Key Performance Indicators

For each project, the adaptation targets and KPIs can be set before the session and are to be discussed with the stakeholder during the session so that they can agree. This way the stakeholders understand the underlying assumptions and objectives and can agree, after which the final targets can be set in the interface. The way to make a first proposal for target values is elaborated below.

Storage capacity

The required storage capacity and normative runoff can be set based on the so-called Storage Discharge Frequency relations. These SDF-curves can be used to estimate the required gross storage demand in a district in view of the existing or future stormwater discharge capacity. The figure below shows an example of SDF curves.

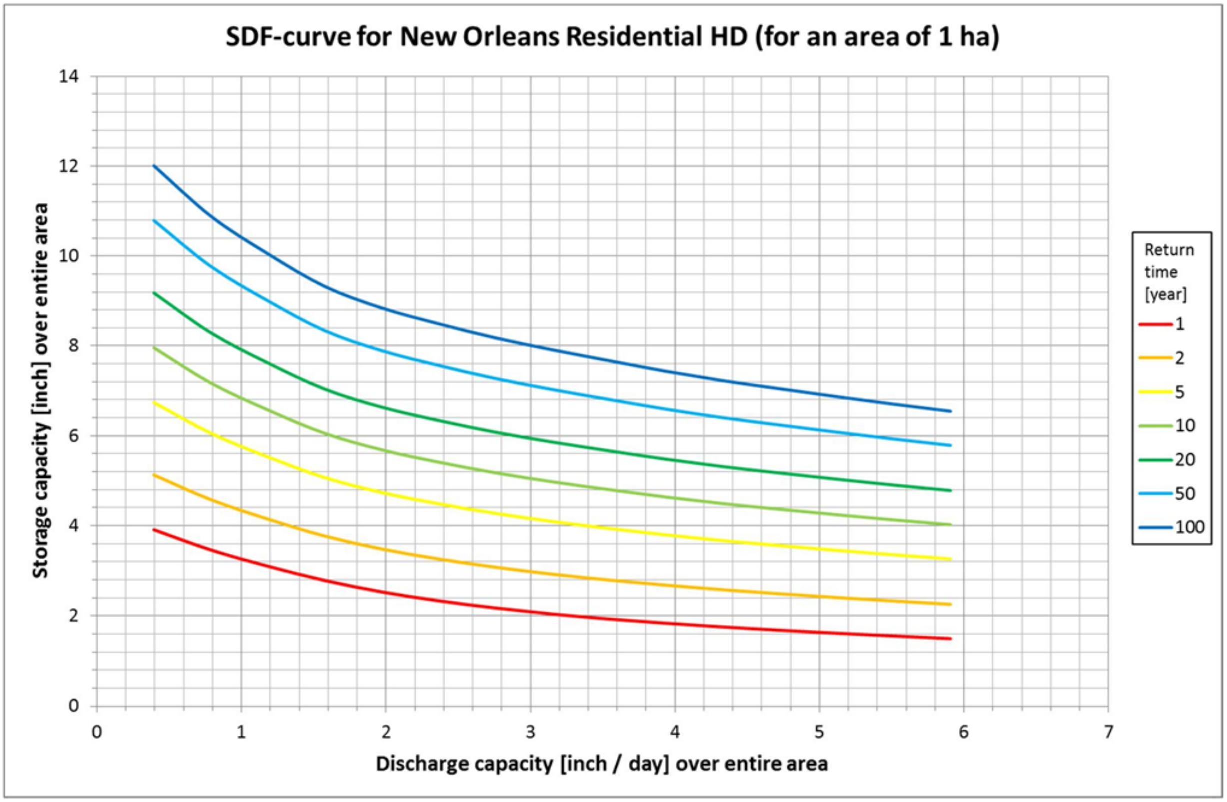


Figure 1. Example of SDF curves for different return periods

The first thing you have to agree on is the acceptable return period of exceedance of a runoff event (i.e., a runoff event with a certain discharge or more). The lines in the graph represent the relation between storage capacity and discharge capacity of the water system that is exceeded once every X years. One of these curves is selected.

Next step is to find the discharge capacity of the district. That is the capacity of the pumping station that drains this district to pump out the excess water. This capacity is expressed in inches per day (over the total drainage area of a pumping station). The existing pumping capacity is assessed, or, if reconstruction will take place in the near future, the projected pumping capacity. The selected curve in the graph can be used to find out how much storage capacity (in inches) is to be available given the capacity of the pump. As can be seen from the graph, the larger the discharge capacity the less storage capacity is required to achieve the same probability of exceedance.

This storage capacity (inches) is multiplied by the Project area size to find the **storage capacity target value** (cubic feet).

In case the project area is draining by gravity the capacity of the discharge drain is used instead of the capacity of the pumping station.

It must be noted that installing a larger pumping station is in general not sufficient as the hydraulic capacity of the stormwater drainage system that leads the runoff towards the pumping station must be increased as well. Thus, any plans made with the CRCTool should be considered approximations until engineers and planners can assess the effectiveness of conveyance to the pump station.

Return time factor

The next issue is to control the peak flow of stormwater runoff to this discharge point. We estimate the reduction of return time of a specific runoff volume as an estimator for the normative runoff; the return time factor. Setting a target for the normative runoff is by far not as critical as the storage capacity target value assessment. But green infrastructure detains or retains runoff and reduces peak flows so that flow velocities in canals are reduced. Hence this reduces bank erosion, sediment wash-off and sediment transport. Default value for the normative runoff is considered the event with the 2-year return interval. Depending on the erosion sensitivity of the area **target values for the normative runoff** could then be set events that occur every 5 or 10 years every five or ten years.

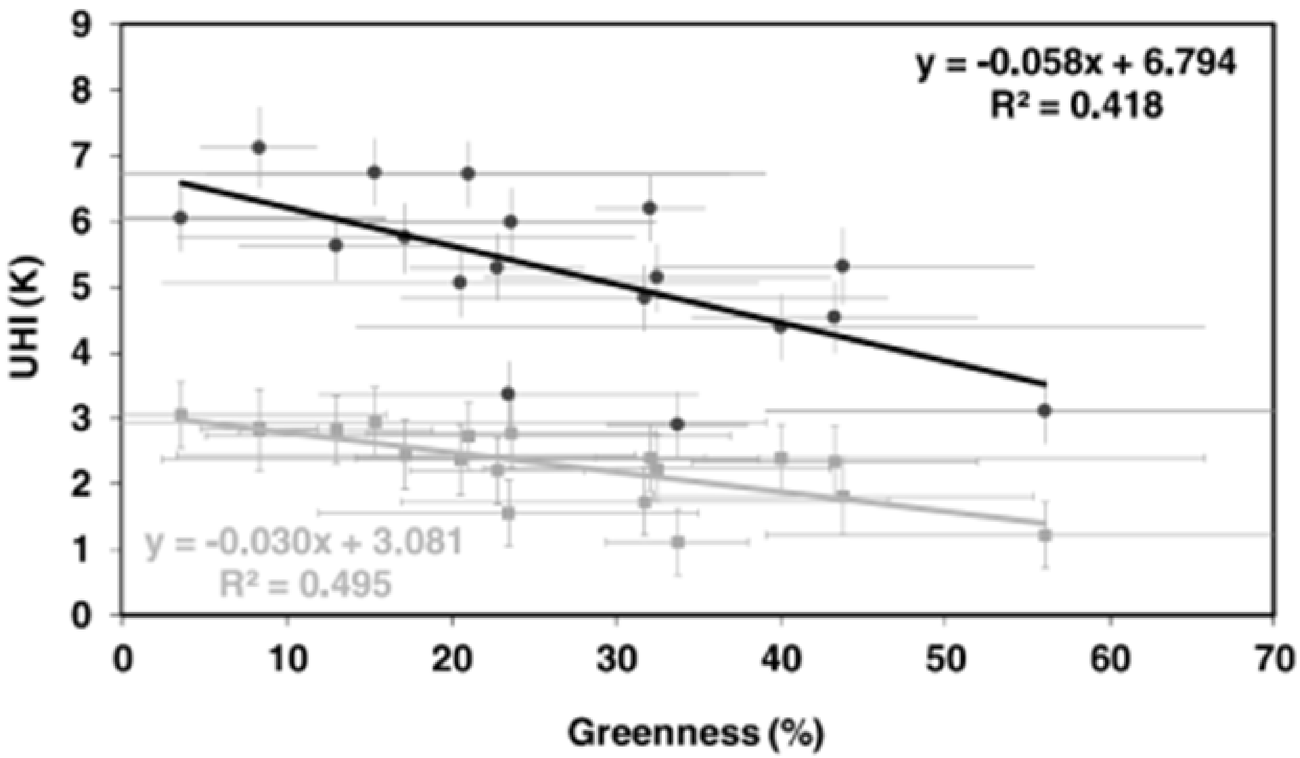
Evaporation (Evapotranspiration)

Evaporation means cooling. The more water evaporates, the less energy is available to heat the air and the less hot it gets. In hydrology we use the term evapotranspiration for the combination of (1) evaporation that occurs from surface water and intercepted water – that is water that is stored temporarily on surfaces - and (2) the water that is transpired by plants. So, the greener and bluer surface in our project area, the more water evapotranspires and the more cooling occurs.

Heatstress reduction

Heatstress reduction is expressed as cooling of the air temperature. One of the main causes of the urban heat island effect is reduced availability of vegetation in urban areas. Less vegetation in urban areas leads to a higher air temperature. A relation that has been determined for the Netherlands is shown below. This relationship is used to quantify the heatstress reduction in the CRCTool.

Heatstress reduction = -0.030 x Area_measure / Area_project



Steeneveld G.J., S. Koopmans, B. G. Heusinkveld,L. W. A. van Hove, and A. A. M. Holtslag (2011), Quantifying urban heat island effects and human comfort for cities of variable size and urban morphology in the Netherlands, Journal of Geophysical Research

Cool spots

Cool spots are areas where people like to be on hot days. Metric for heat stress reduction is the number of cool areas that is created in a project area by applying adaptation measures.
To qualify as a cool spot, adaptation measures should be over 200 m2 and have a significant cooling effect.

Measures that have a significant cooling effect are:

- Adding trees to streetscape
- Fountains, waterfalls, water facades
- Urban forests
- Tree pit bio retention
- Creating shadow

- Urban parks

Water quality

Water quality is extremely important for the functions and services that water can provide. Three groups of water quality parameters are considered: Nutrients, particle bound pollution and pathogenic organisms. Nutrients determine the eutrophication level; pathogenic organisms influence public health risk. Many relevant chemical pollutants tend to absorb on suspended organic particles, clay particles and iron-coated sand particles. Most heavy metals, poly-aromatic hydrocarbons, mineral oil, pesticides and other pollutants and the concentration of suspended sediment, BOD and COD can be seen as particle bound pollution.

Most measures influence the quality of stormwater runoff by capturing, retaining and/or filtering flow. Moreover, many pollutants degrade while still in the water column, in solution or adsorbed on suspended sediment particles. Capturing of pollutants takes place at the inlet of the measure. For example: a sand catcher installed in the inlet of infiltration boxes captures pollutants even before the runoff reaches the measure. Also vegetation growing on/in a measure can capture pollution, for example by intercepting rainfall. Once the runoff enters a measure with storage capacity flow velocity is reduced and suspended sediment starts settling. Particle bound pollutants and pathogens are trapped. As many adaptation measures have a substantial storage capacity this treatment of stormwater by settling is quite effective. Some measures drain runoff through a soil filter. Such a filter effectively captures particles; dissolved pollutants are often adsorbed to the filter material, resulting in an effective removal of pollutants. In addition, all pollutants except heavy metals start being degraded by biological and chemical processes so that their concentration decreases. The longer the residence time the more degradation takes place.

Intensive green roofs are a slightly different case. Such roofs can only be sustained if the vegetation is fertilized. This generally leads to high nutrient levels in the runoff from such roofs, much more than from an extensive, unfertilized extensive green roof. Consequently, runoff from intensive green roofs is polluted with nutrients instead of being treated.

The remaining fractions of pollutant after each of these processes, that is 1.00 minus the treatment efficiency, is shown in Table 2.2. These figures are indicative estimates; results in practice will depend on many factors such as on quality of the rainwater and stormwater and presence of air and water pollution sources, on temperature, duration of dry spells, rainfall intensity and volume, on surface and subsurface characteristics and type of construction materials used.

		Capture	Settling	Filtering	Degrading	Fertilization		
A	Nutrients (emphasis on N)	0,95	0,8	0,2	0,5	6		
B	Adsorbing pollutants (HMs, PAHs min.oil, etc.)	0,9	0,4	0,1	0,7	1		
C	Pathogens	1	0,5	0,1	0,5	1		
	Effect on quality of stormwater runoff from project areas: material balances)							
	Single measure effect:							
	$Q_{out/measure\ x\vert A,B,C} = A_{measure\ x}\{Capture_{\vert A,B,C}*Settling_{\vert A,B,C}*Filtering_{\vert A,B,C}*Degrading_{\vert A,B,C}*Fertilization_{\vert A,B,C}\} / A_{projectarea} = A_{measure\ x}\{Effect_{\vert A,B,C}\}/ A_{projectarea}$							
	All measures effect:							
	$Q_{out/all\ measures\ \vert A,B,C}$ = SUM (x)[Ameasure x {Effect \vert A,B,C}]/ Aprojectarea							

Table Remaining fraction of pollutant after each of the treatment processes (i.e. capturing, settling, filtering and degradation) for nutrients, adsorbed pollutants and pathogenic organisms; Fertilization is an estimated multiplier for intensive green roof nutrient runoff concentration.

Not all measures perform all treatment processes. Pervious pavement, for example, filters runoff while a constructed wetland is settling and degrading pollution; adding trees to the streetscape helps capturing pollutants and so on. All measures were scored on relevant treatment processes; if a treatment process is irrelevant for a specific measure the ‘Remaining fraction’ is set to 1.00, as no pollutants are retained and/or degraded.

Groundwater recharge

Groundwater recharge is relevant in areas sensitive to land subsidence because increased groundwater recharge enhances groundwater levels which in its turn can slow down land subsidence. Next to that, groundwater recharge enhances the availability of water for vegetation during dry periods.

Target values for groundwater recharge depend on the existing and the desired groundwater levels that result from overall groundwater recharge, groundwater abstraction and groundwater drainage next to local subsurface conditions and surface water levels. Setting a target value for groundwater recharge requires a groundwater system analysis using a detailed groundwater model would be required.

Construction costs

If the available total reconstruction budget is known this figure can be used as a ‘target value’ in the sense that this budget should not be exceeded. Construction cost estimates of the CRCTool show considerable uncertainty because these estimates are based on generic unit cost prices and local conditions in the project area are not taken into consideration, if at all known. Moreover, costs often increase when making detailed and final designs due to the fact that extra functionalities are added to the first conceptual designs that are made during our workshops. In order to take this into consideration it is our recommendation to use only 60 – 75 % of the available reconstruction budget as target value in the CRCTool.

Later on, in the planning session attention could be paid to the distribution of construction costs (and benefits) over the stakeholders, being both public authorities and private land and property owners.

Maintenance costs

If the available annual maintenance budget is known this figure can be used as a ‘target value’ in the sense that this budget should not be exceeded. Maintenance cost estimates of the CRCTool show considerable uncertainty, because these estimates are based on generic unit cost prices; moreover, local conditions in the project area are not taken into consideration, if at all known. In order to take this uncertainty into consideration it is our recommendation to use only 60 – 75 % of the available maintenance budget as target value in the CRCTool.

As with a fair distribution of construction costs, attention should be paid to the distribution of maintenance costs over the stakeholders, during the planning of adaptation measures.