# 6 LAND-BASED CONTROL MEASURES (SOURCE CONTROLS)

## 6.1 IDENTIFICATION AND DESCRIPTION OF CONTROL MEASURES

PWD is committed to a balanced "land-water-infrastructure" approach to achieve its watershed management and CSO control goals. This method includes infrastructure-based approaches where appropriate, but relies on a range of land-based stormwater management techniques and physical reconstruction of aquatic habitats where appropriate. The ultimate goal of PWD's approach is to achieve full regulatory compliance in a cost-effective manner while regaining the resources in and around streams that have been lost due to urbanization, both within the City of Philadelphia and in the surrounding counties. Land-based measures are a key part of this approach because they provide benefits to the community beyond water quality improvement. These benefits include recreational opportunities, improved aesthetics, and increased home values.

Philadelphia is making a substantial commitment to reducing the burden on combined sewer infrastructure by controlling stormwater at the source. Development and redevelopment projects are taking place throughout the City under the stormwater requirements enacted in 2006. A number of demonstration projects are complete, in design, or in construction on public lands, including PWD properties, parks and recreation facilities, and schools. PWD will be revising its stormwater rate structure based on impervious cover.

Land-based management measures provide a number of additional long-term benefits. They help to protect the City's investment in stream channel and habitat restoration. They will help reduce sediment loads from runoff and streambank erosion. They help protect infrastructure along stream corridors that can be damaged by high stream flows and velocities. They provide source water protection benefits. By reducing the burden on combined sewers, they help reduce the frequency and severity of basement flooding in some locations. Outside the combined sewered areas, land-based stormwater management is helping Philadelphia to meet requirements of total maximum daily loads (TMDLs) and its Non-Point Discharge Elimination System (NPDES) Phase 1 MS4 permit. The measures also help Philadelphia and the region meeting requirements of Pennsylvania's Act 167 Stormwater Management Program, which requires stormwater management on a watershed basis in developing areas.

Table 6.1 lists the land-based options (source controls) that are being considered for implementation in the initial screening stage and identifies the goals that each option is designed to meet. Descriptions of these options are described in this section. Details on Table 6.1's headers are:

- Required: required under CSO permits
- IWMP: commented to in an Integrated Watershed Management Plan (IWMP)
- Dry Weather WQ: addresses dry weather water quality (WQ)
- Solids / Floatables: addresses solids and floatables
- Recreation: addresses recreation
- Tributary Habitat: addresses tributary habitat
- Water Balance: addresses water balance

## Table 6.1 Land-Based Options (Source Controls)

| | | | Goals Addressed | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | Category | Option | Required | IWMP | Dry Weather WQ | Solids/ Floatables | Recreation | Tributary Habitat | Tidal Habitat | Water Balance | Wet Weather WQ | Stewardship |
| L.1 | Flow reduction | Catch basin modifications | | | | X | | | | | X | |
| L.2 | Flow reduction | Sump pump disconnect | | | | | | | | | X | |
| L.3 | Flow reduction | Catch basin and storm inlet maintenance | X | X | | X | | | | | X | |
| L.4 | Flow reduction | Illicit connection control | X | X | X | | | | | | X | |
| L.5 | Flow reduction | Roof leader disconnect program | | X | | | | | | | X | |
| L.6 | Flow reduction | Street storage (catch basin inlet control) | | | | | | | | | X | |
| L.7 | Flow reduction | Offload groundwater pumpage | | | | | | | | | X | |
| L.8 | Flow reduction | Stream diversion | | X | | | | | | | X | |
| L.9 | Flow reduction | Groundwater infiltration reduction | | X | | | | | | | X | |
| L.10 | Flow reduction | Reduction of contractual flow | | | | | | | | | X | |
| L.11 | Low impact development/ re-development/retrofit | Require existing resources inventory, sketch plan, initial meeting | | X | | | | | | X | X | |
| L.12 | Low impact development/ re-development/retrofit | Require integrated site design | | X | | | | | | X | X | |
| L.13 | Low impact development/ re-development/retrofit | Require post-construction stormwater management | X | X | | | | | | X | X | |
| L.14 | Low impact development/ re-development/retrofit | Post-construction inspection and enforcement | | X | | | | | | X | X | |

| | | | Goals Addressed | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | Category | Option | Required | IWMP | Dry Weather WQ | Solids/ Floatables | Recreation | Tributary Habitat | Tidal Habitat | Water Balance | Wet Weather WQ | Stewardship |
| L.15 | Low impact development/ re-development/retrofit | Demonstration Projects on Public Lands | | X | | | | | | X | X | X |
| L.16 | Low impact development/ re-development/retrofit | Large-Scale Implementation on Public Lands | | X | | | | | | X | X | X |
| L.17 | Low impact development/ re-development/retrofit | Street Trees and Street Greening | | X | | | | | | X | X | X |
| L.18 | Low impact development/ re-development/retrofit | Revise Stormwater Rate Structure | | X | | | | | | X | X | |
| L.19 | Low impact development/ re-development/retrofit | Stormwater Management Incentives for Retrofit | | X | | | | | | X | X | |
| L.20 | Public education | Water Efficiency | | | | | | | | | X | |
| L.21 | Public education | Catch Basin Stenciling | | X | | | | | | | X | X |
| L.22 | Public education | Community Cleanup and Volunteer Programs | | X | X | X | | | | | | X |
| L.23 | Public education | Pet Waste Education | | X | | | | | | | X | X |
| L.24 | Public education | Public Notification and Signage | X | X | X | | X | | | | X | X |
| L.25 | Public education | Litter and Dumping Education | | X | X | X | | | | | X | X |
| L.26 | Public education | School-Based Education | | X | X | X | X | | | | X | X |
| L.27 | Good housekeeping | Loading, Unloading, and Storage of Materials | X | X | | | | | | | X | |
| L.28 | Good housekeeping | Spill Prevention and Response | X | X | X | | | | | | X | |
| L.29 | Good housekeeping | Street Sweeping Programs | | X | | X | | | | | X | |
| L.30 | Good housekeeping | Vehicle & Equipment Management | X | X | | | | | | | X | |
| L.31 | Good housekeeping | Private Scrapyard Inspection and Enforcement | | X | | | | | | | X | |

| | | | Goals Addressed | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | Category | Option | Required | IWMP | Dry Weather QQ | Solids/Floatables | Recreation | Tributary/Habitat | Tidal Habitat | Water Balance | Wet Weather WQ | Stewardship |
| L.32 | Good housekeeping | Employee training | X | X | | | | | | | X | |
| L.33 | Good housekeeping | Record keeping and reporting | X | X | | | | | | | X | |
| L.34 | Good housekeeping | Flow diversion and exposure minimization structures | | X | | | | | | | X | |
| L.35 | Good housekeeping | Responsible landscaping practices on public lands | | X | | X | | | | | X | |
| L.36 | Good housekeeping | Responsible bridge and roadway maintenance | | X | | | | | | | X | |
| L.37 | Pollution prevention | Require industrial pretreatment | X | X | | | | | | | X | |
| L.38 | Pollution prevention | On-lot disposal (septic system) management | | X | X | | | | | | X | |
| L.39 | Pollution prevention | Household hazardous waste collection | | | X | | | | | | X | |
| L.40 | Pollution prevention | Oil/water separator/WQ inlets | | | | | | | | | X | |
| L.41 | Pollution prevention | Industrial stormwater pollution prevention | X | X | | | | | | | X | |
| L.42 | Pollution prevention | Litter and illegal dumping enforcement | | X | X | X | | | | | | |
| L.43 | Pollution prevention | Require construction-phase stormwater/E&S controls | X | X | | X | | | | | X | |

- Wet Weather WQ: addresses wet weather water quality
- Stewardship: addresses stewardship

### L.1 Flow Reduction: Catch Basin Modifications

Philadelphia's catch basins are surface-level inlets to the sewer system that allow runoff from streets and lawns to enter the CSS. These basins include features to prevent floatables from entering the system. Inlet grates installed at the top of many catch basins reduce the amount of street litter and debris that enters the catch basin. Catch basins also contain hoods and traps to capture floatables and a portion of solids from street runoff. These inlets are periodically cleaned.

Additional modifications are possible, including trash buckets installed in the basin beneath the grate and vortex valves. A vortex valve is a conical shaped discharge throttling device installed within catch basins that are able to reduce the frequency and the volume of CSO events by restricting flow through the outlet. Vortex valves have also proven capable of controlling floatables.

### L.2 Flow Reduction: Sump Pump Disconnect

Many buildings have sump pumps to pump floodwater from basements. Often this water is discharged directly into combined and sanitary sewers, adding to wet weather inflow and infiltration and reducing combined sewer capacity. Redirecting this flow away from sewer systems and onto lawns or dry wells or drainfields reduces the volume of stormwater entering the CSS. Discharge of sump pumps to combined and sanitary sewers is not permitted in the City of Philadelphia. Increased enforcement of these rules in Philadelphia and in surrounding municipalities serviced by PWD is recommended as part of a larger wet weather inflow and infiltration control program and may be considered as part of the Green Homes program discussed in Section 10.

### L.3 Flow Reduction: Catch Basin and Storm Inlet Maintenance

Catch basins and storm inlets that are part of the stormwater collection and conveyance system should be cleaned on a regular basis. Sediments, leaves, grass clippings, pet wastes, litter and other materials commonly accumulate in catch basins. These materials can contain significant concentrations of nutrients, organics, bacteria, metals, hydrocarbons, and other pollutants. When a storm occurs, runoff entering the basin may dislodge and suspend some of this material. This debris can be conveyed along the storm sewer system and released to a surface water body.

The City of Philadelphia has in place a catch basin/inlet cleaning program through which approximately 79,000 inlets are cleaned annually.

### L.4 Flow Reduction: Illicit Connection Control

This option refers to illicit or accidental connection of storm drains to sanitary sewer systems and sanitary sewers to storm drains. These connections may impact receiving waters outside the combined sewer areas by causing sanitary sewer overflows. Eliminating these connections is part of a comprehensive watershed approach to water quality improvement. PWD has had a Defective Lateral Abatement Program in place since the early 1990's. This program involves the track-down of cross connected lateral pipes.

Where sanitary sewer systems ultimately drain to a combined sewer interceptor, the increase in flow caused by direct stormwater inflow decreases capacity available for combined sewage and will increase overflows. A program to detect and mitigate these connections can help reduce CSO. A program to reduce direct inflows in Philadelphia and in surrounding municipalities serviced by PWD is recommended as part of a larger wet weather inflow and infiltration control program.

### L.5 Flow Reduction: Roof Leader Disconnect Program

In the combined sewer systems in Philadelphia, roof drains are required to convey rainfall directly from residential and commercial roofs into the CSS. In some cases, flow into the CSS can be safely reduced by redirecting roof drains onto lawns or into dry wells or drainfields where flows can infiltrate into the soil. To reduce direct inflows, changes to municipal codes are first required to allow roof leader disconnection where practical without causing property damage or a safety hazard. Following those legal changes, a program can be designed to encourage or require disconnection through public education and technical assistance programs. Many of these tools will be discussed as part of a Green Homes program in Section 10.

### L.6 Flow Reduction: Street Storage (Catch Basin Inlet Control)

Flow restriction and flow slipping methods utilize roadways and overland flow routes to temporarily store stormwater on the surface, or to convey stormwater away from the CSS. Flow restriction is accomplished by installing static flow or "braking" devices in catch basins to limit the rate at which surface runoff can enter the CSS. Excess storm flow is retained on the surface and enters the system at a controlled rate, eliminating or reducing the chance that the system will be hydraulically overloaded and overflow. The volume of on-street storage is governed by the capacity of the static flow device, or orifice, used for restriction, as well as surface drainage patterns. In Philadelphia, widespread implementation of this option may not be practical due to street configurations and curb heights. However, this option should be retained as one tool to be considered in a larger green streets program. These tools will be considered as part of a Green Streets program.

### L.7 Flow Reduction: Offload Ground Water Pumpage

Groundwater is continuously pumped in some industrial and commercial areas and discharged directly to a combined sewer system. Where possible, this flow should be discharged directly to a receiving water (with appropriate permitting) rather than discharged to the CSS. This situation does occur in some parts of Philadelphia. A program to reduce these inflows is recommended as part of a larger wet weather inflow and infiltration control program and may be considered as part of the Green Industry and Commerce tool.

### L.8 Flow Reduction: Stream Diversion

As cities grew during the nineteenth and early twentieth centuries, many small streams were routed into pipes to facilitate development. In communities where streams have been routed into CSSs, the surface runoff once conveyed in these streams reduces capacity in the CSS and contributes to overflows. Rerouting natural streams and surface runoff away from the CSS and back to their original watercourse or to other receiving waters can have a significant impact on CSS capacity. Urban stream diversion is one of the more expensive inflow reduction options since it typically requires design and construction of new storm drain lines. Stream diversion resembles CSO separation in that new alternative flow routes are required for surface runoff. It is typically employed in situations where less expensive and less disruptive options for inflow reduction are not feasible, or do not provide sufficient inflow reduction. The potential amount of inflow to be diverted from the CSS needs to be well documented in order to assess its cost-effectiveness.

### L.9 Flow Reduction: Groundwater Infiltration Reduction

Groundwater infiltration into combined sewers, and into sanitary sewers that ultimately discharge into combined sewer interceptors, represents a significant portion of the average daily dry weather flow in the collection and treatment system. This infiltration of groundwater into the CSS takes up wet weather capacity that would otherwise be available to stormwater flows. The primary measure to reduce these inflows is through a long-term program of combined sewer rehabilitation. PWD and municipal sewer authorities have these programs in place. Expansion of the rate at which sewers are repaired and rehabilitated should be considered. A program to reduce these inflows is recommended as part of a larger wet weather inflow and infiltration control program.

### L.10 Flow Reduction: Reduction of Contractual Flow

PWD contracts with ten other municipalities to discharge a specific flow of sanitary sewage to Philadelphia's combined sewer system. Contracted flows are discussed in detail in Section 3. As explained in Section 3.3, allowable flow is typically expressed as peak, daily, and annual average flow. Reducing these contractual flows is one option to increase capacity in the CSS for flows within the City of Philadelphia. Working with other municipalities to reduce wet weather inflows over the long-term is recommended as part of a larger wet weather inflow and infiltration control program.

### L.11 Low Impact Development/Redevelopment/Retrofit: Require Existing Resources Inventory, Sketch Plan, Initial Meeting

The developer's first task is to assess features and conditions at the site before design begins. It is during this initial step that the developer is required to complete the Existing Resources and Site Analysis (ERSA) Worksheet.

Philadelphia requires a PWD Development Review meeting early in the development process, before developers have invested extensive time and money in design and engineering. The goal is to decrease the plan approval time by addressing issues early in the process while helping to ensure compliance with the stormwater regulations. The developer is required to prepare a conceptual plan, an ERSA map and submit photographs from each face of the parcel being developed.

PWD representatives review the ERSA, ERSA map, site photographs, and concept plan and, if needed, meet with the developer and their engineers to discuss the conceptual development plan in terms of water, sewer, and stormwater utilities.

Based on the recommendations from PWD, the Philadelphia City Planning Commission, and the Streets Department, the developer prepares a final site plan.

### L.12 Low Impact Development/Redevelopment/Retrofit: Require Integrated Site Design

The City's Stormwater Management Manual provides a recommended site design procedure for comprehensive stormwater management. It is based on the procedure recommended by the Pennsylvania Department of Environmental Protection (PADEP), with minor modifications to adapt it to conditions in Philadelphia. This procedure includes non-structural controls that reduce the quantity of stormwater that needs to be managed and structural controls that meet the water quality, channel protection, and flood control requirements of the regulations. The integrated site design procedure can be summarized in three steps:

1. Protect and utilize existing site features
2. Reduce impervious cover to be managed
3. Manage remaining stormwater using a systems approach to stormwater management facility design

### L.13 Low Impact Development/Redevelopment/Retrofit: Require Post-Construction Stormwater Management

Land-based stormwater management approaches include Philadelphia's stormwater management regulations for new development and redevelopment, enacted in 2006. These regulations focus on restoring a more natural balance between stormwater runoff and infiltration, reducing pollutant loads, and controlling runoff rates at levels that minimize stream bank erosion. When a given site is developed in accordance with the requirements, the regulations ensure that the site will not contribute to impairment of a surface water body in Philadelphia. Site designers can provide the level of performance required using a variety of controls such as disconnection of impervious cover, bioretention, subsurface storage and infiltration, green roofs, swales, and tree canopy.

### L.14 Low Impact Development/Redevelopment/Retrofit: Post-Construction Inspection and Enforcement

With post-construction stormwater control requirements in place, an inspection and enforcement program is necessary to ensure that controls are properly constructed and maintained on private land. PWD inspectors verify that facilities are constructed in accordance with post-construction stormwater management plans approved by PWD. Inspectors also make periodic inspection to check that facilities are maintained in accordance with operation and maintenance agreements required under Philadelphia's stormwater regulations.

### L.15 Low Impact Development/Redevelopment/Retrofit: Demonstration Projects on Public Lands

Retrofit of public lands with innovative stormwater management measures provide a benefit and also serve as an example to developers and others in the region. This demonstration program will allow PWD to implement various types of projects on a small scale in order to assess effectiveness of various technologies.

### L.16 Low Impact Development/Redevelopment/Retrofit: Large-Scale Implementation on Public Lands

In addition to stormwater management required in redevelopment projects, the City of Philadelphia plans to lead by example. Retrofit of public lands with innovative stormwater management measures provide a benefit and also serve as an example to developers and others in the region.

### L.17 Low Impact Development/Redevelopment/Retrofit: Street Trees and Street Greening

Increased tree cover over streets reduces runoff while providing a range of additional benefits including aesthetics. When possible, additional street greening measures can further improve the appearance and stormwater management performance of a street. These include surface vegetated practices, tree trenches that receive street and sidewalk runoff, and infiltration inlets.

### L.18 Low Impact Development/Redevelopment/Retrofit: Revise Stormwater Rate Structure

PWD has conducted an extensive study of the possibility of stormwater management fees based on impervious cover. As the owner and operator of combined and separate storm sewers, PWD is considered a stormwater utility and has the authority to collect a stormwater service fee. Currently, that fee is tied to the size of a customer's meter. The new stormwater rates will tie the fee to the area of impervious cover on the customer's site, creating an incentive to reduce impervious cover. If a residential property is four units or less, they will not be charged based on the individual property characteristics.

### L.19 Low Impact Development/Redevelopment/Retrofit: Stormwater Management Incentives for Retrofit

Incentives and outreach form the third part of Philadelphia's long-term plan for widespread implementation of stormwater management. PWD is studying a number of potential programs to encourage stormwater controls beyond those required by ordinance.

### L.20 Public Education: Water Efficiency

Water efficiency can be defined as practices, techniques, and technologies that improve the efficiency of water use. An effective water efficiency program helps to reduce CSOs by reducing sanitary flow. This reduction provides an increase in CSS collection and treatment capacity during storm events. A water efficiency program can improve both CSO control and the long-term sustainability of the urban water system.

### L.21 Public Education: Catch Basin Stenciling

Storm drain marking involves labeling storm drain inlets with plaques, tiles, painted or pre-cast messages warning citizens not to dump pollutants into the drain. The messages are generally a simple phrase or graphic to remind those passing by that the storm drains connect to local waterbodies and that dumping will pollute those waters. Some storm drain markers specify which waterbody 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." In addition, storm drain markers often have pictures to convey the message, including common aquatic fauna or a graphic depiction of the path from drain to waterbody. Communities with a large population which speak other languages might wish to develop markers in both English and that other language, or use a graphic alone.

In the City of Philadelphia, on an annual basis, community and watershed volunteers participate in PWD and Water Quality Council sponsored Earth Day service project by installing storm drain curb markers throughout the City. Roughly 10,000 stencils are decaled annually.

### L.22 Public Education: Community Cleanup and Volunteer Programs

Hosting a stream cleanup is an effective way to promote stormwater awareness. A stream cleanup allows concerned citizens to become directly involved in water pollution prevention and to see the effects of pollution. Participants volunteer to walk (or paddle) the length of the stream or river, collecting trash and recording information about the quantity and types of garbage that has been removed. Stream cleanups also educate members of the community about the importance of stream water quality through media coverage and publicity efforts. Many programs have experts on hand at the event to discuss the stream's ecology and history. As a result, the stream is cleaner, volunteers feel a sense of accomplishment, and the community is better informed. The watershed partnerships initiated by PWD coordinate stream cleanups throughout the year. The PWD Waterways Restoration Team have been able to assisted these efforts by removing large debris that volunteers would not be able to remove by hand. Continuation of these practices is recommended.

### L.23 Public Education: Pet Waste Education

Pet waste is a major contributor of bacteria loading in urban stormwater. The City of Philadelphia actively enforces code which covers the regulation of animal waste. The Philadelphia Code and Charter Chapter 10.100 – Animals and Chapter 10.700 – Refuse and Littering address the proper clean-up of pet waste and applicable fines and penalties. In addition, signs advertising the said penalties are displayed city-wide in any effort to prevent residents from violating this statute. The

City of Philadelphia also provides the text of this code online at http://municipalcodes.lexisnexis.com/codes/philadelphia/.

## L.24 Public Education: Public Notification and Signage

PWD has developed and will continue to develop a series of informational brochures and other materials about its CSO discharges and the potential effect on the receiving waters. Brochures and other educational materials discuss the detrimental effects of these overflows and request that the public report these incidences to the department.

*CSO Outfall Signage*

The CSO Signage project was initiated to inform the public of the potential hazards of contact with the stream during combined sewer overflow events. The signs, placed at outfalls that are accessible by the public, let people know that during wet weather, it is possible for polluted water to flow from the outfall and that it would be hazardous to their health to contact the water during such events. It also requests that PWD be informed of any overflows during dry weather and provides an emergency number to call.

The CSO Signage Project was a pilot project aimed at determining if outfall signage was a feasible way to accomplish public notification of combined sewer overflows. PWD, in conjunction with the Philadelphia Department of Parks and Recreation, installed 13 signs at CSO outfalls in the City. Survey of the sites determined that several of the signs were removed or vandalized. Of the thirteen signs that were installed, five of them were vandalized or removed during the short amount of time between installation and the survey.

Although signage is seen as a simple, low-cost, visual way to raise awareness of combined sewer outfalls, this pilot project has highlighted the difficulties in using signs as a public notification system in Philadelphia due to the high rate of vandalism or loss of the signs in the field.

*CSO Identification Signage*

Signage was installed at each of Philadelphia's CSO outfalls, with the exception of eight difficult to reach sites. The CSO outfalls now have identification signs displaying their outfall ID number. These signs are very useful if the public needs to report a problem at an outfall, they are able to accurately identify the outfall. This helps to alleviate communication problems between the public and the PWD responders.

## L.25 Public Education: Litter and Dumping Education

Because stormwater runoff is generated from dispersed land surfaces—pavements, yards, driveways, and roofs—efforts to control stormwater pollution must consider individual, household, and public behavior and activities that can generate pollution from these surfaces.

It takes individual behavior change and proper practices to control such pollution. Therefore it is important to make the public sufficiently aware and concerned about the significance of their behavior for stormwater pollution, through information and education.

CSS permittees are required to educate their community on the pollution potential of common activities, and increase awareness of the direct links between land activities, rainfall-runoff, storm drains, and their local water resources. Most importantly the requirement is to give the public clear guidance on steps and specific actions that they can take to reduce their stormwater pollution potential.

The intent of the NMC 8, public notification, is to inform the public of the location of CSO outfalls, the actual occurrences of CSOs, the possible health and environmental effects of CSOs, and the recreational or commercial activities (*e.g.*, swimming and shellfish harvesting) curtailed as a result of CSOs. Public notification is of particular concern recreation areas directly or indirectly affected by CSOs. Potential risk is generally indicated by the exceedance of relevant water quality criteria.

The City of Philadelphia promotes, develops, and implements litter reduction programs, in an effort to increase public awareness of litter as a source of stormwater pollution. To supplement the Streets Department street cleaning program and to create awareness, the Philadelphia More Beautiful Committee organizes neighborhood cleaning events city-wide.

### L.26 Public Education: School-Based Education

School-based watershed education takes many forms, from lesson plans within the classroom, to hands-on activities outside of the classroom such as field trips to the Cobbs and Darby Creeks and nearby nature centers, as well as conducting actual restoration projects. Teacher training programs, developed to assist teachers in bringing watershed concepts to their students. Being engaged in actual restoration projects, whether through service learning, after school clubs, or as part of lesson plans, translates lessons into action. The Fairmount Waterworks Interpretive Center utilizes innovative technology and provides an engaging field trip to teach school groups about their impact on Philadelphia's watersheds..

### L.27 Good Housekeeping: Loading, Unloading, and Storage of Materials

Responsible management of common chemicals, such as fertilizers, solvents, paints, cleaners, and automotive products, can significantly reduce polluted runoff. Such products must be handled properly in all stages of development, use, and disposal. Materials management entails the selection of the individual product, the correct use and storage of the product, and the responsible disposal of associated waste(s).

Failure to properly store hazardous materials dramatically increases the probability that they will end up in local waterways. Many people have hazardous materials stored throughout their homes, especially in garages and storage sheds. Practices such as covering hazardous materials or storing them properly can have dramatic impacts. The Philadelphia Streets Department advertises locations and times of household hazardous waste can be dropped off at http://www.phila.gov/streets/HHW.html. The website also describes the types of waste that can be collected and other online resources.

### L.28 Good Housekeeping: Spill Prevention and Response

Spill prevention is prudent both economically and environmentally, because spills increase operating costs and lower productivity. The City's response plan to contain harmful spills that may discharge to the municipal sewer system is managed by the Philadelphia Local Emergency Planning Committee. PWD is represented by the Industrial Waste Unit (IWU), whose personnel are charged with response to such events.

In order to protect the PWD's structures and treatment processes, IWU personnel respond to oil and chemical spills and other incidents that have the potential to threaten the water supply or impact the combined sewer system, twenty-four hours per day, seven days per week. IWU supervises cleanup activities and assesses environmental impact. The inspectors also investigate various other types of complaints.

### L.29 Good Housekeeping: Street Sweeping Programs

Street and parking lot cleaning performed on a regular basis in urban and dense residential areas can be an effective measure for minimizing stormwater pollutant, sediment, and floatables loading to receiving waters.

Street sweeping programs had largely fallen out of favor as a pollutant removal practice following the U.S Environmental Protection Agency's (US EPA's) 1983 Nationwide Urban Runoff Program (NURP) report. Recent improvements in street sweeper technology, however, have enhanced the ability of modern machines to pick up the fine grained sediment particles that carry a substantial portion of the stormwater pollutant load, and have led to a recent reevaluation of their effectiveness. New studies show that conventional mechanical broom and vacuum-assisted wet sweepers reduce non-point pollution by 5 to 30% and nutrient content by 0 to 15%. However, newer dry vacuum sweepers can reduce non-point pollution by 35 to 80% and nutrients by 15 to 40% for those areas that can be swept (Runoff Report, 1998). A benefit of high-efficiency street sweeping is that by capturing pollutants before they are made soluble by rainwater, the need for structural stormwater control measures might be reduced. Structural controls often require costly added measures, such as adding filters to remove some of these pollutants and requiring regular maintenance to change-out filters. Street sweepers that can show a significant level of sediment removal efficiency may prove to be more cost-effective than certain structural controls, especially in more urbanized areas with greater areas of pavement.

### L.30 Good Housekeeping: Vehicle & Equipment Management

Common activities at municipal maintenance shops include parts cleaning, vehicle fluid replacement, and equipment replacement and repair. Automotive maintenance facilities are considered to be stormwater "hot spots." Hot spots are areas that generate significant loads of hydrocarbons, trace metals, and other pollutants that can affect the quality of stormwater.

Fluid spills and improper disposal of materials result in pollutants, heavy metals, and toxic materials entering ground and surface water supplies, which can create public health and environmental risks. Municipal facilities that properly store automotive fluids and thoroughly clean up spills can help reduce the effects of automotive maintenance practices on stormwater runoff and, consequently, local water supplies.

### L.31 Good Housekeeping: Private Scrapyard Inspection and Enforcement

Automobile recycling facilities can release stormwater polluted with oil, antifreeze, pesticides, animal waste, and a range of other materials. Increased enforcement can be an effective pollution prevention measure when owners fail to follow required best management practices.

### L.32 Good Housekeeping: Employee Training

In-house employee training programs are established to teach employees about stormwater management, potential sources of contaminants, and Best Management Practices (BMPs). Employee training programs should instill all personnel with a thorough understanding of their Storm Water Pollution Prevention Plan (SWPPP), including BMPs, processes and materials they are working with, safety hazards, practices for preventing discharges, and procedures for responding quickly and properly to toxic and hazardous material incidents.

### L.33 Good Housekeeping: Record Keeping and Reporting

Keeping records of spills, leaks, and other discharges can help a facility run more efficiently and cleanly. Records of past spills contain useful information for improving BMPs to prevent future spills. Typical items that should be recorded include the results of routine inspections, and reported spills, leaks, or other discharges.

### L.34 Good Housekeeping: Flow Diversion and Exposure Minimization Structures

Flow diversion structures (such as gutters, drains, sewers, dikes, berms, swales, and graded pavement) are used to collect and divert runoff to prevent the contamination of stormwater and receiving water. Flow diversion structures can be used in two ways. First, flow diversion structures may be used to channel stormwater away from industrial areas so that it does not mix with on-site pollutants. Second, flow diversion may be used to carry contaminated runoff to a treatment facility.

### L.35 Good Housekeeping: Responsible Bridge and Roadway Maintenance

Sediment and pollutants are generated during daily roadway and bridge use and scheduled repair operations, and these pollutants can impact local water quality by contributing heavy metals, hydrocarbons, sediment and debris to stormwater runoff. The use of road salt and de-icing material is a public safety as well as a water quality issue. Aside from contaminating surface and groundwater, high levels of sodium chloride from road salt can kill roadside vegetation, impair aquatic ecosystems, and corrode infrastructure such as bridges, roads, and stormwater management devices. Responsible maintenance includes proper storage and application of materials to the roadways. There are six municipal salt storage areas in the City, all of which have been covered to prevent precipitation from coming in contact with the salt.

### L.36 Pollution Prevention: Require Industrial Pretreatment

Under the NMC 3, the municipality should determine whether nondomestic sources are contributing to CSO impacts and, if so, investigate ways to control them. The objective of this control is to minimize the impacts of discharges into CSSs from nondomestic sources (*i.e.*, industrial and commercial sources, such as restaurants and gas stations) during wet weather events, and to minimize CSO occurrences by modifying inspection, reporting, and oversight procedures within the approved pretreatment program. Once implemented, this minimum control should not require additional effort unless CSS characterization and modeling indicate that a pollutant from a nondomestic source is causing a specific health, water quality, or environmental problem.

### L.37 Pollution Prevention: On-Lot Disposal (Septic System) Management

Septic tank management programs are presently required of all Pennsylvania municipalities as part of their Official Act 537 Sewage Facilities Plans. Keeping these plans up to date, including provisions related to operation and maintenance of on-lot sewage disposal systems is an important means of controlling the release of pathogens and nutrients within the watershed.

### L.38 Pollution Prevention: Household Hazardous Waste Collection

Leftover household products that contain corrosive, toxic, ignitable, or reactive ingredients are considered to be "household hazardous waste." Products, such as paints, cleaners, oils, batteries, and pesticides that contain potentially hazardous ingredients require special care when disposed of.

Improper disposal of household hazardous wastes can include pouring them down the drain, on the ground, into storm sewers, or in some cases putting them out with the trash. The dangers of such disposal methods might not be immediately obvious, but improper disposal of these wastes can pollute the environment and pose a threat to human health.

### L.39 Pollution Prevention: Oil/Water Separator/WQ Inlets

Water quality inlets (WQIs), also commonly called oil/grit separators or oil/water separators, consist of a series of chambers that promote sedimentation of coarse materials and separation of free oil (as opposed to emulsified or dissolved oil) from stormwater. Most WQIs also contain screens to help retain larger or floating debris, and many of the newer designs also include a coalescing unit that helps to promote oil/water separation. WQIs typically capture only the first portion of runoff for treatment and are generally used for pretreatment before discharging to other BMPs.

#### L.40 Pollution Prevention: Industrial Stormwater Pollution Prevention

These measures include monitoring and enforcing existing industrial stormwater permit requirements under Phase I of the NPDES program, as well as, Official Industrial Pollution Prevention Plans and Spill Response Actions required by the state. Full implementation of these measures should be monitored and enforced throughout the watershed.

#### L.41 Pollution Prevention: Litter and Illegal Dumping Enforcement

This option involves increased enforcement of Philadelphia's litter and dumping ordinance.

#### L.42 Pollution Prevention: Require Construction-Phase Stormwater/E&S Controls

PWD enforces construction-phase erosion and sediment (E&S) control within the City in accordance with PADEP requirements. These measures reduce the load of solids to the combined sewer system and receiving waters. PWD staff review and approve E&S plans submitted by developers. During construction, site inspections are conducted and fines are levied if necessary to ensure compliance.

## 6.2 Detailed Evaluation of Green Infrastructure Feasibility

For the reasons discussed in Section 6.1, there is no question that measures to control stormwater at the source will be part of the City's CSO LTPCU. The questions to be answered by the screening and analysis tools discussed in this section are the following:

- How much land-based stormwater management is possible over the long-term planning horizon? In other words, at the conclusion of the period covered by the CSO LTCPU, what land area can be served by measures to manage stormwater at the source?

- What is the benefit of these land-based measures in terms of the water quality and CSO control goals set forth earlier in this LTCPU?

### 6.2.1 Performance Criteria

Philadelphia's stormwater ordinance, contained in Chapter 14-1600 of the City's Code and Charter, lays out a broad framework for required post-construction stormwater controls. Chapter 14 1603.1.6.c.1 of the ordinance allows the PWD to develop additional regulations that clarify requirements of the ordinance and specify types of controls that can be used to meet the requirements.

Requirements of the Stormwater Management Regulations define a minimum level of performance for all stormwater controls in the City. There are three major elements to the Philadelphia Stormwater Regulations: a water quality requirement, a channel protection and CSO reduction requirement, and a flood control requirement.

*Water Quality Requirement*

The Water Quality Requirement is equivalent to 1.0 in of precipitation over the directly connected impervious area (DCIA) on a site. This requirement is established to: 1) recharge the groundwater table and increase stream baseflow; and 2) reduce stormwater runoff and combined sewer overflow. The requirement is similar to water quality requirements in surrounding states and in other major cities.

1. The management technique required is infiltration unless infiltration is determined to be physically impossible (due to contamination, high groundwater table, shallow bed rock, impermeable soil) or where it can be shown that doing so would cause property or environmental damage. Infiltration efficiently reduces overflow volume, frequency, and duration by preventing water from reaching the combined sewer system

2. Where infiltration is not feasible for the entire volume, any remaining portion that cannot be infiltrated must be detained and released at a specified rate. This slow release rate reduces overflow volume and frequency by diverting more flow to wastewater treatment plants. However, detention and slow release are less efficient at reducing CSOs than infiltration, as demonstrated by results presented later in this section

In addition to efficiency in preventing overflow, infiltration is desirable for a number of reasons:

- Nearly all portions of streams in Philadelphia are listed as impaired by quantity-related issues (high flows and velocities caused by urban runoff), while only a few are listed for quality-related issues. Infiltration restores a more natural water balance, reducing both the quantity and duration of runoff and overflow
- The easiest way to manage the 1.0 in water quality volume is to infiltrate it. Designing a control structure to store and release runoff at a slow rate is more difficult technically and requires more maintenance
- Approximately 0.3 to 0.5 in of recharge is sufficient to restore the natural (historical) water balance on a watershed basis. However, redevelopment takes place very slowly and it makes sense to infiltrate more than this amount on sites where it is feasible. Most development taking place in the City will be redevelopment
- The water table is deep in most parts of the City, and there is little concern that increased infiltration on redevelopment sites will lead to a regional water table rise that will cause problems. The water table can be assessed on a site-by-site basis
- Many peer cities require a portion of the water quality volume to be infiltrated based on natural soil type. Philadelphia has mostly urban soils and limited information is available for them. It makes sense to determine infiltration capacity on a site-by-site basis rather than prescribe it
- Design alternatives exist to address many common objections to infiltration, such as wet basements and groundwater contamination due to small amounts of pollutants in parking lot runoff

*Channel Protection Requirement*

The channel protection requirement results in release of runoff from a 1 -yr, 24-hr event at a specified rate. The channel protection requirement is established to: 1) protect quality of stream channels and banks, fish habitat, and man-made infrastructure from the influences of high stream velocity erosive forces and 2) further reduce the quantity, frequency and duration of CSOs. Philadelphia's channel protection requirement is modeled after those adopted in many other cities and states, including Atlanta, Baltimore, Boston, Detroit, Minneapolis, Portland, Seattle, Washington D.C., Maryland, New Jersey, and New York.

Some development sites receive an exemption from the requirement because they provide a sufficient level of control without it. The channel protection requirement does not apply to sites directly discharging to the larger rivers or tidal waters. As an incentive for innovative design, sites are exempt if they can demonstrate a minimum 20% reduction in DCIA between the pre-construction and post-construction conditions. Finally, sites with less than one ac of earth disturbance receive an exemption because it is believed the requirement may be a disincentive for redevelopment on smaller sites.

Numerically, the channel protection requirement states that the design must detain and release runoff from a 1-yr, 24-hour event at an average rate of 0.12 cfs per ac and a maximum rate of 0.24 cfs per ac in no less than 24 hours and no more than 72 hours. This release rate protects streambanks by approximating streamflow in an undeveloped watershed. Modeling results, presented later in this section, demonstrate that it is sufficient to reduce, but not eliminate, combined sewer overflows. The specified release rate in combined sewered areas was not further reduced because it is believed that design and maintenance of a control structure to provide an even smaller release rate may be infeasible on smaller sites. Design alternatives exist to prevent clogging of small orifices, but practical limits exist to these technologies.

*Flood Control Requirement*
The flood control requirement is established to reduce or prevent the occurrence of flooding in areas downstream of the development site caused by inadequate sewer capacity or overtopping of stream banks. In general, a development project is required to limit peak runoff in the post-development condition to peak runoff in the pre-development condition. The flood control requirement is not intended to provide a significant CSO or water quality benefit but is a necessary part of a comprehensive stormwater management program.

*Systems Approach to Design of Stormwater Management Practices*
The design process is intended to meet the level of control required. Site designers can provide the level of performance required using a variety of controls such as disconnection of impervious cover, bioretention, subsurface storage and infiltration, green roofs, swales, and tree canopy.

A structural stormwater management facility is a system that uses physical, chemical, and biological processes to provide the level of stormwater control required. These requirements are met through the five principle hydraulic functions of stormwater control structures: storage, infiltration, evapotranspiration, controlled release, and overflow or bypass flow. Figure 6.1 illustrates a variety of design elements available to provide these functions. Depending on the configuration, physical, chemical, and biological processes lead to removal of pollutants during these processes.

By combining design components in a variety of ways, the designer can identify alternative systems that achieve a given function. Figure 6.2 illustrates several different designs that are capable of storing the runoff from a 1-yr storm over a parking lot, infiltrating the first inch of runoff, and releasing the remainder at a slow rate.

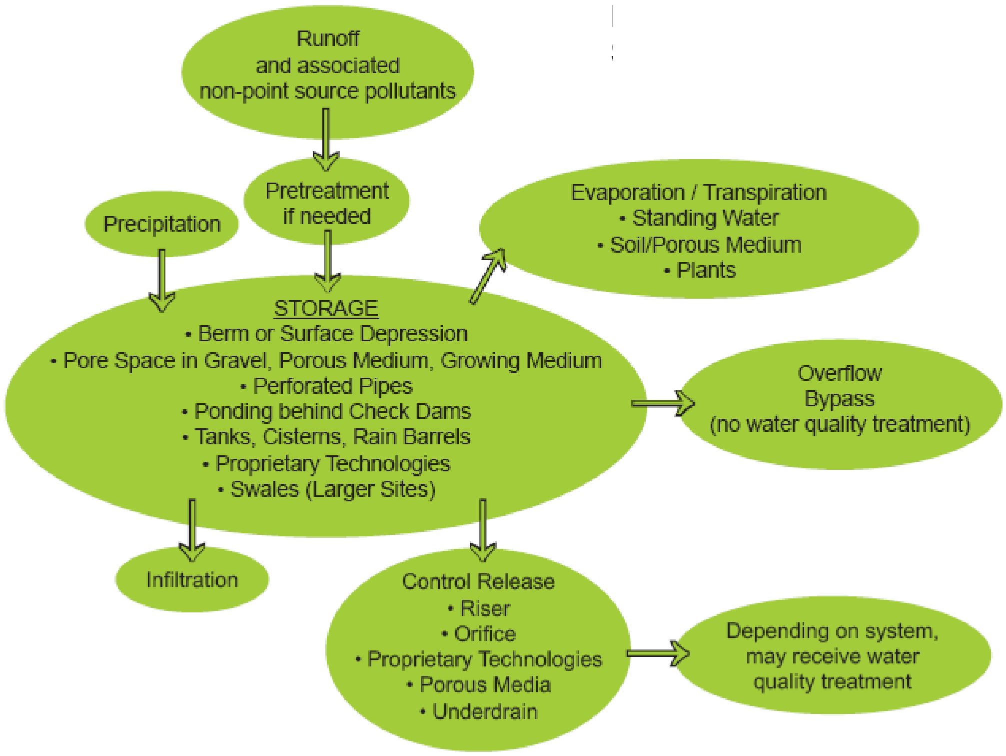



**Figure 6.1 Systems Approach to SMP Design**

### 6.2.2 Study Methods

The US EPA's Storm Water Management Model (SWMM) was chosen to evaluate the operational characteristics and benefits of structural measures because it is suitable to the hydrologic and hydraulic complexity of the system and provides the capability to simulate the operation of most structural options under consideration. In addition, a SWMM-based model of land-based measures can easily interface with PWD's SWMM combined sewer model.

Modeling was conducted according to the same systems principles applied to facility design. Philadelphia's stormwater regulations require a minimum level of performance from post-construction stormwater management structures (hereafter referred to as Stormwater Regulations Level of Control, SRLC). Rather than focusing on differences in structure between different land-based practices, the modeling team assumed that an appropriate practice or mix of practices can be designed to meet this level of performance. The team modeled a general structure that meets management goals through some combination of storage, infiltration, and slow release. Details of the modeling approach are discussed in Section 5.

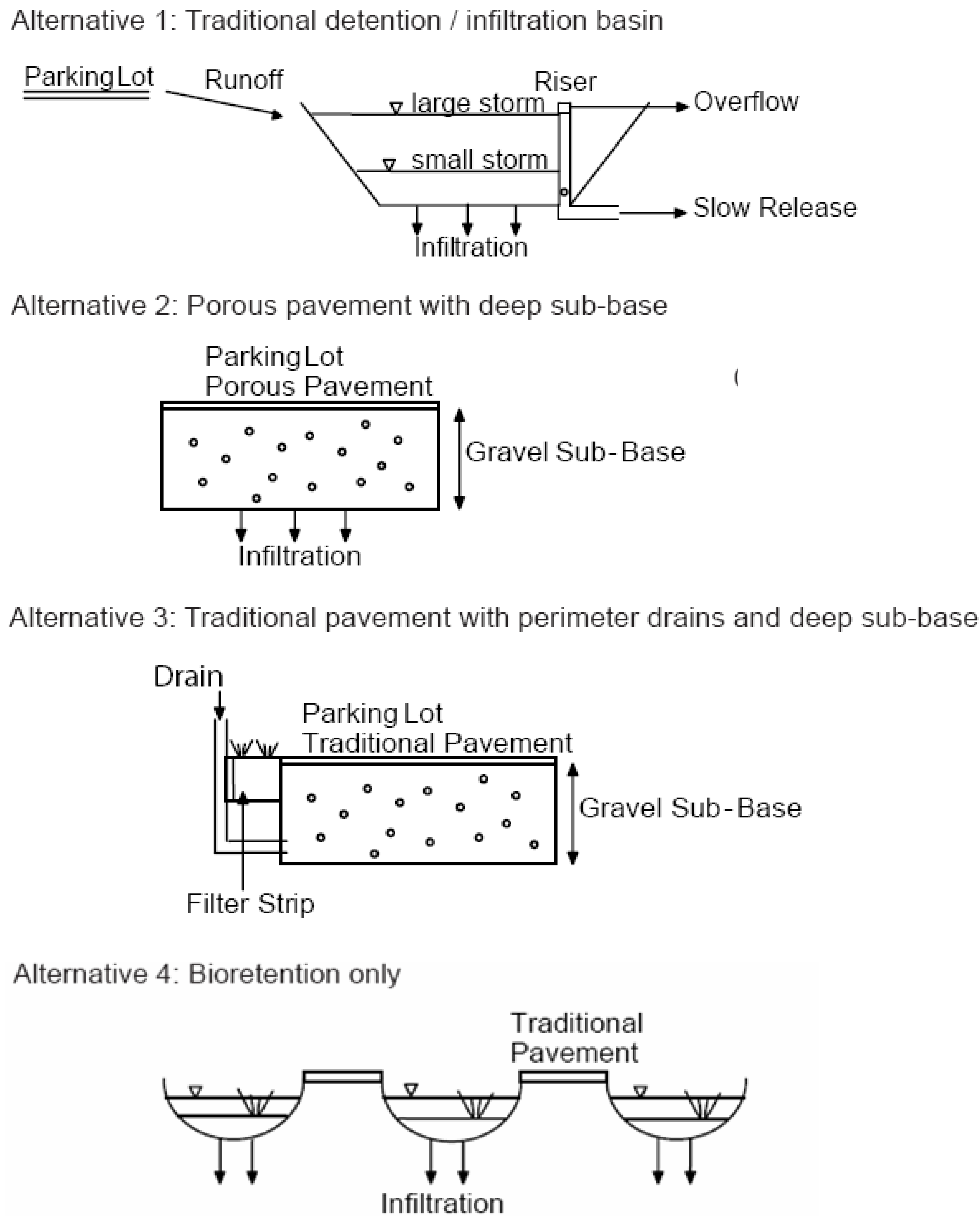
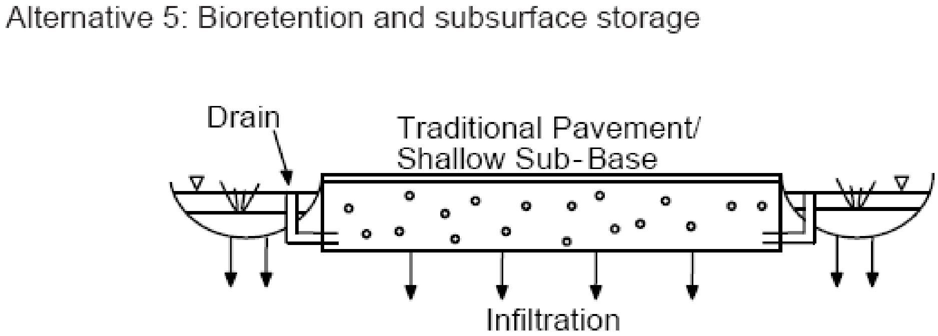



**Figure 6.2 Different Designs for Storing Runoffs**



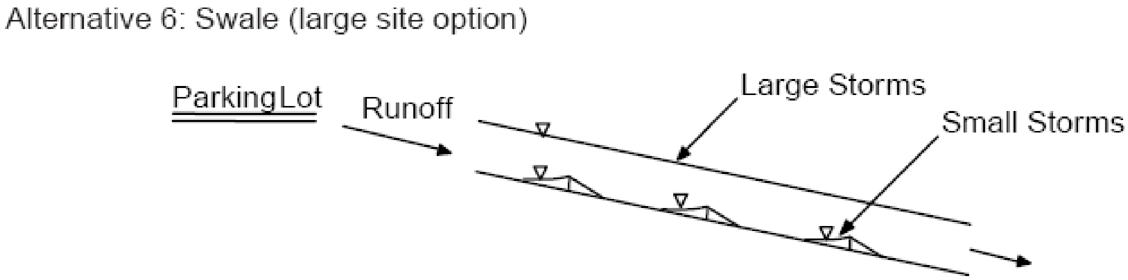




**Figure 6.2 Different Designs for Storing Runoffs (Continued)**

### 6.2.3 Results

*Green Infrastructure Performance Simulation Results*

The primary purpose of green infrastructure is to restore a water balance more similar to natural, pre-development conditions. The water budgets for SRLC simulations with varying levels of implementation for each drainage district are shown in Table 6.2. Figures 6.3 through 6.5 show a visual representation of results for the SE, NE and SW districts, respectively. These show changes in soil infiltration volume, detained and released volume, overflow from management facilities, surface evaporation and uncontrolled runoff volume as the percentage of land area managed increases. As the level of implementation increases, the total runoff is reduced. The runoff instead either infiltrates the soil or is detained and released prior to entering the combined sewer system.

**Table 6.2 Component Volumes of the Water Budget Comparing Results of Baseline Model Simulations to SRLC Simulations Representing Varying Levels of Impervious Area Served by Land-Based Controls for Each Drainage District**

| SE Drainage District | | | | | | |
|---|---|---|---|---|---|---|
| Model | Percent of Area Served by LID | LID Overflow (MG) | Detained and Released (MG) | Soil Infiltration (MG) | Surface Evaporation (MG) | Uncontrolled Runoff (MG) |
| Upper Limit of Uncertainty Range | | | | | | |
| Baseline | Existing | - | - | 4,350 | 534 | 6,375 |
| SRLC | 25% | 134 | 202 | 5,554 | 541 | 4,976 |
| SRLC | 50% | 265 | 406 | 6,754 | 548 | 3,564 |
| SRLC | 75% | 394 | 611 | 7,957 | 559 | 2,144 |
| SRLC | 100% | 523 | 818 | 9,164 | 582 | 704 |

| SE Drainage District | | | | | | |
|---|---|---|---|---|---|---|
| Model | Percent of Area Served by LID | LID Overflow (MG) | Detained and Released (MG) | Soil Infiltration (MG) | Surface Evaporation (MG) | Uncontrolled Runoff (MG) |
| Lower Limit of Uncertainty Range | | | | | | |
| SRLC | 25% | 101 | 151 | 6,850 | 397 | 3,872 |
| SRLC | 50% | 200 | 304 | 7,754 | 405 | 2,805 |
| SRLC | 75% | 298 | 458 | 8,660 | 417 | 1,731 |
| SRLC | 100% | 395 | 613 | 9,567 | 439 | 643 |
| NE Drainage District | | | | | | |
| Model | Percent of Area Served by LID | LID Overflow (MG) | Detained and Released (MG) | Soil Infiltration (MG) | Surface Evaporation (MG) | Uncontrolled Runoff (MG) |
| Upper Limit of Uncertainty Range | | | | | | |
| Baseline | Existing | 0 | 0 | 10,879 | 1,262 | 12,218 |
| SRLC | 25% | 267 | 591 | 13,098 | 1,254 | 9,508 |
| SRLC | 50% | 518 | 1,186 | 15,137 | 1,266 | 6,893 |
| SRLC | 75% | 770 | 1,785 | 17,181 | 1,285 | 4,267 |
| SRLC | 100% | 1,040 | 2,387 | 19,230 | 1,325 | 1,628 |
| Lower Limit of Uncertainty Range | | | | | | |
| Baseline | Existing | 0 | 0 | 13,936 | 927 | 9,499 |
| SRLC | 25% | 200 | 443 | 15,615 | 933 | 7,443 |
| SRLC | 50% | 396 | 889 | 17,148 | 947 | 5,480 |
| SRLC | 75% | 590 | 1,336 | 18,683 | 968 | 3,505 |
| SRLC | 100% | 770 | 1,785 | 20,221 | 1,003 | 1,495 |
| SW Drainage District | | | | | | |
| Model | Percent of Area Served by LID | LID Overflow (MG) | Detained and Released (MG) | Soil Infiltration (MG) | Surface Evaporation (MG) | Uncontrolled Runoff (MG) |
| Upper Limit of Uncertainty Range | | | | | | |
| Baseline | Existing | 0 | 0 | 8,702 | 727 | 9,031 |
| SRLC | 25% | 181 | 404 | 10,271 | 736 | 6,973 |
| SRLC | 50% | 360 | 810 | 11,832 | 750 | 5,018 |
| SRLC | 75% | 536 | 1,218 | 13,397 | 769 | 3,050 |
| SRLC | 100% | 710 | 1,628 | 14,995 | 807 | 1,057 |
| Lower Limit of Uncertainty Range | | | | | | |
| Baseline | Existing | 0 | 0 | 10,939 | 534 | 6,998 |
| SRLC | 25% | 136 | 304 | 12,137 | 545 | 3,811 |
| SRLC | 50% | 271 | 608 | 13,315 | 560 | 2,686 |
| SRLC | 75% | 405 | 914 | 14,494 | 580 | 1,554 |
| SRLC | 100% | 537 | 1,223 | 15,717 | 611 | 407 |

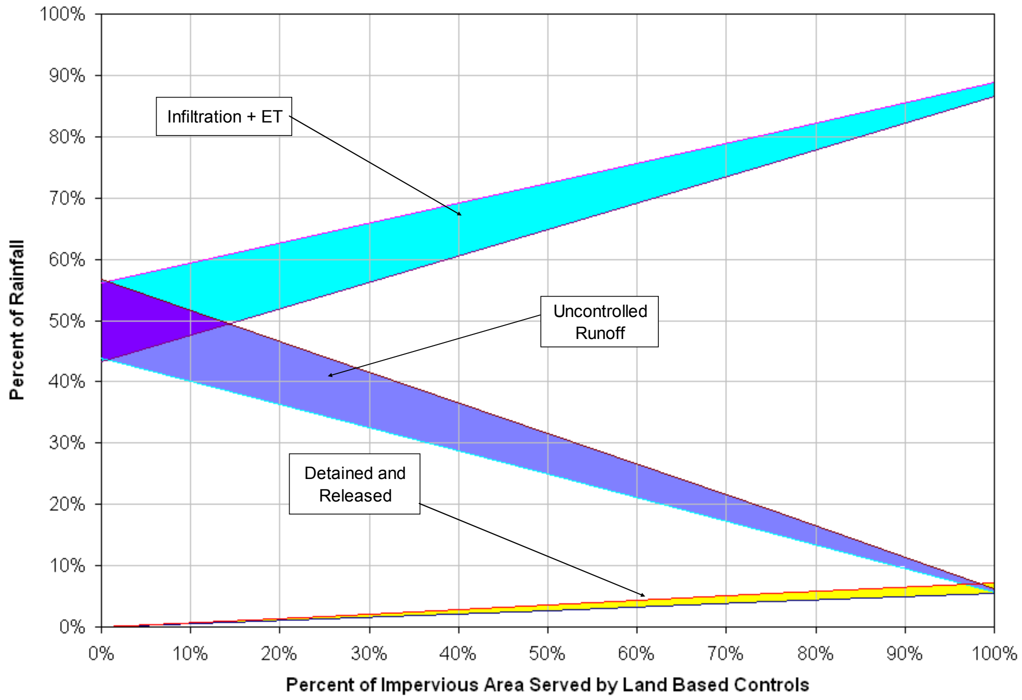



**Figure 6.3 SE Drainage District Water Budget Estimated From Simulating Stormwater Regulations for Varying Levels of Implementation. The Shaded Region Represents a Range of Uncertainty for the Quantity of Runoff Occurring**

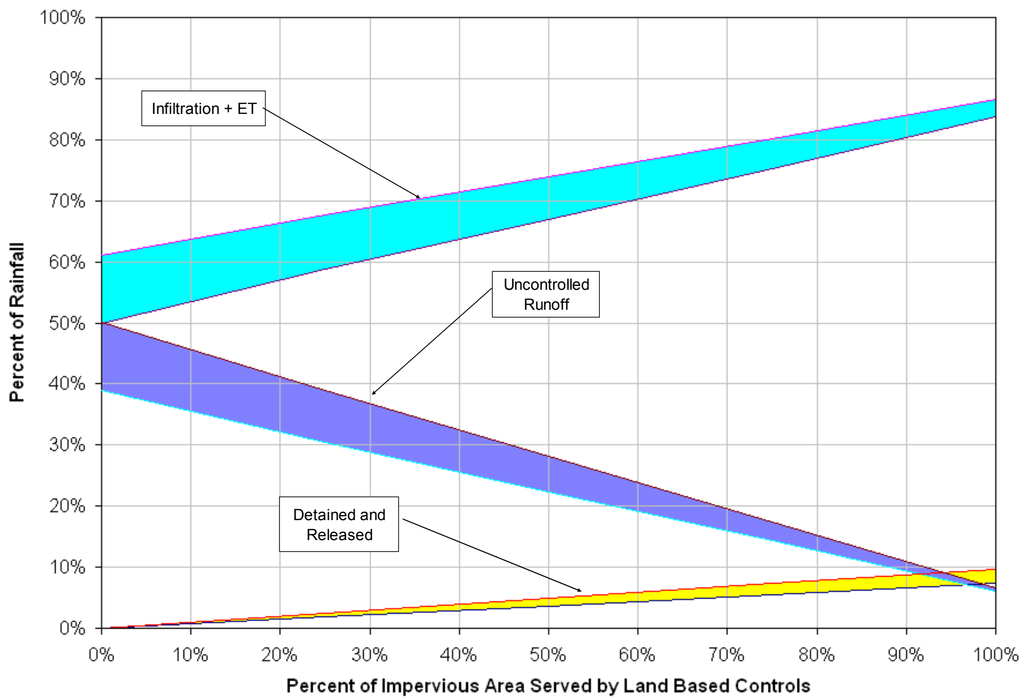



**Figure 6.4 NE Drainage District Water Budget Estimated From Simulating Stormwater Regulations for Varying Levels of Implementation. The Shaded Region Represents a Range of Uncertainty for the Quantity of Runoff Occurring**

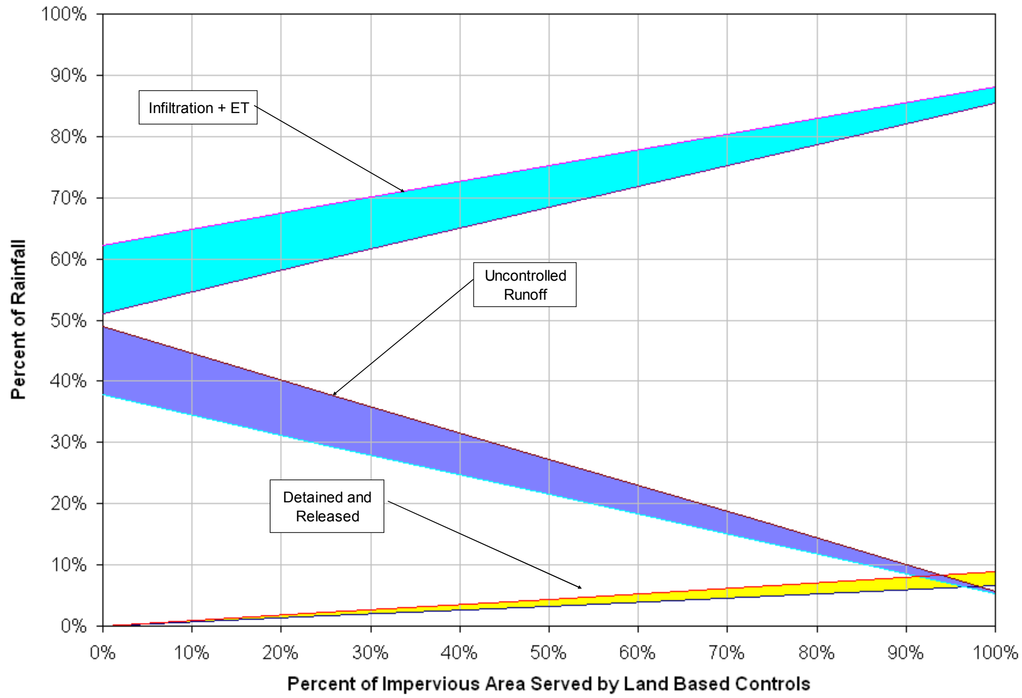



**Figure 6.5 SW Drainage District Water Budget Estimated From Simulating Stormwater Regulations for Varying Levels of Implementation. The Shaded Region Represents a Range of Uncertainty for the Quantity of Runoff Occurring**

Percent capture is a measure of the CSS performance and is defined as the percent of total combined sewage collected that is conveyed to the water pollution control plant (WPCP) during wet weather. Green Infrastructure implementation, however, reduces the volume of stormwater entering the CSS and thereby reduces the volume requiring treatment at the WPCP. In order to account for this performance benefit, an effective capture volume is determined as the total baseline combined sewage volume (sum of captured and overflow volumes) minus the SRLC simulation combined sewer overflow volume.

### 6.2.4 Feasible Implementation Range

*Analysis of Impervious Surfaces in Combined-Sewered Areas*

<u>Distribution of Impervious Surfaces by Type</u>

The type of impervious structure influences options available for management of stormwater. The distribution of buildings, parking, streets, and sidewalks is relatively constant in the three drainage districts, although highways are more significant in the southeast due to the smaller drainage area relative to Interstate 95 (Table 6.3).

Surfaces intended for parking (parking lots and driveways) represent approximately 20% of total impervious surfaces. Parking presents some of the most technically feasible stormwater management options. A portion of a parking lot can be converted to a surface vegetated management facility where space is available. Subsurface pretreatment, storage, and infiltration facilities, below traditional or porous pavement, can be installed where space is limited. Strategies on public and private land are similar.

Building roofs represent approximately 40% of impervious surfaces in the combined-sewered areas of Philadelphia. In the space-limited urban environment, managing stormwater from roofs can be

**Table 6.3 Distribution of Impervious Surfaces by Type**

| Impervious Surface Type | Combined-Sewered Impervious Area (ac) | | | | Combined-Sewered Impervious Area (% of total) | | | |
|---|---|---|---|---|---|---|---|---|
| | City-Wide | SEDD | NEDD | SWDD | City-Wide | SEDD | NEDD | SWDD |
| Building | 11,385 | 2,538 | 5,026 | 3,821 | 40 | 39.9 | 39.1 | 41.4 |
| Parking | 5,959 | 1,229 | 2,896 | 1,834 | 21 | 19.3 | 22.5 | 19.9 |
| Street+Sidewalk | 10,774 | 2,426 | 4,828 | 3,519 | 37.9 | 38.2 | 37.6 | 38.1 |
| Highway | 315 | 165 | 94 | 56 | 1.1 | 2.6 | 0.7 | 0.6 |

more challenging than managing parking lot runoff. Where space is available, runoff can be directed to the ground or subsurface level and managed using the same types of structures used to manage parking runoff. Where space is limited, green roofs are an option. Strategies on public and private land are similar.

Surfaces related to transportation (streets, sidewalks, and highways) represent approximately 40% of the total, including approximately 1% covered by interstate highways. This finding is significant because it suggests management of street runoff is critical to a program of widespread impervious cover mitigation. Management options include increased street tree cover with or without additional subsurface storage, surface vegetated approaches, porous pavement, and inlets designed for pretreatment and infiltration. These approaches may be more technically and programmatically challenging than management of building and parking lot runoff.

Distribution of Impervious Surfaces by Ownership/Management

Ownership of impervious surfaces has implications for management strategies. Although technical approaches on public and private land may be similar, approaches to implementation may be different. Approaches on private land include regulation and incentive programs. Approaches on public land require a commitment and coordinated implementation strategy across multiple agencies. Section 10 includes a description of the many tools available.

Approximately 55% of land in the combined-sewered areas is privately owned. Public land is dominated by streets and sidewalks, managed in Philadelphia by the Philadelphia Streets Department. PWD, Department of Parks and Recreation, School District, and other City agencies manage a relatively small portion (approximately 3%) of impervious area but have an opportunity to demonstrate and lead an effective city-wide implementation program. Approximately 2-3% of impervious surfaces are found on vacant or abandoned lands. In the long-term, these lands can either be left as open space or redeveloped in a way that does not impact water resources.

Distribution of Impervious Surfaces by Size

The distribution of parking lot sizes suggests that to achieve widespread implementation, both smaller and larger lots must be targeted. Small lots and driveways up to 1 ac in area make up approximately 55% of the total impervious area related to parking. Lots between 1 ac and 5 ac make up approximately 25% of the total. The largest lots greater than 5 ac make up approximately 20% of the total (Table 6.5).

**Table 6.4 Distribution of Impervious Surfaces by Ownership/Management**

| Impervious Surface Owner/Manager | Combined-Sewered Impervious Area (ac) | | | | Combined-Sewered Impervious Area (% of total) | | | |
|---|---|---|---|---|---|---|---|---|
| | City-Wide | SEDD | NEDD | SWDD | City-Wide | SEDD | NEDD | SWDD |
| Private Owner | 15,734 | 3,291 | 7,261 | 5,182 | 55.3 | 51.8 | 56.5 | 56.1 |
| PWD | 22 | 6 | 5 | 12 | 0.1 | 0.1 | 0.04 | 0.1 |
| Streets Department | 10,774 | 2,426 | 4,828 | 3,519 | 37.9 | 38.2 | 37.6 | 38.1 |
| Interstate Highway | 315 | 165 | 94 | 56 | 1.1 | 2.6 | 0.7 | 0.6 |
| Recreation Department | 115 | 26 | 65 | 25 | 0.4 | 0.4 | 0.5 | 0.3 |
| Fairmount Park Commission | 157 | 63 | 50 | 44 | 0.6 | 1 | 0.4 | 0.5 |
| School District of Philadelphia | 404 | 91 | 198 | 116 | 1.4 | 1.4 | 1.5 | 1.3 |
| Other Public Property | 213 | 83 | 68 | 62 | 0.7 | 1.3 | 0.5 | 0.7 |
| Vacant/Abandoned Property | 699 | 208 | 277 | 215 | 2.5 | 3.3 | 2.2 | 2.3 |

**Table 6.5 Distribution of Parking Area (City-Wide Combined Sewered Area)**

| Parking Area | Percent of Total | Cum. Percent of Total Parking Area |
|---|---|---|
| ≤ 10,000 $ft^2$ | 30.8 | 30.8 |
| ≤ 20,000 $ft^2$ | 3.9 | 41.9 |
| ≤ 30,000 $ft^2$ | 6.3 | 48.2 |
| ≤ 1 ac | 6.4 | 54.6 |
| ≤ 2 ac | 12..7 | 67.3 |
| ≤ 3 ac | 6.7 | 74.0 |
| ≤ 5 ac | 7.4 | 81.4 |
| ≤ 10 ac | 6.9 | 88.3 |

**Table 6.6 Distribution of Building Area (City-Wide Combined Sewered Area)**

| Percentile | Size ($ft^2$) | Percent of Total | Cum. Percent of Total Building Area |
|---|---|---|---|
| 10 | 404 | 0.40% | 0.40% |
| 20 | 933 | 1.20% | 1.60% |
| 30 | 1,421 | 2.20% | 3.80% |
| 40 | 1,812 | 2.90% | 6.70% |
| 50 | 2,205 | 3.70% | 10.40% |
| 60 | 2,837 | 4.50% | 14.90% |
| 70 | 4,549 | 6.50% | 21.40% |
| 80 | 7,645 | 10.90% | 32.30% |
| 90 | 13,568 | 18.60% | 50.90% |
| 95 | 19,277 | 14.70% | 65.60% |
| 99 | 42,608 | 18.80% | 84.40% |
| 100 | 1,102,144 | 15.50% | 100.00% |

The distribution of roof sizes suggests that it may be efficient to focus on larger buildings. The smallest half of buildings represents only 10% of total roof area, while the largest 10% represents nearly 50% of total roof area (Table 6.6).

Interstate Highways and Waterfront Land

Properties located close to the Delaware and Schuylkill waterfronts present opportunities for sewer separation, appropriate pretreatment of stormwater, and direction of stormwater to public or private permitted outfalls. It is important to note that the same land-based stormwater management techniques being considered for the combined sewer system can function as pretreatment for runoff entering a separate storm sewer system. This runoff would no longer be included in PWD's CSO management program but would continue to be managed through PWD's larger stormwater and watershed management programs.

Table 6.7 lists the "waterfront" drainage area currently draining to combined sewers. Waterfront can be defined in one of two ways. Defined as all land between interstate highways and rivers, it comprises approximately 4% of combined drainage area. This percentage is highest in the southeast drainage district at 7%. Defined more narrowly as the area between combined sewer regulator structures and the river, the waterfront area comprises approximately 2% of drainage area. There is also a long-term potential to disconnect the interstate highways themselves from the combined sewer system.

**Table 6.7 Distribution of Waterfront Land**

| Land Location | Combined-Sewered Impervious Area (ac) | | | | Combined-Sewered Impervious Area (% of total) | | | |
|---|---|---|---|---|---|---|---|---|
| | City-Wide | SEDD | NEDD | SWDD | City-Wide | SEDD | NEDD | SWDD |
| Non-waterfront | 43,414 | 8,700 | 20,060 | 14,654 | 95.8 | 91.5 | 98.4 | 94.9 |
| Between regulator structures and rivers | 681 | 157 | 245 | 279 | 1.6 | 1.8 | 1.2 | 1.9 |
| Between major highways and rivers | 1,507 | 578 | 234 | 695 | 3.5 | 6.6 | 1.2 | 4.7 |
| Highway | 315 | 165 | 94 | 56 | 1.1 | 1.9 | 0.5 | 0.4 |
| Waterfront + hghway | 1,822 | 743 | 327 | 752 | 4.2 | 8.5 | 1.6 | 5.1 |

## 6.3 SCREENING RESULTS

The following criteria are proposed for initial screening of options:

1. Options that are required by NPDES permit or other regulation are recommended for inclusion in all management alternatives.
2. Options recommended for implementation in one of PWD's Integrated Watershed Management Plans are recommended for inclusion in all management alternatives.
3. Other options must meet at least one stated goal of the LTCPU to be considered for inclusion in management alternatives. Options also must be technically feasible to implement and maintain.

**Table 6.8 Recommendations for Land-Based Options**

| Number | Category | Option | Include in All Alternatives | Consider Including in Alternatives | Do Not Include in Alternatives |
|---|---|---|---|---|---|
| L.1 | Flow reduction | Catch basin modifications | X | | |
| L.2 | Flow reduction | Sump pump disconnect | X | | |
| L.3 | Flow reduction | Catch basin and storm inlet maintenance | X | | |
| L.4 | Flow reduction | Illicit connection control | X | | |
| L.5 | Flow reduction | Roof leader disconnect program | X | | |
| L.6 | Flow reduction | Street storage (catch basin inlet control) | | X | |
| L.7 | Flow reduction | Offload groundwater pumpage | X | | |
| L.8 | Flow reduction | Stream diversion | X | | |
| L.9 | Flow reduction | Groundwater infiltration reduction | X | | |
| L.10 | Flow reduction | Reduction of contractual flow | X | | |
| L.11 | Low impact development/ redevelopment/retrofit | Require existing resources inventory, sketch plan, initial meeting | X | | |
| L.12 | Low impact development/ redevelopment/retrofit | Require integrated site design | X | | |
| L.13 | Low impact development/ redevelopment/retrofit | Require post-construction stormwater management | X | | |
| L.14 | Low impact development/ redevelopment/retrofit | Post-construction inspection and enforcement | X | | |
| L.15 | Low impact development/ redevelopment/retrofit | Demonstration projects on public lands | X | | |
| L.16 | Low impact development/ redevelopment/retrofit | Large-scale implementation on public lands | X | | |
| L.17 | Low impact development/ redevelopment/retrofit | Street trees and street greening | X | | |
| L.18 | Low impact development/ redevelopment/retrofit | Revise stormwater rate structure | X | | |
| L.19 | Low impact development/ redevelopment/retrofit | Stormwater management incentives for retrofit | X | | |
| L.20 | Public education | Water efficiency | | X | |
| L.21 | Public education | Catch basin stenciling | X | | |
| L.22 | Public education | Community cleanup and volunteer programs | X | | |
| L.23 | Public education | Pet waste education | X | | |
| L.24 | Public education | Public notification and signage | X | | |
| L.25 | Public education | Litter and dumping education | X | | |
| L.26 | Public education | School-based education | X | | |
| L.27 | Good housekeeping | Loading, unloading, and storage of materials | X | | |

| Number | Category | Option | Include in All Alternatives | Consider Including in Alternatives | Do Not Include in Alternatives |
|---|---|---|---|---|---|
| L.28 | Good housekeeping | Spill prevention and response | X | | |
| L.29 | Good housekeeping | Street sweeping programs | X | | |
| L.30 | Good housekeeping | Vehicle & equipment management | X | | |
| L.31 | Good housekeeping | Private scrapyard inspection and enforcement | X | | |
| L.32 | Good housekeeping | Employee training | X | | |
| L.33 | Good housekeeping | Record keeping and reporting | X | | |
| L.34 | Good housekeeping | Flow diversion and exposure minimization structures | X | | |
| L.35 | Good housekeeping | Responsible bridge and roadway maintenance | X | | |
| L.36 | Pollution prevention | Require industrial pretreatment | X | | |
| L.37 | Pollution prevention | On-lot disposal (septic system) management | X | | |
| L.38 | Pollution prevention | Household hazardous waste collection | X | | |
| L.39 | Pollution prevention | Oil/water separator/WQ inlets | | | X |
| L.40 | Pollution prevention | Industrial stormwater pollution prevention | X | | |
| L.41 | Pollution prevention | Litter and illegal dumping enforcement | X | | |
| L.42 | Pollution prevention | Require construction-phase stormwater/E&S controls | X | | |