APPENDIX O

Added 03/18/13 Ordinance 2013-12

Low Impact Development / Green Infrastructure (LID/GI) Project Application

Table of Contents

1. Bioretention

Refer to Chapter 1 of Low Impact Development Guidebook, Phase I Edition V1.0, September 30, 2010.

2. Rainwater Harvesting

Refer to Chapter 2 of Low Impact Development Guidebook, Phase I Edition V1.0, September 30, 2010.

3. Constructed Stormwater Wetlands

Refer to Chapter 3 of Low Impact Development Guidebook, Phase I Edition V1.0, September 30, 2010.

4. Permeable / Porous Pavement

Refer to Chapter 4 of Low Impact Development Guidebook, Phase I Edition V1.0, September 30, 2010.

5. Riparian Buffers

5.1 Overview

Riparian buffer areas protect water quality by cooling water, stabilizing banks, mitigating flow rates, and providing for pollution and sediment removal by filtering overland sheet runoff before it enters the water. The Environmental Protection Agency defines buffer areas as, “areas of planted or preserved vegetation between developed land and surface water, [which] are effective at reducing sediment and nutrient loads.” (SEMCOG, 2008)

5.2 Application and Limitations

Application	
Residential	Yes
Commercial	Yes
Industrial	Yes
Retrofit	Yes
Highway/Road	Limited
Recreational	Yes
Steep slopes	No
Shallow Water Table	Yes
Poorly Drained Soils	Yes

Considerations	
Construction Cost	Low/Med
Maintenance	Low
Soils	All
Sun/Shade	Sun/p. shade
Stormwater Quantity Function	Low/ Med
Stormwater Quality Function	High/Med High
Habitat	Med/high
Drainage area	Small/med
Space required	med

Benefits	Limitations
• Improves water quality; • Reduces runoff velocity and flow; • Enhances aesthetics, habitat; • Reduces shore/bank erosion; • Improves flood control; and • Reduces water temperature.	• Limited in reducing total runoff volumes; and • Size of lot and/ or project may reduce ability to protect riparian buffers.

Source: SEMCOG, 2008.

5.3 Design Considerations

Applicant shall consider the following when protecting the proper riparian buffer area width and related specifications:

- Existing or potential value of the resource to be protected,
- Site, watershed, and buffer characteristics,
- Intensity of adjacent land use, and
- Specific water quality and/or habitat functions desired.

Riparian buffers shall be divided into different zones that include vegetation to enhance the quality of the body of water.

Zone 1

Also termed the “streamside zone,” shall begin at the edge of the stream bank of the active channel and extend a minimum distance of 50 feet (*City of Daphne Land Use & Development Ordinance Article 18-3 C(3))*, measured horizontally on a line perpendicular to the water body. Undisturbed vegetated area shall protect the physical and ecological integrity of the stream ecosystem. The vegetative target for the streamside zone is undisturbed native woody species with native plants forming canopy, understory, and duff layer. Where such forest does not grow naturally, native vegetative cover appropriate for the area (such as grasses, forbs, or shrubs) shall be installed.

Zone 2

Also termed the “middle zone,” shall extend immediately from the outer edge of Zone 1 for a minimum distance of 55 feet (ADEM 20-100’). This managed area of native vegetation shall protects key components of the stream ecosystem and provide distance between upland development and the streamside zone. The vegetative target for the middle zone is either undisturbed or managed native woody species or, in its absence, native vegetative cover of shrubs, grasses, or forbs. Undisturbed forest, as in Zone 1, is encouraged strongly to protect future water quality and the stream ecosystem. Otherwise, native vegetative cover appropriate for the area (such as grasses, forbs, or shrubs) shall be installed.

Zone 3

Also termed the “outer zone,” shall extend a minimum of 20 feet immediately from the outer edge of Zone 2. This zone prevents encroachment into the riparian buffer area, filters runoff from adjacent land, and encourages sheet flow of runoff into the buffer. The vegetative target for the outer zone shall consist of native woody and herbaceous vegetation to increase the total width of the buffer; native grasses and forbs are acceptable.

5.4 Maintenance

The following maintenance activities are required with riparian buffers:

Task	Frequency/Notes
Irrigation	Twice per week for 6 weeks after planting; continued as needed during severe drought.
Dead vegetation removal and replacement	Annual.
Check for streambank erosion or gullies	Annual, repair as needed.
Mowing of turfgrass	As needed, more often in summer months. Minimum 3-5”, max 12”.
Check for invasive / nonnative plants	Annual, remove as needed.
Mowing of native grasses	Annual, before new growth in spring.
Correction of wildlife damage	As needed.
Repair damaged fencing	As needed (as applicable).
Tree thinning	As needed. Those with >2” diameter should not be removed. Thinning shall not occur until proper tree density or cover is present.

6. Level Spreaders

6.1 Overview

Level spreaders promote infiltration and improve water quality by evenly distributing flows over a stabilized, vegetated surface. This allows for better infiltration and treatment. There are two types of level spreaders:

<u>Inflow</u>

Inflow level spreaders are meant to evenly distribute flow entering into another structural BMP, such as a filter strip, infiltration basin, or vegetated swale. Examples of this type of level spreader include concrete sills and earthen berms.

<u>Outflow</u>

Outflow level spreaders are intended to reduce the erosive force of high flows while at the same time enhancing natural infiltration opportunities. Examples of this second type include earthen berms and a level, perforated pipe in a shallow aggregate trench and flow reaches the spreader via the solid pipe. (SEMCOG, 2008).

6.2 Application and Limitations

Application	
Residential	Yes
Commercial	Yes
Industrial	Yes
Retrofit	Yes
Highway/Road	Yes
Recreational	Yes
Steep slopes	No
Shallow Water Table	No
Poorly Drained Soils	No

Considerations	
Construction Cost	Low
Maintenance	Low
Soils	sandy
Sun/Shade	Either
Stormwater Quantity Function	Low
Stormwater Quality Function	Low
Habitat	Med
Drainage area	Small
Space required	Large

Benefits	Limitations
• Low cost; • Wide applicability; • Ability to work with other BMPs in a treatment train; and • Avoids concentrated discharges and their associated potential erosion.	• Low stormwater benefits by itself; and • Careful construction and design required to function properly.

Source: SEMCOG, 2008.

6.3 Design Considerations

Level spreaders are considered a permanent part of a site's stormwater management system. Therefore, uphill development should be stabilized before any dispersing flow techniques are installed. If the level spreader is used as an erosion and sedimentation control measure, it must be reconfigured (flush perforated pipe, clean out all sediment) to its original state before use as a permanent stormwater feature. All contributing stormwater elements (infiltration beds, inlets, outlet control structures, pipes, etc) should be installed first. In addition, the following shall be implemented:

1. Provide as many outfalls as possible and avoid concentrating stormwater. This can reduce or eliminate the need for engineered devices to provide even distribution of flow.

2. Level spreaders are not applicable in areas with easily erodible soils and/or little vegetation. The slope below the level spreader shall be at a maximum eight percent in the direction of flow to discourage channelization. More gentle slopes (e.g., as low as one percent) are also acceptable.

3. The minimum length of flow after the level spreader (of the receiving area) shall be 15 feet.

4. Level spreaders shall not be constructed in uncompacted fill. Undisturbed virgin soil and compacted fill is much more resistant to erosion and settlement than uncompacted fill.

5. Most variations of level spreaders should not be used alone for sediment removal. Significant sediment deposits in a level spreader will render it ineffective. A level spreader may be protected by adding a forebay to remove sediment from the influent. This can also make sediment cleanout easier.

6. Perforated pipe used in a level spreader may range in size from 4-12 inches in diameter. The pipe is typically laid in an aggregate envelope, the thickness of which is left to the discretion of the engineer. A deeper trench will provide additional volume reduction and shall be included in such calculations. A layer of nonwoven geotextile filter fabric shall separate the aggregate from the adjacent soil layers, preventing migration of fines into the trench.

7. The length of level spreaders is primarily a function of the calculated influent flow rate. The level spreader shall be long enough to freely discharge the desired flow rate. At a minimum, the desired flow rate shall be that resulting from a 10-year design storm. This flow rate shall be safely diffused without the threat of failure (i.e., creation of erosion, gullies, or rills). Diffusion of the storms greater than the 10-year storm is possible only if space permits. Generally, level spreaders should have a minimum length of 10 feet and a maximum length of 200 feet.

8. Conventional level spreaders designed to diffuse all flow rates shall be sized based on the following:
   - For grass or thick ground cover vegetation:
     - 13 linear feet of level spreader for every one cubic feet per second (cfs)
     - Slopes of eight percent or less from level spreader to toe of slope
   - For forested areas with little or no ground cover vegetation:
     - 100 linear feet of level spreader for every one cfs flow
     - Slopes of six percent or less from level spreader to toe of slope

       For slopes up to 15 percent for forested areas and grass or thick ground cover, level spreaders may be installed in series. The above recommended lengths should be followed.

9. The length of a perforated pipe level spreader may be further refined by determining the discharge per linear foot of pipe. A level spreader pipe should safely discharge in a distributed manner at the same rate of inflow, or less. If the number of perforations per linear foot (based on pipe diameter) and average head above the perforations are known, then the flow can be determined by the following equation:

   Where: $L = Q_P/Q_L$
   L = length of level spreader pipe (ft.)
   QP = design inflow for level spreader (cfs)
   QL = level spreader discharge per length (cfs/ft.)
   AND $Q_L = Q_O \times N$
   Where:
   Q_L = level spreader discharge per length (cfs/ft.)
   Q_O = perforation discharge rate (cfs.)

N = number of perforations per length of pipe, provided by manufacturer based on pipe diameter (#/ft)

AND $$Q_O = C \times A \times \sqrt{2gH}$$

Where:

Q_O = perforation discharge rate (cfs)

Cd = Coefficient of discharge (typically 0.60)

A = Cross sectional area of one perforation (ft^2)

g = acceleration due to gravity, 32.2 ft./sec^2

H = head, average height of water above perforation (ft.) (provided by manufacturer)

10. Flows may bypass a level spreader in a variety of ways, including an overflow structure or upturned ends of pipe. Cleanouts/overflow structures with open grates can also be installed along longer lengths of perforated pipe. Bypass may be used to protect the level spreader from flows above a particular design storm.

11. Erosion control matting, compost blanketing, or riprap on top of filter fabric shall be implemented immediately downhill and along the entire length of the level spreader, particularly in areas that are unstable or have been recently disturbed by construction activities. Generally, low flows that are diffused by a level spreader do not require additional stabilization on an already stabilized and vegetated slope.

6.4 Maintenance

The following maintenance activities are required with level spreaders:

Task	**Frequency/Notes**
Inspect diverter box, clean and make repairs	Monthly and after rainfall >2”. Look for clogged inlet/outlet pipes and trash/debris in box.
Inspect forebay and level spreader, clean and make repairs	Monthly and after rainfall >2”. Look for: • Sediment in forebay and along level spreader lip; • Trash and/or leaf buildup; • Scour, undercutting; • Settlement of structure (see silt downhill below spreader) • Fallen trees; and • Stone from below the spreader lip washing downhill.
Inspect the filter strip and the bypass swale and make repairs as needed	Monthly and after rainfall >2”. Look for: • Damaged turf reinforcement or riprap rolling downhill; • Erosion within the buffer or swale; and • Gullies or sediment flows from concentrated flows downhill of level spreader.
Remove any weeds or shrubs growing on level spreader or in swale	Annual.

7. Maximize Native Plants / Minimize Sod

7.1 Overview

The goal of utilizing and maximizing native plants while minimizing sod area in the landscape is set forth to:

- Improve developed green space as habitat
- Improve water quality
- Lessen water consumption, and
- Reduce long-term maintenance costs.

This goal is applicable to all landscape/green space requirements set forth currently by the Zoning Ordinance of the City of Daphne. This allows for space that is already allocated as green space to achieve additional performance benefits through the use of LID techniques.

7.2 Application and Limitations

Application	
Residential	Yes
Commercial	Yes
Industrial	Yes
Retrofit	Yes
Highway/Road	Yes
Recreational	Yes
Steep slopes	Yes
Shallow Water Table	Yes
Poorly Drained Soils	Yes

Considerations	
Construction Cost	Low/Med
Maintenance	Low
Soils	All
Sun/Shade	All
Stormwater Quantity Function	Med/High
Stormwater Quality Function	Med/High
Habitat	High
Drainage area	All
Space required	N/A

Benefits	Limitations
• Improves water quality; • Reduces runoff velocity and flow; • Enhances aesthetics, habitat; • Lessens fertilizer usage and subsequent runoff; and • Reduces maintenance requirements over time, thereby reducing pollution, etc.	• Limited where open field recreation and/or land uses are required; and • Projects with phased construction or large lots that would normally employ turfgrass will incur higher front end costs.

7.3 Design Considerations

When utilizing this method, a sequence of performance criteria shall be met as follows:

- First, the required landscape/green space area for the project shall be a maximum of 20% turfgrass. This satisfies the “Minimize Sod” goal of the credit.
- Second, the 80% balance of the landscape/green space area for the project shall be planting area. Planting area is defined as a planting space that has trees, shrubs, groundcover, and other plants that are located within a bed area that has a reasonable continuous organic mulch layer throughout.
- Finally, within the planting area, 70% of the area shall utilize native plant species. The native species shall be designated as such in the plant schedule on the required landscape planting plan for the project. The City reserves the right to reject a species submitted as “native” at its discretion.

A landscape plan implementing this method shall include a landscape area diagram that shows sod area vs. native species planting area vs. ornamental species planting area for the site with percentage calculations included. Note: include prohibition on invasive species? References list source.

7.4 Maintenance

The following maintenance activities are required when this technique is employed:

Task	Frequency/Notes
Irrigation	Deep, frequent irrigation to supplement inadequate rainfall is needed in the first year of planting. After this, irrigation should only be needed during extended drought periods if at all.
Dead vegetation removal and replacement	Periodic, as needed for aesthetics.
Mowing of turfgrass	As needed, more often in summer months.
Check for invasive / nonnative plants	Remove as needed.
Correction of wildlife damage	As needed.

8. Swales / Dry Swales

8.1 Overview

A swale is a narrow, gently sloping landscaped depression that collects and conveys stormwater runoff. The densely planted swale filters stormwater as it flows the length of the structure and allows infiltration of water into the ground. The swale discharges to a storm sewer or other approved discharge point. Compared to vegetated swales, LID/GI swales may be shorter and narrower, but require deeper levels of amended soil and a subsurface drain rock layer to compensate for the smaller size and to function effectively (Clean Water Services, et. al, 2009).

8.2 Application and Limitations

Application	
Residential	Yes
Commercial	Yes
Industrial	Yes
Retrofit	Limited
Highway/Road	Yes
Recreational	Yes
Steep slopes	Yes
Shallow Water Table	Yes
Poorly Drained Soils	Yes

Considerations	
Construction Cost	Low
Maintenance	Low
Soils	Any
Sun/Shade	Any
Stormwater Quantity Function	Low/med
Stormwater Quality Function	Medium
Habitat	Low
Drainage area	Small
Space required	Low

Benefits	Limitations
• Can replace curb and gutter for site drainage and provide significant cost savings; • Water quality; and • Peak and volume control with infiltration.	• Limited application in areas where space is a concern; and • Unless designed for infiltration, there is limited peak and volume control.

Source: Clean Water Services, et. al, 2009 and SEMCOG, 2008.

8.3 Design Considerations

The following design factors shall be considered when implementing this methodology:

<u>Sizing</u>

The size of the swale shall depend upon the infiltration rate of existing soils. A sizing factor of 0.06 assumes the site infiltration rate is less than 2 in/hr. For example, the size of a swale managing 1,500 square feet of total impervious area would be 90 square feet (1,500 x 0.06). Size may be decreased if:

- Demonstrated infiltration rate is greater than 2 in/hr using ASTM D3395-09 method; or
- Amended soil depth is increased.

<u>Geometry/Slopes</u>

A swale's slope end to end shall be at least 0.5% and no more than 6%. For sites with steeper slopes, check dams may be incorporated into the design. Side slopes from the bottom to the top of the swale shall be 3:1 or less. The minimum bottom width shall be 2 feet with a minimum depth of 1 foot.

<u>Piping for LIDA Swales</u>

If needed, stormwater may be directed from impervious surfaces to swales by piping per plumbing code requirements, or may flow directly into the swale via curb openings. A LID/GI swale shall have no underdrain. An overflow drain shall allow no more 6 inches of water depth to collect in the swale. The overflow drain and piping must meet plumbing code requirements and direct excess stormwater to an approved disposal point.

Setbacks

The City of Daphne Land Use & Development Ordinance site-specific setback requirements shall apply.

Soil Amendment/Mulch

Amended soils with appropriate compost serve numerous benefits: infiltration; detention, retention; better plant establishment and growth; reduced summer irrigation needs; reduced fertilizer need; increased physical/chemical/microbial pollution reduction; and reduced erosion potential. Primary treatment shall occur in the top 18 inches of the swale. Amended soil in the treatment area shall be composed of imported soil, mix of one part organic compost, one part gravelly sand, and one part top soil. Compost shall be weed-free, decomposed, non-woody plant material; animal waste is not allowed. Water velocities and potential erosion shall be reduced by providing energy dissipaters such as river rock at entrances to the swale. Check with the District or local jurisdiction for Seal of Testing Approval Program (STA) Compost provider – Chad checking into this. To avoid erosion, appropriate erosion control BMPs shall be implemented.

Vegetation

The entire swale area including side slopes and treatment areas shall be planted with vegetation appropriate for the soil conditions. Planting conditions vary from wet to relatively dry within the swale. The flat bottom will be inundated frequently and shall be planted with species such as rushes, sedges, perennials, ferns, and shrubs well-suited to wet-to-moist soil conditions. The side slope moisture gradient varies from wet at the bottom to relatively dry near the top where inundation rarely occurs. The moisture gradient will vary depending upon the designed water depth, the swale depth, and side slope steepness. The transition zone from the bottom of the swale to the designed high water line or top of freeboard shall be planted with sedges, rushes, perennials, ferns, and shrubs that can tolerate occasional standing water and wet-to-moist planting conditions. The areas above the designed high water line and immediately adjacent to the swale will not be regularly inundated and shall be planted with self-sustaining, low maintenance grasses, perennials, and shrubs suitable for the local climate and site.

Native plants are encouraged, but appropriate, noninvasive ornamentals are acceptable for aesthetic and functional value. All vegetation should be densely and evenly planted to ensure proper hydrological function of the swale.

Quantities:

Bottom of the swale (wet-to-moist zone, per 100 sf) shall include at a minimum:

- 115 herbaceous plants, 1’ on center spacing, ½-gal container size; or
- 100 herbaceous plants, 1’ on center, and 4 shrubs, 1-gal container size, 2’ on center

Side slopes and top of the swale (wet-to-moist transition zone and dry zone) shall include at a minimum:

- 1 tree per 300 sq. ft, minimum 2-gal container size by 2 ft-tall and
- 10 shrubs (1-gal) and 70 groundcovers (½-gal) per 100 sf

Side slope trees shall be selected by adaptability to wet-to-moist conditions and size at maturity. An area twice the width of the tree rootball and the depth of the rootball plus 12” (or total depth of 30”, whichever is greater) shall be backfilled with amended soil for optimal growth, with no sub-surface rock layer (Clean Water Services, et. al, 2009.)

8.4 Maintenance

The following maintenance activities are required with swales:

Task	**Frequency/Notes**
Irrigation	As needed, water efficient irrigation shall be applied for the first two years after construction of the facility, particularly during the dry summer months, while plantings become established. Irrigation after two years is at the discretion of the owner.
Landscape maintenance (replanting and nonnative species removal).	At least twice annually, in spring and fall, evaluate and replant as necessary to ensure a minimum of 80% survival rate of the required vegetation and 90% facility coverage. Remove nonnative, invasive plant species when found in the facility. Design swales so that they do not require mowing.
Debris removal	At least twice annually, in spring and fall, remove garbage, landscaping debris and other material that may impede water flow and clog the system.
Structural inspection and maintenance	At least twice annually, in spring and fall, Check inlet pipes and outlet structure for damage or missing pieces. Inlet pipes and outlet structures shall be free of obstructions and heavy vegetation.

Note: If public, the permittee is responsible for the maintenance of the swale for a minimum of two years following construction and acceptance of the facility. All publicly maintained facilities not located in the public right-of-way must have a public easement. If private, the property owner is responsible for ongoing maintenance per a recorded maintenance agreement (Clean Water Services, et. al, 2009).

9. Sand Filter/Oil and Grit Separation

9.1 Overview

Constructed filters are structures or excavated areas containing a layer of sand, compost, organic material, peat, or other media that reduce pollutant levels in stormwater runoff by filtering sediments, metals, hydrocarbons, and other pollutants. Constructed filters are suitable for sites without sufficient surface area available for bioretention.

9.2 Application and Limitations

Application	
Residential	Limited
Commercial	Yes
Industrial	Yes
Retrofit	Yes
Highway/Road	Yes
Recreational	Yes
Steep slopes	n/a
Shallow Water Table	n/a
Poorly Drained Soils	n/a

Considerations	
Construction Cost	Med/high
Maintenance	High
Soils	n/a
Sun/Shade	n/a
Stormwater Quantity Function	Low/high *
Stormwater Quality Function	High/med /low (temp)
Habitat	n/a
Drainage area	Max 5 acre
Space required	low

Benefits	Limitations
• Good water quality performance; • Variations for different applications; and • Can be effective pretreatment for other BMPs.	• Limited water quantity benefits; • Relatively high cost; and • High maintenance needs.

*Function is low without infiltration and increases when infiltration is provided. Source: SEMCOG, 2008.

9.3 Design Considerations

The following design factors shall be considered when implementing this methodology:

1. All constructed filters shall be designed so that larger storms may safely overflow or bypass the filters. Flow splitters, multi-stage chambers, or other devices may be used. A flow splitter may be necessary to allow only a portion of the runoff to enter the filter. This would create an “off-line” filter, where the volume and velocity of runoff entering the filter is controlled. If the filter is “on-line”, excess flow shall be designed to bypass the filter and continue to another water quality BMP.

2. Entering velocity shall be controlled. A level spreader may be used to spread flow evenly across the filter surface during all storms without eroding the filter material. Level spreaders for this purpose should use a concrete lip or other non soil material to avoid clogging as a result of failure of the level spreader lip. Parking lots may be designed to sheet flow into filters. Small rip-rap or landscaped riverstone edges may be used to reduce velocity and distribute flows more evenly.

3. Contributing areas shall be stabilized with vegetation or other permanent soil cover before runoff enters filters. Permanent filters shall not be installed until the site is stabilized. Excessive sediment generated during construction can clog the filter and prevent or reduce the anticipated post construction water quality benefits.

4. Pretreatment may be necessary in areas with especially high levels of debris, large settled particulates, etc. Pretreatment may include a forebay, oil/grit separators, vegetated filter strips, or

grass swales. These measures will settle out the large particles and reduce velocity of the runoff before it enters the filter. Regular maintenance of the pretreatment is critical to avoid wastes being flushed though and causing the filter to fail.

5. There shall be sufficient space (head) between the top of the filtering bed and the overflow of the filter to allow for the maximum head designed to be stored before filtration.

6. The filter media may be a variety of materials (sand, peat, GAC, leaf compost, pea gravel, etc.) and in most cases should have a minimum depth of 18 inches and a maximum depth of 30 inches, although variations on these guidelines are acceptable if justified by the designer. Coarser materials allow for greater hydraulic conductivity, but finer media filter particles of a smaller size.

   Sand has been found to provide a good balance between these two criteria, but different types of media remove different pollutants.

   The filter media shall have a minimum hydraulic conductivity (k) as follows:
   - Sand 3.5 feet/day;
   - Peat 2.5 feet/day; and
   - Leaf compost 8.7 feet/day.

   Depending on the characteristics of the stormwater runoff, a combination of filter materials will provide the best quality results. In addition to determining the degree of filtration, media particle size determines the travel time in the filter and plays a role in meeting release rate requirements.

7. A gravel layer at least six inches deep is required beneath the filter media.

8. Underdrain piping shall be four-inch minimum (diameter) perforated pipes, with a lateral spacing of no more than 10 feet. A collector pipe can be used, (running perpendicular to laterals) with a slope of one percent. All underground pipes shall have clean-outs accessible from the surface. Underdrain design must minimize the chance of clogging by including a pea gravel filter of at least three inches of gravel under the pipe and six inches above the pipe.

9. Infiltration filters shall be underlain by a layer of permeable nonwoven geotextile.

10. A total drawdown time of not more than 72 hours is recommended for constructed filters, though the surface should drawdown between 24 and 48 hours. The drawdown time can be estimated using the filter surface area and the saturated vertical infiltration rate of the filter media. If the storage does not drawdown in the time allowed, adjust pretreatment depth, filter media depth, and surface area. Adjust the design until the volume (if applicable) and drainage time constraints are met.

11. The filter surface area may be estimated initially using Darcy’s Law, assuming the soil media is saturated:

    $A = V \text{ X } d_f / [k \text{ x } (h_f + d_f) \text{ x } t_f]$, where:

    A = Surface area of filter (square feet)
    V = Water volume (cubic feet)
    d_f = Depth of filter media (min 1.5 ft; max 2.5 ft)
    t_f = Drawdown time (days), not to exceed 3 days
    h_f = Head (average head in ft; typically ½ the maximum head on the filter media, which is typically ≤ to 6 ft)

k = Hydraulic conductivity (ft/day)

12. For vegetated filters, a layer of nonwoven geotextile between non-organic filter media and planting media shall be required.

9.4 Maintenance

The following maintenance activities are required with sand filter/oil and grit separation:

Task	**Frequency/Notes**
Filter media inspection and maintenance, replacement as necessary	Four times per year. Check for accumulated sediment in pore space, and reduced hydraulic conductivity. Symptoms include: • Standing water – any water left in a surface filter after the design drain down time indicates the filter is not functioning according to design criteria. • Film or discoloration of any surface filter material – this indicates organics or debris have clogged the filter surface.
Remove trash and debris	Four times per year
Rake scrape silt if collected on top of the filter	Four times per year
Till and aerate filter area	Four times per year
Replenish filtering medium	Four times per year, if scraping/removal has reduced depth of filtering media
Repair leaks from the sedimentation chamber or deterioration of structural components	Four times per year
Clean out accumulated sediment from filter bed chamber and/or sedimentation chamber	Four times per year
Clean out accumulated sediment from underdrains	Four times per year

Note: In areas where the potential exists for the discharge and accumulation of toxic pollutants (such as metals), filter media removed from filters must be handled and disposed of in accordance with all state and federal regulations.

10. Green Roofs

10.1 Overview

A green roof (or ecoroof) is a lightweight vegetated roof system with waterproofing material, drainage, growing medium, and specially selected plants. A green roof can reduce site impervious area and manage stormwater runoff. Green roofs reduce peak runoff to near predevelopment rates and reduce annual runoff volume by at least 50% (Cost Benefit Evaluation of Ecoroofs, Portland Bureau of Environmental Services, 2008). Green roofs also help mitigate runoff temperatures by keeping roofs cool and retaining most of the runoff in dry seasons. Green roofs typically have thin layers of lightweight growing medium (4 to 8 inches) and low growing succulent vegetation. Alternatively, roof gardens that are designed to be walked on have deeper soils (8+ inches) and are more heavily planted. Professional design consultation is necessary to ensure the structural requirements of building codes are met. Green roofs must be low maintenance and use irrigation only to sustain the health of vegetation.

10.2 Application and Limitations

Application	
Residential	Yes
Commercial	Yes
Industrial	Yes
Retrofit	No
Highway/Road	n/a
Recreational	n/a
Steep slopes	n/a
Shallow Water Table	n/a
Poorly Drained Soils	n/a

Considerations	
Construction Cost	Varies
Maintenance	Moderate/ high
Soils	n/a
Sun/Shade	Sun
Stormwater Quantity Function	Varies
Stormwater Quality Function	Good
Habitat	Good
Drainage area	Roof Size
Space required	Small

Benefits	Limitations
• Increased energy efficiency; • Improved air quality; • Reduced temperatures in urban areas; • Noise reduction; • Improved aesthetics; • Extended roof life; and • Improved stormwater management.	• Complex engineering and design factors, • Higher initial cost than conventional; • Climate limitations; and • Potentially costly repairs.

Source: Clean Water Services, et. al, 2009 and SEMCOG, 2008.

10.3 Design Considerations

Sizing

Green roofs replace impervious area at a 1:1 ratio. They shall not receive water from other impervious areas such as an adjacent conventional roof.

Slope

Maximum roof pitch is 4:12 (3H:1V slope) unless the applicant provides documentation of runoff retention and erosion control on steeper slopes.

Waterproofing

On the roof surface a waterproofing material such as modified asphalt, synthetic rubber, or reinforced thermal plastics is required. Waterproofing materials also may act as a root barrier. Waterproof membranes shall be thoroughly tested to identify and remedy potential defects and leaks prior to installation of any green roof components.

Protection boards or materials (recommended)

These materials protect the waterproof membrane from damage and are usually made of soft fibrous materials. They may be required to maintain the waterproofing warranty, depending on the membrane used. Consult with roofing manufacturer for requirements.

Ballast (optional)

Gravel ballast may be placed along the roof perimeter and at air vents or other vertical elements to separate roofing elements and vegetation. The need for ballast depends on the type of roof and rooftop flashing details. Ballast or rooftop pavers may be used to provide access, especially to vertical elements that require maintenance.

Header/separation board (optional)

If needed, a header or separation board may be placed between gravel ballast and soil or drains.

Root barrier

A root barrier may be required, depending on the waterproofing material, warranty requirements, and the types of vegetation proposed. Root barriers impregnated with pesticides, metals, or other chemicals that could leach into stormwater shall not be applied unless documentation that leaching does not occur is provided. If a root barrier is used it must extend under any gravel ballast and the growing medium, and up the side of any vertical elements.

Drainage

A method of drainage shall allow excess water to flow into drains when soils are saturated. A manufactured drain mat, filter fabric, aggregate or gravel layers, or the growing medium itself may be used if water drains when soils are saturated. The green roof shall have an approved discharge location and drain or drains.

Growing medium

The growing medium depth is 3 to 4 inches or more, depending on the project. This material shall be lightweight and provide a good base for plant growth. Mixes range from 5% organic/95% inorganic to 30% organic/70% inorganic, depending on specific vegetation needs. Growing media shall be stable over time and not break down into fine particles that might increase compaction and clog drainage layers. Components include pumice, perlite, paper pulp, digested organic fiber, and water retention components such as expanded slate, diatomaceous earth, or polymers. For growing media specification, include all constituent elements and their percent composition, and a saturated weight per cubic foot (pcf) that has been tested by a third party lab.

Vegetation and coverage

Green roof vegetation traits:

- Adapted to seasonal drought, excess heat, cold and high winds and other harsh conditions;
- Fire resistant;

- Requires little or no irrigation once established;
- Predominately self-sustaining, low maintenance, with minimal fertilizer;
- Perennial or self-sowing annuals that are dense and mat-forming; and
- Diverse palette to increase survivability and good coverage.

Examples of appropriate species: Sedum, ice plant, blue fescue, sempervivum and creeping thyme. Other herbs, forbs, grasses, and low groundcovers can provide additional benefits and aesthetics, but may need more watering and maintenance to survive and may be prone to additional fire risk if allowed to dry out. Planting lists shall be City-approved and based on reliable sources from this region including local growers and plant suppliers.

Species shall achieve 90% plant coverage within the 2 year maintenance period. At least 70% of the green roof should be evergreen species. No more than 10% of the green roof may be non-vegetated components such as gravel ballast or pavers for maintenance access. Mechanical units may protrude through the green roof, but are not considered elements of the green roof and may be removed from square foot totals.

Exposed areas during establishment periods shall be mulched with an approved, biodegradable mesh blanket, straw, gravel, and pebbles or pumice to protect exposed soil from erosion.

10.4 Maintenance

The following maintenance activities are required with sand filter/oil and grit separation:

Task	**Frequency*/Notes**
Remove drain debris	Monthly during rainy season.
Remove dead plants and replant	As needed in spring and fall to maintain the required 90% plant coverage.
Remove weeds and undesirable plant growth	During first growing season monthly, and in late spring and early fall in subsequent years.
Fertilization	As needed, non-chemical, organic and slow release as approved by the City of Daphne.
Weed/pest abatement	Pesticides and herbicides of any kind are prohibited, unless approved by the City of Daphne to contain a detrimental outbreak of weeds or other pests.
Irrigation	As needed, minimal irrigation may be necessary to maintain vegetation health and ecological function of green roofs. Harvested rainwater is highly recommended for irrigation. Green roofs larger than 1,000 square feet should have an automatic irrigation system for more efficient coverage and to eliminate the need for hand watering. Those larger than 5,000 square feet also should have an irrigation flow meter to monitor water usage.

*The level of maintenance will vary depending on soil depth, vegetation type, and location.

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