BIORETENTION & RAIN GARDENS

Bioretention is a shallow landscaped depression with a designed soil mix (the bioretention soil mix or "BSM") and plants adapted to local climate and soil moisture conditions.

Bioretention can be designed as a cell, a swale (conveying stormwater in addition to treating it), a planter (with impervious sides and an open bottom), or a planter box (with impervious sides and a bottom).

Bioretention facility designs are required to be stamped by a professional engineer.

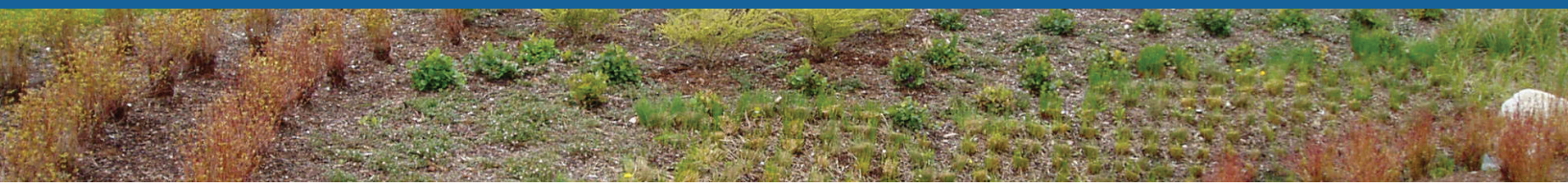
Benefits

- Can be designed to create an **attractive landscape feature**.
- Provides **habitat** for beneficial insects and birds.
- Can help in meeting **on-site stormwater management, water quality treatment**, and **flow control** requirements.
- **Increases property values** through social, economic, and environmental benefits that help to offset design costs.
- Can be used as a **traffic calming** feature.

Design Tips

- Provide a 4- to 6-inch drop from the curb to **prevent sediment and debris clogging the inlet** and stormwater from entering the facility.
- Include a concrete pad or rock at the bottom of the inlet to **prevent erosion**.
- Facilitate easier long-term maintenance by **adjusting curb cut openings and the curb bulb radius** to accommodate available sweeping and vactor equipment.
- **Incorporate maintenance or pedestrian pathways** through bioretention areas to reduce future soil compaction.

In 2003, the **Seattle Housing Authority** redeveloped the High Point neighborhood in West Seattle to increase housing density. A primary feature of the project is over 11,000 linear feet of bioretention swales constructed to manage and treat stormwater runoff.



What's New in Design & Installation

A **variety of curb cut inlet configurations** have been used for bioretention facilities, addressing concerns over car tires rolling through the openings, trash buildup at the inlet, and inefficient flow capture from the curb line to the cell. Solutions include curb covers at the inlet to deter car tires, expanded curb cut widths and a 4- to 6-inch drop into the facility to reduce buildup of debris, and a depression in the gutter line to help direct flows into the facility.

A **mortar bed** can be used in pre-settling zones to hold cobbles in place that filter sediment before it spreads across the facility, thereby reducing maintenance demands. **Dry filter boxes** can also be installed at curb cut inlets to collect sediment and other debris and to facilitate easy long-term maintenance.

Elevated underdrains can be integrated into a bioretention facility design to reduce nitrogen in stormwater (nitrogen is a contaminant of concern for marine and groundwater) and provide more moisture for plants during our dry summers.

The current bioretention soil mix specification (40% compost and 60% sand) should not be used within ¼ mile of **phosphorus-sensitive waterbodies** per the 2019 Stormwater Management Manual for Western Washington (Volume V, Chapter 5). A new bioretention soil mix specification is being developed that can be used near phosphorus-sensitive waterbodies and should be available for use in 2020.

Select **native perennial plants** that are already adapted to the region, have **lower irrigation demands**, and require **less maintenance once established**.

What's New in Maintenance

Traditional **landscaping crews may need additional training** for bioretention maintenance versus traditional landscaping maintenance. Often, bioretention facilities are designed for a lower level of pruning and vegetation removal than a typical landscaped feature.

Bring boards to stand on or use maintenance pathways (see Design Tips) during maintenance to reduce soil compaction.

Use a vactor truck to quickly and easily clean out a mortar bed or dry filter box (see What's New in Design and Installation).

More Information & Resources

- Stormwater Management Manual for Western Washington
- Low Impact Development Technical Guidance Manual for Puget Sound
- Rain Garden Handbook for Western Washington
- Western Washington LID O&M Guidance Document
- Statewide LID Training Program Module 3.2 (Intermediate LID Design: Bioretention), Module 5.0 (Advanced Long-term LID Operations: Bioretention), and Module 6.2 (Advanced LID Design: Bioretention Media and Compost Amended Soils)

PERVIOUS CONCRETE

Pervious concrete is a rigid pavement similar to conventional concrete that uses a cementitious material to bind aggregate together. The fine aggregate (sand) component is reduced or eliminated in the gradation compared to conventional concrete; as a result, voids form between the aggregate in the pavement surface and allow water to infiltrate.

Pervious concrete is typically used for low-volume residential streets, parking lots, public walkways and sidewalks, bike lanes, plazas, and patios. Pervious concrete is a durable pavement with a similar life span to conventional concrete.

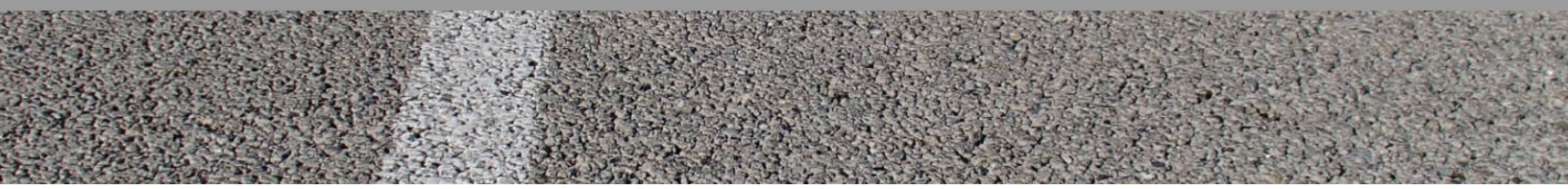
Benefits

- Allows for direct infiltration into the subgrade soils, **maximizing site functionality** while **reducing surface runoff**
- Can **reduce or eliminate the need** for traditional curbs, gutters, drainage structures, piping, water quality treatment, and detention, which saves on overall project cost and space
- Can be **mixed in smaller batches** for repair and replacement
- **Reduces noise** caused by tire-pavement interaction
- **Long lasting, high strength** choice for permeable pavement

Design Tips

- **Different colors** can be added to pervious concrete to integrate **artistic elements** and **designate different use areas** in plazas, patios, walkways, or parking lots (e.g., parking stalls, walkways, play areas, etc.).
- **Can be used on slopes up to 6%** with check dams in the reservoir course.
- **Plan project staging and erosion control measures** to avoid contaminating or compacting the subgrade.
- **Can be striped** like conventional solid pavement.

The **City of Lacey Regional Athletic Complex** includes 36,000 square feet of pervious concrete that directly infiltrates rainfall through the ballfield plaza. A majority of the site's two miles of trails were constructed with porous asphalt. Stormwater runoff from the remainder of the 70-acre site is routed to infiltration trenches located beneath the ballfields.



What's New in Design & Installation

Pervious concrete specifications developed by the APWA-WA Construction Materials Committee are now part of WSDOT's General Special Provisions (GSPs) and have **addressed design issues and inconsistent specifications** encountered in past installations: www.wsdot.wa.gov/partners/apwa

Researchers are currently testing pervious concrete mixes with additives such as **carbon fiber composites** to increase durability and strength. The composites—a waste product of the aviation industry—are dispersed throughout the pavement mix to provide uniform strength.

Setting time and shrinkage are accelerated in pervious concrete construction. Joint installation should quickly follow compaction. **Rolling joint tools** are recommended for their efficiency and are recommended over sawcutting to reduce raveling and clogging from cutting operations.

The National Ready Mixed Concrete Association (NRMCA) offers a **Pervious Concrete Contractor Certification Program**. Three levels of certification are available: Pervious Concrete Technician, Pervious Concrete Installer, and Pervious Concrete Craftsman. The Washington Aggregates & Concrete Association (WACA) offers courses on an as-needed basis. A database of the certifications can be found on NRMCA's website: www.nrmca.org/certifications/pervious/SearchNew

Pervious concrete is **designed using traditional rigid pavement methods** using a factored flexural strength; however, traditional ASTM test methods for concrete do not apply, and alternate construction verification methods are used.

Observation wells (6-inch PVC pipe) that extend to the bottom of the aggregate layer should be integrated into the design to **help facilitate routine inspections and maintenance**.

What's New in Maintenance

Routine vacuuming with a regenerative air vacuum sweeper is recommended to remove accumulated sediments. The frequency of the vacuuming directly depends on the amount of sediment buildup over time, but it should be done **at least once annually**.

Small ride-on cleaning equipment is now available for routine and restorative maintenance of pervious concrete surfaces.

Restorative maintenance is more expensive and time-consuming than routine maintenance, but can be used to restore sections of pavement that have not been adequately maintained in the past.

More Information & Resources

- Stormwater Management Manual for Western Washington
- Western Washington LID O&M Guidance Document
- Pervious Concrete Contractor Certification Program
- Statewide LID Training Program Module 3.3 (Intermediate LID Design: Permeable Pavement) and Module 5.1 (Advanced Long-term LID Operations: Permeable Pavement)

POROUS ASPHALT

Porous asphalt is a flexible pavement similar to conventional asphalt that uses a bituminous binder to bind aggregate together. The fine aggregate (sand) component is reduced or eliminated in the gradation compared to conventional asphalt; as a result, voids form between the aggregate in the pavement surface and allow water to infiltrate.

Porous asphalt is typically used for low-volume residential streets, parking lots, public walkways and sidewalks, bike lanes, plazas, and trails.

Benefits

- Allows for direct infiltration into the subgrade soils, **maximizing site functionality while reducing surface runoff**.
- Can **reduce or eliminate the need** for traditional curbs, gutters, drainage structures, piping, water quality treatment, and detention, which saves on overall project cost and space.
- **Reduces noise** caused by tire-pavement interaction.
- **Does not have to cure** and can be opened to traffic sooner.
- **Lower cost choice** for permeable pavement.

Design Tips

- **Seasonal availability of the required asphalt binder** should be considered in project planning.
- Can be used **on slopes up to 6%** with check dams in the reservoir course.
- **Plan project staging and erosion control measures** to avoid contaminating or compacting the subgrade.
- **Can be striped** like conventional solid pavement.

In 2007, the **City of Olympia, WA** conducted a study of varying stormwater mitigation strategies on two blocks of Decatur Street between 9th and 11th. A total of 200 feet of porous asphalt roadway was compared to conventional asphalt and traditional stormwater management facilities, and was found to have similar cost/benefit ratios for treatment efficiency.

What's New in Design & Installation

Porous asphalt specifications developed by the APWA-WA Construction Materials Committee are now part of WSDOT's General Special Provisions (GSPs) and have **addressed design issues and inconsistent specifications** encountered in past installations: www.wsdot.wa.gov/partners/apwa

Porous asphalt **does not require proprietary ingredients or special paving equipment**. With proper mix design, general contractors can install porous asphalt with minimal additional training or certification.

Insulated covers over loads during hauling can reduce heat loss during transport and increase working time. Temperatures at delivery that are too low can result in shorter working times, increased labor for hand work, and increased cleanup from asphalt adhering to machinery.

Air temperatures should be **no lower than 45 degrees Fahrenheit** during installation of porous asphalt.

Observation wells (6-inch PVC pipe) that extend to the bottom of the aggregate layer should be integrated into the design to **help facilitate routine inspections and maintenance**.

What's New in Maintenance

Routine vacuuming with a regenerative air vacuum sweeper, or pressure washing, is recommended to remove accumulated sediments. The frequency of the vacuuming directly depends on the amount of sediment buildup over time, but it should be done **at least once annually**.

If pavement patching is necessary, **conventional asphalt can be used** for small areas (typically less than 10% of the pavement area).

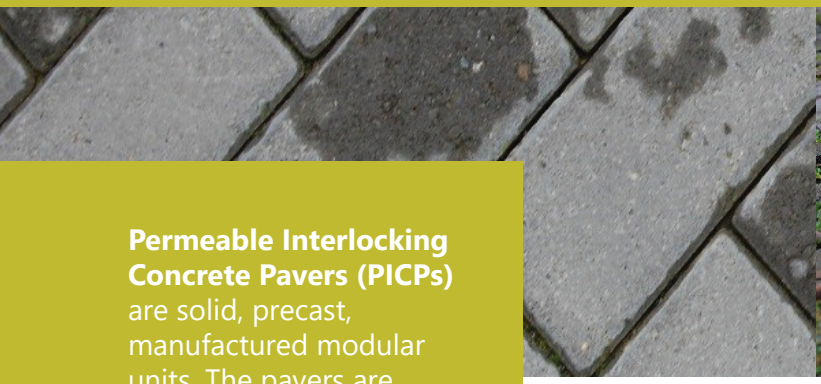
Small ride-on cleaning equipment is now available for routine and restorative maintenance of porous asphalt pavement.

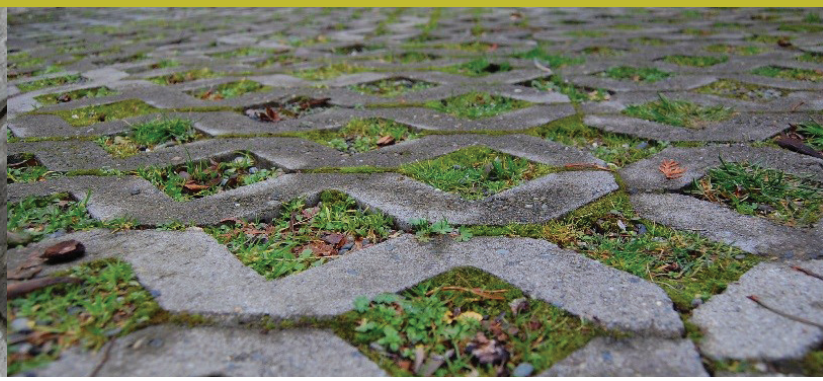
Restorative maintenance is more expensive and time-consuming than routine maintenance, but can be used to restore sections of pavement that have not been adequately maintained in the past.

More Information & Resources

- Stormwater Management Manual for Western Washington
- Western Washington LID O&M Guidance Document
- National Asphalt Pavement Association
- Statewide LID Training Program Module 3.3 (Intermediate LID Design: Permeable Pavement) and Module 5.1 (Advanced Long-term LID Operations: Permeable Pavement)

PERMEABLE PAVERS / OPEN CELL GRIDS





Permeable Interlocking Concrete Pavers (PICPs) are solid, precast, manufactured modular units. The pavers are solid (impervious) and the joints are filled with aggregate (permeable). Permeable pavers are typically installed in plazas, patios, sidewalks, driveways, and parking lots.

Open celled grid systems are made of concrete or plastic. The grid openings can be filled with topsoil and grass, or aggregate (permeable). Grid systems are typically installed in overflow parking areas, emergency vehicle access roads that are not frequently used, and driveways.

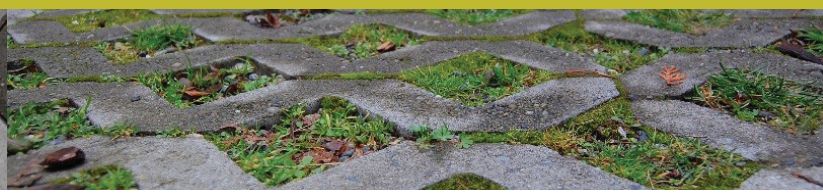
Benefits

- Permeable pavers and open celled grid systems allow for direct infiltration into the subgrade soils, **maximizing site functionality** while **reducing surface runoff.**
- Can reduce or eliminate the need for traditional curbs, gutters, drainage structures, piping, water quality treatment, and detention, which **saves on overall project costs and space requirements.**
- Ability to **remove a few pavers or grid segments at a time** to access underlying aggregate, then replace by hand rather than sawcut and repave.

Design Tips

- Permeable pavers can be used to **integrate artistic elements** into plazas, patios, or walkways.
- Different **colors or patterns** of permeable pavers can be used to designate different areas in a parking lot (e.g. parking stalls, walkways, play areas, etc.)
- Permeable pavers and open celled grid systems can be installed just in **parking stalls or in entire parking lots**.
- Open celled grid systems can be a helpful solution for overflow parking areas since they typically have **low maintenance needs and costs**.

Chuck's Produce in Vancouver, WA integrated permeable pavers into their parking lot design when they opened a second location. A total of **29,000 square feet of permeable pavers** were installed in the **parking stalls and sidewalks**. Colored pavers designate sidewalks and areas where shopping carts should be returned.



What's New in Design & Installation

Permeable pavers and open celled grid systems can be used for **low-speed, heavier vehicle traveling surfaces**. With an appropriate aggregate course depth below, permeable pavers can support up to 8,000 pounds per square inch and open celled grid systems can support up to 15,000 pounds per square inch.

Some of the original permeable pavers on the market did not meet ADA standards due to the width of the aggregate-filled joints; however, there are now **numerous options available** from several different vendors with narrower joints that **meet ADA standards**. Several open celled grid systems can also be designed to meet ADA standards.

Mechanical paver installations can save time and money on larger paver installations compared to manual paver installations, but only work with full pavers (no partial bricks) and specific patterns.

> **Mechanical paver installation:** ~3,000 to 10,000 square feet per machine per day
> **Manual paver installation:** ~1,000 square feet per person per day

In addition to PICP and open celled grid systems, there is also a **pervious paver available made of natural stone**. Water can flow through the pervious paver itself (approximately one gallon per second per square foot), so the aggregate-filled joints included in a traditional PICP system are not necessary to include in the design, and a smaller area of pervious pavers may be needed to manage stormwater runoff from the site.

The ICPI offers a one-day PICIP **course for contractors on installing permeable pavers**. A PICP Specialist designation can also be earned by meeting additional requirements: www.icpi.org/node/2727.

What's New in Maintenance

Moss grows on permeable and impermeable pavement in the Pacific Northwest, but there are **options for removing moss and weeds** in paver joints. If moss is inhibiting infiltration or posing a slip safety hazard, it can be removed from sidewalks using a stiff broom in the summer when it is dry. Vacuum sweeping or a combination of a stiff broom/power brush can remove moss from parking lots and roadways. Weed burners can be useful tools for removing weeds growing in paver joints.

The Interlocking Concrete Pavement Institute (ICPI) and multiple vendors have developed **materials to support design and maintenance** to ensure permeable pavers are properly installed and meet long-term performance goals.

More Information & Resources

- Stormwater Management Manual for Western Washington
- Western Washington LID O&M Guidance Document
- Interlocking Concrete Pavement Institute (ICPI)
- Statewide LID Training Program Module 3.3 (Intermediate LID Design: Permeable Pavement), and Module 5.1 (Advanced Long-term LID Operations: Permeable Pavement).

VEGETATED ROOFS

Vegetated roofs (also known as green roofs and ecoroofs) are thin layers of engineered soil and vegetation constructed on top of conventional flat or sloped roofs. All vegetated roofs consist of four basic components:

- Waterproof membrane
- Drainage layer
- Lightweight growth medium (typically 2 to 6 inches)
- Vegetation (ranging from low groundcover to trees)

Additional (optional) components may include:

- Protection layer
- Root barrier
- Insultation
- Moisture retention mat
- Leak detection system
- Filter fabric

Benefits

- **Increases property values** through social, economic, and environmental benefits that help to offset design costs.
- **Reduces energy usage** (average of 10%) and **doubles the lifespan of a typical roof** (to 50 years).
- Provides an **aesthetically pleasing** amenity that has been shown to relieve mental fatigue and lower stress.
- **Reduces peak flows** (by approximately 50%) and total runoff volume (up to 70%).
- **Reduces heat island effects and improves air quality** within dense urban settings.

Design Tips

- A **variety of planting palettes** can accommodate varying light availability, roof slope, irrigation, and desired maintenance frequency. Plants can range from low groundcover to tall trees.
- Roof slopes between **5 to 20 degrees are most suitable**, but vegetated roofs can be installed on roofs with **slopes up to 40 degrees** with specific design.
- Vegetated roofs should be **combined with a rainwater harvesting system** with caution. The water filtered through the vegetated roof contains tannins and fine sediment.

Mukilteo City Hall (completed in 2008) was the first facility in Snohomish County to be certified as LEED Gold. It includes a 2,900 square foot vegetated roof in addition to permeable pavement (pervious concrete and open-celled grass grids) and a biofiltration swale.

What's New in Design & Installation

Modular vegetated roof systems are available in trays or mats, which can **speed up the installation process and reduce costs**. Trays or mats can be delivered to the site either partially or fully planted.

There is a **Green Roof Professional (GRP) training and accreditation program** available that addresses design and installation, waterproofing and drainage, and plants and growing media: https://greenroofs.org/green-roof-professional-training

Vegetated roof retrofits can occur on existing conventional roofs with the assistance of a licensed structural engineer. Considerations should be made for the additional dry and wet soil weight, as well as wind loading.

The City of Portland's Ecoroof Program has developed **numerous helpful vegetated roof resources** including an Ecoroof Handbook, an Ecoroof Guide, information on a 2008-2012 incentive program, and videos addressing a range of topics including permitting, vegetation, installation, operations and maintenance, irrigation, and case studies: www.portlandoregon.gov/bes/44422

What's New in Maintenance

Weeding and irrigation are the primary maintenance requirements for vegetated roofs. **Roof drains must be kept clear of blockage and debris** to prevent clogging.

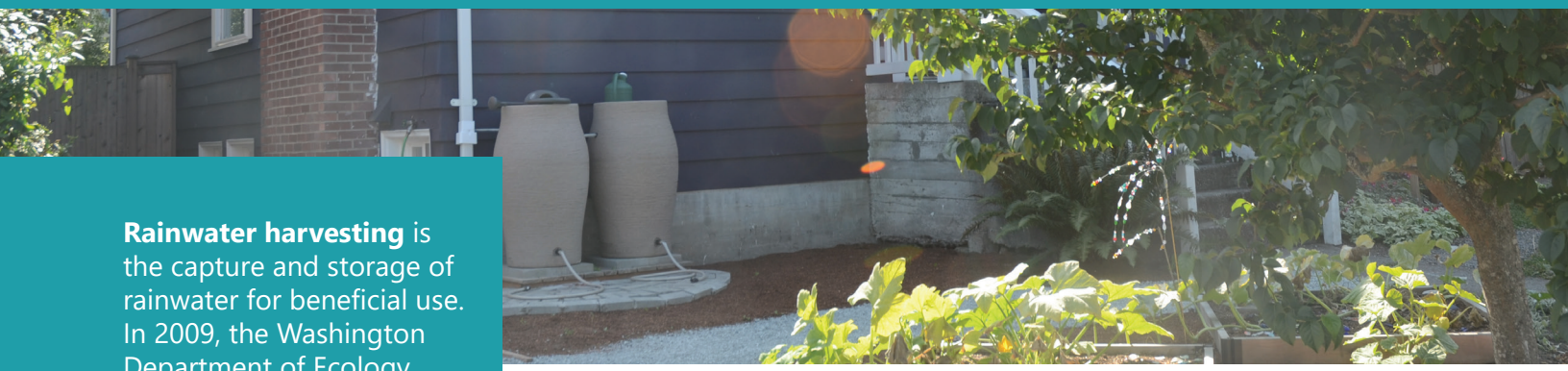
Vegetated roofs require a specialized growth medium engineered for the specific system installed. Adding compost per manufacturer's recommendations will help to **maximize functionality and plant growth**.

Sedums can be **mulch mowed** to create cuttings and encourage establishment during the first two years or as needed to increase establishment in future years.

More Information & Resources

- Stormwater Management Manual for Western Washington
- Low Impact Development Technical Guidance Manual for Puget Sound
- Western Washington LID O&M Guidance Document
- Statewide LID Training Program Module 3.5 (Rainwater Collection Systems and Vegetated Roofs) and Module 2.1 (Introduction to LID for Inspection and Maintenance Staff)

RAINWATER HARVESTING



Rainwater harvesting is the capture and storage of rainwater for beneficial use. In 2009, the Washington Department of Ecology issued a rainwater interpretive policy, which clarifies that a water rights permit is not required to use water collected from a rooftop in Washington.

Roof runoff may be routed to cisterns for storage and nonpotable uses such as:

- Irrigation
- Toilet flushing
- Cold water laundry

Rainwater harvesting occurs on larger-scale commercial and institutional projects and on smaller-scale residential projects with pumped systems and simple gravity-fed rain barrel systems.

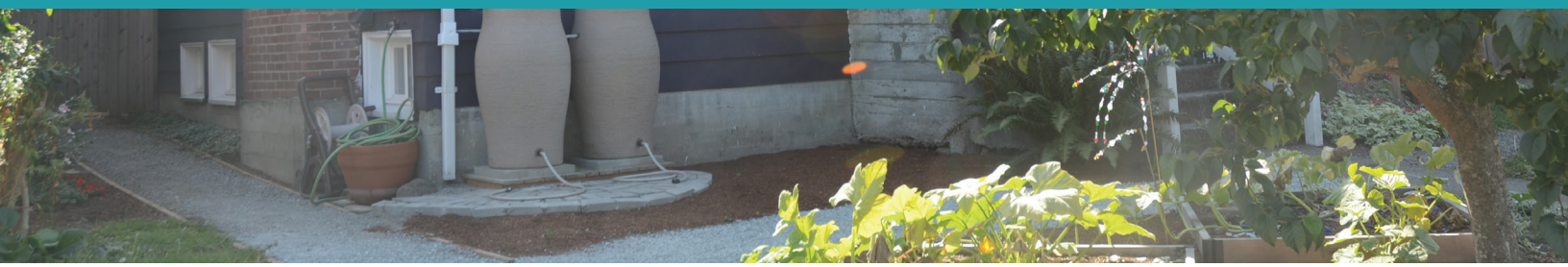
Benefits

- **Reduces energy consumption** within a community by **decreasing demand** for treated water distributed by local municipalities.
- **Conserves water** and **mitigates stormwater** flows.
- Marketed as a **green feature** alongside other low impact development features such as bioretention or rain gardens.

Design Tips

- Can be designed for **potable or non-potable** uses. Potable uses are limited to single-family residential applications.
- Cisterns are available in a **variety of sizes, shapes, materials, and colors** to fit site constraints, cost, and aesthetics, either blending in or contrasting with the building and site design.
- Cisterns may be placed **above, below, or partially buried** below the ground surface.
- For potable systems, **prefinished metal roofing** is preferred.
- Install **pre-filters** and **screen** all inflows to the cistern with 1/16" stainless steel mesh to prevent leaves and other debris from entering the cistern.

The **Center for Urban Waters in Tacoma, WA** (completed in 2010) follows the concept of a living laboratory, incorporating sustainable features to minimize the building's environmental footprint. Rainwater is collected into a 10,000-gallon cistern and reused for irrigation and low-flow flush fixtures within the building.



What's New in Design & Installation

Material lifespan is an important design consideration when installing a rainwater harvesting system. **Typical warranties** for cisterns range from **15 to 30 years**, while pumps have warranty periods ranging from **2 to 10 years**.

The American Rainwater Catchment Systems Association (ARCSA) and the American Society of Plumbing Engineers (ASPE) have developed **design and installation standards** for rainwater catchment systems for engineers, designers, plumbers, builders/developers, local government officials, and end users: www.aspe.org/content/arcsaaspeansi-63-2013-rainwater-catchment-systems-electronic-download

The ASPE offers an **on-demand rainwater harvesting webinar** and a **Green Plumbing Design certificate program**:

> ***Rainwater Harvesting Webinar:*** https://education.aspe.org/products/rainwater-harvesting
> ***Green Plumbing Design program:*** https://aspe.org/GPD

The RainWise program in King County and Seattle offers **training and certification courses** for contractors and **rebates for eligible property owners**: www.700milliongallons.org/rainwise

The Washington Stormwater Center developed a video that documents a simple potable rainwater system: https://vimeo.com/133942623

What's New in Maintenance

Cisterns generally have low maintenance demands but can accumulate sediment over time. An **annual cistern inspection** is recommended to identify and remove any debris. **Keeping roof gutters clear** is an important step to reducing sediment accumulation and maintenance issues.

One of the most common maintenance requirements is **annual filter replacement**. Pump replacement can be minimized with proper care of system components.

Water quality testing is required for rainwater harvesting for potable use.

More Information & Resources

- Stormwater Management Manual for Western Washington
- Rainwater Interpretive Policy and Rainwater Harvesting Calculator
- Statewide LID Training Program Module 3.5 (Rainwater Collection Systems and Vegetated Roofs) and Module 2.1 (Introduction to LID for Inspection and Maintenance Staff)

Amended Soil

Amended soil refers to the practice of restoring soils that are disturbed during construction activities.

Options to restore disturbed soils include:

1. Till compost into existing soil
2. Stockpile and reuse existing topsoil (amend if needed to meet organic matter content requirements)
3. Import compost-amended topsoil and till into existing soil.

Benefits

- **Reduces** need for **fertilizers and pesticides**.
- **Reduces irrigation demand by up to 50 percent** (three- to seven-year payback on irrigation savings alone).
- **Creates marketable buildings and landscapes.**
- **Decreases erosion.**
- **Improves plant health and survival.**

Design Tips

- Leaving **undisturbed vegetation and soil** is always the preferred method for retaining soil health, but not always feasible in construction projects.
- **Redistribute existing topsoil** whenever feasible to maintain soil health.
- Where existing soils cannot be reused, establish new topsoil to a **minimum of eight inches** to promote healthy plantings.
- Development of a **soil management plan** is often required with this BMP to determine the amounts of compost, amended soil, and mulch to be used on site.

Redmond Ridge, a large, master-planned development, had soft soils with excessive water retention and low nitrogen content. Developers graded the site 12 inches below finished grade and applied 14 inches of amended soil mix. Native duff and compost were blended offsite. Organic matter, pH, and C:N ratios were controlled to meet amended soil requirements and to achieve optimal plant growth.

What's New in Design & Installation

	In some jurisdictions, **compost used for erosion control** (compost blankets, berms, and socks) **can be incorporated into the soil to meet amendment requirements**, which eliminates disposal costs and promotes faster plant establishment and growth for significant cost savings.
	"Topsoil" is not a defined, regulated product. Topsoil products can often include subsoil, uncomposted organic material, and/or land clearing and construction debris. **Use mixes containing only clean compost and mined sand or "sandy loam,"** as defined by the USDA.
	Make sure to **fence soil protection zones** and inform all contractors and subs that **stockpiles and vehicle and equipment traffic is not allowed** in fenced areas. If temporary vehicle access is required, place steel plates over six inches of coarse wood chips.

What's New in Maintenance

	The most important maintenance activity is **replenishing the soil organic matter content** by leaving leaf litter and grass clippings on-site and **maintaining two to three inches of mulch** over bare areas in the spring or fall. Arborist wood chips are preferred.
	In order to maintain infiltration, compacted turf areas should be **aerated and top-dressed with ¼ to ½ inch of compost**.
	Weeds should be removed manually using pincer-type weeding tools, flame weeders, or hot water weeders. Unhealthy vegetation should be removed and replaced.

More Information & Resources

- Stormwater Management Manual for Western Washington
- Western Washington LID O&M Guidance Document
- Statewide LID Training Program *Module 2.1 (Introduction to LID for Inspection and Maintenance Staff) and Module 6.2 (Bioretention Media and Compost Amended Soils)*
- Building Soil Manual
- Erosion Control with Compost

Minimal Excavation Foundations

A minimal excavation foundation minimizes a building's required mass grading and site disturbance by distributing its structural load onto piles or shorter perimeter walls, as opposed to using solid foundation slabs dug into the earth.

- Piles are slender elements (pins, screws, or clusters) embedded on end into the ground to support a structural load.
- Perimeter walls (also called post and beam, grade beam, or fin wall structures) are short and thick walls at building exteriors, that spread the building weight over a larger area of soil.

Benefits

- **Minimizes or eliminates excavation** of soil, which helps store and filter stormwater flows.
- **Can make sites developable that were otherwise undevelopable**. Can be installed in areas with poor soils/drainage.
- Conserves materials by **using 5 to 10 percent of the concrete** that would be required for a typical foundation.
- While minimal excavation foundations are often used for **boardwalks, decks, porches, and carports**, they can also be used for **entire houses or small commercial buildings** (up to three stories high).

Design Tips

- Pile designs can be installed "**pile first,**" where piles are installed prior to the supporting structure, or "**post pile**", where the structural walls are constructed and then the piles are driven through.
- A **variety of materials** can be used for piles – concrete, steel, or wood – depending on the design and cost constraints of the project.
- Perimeter walls should be **terraced on sloped sites** to minimize excavation requirements.

Case Study TBD
Will follow-up with Curtis on a case study (Clearwater Commons, other?)

What's New in Design & Installation

	Minimal excavation foundations can be installed as a **combination of piles and pre-cast walls**. This configuration allows for installation of sloped wall bases, with minimal grading requirements.
	Pin foundation systems require a **heavy-duty air compressor and minor labor** without any assistance from large machinery.
	Piles and perimeter walls **reduce soil compaction** from heavy machinery and equipment, as they can typically stay at the edges of the site.
	Some foundation systems can be designed to allow for the **removal and replacement of pilings**, which can extend the life of the support indefinitely.

What's New in Maintenance

	Good drainage is critical to maintaining foundations. Maintaining a free-draining buffer material that separates the soil from the grade beam or other structural element mitigates risks of rot or corrosion.
	Corrosion rates for galvanized or coated steel piling, or **degradation rates** for concrete piling, are **typically very low to non-existent**, and piling for these types of foundations can last for the life of the structure.
	Maintenance or replacement may be needed for wood piling or systems that are exposed to **salt air or highly caustic soils** (typically in industrial areas).

More Information & Resources

- Stormwater Management Manual for Western Washington
- Low Impact Development Technical Guidance Manual for Puget Sound

DISPERSION

Dispersion is the release of surface and stormwater runoff through a vegetated area, resulting in attenuation of peak flows, some infiltration, and water quality benefits.

The four primary types of dispersion are:

- Downspout dispersion
- Concentrated flow dispersion
- Sheet flow dispersion
- Full dispersion

Downspout dispersion systems are focused on roof runoff and can include splash blocks or gravel-filled trenches (also called dispersion trenches).

Benefits

- Dispersion is a **simple design** that can be easily installed or retrofitted into a property to handle runoff from driveways, sidewalks, and roofs. Dispersion also works well on linear roadway projects.
- It **reduces peak flows** by slowing entry of the rainwater into the conveyance system.
- It is generally **cost effective**, where space is available, as minimal infrastructure and maintenance is required.

Design Tips

- Use a **level spreader** to evenly distribute collected flows across vegetated areas.
- **Avoid slopes greater than 15 percent** where possible, unless using a level spreader (which can manage slopes of up to 33 percent).
- Construct flowpaths as groundcover in vegetated flowpaths are traditionally **undisturbed native landscape or grass**, but constructed flowpaths may be feasible (see *What's New in Design & Installation*).
- Dispersion flowpaths may be restricted or infeasible in **environmentally critical areas**, including steep slopes, contaminated sites, and septic drain fields.
- **Minimize the area that needs to be cleared or grubbed**. Maintaining plant root systems is important for dispersion areas.

Insert Case Study Photo

Dispersion case study TBD

What's New in Design & Installation

	Previously developed areas can be **converted to native vegetation** suitable for dispersion, provided underlying soils are compost amended, soils are de-compacted, and native species are planted to a specified density. Additional information can be found in the Stormwater Management Manual for Western Washington (BMP T5.30 – Full Dispersion).
	Using **low-ground pressure vehicles and equipment** during construction minimizes compaction.

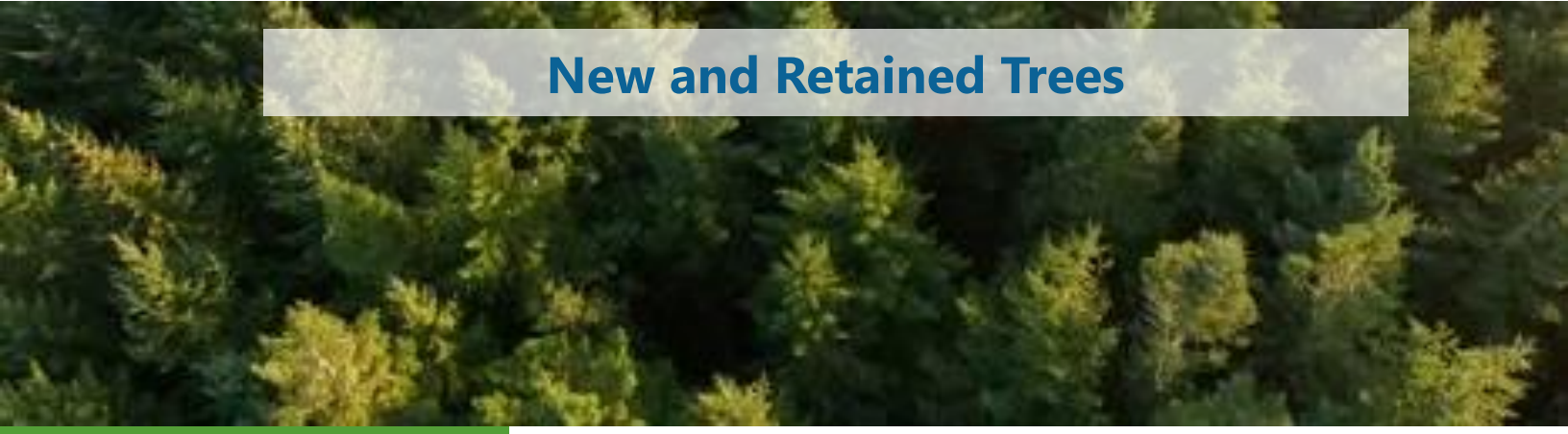
What's New in Maintenance

	Dispersal areas must be **watered once every one to two weeks during the establishment period** (initial one to two years) and during prolonged dry periods.
	If vegetation coverage is poor, **assess for nutrient deficiencies, amend soils** to promote plant health, and/or **replant as needed** with appropriate species for the soil and moisture conditions.
	Aggregate in rock pads must be occasionally **replaced** as it becomes dislodged over time. [Comment from Angela: I have no idea what this means but perhaps your reader will?]
	Vegetative flowpaths must be maintained to **remove obstructions such as weeds and rodent holes or mounds**.

More Information & Resources

- Stormwater Management Manual for Western Washington
- Western Washington LID O&M Guidance Document
- Statewide LID Training Program *Module 2.1 (Introduction to LID for Inspection and Maintenance Staff)*
- WSDOT Highway Runoff Manual

New and Retained Trees



Tree retention refers to retaining trees during new development and redevelopment activities. If retained trees meet specific size, location, and viability requirements, then a jurisdiction may allow a flow control credit to be applied.

Tree planting refers to planting new trees during new development and redevelopment activities. Similar to retained trees, new trees must meet specific size, location, and viability requirements to receive flow control credit (if allowed by the local jurisdiction).

Evergreen trees receive a larger flow control credit than deciduous trees. Flow control credits are not typically applicable to trees in native vegetation areas or in planter boxes.

Benefits

- Trees can **increase property values.**
- Retaining trees or planting new trees can **reduce the size of other onsite stormwater facilities** if flow control credit is applied.
- Networks of tree roots can **improve soil stability**, as roots can bridge weaker soils and anchor to more stable areas.
- Trees can provide additional benefits such as **reduced heat island effect** and **improved air quality**.

Design Tips

- **Maintain setbacks** between structures and new or retained trees in order to provide adequate space and light for optimal growth without interference.
- New and retained trees must **meet minimum size requirements** and be viable for long-term retention.
- **Supplemental irrigation** should be incorporated into site designs where new trees are planted to provide irrigation for three to five years following installation.

Case Study TBD:
We reached out to WA DNR regarding their "Protesting Trees During Construction" seminar series conducted in 2019 and are waiting on a short case study and photo from them.

What's New in Design & Installation

	Approved trees vary by jurisdiction due to local climates and soils. Check with local jurisdictions for currently accepted species if you are planning on planting a new tree in the right-of-way or applying a flow control credit.
	Consult an arborist if soil disturbance is proposed within the critical root zone (CRZ) of a retained tree. The CRZ is defined as the line encircling the base of the tree with half the diameter of the drip line. Specialized techniques such as augering or compressed air excavation instead of trenching can be used to protect and preserve tree roots during construction activities.
	If roots on a retained tree must be cut, minimize impacts by **avoiding excavation activities during hot and dry weather**. K**eep the retained trees well-watered** before and after excavation activities and **cover the exposed roots with mulch** as soon as possible.

What's New in Maintenance

	Apply mulch by hand in a ring around the tree to avoid covering the root flare. Avoid mulch volcanos!
	Prune trees at the **right time of year**. Avoid pruning during spring growth flush. Deciduous trees should be pruned from November through February. Hazardous trees should be pruned at any time of the year to avoid risk or injury.
	To reduce scald injury, **do not prune trees with thin bark in the summer**. **Do not prune pine or elm species from May through October** to reduce possible exposure to bark beetle (pine) or Dutch Elm Disease (elm).
	Ensure that trees receive adequate water during a three- to five-year establishment period. Most trees require 10 to 15 gallons once every one to two weeks during the first summer and every two to four weeks during the second and third summers. Additional watering may be needed during prolonged dry periods.
	Utilizing native species will help reduce maintenance requirements, as they require less care within the environment.

More Information & Resources

- Stormwater Management Manual for Western Washington
- Low Impact Development Technical Guidance Manual for Puget Sound
- Western Washington LID O&M Guidance Document
- Statewide LID Training Program *Module 2.1 (Introduction to LID for Inspection and Maintenance Staff)*
- King Conservation District Urban Forest Health Program