water

Supplementary Materials: Runoff Effect Evaluation of LID through SWMM in Typical Mountainous, Low-lying Urban Areas: A Case Study in China

Qinghua Luan, Xiaoran Fu, Cuiping Song, Haichao Wang, Jiahong Liu, Ying Wang

S1. The calculation process of design precipitation

In this study, the typical precipitation process of one-year, two-year, five-year and ten-year return periods (five-minute-precipitation process, which lasts 24 hours) were selected according to the local standard and technical code [1,2], and calculated through the hydrological calculation formulas as followed.

Firstly, the average precipitation $\overline{H_t}$ (mm) and the corresponding coefficient of variation C_v of the standard time interval t (10 min, 30 min, 60 min, 360 min and 1440 min) were obtained from the "Beijing City Hydrology Handbook" [3]. Secondly, the coefficient of modulus K_p was calculated by equation (1), where the coefficient of dispersion Φ_p was obtained by the statistic table of Pearson Ⅲ. Thirdly, the point precipitation values $H_{tp}{}^*$ (mm) of a certain standard time interval and a certain return period was calculated by equation (2).

$$K_p = 1 + C_v * \Phi_p \quad (1)$$

$$H_{tp}{}^* = K_p * \overline{H_t} \quad (2)$$

Then, the designed storm of any time of different return period H_{tp} (mm) could be obtained by equation (3).

$$H_{tp} = H_{bp} * (t/t_b)^{1-n_{ab}} \quad (3)$$

Where, n_{ab} is the storm attenuation coefficient between the designed storm $H_{ap}{}^*$ and $H_{bp}{}^*$ (a and b mean the different but adjacent standard time; a means the former time and b means the latter time). The value of n_{ab} was calculated according to the following equations (equation (4) ~ (7)), n_1 ~ n_4 mean the descending exponent of 10 ~ 30min, 30 ~ 60min, 60 ~ 360min and 360 ~ 1440min respectively. They were calculated as equation (4) ~ (7) respectively.

$$n_1 = 1 + 2.096 * \lg\left(\frac{H_{10p}}{H_{30p}}\right) \quad (4)$$

$$n_2 = 1 + 3.322 * \lg\left(\frac{H_{30p}}{H_{60p}}\right) \quad (5)$$

$$n_3 = 1 + 1.285 * \lg\left(\frac{H_{60p}}{H_{360p}}\right) \quad (6)$$

$$n_4 = 1 + 1.661 * \lg\left(\frac{H_{360p}}{H_{1440p}}\right) \quad (7)$$

At last, the calculated precipitation process with different return periods in 24 hours were allocated in 1440min (every 5min a data) according to the storm pattern assignment table of "storm runoff calculation standard for urban rainwater systematic planning and design"[1].

Table S1. Parameters of the study area.

Code	*A*(ha)	*W*(m)	Slope(%)	Impervious ratio (%)	Impervious area(ha)	Code	*A*(ha)	*W*(m)	Slope(%)	Impervious area ratio(%)	Impervious area(ha)
S1	31.17	412.16	37.94	0.00	0.000	S37	1.44	90.16	5.57	70.83	1.020
S2	78.69	653.12	39.42	0.00	0.000	S38	2.60	120.48	3.61	46.63	1.212
S3	74.65	632.32	31.70	0.03	0.022	S39	16.48	303.68	18.81	0.74	0.122
S4	42.66	480.64	32.40	0.00	0.000	S40	14.03	273.44	22.55	0.43	0.060
S5	73.99	630.08	31.60	0.07	0.052	S41	6.57	198.88	17.32	0.78	0.051
S6	101.31	735.04	30.53	0.00	0.000	S42	1.93	108.48	14.44	19.90	0.384
S7	15.96	295.04	8.26	9.55	1.524	S43	3.95	149.84	6.44	30.40	1.201
S8	12.44	267.2	35.68	4.47	0.556	S44	4.66	162.56	7.69	34.84	1.624
S9	10.04	233.28	26.66	3.62	0.363	S45	2.78	128.16	10.59	17.59	0.489
S10	8.39	220.16	19.19	8.81	0.739	S46	3.75	142.72	5.81	37.12	1.392
S11	2.56	120.32	10.97	6.82	0.175	S47	3.53	141.04	7.52	39.84	1.406
S12	1.37	88.16	7.08	33.02	0.452	S48	2.91	136.08	7.63	17.25	0.502
S13	6.62	190.56	8.54	1.36	0.090	S49	6.06	184.16	11.18	19.07	1.156
S14	6.99	198.88	12.12	11.79	0.824	S50	4.40	159.92	6.62	30.95	1.362
S15	6.31	192.48	4.69	16.88	1.065	S51	7.35	200.64	4.77	36.47	2.681
S16	26.19	379.52	6.96	0.44	0.115	S52	6.35	191.04	5.56	26.84	1.704
S17	4.61	167.04	3.86	3.92	0.181	S53	4.11	154.80	6.31	28.70	1.180
S18	5.95	181.60	5.56	1.51	0.090	S54	3.28	136.88	6.03	4.81	0.158
S19	15.39	290.72	5.10	10.78	1.659	S55	2.76	127.44	5.97	52.54	1.450
S20	1.21	80.32	5.44	1.62	0.020	S56	4.05	154.72	6.68	39.80	1.612
S21	2.76	124.48	2.85	22.77	0.628	S57	2.50	123.52	6.00	33.99	0.850
S22	33.57	429.12	46.18	0.00	0.000	S58	1.72	100.24	5.94	19.20	0.330
S23	25.74	373.76	47.56	0.00	0.000	S59	2.22	116.96	5.80	44.22	0.982
S24	73.96	633.92	38.75	1.00	0.740	S60	4.86	164.64	4.63	32.23	1.566
S25	43.94	490.88	32.89	0.01	0.004	S61	4.84	165.92	6.72	36.43	1.763
S26	29.17	408.00	46.99	0.19	0.055	S62	3.79	149.52	4.83	38.96	1.477
S27	7.82	215.84	16.37	19.45	1.521	S63	1.39	89.28	5.64	52.65	0.732
S28	44.61	496.32	48.83	1.20	0.535	S64	4.26	154.24	5.34	36.50	1.555
S29	48.65	517.12	33.89	0.57	0.277	S65	5.18	170.88	5.85	42.18	2.185
S30	17.86	314.88	32.50	1.71	0.305	S66	7.02	196.16	5.31	45.31	3.181
S31	46.23	507.52	31.15	3.96	1.831	S67	9.22	224.96	5.12	20.37	1.878
S32	41.18	470.72	28.99	2.44	1.005	S68	7.19	196.96	2.99	3.72	0.267
S33	27.57	392.00	22.10	2.01	0.554	S69	3.45	138.32	2.62	36.62	1.263
S34	5.86	181.12	8.29	52.30	3.065	S70	11.32	245.60	3.71	59.59	6.746
S35	6.13	183.84	7.69	32.69	2.004	S71	6.27	185.76	3.81	31.31	1.963
S36	1.66	99.12	7.49	26.53	0.440	S72	22.59	345.00	5.212	71.02	16.042

Table S2. Parameters of the concave greenbelts.

Code of sub-catchment	Area of green fields(ha)	*W*(m) with different concave ratio		
		50%	70%	90%
S27	6.23	136.98	162.07	183.77
S35	4.13	106.65	126.19	143.09
S36	1.22	60.08	71.08	80.60
S38	1.39	62.24	73.64	83.50
S43	2.75	88.39	104.59	118.59
S44	3.04	92.79	109.79	124.49
S47	2.12	77.35	91.53	103.78
S50	3.04	93.97	111.18	126.07
S51	4.67	113.08	133.80	151.71
S52	4.65	115.54	136.71	155.02
S53	2.93	92.43	109.36	124.00
S57	1.65	70.96	83.96	95.21
S59	1.24	61.77	73.09	82.87
S61	3.08	93.54	110.68	125.50
S62	2.31	82.60	97.74	110.82
S64	2.71	86.91	102.83	116.60
S66	3.84	102.58	121.37	137.62
S67	7.34	141.95	167.95	190.44
S71	4.31	108.86	128.81	146.06
S72	6.55	131.33	155.40	176.20

Table S3. Parameters of the permeable pavement in residential community roads.

Code of sub-catchment	Slope (%)	Area of Road(m^2)	*W*(m)with different permeable ratio		
			50%	60%	70%
S27	16.37	8691.37	50.88	55.74	60.20
S35	7.69	11450.84	56.18	61.55	66.48
S36	7.49	2516.56	27.29	29.90	32.29
S38	3.61	6927.89	43.98	48.17	52.03
S43	6.44	6861.71	44.16	48.38	52.25
S44	7.69	9277.39	51.29	56.19	60.69
S47	7.52	8036.30	47.58	52.13	56.30
S50	6.62	7781.71	47.56	52.10	56.27
S51	4.77	15317.40	64.77	70.95	76.63
S52	5.56	9739.09	52.90	57.95	62.60
S53	6.31	6740.40	44.33	48.5	52.45
S57	6.00	4855.71	38.49	42.17	45.55
S59	5.80	5609.62	41.57	45.54	49.19
S61	6.72	10075.50	53.53	58.64	63.34
S62	4.83	8437.62	49.89	54.65	59.03
S64	5.34	8885.14	49.81	54.56	58.94
S66	5.31	18175.78	70.58	77.32	83.51
S67	5.12	10732.08	54.27	59.45	64.21
S71	3.81	11217.93	55.56	60.86	65.74
S72	5.21	91672.80	155.41	170.24	183.88

Table S4. Parameters of the permeable pavement in municipal sidewalks.

Code of sub-catchment	Slope (%)	Area of Road(m^2)	*W*(m)
S14	8.96	4862.01	52.45
S17	3.86	5037.04	55.22
S18	5.56	3591.38	44.62
S19	5.11	11935.32	80.96
S21	1.43	1699.31	30.89
S24	27.56	2731.23	38.52
S25	24.63	1704.16	30.57
S33	15.69	1981.59	33.23
S34	6.57	1446.46	28.46
S37	5.57	1363.01	27.74
S39	18.81	1287.19	26.84
S44	7.69	3135.31	42.17
S45	10.59	2626.78	39.40
S46	5.8	2315.57	35.46
S47	7.52	5729.84	56.82
S48	7.63	4093.53	51.04
S50	6.09	1761.00	31.99
S51	4.77	3239.10	42.12
S53	6.31	3888.98	47.62
S55	5.97	2246.12	36.36
S58	5.94	2695.35	39.68
S59	6.12	2075.53	35.76
S60	4.63	8674.71	69.56
S62	4.83	6100.30	59.99
S64	5.34	3015.94	41.04
S65	5.85	6062.12	58.46
S67	5.13	8559.85	68.54
S68	4.05	2856.66	39.26
S71	3.81	5599.97	55.52
S72	5.21	3741.78	44.40

Table S5. Parameters of the Bio-retention cells.

Code of sub-catchment	Store Volume (m^3)	Area of single position (m^2)	Position count	*W*(m)
S21	314.23	150	13	11.81
S69	631.70	150	28	11.81

Table S6. Storage area of different depth in different vegetative swales.

Length of Swale (m)	Storage area of different depth (m^2)									
	0.01m	**0.02m**	**0.03m**	**0.04m**	**0.05m**	**0.06m**	**0.07m**	**0.08m**	**0.09m**	**0.1m**
25	19	27	33	38	42	46	50	53	56	59
213.43	162.21	230.50	281.73	324.41	358.56	392.71	426.86	452.47	478.08	503.69
313.86	238.53	338.97	414.29	477.07	527.28	577.50	627.72	665.38	703.05	740.71
63.41	48.19	68.48	83.70	96.38	106.53	116.67	126.82	134.43	142.04	149.65
130.63	99.28	141.08	172.43	198.56	219.46	240.36	261.26	276.94	292.61	308.29
275.92	209.70	297.99	364.21	419.40	463.55	507.69	551.84	584.95	618.06	651.18

[1] 25 was the length of the experiment swale.

References

1. Standard of storm runoff calculation for urban storm drainage system planning and design (DB11/T969-2013). Beijing Academy of Urban Planning & Design: Beijing, China, 2013.
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3. Beijing Water Bureau, Hydrologic Handbook of Beijing City. Beijing Water Bureau: Beijing, China, 1999.