A green roof (also known as an eco-roof or vegetated roof) is a roof with a growing medium and vegetation on top of waterproof membrane. The purpose of the green roof is to provide temporary storage of precipitation so as to allow more water to return to the atmosphere as evapotranspiration than typically evaporates from a conventional roof.

The addition of a green roof can reduce the size needed for a standard stormwater pond or vault. A flow control facility will probably still be needed, but it won’t be as large if we use a green roof to reduce the flows into the facility.

Green roofs are most useful in a commercial setting where physical space for a pond or vault is limited. If the project site is 100% roof area then a green roof can provide a substantial reduction (the size of the reduction varies by climatic conditions) in the size of the flow control facility needed. As non-roof area is added to a project basin the stormwater benefits will diminish. In Germany green roofs are often built in combination with infiltration facilities. This is probably the most effective way to reduce stormwater runoff.

For the purposes of this example we will model both a conventional roof and a green roof side-by-side to show the difference between the two. So let’s get started.

We will model a 1-acre industrial building roof adjacent to the Seattle-Tacoma (SeaTac) Airport. The first thing that we will do is to locate our project on the project map.
SeaTac Airport is located in King County, Washington. We click on the map to select the project location. Based on our project location WWHM4 selects the appropriate precipitation record and precipitation multiplication factor. We then have the option to fill in the Site Information boxes.

For the Predevelopment scenario we select a standard land use basin. We have to decide the appropriate predevelopment land use for the project site. Because this project is located in Western Washington and has to meet Washington State Department of Ecology regulations, we select C soil, Forest vegetation, and Flat land slope (0-5%).

The project site is 1 acre.

Because we are modeling both a conventional roof and a green roof side-by-side (normally you would just model one or the other), we have two basins with the same information. POC 1 represents the conventional roof predevelopment runoff; POC 2 represents the green roof predevelopment runoff. Because the predevelopment land use is the same for both POC 1 and POC 2 the predevelopment runoff will be the same. This will not be true for the mitigated (post-development) runoff.
For the Mitigated scenario we will use the standard basin element to represent the conventional roof and the green roof element to represent the green roof.

The convention roof will still need some form of mitigation for the extra runoff produced when the forest is removed and the 1-acre building constructed. One mitigation option is to place a stormwater vault under the building or an adjacent parking lot to collect the runoff and then discharge it at the predevelopment flow rate. That is what we will do in this example.
First we add the basin element, rename it “Conventional Roof”, and assign 1 acre of Roof, Flat land use.
We add a vault element (naming it ‘Conventional Vault’) and connect its outlet to POC 1. Now we can use Auto Vault to size the vault.
We set the adjustment level (amount of optimization) to its highest level (5) and then click “Create Vault”. Take a break while Auto Vault runs through its iterations and I see you after it has finished.
Auto Vault is finished. It gives us a conventional vault size of 58.3 feet long by 58.3 feet wide by 7 feet deep. Big vault.

Now we will model the same 1-acre roof as a green roof.

We add the green roof element. The first question that we have to ask ourselves is: “Do we think that the green roof by itself can do all of the needed stormwater mitigation?” If the answer is yes, then we designate the outflow from the green roof as POC 2. If the answer is no, then we will need additional mitigation, perhaps in the form of a vault (but hopefully a smaller vault than required for the conventional roof).

Let’s be optimistic and assume that the green roof by itself will be sufficient for stormwater mitigation. We designate its outlet as POC 2. If this doesn’t work we can later add the vault.
When we connect the green roof outlet to the point of compliance we must include the groundwater component of the runoff. Usually when modeling stormwater we do not include groundwater because it does not show up on the project site, but enters the conveyance system somewhere downstream. With a green roof the groundwater component acts like interflow (green roofs really don’t have groundwater) and cannot be ignored. It directly contributes to the stormwater runoff on site.

We now have to input the green roof element information.
We input the green roof characteristics and dimensions.

The green roof area is 1 acre.

We will put 4 inches of soil on the roof (this is the default value).

The roof slope must be greater than zero to provide drainage slope. We want a very low slope and use 0.001 foot/foot.
We have three choices of vegetative cover: ground cover, shrubs, and trees. Four inches of soil is not going to support trees. We select ground cover, which can include a range of low growing plants that will survive in the extreme conditions found on top of a roof.
The length of rooftop is the distance the water has to travel to reach a roof top drain. At most it is the length of roof, but it can be less. The default value is 50 feet.

Our roof is approximately 200 feet by 200 feet. Due to the slope of the roof water has to travel a maximum of 100 feet to reach a drain. We change the length of rooftop from 50 feet to 100 feet.

Now we are ready to click on “Run Scenario” and find out if the green roof provides sufficient flow control mitigation.
The green roof flow duration results show that the green roof does not reduce the erosive flows to predevelopment levels and does not meet the Washington State Department of Ecology flow control standard. Additional mitigation is required.
We decide that a vault will be needed in addition to the green roof. In connecting the green roof to the vault we need to make sure that we connect all three stormwater components: surface runoff, interflow, and groundwater. Usually we don’t connect groundwater (see the above discussion related to groundwater and POC 2), but with green roofs the water can’t go anywhere else – otherwise we will have a leaky green roof.

Set the outlet of the green roof vault as POC 2.
As with the conventional roof vault, we will use Auto Vault to size the green roof vault. You know the drill. Set the Auto Vault optimization adjustment level to 5 and get up and stretch your legs. I will catch up with you when Auto Vault is finished.
Looking at the green roof vault results produced by Auto Vault and comparing them with the conventional vault we see that the green roof reduces the size of the conventional vault by approximately 10%.

We might be able to do better. The green roof vault was sized by Auto Vault using an outlet of one orifice and a notched rectangular weir. In the vast majority of the mitigation facility sizing situations the one orifice and notched rectangular weir outlet solution is the most efficient and produces the smallest size facility. But in this case we might be able to do better with the three-orifice outlet solution.

Let’s see what Auto Vault can do with the three-orifice outlet option.
With the three-orifice outlet configuration Auto Vault reduced the vault dimensions to 52.9 feet by 52.9 feet by 7 feet. This is an 18% reduction in vault storage volume compared to the conventional roof vault. That is better than the 10% reduction for the one-orifice and notched weir outlet solution.

What can we do to make the green roof more green and get a bigger stormwater benefit? First, the depth of growth material on the roof makes a big difference. Four inches doesn’t store a lot of water. Eight inches would be better or even 12 inches. Twelve inches will also support shrubs, which have greater ability to provide interception storage of precipitation and evapotranspiration. On a green roof what doesn’t return to the atmosphere as evapotranspiration must eventually become runoff.

The other major factor is where the green roof is located climate-wise. Building a green roof in the Seattle area doesn’t produce as much of a stormwater benefit as if that same green roof was built in Atlanta, Georgia, or Dallas, Texas. If the potential evapotranspiration (PET) is low during the rainy season (as it is in Seattle) then the green roof stormwater benefits will be less. That is just a fact of hydrology.

For comparison I modeled a green roof in San Jose, California. The San Jose green roof results in a 68% reduction in the size of the stormwater vault compared to the conventional roof. Definitively a better outcome than the Seattle green roof.

**SUMMARY:**

1. Locate project site on map.
2. Input Pre-project for each basin in the project site. Connect the Pre-project basin to the POC 1. Run Scenario.
3. Add the green roof element to the Mitigated scenario.
4. Input green roof element information.
5. Add a vault to the Mitigated scenario. Remember to connect the green roof groundwater to the vault. Connect the vault to POC 1.
6. Size the vault with AutoVault.
7. Finished.