as grass-cycling, reduces solid waste and can decrease the need for fertilizer and water by adding nutrients and limiting evaporation. Yard clippings do not contribute to thatch buildup, because thatch is comprised of the stems and roots of grass, not the blades (Mugaas, 1999; Relf, 1997). Removing a mower's collection bag is an easy way to automatically incorporate grass-cycling into regular mowing activities (PLCAA, no date (a)). Yard waste can also be composted and reapplied to improve water retention, add nutrients, and reduce erosion (Relf, 2001). Full bans on disposal are not the only option for yard waste management; partial bans and voluntary programs can also help to encourage citizens to employ yard waste management practices such as composting and leaving clippings on the lawn. Communities can integrate yard waste into their solid waste management program by offering curbside collection services or providing public drop-off sites (USEPA, 1994).

9.3.2.6 Minimal fertilization

Based on the results of the soil test described above, a lawn might require additional nutrients to promote or maintain healthy growth. Nutrients can be partly supplied by leaving a moderate amount of fine grass clippings on the lawn after mowing—these clippings can provide nearly half of the required nutrients to the lawn and they hold in moisture, speed decomposition, and relieve the burden of landfills to handle excess yard waste. Additional nutrients can be supplied with compost or commercial fertilizers that are of an organic or encapsulated nitrogen type, but they should be applied at or below the rates prescribed on the packaging. Compost or organic and encapsulated nitrogen fertilizers reduce the risk of nutrient leaching and have been shown to release nutrients more gradually. Slow-release fertilizers are also beneficial for reducing nitrogen

losses from soils that are prone to leaching (Bureau, 2001). Organic products offer the additional benefits of increasing soil condition and promoting the growth of desirable soil organisms.

Timing of fertilization is very important. Cool-season grasses respond best to fall fertilization followed by light applications of fertilizer in the spring. Warm-season grasses generally benefit more from spring and summer fertilization. Fertilizers require water for activation; a light watering is usually enough (note that fertilizer should not be applied if rainfall is expected).

Excessive fertilization causes unwanted growth and the need to mow more often. Fertilizing at the wrong time of year may favor the growth of weeds rather than healthy turf. Excessive fertilization along with excessive watering can lead to the buildup of thatch that can increase insect and disease problems (Troutman, 2003).

The City of Austin recently commissioned Texas A&M University to conduct a study of the potential effects of residential lawn care practices on water quality in Stillhouse Spring, located in the environmentally sensitive recharge zone of the Northern Edwards Aquifer. Water quality tests have shown that nitrate levels in the aquifer are among the highest in the city. Nine different fertility treatments on test plots were studied. The plots were tested for appearance and the amount of nitrogen, phosphorous, and potassium that leached through the soil to ground water. The study resulted in a reevaluation of recommended fertilization practices for citizens. Recommendations still include soil testing, careful calculation of fertilizer amounts, and grass-cycling. However, researchers found that organically fertilized plots had less nitrogen leaching, were denser and more attractive, and were successful in retaining soil moisture and decreasing runoff in storm events. Because soils in Austin are particularly high in phosphorus, citizens in the area are now advised to use low-phosphorus fertilizers (Provin, 2002). Additional studies of residential lawn care practices and regionally specific runoff from urban lawns would be a beneficial addition to the large body of research on turf grass.

A local cooperative extension service should be consulted about the proper use of fertilizers. State-specific cooperative extension service information is available from the Cooperative State Research, Education, and Extension Service (CSREES) at http://www.csrees.usda.gov.

9.3.2.7 Weed control and tolerance

A property owner must decide how many weeds can be tolerated before action is taken to eradicate them. A few weeds will not substantially interrupt the continuity of the turf. The best way to keep weeds at bay is to maintain a healthy, dense lawn that shades the ground surface, preventing weed seedlings from taking root. However, if weeds do take hold, they should be dug or pulled out. Chemical herbicides should be used to spot-treat weeds, not applied universally. A local cooperative extension service should be consulted about the proper use of herbicides. State-specific information regarding cooperative extension services is available from CSREES at http://www.csrees.usda.gov.

9.3.2.8 Pest management

Integrated Pest Management (IPM) is an effective and environmentally sensitive approach that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. This

Targeted Herbicide Application

Targeted herbicide application, which uses infrared and other technologies, can help locate and control roadside weeds at lower costs than conventional weed control methods (Stidger, 2001). Patchen, Inc., which is located in Ukiah, California, manufactures small sensors that can be used on trucks or other equipment to pinpoint the location of undesirable plants and then target and spray the weed with herbicide. Each sensor views a 12-inch wide area and upon finding weeds, it signals a spray nozzle to deliver a precise amount of herbicide. The unit will spray only on weeds and not on bare ground. Several California Department of Transportation districts have already mounted the sensors onto equipment. According to company reports, a side-mounted strip of sensors at the rear of the vehicle lets the unit target and spray roadside weeds at 10 miles an hour. Sensors can be also used at night when there is less traffic because the sensors have their own light source. Compared to broadcast or manual spot spraying, sensors reduce the quantity of herbicide used and cut overall costs by 50 to 80 percent. Sensors also cut costs by reducing required work hours, because only the driver is needed to apply the herbicide.

Research at North Carolina State University (Burton and Skroch, 1997) developed an herbicide applicator to attach to weed mowers to control roadside vegetation. The unit applies a film of chemical to the weed stem as the mower cuts the plant. Between 70 and 90 percent of the herbicide is absorbed into the plant to prevent future growth. With other methods, as much as 80 to 90 percent of the sprayed chemical misses its target and is wasted.

The Minnesota Department of Transportation tested four innovative herbicide sprayer designs in an effort to reduce costs. According to a research report, all four sprayers saved money when compared to traditional sprayer use. Net annual savings from each of the four sprayers ranged between $23,255 and $65,812.

information, in combination with available pest control methods, is used to manage pest damage by the most economical means and with the least possible hazard to people, property, and the environment.

IPM is not a single pest control method but a series of pest management evaluations, decisions, and controls. IPM is a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools. Biological controls involve the use of natural enemies to manage pests. Cultural practices include mowing, fertilization, irrigation, aeration, dethatching, and rolling. Physical controls include removal of insects and affected plant material by hand or removal of pests with store-bought traps. Chemical controls involve the use of pesticides. Municipalities can encourage citizens and lawn care professionals to practice IPM and train municipal maintenance crews to use these techniques for public open space.

Effective pest management begins with maintenance of a healthy, vigorous lawn that is naturally disease-resistant. Mulching can be used to prevent weeds where turf is absent; fencing can be installed to keep rodents out; and netting can be used to keep birds and insects away from leaves and fruit. Planting disease-resistant species and alternating different types of plants can help prevent infestation. In addition, simple pest prevention techniques can reduce the likelihood that pesticides will be needed. These include destroying hiding places such as diseased plants and fallen fruit, cleaning up pet waste, and removing puddles (USEPA, 1995). Citizens should monitor plants for obvious damage and should check for the presence of pest organisms. It is important to be able to distinguish beneficial insects and arachnids, such as green lacewings, ladybugs, and most spiders, from ones that will damage plants. When damage is detected or

when harmful organisms are present, citizens should determine the level of damage the plant is able to tolerate. No action should be taken if the plant can maintain growth and fertility in the presence of these pest organisms. If controls are needed, there is an arsenal of low-impact pest management controls and practices to choose from that include preventative measures such as planting disease-resistant species and promoting beneficial organisms. See the USDA Regional Pest Management Centers Information System Web site at http://www.ipmcenters.org/ for more low impact strategies.

Integrated Pest Management (IPM) combines the use of these lower-impact practices with targeted chemical controls. Chemical controls are highly effective but may result in damage to or death of desirable species, such as bees. If strong chemical pesticides are applied improperly, they can contaminate receiving waters. Several less-toxic pesticide alternatives are available to prevent infestations or halt current infestations. Biopesticides, for example, are used to control pests without the use of poison. Biopesticides can be "biochemical," such as garlic and pheromones, or "microbial," such as bacteria, fungi and viruses (USEPA, 2003). Garlic and baking soda have been shown to be effective when applied as an aqueous solution to plants. Other pest control alternatives include insecticidal soap, which destroys pest membranes, *Bacillus thuringiensis* (a beneficial bacteria found in compost and other organic soil additives), milky spore (a natural bacteria that kills the grub phases of Japanese beetles), and dormant oil sprays applied when the plants are not growing. When used as a component of IPM programs, biopesticides can greatly decrease the need for conventional pesticides. The Biopesticides and Pollution Prevention Division in EPA's Office of Pesticide Programs promotes the use of biopesticides as components of IPM programs. The Biopesticides Web site, http://www.epa.gov/pesticides/biopesticides, provides information on biopesticide registration, active ingredients, product lists, and contact information.

Municipalities should try to select the least-toxic, least-water-soluble, and least-volatile pesticides possible. Pesticides should be evaluated based on their toxicity and their potential to run off to surface water or leach into ground water (Peacock et al., no date). Organophosphate pesticides, such as diazinon and chlorpyrifos, were popular because they target a broad range of pests and they are less expensive than newer, less-toxic pesticides. A risk assessment by EPA has determined that chlorpyrifos posed an unacceptable risk to public health, particularly children's health (USEPA, 2000). It was found that diazinon posed unacceptable risks to agricultural workers, birds, and other wildlife species. Chlorpyrifos was removed from retail sale and residential uses in 2001, and diazinon was phased out in 2004. Synthetic pyrethroids are more selective and typically much less toxic than organophosphates, yet they still can harm beneficial insects. When applying pesticides such as these, careful and judicious use is recommended to avoid harming non-target species.

Pesticide applicators should always read and follow instructions on the label. Pesticides should be applied to minimize drift or runoff, and they should not be sprayed near water sources. Application should be avoided during windy conditions or when rain is forecast. Granular applications should be avoided or minimized near impervious surfaces and bodies of water. Equipment should be checked for proper calibration before pesticide application. After pesticides are applied, label directions should be followed to safely dispose of containers. A local cooperative extension service can be consulted about the proper use of pesticides. State-specific

information regarding cooperative extension services is available from CSREES at http://www.csrees.usda.gov.

Pest management methods can also be controlled legislatively. In response to the negative effects of many pesticides, some localities are planning to restrict or prohibit the use of certain hazardous pesticides (Johnson, 1999). For example, the city of Seattle and King County, Washington, intend to stop using pesticides that are deemed most hazardous to control bugs and weeds along roads, in parks, and on other public land. The plan will phase out the use of dozens of harmful pesticides as the city and county explore less toxic alternatives. Pesticides that will be phased out contain known cancer-causing ingredients, seep quickly into ground water or surface water, or are labeled highly toxic to birds, fish, or other animals. There will be exceptions to the ban on some chemicals, but generally only if there are major health or safety considerations.

Restrictions on the use of certain pest control products were also implemented in California. In 1994 a bill was passed that would restrict the sale and use of copper-containing root killers and copper and tri-butyl tin-containing cooling tower additives (City of Palo Alto, California, Environmental Compliance Division, 1997). These pest control products contribute to the Regional Water Quality Control Plant's exceedances of San Francisco Bay discharge standards. When used, these products are discharged to sanitary sewer systems or to storm drains that flow untreated to creeks and bays. Because cost-effective alternatives for these products are available, the Regional Water Quality Control Plant and other local wastewater treatment plants have urged restrictions on the three types of chemicals. In December 1995 the California Department of Pesticide Regulation adopted regulations that made it illegal to sell or use copper-based root control products and tri-butyl tin-containing cooling water additives within the nine San Francisco Bay area counties. These regulations became permanent in November 1996.

9.3.2.9 Point-of-sale education

Municipalities and local cooperative extensions can encourage IPM by promoting education at the point of purchase. Two studies found that most citizens who apply pesticides used home and garden centers as their source of information on pest management (Lajeunesse et al., 1997; Sclar et al., 1997). Educating store employees on less-toxic alternatives, keeping less-toxic materials in stock, and providing information on the proper use of pesticides will help facilitate the IPM process. Czapar et al. (1998) surveyed 656 retail stores in Illinois that sell pesticides. Approximately 83 percent of the survey respondents were willing to send employees to a training program on pesticides, safe handling practices, and how to recommend appropriate pesticides to customers.

The Bay Area Stormwater Management Agencies Association in the San Francisco Bay Area established the "Our Water, Our World" program to educate citizens on less-toxic alternatives to pesticides without using negative messages about conventional products. The program consists of partnerships with local retail stores that display alternative products and educational materials. The program also involves media and advertising campaigns, efforts to institute regulatory change, and monitoring of the effects of the program. Initial results from 20 participating stores indicated an increase in the sale of less-toxic products and employee satisfaction with the associated training programs (http://www.epa.gov/oppbppd1/PESP/strategies/2000/basmaa00.htm).

Bio Integral Resource Center IPM Partnership Program

The Bio Integral Resource Center (BIRC) in the San Francisco Bay Area has developed a partnership between water pollution prevention agencies, nurseries, hardware stores, and the local cooperative extension to educate the public on less-toxic pest management. The program focuses on educating consumers about pest control products at the point of purchase from nurseries and hardware stores. BIRC encourages stores to carry less-toxic products and trains employees on the use of these products.

BIRC also conducts a Healthy Garden Workshop, which is a four-hour public seminar to introduce home gardeners to various aspects of IPM such as monitoring, physical controls, horticultural controls, and biological controls. Additional topics include water conservation and the use of native plants. An illustrated Healthy Garden Handbook accompanies the workshop, and an instructor's guide is available to assist others who are interested in giving the class (http://www.pesp.org/2000/birc00-final.htm).

Alliance for Chesapeake Bay IPM Partnership Program

The Alliance for Chesapeake Bay IPM Partnership Program promotes IPM by citizens through a partnership with retailers in which less-toxic pest control options are labeled with the slogan, "From your home to our streams…Choose less toxic products." The program includes employee training workshops, IPM informational displays and fact sheets available at participating retail stores. Partnerships with garden clubs and Master Gardeners provide training on minimizing environmental impacts and less-toxic pest management techniques.

IPM information displays began appearing in retail locations in central Pennsylvania in March 2003. The IPM project is funded by the National Foundation for IPM Education and the Environmental Protection Agency. For more information contact: Susan Richards, 717-737-8622, http://www.acb-online.org/project.cfm?vid=89.

9.3.2.10 Sensible irrigation

The natural reaction of grasses to drought stress is to become dormant, halting growth, conserving resources, and turning dry and brown. In spite of this natural drought tolerance mechanism, many property owners strive to maintain lush, green lawns, even in times of dry weather. Watering practices vary from a light sprinkling to regular, sometimes excessive, automated watering. Underwatering fails to provide water below a few inches of soil, causing grasses to be fragile and shallow-rooted. Overwatering promotes excessive growth and humid, disease-prone conditions that can damage the lawn. Overwatering can also result in runoff and leaching of nutrients (PLCAA, no date (b)). One study found that overwatering increased by five to 11 times the amount of nitrogen leached (Morton et al., 1998).

It is best to water deeply, but not too often. Deep watering encourages the grass to grow deep roots, whereas shallow watering maintains shallow roots and reduces the lawn's ability to retain moisture during dry periods (USEPA, 1992). The lawn should be watered only when needed and sprinklers should be carefully calibrated to wet the soil to a depth of 6 inches without causing runoff. Additionally, watering should be done early in the morning to prevent excessive evaporation (USEPA, 1992). Determining and controlling the rate, amount, and timing of

watering will reduce soil erosion, runoff, and fertilizer and pesticide movement. An irrigation system should be designed to have an average application rate that is less than the infiltration capacity of the soil to avoid surface ponding and to maximize water percolation. Trickle and drip irrigation systems can save water by more directly irrigating the roots, resulting in less evaporation than overhead sprinklers (Relf, 1996).

Moisture in a home lawn can be retained more efficiently with organic matter, mulch, shade, and windbreaks. Organic matter increases the capacity of sandy soils to hold moisture and the availability of moisture in clay soils. Mulching helps reduce evaporation and retain moisture and humidity. Providing partial shade, particularly in the summer, and blocking wind, can also decrease moisture demand (Relf, 1996).

9.3.3 Commercial Activities

9.3.3.1 Detect and eliminate illicit connections

Illicit connections are defined as "illegal and/or improper connections to storm drainage systems and receiving waters" (Caraco et al., 1998). A discharge of industrial wastewater to a storm sewer is "illicit" because discharges of that type would ordinarily require a permit under NPDES. Many building owners and operators are unaware that improper connections exist in their facilities. In extreme cases of illicit dumping, legal action is necessary.

Illicit discharge detection and elimination programs are designed to prevent contamination of surface and ground water supplies by monitoring, inspection, and removal of these non-storm water discharges, which are illegal if an ordinance has been enacted. These ordinances grant a municipality the authority to inspect properties suspected of releasing contaminated discharges into storm drain systems. Another important factor is the establishment of enforcement actions for those properties found to be in noncompliance or that refuse to allow access to their facilities. EPA (1999), in conjunction with the Center for Watershed Protection, published a model ordinance for illicit discharges on their model ordinances Web site (http://www.epa.gov/nps/ordinance/discharges.htm). The model ordinance includes language to address illicit discharges in general as well as illicit connections specifically from industrial sites. Municipalities should modify the language to take into consideration enforcement methods that are appropriate for the local area. The Center for Watershed Protection (Brown et al., 2004) also published *Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments*. This publication provides information on cost-effective methods to detect and eliminate illicit discharges from municipal storm drains. The document is available for download at http://www.cwp.org/PublicationStore/TechResearch.htm.

Identification of illicit and improper connections is necessary for all sanitary and storm sewer systems, especially in areas where pollutants with unknown sources have been detected in receiving waters. The level and type of industrial activities and the surrounding land uses will affect the methods used to identify illicit connections.

The following are some practices used to prevent, discover, and eliminate illicit connections:

- Conducting water quality monitoring and field screening at outfalls and in receiving waters to identify areas where pollutant levels are elevated. Consider bacterial source

tracking analysis to determine the origins of elevated bacteria levels (see Section 2.3.5 for more information about water quality indicators and bacterial source tracking).

- Instituting building and plumbing codes to prevent connections of potentially hazardous pollutant sources to storm drains.

- Organizing structures to be inspected for illicit connections by building age, with older buildings identified as priorities. Businesses whose activities have the greatest potential to create sources that could adversely affect water quality and pose human health problems also should be given priority.

- Mapping each area to be surveyed and indicating the route of the sewer system and the locations of storm drains on the map. This enables watershed managers to estimate the likely locations of illicit connections.

- Surveying individual buildings to discover where connections to the storm drain exist.

- Inspecting sewer lines with television equipment to visually identify all physical connections.

- Comparing the results of field tests and video inspections with the known connections on the map. Areas with suspected connections should be further investigated.

- Instituting mandatory inspections for new development, redevelopment, and remodeling projects.

- Removing and testing sediment from catch basins or equivalent structures.

- Inspecting questionable connections to determine whether they should be connected to the storm drain system or to the sanitary sewer. Methods of illicit connection identification, such as dye testing, visual inspection, smoke testing, and flow monitoring, are described below.

  - *Dye testing*. Flushing fluorometric dye into suspected connections can be useful to identify illicit connections. Once the dye has been introduced into the suspected connection, the water in the collection system is monitored to determine whether a connection is present.

  - *Visual inspection*. Remotely guiding television cameras through sewer lines is another way to identify physical connections.

  - *Smoke testing*. Smoke testing is another method used to discover illicit connections. Zinc chloride smoke is injected into the sewer line and emerges via vents on connected buildings or through cracks or leaks in the sewer line. By monitoring and recording where the smoke emerges, crews can identify all connections, legal and illegal, to the sewer system. (Mechanisms on drains should prevent the smoke from entering buildings; however, in some instances, this will occur. It is important to

notify the public that the smoke is nontoxic, though it should be avoided as it can cause irritation of the nose and throat in some people.)

- *Flow monitoring*. Monitoring increases in storm sewer flows during dry weather can lead investigators to sources of infiltration or flow due to illicit connections.

Rain can hamper efforts to monitor flows and conduct visual inspections. Smoke and dye testing are more accurate than visual inspection and are the preferred methods for identifying illicit connections.

The cost of smoke testing, dye testing, visual inspection, and flow monitoring can be significant and time-consuming. Site-specific factors, such as the level of impervious area, the density and ages of buildings, and land use will determine the level of investigation necessary. Case studies in Michigan have estimated the cost of two full-time field staff and other required support to be between $182,000 and $187,000 annually (Ferguson et al., 1997).

An illicit discharge detection program can be an effective method to reduce the quantity of pollutants related to industrial and commercial activities that enter the storm drain system. For example, the Montgomery County, Maryland, Department of Environmental Protection (MCDEP) has an illicit discharge detection and elimination program called "Pipe Detectives" that uses volunteer monitoring and community hotlines to identify suspicious discharges (MCDEP, 1997). When discharges are reported, DEP consults maps of surrounding areas and targets these areas for additional monitoring to narrow the search for the illicit connection. In one instance, a "milky white" discharge was reported in an area with many small businesses and large apartment buildings. Businesses were sent informational letters advising them of the discharge and requesting their assistance in identifying it by allowing MCDEP to survey the properties. Through this cooperative effort, three illicit connections were detected and removed, including a sink that was used to wash paintbrushes (the source of the milky white discharge).

The City of Portland, Oregon, addressed illicit discharges from industrial sites by developing a memorandum of agreement with the Oregon Department of Environmental Quality, the state agency charged with administering municipal storm water permits. The purpose of the agreement was to streamline the enforcement process by delegating authority to administer the permits to the city. The agreement specified the city's role in inspections, compliance, and enforcement. The first component of the city's Illicit Discharge Elimination Program involves the prioritization of storm water outfalls based on pipe size, land use, historical pollution problems, complaints, and monitoring data. These outfalls are subject to dry weather monitoring, and once pollutants are detected, upstream investigations are conducted. Second, the Connection Verification Program inventoried all connections to the MS4 from individual properties and reviewed them for questionable connections. A citizen complaint program and partnership agreements facilitate public input and participation and provide a low-cost way to improve enforcement efforts (Pronold, 2003).

The Santa Clara Valley (California) Nonpoint Source Control Program published a guide with pollution prevention practices for industrial facilities entitled *Best Management Practices for Industrial Storm Water Pollution Control* (Duke and Shannon, 1992). The guide presents 21 practices intended to reduce nonpoint source loadings from industrial and commercial

activities, including employee and customer training; illicit discharge elimination; waste storage, handling, and disposal; equipment inspection and maintenance; facility design features; and storm water management. The guide presents detailed technical guidance for common pollutants generated by commercial and industrial activities. The Santa Clara Valley Nonpoint Source Control Program has other pollution prevention publications that target specific businesses, such as automotive repair, construction trades and roadwork, landscape/gardening and pool maintenance, mobile cleaners and detailers, and restaurants. Additional information can be obtained by contacting the Nonpoint Source Control Program Information Line at 800-794-2482.

9.3.3.2 Encourage good housekeeping practices at commercial facilities

One of the best and least-expensive ways to reduce or eliminate pollutants in runoff is to limit the exposure of materials that can be eroded or dissolved by rainfall and runoff. An inventory of the items on commercial sites that are exposed to rain and runoff provides useful information and a starting point for exposure-reduction activities. To help keep rain from contacting pollutants, businesses should be advised to keep dumpsters and other containers securely closed, store containers under cover, and cover stockpiled materials, such as gravel, wood chips, and building materials, with plastic sheeting. Businesses should be asked to clean up their sites, but not by washing grit and grime into the storm drain system. Instead they should pick up litter, sweep, dispose of sweepings in the garbage (unless they are hazardous and require special disposal), and use absorbent materials such as manufactured absorbent snakes, kitty litter, or sawdust to absorb oils.

9.3.3.3 Provide training and education for employees and customers

Education of employees and customers at commercial sites is key to establishing good pollution prevention practices. Training programs provide information on material handling and spill prevention and response to better prepare employees in case of an emergency. Employees should also be trained on the purpose, operation, and maintenance of pollution prevention management practices. Employees can be continually educated with periodic training courses and with signs reminding workers of good housekeeping practices. Customers should be informed of efforts to

Illicit Discharge Elimination Training

The Wayne County, Michigan, Department of Environment's Illicit Connection/Discharge Elimination Training Program provides training for county and local staff responsible for illicit discharge detection and elimination. The training program involves technical presentations, "hands on" instruction in investigative techniques, and provision of software to aid in program management. Each participant receives a notebook containing recommended standard operating procedures and field forms. State-of-the-art technology is employed, including Global Positioning System (GPS) for locating outfalls and a GIS/database software package developed by the County for site investigation. The goal of the software package is to promote coordination in reporting/tracking of illicit connections/discharges. The training program also instructs participants in the use of chemical analysis field kits for measuring water quality parameters. As of September 2002, the program had trained nearly 800 state, local and community personnel (Tuomari, 2003; Wayne County Department of Environment, 2001).

reduce waste and pollution using signage or pamphlets so they will be less likely to contribute to pollution problems that are ultimately the responsibility of the business.

9.3.3.4 Devise spill prevention, control, and clean-up plans

The best way to avoid runoff contamination from spilled materials is to prevent the spill from occurring. Careful storage of materials in sound, clearly labeled containers, and regular inspection and maintenance of equipment, are key practices to prevent spills. Materials stored outdoors should be covered and kept on a paved area to protect them from being mobilized by wind and runoff. If not roofed, the storage area should be designed to drain with a slight slope (approximately 1.5 percent) to an area that will provide treatment prior to disposal. Runoff from other areas should be excluded to reduce the volume of runoff requiring treatment by installing berms, curbs, or diversions on the perimeter of the storage area. Secondary containment should be used when liquids are stored, and runoff or spills from the containment area should be directed to the sanitary sewer where permissible or to an appropriate storage or treatment facility for reuse or disposal.

Business managers should develop and post a set of well-defined procedures for handling spills of any materials that might be exposed to rainfall or runoff. Procedures should cover small, easy-to-handle spills as well as large spills that require employees to contact emergency personnel. The procedures should emphasize that spills must be cleaned up promptly and should specify how each type of material should be handled. The use of water for clean-up should be strongly discouraged. Shop rags should be used for small spills of non-volatile chemicals, and used rags should be sent to a professional cleaning service to prevent them from causing a pollution problem in a landfill or other disposal area. Larger spills should be absorbed with vermiculite, sawdust, kitty litter, or absorbent "snakes." Disposal methods depend on the hazard level of the spilled material. Nonvolatile liquids can be cleaned up with a wet/dry shop vacuum and disposed of with the rest of the facility's waste. Drains or inlets to storm sewers should be plugged during spill remediation to prevent off-site export of pollutants.

9.3.3.5 Conduct an environmental audit

Another approach to pollution prevention at commercial sites is to focus on source reduction, which reduces the amount of waste materials that have the potential to contaminate runoff. A reduction assessment can be performed to evaluate the type and amount of materials currently used, processes conducted, and wastes generated. Such an assessment can provide recommendations for modifying the commercial process to generate less waste, using alternative raw materials to generate non-hazardous wastes, and identifying recycling options to reduce the amount of wastes that require disposal. EPA's Office of Pollution Prevention and Toxics Web site (http://www.epa.gov/oppt/pollutionprevention/) offers technical information and assistance about environmental audits for both businesses and state regulatory agencies (USEPA, 2001a).

9.3.3.6 Practice safe equipment washing and maintenance

It is important when washing and maintaining equipment to adhere to certain pollution prevention measures. The flow of water resulting from cleaning industrial equipment, must be discharged as process wastewater to the sanitary sewer and is not allowed in storm drains, in

most cases. When cleaning greasy equipment or trucks, a special cleaning area should be designated and equipment installed to capture, pre-treat, and discharge the wash water to the sanitary sewer. In addition, instructional signs that prohibit changing vehicle oil, washing with solvents, and other activities should be posted in non-wash areas. Finally, sumps or drain lines should be installed to collect wash water for treatment and discharge to the sanitary sewer.

Waste materials from vehicle maintenance activities also deserve special attention. Proper storage of materials and proper disposal of waste products are imperative. For example, waste oil, antifreeze, spent solvents, and some other liquids can be recycled. Spent batteries, however, should not be discarded with trash, but must either be disposed of as a hazardous waste or returned to the dealer from whom they were purchased. In addition vehicle maintenance should be performed in an indoor garage, not in an outdoor parking area. If performing work outdoors, all oil and grease should be captured unless precautions are taken to prevent them from being carried in runoff, such as with the use of absorbent pads in inlets or grates.

9.3.3.7 Use care when performing construction, repairs, or remodeling

When repairing, remodeling, or constructing buildings there are several key techniques that can prevent adverse effects on natural systems. Paints should be mixed where spills can be recovered or cleaned easily, and an impermeable ground cloth should be used while painting. Paint chips and scrapings might contain lead and should be managed properly to prevent contamination of water or soil. Paint buckets and barrels of materials should be stored away from contact with runoff. During painting clean-up, if a water-based paint was used, brushes and equipment should be cleaned in a sink connected to the sanitary sewer; if oil-based paints were used, they should be stored or recycled and not be disposed of in the sink or storm drain. Spray painting requires a few extra precautions. Temporary scaffolding should be used to hang drop cloths or draperies to shield the user from the wind, to collect overspray, and to minimize the spreading of windblown materials. Users should be aware of air quality restrictions on spray paints that use volatile chemicals and should consider water-based spray paints instead to minimize adverse effects on air quality.

Sand blasting can be controlled to keep particles off of paved surfaces and out of storm drains by placing a tarp or ground cloth beneath the work to capture the blasting medium, protect the work area from wind, and capture airborne particles.

9.3.3.8 Proper disposal of pet waste

Pet owners have several options for properly managing pet waste. Collecting the waste and flushing it down the toilet, where it can be treated by a sewage treatment facility or septic tank, is the preferred method. Small quantities can also be buried in the yard (when ground water is not used in the home), where the waste can decompose slowly. When buried, the waste should be at least 5 inches below the ground surface and away from water bodies and vegetable gardens. In public areas, the waste can be sealed in a plastic bag and thrown in the trash, which is legal in most areas (Water Quality Consortium, 1999).

Many communities implement pet waste management programs by posting signs in parks or other areas frequented by pet owners, sending mailings, and making public service

Los Angeles County Pet Waste Program

The Los Angeles County Department of Public Works Environmental Programs Division developed a program to control pet waste (Lehner et al., 1999). By profiling various groups of pet owners, the division identified the best targets for reducing coastal pollution. The program included a multimedia campaign to educate new and existing pet owners about the water quality impacts of pet waste. The program also distributed clean-up kits to owners and installed plastic bag dispensers in parks. The division established partnerships with local pet stores and pet supply companies to promote the program.

announcements. Many communities have "pooper scooper" ordinances that govern pet waste clean-up. Some of these laws specifically require anyone who takes an animal off his or her property to carry a bag, shovel, or scoop. Any waste left by the animal must be cleaned up immediately (Hill and Johnson, 1994). In addition to postings, many communities have installed "pet waste stations" in popular dog parks. These stations contain waste receptacles as well as a supply of waste collection bags, scoops, and shovels.

9.3.4 Trash

When developing control strategies for trash, one should keep in mind the source of the trash and the most prevalent types of trash to target ways to control it. Second, the costs for each control strategy should be evaluated, and a budget should be developed that takes into consideration the services and facilities that are already available. Third, regular cleaning and maintenance of storm water control infrastructure is necessary to prevent the accumulation of trash at control structures from becoming a hazard. Finally, it is important to understand that control strategies should not just transport trash to another water body but should also reduce the quantity of trash entering water bodies.

There are two methods of trash control: source controls and structural controls. There are four source control types: community education, improved infrastructure, waste reduction, and clean-up campaigns. Community education, such as informing citizens about options for recycling and waste disposal and educating them about the consequences of littering, is one of the best ways to reduce the amount of trash that enters runoff control structures and receiving waters. Another topic that should be emphasized is proper trash storage and disposal. Improved infrastructure can include optimizing the location, number, and size of trash receptacles, recycling bins, and cigarette butt receptacles based on expected need. Waste reduction includes encouraging consumers to purchase products with less disposable packaging and manufacturers to reduce the amount of packaging they use. Finally, clean-up campaigns are an effective way to reduce trash. Municipal projects such as street sweeping (see section 7.3.5.1), receptacle servicing, and clean-up crews along roadsides can also be effective in preventing trash from accumulating and entering waterways. Municipalities should review their litter control program to determine if the number and placement of receptacles is adequate and if regular maintenance activities (e.g., sweeping, receptacle servicing) are preventing litter from entering receiving waters.

Structural controls include physical filtering structures and continuous deflection separation. Physical filtering structures concentrate diffuse, floating debris and trash and prevent it from traveling downstream. Some examples are trash racks, mesh nets, bar screens, and trash booms. Continuous deflection separation targets trash from storm flows during and after heavy

precipitation and involves physical separation of solids and floatables from water in runoff detention structures.

The costs for trash controls vary depending on the method employed. For example, the cost of a community education program or a plan to increase the number of trash receptacles can be minimal, depending on the quality of existing programs and extent of existing infrastructure. On the other hand, a structural control strategy can be quite costly. Physical filtering structures, including trash racks, bar screens, and silt traps, can range from $250,000 to $1 million or more, not including maintenance. A large-scale, continuous deflection separation device for urban runoff can cost as much as $3 million (capital cost only).

9.3.5 Nonpoint Source Pollution Education for Citizens

Many citizens know very little about nonpoint source pollution. Schueler and Swann (2000a) reported that an estimated 41 percent of the population had an idea of what the term "watershed" means, and only 22 percent understood that runoff is the most common source of pollution to streams, rivers, and oceans. Therefore, watershed and nonpoint source education for citizens is important to increase awareness about the environmental consequences of everyday actions. A survey of the effectiveness of outreach programs showed that media campaigns and intensive training of target audiences are the most effective ways to effect change in citizen behavior (up to 10 percent change in behavior in target populations). Specifically, TV ads and programs, newspaper ads, radio ads, and direct mail campaigns were shown to be the most influential and memorable messages to the public. Table 9.2 provides a summary of cost information and target audiences for various outreach methods.

Table 9.2: Select cost and audience information for various outreach techniques (Worlton, 2003).

Element	Cost	Unit	Audience
Flyers	$0.40–$1.20	Each	Limited by requests
Fact Sheets	$0.40–$1.20	Each	Limited by requests
Radio	$2,000 or more	Per station	500,000–2,000,000
Television	$2,400 or more	Per month	250,000–500,000 per day
Billboards	$700	Per board	6,800 per day
Markers	$2.94	Each	0–5,000 per day
Trailers	$165	Per theater	5,000 or more per day

Schueler and Swann (2000a) recommend the following techniques to effectively market a watershed message:

- Present a simple, direct watershed message, repeat it frequently, use multiple types of media, and emphasize the connection between the message and a local water body.
- Develop awareness of the connection between yards, streets, storms, and streams.
- Pool resources with other local or regional organizations to expand the campaign's budget.

- Use cable network and public television channels for commercials and targeted TV programs to more effectively reach target audiences.

- Focus the campaign on one or more target audiences. Many communities are ethnically and culturally diverse, and a portion of the population speaks languages other than English, which requires a campaign specifically tailored to the local demographics. Communities can also direct messages to children or focus efforts towards reaching the disadvantaged, who otherwise might not have the opportunity to learn about or participate in programs and activities. A survey of watershed demographics and problem pollutants should be conducted to better identify target populations.

- Keep the message simple and humorous and develop durable, attractive, non-technical outreach materials.

- Educate and partner with private-sector companies such as septic tank cleaners, commercial car washes, and oil change franchises.

9.3.5.1 Use multilingual nonpoint source messages

Many communities are ethnically and culturally diverse, and a portion of the population speaks languages other than English. The messages contained in signs, brochures, advertisements, newsletters, and other outreach materials that are printed only in English are mostly lost on these groups. For example, in areas such as southern Florida and southern California, where a large proportion of the population consists of Spanish-speaking immigrants, it is important to reach out to non-English-speaking residents and inform them about storm water pollution issues and the importance of clean water, because their activities can generate a substantial amount of pollution. This type of expanded outreach program is not limited to these areas. Census 2000 figures show increasing minority populations in urban centers and suburbs such as Washington, DC (Fernandez, 2001; Cohn and Witt, 2001), and New York (Cohn, 2001), among others.

Outreach materials can be printed in multiple languages based on the demographics of a community. The North Central Texas Council of Governments (NCTCOG), as part of its pollution prevention and public awareness campaign, printed articles, press releases, brochures, flyers, and bill stuffers in both English and Spanish (NCTCOG, 2000). The University of Texas at Austin designed and installed storm drain markers in both English and Spanish (University of Texas at Austin, 1997).

9.3.5.2 Use classroom education to deliver nonpoint source messages

Providing nonpoint source education to children through schools delivers the educational message not only to students but to their parents as well, because children often take home what they learn. Watershed managers have partnered with educators and experts to develop storm water-related curricula for the classroom. Fortunately, these lessons need not be elaborate or expensive to be effective.

An example of this type of education is the Children's Water Festival in Albuquerque, New Mexico. Several hundred fourth-grade students from schools in the area engaged in hands-on

earning activities about water science, history, geography, and drama. The Albuquerque-based Ciudad Soil and Water Conservation District used its "Rolling River" educational model to show how all the components of a watershed are connected and how changes in one part affect others. Students created a mini-river, purified water from the Rio Grande, and built aquifers from edible ingredients. They also used a computer model to make projections of water use in the future and a ground water model to see how water moves underground. Students analyzed water samples and played the roles of algae, fish, and raptors to understand how toxins can travel through the food chain. They created wetlands, simulated flood and drought situations, changed the infrastructure, and then observed the effects of their manipulations.

9.4 Information Resources

9.4.1 General

The Center for Watershed Protection published *Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments*. This publication provides information on cost-effective methods to detect and eliminate illicit discharges from municipal storm drains. The document is available for download at http://www.cwp.org/PublicationStore/TechResearch.htm.

EPA's GreenScapes program provides cost-efficient and environmentally friendly solutions for large-scale landscaping. GreenScapes encourages companies, government agencies, and other entities to make more holistic decisions regarding waste generation and disposal. The GreenScapes program emphasizes four elements: reduce, reuse, recycle, and re-buy**.** More information about the GreenScapes program can be found at the program's Web site at http://www.epa.gov/greenscapes.

EPA's Office of Solid Waste has released "A Collection of Solid Waste Resources" on CD-ROM. This resource contains more than 300 publications on hazardous and non-hazardous waste; documents are listed by topic and are searchable, and some documents are in both English and Spanish. More information about this CD-ROM is available at EPA's Office of Solid Waste Web site at http://www.epa.gov/epaoswer/osw/cdoswpub.htm.

EPA's Used Oil Management Program developed the "You Dump It, You Drink It" campaign aimed to educate the Hispanic automotive repair and service industry and consumers about the impacts of improper disposal of used oil. The campaign includes posers, brochures, and bumper stickers in both English and Spanish. These materials, a description of the Used Oil Management Program, and relevant publications, rules, notices, regulations, and links can be found at http://www.epa.gov/epaoswer/hazwaste/usedoil/index.htm.

Appropriate Technology Transfer in Rural Areas (ATTRA) published the guidance *Integrated Pest Management: Fundamentals of Sustainable Agriculture*, which provides a basic understanding of IPM for individuals interested in agriculture. It incorporates the steps that need to be taken prior to IPM implementation, the tools used, and some ideas about future trends for IPM. The ATTRA publication is available at http://www.attra.org/attra-pub/ipm.html (Dufour and Bachmann, 1998).

The City of Seattle's ProIPM (Seattle Public Utilities, 2000) is the Green Gardening Program's series of IPM fact sheets for landscaping professionals. The fact sheets were designed to assist landscapers in the field and when explaining the IPM approach to clients. Each provides essential facts about various northwestern United States pest or disease problems, including information regarding pest identification, life cycle information, monitoring, damage threshold, and treatments. The fact sheets are available for download at http://www.seattle.gov/util/Services/Yard/For_Landscape_Professionals/Integrated_Pest_Management/index.asp or by calling the Green Gardening Program at 206-547-7561. The ProIPM Web site also provides information about proper disposal methods for pesticide products.

The U.S. Air Force's PRO-ACT program is an environmental research service and information exchange clearinghouse (PRO-ACT, 2000). PRO-ACT's *Integrated Pest Management Fact Sheet* provides information regarding IPM policy and guidance, typical components of an IPM program, control techniques available to pest managers, and management practices that can be implemented in an IPM program. The fact sheet is available at http://www.afcee.brooks.af.mil/pro-act/fact/intpst.asp. PRO-ACT may be contacted by phone at 800-233-4356 or by e-mail at pro-act@hqafcee.brooks.af.mil.

The USDA Regional Pest Management Centers Information System Web site (http://www.ipmcenters.org/) provides information about agricultural commodities, pests, and pest management practices, as well as links to each of the four Regional Pest Management Centers. Users can access the complete Crop Profiles and Pest Management Strategic Plans databases, an IPM Expertise database, information on pesticide use, current pest management research, funding opportunities, and links to related sites. Additional region-specific information, news, and announcements can be found at the regional Web sites.

NRCS (no date) has prepared a backyard conservation tip sheet that provides the public with information on pest management. The tip sheet helps readers to identify the problem, to know what to look for, and to control various types of pests with mechanical, physical, biological, and chemical control strategies. The NRCS tip sheet is available at http://www.nrcs.usda.gov/feature/backyard/pdf/PestMgt.pdf.

The International Turf Producers Foundation (ITPF, no date) recently published *Water Right: Conserving Our Water, Preserving Our Environment*. The publication provides information about a variety of water topics, including water use and conservation, environmental and economic benefits of responsible landscape management, and landscape water conservation techniques. The document is available for download at http://www.turfgrasssod.org/waterright.html or can be obtained by contacting ITPF at 1855 Hicks Road, Suite C, Rolling Meadows, Illinois, 60008; 847-705-9898 or 800-405-8873.

Audubon Magazine published *The Audubon Guide to Home Pesticides* in 2000. This guide provides citizens with a list of popular pesticides, along with their typical uses, their toxicity to humans and wildlife, EPA's toxicity rating, and alternatives for each of the chemicals. The guide is available for download at http://www.magazine.audubon.org/pdf/pesti_chart.pdf.

The Pest Management Branch of the California Department of Pesticide Regulation published *Suppliers of Beneficial Organisms in North America*. The publication lists 143 commercial suppliers of 130 beneficial organisms that are used for biological control. Suppliers are located in Canada, Mexico, and the United States. The booklet is available for download at http://www.cdpr.ca.gov/docs/ipminov/bensuppl.htm.

The EXtension TOXicology NETwork (EXTOXNET) is a joint effort of the University of California at Davis, Oregon State University, Michigan State University, Cornell University, and the University of Idaho. EXTOXNET provides a variety of information about pesticides, including discussions of toxicological issues of concern; toxicology newsletters, fact sheets, and information briefs; pesticide information profiles; and other resources for toxicology information. The network can be accessed at http://ace.orst.edu/info/extoxnet.

The National Pesticide Telecommunication Network is a cooperative effort of Oregon State University and the U.S. Environmental Protection Agency. The network is a source of chemical, health, and environmental information about more than 600 pesticide active ingredients incorporated into at least 50,000 different products registered for use in the U.S. since 1947. The toll-free telephone service (800-858-7378) provides information about pesticide products, recognition and management of pesticide poisoning, toxicology, and environmental chemistry to any caller in the United States, Puerto Rico, or the Virgin Islands.

Nonpoint Education for Municipal Officials (NEMO) is an educational program created by the University of Connecticut for local land use decision-makers that addresses the relationship between land use and protection of natural resources, particularly water resources. NEMO is an award-winning program that uses remote sensing, geographic information systems, and Internet technologies. The NEMO model is being adapted around the country, and NEMO projects are being planned and implemented by various agencies and organizations. This nationwide group, under the leadership and coordination of the University of Connecticut NEMO Project, is called the National NEMO Network. Additional information about NEMO is available at http://www.nemo.uconn.edu/.

Organic Gardening magazine and Web site (http://www.organicgardening.com/) provide information about organic pest control and help users find soil-testing labs in their area.

Riversides is a Canadian nonprofit organization that promotes source control and nonpoint source pollution prevention strategies. An important component of the Riversides Web site is H_2infO: The Water Information Network, which provides information about current campaigns, resources, and services offered by the network. Also offered are listservers and links to agencies, associations, and non-governmental organizations. The H_2infO Web site can be accessed at http://www.h2info.org/. Also, H_2infO can be contacted at 590 Jarvis Street, Suite 200, Toronto, Ontario, Canada, M4Y 2J4; phone 416-392-1757; fax 416-960-9944; e-mail input@H2infO.org.

EPA's Biopesticide Web site provides users with specific information about biopesticides, including fact sheets, decision documents, product lists, labels, company lists, study reviews, bibliographies, regulatory information, and federal register notices. The Web site can be accessed at http://www.epa.gov/pesticides/biopesticides.

EPA (1995) published the *Citizen's Guide to Pest Control and Pesticide Safety*, which provides users with important information about pesticides, including steps to control pests in and around the home; alternatives to chemical pesticides; methods for choosing, using, storing, and disposing of pesticides; how to reduce exposure when others use pesticides; how to choose a pest control company; and what to do if someone is poisoned by a pesticide. The guide is available at http://www.epa.gov/oppfead1/Publications/Cit_Guide/citguide.pdf.

EPA (1999) published *Education Projects in the Office of Water: A How-to Guide for Developing Environmental Education Projects*. The document provides a road map for creating quality environmental education projects and outlines EPA's procedural guidelines for producing a product or supporting related projects already in existence. It also lists publications, contacts, and references, including Web sites, training opportunities, and available materials, that provide the reader with further detail and insight into the process of developing effective environmental

education pieces. A list of agencies and organizations that have water-related environmental education programs and projects is provided in an appendix. The publication is available from EPA's National Service Center for Environmental Publications Web site at http://www.epa.gov/ncepihom. It can also be ordered by phone, fax, or mail from USEPA/NSCEP, P.O. Box 42419, Cincinnati, Ohio 45242-2419; toll-free 800-490-9198; fax 513-489-8695.

The Commonwealth of Kentucky published *Turfgrass: Best Management Practices for Protection of Water Resources* (USEPA, 2001b). The manual provides information and guidance on turf grass management practices that decrease adverse effects on water resources. Information about the manual, along with a list of commonly used best management practices for turf management, is available at http://www.epa.gov/Region4/water/nps/projects/ky94-2.htm.

The Council of State Governments (1999) published *Getting in Step: A Guide to Effective Outreach in Your Watershed*. The guide presents a step-by-step approach for developing and implementing an effective watershed outreach plan. *Getting in Step* is available for download in PDF format at http://www.epa.gov/owow/watershed/outreach/documents/getnstep.pdf or by calling Books on Demand (800-521-3042).

State-specific cooperative extension service information is available from the Cooperative State Research, Education, and Extension Service (CSREES) at http://www.csrees.usda.gov/.

The California Peer Review Project, funded by the California Integrated Waste Management Board, compiles and reviews scientific research on the health effects, environmental effects, and efficacy of alternative household products. The project allows interested parties to participate during the review process, and findings from these literature reviews are available for download on the Web site (http://www.peerreview.com/).

The Stormwater Quality Management Committee, sponsored by the Clark County Regional Flood Control District in Las Vegas, Nevada, has developed a Web site devoted to its campaign to prevent pollution from urban runoff. The site has a number of resources for developing education and outreach materials, including examples of a bus stop shelter ad campaign, public service announcements, brochures, and community presentations at http://www.lvstormwater.com/.

The EPA's Web site, *Yard Trimmings/Food Scraps,* provides basic information on the environmental and economic benefits of recycling yard waste and food scraps. It also includes descriptions of practices for citizens, links to case studies, and technical fact sheets. The site can be accessed at http://www.epa.gov/epaoswer/non-hw/muncpl/yard.htm.

In 1994 the EPA published *Composting Yard Trimmings and Municipal Solid Waste,* a 151-page manual on the inclusion of composting as part of an integrated solid waste management program. It provides guidance on program development, facility siting and design, and costs and benefits, and includes information on many helpful resources. This manual can be downloaded in PDF format at http://www.epa.gov/epaoswer/non-hw/compost/cytmsw.pdf.

The Region 4 DoD Pollution Prevention Partnership published *Best Management Practices Resource Guide—Household Hazardous Waste* to guide pollution prevention activities on

military bases, but the information is applicable to any pollution prevention initiative. It includes guidance on proper management of household chemicals, as well as descriptions of applicable state and federal laws, regulations and reporting requirements, and state resources. It describes various types of collection programs, lists resources for disposal and recycling by material type, and includes examples of outreach and education materials. The resource guide is available in PDF format at http://www.p2pays.org/ref/13/12935.pdf.

9.4.2 Yards: General Resources

The Bay Area Water Pollution Prevention Agency's "Our Water, Our World" program published *Less-Toxic Pest Management: Problem Pesticides,* a fact sheet describing the current state of chlorpyrifos and diazinon regulation, as well as some additional pesticides of concern. It provides information on alternative pest management techniques and sources of additional information. The site can be accessed at http://www.ci.livermore.ca.us/wrd/pdf_files/pesticides.pdf.

The *National Foundation for IPM Education* (NFIPME) is a non-profit organization that promotes education, provides information, and encourages research on integrated pest management. The Web site, http://www.ipm-education.org/, contains links to sponsored programs and information on grants for pesticide environmental stewardship.

Robert Mugaas at The University of Minnesota Cooperative Extension published *Responsible Fertilizer Practices for Lawns.* The paper provides soil-specific information on fertilizer application practices to protect water quality. It can be accessed at http://www.extension.umn.edu/distribution/horticulture/DG6551.html.

9.4.3 Yard Resources for Homeowners

Water Quality and Home Lawn Care, by the North Carolina State University Cooperative Extension, takes citizens through the process of establishing a healthy lawn and maintaining it using practices that protect water quality. It provides specific instructions on watering, mowing, and fertilization. This fact sheet can be downloaded in PDF format from http://www.turffiles.ncsu.edu/PUBS/MANAGEMENT/HOMELAWN.PDF.

The U.S. EPA publication *Healthy Lawn, Healthy Environment* is a user-friendly brochure that describes lawn care practices for citizens. It covers the basic principles of soil building, mowing techniques, appropriate thatch buildup, and IPM. The brochure also discusses important considerations for citizens in selecting a professional lawn care service. The brochure can be downloaded in PDF format from http://www.epa.gov/oppfead1/Publications/lawncare.pdf.

9.4.4 Yard Resources for Lawn Care Professionals

The University of Florida Cooperative Extension maintains a database of fact sheets for lawn care professionals, *Professional Lawn and Landscape Fact Sheets*. The fact sheets cover athletic fields, golf courses, roadsides, interiorscapes and non-residential lawns. The fact sheets can be downloaded from http://edis.ifas.ufl.edu/TOPIC_Professional_Lawn_and_Landscape.

The North Carolina State University Cooperative Extension's fact sheet, *Water Quality & Commercial Lawn Care*, is a resource for lawn care professionals on fertilizer, mowing, and irrigation practices. It includes information on the leaching potential of specific chemicals, turf

grass selection, and fertilizer use. The fact sheet is available in PDF format at http://www.turffiles.ncsu.edu/pubs/new/commcare.pdf.

The North Carolina State University Cooperative Extension has published *Pest Control for Professional Turfgrass Managers*. This document includes information on proper use and leaching potential for commonly used insecticides and herbicides. It provides information on tolerance and disease resistance for turf grass species. It is available for free download in PDF format from http://ipm.ncsu.edu/AG408/turfgrass.pdf.

Water Quality for Golf Course Superintendents and Professional Turf Managers, produced by the North Carolina State University Cooperative Extension, describes lawn care practices that help to protect water quality. The discussion covers turf grass selection, IPM, mowing, and fertilizer practices that are specific to commercial lawn care. The fact sheet is available as a PDF at http://www.turffiles.ncsu.edu/PUBS/MANAGEMENT/PROTURF.PDF.

North Carolina State University Cooperative Extension's fact sheet, *Water Quality and Pesticide Selection for Professional Turf Managers,* provides guidance on the chemical selection process and information on leaching potential and toxicity for herbicides, insecticides, and fungicides. The fact sheet is available as a PDF at www.turffiles.ncsu.edu/PUBS/MANAGEMENT/PESTFORMAT1.PDF.

The Cooperative Extension at Rutgers State University maintains an online *Database of Commercial Turfgrass and Landscape Maintenance Fact Sheets*, a resource for lawn care professionals. It is accessible at http://www.rce.rutgers.edu/pubs/subcategory.asp?cat=5&sub=35.

The Golf Course Superintendents Association of America (GCSAA) has developed a set of principles for the protection of water quality in golf course planning and siting, design, construction, and maintenance. These principles and practices are summarized in the online publication, *Golf and the Environment.* It can be accessed at http://www.gcsaa.org/resources/facts/principles.asp.

The Professional Lawn Care Association of America's *Grasscycling Guide* describes recommended mowing heights for various grass types, the benefits of recycling grass clippings, and simple techniques for returning grass clippings to lawns. The guide is available in PDF format at http://turf.ufl.edu/BMPmanual.pdf.

The Florida Department of Environmental Protection produced *Best Management Practices for Protection of Water Resources in Florida* to provide guidance on specific lawn care industry practices to protect water quality. The manual covers practices such as employee training, irrigation system design, the design and installation of landscapes, and irrigation system maintenance. It explains techniques for mulching, mowing and pruning, material disposal, fertilizer application, IPM, and spill prevention. It is available for download in PDF format at http://miami-dade.ifas.ufl.edu/programs/fyn/publications/PDF/GI-BMP6-20-02.pdf.

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