

Integrated Hydrological Modeling for Watershed Analysis, Flood Prediction, and Mitigation Using Meteorological and Morphometric Data, SCS-CN, HEC-HMS/RAS, and QGIS

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Table S1. Giza station records of maximum rainfall data from 1990 – 2021.

Year	Max. Rainfall (mm)	Year	Max. Rainfall (mm)
1990	12.00	2006	10.00
1991	9.00	2007	6.00
1992	11.00	2008	8.00
1993	6.00	2009	7.00
1994	9.00	2010	5.00
1995	7.00	2011	5.00
1996	4.00	2012	16.00
1997	7.00	2013	17.00
1998	4.00	2014	8.00
1999	6.00	2015	5.00
2000	11.00	2016	5.00
2001	9.00	2017	10.00
2002	7.00	2018	11.00
2003	7.00	2019	31.00
2004	7.00	2020	11.00
2005	6.00	2021	10.00

Table S2. Morphometric characteristics of wadi An-Nawayah sub-basins.

Sub-basin No.	Area (Km ²)	Longest Flow path length (km)	Longest Flow path Slope (m/m)	Basin slope (m/m)	Basin Relief (m)	Relief Ratio	Elonga-tion Ratio	Density (km/km ²)	CN
1	12.80	14.10	0.022	0.13	316	0.022	0.29	0.54	94.3
2	15.00	9.77	0.023	0.09	221	0.023	0.45	0.23	85.9
3	13.30	15.72	0.023	0.19	358	0.023	0.26	0.57	94.0
4	33.80	25.60	0.018	0.18	451	0.018	0.26	0.56	94.6
5	12.90	10.22	0.024	0.16	250	0.024	0.40	0.33	96.3
6	7.00	6.30	0.019	0.14	119	0.019	0.47	0.01	95.9
7	8.30	8.38	0.015	0.12	139	0.017	0.39	0.23	92.6
8	38.10	26.39	0.009	0.13	249	0.009	0.26	0.50	94.2
9	8.30	10.38	0.020	0.15	209	0.020	0.31	0.28	94.9
10	21.20	14.34	0.016	0.20	239	0.017	0.36	0.42	96.8
11	28.30	19.88	0.009	0.14	180	0.009	0.30	0.48	94.1
12	17.30	12.78	0.018	0.22	231	0.018	0.37	0.68	97.8
13	2.10	3.80	0.050	0.29	192	0.051	0.43	1.53	96.7
14	6.20	7.27	0.025	0.29	179	0.025	0.38	1.00	97.8
15	7.20	9.61	0.024	0.34	234	0.024	0.31	1.25	96.7
16	4.60	4.78	0.035	0.28	192	0.040	0.51	0.92	96.3
17	29.50	18.71	0.017	0.21	318	0.017	0.33	0.56	93.9
18	4.80	5.19	0.033	0.10	174	0.034	0.48	0.67	87.7
19	2.20	3.39	0.013	0.08	80	0.024	0.49	0.76	91.3
20	3.10	4.20	0.024	0.11	105	0.025	0.47	1.18	89.8
21	15.90	8.65	0.016	0.07	137	0.016	0.52	0.41	83.5
Min.	2.10	3.39	0.009	0.07	80.00	0.009	0.26	0.01	83.5
Max.	38.10	26.39	0.050	0.34	451.00	0.051	0.52	1.53	97.8
Mean	13.90	11.40	0.022	0.17	217.76	0.023	0.38	0.62	93.6

Table S3. Morphometric characteristics of sub-basins of wadi Al-Rashrash.

Sub-basin No.	Area (Km ²)	Longest Flow path length (km)	Longest Flow path Slope (m/m)	Basin slope (m/m)	Basin Relief (m)	Relief Ratio	Elonga-tion Ratio	Density (km/km ²)	CN
1	31.10	11.70	0.017	0.10	1062.99	0.017	0.33	0.50	86.4
2	20.50	7.20	0.016	0.14	626.64	0.016	0.44	0.36	96.2
3	21.10	7.40	0.015	0.14	675.85	0.017	0.44	0.45	97.0
4	21.20	12.60	0.018	0.19	1204.07	0.018	0.26	0.82	94.9
5	13.50	7.20	0.020	0.18	793.96	0.021	0.36	0.32	94.2
6	28.50	11.90	0.012	0.12	751.31	0.012	0.31	0.60	96.1
7	24.30	8.60	0.014	0.11	633.20	0.014	0.40	0.49	94.2
8	10.90	5.80	0.019	0.14	606.96	0.020	0.40	0.20	96.7
9	11.90	7.40	0.016	0.17	639.76	0.016	0.33	0.18	97.9
10	35.10	11.10	0.012	0.12	741.47	0.013	0.37	0.54	96.5
11	21.30	6.70	0.014	0.11	505.25	0.014	0.48	0.32	95.9
12	11.20	5.20	0.013	0.14	393.70	0.014	0.45	0.09	96.9
13	71.20	16.70	0.010	0.11	882.55	0.010	0.35	0.43	97.2
14	13.90	6.10	0.008	0.09	298.56	0.009	0.43	0.28	96.9
15	0.40	0.90	0.067	0.24	318.24	0.068	0.48	2.69	98.0
16	3.10	2.50	0.030	0.25	485.56	0.036	0.49	1.73	97.3
17	5.40	2.90	0.025	0.16	436.35	0.028	0.55	0.92	98.0
18	20.80	8.90	0.015	0.17	695.54	0.015	0.36	0.73	97.6
19	19.60	7.80	0.015	0.16	646.33	0.016	0.40	0.60	97.7
20	3.20	2.80	0.040	0.21	600.39	0.041	0.45	1.05	98.0
21	30.30	9.50	0.016	0.24	810.37	0.016	0.40	0.59	97.2
22	6.80	3.80	0.026	0.24	547.90	0.027	0.48	0.96	98.0
23	45.00	11.60	0.013	0.22	830.05	0.014	0.41	0.48	96.8
24	13.70	5.10	0.026	0.30	784.12	0.029	0.51	0.71	96.8
25	72.50	20.80	0.013	0.29	1430.45	0.013	0.29	0.71	95.1
26	42.30	12.30	0.016	0.12	1056.43	0.016	0.37	0.64	87.9
27	13.10	9.90	0.010	0.05	541.34	0.010	0.26	0.93	80.4
Min.	0.40	0.90	0.008	0.05	298.56	0.009	0.26	0.09	80.4
Max.	72.50	20.80	0.067	0.30	1430.45	0.068	0.55	2.69	98.0
Mean	22.66	8.31	0.019	0.17	703.68	0.020	0.40	0.68	95.4

Table S4. Lag Time values of Sub-basins of wadi An-Nawayah sub-basins.

Subbasin No.	Length (m)	Length (ft)	Basin Slope	Basin Slope (%)	S	Lag Time (hrs.)	Lag Time (min)
1	14096.97	46238.06	0.13	13.15	0.60	1.09	65.40
2	9769.68	32044.55	0.09	8.57	1.64	1.43	85.70
3	15723.05	51571.60	0.19	18.86	0.64	1.01	60.50
4	25596.68	83957.11	0.18	17.97	0.57	1.48	88.90
5	10221.41	33526.22	0.16	15.85	0.38	0.69	41.60
6	6299.93	20663.77	0.14	14.14	0.43	0.51	30.50
7	8383.78	27498.80	0.12	11.86	0.80	0.82	49.20
8	26392.83	86568.48	0.13	13.49	0.62	1.79	107.20
9	10379.97	34046.30	0.15	15.43	0.54	0.76	45.90
10	14344.58	47050.22	0.20	20.03	0.33	0.79	47.10
11	19883.84	65219.00	0.14	13.88	0.63	1.41	84.70
12	12779.93	41918.17	0.22	22.40	0.22	0.64	38.40
13	3797.83	12456.88	0.29	29.37	0.34	0.23	13.50
14	7273.62	23857.47	0.29	28.76	0.22	0.36	21.60
15	9609.72	31519.88	0.34	33.75	0.34	0.44	26.50
16	4782.38	15686.21	0.28	27.77	0.38	0.28	17.10
17	18709.32	61366.57	0.21	21.35	0.65	1.09	65.60
18	5185.80	17009.42	0.10	9.57	1.40	0.76	45.70
19	3390.63	11121.27	0.08	8.23	0.95	0.51	30.40
20	4195.21	13760.29	0.11	11.23	1.14	0.55	32.80
21	8652.26	28379.41	0.07	7.05	1.98	1.55	93.10
Min.	3390.63	11121.27	0.07	7.05	0.22	0.23	13.50
Max.	26392.83	86568.48	0.34	33.75	1.98	1.79	107.20
Mean	11403.31	37402.84	0.17	17.27	0.70	0.87	51.97

Table S5. Lag Time values of Sub-basins of wadi Al-Rashrash.

Subbasin No.	Length (m)	Length (ft)	Basin Slope	Basin Slope (%)	S	Lag Time (hrs.)	Lag Time (min)
1	11727.10	38464.79	0.10	10.45	1.57	1.47	88.20
2	7202.90	23625.51	0.14	13.69	0.40	0.57	34.00
3	7352.14	24115.02	0.14	13.51	0.31	0.55	33.30
4	12608.90	41357.26	0.19	18.90	0.54	0.81	48.40
5	7221.66	23687.04	0.18	17.72	0.62	0.55	33.20
6	11891.50	39004.25	0.12	12.45	0.41	0.89	53.50
7	8559.71	28075.85	0.11	11.42	0.62	0.79	47.30
8	5762.35	18900.51	0.14	13.58	0.34	0.46	27.80
9	7449.06	24432.92	0.17	16.70	0.21	0.48	28.70
10	11135.60	36524.67	0.12	12.41	0.36	0.83	49.70
11	6736.72	22096.44	0.11	10.60	0.43	0.62	37.20
12	5228.85	17150.63	0.14	14.02	0.32	0.42	25.00
13	16672.60	54686.13	0.11	10.97	0.29	1.17	70.30
14	6106.83	20030.4	0.09	8.81	0.32	0.60	35.70
15	882.65	2895.092	0.24	23.56	0.20	0.07	4.40
16	2526.05	8285.44	0.25	24.66	0.28	0.17	10.30
17	2943.55	9654.84	0.16	16.04	0.20	0.23	13.80
18	8916.95	29247.6	0.17	17.19	0.25	0.55	33.20
19	7848.98	25744.65	0.16	15.67	0.24	0.52	31.20
20	2799.88	9183.61	0.21	21.06	0.20	0.19	11.60
21	9528.61	31253.84	0.24	24.25	0.29	0.50	30.20
22	3825.29	12546.95	0.24	24.20	0.20	0.23	13.90
23	11560.50	37918.31	0.22	22.27	0.33	0.63	37.60
24	5081.43	16667.09	0.30	29.93	0.33	0.28	16.80
25	20762.00	68099.39	0.29	29.28	0.52	0.96	57.40
26	12264.70	40228.05	0.12	11.99	1.38	1.34	80.70
27	9851.98	32314.49	0.05	25.04	2.44	2.25	135.20
Min.	882.65	2895.09	0.05	8.81	0.20	0.07	4.40
Max.	20762.00	68099.39	0.30	29.93	2.44	2.25	135.20
Mean	8312.91	27266.33	0.17	17.42	0.50	0.67	40.32

Table S6. Runoff and losses volumes and peak discharges in sub-basins of W. An-Nawayah during return periods (25, 50 and 100 years).

Sub-basin No.	25-year			50-year			100-year		
	Peak Dis-charge (m ³ /s)	Discharge Volume (×10 ⁻³ m ³)	Loss volume (×10 ⁻³ m ³)	Peak Dis-charge (m ³ /s)	Discharge Volume (×10 ⁻³ m ³)	Loss volume (×10 ⁻³ m ³)	Peak Dis-charge (m ³ /s)	Discharge Volume (×10 ⁻³ m ³)	Loss volume (×10 ⁻³ m ³)
1	9.70	107.00	140.60	17.80	190.30	160.00	21.70	231.20	166.50
2	1.70	34.20	255.10	5.60	88.90	320.40	8.00	119.60	345.10
3	10.20	106.30	150.50	18.80	191.30	172.00	23.00	233.20	179.40
4	21.80	294.20	358.10	39.20	517.20	405.40	47.60	626.40	421.20
5	17.90	143.10	105.60	29.70	235.80	115.90	35.20	280.20	119.30
6	10.90	73.50	61.18	18.10	123.00	68.40	21.60	146.80	70.50
7	5.70	54.40	106.20	11.50	103.20	123.90	14.40	127.80	130.10
8	19.90	312.90	421.80	36.80	558.60	480.60	45.00	679.50	505.50
9	8.80	75.50	84.90	15.50	131.30	95.60	18.70	158.40	99.20
10	29.50	252.70	156.00	47.50	408.60	169.50	55.90	482.60	173.80
11	17.30	229.10	316.50	31.80	410.60	361.20	38.90	500.00	376.30
12	31.80	238.70	94.90	48.90	371.00	100.80	56.70	433.10	102.60
13	5.10	24.40	15.60	8.30	39.60	17.00	9.80	46.80	17.50
14	15.80	85.00	33.80	24.10	132.20	35.90	28.00	154.30	36.60
15	13.90	84.20	53.90	22.60	136.60	58.70	26.60	161.60	60.30
16	10.10	51.30	37.80	16.50	84.50	41.50	19.50	100.40	42.70
17	20.80	232.50	337.20	39.00	419.80	386.10	47.90	512.50	402.70
18	1.20	14.80	77.20	3.60	34.80	95.40	4.90	45.70	102.10
19	1.60	11.90	30.60	3.40	23.80	36.40	4.40	30.00	38.40
20	1.60	13.30	46.30	3.90	28.40	55.9	5.10	36.30	59.40
21	0.90	22.90	283.80	3.80	70.20	363.60	5.70	98.10	394.50
Min.	0.90	11.90	15.60	3.40	23.80	17.00	4.40	30.00	17.50
Max.	31.80	312.90	421.80	48.90	558.60	480.60	56.70	679.50	505.50
Mean	12.20	117.23	150.84	21.26	204.75	180.42	25.65	247.83	183.03

Table S7. Runoff and losses volumes and peak discharges in sub-basins of W. Al-Rashrash during return periods (25, 50 and 100 years).

Sub-basin No.	25-year			50-year			100-year		
	Peak Dis-charge (m ³ /s)	Discharge Volume (×10 ⁻³ m ³)	Loss volume (×10 ⁻³ m ³)	Peak Dis-charge (m ³ /s)	Discharge Volume (×10 ⁻³ m ³)	Loss volume (×10 ⁻³ m ³)	Peak Dis-charge (m ³ /s)	Discharge Volume (×10 ⁻³ m ³)	Loss Vol-ume (×10 ⁻³ m ³)
1	4.00	128.60	522.00	7.50	128.60	588.70	12.30	195.20	652.60
2	32.10	224.20	171.20	42.00	292.90	180.40	53.10	371.10	188.30
3	37.40	259.20	148.00	47.90	332.70	154.60	59.50	415.80	160.10
4	21.80	192.90	216.90	29.70	259.00	231.50	38.60	335.40	244.30
5	15.60	110.60	149.10	21.60	150.70	160.10	28.50	197.50	169.90
6	32.90	307.80	242.90	43.30	402.90	256.20	55.10	511.30	267.60
7	22.60	199.40	268.70	31.30	271.70	288.70	41.40	356.00	306.20
8	20.30	127.80	81.90	26.30	165.10	85.80	33.00	207.40	89.50
9	25.80	167.30	63.10	32.40	210.60	65.10	39.60	259.00	66.90
10	45.40	400.60	276.00	59.00	519.90	289.90	74.20	655.30	301.70
11	30.30	223.40	188.00	40.10	293.70	198.70	51.10	374.00	207.90
12	23.30	135.10	80.30	29.90	173.90	83.90	37.40	217.70	87.00
13	80.40	900.90	473.80	102.70	1151.60	493.70	127.60	1434.10	510.40
14	23.50	167.80	99.70	30.20	215.90	104.20	37.60	270.30	108.10
15	1.50	5.20	1.90	1.90	6.50	1.90	2.30	8.00	2.00
16	10.40	40.20	20.30	13.20	51.30	21.10	16.30	63.80	21.80
17	15.80	77.10	27.50	19.70	96.90	28.40	24.00	118.90	29.10
18	40.00	278.40	122.20	50.40	352.70	126.80	61.90	436.20	130.50
19	39.00	267.40	111.80	48.90	338.10	115.80	59.90	417.30	119.10
20	10.80	46.10	16.50	13.50	57.90	17.00	16.50	71.10	17.40
21	56.40	382.80	201.30	71.80	489.40	209.80	89.30	609.50	216.90
22	19.80	97.30	34.70	24.70	122.20	35.80	30.20	150.00	36.70
23	72.80	537.10	331.50	93.90	692.60	347.10	117.40	868.50	360.20
24	32.00	162.90	105.50	41.00	210.10	10.5.5	51.00	263.40	109.20
25	67.80	678.20	721.90	91.40	906.60	769.10	118.50	1170.10	810.30
26	8.10	135.70	681.60	14.20	215.10	763.10	22.30	316.00	840.20
27	56.40	382.80	243.60	0.70	20.60	281.80	1.40	37.80	319.50
Min.	1.50	5.20	1.90	0.70	6.50	1.90	1.40	8.00	2.00
Max.	80.40	900.90	721.90	102.70	1151.60	769.10	127.60	1434.10	840.20
Mean	31.34	245.81	207.48	38.12	301.08	226.89	48.15	382.62	236.05

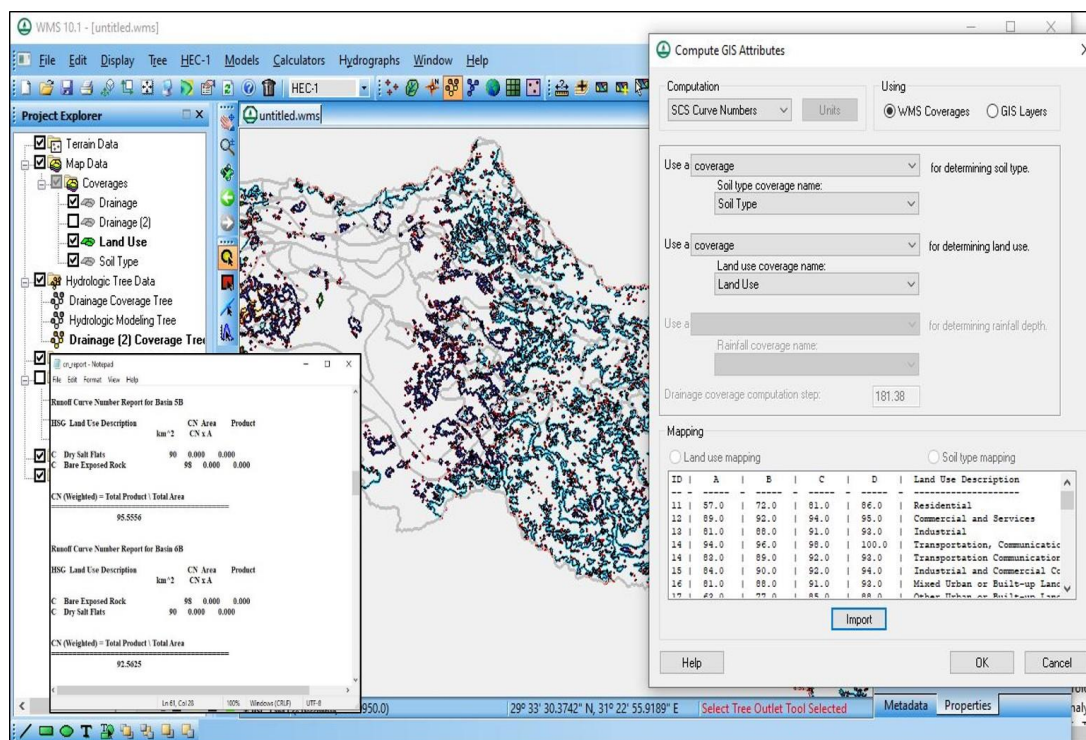


Figure S1. Calculation of CN values of sub-basins using WMS software.

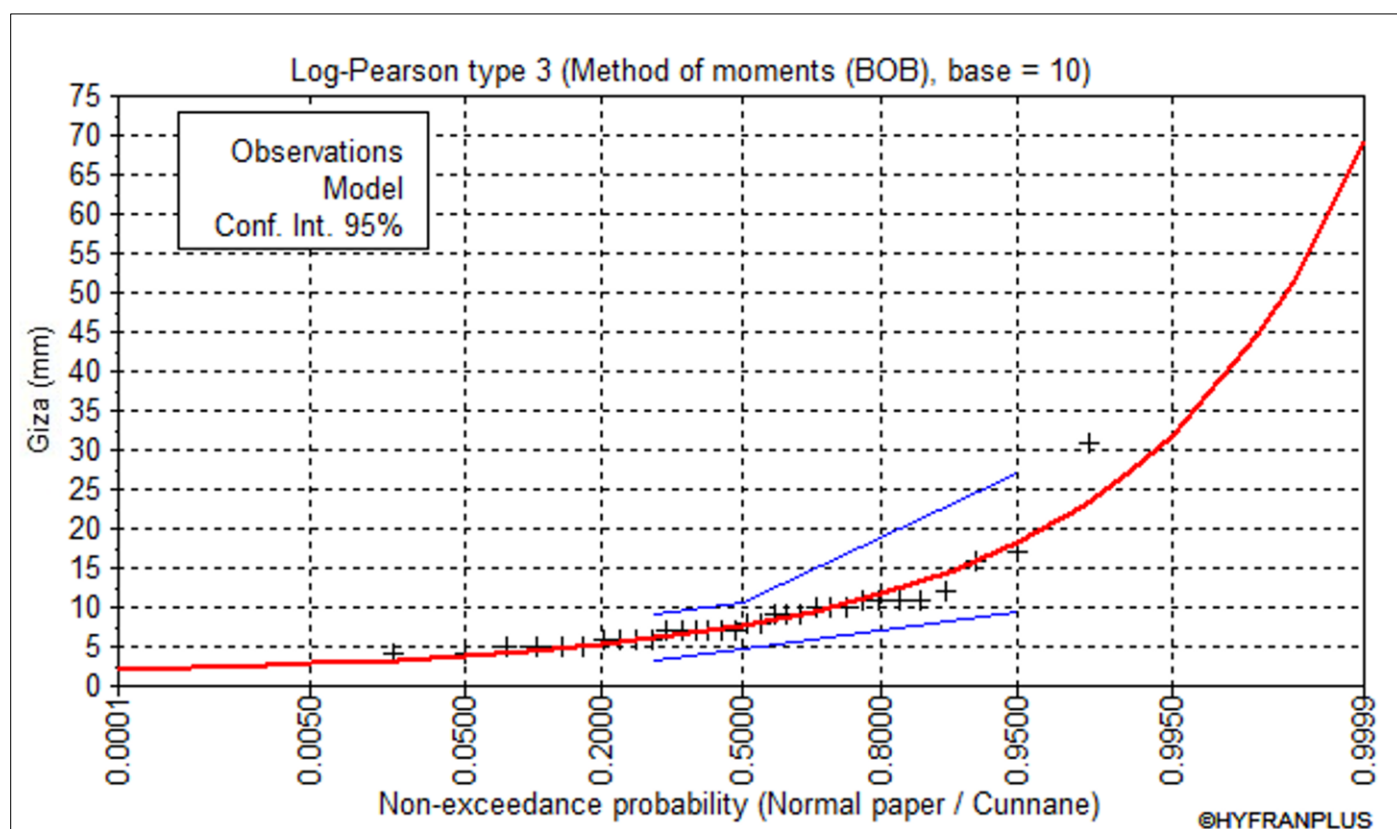


Figure S2. The rainfall theoretical frequency distributions fitting of Log-Pearson type 3.

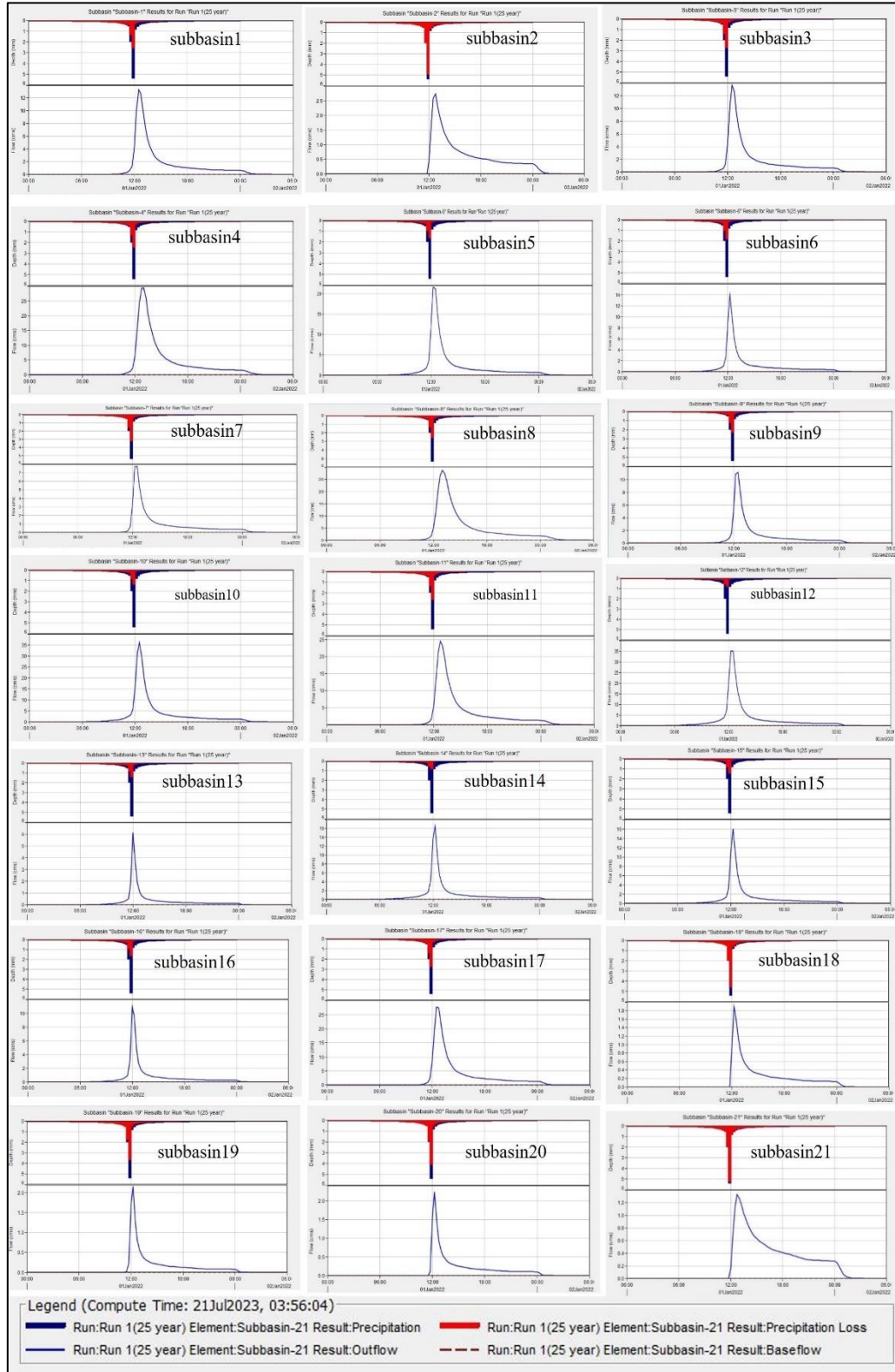


Figure S3. Hydrographs of sub-basins of W. An-Nawayah during 25-year return period.

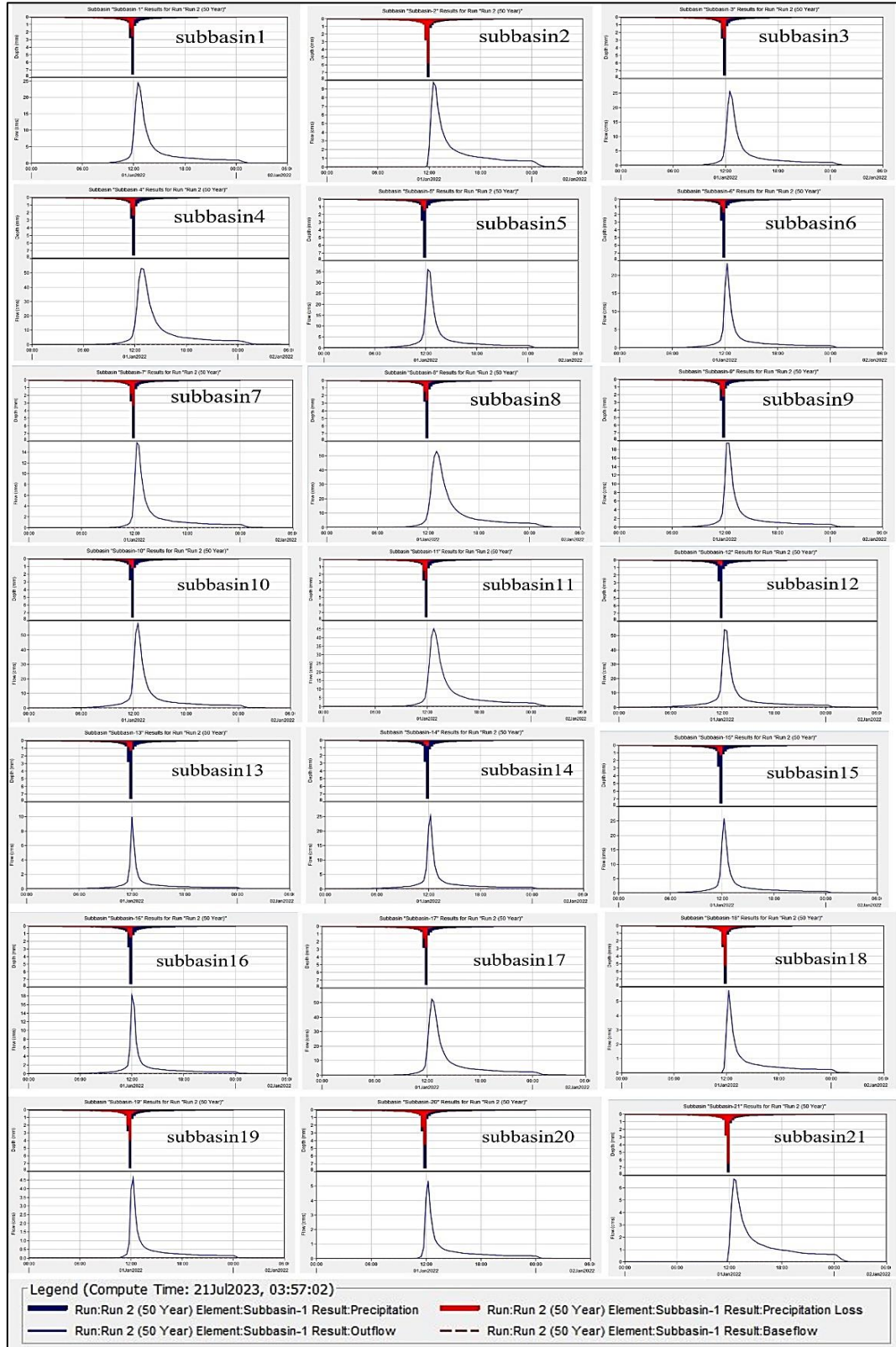


Figure S4. Hydrographs of sub-basins of W. An-Nawayah during 50-year return period.

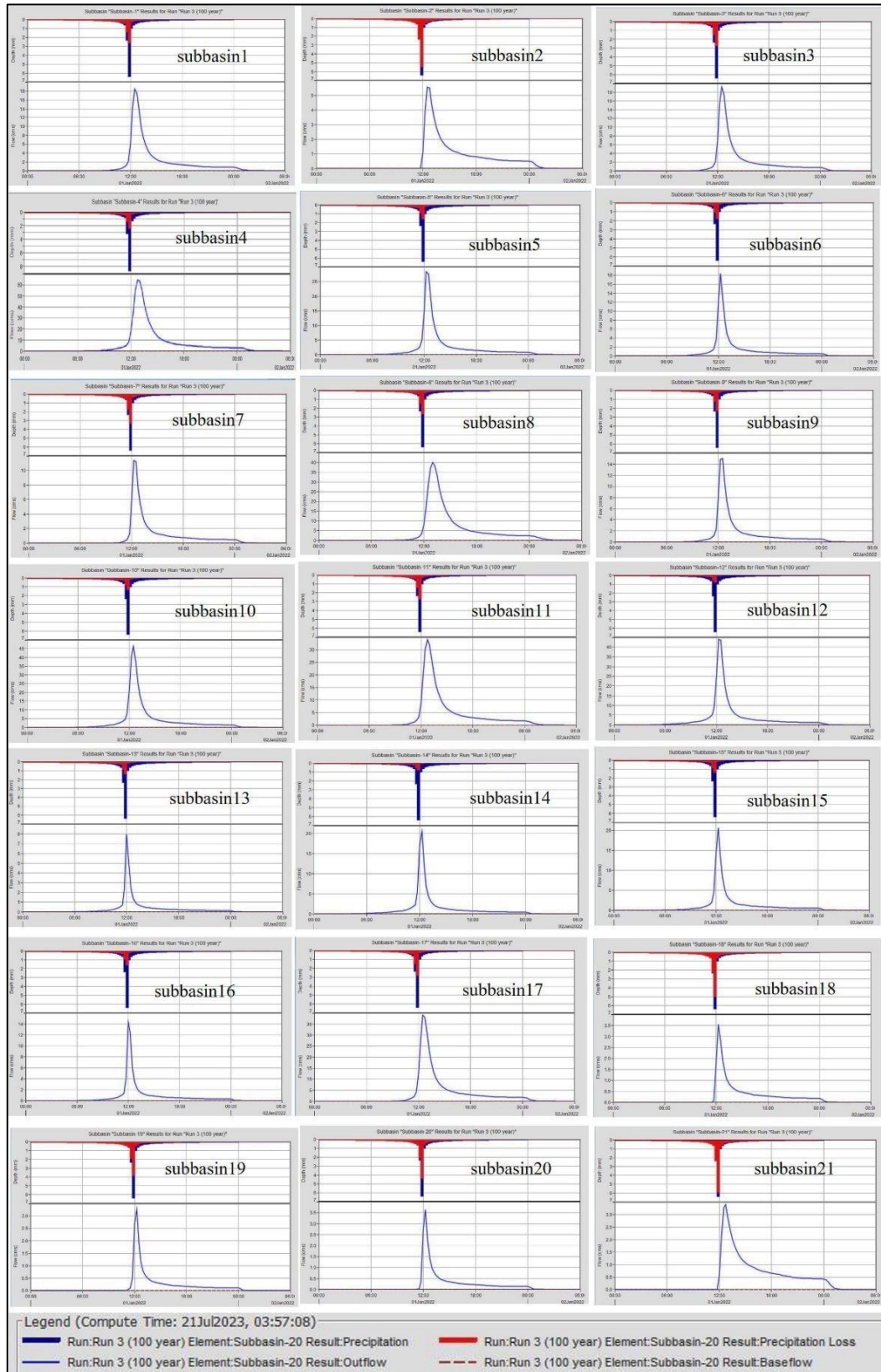


Figure S5. Hydrographs of sub-basins of W. An-Nawayah during 100-year return period.

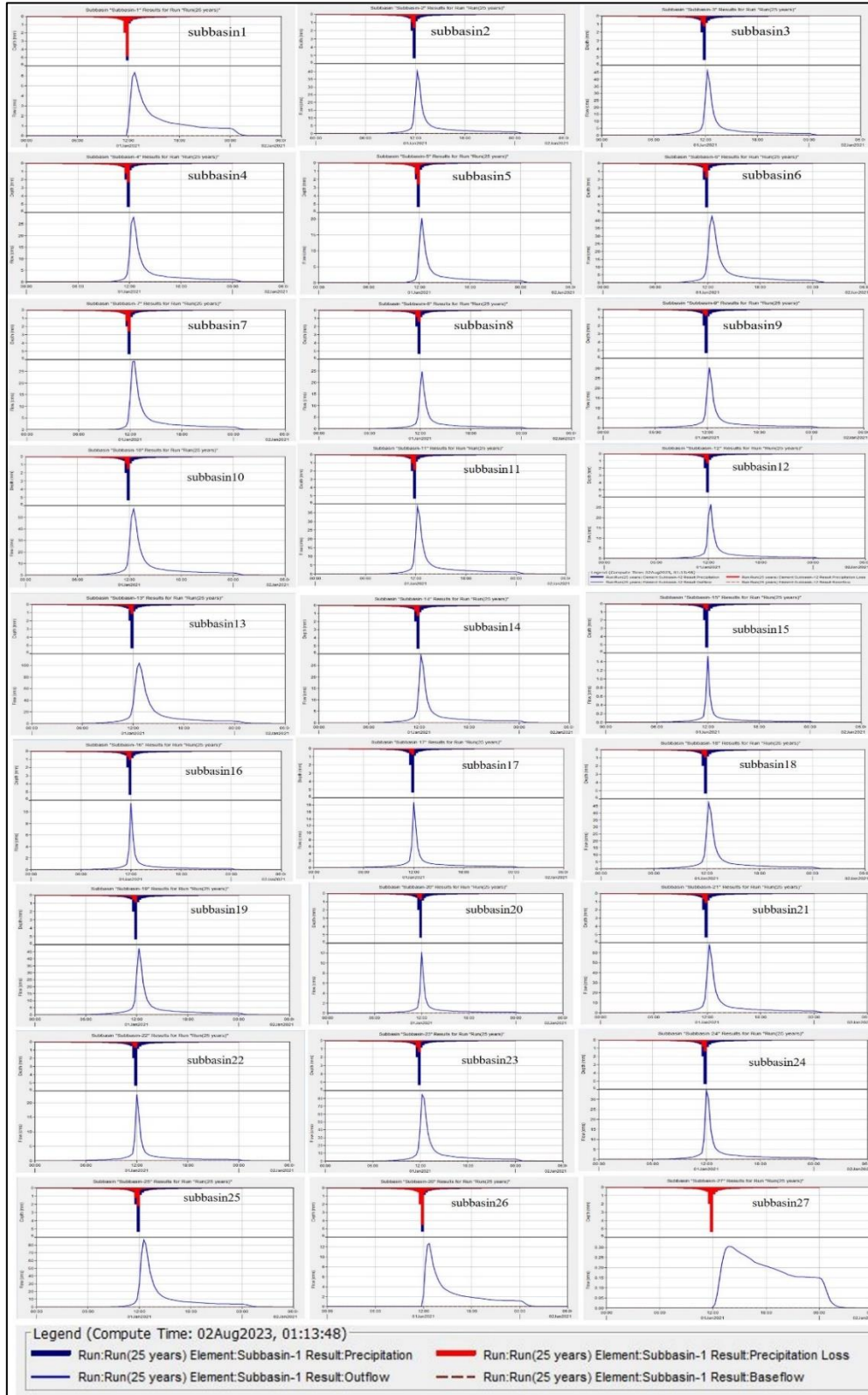


Figure S6. Hydrographs of sub-basins of W. Al-Rashrah during 25-year return period.

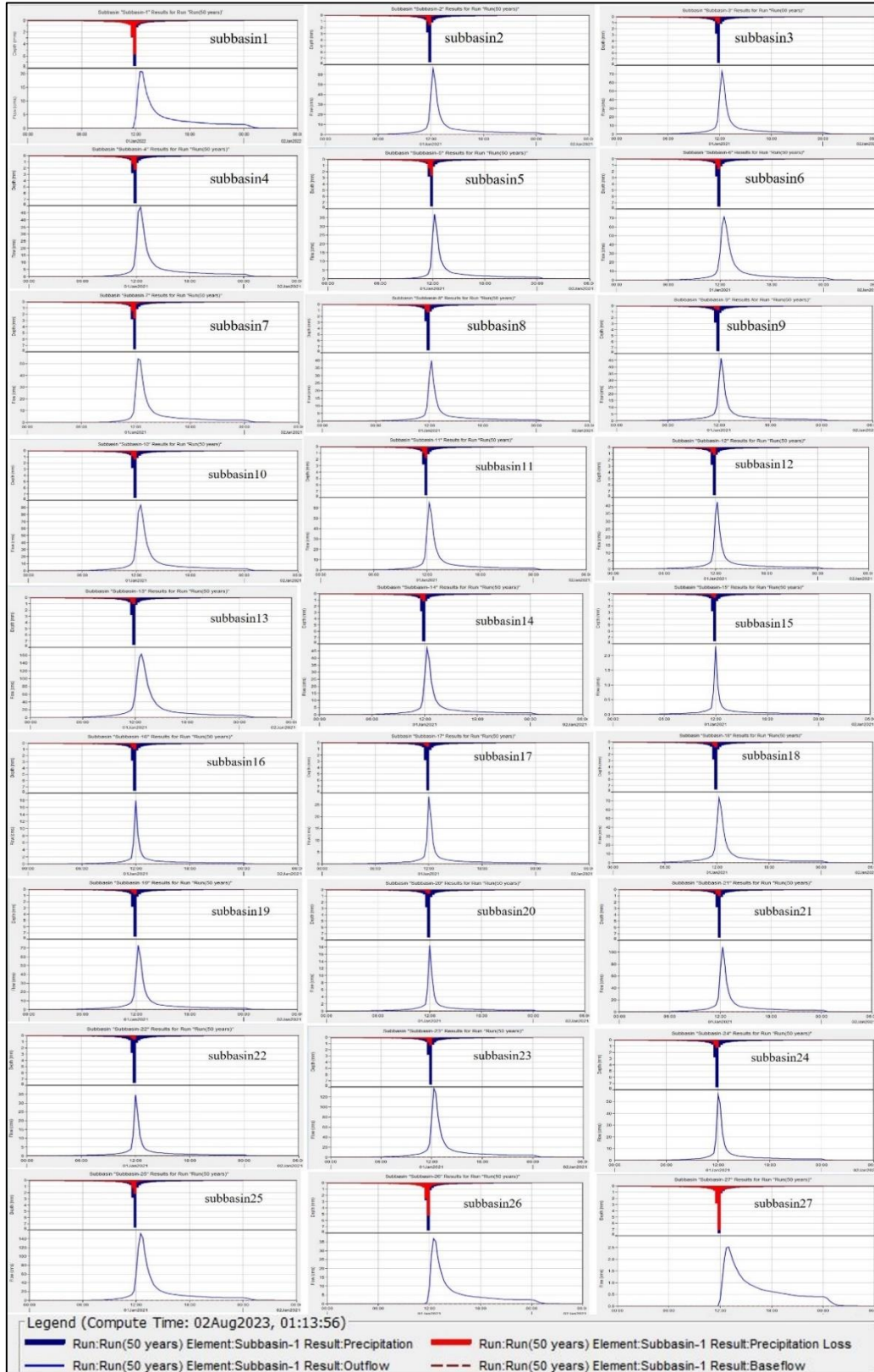


Figure S7. Hydrographs of sub-basins of W. Al-Rashrash during 50-year return period.

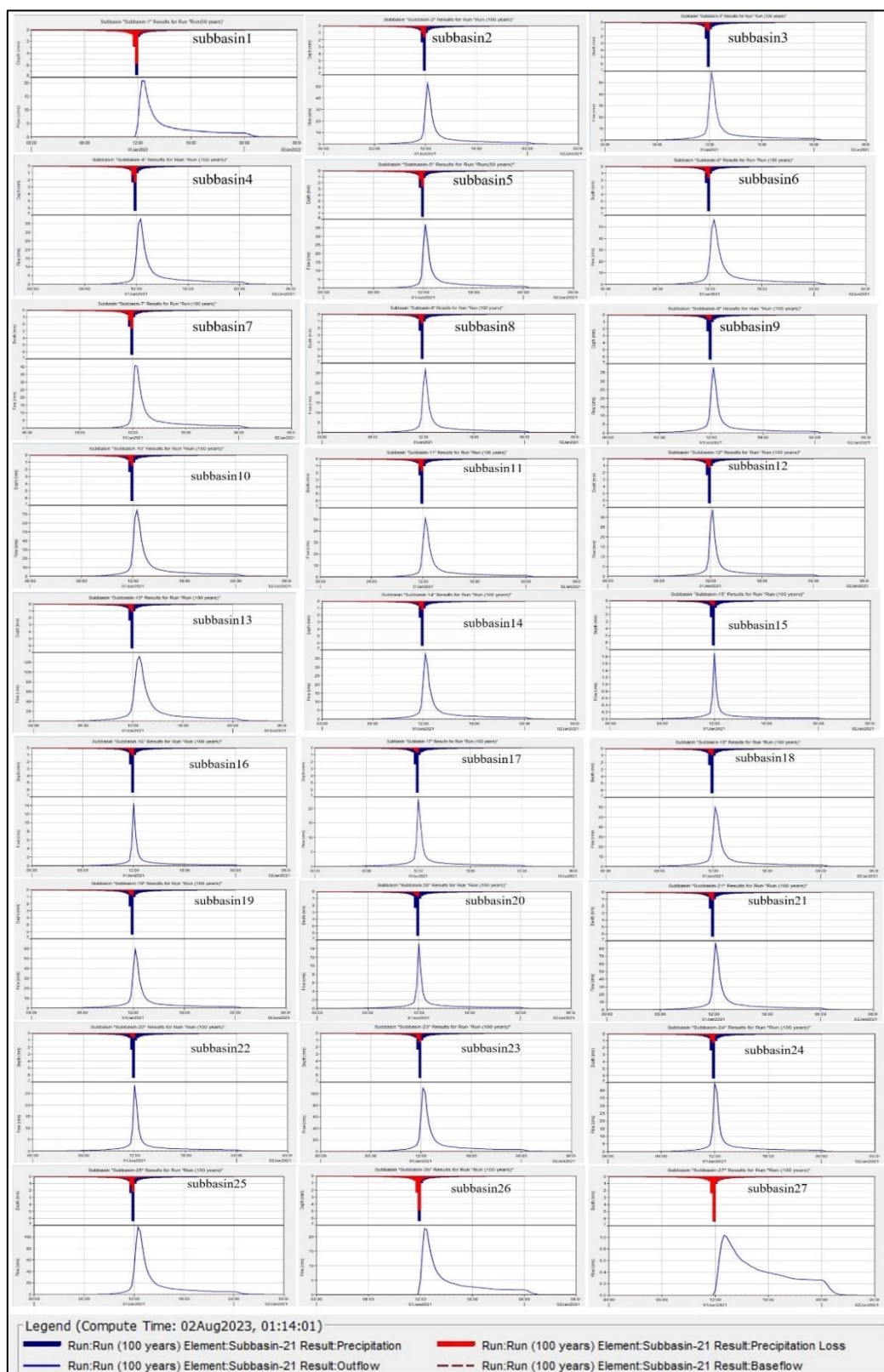


Figure S8. Hydrographs of sub-basins of W. Al-Rashrash during 100-year return period.