Low Impact Development in the Design Phase

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After site planning has been completed, a thorough design process, usually culminating in a set of drawings and specifications and a stormwater report, is needed to ensure that proposed low impact development practices function optimally according to the client's desired outcomes (i.e., remove pollutants, relieve flooding, provide habitat). This fact sheet points out some key hydraulic and hydrologic considerations for the design phase that apply generally to the project. More detailed design considerations for specific best practices can be found in individual fact sheets in this series.

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Figure 1.—Permeable pavers are a beautiful amenity at the Red Hills Market in Dundee, Oregon.

Optimizing design

Throughout the design phase, LID design should continue to be informed by on-site conditions, the client's budget, stakeholder preferences regarding long-term operations and maintenance, and jurisdictional regulations, which are often driven by the larger watershed context.

If a sustainable stormwater master plan is to be implemented properly in subsequent phases, modeling and permit drawings will refine the master plan, detailing a blend of structural and non-structural practices. Hydrologic modeling is also needed to confirm the assumptions about feasibility made during the planning phase. Often, the final design is a result of numerous iterations of hydrologic modeling and locating and sizing practices on the plans to achieve a variety of goals; for instance, minimizing piping lengths by using overland vegetated conveyance swales or locating an additional facility at the top of the site, so that the room left for another facility at the bottom of the site is adequate.

In addition to the stormwater plan, opportunities to address and convey important information about the stormwater management system may exist on the cover sheet; site layout; grading and erosion control plans; sewer and water plan; landscape plan; mechanical, electrical, and plumbing plans; and details sheet—in other words, every sheet associated with site work. Often the grading plan, expressing how water will move around the various on-site surfaces, dictates where facilities can be located, and the best LID grading plans will minimize excavation and grading.

Cost-effective designs

Facilities must be cost-effective when considering both short-term construction costs and long-term maintenance costs. Non-structural

LOW IMPACT DEVELOPMENT

FACT SHEET

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practices are usually more cost- and environmentally effective than structural practices. In addition to the up-front cost savings, LID often results in additional cost savings.

Retrofits always add cost up-front, since they either must remove some existing infrastructure or are simply additive, meaning there is no economic driver, such as selling the property at the end of the retrofit, that might help cover costs. Sometimes, though, retrofits can save money in the long term as a result of incentive programs or reduced maintenance.

For new or redevelopment projects required to manage stormwater, the table below gives typical cost savings scenarios to developers and landowners for both a non-structural and a structural LID practice.

Jurisdictions can also save their communities a substantial amount of money by encouraging and incentivizing LID practices. For more information on these benefits, see the Oregon Environmental Council's publication on LID[1] and the USDA's Forest Service publication, *Western Washington and Oregon Community Tree Guide.*[2]

Applicability

The LID applicability tables[1] on the OSU Stormwater Solutions website provide information on what runoff surfaces a particular LID facility may be effective on ("Applicability by Surface Runoff Type") and also on challenging sites. For instance, sites with steep slopes, seasonal high groundwater tables, shallow bedrock, or inadequate setbacks are considered unsuitable for infiltration of runoff; however, infiltration and evaporation of rainfall and evaporation of runoff are still viable on these sites.

Slow-draining soils are not automatically a barrier to infiltration, but they will make runoff-management facilities, such as rain gardens, larger, which could lead to inadequate setbacks. Expansive clays soils are unsuitable for porous pavements, but do not affect vegetated facilities.

Hydrologic modeling

Modeling is used to predict how facilities will respond to and manage a variety of stormwater events. While models may give us very specific values of interest, such as peak flows before and after development, use these values cautiously. All models must always leave something out and should be considered a rough estimate of the real world, good for

1 "Low Impact Development: Protecting Oregon's waters as we grow." Oregon Environmental Council. http://bit.ly/1mKgPIQ [last accessed 6-2-14]

2 "Western Washington and Oregon Community Tree Guide: Benefits, Costs and Strategic Planting" http://1.usa.gov/T7Nrnl [last accessed 6-2-14]

3 http://bit.ly/SoIcyX [last accessed 6-2-14]

Table 1. LID and cost savings.

LID Type	LID Practice	Cost savings
Non-structural	Reduce impervious pavement (e.g., narrow streets, minimum parking standards, reduced building setbacks).	Reduced pavement area to be installed. Less runoff to be managed results in smaller facilities. Long-term maintenance costs such as seal coating and replacement are reduced.
Structural	Install distributed infiltration rain gardens instead of a single, end-of-pipe detention basin.	Except for piping and an area drain for overflow, which are often installed in landscape anyway, rain gardens have a cost similar to that of conventional landscapes. Infiltration rain gardens take up much less space than detention basins and should be distributed throughout a development's landscape areas usually already required by zoning and planning regulations The space where the detention basin would have been is now buildable land.

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Figure 2.—Rain gardens (back left) were integrated with other infrastructure in the public right-of-way to create an attractive and welcoming streetscape on the Rogue River Highway (OR-99) in Grants Pass, Oregon.

comparing different practices on one site or for comparing across different sites with similar conditions.

The Santa Barbara Urban Hydrograph (SBUH) method, which uses an approach similar to the Soil Conservation Service (SCS) method described in *Urban Hydrology for Small Watersheds,*[1] doesn't account for evaporation and the complexities of plant and soil animal interaction, and has other limitations that the designer should be aware of before embarking on modeling. Nonetheless, this is the most common model in use today by jurisdictions in western Oregon. The modeling tools provided by the OSU Stormwater Solutions website use the SBUH method as a means of protecting water quality and managing quantity through infiltration. To encourage runoff reduction through evaporation, it's important to incorporate as much existing and new vegetation as possible into your site plans.

EXCEL CALCULATORS

Western Oregon rainfall distribution is represented by the Type IA storm. To create the Stormwater Sizing Calculators for rain gardens, planters, and porous pavements, we adapted a hybrid approach used by the City of Portland. The Santa Barbara Urban Hydrograph (SBUH) Type IA storm distribution curve is embedded into the model, but peak flows for a given storm size are generated using the rational method (Q=CIA). The rational method is applicable only to sites up to 300 acres.[1] No time of concentration is included, making the model more conservative in sizing facilities than a straight SBUH approach.

Since runoff can come from impervious and landscape areas, the calculator allows the user to enter the desired runoff coefficient, C, which is from the rational method. Landscape soils that have been disturbed by construction and not restored with compost amendment (at a minimum) could be conservatively included in the contributing area as impervious, especially if soils have a high clay content, which is easily compacted during construction. A high C-value might also be assigned to seasonally saturated soils (i.e., areas with high groundwater tables), since rainfall is more likely to run off when falling on these areas. Landscape areas that were preserved during construction can be assumed to be self-managing and can be exempted entirely from the hydrologic analysis.

More-detailed information, including how to enter data and calculations within the model, is available on the OSU Stormwater Solutions website. Excel models are available for rain gardens, stormwater planters,[2] and porous pavement.[3]

Consult a civil engineer to perform hydrologic modeling if significant areas of landscape areas are planned for the proposed development or other complexities, such as routing questions, arise.

4 http://1.usa.gov/RYPkS1 [last accessed 6-2-14]

5 ODOT Hydraulics Manual, Chapter 7, Appendix F. 2005. (http://bit.ly/1kqHmN1) [last accessed 6-2-14]

6 http://bit.ly/1iMnFL4 [last accessed 6-2-14]

7 http://bit.ly/RYPWXC [last accessed 6-2-14]

STORMWATER PLANTER SIZING CALCULATOR 24 Hour Storm, SBUH Type 1A Rainfall Distribution			
USER INPUTS			
24 Hour Rainfall Depth =	1.45	in	Enter
Drainage area =	1000	sf	Enter
Drainage Area Runoff Coefficient =	0.9		0.9 - 0.98 for imp surface
Native Soil Infiltration Rate =	2.3	in/hr	Enter
Depth of Rock Trench Below Planter (optional) =	0	inches	Enter, optional
Void Ratio for RockTrench =	40%	%	Typically 40% for uniformly graded rock
Planter Area =	24	sf	Adjust this until max ponding depth in raingarden is 12 inches and the facility is completely empty in 30 hours
CALCULATED DESIGN CRITERIA			
Maximum Ponding Depth in Planter =	11.38	in	Calculated
Depth of Water Left in Rock Trench After 30 Hours =	0.00	in	Calculated
Depth of Water Left in Planter After 30 Hours =	0.00	in	Calculated
Planter Area is Adequately Sized?	TRUE		Calculated, if FALSE, increase Planter Area and/or Depth of Rock Trench Below Planter until TRUE
OTHER CALCULATED VALUES			
Peak Rainfall Intensity =	0.47	in/hr	Calculated from distribution
Ratio of Planter to Drainage Area =	0.024		Calculated (aka Sizing Factor)
Storage Capacity of Rock Trench=	0.00	cf	Calculated

Figure 3.—The sizing calculators on the OSU Stormwater Solutions website are simple and well-documented, allowing even nontechnical users to size facilities, but robust enough to include values of interest to technical users.

Choosing a suitable design storm

In general, the designer will reduce runoff by preventing it in the first place, or by mitigating runoff volume through a blend of disposal methods including infiltration, evaporation, and, to a lesser degree in western Oregon, re-use. For structural facilities, the jurisdiction and/or designer must decide how to optimize water-quality treatment, meet regulatory requirements, and keep costs low. One way to keep costs low is to identify the smallest storm size required by regulation to be treated.

PROTECT WATER QUALITY ON-SITE

Often, when we imagine scouring and erosion, we think of large storms; however, most degradation in our waterways is caused by the small, frequent storms (e.g., 6-month 24-hour design storm) capable of scouring pollutants from the land's surfaces. There are a few commonly used approaches for defining this storm size.

One common rule of thumb, still seen in regulatory documents, is to dispose of the 1-inch 24-hour design storm to meet on-site water quality treatment goals such as capturing 90 percent total suspended solids. The 1-inch storm may be larger or smaller than the actual storm that scours pollutants and carries them downstream, so this approach will treat stormwater adequately on-site only when the actual water-quality design storm is less than or equal to 1 inch.

For some locations in western Oregon, though, the water-quality storm will exceed 1 inch in 24 hours. In this case, the minimum volume reduction should be equal to the water-quality storm. Another simple way to choose a water-quality 24-hour storm is to use the water quality precipitation maps for the 6-month design storm, provided on the OSU Stormwater Solutions website.[1]

Seth Leanerts

Figure 4.—This rain garden in Lincoln City is flaunting its "seasonal interest" on a sunny summer day and protecting water quality in Devil's Lake during the rainy season. Don't forget to include a signage designer on your team.

A third common way is to assume that the water-quality storm is $^2/_3$ the size of a 2-year storm. Again, you can use the precipitation maps online or NOAA isopluvials to determine the 2-year storm and multiply it by 0.67 to find the size of the water-quality storm.

PROTECT WATER QUALITY WATERSHED-WIDE *AND* STATEWIDE

Treating the very small, frequent water-quality storm does provide some water quality benefits; however, the EPA has recognized that 95 percent of the rainfall in a pre-developed condition nationally is either infiltrated or evapotranspired (a term that includes evaporation and transpiration by vegetation).[1] As long as a larger *volume*—not just peak flow—of water is leaving the site over the pre-developed conditions, then stream banks will be scoured, re-polluting the waterways with sediment. In Oregon, jurisdictions are bound by statewide planning goals that dictate, to some extent, how they should approach water-quality regulation. Specifically, Goal 6 intends to "maintain and improve the quality of air, water, and land resources of the state."[2] Considering this overarching goal and what we are learning from scientific study of watershed responses to urbanization and rainfall, water-quality goals cannot be met by simply protecting water quality on-site.

To meet state and federal regulations, define a 24-hour storm and protect water quality on site by determining the 95th percentile storm. To do this, download historical rainfall data from the United States Geological Survey (USGS) for a rain gauge in your jurisdiction. In Excel or other statistical software, modify the data, as needed, to reflect a series of daily rainfall events and count the frequency of various sized storms to tenths of an inch. After deleting all storms less than 0.1 inches, find the storm size that includes 95 percent of all the storms. This may seem like a complicated procedure, but actually doesn't take more than an hour or two. More detail is provided in the EPA's document.[7]

Unlike detention and other conventional stormwater management techniques,[3] reducing runoff volume from 95 percent of a region's storms will stabilize stream banks, provide higher water-quality treatment, recharge the aquifer, *and* reduce flooding. While the 95th percentile storm may sound like a very large storm, when all the storms are counted up, small storms occur far more frequently and weight the analysis toward a smaller value. For similar reasons, the annual precipitation depth also does not significantly increase the value of the 95th percentile storm. For instance, one analysis for retrofits in Kailua, Hawai'i, which receives 37 inches of rain a year, found that the 90th percentile storm size (sometimes used instead of the 95th percentile storm for retrofit projects) was 1.43 inches. Another area in the same study, Hilo, Hawai'i, receives 130 inches of annual precipitation; however, the 90th percentile storm turned out to be 1.39 inches, as a result of receiving more frequent small storms than Kailua.

8 http://bit.ly/1pAJncq [last accessed 6-2-14]

9 "Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act," December 2009. http://1.usa.gov/1h0NlIB [last accessed 6-2-14]

10 http://1.usa.gov/1l1jWgU [last accessed 6-2-14]

11 "Low Impact Development: Protecting Oregon's waters as we grow." Oregon Environmental Council. http://bit.ly/1mKgPIQ [last accessed 6-2-14]

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Figure 5.—A meticulous grading plan and a willing contractor saved many existing trees in the parking lot of the Bend Park & Recreation District's administration building in Bend, Oregon.

In practice, even with very high average annual rainfalls, it is likely to be a much smaller value than if the jurisdiction had adopted the City of Portland's standard. This standard manages the 10-year frequency storm, because the EPA regulates Portland to reduce overflows from combined sewers. Since most small cities in Oregon don't have combined sewers, a lot of money can be saved by analyzing their own rainfall data.

A more simplified approach could be to manage the 2-year 24-hour design storm, which is a rule of thumb that tends to attenuate the 25-year 24-hour flood storm and provide all the other benefits. This would be a good approach if a designer's criteria includes water-quality protection but the designer doesn't have regulatory requirements to follow or the budget in his or her fee to calculate the 95th percentile storm.


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Figure 6.—In accordance with the Fairview Masterplan, the Pringle Creek Community in Salem, Oregon, implemented a sustainable site on clay soils. Pictured here are pervious concrete, porous asphalt, green roofs, a preserved tree grove, and new trees.

Jurisdictional regulations

Stormwater is regulated through multiple local, state, and federal regulatory organizations. The following are just a few of the most common jurisdictions you should be aware of when permitting a project:

CITIES

Large cities often have a separate sewer department, but many small cities also have a stormwater or water-quality coordinator who can help you navigate requirements where water quality codes often fall under the Public Works or Engineering departments.

COUNTIES

Some counties defer to other jurisdictions to oversee their regulatory requirements. For instance, Jackson County works with Rogue Valley Sewer Services.

STATE OF OREGON

The Oregon Department of Environmental Quality Water Quality Division has jurisdiction over water quality at the state level.

Some of the programs apply only to jurisdictions:

Total Maximum Daily Loadings (TMDL)[1] is defined by the DEQ as the "calculated pollutant amount that a waterbody can receive and still meet Oregon water quality standards."[11]

12 http://bit.ly/1hsRIge [last accessed 6-2-14]

See the OSU Stormwater Solutions website for the "Stormwater Management Plan Template"[2] that may be used to more easily meet your TMDL regulatory requirements.

Municipal Separate Storm Sewer System (MS4) is defined by the DEQ as "a conveyance or system of conveyances (e.g., roads with drainage systems, municipal streets, catch basins, curbs, gutters, manmade channels or storm drains) owned or operated by a governmental entity that discharges to waters of the State. Sources that need to obtain an MS4 permit are classified as either "Phase I"[3] or "Phase II."[4] Phase I MS4s are

13 http://bit.ly/1jNe1aE [last accessed 6-2-14] those with populations greater than 100,000, while regulated Phase II (or 'small') MS4s serve populations less than 100,000 located within Census Bureau-defined Urbanized Areas. Federal regulations also provide EPA and the states the discretion to require other MS4s outside of Urbanized Areas to apply for a permit."

Designers and jurisdictions alike should be aware of the following regulations for project-related work:

Underground Injection Control (UIC)[5] Program is responsible for "regulating the construction, operation, permitting, and closure of injection wells that place fluids underground for storage or disposal."[15]

See the OSU Stormwater Solutions web page on UICs[6] for more information on how to avoid creating a UIC when using some LID practices. UIC information is also included in each fact sheet.[7]

National Pollutant Discharge Elimination System (NPDES) Stormwater Dishcharge Permits to control discharges for projects under construction[8] or for industrial activities.[9] NPDES permits are required for "storm water discharges to surface waters from construction and industrial activities and municipalities if stormwater from rain or snow melt leaves your site through a 'point source' and reaches surface waters either directly or through storm drainage. A point source is a natural or human-made conveyance of water through such things as pipes, culverts, ditches, catch basins, or any other type of channel."[18]

The Oregon Department of State Lands regulates work in wetlands and waterways through the Removal-Fill Permit[10] to "protect public navigation, fishery and recreational uses of the waters."[20]

US Army Corps of Engineers permits[11] are "necessary for any work, including construction and dredging, in the Nation's navigable waters."[21]

See the OSU Stormwater Solution's "Stormwater Management Plan Template"[12] for more information on additional jurisdictions, such as the Oregon Dept. of Fish and Wildlife, that may regulate your project. Also, consult a civil engineer, environmental scientist, and your jurisdiction for any other permits that may apply to construction of LID facilities.

Considerations

DETAILED DESIGNS

Since many of these approaches will be new to your community, more information than might typically be included is likely needed on every plan. The grading plan often becomes integral to directing stormwater overland toward shallow facilities. Tight tolerances for inlets, outlets, weir structures, and other infrastructure might apply to rain gardens and stormwater planters and careful detailing of these to ensure proper construction and function is essential. *To see an example of the level of detail needed for even small projects, download a set of plans from the parkingforest.org website.[1]*

Even if an approach is familiar, such as tree protection, extra detail over conventional developments will be helpful. For instance, tree protection fencing should be shown on the tree protection plan, the grading plan, the utility plans, and the landscape plans at a minimum. Different contractors may be working on different portions of the work, but all of them need to know the limits of disturbance allowed and where they can and cannot stockpile materials.

To download standard details for a variety of swales, drywells, rain gardens, stormwater planters, vegetated filter strips, and porous pavement in AutoCAD, pdf, and jpg format, see the OSU Stormwater Solutions website.[2]

14 http://bit.ly/1oP6ZtW [last accessed 6-2-14]

15 http://bit.ly/1rE7bOP [last accessed 6-2-14]

16 http://bit.ly/1n5Lu4Z [last accessed 6-2-14]

17 http://bit.ly/T89w50 [last accessed 6-2-14]

18 http://bit.ly/1kyneJ5 [last accessed 6-2-14]

19 http://bit.ly/1nIK6bX [last accessed 6-2-14]

20 http://bit.ly/1kynurE [last accessed 6-2-14]

21 http://1.usa.gov/SoUsPL [last accessed 6-2-14]

22 http://1.usa.gov/1mKHiWJ [last accessed 6-2-14]

23 http://bit.ly/1jNe1aE [last accessed 6-2-14]

24 http://bit.ly/1rE8Wvf [last accessed 6-2-14]

25 http://bit.ly/1hsUm5E [last accessed 6-2-14]

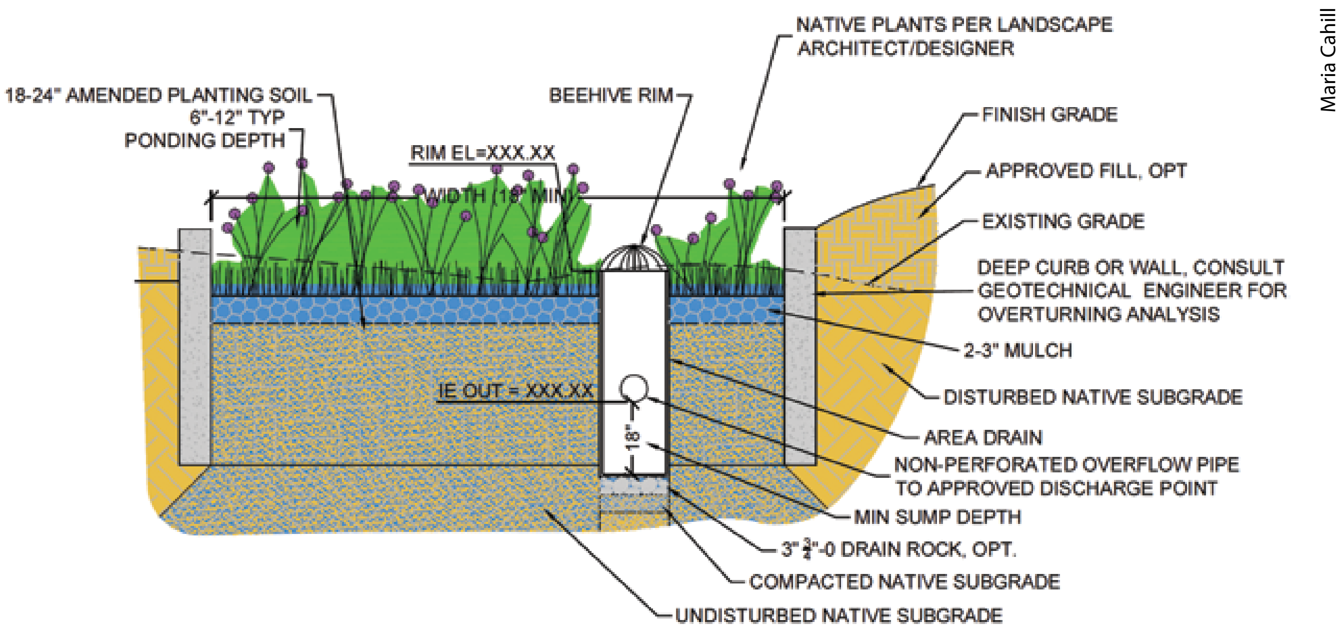

Figure 7.—Standard details for a variety of LID facilities, including this infiltration stormwater planter, are available for download on the OSU Stormwater Solutions website.

TREATMENT TRAIN

A treatment train can be created by routing stormwater runoff from LID approach to LID approach. For instance, runoff from impervious pavement might enter a forebay for pretreatment of total suspended solids and overflow a weir to enter a rain garden, where additional sediments will settle. Some or all of the runoff might then infiltrate into a vegetated soil medium (either the amended planting or native soil), where, for instance, metals are mechanically filtered and sequestered, hydrocarbons are broken down by biological activity, and nitrogen and phosphorus are taken up by the soil or plants. Any additional runoff that cannot be infiltrated from this theoretical rain garden might be conveyed via a vegetated dry swale, which will slow flows to a soakage trench that will infiltrate the remaining volume. Of course, this is just one example. There are endless combinations, but it's necessary to capture as much sediment at the beginning of your treatment train as possible to reduce the need for maintenance due to clogging.

HIGH-FLOW BYPASS

Depending on site conditions and how vegetated facilities are designed, exposure to high-velocity flows can cause erosion and impact long-term functioning and maintenance as well as their value for water quality protection. In these cases, a high-flow bypass system should be employed to allow only selected flows to enter an LID facility, while routing the rest around the facility. For instance, a filtration facility that will only address water quality might be designed to store and infiltrate the volume of the water-quality storm, but a bypass structure could send the remaining

Figure 8.—This facility is being eroded and exporting sediment off-site. A high-flow bypass, or better plant placement and establishment, could help.

less-polluted and less sediment-laden storm volumes to another facility, such as a drywell, for infiltration, thereby protecting the water-quality facility from erosive flows and reducing maintenance. A control structure similar to those used in detention basins is one example of how this might be achieved.

ADDRESSING THE 100-YEAR STORM

No stormwater facility can be designed for every size storm. There will always be a lower frequency, larger storm, such as the 100-year storm, that cannot be accommodated; therefore, all stormwater facilities should have a safe overland route that water can take without damaging property. That route should be clearly indicated on the plans. Final grades critical to overland conveyance should be confirmed at the end of the construction phase to ensure that runoff will actually flow as intended.

INFILTRATION FACILITY SITING

In order to protect structures and natural features from water-quantity impacts such as localized flooding or landslides, infiltration facilities have a number of vertical and horizontal setbacks, defined in the OSU Stormwater Solutions fact sheets.[1] In addition, jurisdictions may also have specific and differing setbacks. For instance, water departments are especially protective of water lines, where health concerns about possible contamination prevail. Water leaving an infiltration system too close to a utility is likely to take the path of least resistance, finding its way into the base rock on which the utility line sits and mixing via leaky spots with potable water.

Decision trees

Decision trees[1] (aka wizards) have been developed as an alternative way to navigate low impact development resources offered on the OSU Stormwater Solutions website. Answer Yes or No to each question at the top of the page. Additional information and graphics are provided to assist you in answering accurately.

CHOOSE THE RIGHT RAIN GARDEN

OSU Extension Service offers a number of variations on rain gardens. The “Choose the Right Rain Garden”[1] decision tree helps users arrive at and implement the rain garden configuration that best suits their site conditions. When to use what is based primarily on where you plan to put it and the condition of the soil. While rain gardens alone probably will not fully protect or restore your watershed, the goal of this wizard is to help you avoid the most complicated and therefore most costly to build and maintain configuration: the lined filtration rain garden. Throughout Oregon, these facilities don’t mimic pre-developed hydrology; additional runoff volumes (aka hydromodification) flowing in and out of a lined facility are likely to damage downstream waterways, impacting water quality, habitat, and groundwater availability.

POROUS PAVEMENT SITING CRITERIA

The “Porous Pavement Siting Criteria”[1] decision tree will help you determine whether a site or location on a site is suitable for infiltration using porous pavement. This decision tree is not intended to help you decide what kind of porous surface—porous asphalt, pervious

26 http://bit.ly/1kyneJ5 [last accessed 6-2-14]

27 http://bit.ly/1h0SOPE [last accessed 6-2-14]

28 http://bit.ly/1kC5Spy [last accessed 6-2-14]

29 http://bit.ly/1wWAXhE [last accessed 6-2-14]

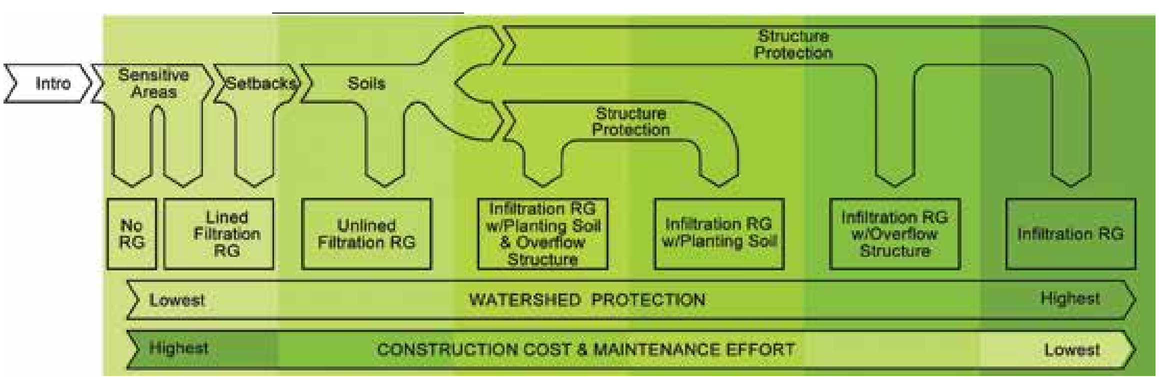

Figure 9.—The “Choose the Right Rain Garden” decision tree can help identify the lowest cost, most environmentally effective rain garden configuration for your site’s natural conditions.

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Figure 10.—A stormwater planter and permeable pavers enhance the RCC/SOU Higher Education Learning Center in Medford, Oregon. All of the disciplines listed in Table 2 would have a stake in this design.

concrete, permeable pavers, flexible pavements, etc.—to use. Surfacing decisions may be based on traffic speeds and loading, budget and cost, durability, availability, maintenance equipment currently owned or available, green goals, perceptions, etc. For a comparison of some of these elements, refer to the *Porous Pavements* fact sheet.[2]

Interdisciplinary communication

Design is an iterative process that often includes a schematic design and a design development phase that results in a bid/permit drawing set. As various members of the team make changes to the site plan, multiple refinements of the drawing set, hydrologic model, cost estimate, and other deliverables will be needed.

Interdisciplinary communication in the design phase of course occurs via regular meetings, calls, and e-mails; however, another important means of communication is via the plan set. Every discipline contributes some impact to the site that is likely to need addressing to meet water-quality regulatory requirements, so careful review of every site plan during the various schedule and design development phases is critical.

Many of the disciplines represented on a typical site-development team may have water-quality and -quantity impacts during the design phase (see Table 2).

30 http://bit.ly/1opdZKn [last accessed 6-2-14]

Table 2. Examples of how various disciplines might affect water quality and runoff volume during the design phase.

This discipline…	…might affect runoff volume by…
Architect	…choosing a building footprint or by stepping the finished floor elevations inside the building to reduce cut and fill on-site.
Geotechnical engineer	…determining site suitability for infiltration. Infiltration rates of soils affect structural facility feasibility and sizing; however, non-structural practices may still be employed.
Contractor	…ensuring that the design is within budget and constructible without causing damage to natural features intended to be protected.
Mechanical, electrical, and plumbing engineer	…locating the sanitary, storm, and water main connections at the building exterior, which can limit where infiltration facilities are located.
Wetland scientist	…delineating wetlands, which may be used to disperse stormwater if appropriate, but may limit application of other LID practices.
Arborist	…performing an analysis of tree health to determine hazard trees and make recommendations for trees to be protected.
Landscape architect	…responding to programmatic needs that generate impervious surfaces associated with roofs, driveways, parking lots, or sidewalks, or that generate semi-pervious surfaces such as lawns.
Civil engineer	…prioritizing LID development facilities that improve water quality by reducing runoff and avoiding flow-based-only facilities that allow excess volumes to leave the site.

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