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MDPI

Supplementary Material

Multi-Objective Optimization for Urban Drainage or Sewer Networks Rehabilitation through Pipes Substitution and Storage Tanks Installation

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Supplementary Material

In the manuscript referred above, a case study was used to present the validity of the method described. It is the aim of the authors to allow any researcher to be able to reproduce the results obtained. For this reason, the data and the results are included in this supplementary material.

The network of E-Chicó is presented in the Figure S1 below.

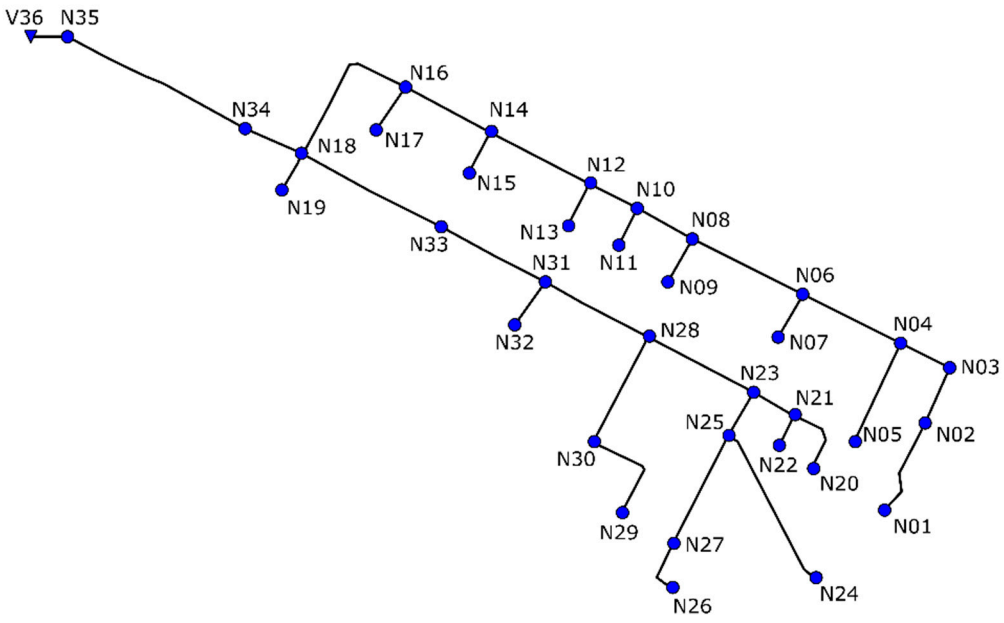

Figure S1. Representation of E-Chicó drainage network.

For the network described above, three different rehabilitation scenarios were performed depending on the selection of the decision variables. The results of these scenarios for the case of not having flooding are also presented.

1. Case Study Data

Table S1. Data for nodes and subcatchments in the network used as a case study.

Node ID	Invert Elevation (m)	Max. Depth (m)	Flooding Area (m^2)	Sub-Catchment Area (ha)	Impervious Area (%)	Width (m)	Slope (%)
N01	2585.94	1.40	1380	1.38	73.6	44	16.9
N02	2574.53	2.25	1240	1.24	80.9	25	12.3
N03	2573.25	2.25	1080	1.08	29.2	84	27.7
N04	2567.97	1.72	930	0.93	100	46	4.8
N05	2575.26	2.06	1530	1.53	82.8	38	7.0
N06	2563.08	1.83	1890	1.89	100	43	3.1
N07	2563.67	2.45	1250	1.25	100	43	3.9
N08	2558.57	2.49	1930	1.93	100	45	3.1
N09	2560.66	1.32	1130	1.13	100	43	3.8
N10	2556.14	2.19	700	0.70	100	16	2.0
N11	2556.62	3.35	820	0.82	100	42	2.6
N12	2555.55	2.43	1730	1.73	100	42	1.1
N13	2555.97	2.74	1000	1.00	100	45	1.1
N14	2553.85	1.97	1530	1.53	100	40	0.9
N15	2555.04	1.38	1160	1.16	100	42	0.8
N16	2553.02	2.29	1480	1.48	100	28	0.7
N17	2553.31	2.10	1000	1.00	100	45	0.9
N18	2551.24	2.81	2520	2.52	100	27	0.9
N19	2552.88	1.38	470	0.47	100	22	0.8
N20	2575.59	1.25	1450	1.45	52.6	26	7.5
N21	2570.06	1.57	990	0.99	86.2	25	4.7
N22	2572.07	1.90	620	0.62	64.7	29	4.7
N23	2564.59	2.61	450	0.45	100	22	3.4
N24	2587.65	2.60	1280	1.28	61.5	110	24.4
N25	2568.14	2.26	2190	2.19	90.3	44	4.8
N26	2571.98	1.48	1250	1.25	94.8	29	3.3
N27	2571.38	2.42	1120	1.12	85.3	42	4.3
N28	2561.86	2.63	2420	2.42	100	48	3.6
N29	2569.21	1.53	1530	1.53	100	55	3.6
N30	2565.41	1.28	1950	1.95	100	49	3.8
N31	2556.50	3.49	2710	2.71	100	21	2.2
N32	2559.00	0.91	1500	1.50	90.6	25	1.9
N33	2553.39	1.94	3030	3.03	100	24	1.1
N34	2548.97	3.07	3270	3.27	100	44	0.5
N35	2548.43	3.07	1210	1.21	90.6	20	0.7

Table S2. Data for conduits in the network used as a case study.

Link ID	Node 1	Node 2	Length (m)	Manning Roughness	Diameter (m)
P01	N01	N02	172.65	0.011	0.40
P02	N02	N03	90.99	0.011	0.40
P03	N03	N04	93.17	0.011	0.40
P04	N04	N06	187.94	0.011	0.55
P05	N05	N04	180.27	0.011	0.40
P06	N06	N08	203.82	0.011	0.60
P07	N07	N06	85.55	0.011	0.40
P08	N08	N10	113.02	0.011	0.75
P09	N09	N08	85.62	0.011	0.40
P10	N10	N12	81.80	0.011	0.75
P11	N11	N10	68.24	0.011	0.30

P12	N12	N14	187.31	0.011	0.90
P13	N13	N12	80.08	0.011	0.40
P14	N14	N16	169.06	0.011	1.10
P15	N15	N14	79.98	0.011	0.50
P16	N16	N18	270.92	0.011	1.20
P17	N17	N16	84.81	0.011	0.40
P18	N18	N34	90.38	0.011	1.30
P19	N19	N18	66.74	0.011	0.40
P20	N20	N21	124.22	0.011	0.45
P21	N21	N23	79.16	0.011	0.45
P22	N22	N21	52.91	0.011	0.30
P23	N23	N28	194.54	0.011	0.60
P24	N24	N25	270.94	0.011	0.56
P25	N25	N23	85.78	0.011	0.60
P26	N26	N27	91.21	0.011	0.40
P27	N27	N25	203.14	0.011	0.55
P28	N28	N31	201.07	0.011	0.75
P29	N29	N30	180.09	0.011	0.50
P30	N30	N28	197.82	0.011	0.60
P31	N31	N33	187.12	0.011	0.85
P32	N32	N31	88.46	0.011	0.40
P33	N33	N18	273.72	0.011	1.00
P34	N34	N35	337.56	0.011	1.40
P35	N35	V36	33.19	0.011	1.40

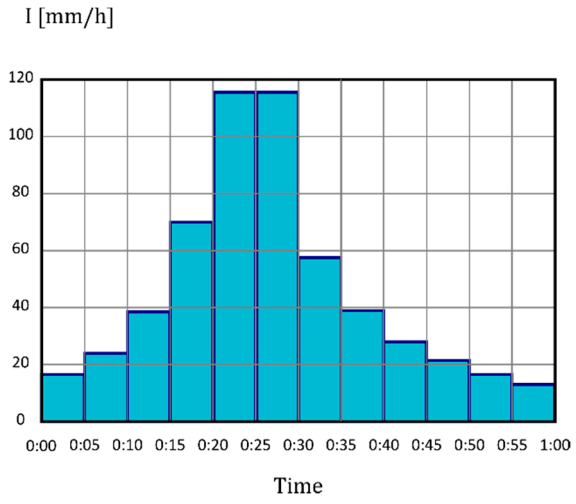

Figure S2. Design storm based on the Alternating Blocks Method.

Table S3. Time series for the design storm used in the case study.

Time	Value
0:00	16.73
0:05	24.4
0:10	38.78
0:15	70.61
0:20	118
0:25	118
0:30	57.48

0:35	39.12
0:40	28.3
0:45	21.39
0:50	16.73

Table S4. Series of suitable diameters and their associated for the case study.

Diameter (m)	Unit Cost (€/m)	Diameter (m)	Unit Cost (€/m)
0.30	30.93	1.30	404.51
0.35	39.73	1.40	464.76
0.40	49.56	1.50	529.16
0.45	60.44	1.60	597.73
0.50	72.36	1.80	747.35
0.60	99.31	1.90	828.40
0.70	130.43	2.00	913.61
0.80	165.71	2.20	1096.52
0.90	205.15	2.40	1296.07
1.00	248.75	2.60	1512.27
1.10	296.51	2.80	1745.11
1.20	348.43	3.00	1994.60

2. Results of the Case Study

Next, the results of these scenarios for the case of not having flooding are presented.

Table S5. Results for scenario 1, all 35 conduits are suitable to change their diameters.

Link ID	Original Diameter (mm)	New Diameter (mm)	Cost (€)
P01	400	400	0.00
P02	400	800	15,077.63
P03	400	1000	23,175.57
P04	550	700	24,512.81
P05	400	400	0.00
P06	600	800	33,774.28
P07	400	500	6190.18
P08	750	1100	33,511.12
P09	400	400	0.00
P10	750	1200	28,501.44
P11	300	400	3382.22
P12	900	1100	55,538.56
P13	400	900	16,428.02
P14	1100	1400	78,571.75
P15	500	450	4834.02
P16	1200	1300	109,590.36
P17	400	600	8422.70
P18	1300	1400	42,004.70
P19	400	1000	16,601.24
P20	450	450	0.00
P21	450	450	0.00

Link ID	Original Diameter (mm)	New Diameter (mm)	Cost (€)
P22	300	800	8767.53
P23	600	800	32,236.52
P24	560	500	19,604.54
P25	600	1000	21,337.35
P26	400	800	15,114.08
P27	550	1300	82,172.55
P28	750	900	41,248.53
P29	500	450	10,884.71
P30	600	900	40,581.80
P31	850	1100	55,482.22
P32	400	450	5346.56
P33	1000	1300	110,723.00
P34	1400	1800	252,274.59
P35	1400	1500	17,562.90
Total	**-**	**-**	**1,213,453.48**

Table S6. Results for scenario 2, all 35 nodes are suitable locations for detention tanks.

Node ID	Max. Depth (m)	Volume (m^3)	Cost (€)
N01	1.40	100	24,828.79
N02	2.25	200	33,809.91
N03	2.25	0	0.00
N04	1.72	300	35,380.99
N05	2.06	250	35,357.73
N06	1.83	600	47,077.61
N07	2.45	100	28,297.18
N08	2.49	0	0.00
N09	1.32	150	26,826.63
N10	2.19	400	42,959.93
N11	3.35	400	51,245.61
N12	2.43	0	0.00
N13	2.74	100	29,155.07
N14	1.97	250	34,830.14
N15	1.38	0	0.00
N16	2.29	0	0.00
N17	2.10	550	48,086.08
N18	2.81	1250	81,134.49
N19	1.38	0	0.00
N20	1.25	0	0.00
N21	1.57	0	0.00
N22	1.90	300	36,614.59
N23	2.61	650	56,933.33
N24	2.60	0	0.00
N25	2.26	0	0.00
N26	1.48	0	0.00
N27	2.42	0	0.00
N28	2.63	0	0.00
N29	1.53	150	27,824.11
N30	1.28	0	0.00
N31	3.49	0	0.00
N32	0.91	1350	49,361.14

N33	1.94	150	29,643.16
N34	3.07	0	0.00
N35	3.07	0	0.00
Total	**-**	**-**	**719,366.52**

Table S7. Results for scenario 3, all 35 conduits are suitable to change their diameters and all 35 nodes are suitable locations for detention tanks.

Link ID	Original Diameter (mm)	New Diameter (mm)	Cost (€)	Node ID	Max. Depth (m)	Volume (m^3)	Cost (€)
P01	400	400	0.00	N01	1.40	0	0.00
P02	400	300	2814.40	N02	2.25	250	36,445.79
P03	400	400	0.00	N03	2.25	0	0.00
P04	550	550	0.00	N04	1.72	0	0.00
P05	400	400	0.00	N05	2.06	300	37,677.14
P06	600	300	6304.34	N06	1.83	1450	70,434.18
P07	400	400	0.00	N07	2.45	0	0.00
P08	750	600	11,224.31	N08	2.49	0	0.00
P09	400	400	0.00	N09	1.32	0	0.00
P10	750	750	0.00	N10	2.19	1550	79,723.98
P11	300	300	0.00	N11	3.35	0	0.00
P12	900	350	7441.28	N12	2.43	0	0.00
P13	400	400	0.00	N13	2.74	0	0.00
P14	1100	1100	0.00	N14	1.97	0	0.00
P15	500	500	0.00	N15	1.38	500	39,218.34
P16	1200	1200	0.00	N16	2.29	0	0.00
P17	400	400	0.00	N17	2.10	0	0.00
P18	1300	1300	0.00	N18	2.81	0	0.00
P19	400	400	0.00	N19	1.38	0	0.00
P20	450	450	0.00	N20	1.25	0	0.00
P21	450	400	3923.45	N21	1.57	0	0.00
P22	300	300	0.00	N22	1.90	0	0.00
P23	600	600	0.00	N23	2.61	0	0.00
P24	560	560	0.00	N24	2.60	0	0.00
P25	600	300	2653.25	N25	2.26	1300	74,096.64
P26	400	450	5512.77	N26	1.48	0	0.00
P27	550	500	14,698.70	N27	2.42	0	0.00
P28	750	750	0.00	N28	2.63	1000	70,125.66
P29	500	500	0.00	N29	1.53	0	0.00
P30	600	300	6,118.75	N30	1.28	950	49,146.22
P31	850	850	0.00	N31	3.49	0	0.00
P32	400	400	0.00	N32	0.91	0	0.00
P33	1000	1000	0.00	N33	1.94	0	0.00
P34	1400	1400	0.00	N34	3.07	0	0.00
P35	1400	1400	0.00	N35	3.07	0	0.00
Total	**-**	**-**	**60,691.26**	**-**	**-**	**-**	**456,867.95**