Supplementary Material

1. Full optimization results

The optimization results of the 10 runs (each with a different starting random seed) for each optimization method and decision variable set formulation are shown in Table S1. In addition, the number of generations and evaluations required for all runs are listed in Table S2.

Table S1. Full optimization results obtained from three optimization methods and four decision variable set formulations.

	Run No.	Formulation 1: 126DVs		Formulation 2: 4DVs		Formulation 3: 10DVs		Formulation 4: 34DVs	
		Ave RMSE (m)	Run Time (hr)	Ave RMSE (m)	Run Time (hr)	Ave RMSE (m)	Run Time (hr)	Ave RMSE (m)	Run Time (hr)
SLSQP	1	1.334	4.48	1.709	0.02	1.469	0.08	1.407	0.57
	2	1.330	3.90	1.709	0.02	1.468	0.08	1.410	0.50
	3	1.333	3.82	1.709	0.02	1.468	0.08	1.410	0.57
	4	1.334	3.61	1.709	0.02	1.469	0.08	1.407	0.75
	5	1.333	4.93	1.709	0.01	1.468	0.10	1.409	0.57
	6	1.333	4.12	1.709	0.02	1.468	0.06	1.414	0.40
	7	1.332	3.86	1.709	0.01	1.469	0.08	1.410	0.40
	8	1.332	4.35	1.709	0.02	1.468	0.06	1.411	0.35
	9	1.332	4.68	1.709	0.02	1.468	0.09	1.407	0.44
	10	1.332	4.31	1.709	0.01	1.469	0.10	1.409	0.50
	Avg.	**1.333**	**4.21**	**1.709**	**0.02**	**1.468**	**0.08**	**1.409**	**0.51**
GA	1	1.323	44.69	1.709	0.77	1.468	4.56	1.400	23.70
	2	1.322	47.62	1.709	0.72	1.468	5.10	1.400	19.76
	3	1.322	45.81	1.709	0.68	1.468	4.44	1.405	20.38
	4	1.322	40.25	1.709	0.60	1.468	3.75	1.400	23.29
	5	1.320	69.43	1.709	0.64	1.468	4.60	1.400	23.15
	6	1.323	46.99	1.709	0.57	1.468	3.70	1.400	18.20
	7	1.321	58.08	1.709	0.49	1.468	4.16	1.400	23.05
	8	1.322	36.96	1.709	0.83	1.468	3.58	1.400	16.07
	9	1.320	67.86	1.709	0.70	1.468	4.75	1.400	22.89
	10	1.324	39.59	1.709	0.79	1.468	5.16	1.400	22.81
	Avg.	**1.322**	**49.73**	**1.709**	**0.68**	**1.468**	**4.38**	**1.400**	**21.33**
DE	1	1.382	15.67	1.709	0.87	1.468	2.00	1.401	10.33
	2	1.380	15.44	1.709	0.88	1.468	2.41	1.405	10.37
	3	1.389	15.97	1.709	0.88	1.468	2.35	1.407	10.77
	4	1.383	16.01	1.709	0.88	1.468	2.51	1.405	10.33
	5	1.390	15.80	1.709	0.78	1.468	2.52	1.410	10.24
	6	1.381	15.59	1.709	0.90	1.468	2.21	1.404	10.48
	7	1.372	16.41	1.709	0.93	1.468	2.57	1.403	10.67
	8	1.392	15.26	1.709	0.88	1.468	2.15	1.416	10.57
	9	1.380	15.72	1.709	1.03	1.468	2.62	1.403	10.36
	10	1.388	15.70	1.709	0.82	1.468	2.44	1.416	10.56
	Avg.	**1.384**	**15.76**	**1.709**	**0.88**	**1.468**	**2.38**	**1.407**	**10.47**

Table S2. The number of generations and evaluations required for all runs.

	Run No.	Formulation 1: 126DVs		Formulation 2: 4DVs		Formulation 3: 10DVs		Formulation 4: 34DVs	
		No. of generations	No. of evaluations	No. of generations	No. of evaluations	No. of generations	No. of evaluations	No. of generations	No. of evaluations
SLSQP	1	346	43608	31	173	64	725	159	5565
	2	290	36473	32	177	66	728	134	4725
	3	270	33940	28	156	63	712	151	5302
	4	271	34062	25	142	70	779	203	7119
	5	370	46534	20	105	88	988	148	5222
	6	306	38651	28	148	51	568	111	3877
	7	297	37500	24	129	71	797	112	3906
	8	328	41308	27	150	54	591	98	3420
	9	358	45003	31	169	76	861	123	4309
	10	339	42716	21	120	85	947	137	4801
	Avg.	**318**	**39980**	**27**	**147**	**69**	**770**	**138**	**4825**
GA	1	1013	405200	136	6800	414	41400	638	223300
	2	1094	437600	138	6900	465	46500	527	184450
	3	1088	435200	132	6600	403	40300	518	181300
	4	949	379600	110	5500	363	36300	593	207550
	5	1625	650000	119	5950	430	43000	618	216300
	6	1083	433200	104	5200	330	33000	494	172900
	7	1334	533600	92	4600	393	39300	602	210700
	8	861	344400	154	7700	336	33600	421	147350
	9	1566	626400	128	6400	443	44300	605	211750
	10	937	374800	143	7150	478	47800	608	212800
	Avg.	**1155**	**462000**	**126**	**6280**	**406**	**40550**	**562**	**196840**
DE	1	250	100000	85	8500	185	18500	295	100300
	2	250	100000	85	8500	230	23000	295	100300
	3	250	100000	85	8500	225	22500	295	100300
	4	250	100000	85	8500	240	24000	295	100300
	5	250	100000	85	8500	235	23500	295	100300
	6	250	100000	85	8500	205	20500	295	100300
	7	250	100000	85	8500	240	24000	295	100300
	8	250	100000	85	8500	200	20000	295	100300
	9	250	100000	85	8500	245	24500	295	100300
	10	250	100000	85	8500	235	23500	295	100300
	Avg.	**250**	**100000**	**85**	**8500**	**224**	**22400**	**295**	**100300**

2. Full evaluation results over the calibration period

The minimum average of the five RMSE values from the five pressure sensor locations is calculated to be 1.709 m. The breakdown of the average measured and modeled values, percentages, as well as the individual RMSE value at each monitoring site, is summarized in Table S3.

The field-observed HGL and flows versus the model-predicted values at each pressure monitoring site are shown in Figure S1 below. In general, a good match between the modeled and the observed values of each site has been achieved. Slight differences evident at some time steps can be caused by anomalies that occurred during the measurement process of pressures and instantaneous flows of individual outlets.

Table S3. Observed and simulated pressure data over the calibration period at each monitoring site.

Pressure monitoring sites							
Pressure monitoring site	**Average observed HGL (m)**	**Average modeled HGL (m)**	**Average observed pressure (m)**	**Average modeled pressure (m)**	**Average difference (m)**	**Percentage difference in pressures**	**RMSE (m)**
RTU1	141.36	141.50	70.62	70.76	-0.13	-0.19%	0.340
RTU2	138.57	137.13	69.54	68.10	1.43	2.06%	1.739
RTU3	131.95	133.30	70.04	71.39	-1.35	-1.93%	1.977
RTU4	135.66	135.15	72.92	72.41	0.52	0.71%	2.515
RTU5	131.72	131.80	62.10	62.18	-0.07	-0.12%	1.972
						Avg.	**1.709**
Flow monitoring site							
Flow monitoring site	**Average observed flow (L/s)**		**Average modeled flow (L/s)**		**Average difference (L/s)**	**Percentage difference**	**RMSE (L/s)**
Sys_Flow	2528		2501		27	1.06%	53

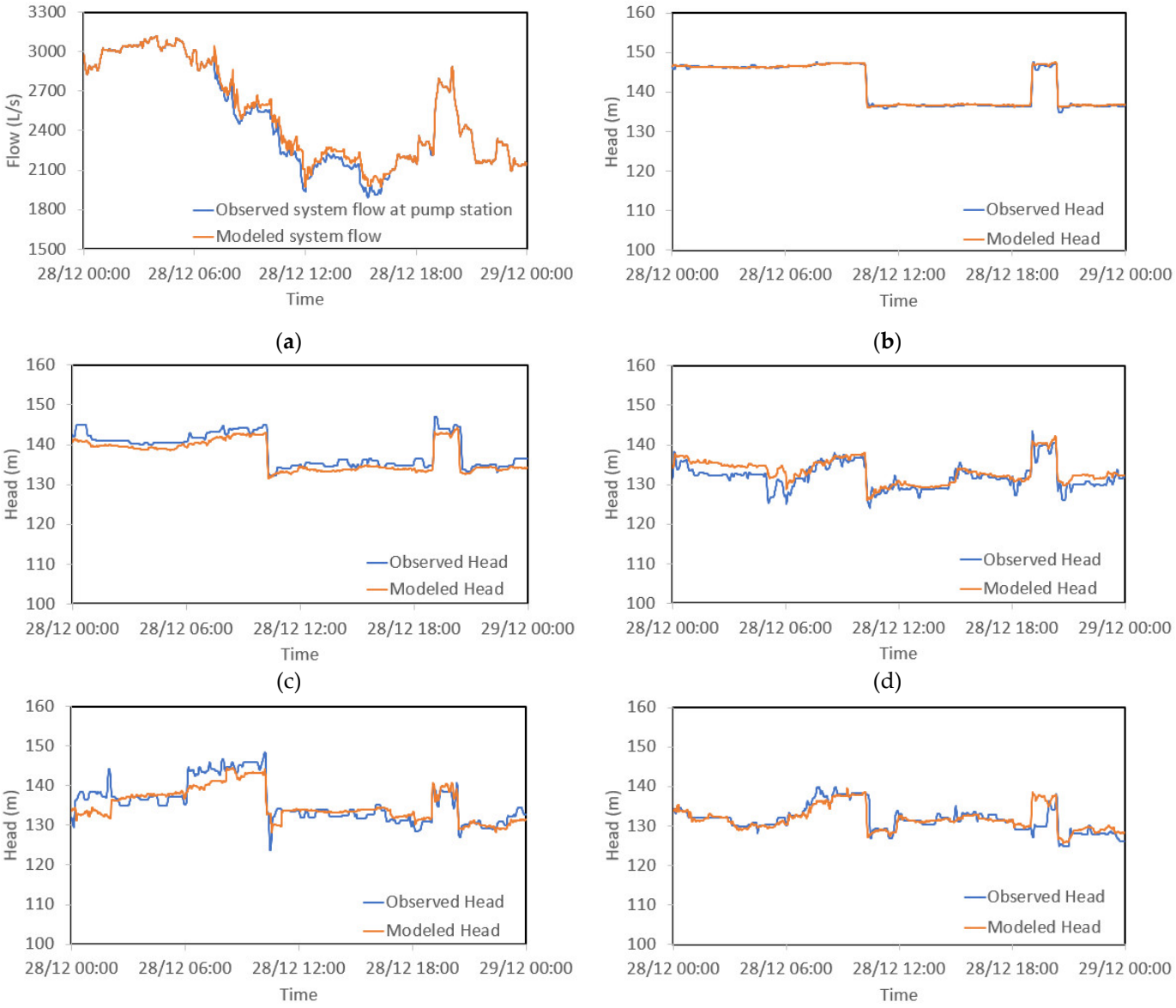

Figure S1. (a) Comparison of the observed and modeled system total flow during the calibration period; (b) to (f): Comparison of the observed and modeled HGL at RTU1 to RTU5 during the calibration period.