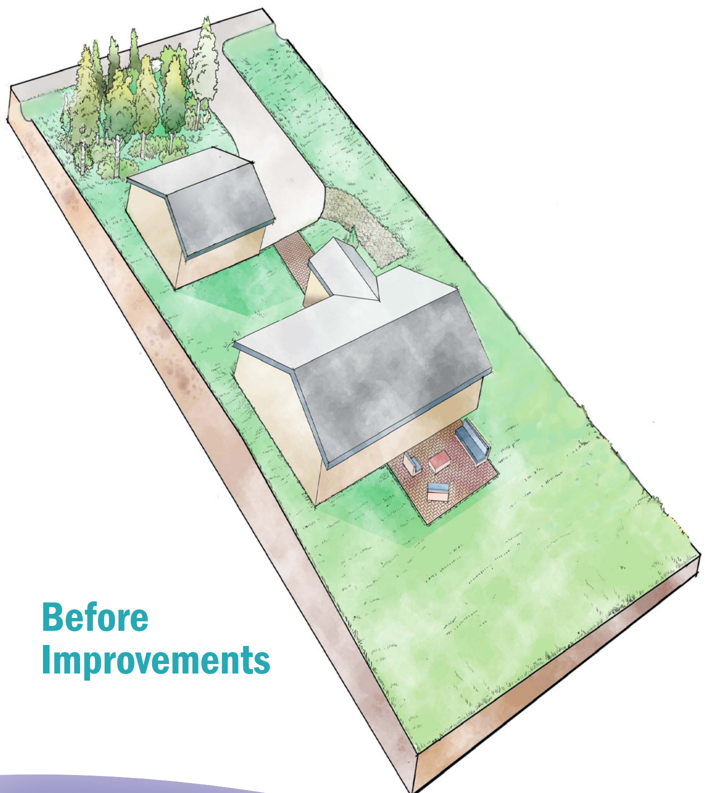
Evaluate Your Site

Keeping runoff from leaving your property begins with taking a good look at how your property works now, and then planning for improvements. Here's how.

This module is all about the numbers. You don't have to do these calculations to implement the practices, but they are here for those who want to 'put a fine point on it' and understand how much good they are really doing.

Why control runoff on your lot?

Left unchecked and untreated, stormwater runoff adds nutrients, sediment, metals, hydrocarbons, bacteria and pesticides--and more--to what ends up in our creeks, rivers, lakes, and sometimes even aquifers. Historically, properties have not been developed with the idea of keeping runoff on site, and this creates more and more challenges for the storm drainage system as more and more land is developed. About half of all stormwater is generated by the road network; the other half comes from developed land. Doing your part to restore the functionality of your property to how it was before it was developed is a very important part of mitigating flood and drought, keeping the drainage system working into the future, and protecting our water bodies.



Before Improvements

Let's Get Started!

Introducing our example lot, a typical 50 foot wide by 100 foot long property. The top of the lot slopes down to the road and the bottom of the lot slopes down to the backyard, which may face a neighbour, have a lane, or maybe be on a waterfront.

We will use this lot to show the steps to evaluate your own lot and make a plan for improvements.

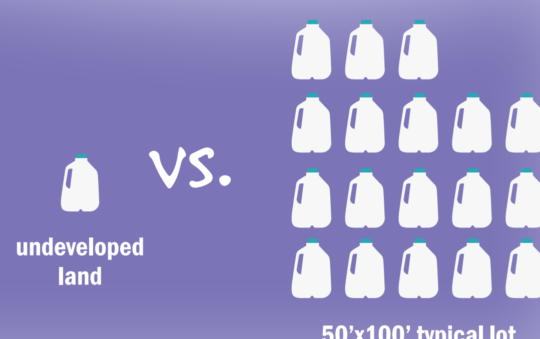
Whether you have an existing property or are building new, the methods to evaluate a site are the same. And the methods apply equally well to commercial, industrial and institutional properties. Solutions between new builds and retrofits vary.

Did You Know?

A typical suburban lot generates about 18 times more runoff* than a natural landscape!

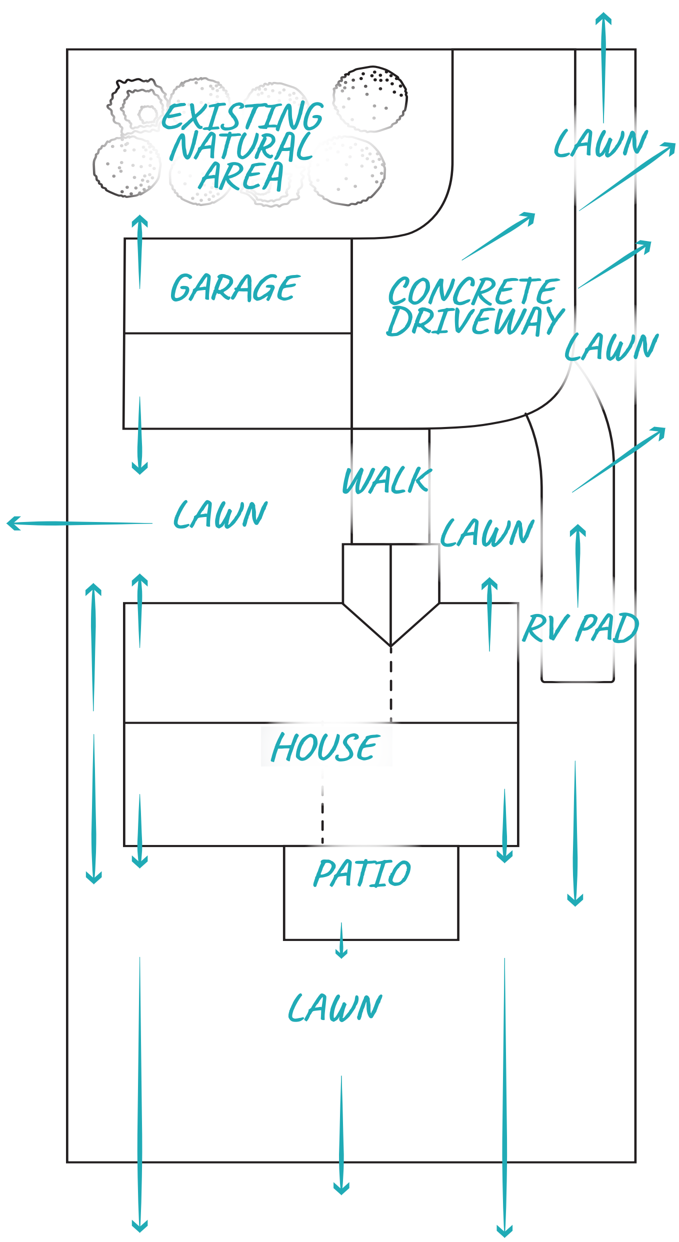
In addition to directly impacting water quality, excess runoff causes flooding and unnatural levels of erosion. Land that is developed to a higher density than our example lot generates even more runoff, with even more consequences.

*on an average annual basis, depending where you live.



Step 1: Identify Sources of Runoff and Where They Go

Begin by drawing up the features of your property so you can decide on the size and placement of improvements. Follow along with our example.



1. Get or make a base drawing. Start with a site plan that is to scale. The builder's site plan or a copy of the Real Property Report will work. You can also take measurements yourself and create your own site plan. Use your plan to estimate the area of the different surfaces on your property, or go out and measure the areas to be sure.

2. Identify and calculate the area of hard or compacted surfaces. These include roofs; concrete and asphalt surfaces; gravelled areas; areas with pavers; decks; and lawns. Measure in square metres.

3. Exclude non-contributing areas from your calculation. These include trees, planting beds, vegetable gardens, natural areas (undisturbed from their original condition with intact vegetation), unmown areas, and any other kinds of areas left to naturalize. These will generally have deeper soil that is less compacted with robust vegetation so they don't count as hard surfaces. For trees, exclude the area within the drip line (the widest extent of the tree), or the unmown area under the tree, whichever is less. If you happen to have a pond or a pool, exclude that too.

4.Identify flows. How does the land slope? Imagine if it rained enough to create runoff, where would water flow from the surfaces you've identified, and where would those flows exit your lot? Add arrows to help you remember.

runoff

***noun* | *run·off* | \ *ˈrənäf* **

The stormwater that drains over the landscape when there is more rainfall or snowmelt than soil can absorb.

Step 2: Calculate Volumes and Identify Catchments

How much runoff does a property such as this generate? This could be a real eye-opener! See all the calculated volumes for our example property on the next page.

Why do we care about the 1-inch rain event?

The 1-inch (2.5 cm) rain event represents 90 to 95% of all storms that happen (depending on where you live in the province). Keeping runoff from storms up to this size on your site restores the natural balance.

Bigger storms--those that happen once in 25 or 50 years or more--are not feasible to retain, nor are they the most impactful from a water quality perspective (truly!)

Whatever you do to deal with smaller, more frequent rainfall events will help to mitigate the larger events, and it will make the whole system perform better, no matter what size the storm is.

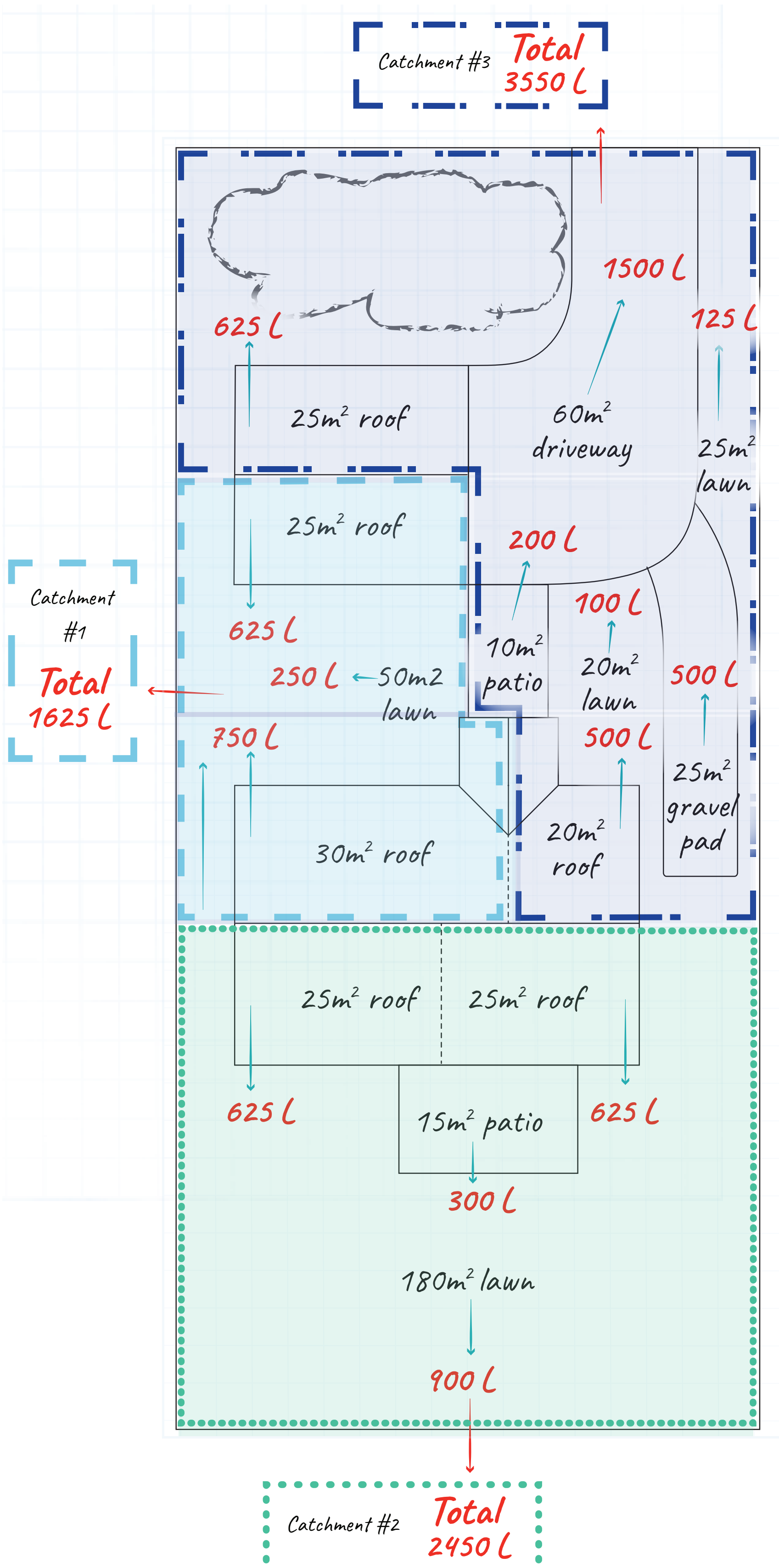
1. Determine the amount of water generated by each hard surface. Multiply your area estimates by the runoff they generate using the table below. This is how much runoff you will want to keep from leaving our property. (Don't be too fussy with measuring, but remember to input areas in square metres so the results will be in Litres.)

Runoff Generated by Surface Type
2.5 cm (1-inch) rain event

SURFACE	RUNOFF (L/m^2)
Concrete, asphalt, roofs	25
Patios, gravel	20
Decks	10
Lawns	5

2. Add up the volumes that go to the same general spot as they exit your lot. For example, if water from a downspout also drains across a lawn, add the two volumes together. These are catchment areas—the area that any particular spot drains. Each catchment must be dealt with on its own. This will become clear in a later step.

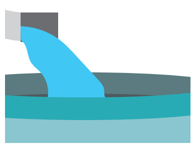
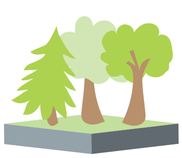
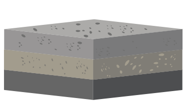
3. Complete the volume calculations for all the catchment areas. There! You have now completed your runoff summary and you know where the water is going and how much you need to keep on your property. Our example property has three areas where runoff exits. In the next step you'll begin to look at ways to hold that runoff on site.


Catchment #3
Total
3550 L
1500 L
625 L
125 L
25m² roof
60m² driveway
25m² lawn
25m² roof
200 L
Catchment #1
Total
1625 L
100 L
625 L
10m² patio
20m² lawn
500 L
250 L
50m2 lawn
750 L
500 L
25m² gravel pad
20m² roof
30m² roof
25m² roof
25m² roof
625 L
15m² patio
625 L
300 L
180m² lawn
900 L
Catchment #2
Total
2450 L

Step 3: Find Opportunities

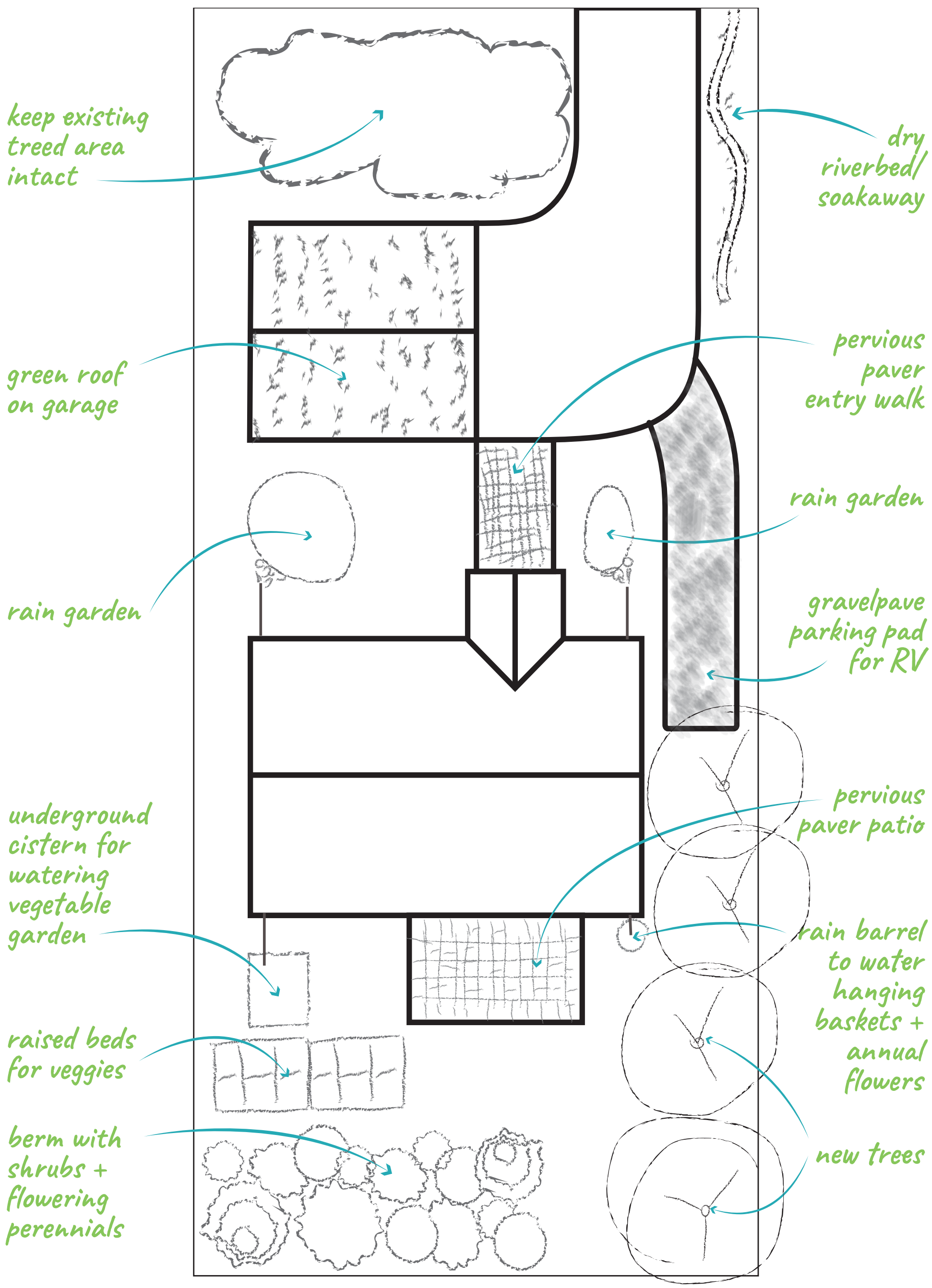
Now that you know how much runoff is generated on your property and where it goes, it's time to think about how you will you create your own beautiful solution to stormwater pollution. There are many ways to tackle it. Some solutions are simple while others are complex or costly. Some things are more feasible for new construction (e.g., deeper topsoil) while others are more suited to existing properties (e.g., rain gardens). The actions highlighted in green below are easy wins for most situations. Combine approaches for best results.

Tools for Controlling Runoff on Your Lot

FEATURE	STRATEGY		
	Spread out and Direct Flows	Add Storage Capacity	Minimize Hard Surfaces
 BUILDINGS AND DOWNSPOUTS	**Direct flows on to planting beds or under trees** Spread flows out on lawns, especially if the lawn has deeper topsoil If installing or replacing eavestroughs, relate the roof area that a downspout serves to the size of the area where the downspout discharges (avoid big flows onto small areas)	Add rain gardens Add **rain barrels** or a cistern for irrigation of high-water-usage plants like vegetables or plants in containers Add soakaways if surface storage is not available and a cistern is not wanted Add a cistern and purple pipe system for toilet flushing	Minimize the building footprint Consider helical piles or other low-impact building foundations, especially for recreational properties Add a green roof
 LANDSCAPING	Reduce slopes to less than 2% Use dry riverbeds and swales to direct flows to parts of the lot where they can be stored/ absorbed	Increase soil depth to more than 125 mm (5 inches) preferably 300 mm (12 inches) Select turf species that are deep-rooted, drought-tolerant and slow-growing **Add rain gardens**	**Retain existing natural areas** Reduce or eliminate mown turf areas in favour of other softer surfaces, let some areas naturalize **Plant trees, shrubs and perennials into deeper soil**
 DRIVEWAYS, SIDEWALKS, PATIOS AND DECKS	Use cross-slopes, interceptors, or shallow cuts on hard surfaces to direct flows to landscaped areas where runoff can be stored/ absorbed	Add gravel storage under permeable pavements to act as a soakaway **Keep areas under decks permeable (soil or gravel) and gap deck boards so water can get through**	Minimize footprints with, e.g., ribbon (AKA Hollywood) driveways Use permeable pavements

Step 4: Possible Solutions on our Example Property

Your solution doesn't have to be as complicated as this! But we wanted to show you many different possibilities and how they are calculated.



Step 5: Discussion of Possible Solutions and Calculations

This is where the numbers all come together. You don't have to make your property this complicated, we're showing you many possibilities.

Catchment #1 generates 1625 L according to our calculations back in Step 2. Our plan proposes a green roof on half of the garage and a rain garden between the house and garage.

The **green roof** will be 25 m^2 with a soil thickness of 10 cm. Calculate:

> 25 m^2 area x 25 L/m^2 water retained per 10 cm of media thickness = 625 L retained. This is equal to the amount calculated in Step 2 to be generated. The 1" (2.5 cm) storm is therefore fully retained.

The **rain garden** will be 10 m^2 with a ponding depth of 10 cm with both the lawn and the downspout from the house routed into it. Calculate:

> 10 m^2 rain garden area x 0.10 m ponding depth = 1.0 m^3 retained. 1.0 m^3 is 1000L. This is equal to the amount calculated in Step 2 to be generated by the roof and the lawn. The 1" (2.5 cm) storm is therefore fully retained.

Catchment #2 generates 2450 L. In this catchment there is a lawn and a modest, aging patio. Our plan proposes to reduce the lawn area substantially, add an underground cistern to water a new raised vegetable garden, install a handy rain barrel to water hanging baskets and thirsty annual flowers, and replace the patio with a new permeable paver installation with an underground storage reservoir. This is more complex than you would probably need to make it, but for illustration purposes we have added lots of options.

Planting trees, adding a berm planted with shrubs and flowering perennials and adding a vegetable garden will take care of the majority of runoff generated by the lawn. Once you subtract all these areas, there is only 20 m^2 of lawn left compared to the original 180 m^2. Since the lawn is not too high in its level compared to the foundation of the building, topdressing the remaining lawn annually over a period of 4 years will add an inch of soil depth and take care of the other 100L generated by the remaining 20 m^2 of lawn (every square metre of lawn at 10 cm depth generates 5 L of runoff). On the flip-side, adding just 2.5 cm of soil depth absorbs 5 L of runoff per square metre.

Sizing the **cistern for vegetables** depends on the watering needs of the plants, the available water from the roof (and the fact you need to be able to store that roof runoff amount), and the severity of drought you want to plan for. These sorts of systems are often disappointing because they are undersized and no one likes an empty tank. Calculate:

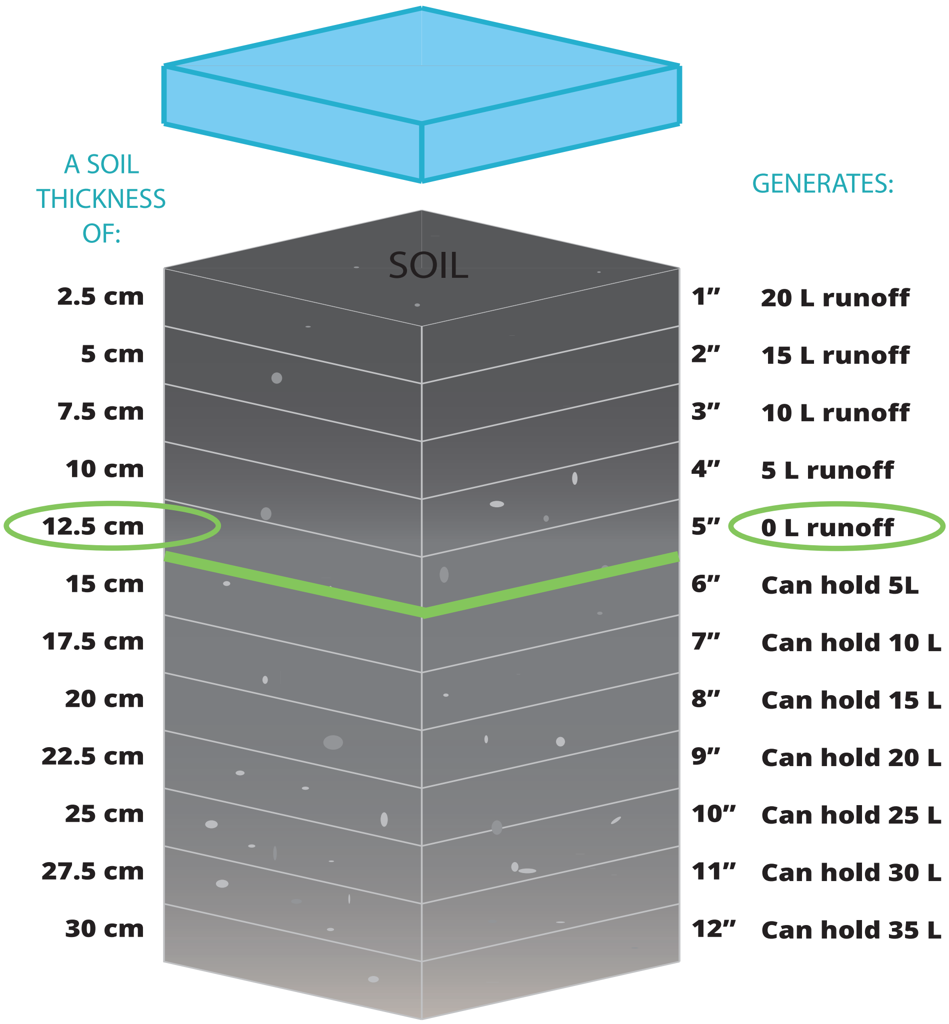
> Vegetable needs: 2.5 cm of water per week x 10 m^2 garden area = 0.025 m x 10 m^2 = 0.25 m^3 x 1000 L/m^3 = 250 L of water needed per week. Plan to store enough for 4 weeks drought = 250 L x 4 = 1000 L minimum for plant needs.
>
> Runoff to be stored from Step 2 Calculation = 625L, add this to the amount for plant needs = 1625 L minimum. Propose 2 m^3 (2000 L) modular storage. Property owner does not want to see exposed tanks, even though above-ground storage of this size is common.

The patio area generates 300 L of runoff. How much storage under a **new permeable paver patio** is needed to handle this? Washed gravel storage has void space rated at 40%. The gravel itself takes up 60% of the space and it is the air between the gravel that we use to store runoff. Calculate:

> 20 cm thick gravel storage layer x 15 m^2 patio area = 3 m^3 gravel volume
>
> 3 m^3 gravel volume x 0.4 void space = 1.2 m^3 = 1200 L

This is more storage than the patio itself needs but, if the overflow from the rain barrel is routed to this storage layer under the patio, it will nicely accommodate the rest of the runoff from the right side of the roof that a rain barrel can't hold. For that matter, the storage layer under the patio could also have the other downspout routed to it and the depth of the storage under the patio increased to accommodate the extra. Another way to do it might be to put the storage under the vegetable garden and create a wicking bed where water is drawn up as-needed for the plants. In cases where flows are not matched directly with storage solutions, it's a matter of routing flows through dry riverbeds, pipes, or careful grading. Many solutions are possible.

An inch of rain (2.5 cm) falling on a 1 m2 surface generates 25 L



Soil has 20% open space. To fully hold this 2.5 cm of rainfall, it will take 12.5 cm of soil depth. If you have deeper soil, you have added capacity to absorb flows from other hard surfaces on top of what occurs naturally: An added 5 L per every 2.5 cm of soil depth per m2. This is a great approach for new development or slopes where you can add soil as terraces.

There's another important consideration when you replace one surface with another surface. Remember we said in the Step 2 calculation that the old patio generated 300 L of runoff. This becomes irrelevant runoff if you replace that surface with something else, because that feature isn't what is there anymore. Whatever the storage of the new feature, you have to subtract 25 L/m^2 over the whole surface area to account for the rainfall on the new feature. This is true for rain gardens as well, and this is partly why rain gardens are recommended to have at least 30 cm of soil beneath them--this phenomenon is factored in. But for other storage-type features you need to factor this in. So our permeable patio calculated above actually has somewhat less capacity:

15 m^2 patio x 25 L/m^2 = 375 L. Subtract from the calculated storage above of 1200 L = 825 L

That's still a good amount to take care of the overflow from the rain barrel which, from Step 2 and the calculation below should be 625 L from the roof less 110 L in the rain barrel. If you wanted to 'cut it closer' you could decrease the storage depth in the patio to:

825 L - 625 L downspout + 110 L rain barrel storage = 310 L excess capacity in paver storage

310 L / 0.4 void space = 775 L / 1000 = 0.775 m^3 / 15 m^2 patio area = 0.05 m depth = 5 cm

Therefore a 5 cm shallower storage depth is possible = 15 cm rather than 20 cm gravel storage layer thickness.

A **rain barrel** is proposed on the right side that is easily accessible for a watering can. Typical rain barrels hold about 220 L. Assume the barrel will be half-empty and that is the amount available to store runoff. Calculate:

220 L / 2 = 110 L

As discussed above this is not adequate to manage the 625 L coming from this downspout. Routing to another storage opportunity, such as under the permeable pavers, towards the nearby planting beds associated with the trees, or to an additional rain garden before the berm are other options for this flow.

How much can the **planting beds** retain? It is a function of soil depth. Assume 40 cm soil depth has been installed throughout the planting bed. Count the area downslope of where the rain barrel overflow can be routed (water can't run uphill). Say the area is 8 m^2 and the soil depth is 40 cm. Calculate:

8 m^2 area x 0.40 m depth x 0.25 void space in soil = 0.8 m^3 = 800 L

Remember, however, that you have counted this planting bed area already at 12.5 cm in order to reduce that area's runoff contribution to zero. So the ***effective*** soil depth available for additional flows is therefore 40 cm minus 12.5 cm = 27.5 cm. Recalculate the available storage for additional flows:

8 m^2 area x 0.275 m depth x 0.25 void space = 0.55 m^3 = 550 L

This is an adequate storage amount for the rain barrel overflow.

Catchment #3 proposes a rain garden, a permeable paver walkway with a different configuration from the patio, a gravelpave RV pad to replace the gravel RV pad, a green roof on the other half of the garage, and a dry riverbed with an underlying soakaway. The natural area of trees between the garage and roadway is retained and does not generate any runoff.

A **gravelpave parking pad** is proposed instead of a plain gravel parking pad. These types of structural cells come in lightweight rolls that are spread out and filled with the aggregate of your choice. They are firmer to walk on and hold rainfall rather than create runoff. They also don't release sediment when it rains the ways that gravel does. This pad area remains the same size, 25 m^2, but instead of contributing 375 L of runoff, it holds runoff back. How much?

25 m2 x 0.25 m thick washed gravel x 0.40 void space = 0.1875 m^3 = 187 L.

Remember this is a surface we are replacing, so we ignore the Step 2 runoff that is generated and subtract the rainfall on the new surface at 25 L/m^2.

25 m2 pad x 25 L/m^2 rainfall = 625 L runoff generated less the storage of the new surface of 187 L = 625 L - 187 = 438 L generated

The runoff of the plain gravel surface was 500 L so this is only a very modest gain. Consider additional storage beneath the surface or do it anyhow for the improved aesthetics, reduced sediment release, and great feel underfoot.

A **rain garden** is proposed for this side of the main entrance to the home as well. It will also have a 10 cm ponding depth. This is the most common configuration. A deeper ponding depth would be useful if the footprint was limited and more water needed to be stored, but these don't drain as quickly. There are limits. (See the minimum surface area table and discussion in the Rain Garden section of the Toolbox for Property Owners). Calculate:

5 m^2 surface are x 0.10 m ponding depth = 5 m^3 = 500L

This is adequate to manage the downspout flow from the roof of the house. Alternatively a storage layer could be added under the gravelpave installation and flows from the downspout and lawn could be routed there.

The main entrance walkway is proposed to be made into a **permeable surface** as well. In all cases of permeable surfaces we are counting the storage under the surface material as the relevant part of the installation. The permeable surface merely facilitates infiltration of the rainfall. This time a small permeable base storage layer is all that is needed to account for the 25 L/m^2 rainfall. Calculate:

10 m^2 surface area x 0.10 m thick storage layer x 0.40 void space = 0.4 m^3 = 400 L storage

10 m^2 x 25 L/m^2 rainfall contribution = 250 L

400 L storage less 250 L for the rainfall = 150 L available for overflow storage

Excess flows from the lawn can be routed to this storage layer for an extra measure of performance.

Way over on the other side of the lot, the flow from the other half of the garage is also proposed to be a **green roof**, with the same characteristics as the other green roof. This is a lovely solution, however it would also be possible to route the flow into the natural area, which will have deep enough soil to handle this extra. On the other hand, the whole system will be even more resilient to flooding if the green roof would be constructed and the natural area left to optimum performance for the biggest events possible.

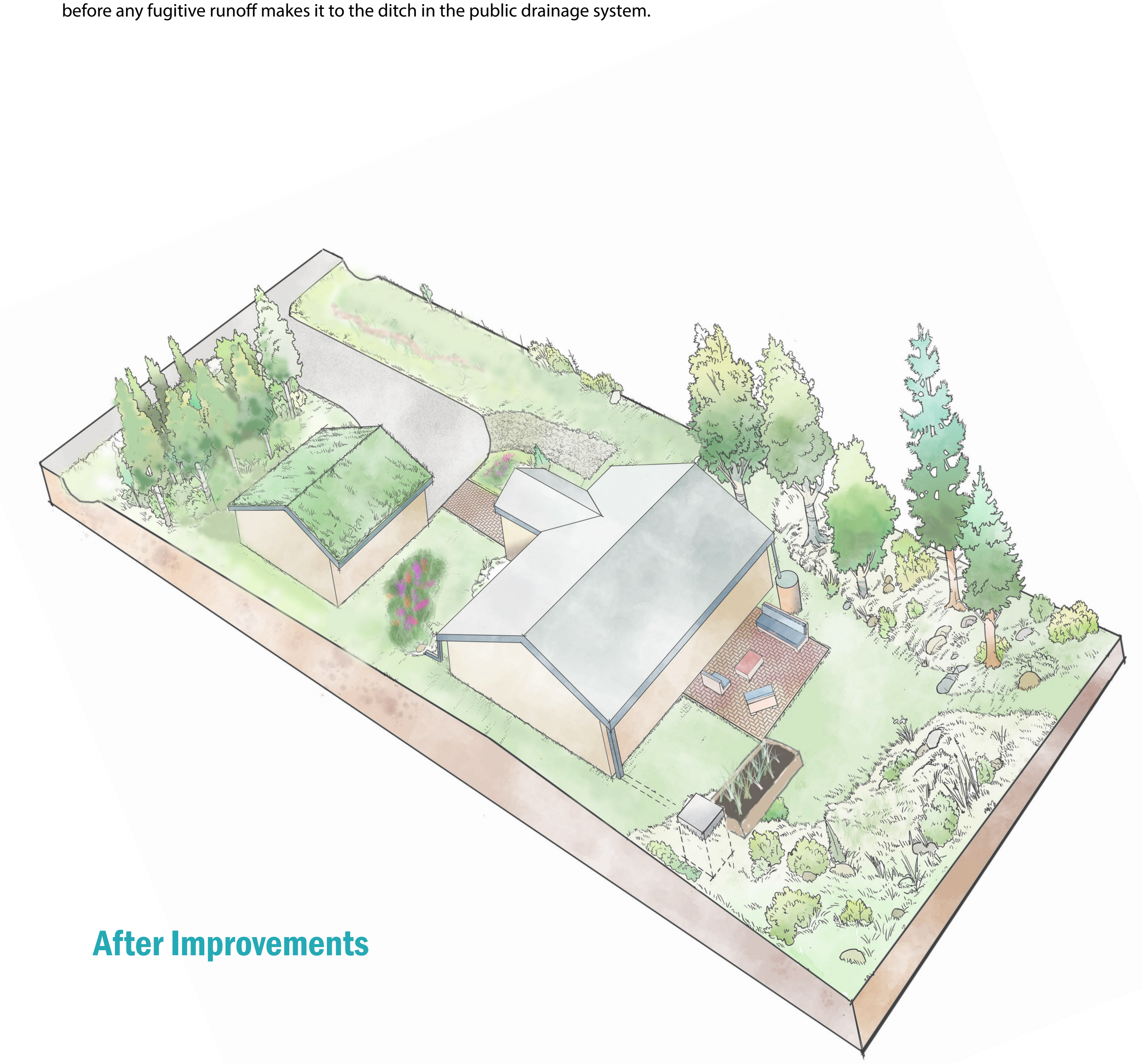
Finally, we are left with the large flow from the driveway. In our imaginary example, the homeowner envisions an **infiltration trench**. Calculate:

15 m^2 storage x 1 m depth x 0.40 void space = 6.0 m^3 = 6000 L Too large! Let's try something smaller:

10 m^2 x 1 m deep x 0.40 void space = 4 m^3 = 4000 L Still too large. Let's try less depth:

10 m^2 storage x 0.50 m deep x 0.40 void space = 2000 L

That's better! 2000 L gives slightly more storage space than is required for the driveway (1500 L) and also accounts for the rainfall that will land directly on the area (10 m^2 x 25 L/m^2 = 250 L), and also allows for last-resort storage in this catchment before any fugitive runoff makes it to the ditch in the public drainage system.



After Improvements

Step 5: What will you do to manage runoff on your property?

Using the information in the Toolbox for Property Owners, you can learn more about how to construct or add the stormwater solutions needed to capture as many Litres of runoff as possible on your property. Make sure to consult your local jurisdiction to understand any local requirements that may differ from the guidance in the Toolbox.

Simple things like rain barrels and converting turf into planting beds are a great place to start.

Roofs and driveways generate substantial amounts of runoff that take a fair amount of storage to fully manage. This is accomplished through rain gardens and directing flows to absorptive areas such as planting beds. On smaller lots this is harder to do because there is less landscaped area to begin with. That's where cisterns and green roofs come into play, generally as part of new construction.

New construction does have an easy win though too: Just put deeper topsoil everywhere and direct downspouts and driveways there with careful grading. This can manage most of the runoff too. It's a matter of planning. Loam is 'dirt' cheap.

Remember, every Litre of water captured on your lot reduces contaminants entering our waterways. Managing runoff on-site takes care of half of the equation. The remainder of runoff management happens in the public realm: On roads, in ditches, and in community spaces. Refer to the forthcoming *Municipal Drainage Guide* to find out what our public spaces can do for us.

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