	http://www.virginiadot.org/business/resources/LocDes/DrainageManual/Combined_Drainage_Manual.pdf

3.13.4 Intensity-Duration-Frequency (IDF) curve method

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Author/s and affiliations: Laura Wendling[1], Ville Rinta-Hiiro[1], Maria Dubovik[1], Arto Laikari[1], Johannes Jermakka[1], Zarrin Fatima[1], Malin zu-Castell Rüdenhausen[1], Peter Roebeling[2], Ricardo Martins[2], Rita Mendonça[2], Maddalen Mendizabal[3]

[1] *VTT Technical Research Centre Ltd, P.O. Box 1000 FI-02044 VTT, Finland*

[2] *CESAM – Department of Environment and Planning, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal*

[3] *TECNALIA, Basque Research and Technology Alliance (BRTA), Mikeletegi Pasealekua 2, 20009 Donostia-San Sebastián, Spain*

Runoff coefficient – IDF curves	**Water Management**
Description and justification	The extent of impermeable surfaces in urban areas is continually increasing as cities develop and expand, due to the construction of buildings, roads, streets, parking lots, etc. A significant consequence is greater runoff in urban areas, which can also lead to flooding. Many factors are affecting the quantity of surface runoff, including soil characteristics, land use and vegetative cover, hillslope, and storm properties such as rainfall duration, amount, and intensity (Sitterson et al. 2017). In general, surface runoff is generated in two ways (Yang, Li, Sun & Ni, 2014): through saturation excess, where runoff is generated when the soil becomes saturated (for example after a lengthy period of rainfall); or, through infiltration excess, where runoff is generated when the rainfall intensity exceeds the infiltration rate of water into the soil (for example during a heavy precipitation event when rain falls more rapidly than it can infiltrate the soil).
Definition	Runoff in relation to precipitation quantity (L/s or m^3/s)
Strengths and weaknesses	+ IDF analysis provides a convenient tool for summarizing regional rainfall information and thus it is useful in municipal stormwater management practices - Requires significant judgment and understanding from the designer - Requires fairly extensive historic rainfall data
Measurement procedure and tool	Statistical estimation of 'peak' runoff rates for return periods of 5,10,100 years based on rainfall and

	catchment characteristics (area, channel slope, length, soil permeability). E.g. IH124 or FEH methods (UK). A summary of the steps necessary to create IDF curves is given by Mirrhosseini et al. (2013): 1. Obtain annual maximum series of precipitation depth for a given duration (15 min, 30 min, 45 min, 1 h, 2 h, 3 h, 6 h, 12 h, 24 h, and 48 h) 2. Use a suitable probability distribution (e.g., generalized extreme value per Mirrhosseini et al., 2013) to find precipitation depths for different return periods (2, 5, 10, 25, 50, and 100 y). One of the most common probability distributions used in the IDF analysis is Gumbel's extreme value distribution (Wang & Huang 2004). 3. Repeat the first two steps for different durations 4. Plot rainfall intensity versus duration for different frequencies In addition, other possible probability distributions can be used. Another possibility to create IDF curves is to use the equation (MTO 1997): $i = A / (t_d + B)^c$ Where *i* is average rainfall intensity (mm/h), t_d is rainfall duration (min) and *A, B*, and *c* are coefficients. The coefficients can be solved by least squares method described in the Ontario Drainage Management Manual produced by the Ministry of Transportation of Ontario (MTO, 1997). When the coefficients are solved, the above equation can be used to produce plots of rainfall intensity vs. duration for different return periods (Wang & Huang 2004).
Scale of measurement	Different sizes of catchments, district scale to region scale
Data source	
Required data	Recorded rainfall data (historic) and catchment characteristics (area, channel length, soil permeability)
Data input type	Quantitative
Data collection frequency	Annually; at minimum, before and after NBS implementation
Level of expertise required	High – requires ability and significant judgement to execute statistical analyses
Synergies with other indicators	Direct relation to *Height of flood peak* and *Time to flood peak* indicators

Connection with SDGs	SDG 6 Clean water and sanitation, SDG 11 Sustainable cities and communities
Opportunities for participatory data collection	No opportunities identified
Additional information	
References	Al Mamoon, A., Joergensen, N.E., Rahman, A., & Qasem, H. (2014). Derivation of new design rainfall in Qatar using L-moment based index frequency approach. International Journal of Sustainable Built Environment, 3(1), 111-118. Fadhel, S., Rico-Ramirez, M.A., & Han, D. (2017). Uncertainty of Intensity-Duration-Frequency (IDF) curves due to varied climate baseline periods. Journal of Hydrology, 547, 600-612. Ministry of Transportation of Ontario (MTO). (1997). Ministry of Transportation of Ontario Drainage Management Manual. Ontario, Canada: Ministry of Transportation of Ontario. Retrieved from http://www.mto.gov.on.ca/english/publications/drainage-management.shtml Mirrhosseini, G., Srivastava, P., & Stefanova, L. (2013). The impact of climate change on rainfall Intensity-Duration-Frequency (IDF) curves in Alabama. Regional Environmental Change, 13(S1), 25-33. Prodanovic, P., & Simonovic, S.P. (2007). Development of Rainfall Intensity Duration Curves for the City of London Under the Changing Climate. Water Resources Research Report No. 058. London, Ontario, Canada: Facility for Intelligent Decision Support, Department of Civil and Environmental Engineering. Wang, X., & Huang, G. (2014). Technical Report: Developing Future Projected IDF Curves and a Public Climate Change Data Portal for the Province of Ontario. Submitted to Ontario Ministry of the Environment. Saskatchewan, Canada: Institute for Energy, Environment and Sustainable Communities (IEESC) of the University of Regina. Retrieved from http://www.ontarioccdp.ca/final_tech_report.pdf