# User Manual for the Peak Flow Search Approach (PFSA) Spreadsheet

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## 1. Introduction

This document provides a detailed manual for the use of the PFSA (Peak Flow Search Approach) spreadsheet tool. The PFSA model was developed by Vasconcelos et al. (2025) and aims to improve the estimation of peak runoff for heterogeneous basins. The spreadsheet was developed by Marcus N. Gomes Jr. and is intended for use in urban hydrology planning and education. The variable definitions are shown in Tab. 1.

## 2. Spreadsheet Overview

### 2.1 Sheet Structure

The spreadsheet consists of a single worksheet named `PFSA_Model_V1`. The user must input subcatchment and hydrologic data in the designated input section starting at row 31.

### 2.2 Required Inputs

For each of the $n$ subcatchments (up to 100 currently supported), the user must provide (see Fig. 1):

- Area [$m^2$]
- Runoff coefficient $C$

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| Symbol | Description | Unit |
|---|---|---|
| $Q_p$ | Peak runoff flow rate | $\mathrm{m}^3/\mathrm{s}$ |
| $i$ | Rainfall intensity | mm/h or m/s |
| $A$ | Drainage area | $\mathrm{m}^2$ |
| $C$ | Runoff coefficient (subarea or average) | – |
| $D$ | IDF offset parameter | min |
| $E$ | IDF exponent | – |
| $B$ | IDF coefficient | $\mathrm{mm}\cdot(\mathrm{min})^{\mathrm{E}}$ |
| $t$ | Rainfall duration | min |
| $t_{crit}$ | Duration that maximizes $Q(t)$ | min |
| $T_c$ | Time of concentration | min |
| $T_{c,j}$ | Tc for subcatchment $j$ | min |
| $A_j$ | Area of subcatchment $j$ | $\mathrm{m}^2$ |
| $C_j$ | Runoff coefficient of subarea $j$ | – |
| $Q_j(t)$ | Discharge from subarea $j$ | $\mathrm{m}^3/\mathrm{s}$ |
| $Q(t)$ | Total discharge at time $t$ | $\mathrm{m}^3/\mathrm{s}$ |
| $\eta_p$ | PFSA–RM peak flow difference | – or % |
| $\eta_t$ | PFSA–RM time difference | min |
| $L_{sh}$, $L_{ch}$ | Sheet/channel lengths | m |
| $S$, $S_{sh}$ | Slopes | m/m |
| $N$, $n_{ol}$ | Roughness coefficients | – |
| $CN$ | Curve Number | – |

Table 1: Symbols, definitions, and units used in the PFSA model.

- Sheet flow length $L_{sh}$ [m]
- Channel length $L_{ch}$ [m]
- Retardance/roughness coefficients $N$, $n_{ol}$
- Slopes: $S$, $S_{sh}$ [m/m]
- Curve Number (CN) if using the NRCS method

## 2.3 IDF Curve Parameters

Parameters are located near the top of the sheet (see Fig. 2):

- $B$, $D$, $E$ — controlling rainfall intensity
- Return period (e.g., RP = 2 years) used to compute lag-time.

| Input Data | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sub-Catchment | Area [$m^2$] | C | $L_{sh}$ [m] | $L_{sc}$ [m] | $L_{ch}$ [m] | N | S [m/m] | $S_{sh}$ [m/m] | $S_{sc}$ [m/m] | $S_{ch}$ [m/m] | $n_{ol}$ [$sm^{-1/3}$] | $n_{ch}$ [$sm^{-1/3}$] | $B_{ch}$ [m] | $h_{ch}$ [m] | CN | Surface |
| 1 | 22500 | 0.15 | 150 | 0 | 0 | 0.2 | 1.0% | 1.0% | 1.0% | 1.0% | 0.15 | 0.015 | 0.15 | 0.3 | 60 | Unpaved |
| 2 | 22500 | 0.15 | 150 | 0 | 0 | 0.2 | 1.0% | 1.0% | 1.0% | 1.0% | 0.15 | 0.015 | 0.15 | 0.3 | 60 | Unpaved |
| 3 | 22500 | 0.95 | 150 | 0 | 0 | 0.02 | 1.0% | 1.0% | 1.0% | 1.0% | 0.011 | 0.015 | 0.3 | 0.6 | 95 | Unpaved |
| 4 | 22500 | 0.95 | 150 | 0 | 0 | 0.02 | 1.0% | 1.0% | 1.0% | 1.0% | 0.011 | 0.015 | 0.3 | 0.6 | 95 | Unpaved |
| 5 | 22500 | 0.95 | 150 | 0 | 0 | 0.02 | 1.0% | 1.0% | 1.0% | 1.0% | 0.011 | 0.015 | 0.3 | 0.6 | 95 | Unpaved |
| 6 | 22500 | 0.95 | 150 | 0 | 0 | 0.02 | 1.0% | 1.0% | 1.0% | 1.0% | 0.011 | 0.015 | 0.3 | 0.6 | 95 | Unpaved |
| 7 | 22500 | 0.95 | 150 | 0 | 0 | 0.02 | 1.0% | 1.0% | 1.0% | 1.0% | 0.011 | 0.015 | 0.3 | 0.6 | 95 | Unpaved |
| 8 | 22500 | 0.95 | 150 | 0 | 0 | 0.02 | 1.0% | 1.0% | 1.0% | 1.0% | 0.011 | 0.015 | 0.3 | 0.6 | 95 | Unpaved |
| 9 | 22500 | 0.95 | 150 | 0 | 0 | 0.02 | 1.0% | 1.0% | 1.0% | 1.0% | 0.011 | 0.015 | 0.3 | 0.6 | 95 | Unpaved |
| 10 | 22500 | 0.95 | 150 | 0 | 0 | 0.02 | 1.0% | 1.0% | 1.0% | 1.0% | 0.011 | 0.015 | 0.3 | 0.6 | 95 | Unpaved |

Figure 1: Input data per subcatchment.

| IDF | |
|---|---|
| *K* | 819.67 |
| *a* | 0.138 |
| *b* | 10.77 |
| *c* | 0.75 |
| RP | 10 years |
| *RP2* | *2 years* |
| *P(2,24)* | *92.1 mm* |

Figure 2: IDF Parameters.

| | | |
|---|---|---|
| n | 10 | *number of sub-catchments* |
| B | 1126.26 | *K*RP^a (RP: Return period in years)* |
| D | 10.77 | |
| E | 0.75 | |
| $t_{c0}$ | 0 | *start rainfall duration* |
| $t_{cf}$ | 60 | *end rainfall duration [min]* |
| $\Delta$tc | 1 | *increments in rainfall duration [min]* |
| 24-h 2-yr depth | 92.1 | *mm* |
| Method | Kirpich | *Time of concentration method* |

Figure 3: Time-stepping parameters, time of concentration method, and 24h-2yr precipitation.

### 2.4 Simulation Settings

Located in cells B11–B15:

- $t_0$ = start time
- $t_f$ = end time
- $\Delta t$ = increment (typically 1 min)

These settings control the sweep over rainfall durations used to evaluate peak flow (see Fig. 3).

## 3. Output Summary

- Peak Flow Critical: Maximum value found in the analysis
- Peak Flow RM: Rational method peak flow.
- Discrepance: Relative difference between peak flows

| *Performance Indicators* | | |
|---|---|---|
| Peak Flow Critical | 6.26 | [m$^3$ s$^{-1}$] |
| Peak Flow RM | 4.16 | [m$^3$ s$^{-1}$] |
| Discrepance | **50.7%** | |
| $t_{critical}$ | **7.00** | min |
| $t_{critical}$ RM | **21.00** | min |
| Discrepance | **-66.7%** | min |

Figure 4: Performance indicators.

- $t_{crit}$ = Critical rainfall duration that maximizes the peak flow
- $t_{crit,RM}$ = Rational method time of concentration
- Discrepance: Relative difference time to peaks.

The performance indicators are shown in Fig. 4.
The PFSA chart is shown in Fig. 5.

# 4. Optimization Guidance

Although the spreadsheet iterates through 0–300 minutes, users can use Excel's Solver or Goal Seek for more precise optimization by maximizing $Q(t)$ with respect to $t$.

# 5. Assumptions and Limitations

- Assumes instantaneous flow collection (no channel routing)
- Rainfall is uniform during storm duration
- $Tc$ is derived from overland/sheet flow only

# 6. Authors and Credits

- PFSA Model: Vasconcelos, J.G.; Gomes Jr., M.N.; Oliveira, P.T.S.; Yang, D.; Fang, X. (2025)
- Spreadsheet and Manual: Marcus N. Gomes Jr.
- Repository: https://github.com/marcusnobrega-eng/PFSA

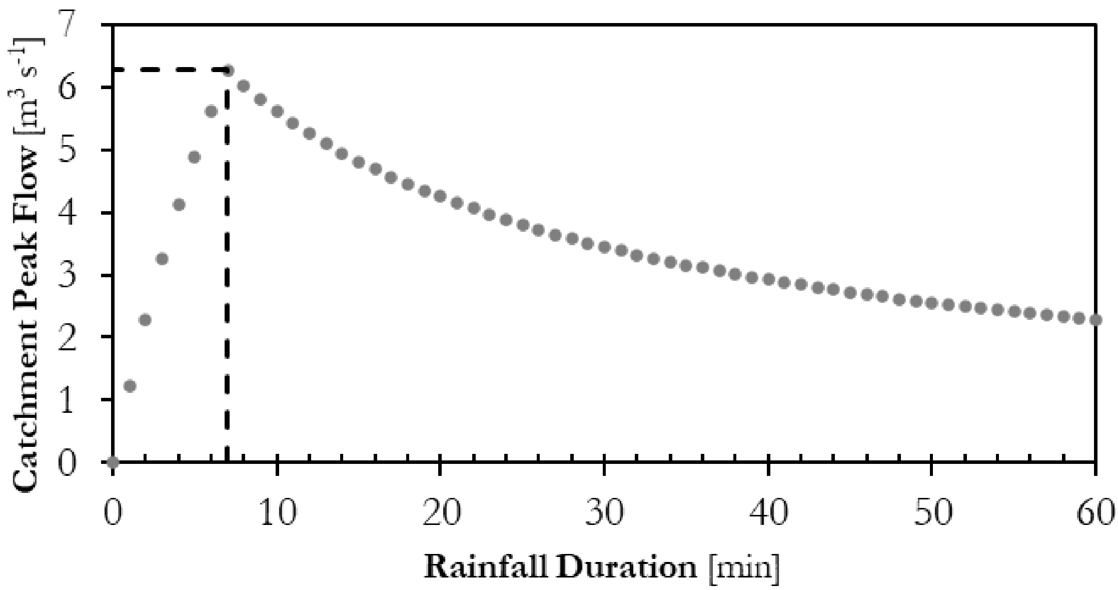


Figure 5: PFSA Chart. The dots represent evaluations of the PFSA method for different rainfall durations. The dashed lines are just to identify the point of maximum outflow.

## 7. References


- Vasconcelos, J.G., Gomes Jr., M.N., Oliveira, P.T.S., Yang, D., Fang, X. (2025). *Reformulating the Rational Method Considering Dissimilar Land Use Types.* Journal of Irrigation and Drainage Engineering, ASCE.
- NRCS (2010). *National Engineering Handbook*, Chapter 15.
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