CITY OF FORTUNA
CONSTRUCTION
LOW IMPACT DEVELOPMENT
(LID)
MANUAL

Nov 2012

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1.0 LOW IMPACT DEVELOPMENT (LID)

Over the past decade, Low Impact Development (LID) has emerged as an innovative stormwater management approach with a basic principle that is modeled after nature: manage rainfall at the source using uniformly distributed decentralized micro-scale controls.

This manual is not intended to be inclusive of every LID best management practice (BMP) or device but as general guidance for installation of possible BMPs or devices. It is also intended to give ideas for techniques that could be utilized for LID. This manual outlines why LID is important, advantages to using LID and several methods for implementing LID.

1.1 OVERVIEW OF TRADITIONAL DEVELOPMENT

Traditional development manages stormwater by conveying and treating stormwater in large, costly end-of-pipe treatment systems. This stormwater management method is based on resolving stormwater issues caused from traditional development. Historically, end-of-pipe treatment and control technologies have been the leading methods of stormwater control.

Currently, stormwater management plans address site design, source control, and pollution prevention strategies. These strategies more effectively address water quality and velocity issues that result from development as opposed to the standard end-of-pipe controls. For the most part, regulatory mandates still preserve the traditional centralized collection and treatment system of control. However, LID principles are currently being incorporated into regulatory mandates. Federal and State regulators are incorporating LID into standard development procedures.

1.2 OVERVIEW OF LID

Unlike traditional development, LID is based on the idea that undeveloped land does not present a stormwater runoff or pollution problem. LID is a source control option that minimizes stormwater pollution by recognizing that the greatest efficiencies are gained by minimizing stormwater generation. This most often translates to high rates of infiltration, vegetative interception, and evapotranspiration.

LID mimics a site's natural, or predevelopment, hydrology by using design techniques and best management practices (BMPs) that infiltrate, filter, store, evaporate, and detain runoff close to its source. LID controls stormwater through integrated systems of decentralized, small, cost- effective features at individual construction sites, including:

- Open spaces
- Rooftops
- Streetscapes
- Parking lots
- Sidewalks
- Medians

These features represent some of the building blocks of LID. LID is a versatile approach that can be applied to new development, urban retrofits, redevelopment, and revitalization projects.

LID implementation is a process that conserves watershed resources, reduces impacts of development, and employs innovative BMPs to meet the stormwater objectives. It is not the use of BMPs alone. These practices, taken in aggregate, limit the observed onsite changes in hydrology resulting from development and present a comprehensive, efficient and beneficial stormwater management approach.

1.3 PRACTICES AND PROCEDURES

The potential of LID is maximized when it is used in conjunction with other conservation and planning approaches. Programs like Smart Growth are the first step of the process. Smart Growth is a community planning process that follows specific principles that include:

- Taking advantage of compact building design
- Creating a range of housing opportunities and choices
- Create walkable neighborhoods
- Foster distinctive, attractive communities with a strong sense of place
- Preserve open space, farmland, natural beauty, and critical environmental areas
- Strengthen and direct development towards existing communities
- Provide a variety of transportation choices
- Make development decisions predictable, fair, and cost effective
- Encourage community and stakeholder collaboration in development decisions

Smart growth practices can lessen the environmental impacts of development with techniques that reduce impervious surfaces and improved water detention. Before LID is implemented, decisions about where and how to develop within the watershed need to be evaluated to limit water quality impacts. Once these decisions are made, LID can then be used to mitigate the impacts of the development. Coordination and integrating LID with Smart Growth and other innovative land use approaches will limit conversion in land cover, preserve natural watershed areas, and maximize the management of stormwater runoff. In urbanized areas, LID can be coordinated with green building and redevelopment efforts and can be used to augment infrastructure projects by enhancing capacity. Retrofitting using LID in urban locations provides opportunity to provide multiple environmental, social, and infrastructure benefits.

1.4 ADVANTAGES OF LID

LID has numerous benefits and advantages over traditional stormwater management approaches. It is a more environmentally sound technology and economically sustainable approach to addressing the adverse impacts of urbanization. By managing runoff close to its source through intelligent site design, LID can enhance the local environment, protect public health, and improve community livability.

Stormwater programs require that a wide array of complex and challenging ecosystem and human health protection goals be addressed. Many of these goals are not being met by conventional stormwater management technology. Communities are challenged with funding the maintenance/expansion of stormwater infrastructure and restoring stream quality in watersheds that have already been densely developed. Relying on impervious area reduction and/or conventional detention ponds to address these issues is not feasible, practical or sustainable. LID provides a practical alternative in its emphasis on minimizing the changes to the local hydrologic cycle or regime.

1.4.1 SIMPLE AND EFFECTIVE

Instead of large investments in complex and costly centralized conveyance and treatment infrastructure, LID allows for the integration of treatment and management measures into urban site features. This involves strategic placement of distributed lot-level controls that can be customized to more closely mimic a watershed's hydrology and water quality regime. The result is a hydrologically functional landscape that generates less surface runoff, less pollution, less erosion, and less overall damage to lakes, streams, and coastal waters.

1.4.2 ECONOMICAL

LID costs less than conventional stormwater management systems to construct and maintain, in part, because of fewer pipes, fewer below-ground infrastructure requirements, and less imperviousness. Additionally, space once dedicated to stormwater ponds can now be used for additional development to increase lot yields or be left as is for conservation. The greater use of on-lot multi-purpose landscaping and vegetation also offers human quality of life opportunities by greening neighborhoods and contributing to livability, value, sense of place, and aesthetics. Other benefits include enhanced property values and redevelopment potential, greater marketability, improved wildlife habitat, thermal pollution reduction, energy savings, smog reduction, enhanced wetlands protection, and decreased flooding.

1.4.3 FLEXIBLE

LID offers a wide variety of structural and nonstructural techniques to provide for both runoff quality and quantity benefits. It works in highly urbanized constrained areas, as well as open regions and environmentally sensitive sites. Opportunities to apply LID principles and practices are extensive since any feature of the urban landscape can be modified to control runoff and/or reduce the introduction of pollution. LID can be used to truly create customized watershed management designs.

1.4.4 BALANCED APPROACH

LID is an advanced, ecologically-based land development technology that seeks to better integrate the built environment with the natural environment. LID principles and practices allow the developed site to maintain its predevelopment watershed and ecological functions.

1.5 Disadvantages Of LID

Even though LID has been demonstrated as an attractive strategy, its application is limited and has not yet been fully integrated. Several barriers have generally slowed and hampered greater

LID adoption. Bureaucratic inertia involving the entrenchment of prevailing conventional practices, institutional structures, and regulatory shortfalls are the prime barriers preventing a broad shift in stormwater management philosophy. In order to appropriately implement LID it is important to assess its role in water quality protection.

LID is one part of a toolkit that can be used to better manage natural resources and limit the pollution delivered to waterways. It is not independent of watershed planning, and to gain optimal benefits, LID needs to be integrated with appropriate land use programs. LID by itself will not deliver the water quality outcomes desired; it does provide enhanced stormwater treatment and mitigates excess volume and flow rates. However, if not integrated in a comprehensive fashion, LID techniques can end up as a series of uncoordinated innovative BMPs that have limited water quality benefit.

2.0 LID METHODS

2.1.1 BIORETENTION SWALES/RAIN GARDENS

Bioretention swales (Figure 1, also known as rain gardens) incorporate mulch, soil and plants to retain stormwater and filter pollutants within it. Bioretention swales (rain gardens) may range from simple shallow depressions to more complex designs, but all are structurally engineered to provide interception/capture, infiltration, filtration, storage, and water uptake by vegetation with respect to stormwater quantity control.

A bioretention swale (see diagram, Page 8) is composed of three layers, a soil layer (recommended mixture of 25% top soil, 50% leaf compost and 25% sandy loam), a sandy layer (recommended mixture of 10% masonry sand, 50% sandy loam, 25% washed pea gravel and 15% organic compost) and a drain rock layer (100% ¼”- ¾” drain rock). This will produce an ideal filter media to maximize infiltration, filtration and storage (hydrologic loading) capacity. A key design aspect of a bioretention facility is its depressed bowl-shaped topography, creating a “ponding area”. This ponding area allows for surface storage of runoff when the soil storage is capacity; promotes evaporation; and allows sedimentation of particulate matter prior to infiltration. Further incorporation of an underdrain (or outlet) and surface overflow element allows the engineer to construct a bioretention facility that can handle the anticipated volume of stormwater runoff in a given area. In fact, bioretention facilities can be designed to handle not only peak discharges, but also the volumetric control of all storms by mimicking existing hydrologic conditions.

Figure 1

Boretention Swale (San Diego, CA)

2.1.1.1 Stormwater Treatment

Bioretention swales function by taking advantage of a variety of natural physical, biological, and chemical treatment processes. Stormwater treatment, or the reduction of pollutant loads in stormwater to receiving waters, is necessary for achieving regulatory water quality requirements.

Studies show that properly designed and constructed bioretention cells are able to achieve excellent removal of heavy metals. Typical reductions of more than 90% in copper (Cu), zinc (Zn), and lead (Pb) are documented. Removal efficiencies as high as 98% and 99% have been achieved for Zn and Pb. The mulch layer is credited with playing the greatest role in this uptake, with nearly all of the metal removal occurring within the top few inches of the bioretention system. Heavy metals affiliate strongly with the organic matter in this layer.

However, nutrient removal is not associated with the mulch layer. The likely mechanism for the removal of the phosphorus is its sorption onto aluminum, iron, and clay minerals in the soil. Phosphorus removals appear to increase linearly with depth and reach a maximum of approximately 80% by about 2 to 3 feet of soil depth. TKN (nitrogen) removal also appears to depend on soil depth but showed more variability in removal efficiencies between studies. Average removal efficiency for cell effluent is around 60%. Generally 70 to 80% reduction in ammonia was achieved in the lower levels of sampled bioretention cells.

Finally, nitrate removal is quite variable, with the bioretention cells demonstrating a production of nitrate in some cases due to nitrification reactions. Currently, the University of Maryland research group is looking at the possibility of incorporating into the bioretention cell design a fluctuating aerobic/anaerobic zone below a raised underdrain pipe in order to facilitate denitrification and thus nitrate removal.

Other pollutants of concern are also addressed by the bioretention cells. For example, sedimentation can occur in the ponding area as the velocity of the runoff slows and solids fall out of suspension. Field studies at the University of Virginia have indicated 86% removal for Total Suspended Solids (TSS), 97% for Chemical Oxygen Demand (COD), and 67% for Oil and Grease. Additional work with laboratory media columns at the University of Maryland has demonstrated potential bioretention cell removal efficiencies greater than 98% for total suspended solids and oil/grease.

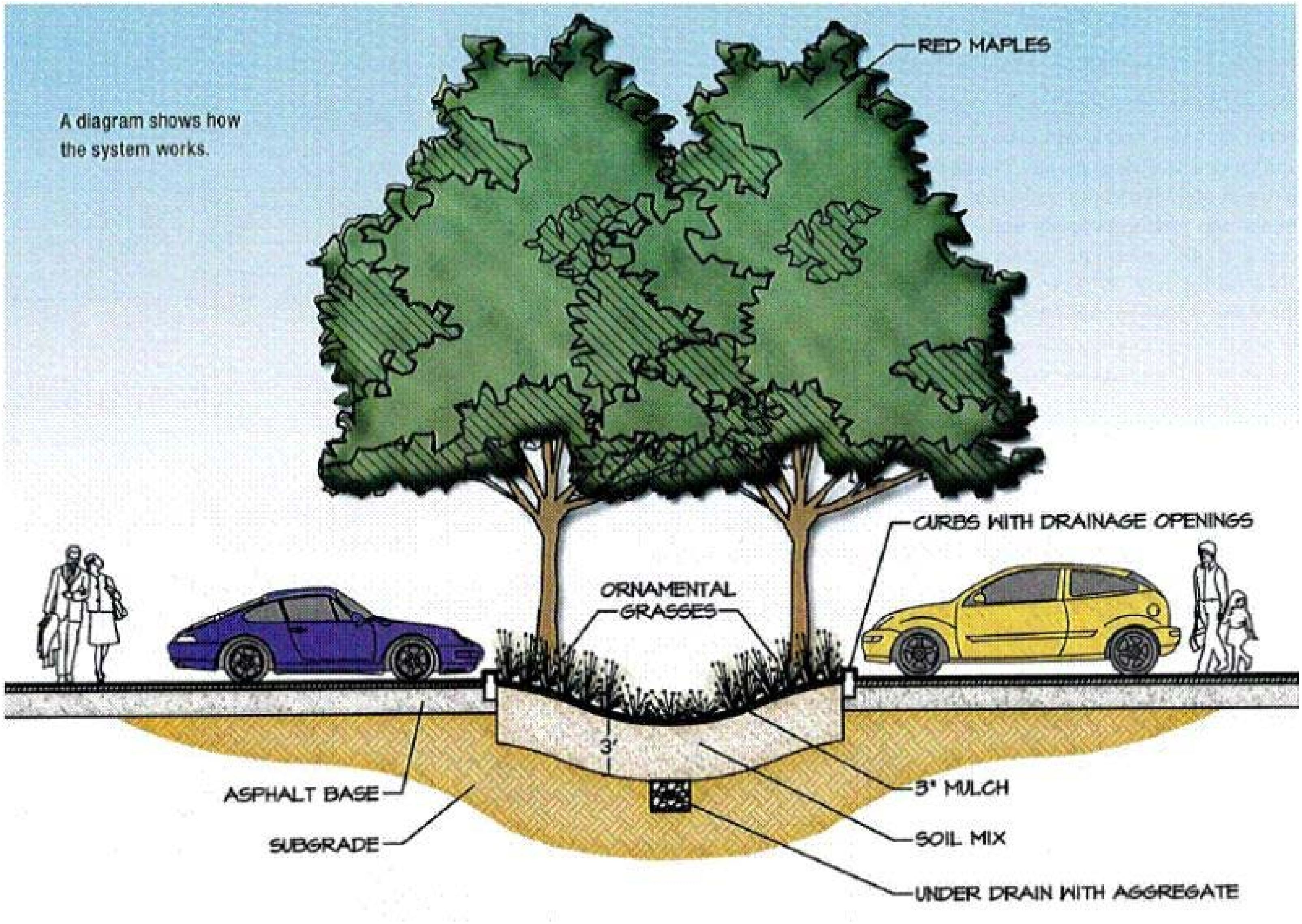
An additional hydrologic benefit of the bioretention cell is the reduction of thermal pollution. Heated runoff from impervious surfaces is filtered through the bioretention facility and cooled; one study observed a temperature drop of 12°C between influent and effluent water. This function of the bioretention cell is especially useful in areas such as the Pacific Northwest where cold water fisheries are important.

2.1.1.2 Stormwater Retention

One of the primary objectives of LID site design is to minimize, detain, and retain post development runoff uniformly throughout a site so as to mimic the site's predevelopment hydrologic functions. Originally designed for providing an element of water quality control, bioretention cells can achieve quantity control as well. By infiltrating and temporarily storing runoff water, bioretention cells reduce a site's overall runoff volume and help to maintain the predevelopment peak discharge rate and timing.

The volume of runoff that needs to be controlled in order to replicate natural watershed conditions changes with each site. Keep in mind that the use of underdrains can make the bioretention cell act more like a filter that discharges treated water to the storm drain system than an infiltration device. Regardless, the ponding capability of the cell will still reduce the immediate volume load on the storm drain system and reduce the peak discharge rate.

Where the infiltration rate of soils in place is high enough to preclude the use of underdrains (at least 1"/hr), increased groundwater recharge also results from the use of the bioretention cell. If used for this purpose, care should be taken to consider the pollutant load entering the system, as well as the nature of the recharge area.



A diagram shows how the system works.

2.1.2 VEGETATED SWALES/STRIPS

Vegetated swales (Figure 2) are broad, shallow, trapezoidal or parabolic channels, densely planted with a variety of trees, shrubs, and grasses covering the sides, slopes and bottom. Vegetated strips are gently sloping areas of vegetative cover that runoff flows through. Both can be natural or manmade, and are designed to trap particulate pollutants (suspended solids and trace metals), promote infiltration and reduce the flow velocity of stormwater runoff.

Vegetated swales can be utilized as stand alone treatment or in conjunction with other LID BMPs or devices. However, strips should only be used to augment other BMPs or devices as they do not have the capacity to adequately treat or detain runoff. The rest of this section pertains to vegetated swales because vegetated strips are simply landscaped areas that receive runoff from impervious surfaces with no specific design criteria. Their installation and maintenance is the same as swales.

2.1.2.1 Design

Vegetated swales can be used wherever the local climate and soils permit the establishment and maintenance of a dense vegetative cover. The feasibility of installing a vegetated swale at a particular site depends on the area, slope, and perviousness of the contributing watershed, as well as the dimensions, slope, and vegetative covering employed in the swale system.

Swales typically have several advantages over conventional stormwater management practice, such as storm sewer systems, including the reduction of peak flows; the removal of pollutants, the promotion of runoff infiltration, and lower capital costs. However, vegetated swales are typically ineffective in, and vulnerable to, large storms, because high-velocity flows can erode the vegetated cover.

Figure 2

Vegetated Swale (Eureka, CA)

A fine, close-growing, water-resistant grass should be selected for use in vegetated swales, because increasing the surface area of the vegetation exposed to the runoff improves the effectiveness of the swale system. Pollutant removal efficiencies vary greatly depending on the specific plants involved, so the vegetation should be selected with pollution control objectives in mind. In addition, care should be taken to choose plants that will be able to thrive at the site. Examples of vegetation appropriate for swales include reed canary grass, grass-legume mixtures, and red fescue.

A parabolic or trapezoidal cross-section with side slopes no steeper than 1:3 is recommended to maximize the wetted channel perimeter of the swale. Longitudinal channel slopes should be between 2 and 4 percent. Slopes greater than 4 percent can be used if check dams are placed in the channel to reduce flow velocity.

The size of the swale can be calculated using various forms of the Manning equation. However, this methodology can be simplified to the following rule of thumb: the total surface area of the swale should be at least one percent of the area (500 square feet for each acre) that drains to the swale. Please consult with the City of Fortuna General Services Division prior to design and have a trained professional perform the work.

2.1.2.2 Installation

The subsurface of the swale should be carefully constructed to avoid compaction of the soil. Compacted soil reduces infiltration and inhibits growth of the grass. Damaged areas should be restored immediately to ensure that the desired level of treatment is maintained and to prevent further damage from erosion of exposed soil.

Check dams can be installed in swales to promote additional infiltration, to increase storage, and to reduce flow velocities. Earthen check dams are not recommended because of their potential to erode. Check dams should be installed at least every 50 feet if the longitudinal slope exceeds 4 percent.

2.1.2.3 Maintenance

The useful life of a vegetated swale system is directly proportional to its maintenance frequency. If properly designed and regularly maintained, vegetated swales can last indefinitely. The maintenance objectives for vegetated swale systems include keeping up the hydraulic and removal efficiency of the channel and maintaining a dense, healthy grass cover. Maintenance activities should include periodic mowing (with grass never cut shorter than the design flow depth), weed control, watering during drought conditions, reseeding of bare areas, and clearing of debris and blockages. Cuttings should be removed from the channel and disposed in a local green-waste disposal site. Accumulated sediment should also be removed manually to avoid the transport of re-suspended sediments in periods of low flow and to prevent a damming effect from sand bars. The application of fertilizers and pesticides should be minimal. Another aspect of a good maintenance plan is repairing damaged areas within a channel. For example, if the channel develops ruts or holes, it should be repaired utilizing a suitable soil that is properly tamped and seeded. The grass cover should be thick; if it is not, reseed as necessary. Any standing water removed during the maintenance operation must be disposed to a sanitary sewer at an approved discharge location. Residuals (e.g., silt, grass cuttings) must be disposed in accordance with local or State requirements.

2.1.3 PERMEABLE PAVERS, PERMEABLE ASPHALT AND PERVIOUS CONCRETE

Most of the 'paving over' in developed areas is due to common roads and parking lots, which play a major role in transporting increased stormwater runoff and contaminant loads to receiving waters. Alternative paving materials such as permeable pavers, permeable asphalt, and pervious concrete (Figure 3) can be used to locally infiltrate rainwater and reduce the runoff leaving a site. This can help to decrease downstream flooding and the thermal pollution of sensitive waters. Use of these materials can also eliminate problems with standing water, provide for groundwater recharge, control erosion of streambeds and riverbanks, facilitate pollutant removal, and provide for a more aesthetically pleasing site.

The effective imperviousness of any given project is reduced while land use is maximized by using pervious pavements. Alternative paving can eliminate the requirement for underground drainage pipes and conventional stormwater retention and detention systems. The drainage of paved areas and traffic surfaces by means of permeable systems is an important building block within an overall LID scheme that seeks to achieve a stormwater management system close to natural conditions.

2.1.3.1 Limitations

The following limitations must be observed for implementing permeable surfaces:

- Slopes greater than 6%. Can consider terracing.
- Not for use at locations with contaminated soil.
- Not for use in locations with high groundwater.
- Locations where there is a real likelihood of a spill. Can consider a filtration or wetland treatment prior to infiltration.

Figure 3

Pervious Concrete (Eureka, CA)

2.1.3.2 Installation of Permeable Surfaces

Permeable pavement in a stormwater management design is a part of a system, and not just a pavement in itself. The pavement supports traffic loading while allowing water to pass through the surface. Installation techniques vary depending on traffic loading and soil permeability. Please consult with the City of Fortuna General Services Division prior to design and have a trained professional perform the work.

2.1.3.3 General Recommendations

- The EPA recommends permeability/ infiltration rate be 0.5”/hour. Some permeable pavements have been successful with an infiltration rate of 0.1”/hour.
- The depth to bedrock is recommended to be at least two (2) feet or greater.
- The depth to groundwater is recommended to be at least five (5) feet or greater.
- The bottom of the infiltration bed should be approximately level.
- Final pavement slope should be no greater than 5%.
- Use existing and available aggregate sources.

2.1.3.4 Maintenance and Repair

- Cracks can be repaired using crack sealant
- Regular cleaning can be completed by flush, jet wash, or vacuum sweeping (recommended twice per year).
- Do not use traditional seal coat treatments.
- Do not use salt or sand for de-icing (contamination of groundwater and reduced permeability)

2.1.4 SOIL AMENDMENTS

Site preparation prior to the construction of residential units typically involves removing or stock piling the existing vegetation and topsoil. This has an immediate hydrologic impact because of the reduction in soil structure, pore space, organic content and biological activity. After construction, a thin layer of topsoil is usually spread on the now very compacted subsoil and then the area is seeded or sodded.

The combination of soil compaction and loss of organic matter has several undesirable consequences:

- With the infiltration capacity of the site significantly reduced, rainwater more quickly runs off into local streams. This, in turn, tends to increase erosion, scouring and the sediment load.
- The rate of groundwater recharge decreases.
- Due to the soil compaction and the loss of organic matter, the availability of subsurface water to plants is reduced.
- The increased volume and frequency of runoff carries pollutants with it that include pesticides, fertilizers, animal wastes and chemicals such as phosphorous and nitrogen.
- Homeowners now have to apply pesticides, fertilizers and irrigation water in increasing amounts in order to maintain their landscapes.

However, soil additives, or amendments (Figure 4), can be used to minimize development impacts on native soils by restoring their infiltration capacity and chemical characteristics. After soils have been amended their improved physical, biological and hydrological characteristics will make them more effective agents of stormwater management.

Figure 4

Soil Amendment

Soil amendments can include compost, mulch, and top soil. In addition, lime and gypsum offset any nutritional deficiencies and control acidity. A thorough soil analysis of the native soil is required to determine the optimum quantity for each component in order to obtain the maximum benefit from amending. Soil amendment components should generally be mixed and applied in the following manner:

- *Compost.* The amount of compost to be applied depends upon the organic content of the existing soil as well as the targeted amount of the proposed soil amendment. Compost typically has an organic content of 45-60% and is often used as the sole means of providing organic material to the soil profile. In soils that have organic contents of less than one percent, 8 to 13 percent by soil weight is a typical target of a proposed soil amendment with compost. As a general rule, a 2-to-1 ratio of existing soil to compost, by loose volume, will achieve the desired organics level. Locally available compost may be utilized if it is of high enough quality and available at a cost effective price.

- *Nutrients and Lime.* If the soil pH is below 6.0 the addition of pelletized dolomite is recommended, with application rates in the range of 50 to 100 pounds per 1000 square feet. Nitrogen requirements usually range from 2 to 8 pounds per 1000 square feet, with slow release water-insoluble forms being the preferred method. Other soil additions may include sulfur and boron with the amount needed determined by soil analysis.

- *Gypsum*. Hydrated calcium sulfate ($CaSO_4 \bullet 2H_2O$) is sometimes applied to a soil in order to increase calcium and sulfur without affecting the pH, as well as to enhance a soil's structure in high clay content soils.

2.1.5 GREEN ROOFS

Green roofs (Figure 5), also known as vegetated roof covers, eco-roofs or nature roofs, are multi-beneficial structural components that help to mitigate the effects of urbanization on water quality by filtering, absorbing or detaining rainfall. They are constructed of a lightweight soil media, underlain by a drainage layer, and a high quality impermeable membrane that protects the building structure. The soil is planted with a specialized mix of plants that can thrive in the harsh, dry, high temperature conditions of the roof and tolerate short periods of inundation from storm events.

Green roofs provide stormwater management benefits by:

- Utilizing the biological, physical, and chemical processes found in the plant and soil complex to prevent airborne pollutants from entering the storm drain system.
- Reducing the runoff volume and peak discharge rate by holding back and slowing down the water that would otherwise flow quickly into the storm drain system.

Green roofs are not only aesthetically pleasing, but they also:

- Reduce city “heat island” effect
- Reduce CO_2 impact
- Reduce summer air conditioning cost
- Reduce winter heat demand
- Potentially lengthen roof life 2 to 3 times
- Treat nitrogen pollution in rain
- Help reduce volume and peak rates of stormwater

Figure 5

Green Roof (Portland, OR)

2.1.6 TREE BOX FILTERS

Tree box filters (Figure 6) are small bioretention areas installed beneath trees that can be effective at controlling runoff, especially when distributed throughout the site. Runoff is directed to the tree box, where it is cleaned by vegetation and soil before entering a catch basin. The runoff collected in the tree-boxes helps irrigate the trees.

Tree box filters are based on an effective and widely used “bioretention or rain garden” technology with improvements to enhance pollutant removal, increase performance reliability, increase ease of construction, reduce maintenance costs and improve aesthetics. Typical landscape plants (shrubs, ornamental grasses, trees and flowers) are used as an integral part of the bioretention/filtration system. They can fit into any landscape scheme increasing the quality of life in urban areas by adding beauty, habitat value, and reducing urban heat island effects.

The system consists of a container filled with a soil mixture, a mulch layer, under-drain system and a shrub or tree. Stormwater runoff drains directly from impervious surfaces through a filter media. Treated water flows out of the system through an under drain connected to a storm drainpipe/inlet or into the surrounding soil. Tree box filters can also be used to control runoff volumes/flows by adding storage volume beneath the filter box with an outlet control device.

Figure 6

Tree Box Filter (Santa Clara, CA)

2.1.7 RAIN BARRELS/CISTERNS

Rain barrels (Figure 7) and cisterns are low-cost, effective, and easily maintainable retention and detention devices that are applicable to residential, commercial and industrial sites to manage rooftop runoff. For residential applications a typical rain barrel design will include a hole at the top to allow for flow from a downspout, a sealed lid, an overflow pipe and a spigot at or near the bottom of the barrel. The spigot can be left partially open to detain water or closed to fill the barrel. A screen is often included to control mosquitoes and other insects. The water can then be used for lawn and garden watering or other uses such as supplemental domestic water supply. Rain barrels can be connected to provide larger volumes of storage. Larger systems for commercial or industrial use can include pumps and filtration devices.

Stormwater runoff cisterns are roof water management devices that provide retention storage volume in above or underground storage tanks. They are typically used for water supply. Cisterns are generally larger than rain barrels, with some underground cisterns having the capacity of 10,000 gallons. On-lot storage with later reuse of stormwater also provides an opportunity for water conservation and the possibility of reducing water utility costs.

Figure 7

Rain Barrels

*2.1.8 INTEGRATED MANAGEMENT PRACTICES (IMP*s)

Always consider Integrated Management Practices (IMPs) as a part of LID. IMPs (Figure 8) are cost-effective features located at the lot level to serve as bioretention and filtration for stormwater runoff. IMPs consist of utilizing a combination of LID BMPs and devices such as bioretention swales, vegetated strips, and permeable pavements—which are distributed throughout the development site.

IMPs are desirable for many reasons. First, LID IMPs can be integrated into easements, setbacks, and odd-shaped portions of a site that would be otherwise landscaped or left unused. Second, IMPs can be aesthetically attractive, substituting for or augmenting landscaping. Third, IMPs are generally low-maintenance and rely on biological activity in the soil to process pollutants and maintain permeability. Fourth, unlike detention basins or wetlands, IMPs are designed to drain completely, leaving no standing water in which mosquitoes might breed. Fifth, LID imitates pre-development hydrology, retaining runoff from small-to medium- sized rainstorms and attenuating peaks and volumes of runoff from larger storms.

Figure 8

Vegetated Strip

Vegetated Swale

Pervious Concrete

IMPs (Fire Training Facility, Eureka, CA)