Ecological instream flow requirements calculation of Pihe River by Montana methodology in Sichuan basin China

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With the rapid economic developments in China, the future water resource developments should be sustainable and that a component of the natural flow of rivers must be reserved to ensure diverse ecological functions. In last 15 years, ecological instream flow requirements (EIFR) research in river is one of the main and hot fields for eco-hydrology scientists. In this paper, we summarized the water flow characteristics and also, the conception of the EIFR was also followed and applied in Pihe River watershed.

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Fig.1 Sketch map of Pihe River in Sichuan Province of China

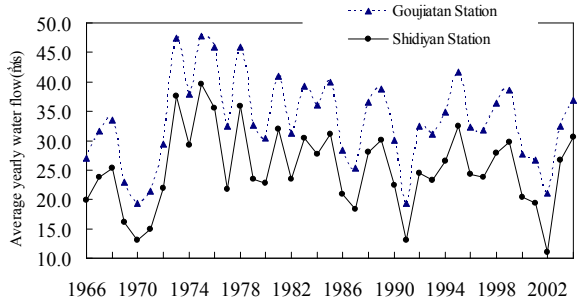

Fig.2 Average water flow in Shidiyan and Goujiatan sections in 1966-2004

The Tennant method was simple and conveniently to be applied. Once the relationships between the water flow and ecosystem was set up, the estimation needs relatively less data. The percent of water requirements in different water flow conditions are cited in Table 1.

Table1 Criterion of river flow to protect aquatic resource (percent of average river flow %)

Water flow	Average river flow in Oct~Mar	Average river flow in Apr~Sep
Maximum	200	200
Prime	60~100	60~100
Best	40	60
Better	30	50
Good	20	40
Middle	10	30
Minimum	10	10
Worst	0~10	0~10

Based on natural characters of Pihe River, the minimum and optimum water requirement of aquatic habitat for the river maintenance were counted. Evaporation water requirement of Pihe River was computed too, which was related with the width of water surface, the river length and evaporation depth. Considering the water quality goal, the diluting pollutant water requirement is taken into accounted.

Water requirements to protect aquatic resource

Table 2 The result of minimum and optimum water requirement of aquatic habitat from Goujiatan to estuary (m^3/s)

TY \ Month		1	2	3	4	5	6	7	8	9	10	11	12
P=50%	Min	1.17	0.78	0.51	0.82	4.34	3.64	3.73	8.55	8.32	6.27	1.16	0.70
(1968)	Opt	3.51	2.33	1.54	2.47	13.02	10.93	11.20	25.64	24.96	18.81	3.47	2.11
P=75%	Min	0.58	0.57	0.50	0.64	1.91	7.56	7.52	4.34	6.65	2.87	0.44	0.43
(1986)	Opt	1.73	1.70	1.50	1.92	5.72	22.69	22.56	13.02	19.96	8.62	1.31	1.30
P=90%	Min	0.43	0.43	0.43	0.52	1.12	6.53	6.29	4.65	5.93	2.68	0.67	0.67
(1987)	Opt	1.30	1.30	1.30	1.57	3.35	19.60	18.88	13.96	17.79	8.03	2.02	2.02

Evaporation water requirement in river

Table 3 Evaporating water requirement for river course from Goujiatan to estuary (m^3/s)

Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12
P=50% (1968)	0.027	0.018	0.012	0.019	0.099	0.083	0.085	0.194	0.189	0.143	0.026	0.016
P=75% (1986)	0.015	0.015	0.013	0.017	0.051	0.202	0.201	0.116	0.178	0.077	0.012	0.012
P=90% (1987)	0.013	0.013	0.013	0.016	0.033	0.196	0.188	0.139	0.178	0.080	0.020	0.020

Diluting water requirement in river

Table 4 Pollutant diluting water requirement for river course from Goujiatan section to estuary in dry season (m^3/s)

Index \ Month	Jan	Feb	Mar	Apr
NH_3-N (In 2003)	20.39	21.27	20.39	20.39
BOD_5 (In 2003)	3.16	3.73	3.16	3.16
NH_3-N (In 2004)	20.48	51.28	20.48	20.48
BOD_5 (In 2004)	14.08	3.35	14.08	14.08

For the multiple functions of water, it is difficult to define the EIFR quantity. The eco-environmental requirement water is overlapped with of water requirements to protect aquatic resource and dilute pollutants in same river reach. So, the EIFR is summation of the evaporation water requirement and the bigger one of the water requirements to protect aquatic resource and diluting water requirement. In this paper, we calculated the EIFR at the assurance rate of 50%, 75%, 90%, respectively. At different assurance rate, the minimum and optimum eco-environmental water requirements in twelve months of three typical years in lower reach of Goujiatan hydrological station are listed in Table 4.

Table 4 Minimum and optimum eco-environmental water requirements for river course from Goujiatan to estuary (m^3/s)

TY \ Month		1	2	3	4	5	6	7	8	9	10	11	12
P=50%	Min	20.47	20.46	20.45	20.46	20.54	20.52	20.53	20.63	20.63	20.58	20.47	20.46
(1968)	Opt	20.47	20.46	20.45	20.46	20.54	20.52	20.53	25.84	25.51	20.58	20.47	20.46
P=75%	Min	20.46	20.46	20.45	20.46	20.49	20.64	20.64	20.56	20.62	20.52	20.46	20.46
(1986)	Opt	20.46	20.46	20.45	20.46	20.49	22.89	22.76	20.56	20.62	20.52	20.45	20.45
P=90%	Min	20.45	20.45	20.45	20.46	20.47	20.64	20.63	20.58	20.62	20.52	20.45	20.45
(1987)	Opt	20.45	20.45	20.45	20.46	20.47	20.64	20.63	20.58	20.62	20.52	20.46	20.46

Note: TY was typical year; P was the assurance rate; Opt was the optimum water requirement and Min was minimum water requirement.

Conclusions

The EIFR of the river of 12 month were ultimately ascertained. Among them, that was 20.64m^3/s and the minimum eco-environmental water requirement of the river was 25.84m^3/s.

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