Appendix D
Recommended Practices and Controls

Low Impact Development (LID) strategies use careful site design and decentralized stormwater management to reduce the environmental footprint of new growth and redevelopment. This approach improves water quality, minimizes the need for expensive pipe and pond stormwater systems, and creates more attractive developments. The following are LID strategies and various benefits of implementation.

1. Vegetated filter strips are uniformly graded, vegetated, pretreatment practices designed to treat low volume concentrated flows or sheet flow from adjacent roads, highways, small parking lots, and residential driveways. Vegetated filter strips are designed to decrease runoff velocities, capture sediment, and decrease runoff volumes. Filter strips provide effective treatment when combined with bioretention areas and stream buffers.

   Applications
   - Pretreat sheet flow from roads, highways, and small parking lots
   - Pretreat runoff from residential driveways
   - Retrofit options in urban settings
   - Side slopes of grass channels or water quality swales to enhance infiltration and remove sediment runoff from small parking lots and roads

   Advantages
   - Volume & peak flow reduction
   - Reduces runoff velocity
   - Effective pretreatment for bioretention cells
   - Can mimic natural hydrology
   - Used as part of runoff conveyance system with other Best Management Practices (BMPs)

   Limitations
   - Design dictates pollutant removal efficiency
   - Effective on drainage areas with less than 6% slopes
   - Improper grading can diminish removal efficiency

   Maintenance
   - Inspect level spreader for sediment buildup and vegetation for signs of erosion
   - Mow grass regularly
   - Reseed eroded and bare vegetated areas to restore surface permeability, increase sedimentation, and prevent creation of concentrated flow
   - Remove trash and debris to prevent creation of concentrated flow
   - Remove accumulated sediment at top of filter strip to maintain appropriate slope and prevent formation of berm.

2. Hydrodynamic Separators are proprietary stormwater BMPs that remove trash, debris, and coarse sediment from incoming flows using screening, gravity settling, and centrifugal forces generated by forcing the influent into a circular motion.

Applications

- Pretreatment only
- Sites with space constraints
- Ultra-urban areas
- Spill

Advantages

- Can be custom-designed to fit specific needs of a specific site
- Smaller footprint required
- Pretreatment device
- Decentralized stormwater treatment
- Ideal for redevelopment or in ultra-urban setting

Limitations

- Must be purchased from a private sector firm
- May require more maintenance
- Performance must be verified by a qualified third party
- No groundwater recharge
- No control of runoff volume

Maintenance

- Inspect and clean in accordance with manufacturer requirements, but no less than twice a year following installation, and no less than once a year thereafter.
- Vactor trucks or manual removal of sediment are typical means used for cleaning these devices

3. Baffle boxes are proprietary concrete or fiberglass structures containing a series of sediment settling chambers separated by baffles.

Applications

- Ideal for retrofits in existing pipes

Advantages

- Good retrofit capability
- Simple and inexpensive
- Good for densely populated urban areas or parking lots
- Relatively small area footprint

Limitations

- Require significant maintenance
- Can re-suspend settled sediment in subsequent storms
- Not designed for nutrient removal
- Not effective at removing finer sediment

Maintenance

- Inspect and clean every 2 to 3 months to dispose of accumulated sediment. If not properly maintained, sediment can re-suspend with subsequent storms. Use vactor trucks to remove sediment
- Remove stagnant water every 2 to 3 months to prevent odors and mosquito breeding
- Consult manufacturer for specific maintenance requirements for their product

4. Bioretention areas (sometimes referred to as rain gardens) use soil, plants, and microbes to treat stormwater, prior to infiltrating or discharging to a stormwater conveyance system or best management practice

Applications

- Bioretention areas provide "firstflush" pollutant removal
- Well suited for ultra-urban environments
- Can be integrated into parking lot islands, median strips and traffic islands to treat urban runoff and promote infiltration.
- Can be distributed around a property to enhance aesthetics.

Advantages

- Used in areas with space constraints
- Can provide groundwater recharge
- Improve aesthetics
- Removal of multiple pollutants
- Provides shade, windbreaks, and absorb noise
- Can modify existing landscape – retrofit
- Reduce urban heat island effect

Limitations

- Requires careful landscaping/maintenance
- Not suitable for areas with slope > 20%
- Not suitable for large drainage areas
- Requires pretreatment
- Not suitable where groundwater is within 6 feet of ground surface

Maintenance

- Inspect pretreatment devices and bioretention areas regularly for sediment build-up, structural damage and standing water
- Inspect for erosion and re-mulch void areas on a monthly basis (or as necessary)
- Remove and replace dead vegetation in spring and fall
- Remove invasive species to prevent from spreading within bioretention area
- Do not store snow in bioretention areas
- Periodically observe function under wet weather conditions

5. Planter boxes are bioretention treatment control measures that are completely contained within an impermeable structure with an underdrain (they do not infiltrate).

   Applications
   - Most commonly used in urban areas adjacent to buildings

   Advantages
   - Small footprint and simple design and construction
   - Aesthetically pleasing
   - Combines stormwater treatment with runoff conveyance
   - Volume & peak flow reduction

   Limitations
   - Vegetative maintenance required
   - Treats small volumes and contributing area
   - Must be constructed with underdrain system to convey excess water

   Maintenance
   - Inspect for erosion and repair areas
   - Remove accumulated fine sediments, dead leaves and trash to restore surface permeability
   - Eradicate weeds and prune back excess plant growth that interferes with facility operation
   - Periodically observe function under wet weather condition

6. Tree box filters are a proprietary biotreatment device that is designed to mimic natural systems such as bioretention areas by incorporating plants, soil, and microbes.

   Applications
   - Commonly used in densely urbanized areas such as along roads, highways, sidewalks and parking lots

   Advantages
   - Reduces volume and rate of runoff
   - Smaller footprint required
   - May be used as pretreatment device
   - Provides decentralized stormwater treatment
   - Ideal for redevelopment or in ultra-urban setting

   Limitations
   - Vegetative maintenance required
   - Treats small volumes
   - Treats small tributary areas

   Maintenance

- Annually check tree
- Rake media surface at least twice a year to maintain permeability
- Replace media when tree is replaced (every 5 to 10 years) to restore permeability and pollutant removal efficiency
- Remove accumulated trash and debris to restore permeability

7. A constructed stormwater wetland is a system designed to maximize pollutant removal through vegetative uptake, retention, and settling.

   Applications
   - Regional detention and treatment
   - Sites without space constraints

   Advantages
   - Low maintenance cost
   - Reduce peak flow rates
   - Treatment of large tributary areas
   - Removes suspended solids and particulate-bound pollutants
   - Provides wildlife habitat
   - Aesthetically pleasing

   Limitations
   - High land requirement
   - High capital cost
   - Does not provide groundwater recharge
   - Potential mosquito habitat if not properly maintained
   - Depth to groundwater and bedrock

   Maintenance
   - Inspect wetland during both the growing and non-growing season during first 3 years after construction is completed to determine dominant wetland plants, presence of invasive wetland species, accumulation of sediment in forebays and micro-pools, and stability of original depth zones.
   - Inspect wetland at least once a year to evaluate health and prevent monocultures of plant species
   - Clean out sediment forebay annually to restore storage volume capacity
   - Clean out sediment in basin/wetland system at least once every 10 years to restore storage volume

8. Sand filters are engineered sand filled depressions that treat stormwater runoff from small tributary areas.

   Applications
   - Can be used in ultra-urban sites with small drainage areas
   - Drainage area can be 100% impervious like parking lots

- Redevelopments/Retrofits

Advantages

- Good retrofit capability
- Long design life if properly maintained
- Good for densely populated urban areas or parking lots
- Relatively small footprint area

Limitations

- Pretreatment required to prevent clogging
- Frequent maintenance required
- Costly to build and install
- Limited removal of dissolved constituents
- May not be effective in winter
- Can be unattractive and create odors

Maintenance

- Inspect filter and remove debris after every major storm for first few months to ensure proper function. Inspect every 6 months thereafter to prevent clogging.
- Rake sand to restore infiltration rates
- Remove sediment and trash that have accumulated on top of sand
- Remove top several inches of discolored media (presence of fine sediments) and replace with clean media to restore filtration removal mechanisms

9. Gravel trenches are long, narrow, gravel-filled trenches, which treat stormwater runoff from small drainage areas. Gravel trenches remove stormwater pollutants through infiltration, sedimentation and filtration.

   Applications

   - Parking lot, local roads, highways and small residential developments.
   - Road shoulders and medians

   Advantages

   - Provide groundwater recharge
   - Preserves natural water balance
   - Suitable for small spaces
   - High degree of pollutant runoff control

   Limitations

   - Requires frequent maintenance to prevent clogging
   - Restricted to small drainage areas
   - Requires depth to groundwater be greater than 2 feet from bottom of trench
   - Requires soils that infiltrate

Maintenance

- Remove trash and debris to prevent clogging and restore permeability
- Remove minor sediment accumulations near inlet structure to prevent clogging
- If clogging is observed, remove top layer of pea gravel and sediment capture layer. If slow conditions persist, entire trench may need to be excavated and replaced
- Periodically observe under wet weather conditions to ensure all components are working properly
- Pollutant Removal Efficiencies

10. Dry wells, or seepage pits, are excavated areas filled with gravel and very similar to infiltration trenches. They are designed to receive and treat stormwater runoff from non-metal roofs or metal roofs outside Zone II, Interim Wellhead Protection Area of a public water supply, or an industrial site.

    Applications

    - Applicable for private and public projects
    - Commercial and residential
    - Retrofits
    - Urban areas adjacent to buildings

    Advantages

    - Reduce stormwater volume through groundwater discharge
    - Efficient removal of trash and sediment
    - Simple, low cost

    Limitations

    - High potential for clogging
    - Treats small tributary area
    - Can cause structural damage to nearby buildings due to water seepage

    Maintenance

    - Inspect well at least 4 times a year and after major storm events to ensure that maximum draw down time (72 hours) is not being exceeded
    - Clean roof gutters to prevent clogging of dry well
    - Replace filter screen as necessary

11. Proprietary Infiltration Device (CULTEC). The CULTEC Contactor® and Recharger® chambers replace conventional stormwater retention/detention systems such as ponds, swales, pipe and stone trenches or beds, or concrete structures. The chambers may be used for drywells.

    Applications

    - Applicable for private and public projects
    - Commercial and residential
    - Retrofits
    - Urban areas adjacent to buildings

Advantages

- Provides volume reduction and groundwater recharge
- Can reduce downstream flooding
- Efficient removal of trash and sediment
- Can be simple and low cost

Limitations

- High potential for clogging
- Can cause structural damage to nearby buildings due to water seepage
- Standing water creates mosquito breeding potential

Maintenance

- Inspect inlets at least twice a year.
- Remove any debris that may be clogging the device

12. Water quality swales are shallow, open conveyance channels with low-lying vegetation designed to settle out suspended pollutants due to shallow flow depths and slow velocities.

Applications

- Commonly implemented adjacent to highways/roadways
- Applicable for commercial, institutional, and residential purposes
- Retrofit options in urban settings, especially in publicly owned green space

Advantages

- Replace expensive curb and gutter systems
- Can achieve volume and peak flow reduction with proper design
- Reduce driving hazards by keeping stormwater from street surfaces
- Compatible with many LID designs

Limitations

- Can erode during large storms
- Treats small tributary areas
- Not for areas with very flat grades, steep topography, or poorly drained soils
- Higher degree of maintenance than curb and gutter systems

Maintenance

- Inspect during first few months to ensure adequate vegetation growth
- Inspect slopes, soil moisture, vegetative health, soil stability, soil compaction, soil erosion, ponding, and sedimentation of swale at least twice a year to maintain overall integrity and efficiency
- Reseed eroded areas to maintain flow reduction and pollutant removal efficiencies

13. Porous pavement is a permeable alternative to conventional asphalt and concrete and constructed in pedestrian, highly urbanized, or residential settings with low traffic speeds and volumes.

    Applications
    - Commercial and industrial parking lots
    - Urban and residential settings
    - Retrofits
    - Low-volume, low-speed areas or pedestrian areas
    - Porous pavements are often used in sidewalks

    Advantages
    - Reduces stormwater volume and peak flow rates
    - Used as a retrofit in parking lots
    - Reduce sediment and particulate bound pollutants

    Limitations
    - Frequent clogging if not maintained
    - No sanding in winter
    - Compacting of underlying soils is common
    - Limited removal of dissolved constituents when underdrains are used

    Maintenance
    - Power wash and vacuum sweep area to prevent clogging
    - Do not sand or salt during the winter
    - Use snowplows with rollers on bottom to prevent damage to porous pavement
    - Periodically observe function under wet weather conditions to determine decrease in performance and clogging

14. Disconnecting impervious surfaces from the public stormwater conveyance system and directing runoff to pervious surfaces can reduce stormwater volumes, flow rates, pollutant loadings, and increase groundwater recharge.

    Applications
    - Single- and multi-residential homes
    - Commercial
    - Densely urbanized areas

    Advantages
    - Reduce stormwater volume and flow rates
    - Simple, low cost, and highly applicable to many situations
    - Groundwater recharge

    Limitations
    - Discharge must be directed to pervious area through sheet flow

Maintenance

- Compacted soil must be amended, tilled, and re-vegetated to restore infiltration capacity
- Clean gutters annually to prevent clogging or downspouts and pervious areas

15. Cisterns and rain barrels are structural tanks designed to capture stormwater runoff from impermeable surfaces for non-potable use. For uses other than irrigation, a filter system must be implemented.

    Applications

    - Applicable for private and public projects
    - Commercial and residential
    - Roof runoff storage
    - Dense urban settings
    - Retrofits

    Advantages

    - Use for irrigation and non-potable uses to save money on water utility bill
    - Reduce runoff volume entering stormwater conveyance system for small storms
    - Simple design and construction
    - Small footprint

    Limitations

    - Provides habitat for mosquitoes if not properly sealed
    - Possible cracking of structure during winter months
    - Effective implementation requires

    Maintenance

    - Inspect seal of rain barrel to prevent mosquito breeding and leaks
    - Clean gutters and roof catchment to prevent clogging of downspouts
    - Inspect overflow pipe to provide proper draining of system during large events
    - If above ground, drain system before winter to prevent cracking of tank

16. Green roofs are vegetated roof covers designed to reduce stormwater volumes through storage of precipitation in a soil media layer and increased evapotranspiration. Green roofs decrease the impervious footprint of buildings and help mimic pre-development hydrology.

    Applications

    - Applicable for private and public projects
    - Commercial, industrial, and residential sites
    - New construction or retrofits
    - Commonly installed on buildings with flat to low-angle rooftops

    Advantages

    - Reduce stormwater volume and flow rates
    - Reduce heating/cooling cost of building

- Conserve space in highly urbanized areas

Limitations

- If a retrofit, requires additional structural analysis of building
- Does not increase groundwater recharge
- May require additional water for irrigation of plants. Irrigation no functional in winter

Maintenance

- Add additional mulch, irrigate, weed, and prune plants as necessary to preserve life of roof and established plants
- Remove wooded plants that may become established to preserve roof integrity
- Fertilize intensive green roofs to support growth of plants

17. Infiltration basins are stormwater impoundments, over permeable soils with vegetated bottoms and side slopes. Infiltration basins are designed to reduce stormwater volumes through exfiltration and groundwater recharge.

Applications

- Contributing drainage area between 2 and 15 acres
- Suitable for sites with gentle slopes, permeable soils, relatively deep groundwater table

Advantages

- Volume reduction
- Groundwater recharge
- Reduces local flooding
- Provides peak flow attenuation
- Can use near cold-water fisheries

Limitations

- Requires pretreatment
- Requires large pervious area
- High maintenance requirement; clogging potential is high
- Not for treating high loads of sediment or other pollutants

Maintenance

- Develop and implement an aggressive maintenance and operations plan
- Inspect basin and pretreatment device after major storms to ensure it is functioning properly, for the first few month's post construction
- Inspect, at a minimum, twice a year for cracking, erosion, leakage in embankments, tree growth, condition of riprap, sediment accumulation, health of turf and signs of differential settlement
- Mow buffer area, side slopes, and basin bottom at least twice a year
- Remove trash and debris to prevent clogging
- Remove sediment from basin as necessary to prevent clogging