Yoshii-gawa

Map of River

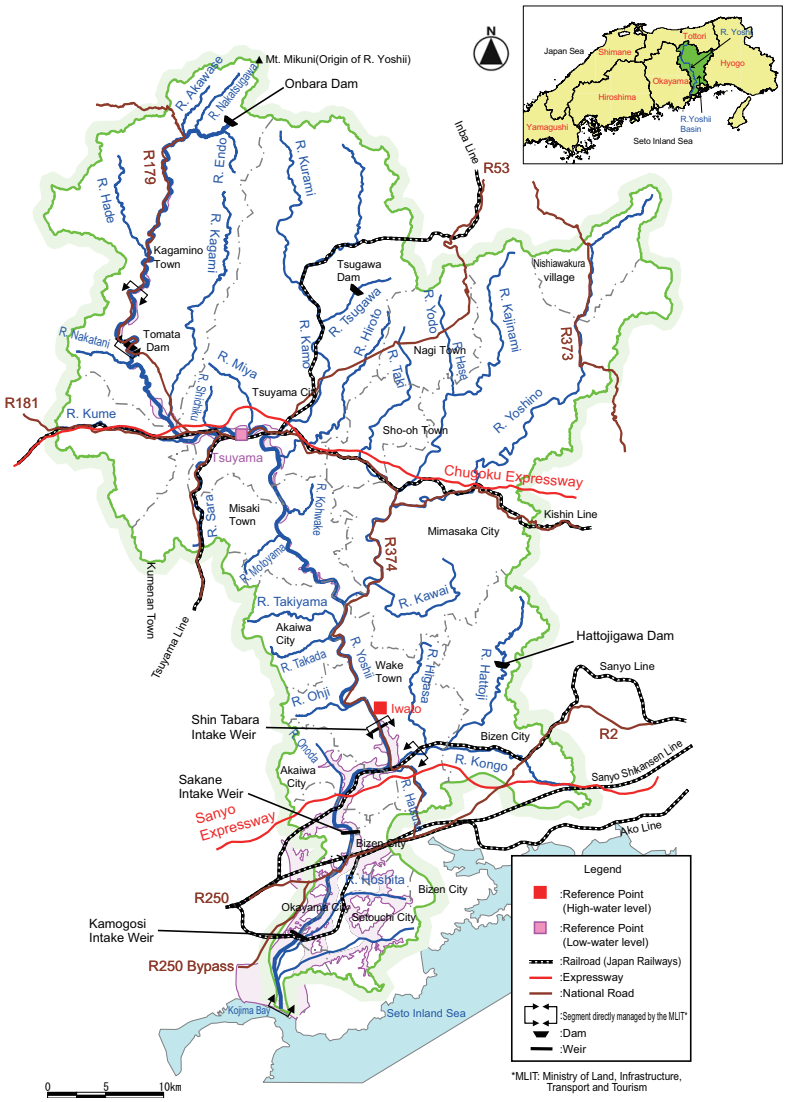


Table of Basic Data

Name: Yoshii-gawa		Serial No.:JAPAN-16
Location: Western Honshu, Japan	N34°36′ - 35°21′	E 133°49′ - 134°25′
Area: 2,110 km^2	Length of main stream: 133 km	
Origin: Mt. Mikuni	Highest point: Mt. Mikunigasen (1,247.7m)	
Outlet: Kojima Bay	Lowest point: River Mouth (0 m)	
Main geological features: Granite, andesite, mudstone, diorite-tuff, deposits, rhyolite, weathered granite		
Main tributaries: Kagami-gawa, Yoshino-gawa, Kamo-gawa, Kongo-gawa		
Main lakes: None		
Main reservoirs: Tomata Dam (84.10 ×10^6 m^3, 2005)		
Mean annual precipitation: 1480.5 mm (1971~2000) at Tsuyama		
Mean annual runoff: 61.44 m^3/s (1966 ~ 2003) at Miyasu		
Population: 294,000 (2000)	Main cities: Okayama, Tsuyama, Mimasaka	
Land use: Mountainous area (85%), cultivated area (10%), urban area (5%)		

1. General Description

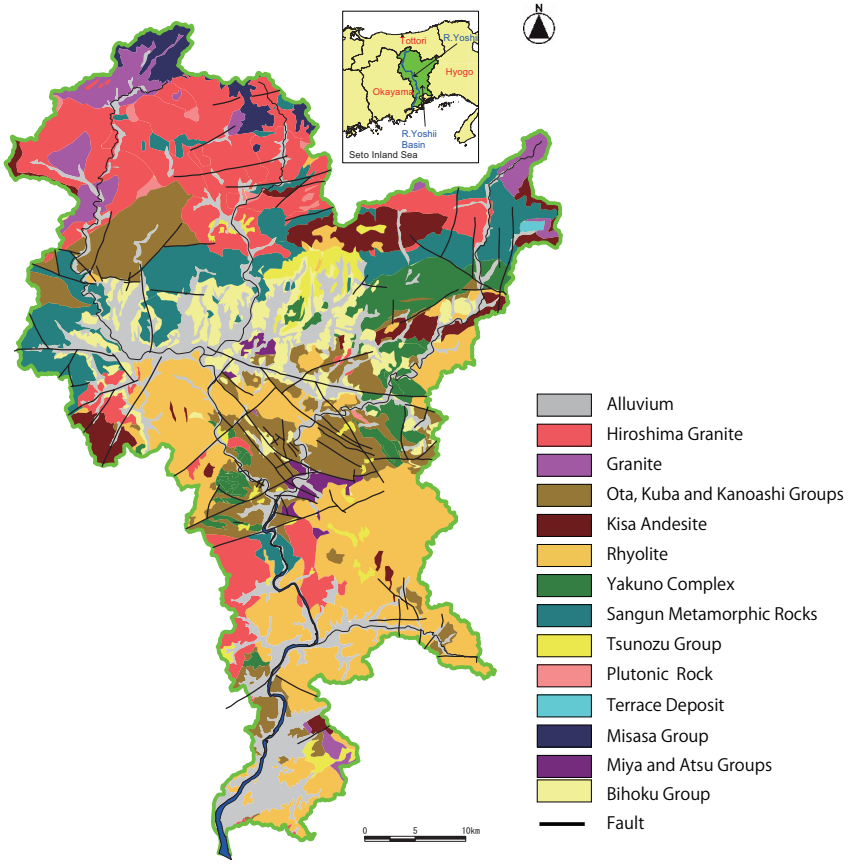
The Yoshii-gawa is one of the three large rivers in Okayama Prefecture (Okayama three rivers; Okayama Sansen), the Yoshii, the Asahi, and the Takahashi. The drainage area of the Yoshii-gawa covers 2,110 km^2, and the length of the main channel is 133 km. The drainage area of the Yoshii-gawa occupies the east part of the Okayama Prefecture, and includes six cities, six towns and one village.

The Yoshii-gawa originating at Mt. Mikunigasen (1,252m) in Kagamino Village runs through the Okutsu Valley, and flows east after entering in the Tsuyama Basin. After the confluence with the Kagami-gawa and that with the Kamo-gawa in Tsuyama City, it flows south through the Kibi Plateau. The Yoshino-gawa joins the Yoshii-gawa in Akaiwa City, and the Kongo-gawa in Wake Town, and then it flows south in the Okayama Plain to reach the eastern end of the Kojima Bay, Saidaiji in Okayama City.

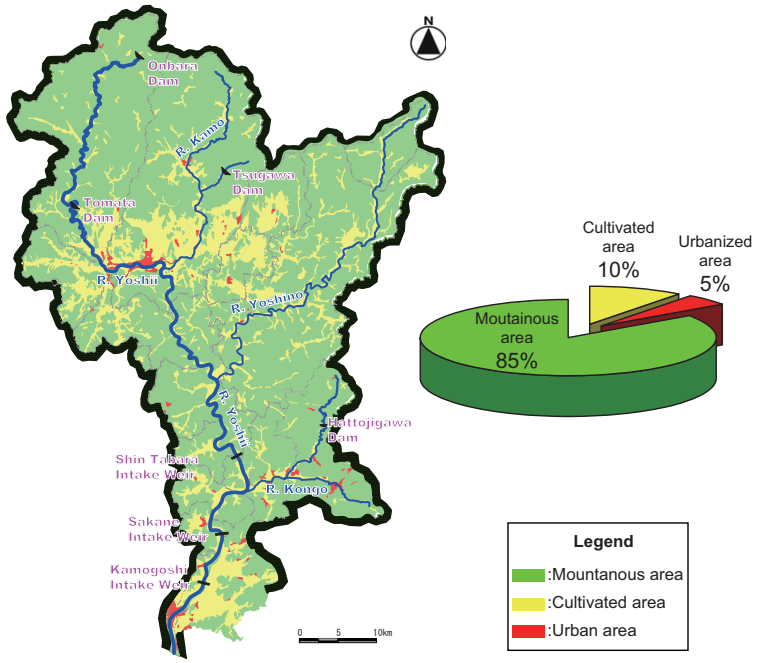
The soil of the upstream area is composed of granite and andesite in Cretaceous Period, and mudstone and diorite-tuff during Palaeozoic and Mesozoic Era. In the midstream, the soil is composed of deposits as gravels, sand and clay in Tertiary period and granite and rhyolite in Mesozoic including Palaeozoic rocks. In the downstream, weathered granite of the Quaternary deposits are found.

2. Geographical Information

2.1 Geological Map



2.2 Land Use Map

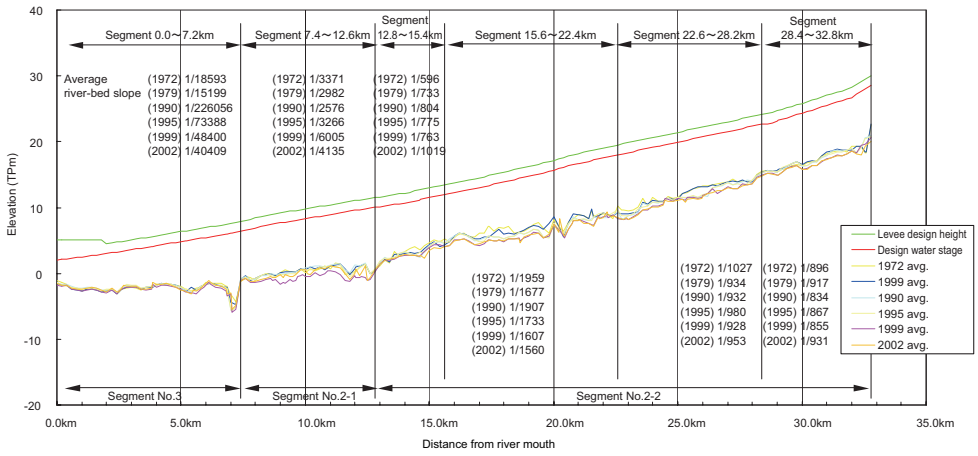


2.3 Characteristics of River and Main Tributaries

No.	Name of river	Length [km] Catchment area [km^2]	Highest peak [m] Lowest point [m]	Cities population (in 2005)	Land use [%]
1	Kamo-gawa	115.4 262.3	1196.6 70.0	Tsuyama 110,569	Mountainous: 85% Cultivated area: 10% Urbanized: 5%
2	Yoshino-gawa	334.5 603.5	1344.6 30.0	Mimasaka 32,479	
3	Kongo-gawa	65.0 161.1	538.6 13.5	Bizen 40,241	

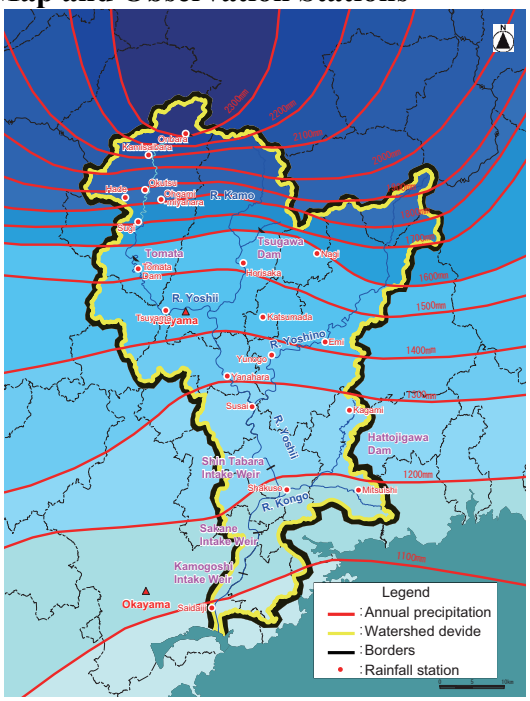
M: Mountainous area F: Flat area

2.4 Longitudinal Profiles



3. Climatological Information

3.1 Annual Isohyetal Map and Observation Stations



* Annual average during 1971 and 2000 according to the website of the Okayama Meteorological Observatory.

3.2 List of Meteorological Observation Stations [1)]

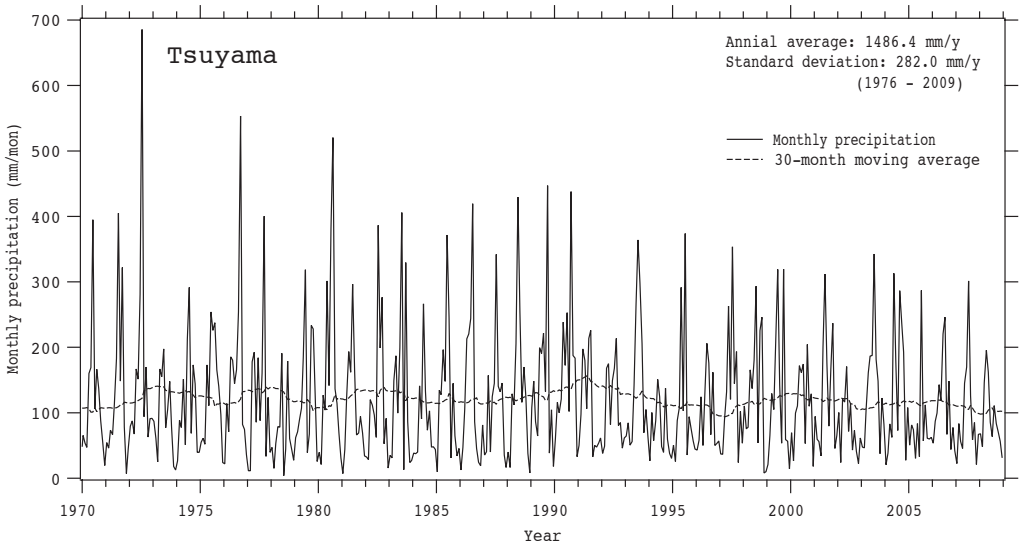
No.[2)]	Station	Elevation [m]	Location	Observation period	Mean annual precipitation [mm]	Observation items [3)]
66306	Wake	35	34°48′54″N 134°11′0″E	1974 -	1197.3 (1979 – 2000)	DS, P, T, W
66251	Akaiwa (Susai)	56	34°55′6″N 134°05′0″E	1974 -	1229.4 (1979 – 2000)	P
66186	Tsuyama	146	35°03′48″N 134°00′30″E	1943 -	1480.5 (1971– 2000)	DS, P, T, W
66127	Nagi	212	35°06′42″N 134°10′12″E	1977 -	1551.9 (1979 – 2000)	DS, P, T, W
66136	Imaoka (Furumachi)	207	35°05′54″N 134°19′30″E	1974 -	1681.9 (1979 – 2000)	DS, P, T, W
66056	Onbara	734	35°18′0″N 133°59′12″E	1981 -	2383.6 (1981– 2000)	P

1) 6 rainfall observation stations managed by Japan Meteorological Agency and 20 ones managed by Ministry of Land, Infrastructure and Transport are operated in the Yoshii-gawa basin. A Part of the stations is listed here.
2) Serial Number used by Japan Meteorological Agency.
3) DS: Duration of sunshine, P: Precipitation, T: Air temperature, W: Wind velocity and wind direction.

3.3 Monthly Climate Data (Observation station: Tsuyama)

Observation item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Period for the mean
Temperature [°C]	2.1	2.6	6.1	12	16.7	20.9	24.8	25.6	21.3	14.9	9	4	13.4	1971 – 2000
Precipitation [mm]	45.8	61.3	101.1	131.4	155.9	210.9	250.3	121.7	208.6	90.5	65.9	37	1480.5	1971 – 2000
Solar radiation [MJ/m^2/d]	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Duration of sunshine [hr]	119.9	120.7	155.3	182.8	196.1	152.1	157.4	182.2	141.4	152.5	116.4	115	1791.7	119.9

3.4 Long-term Variation of Monthly Precipitation



4. Hydrological Information

4.1 Map of Streamflow Observation Stations

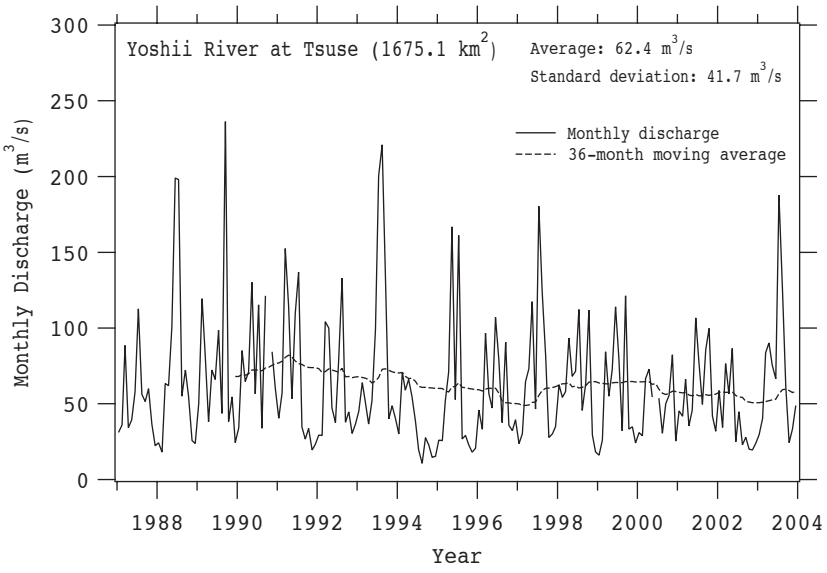
4.2 List of Hydrological Observation Stations [1)]

No.[2)]	Station	Location	Catchment area (A) [km^2]	Observation period	Observation items [3)] (frequency)
30713128770 8030	Hisagi	34°57′11″N 134°3′42″E	978.8	1959 – 2003 (1986, 1988, 1989, 1996 missing)	HQ (hourly)
30713128770 8120	Yunogo	34°59′09″N 134°08′12″E	490.1	1960 – 2003 (1966 missing)	HQ (hourly)
30713128770 8050	Tsuse	34°52′17″N 134°06′25″E	1675.1	1986 – 2003 (1986, 1990, 2000 missing)	HQ (hourly)
30713128770 8090	Miyasu	34°42′29″N 134°05′18″E	1996.1	1966 – 2003	HQ (hourly)

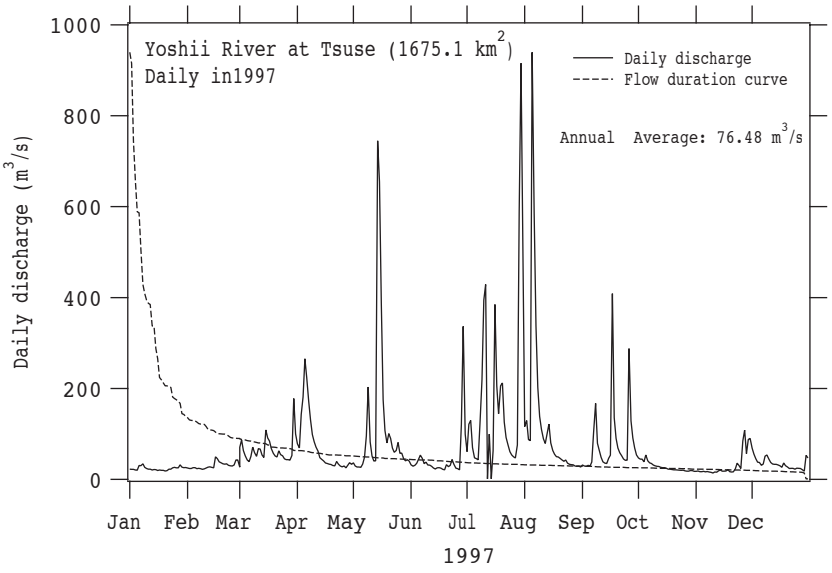
No.	$\overline{Q}$ [4)] [m^3/s]	Q max [5)] [m^3/s]	$\overline{Q}$ max [6)] [m^3/s]	$\overline{Q}$ min [7)] [m^3/s]	$\overline{Q}$ / A [m^3/s/100km^2]	Q max / A [m^3/s/100km^2]	Period of statistics
30713128 7708030	41.16	3842.46	1316.10	7.44	4.21	392.57	1959 – 2003 (1986, 1988, 1989, 1996 missing)
30713128 7708120	17.77	2906.40	993.48	1.45	3.63	593.02	1960 – 2003 (1966 missing)
30713128 7708050	61.92	6987.25	2022.49	12.25	3.70	417.12	1986 – 2003 (1986, 1990, 2000 missing)
30713128 7708090	61.44	7235.34	2217.74	3.91	3.08	362.47	1966 – 2003

1) A part of water stage stations and discharge stations is listed here.
2) Serial Number used by Ministry of Land, Infrastructure and Transport.
3) H: water level, Q: discharge, Q is obtained from rating curve.
4) $\overline{Q}$: Mean annual discharge.
5) Q max : Maximum discharge.
6) $\overline{Q}$ max: Mean maximum discharge.
7) $\overline{Q}$ min: Mean minimum discharge.

4.3 Long-term Variation of Monthly Discharge



4.4 Annual Pattern of Discharge



4.5 Unique Hydrological Features

The precipitation increases from downstream to upstream in the basin. The downstream part is located in the region with the least precipitation where the annual precipitation is 1,200mm and precipitation concentrates in summer season. On the other hand, annual precipitation in the upstream part is about 2,000 mm because of large amount of precipitation throughout the year including winter season. The large amount of precipitation in the upstream has supplied irrigation water sufficient for extensive farmlands that has been reclaimed in the downstream area since late 1600's, although these farmlands are located in low-precipitation area.

While the water resources development for farmlands was started from early times, sufficient river improvement for preventing flood disasters was delayed until 1940's due to damage by the World War 2nd. The downstream area frequently suffered from flood disasters. Approximately 70 large floods are recorded in the Yoshii-gawa Basin during the recent 400 years. With the flood disaster due to the typhoon No. 16th of 1945 (Typhoon "Makurazaki") as a turning point, embankment improvement project was started, and river improvement work is being continued. In 2005, the Tomata Dam was started its operation for flood control.

4.6 Annual Maximum and Minimum Discharges

Station: Tsuse

Year	Maximum [1]		Minimum [2]		Year	Maximum [1]		Minimum [2]	
	Date	[m^3/s]	Date	[m^3/s]		Date	[m^3/s]	Date	[m^3/s]
1983	-*	-*		-*	1995	6.26	3539.94	10.23	11.97
1984	6.26	2481.62	6.7	12.93	1996	6.28	-*	6.7	14.04
1985	6.28	2283.99	12.17	6.52	1997	7.11	2984.53	11.15	11.11
1986	7.11	1905.82	11.20	8.79	1998	10.17	6987.25	12.22	14.46
1987	10.17	1019.51	12.19	9.33	1999	6.3	2728.10	1.15	11.65
1988	6.3	1386.68	2.17	13.97	2000	7.13	-*	-*	-*
1989	7.13	1513.36	12.20	13.19	2001	9.19	2003.73	5.21	10.17
1990	9.19	4872.27	9.11	13.79	2002	7.5	499.18	8.7	13.56
1991	7.5	859.38	12.16	13.33	2003	8.9	1739.51	10.31	14.20
1992	8.9	1519.53	1.30	12.93	2004	7.3	5059.50	12.2	17.39
1993	7.3	2168.26	6.13	14.82	2005	9.30	620.46	5.26	21.51
1994	9.30	606.76	8.19	4.96	2006	6.26	3840.35	10.30	14.07

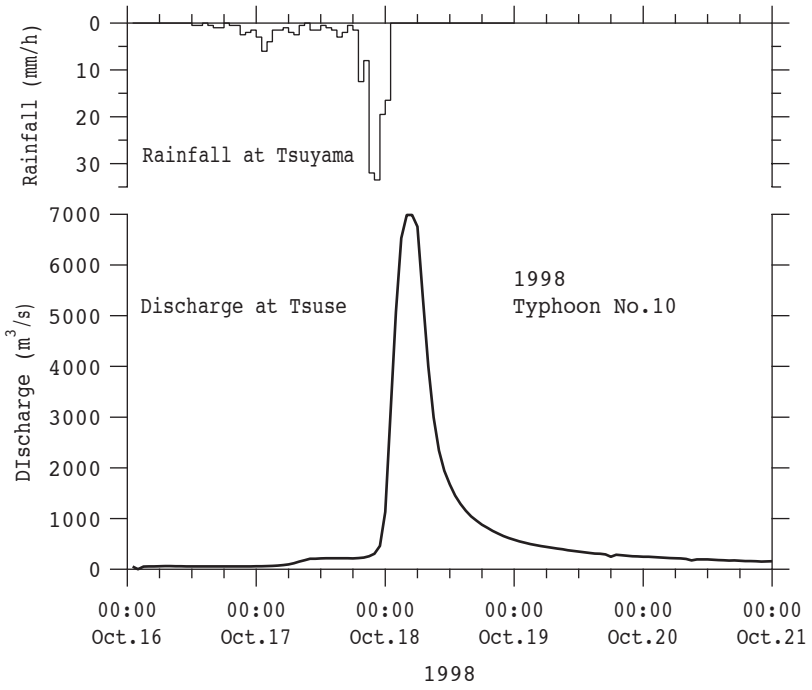
1), 2) Instantaneous observation by recording chart
*: missing data

Station: Tsuyama

Year	Maximum [1]		Minimum [2]		Year	Maximum [1]		Minimum [2]	
	Date	[m^3/s]	Date	[m^3/s]		Date	[m^3/s]	Date	[m^3/s]
1979	10.19	2,255	8.2	22.64	1994	9.30	263	7.23	14.53
1980	-*	-*	-*	-*	1995	7.3	730	9.19	23.22
1981	6.27	438	8.25	22.66	1996	9.17	184	5.26	21.44
1982	-*	-*	-*	-*	1997	8.5	948	6.27	27.17
1983	-*	-*	-*	-*	1998	10.18	2,964	9.14	27.32
1984	-*	-*	-*	-*	1999	6.29	561	5.23	22.54
1985	6.28	510	6.2	30.22	2000	11.2	417	9.7	20.64
1986	7.13	512	11.20	24.07	2001	6.19	594	5.20	24.1
1987	7.17	353	10.14	19.61	2002	9.8	173	10.20	15.7
1988	6.3	382	2.22	23.35	2003	7.13	375	1.16	27.22
1989	9.19	427	6.7	25.44	2004	9.29	640	2.20	26.04
1990	9.19	760	8.2	27.36	2005	9.7	227	6.15	43.58
1993	7.27	736	6.8	34.6	2006	7.19	1,119	10.30	24.25

1), 2) Instantaneous observation by recording chart
*: missing data

4.7 Hyetograph and Hydrograph of Major Flood



5. Water Resources

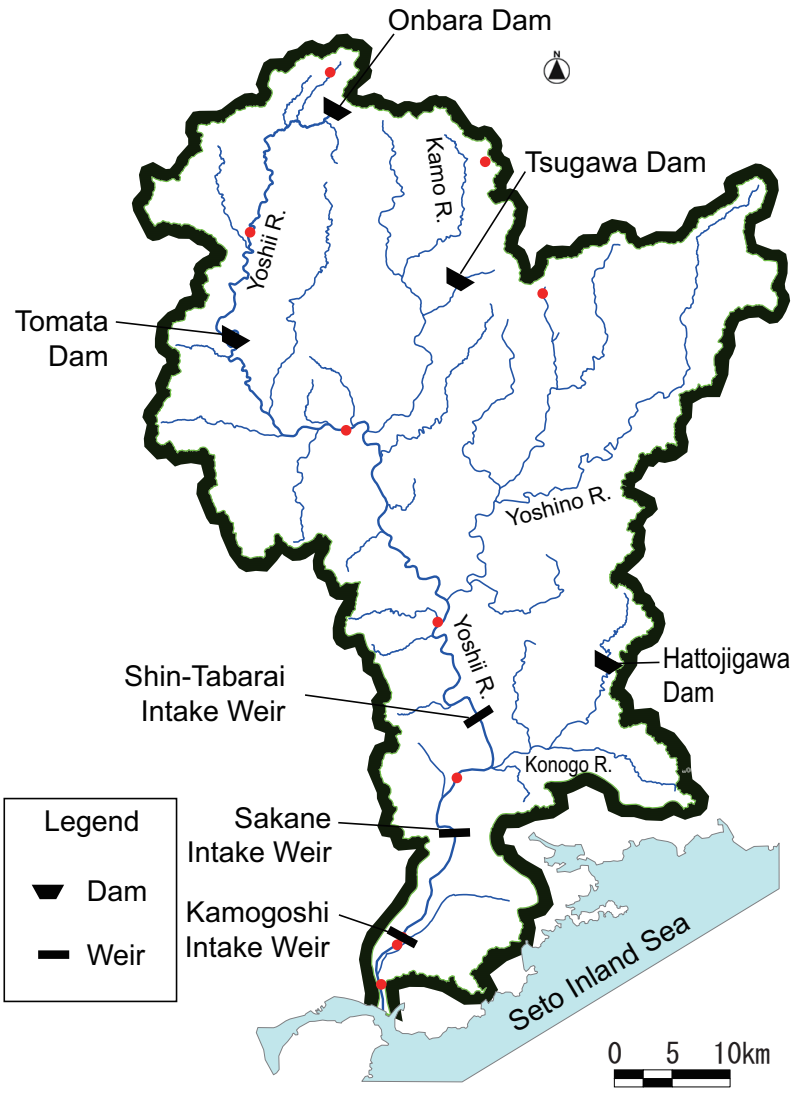
5.1 General Description

Principal water utilization in the Yoshii-gawa System has been for agricultural irrigation since old days. Especially, water resources in the Yoshii-gawa Basin is crucial for irrigation water for farms in reclaimed lands that has been developed since around early 1600's (the Edo Period).

Presently, around 90 % of total water utilization (except for hydropower) in the basin is for agricultural irrigation, and the other for domestic and industrial water use. Most of the water demands is supplied by the Shin-Tabara Intake Weir (1987) and the Sakane Intake Weir (1979). The Sakane Intake Weir also provides water to the outside area of the Yoshii-gawa Basin. For hydropower generation, the Okutsu Second Hydroelectric Power Station established in 2002 is supplying electricity up to 15,200kW.

In addition, operation of the Tomata Dam was started in 2005 to supply water to new domestic and industrial consumers. The Tomata Hydroelectric Power Station established with the dam is also supplying electricity up to 4,600 kW.

5.2 Map of Water Resource Systems



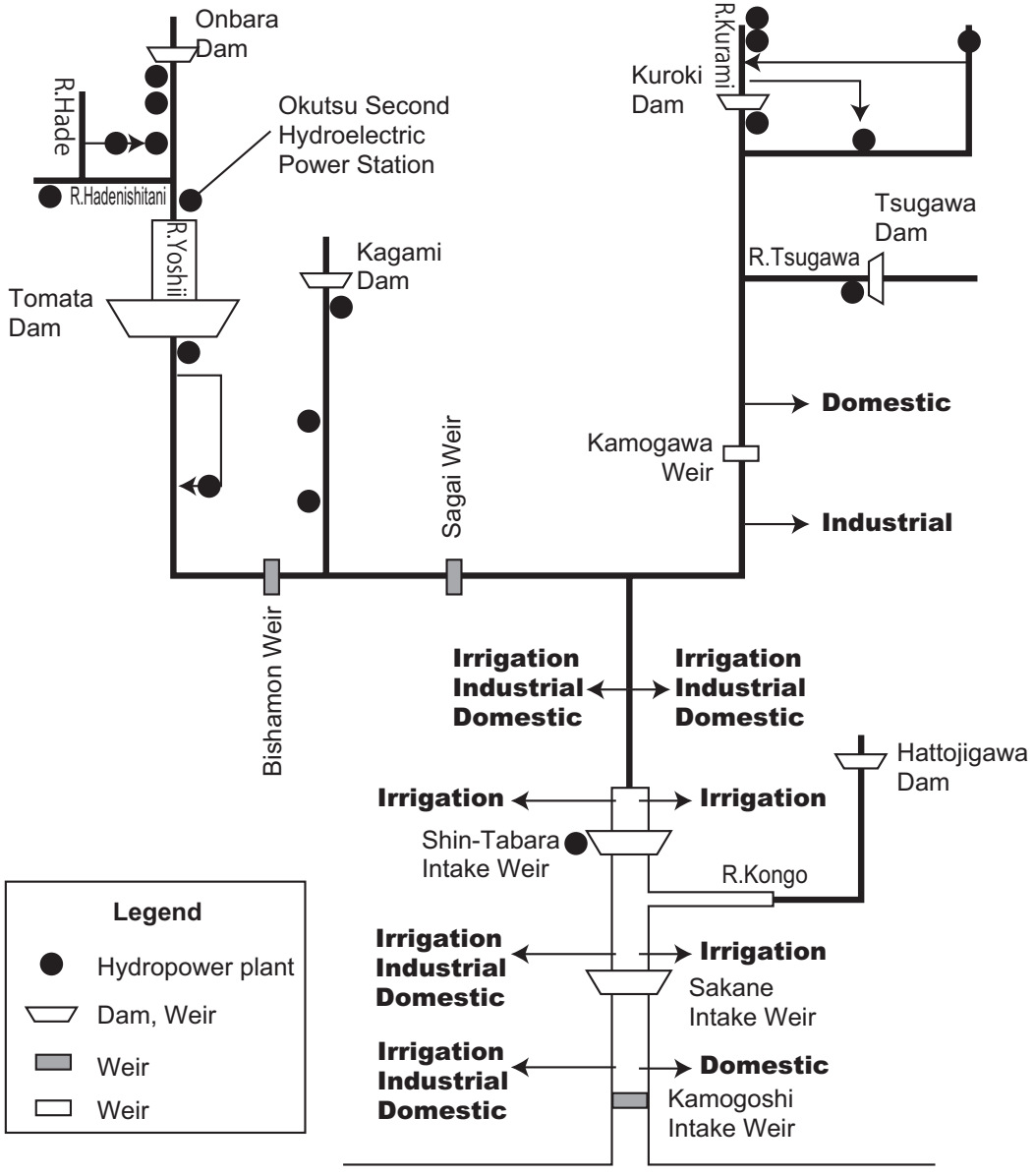
5.3 List of Major Water Resources Facilities

Major Reservoirs

Name of river	Name of dam (reservoir)	Catchment area [km^2]	Gross capacity [10^6m^3]	Effective capacity [10^6m^3]	Purpose [1)]	Year of completion
Yoshii	Tomata (Okutsu)	217.4	84.10	78.10	A, F, I, P, W	2005
Tsugawa	Tsugawa	17.8	5.90	5.45	F, N, P, W	1996
Hattoji (Kongo)	Hattojigawa	35.2	5.70	4.64	F, W	1989
Onbara	Onbara	24.1	1.853	1.752		1928

1) A: Agricultural use F: Flood control I: Industrial use N: Maintenance of normal flows
P: Hydro-power W: Municipal water supply

Major Water Transfer



5.4 Major Floods and Droughts

Major Floods

Date*	Peak discharge [m^3/s]**	Rainfall [mm], Duration	Meteorological cause	Dead and missing	Major damages (Districts affected)
1934. 9.21	3,900	174, 2 days	Typhoon (Muroto Typhoon)	NA	House suffered: 8,092
1945. 9.18	7,600	226, 2 days	Typhoon (Makurazaki Typhoon)	92	House suffered: 14,798
1963. 7.11	5,600	162, 2 days	Low pressure front	2	House washed away: 40 House inundated: 4,876
1965. 7.11	4,000	171, 2 days	Low pressure front	5	House suffered: 4,126
1972. 7.9	5,000	272, 2 days	Low pressure front	3	House totally destroyed and washed away: 13 House inundated: 3,049
1976. 9.10	5,200	256, 2 days	Typhoon No. 17	6	House suffered: 13,759 (All over Okayama Prefecture)
1979. 10.19	4,800	206, 2 days	Typhoon No. 19	2	House destroyed: 101 House inundated: 1,312
1990 9.19	5,100	262, 2 days	Typhoon No. 19	NA	House destroyed and/or washed away: 5 House inundated: 6,185
1998 10.18	8,000	174, 2days	Typhoon No. 10	NA	House destroyed and/or washed away: 14 House inundated: 5,890
2004 9.29	5,400	155, 2 days	Typhoon No. 21	NA	House inundated: 823
2006. 7.19	4,200	168, 2 days	Low pressure front	NA	House inundated: 5

Note: * Peak discharge was observed on this Date.
** Discharge is observed at Iwato.

Major Droughts

Year	Water restriction period Month/Day		No. of days with restriction	Water restriction ratio		
				Tap water	Irrigation water	Industrial water
1978		8/29 - ?			20 %	
1982	1st 2nd	7/1 – 7/3 7/3 – 7/19	3 17	10 % 20 %		20 % 20 %
1994	1st 2nd 3rd 4th	7/15 - 7/19 7/19 - 7/22 7/22 - 8/16 8/16 - 9/30	5 4 25 46	7 % 7 % 7 % 30 %	 50 % 70 % 70 %	 20 % 20 % 30 %
2002		Aug.	11		50%	20 %
2005	1st 2nd	6/17 7/1	15 1		25 % 30 %	

5.5 River Water Quality

River Water Quality [1] at Eian-bashi [2] in 2003

Date	Jan. 08	Jan. 14	Jan. 14	Jan. 15	Jan. 15	Feb. 04	Mar. 11	Apr. 23	Apr. 23	May. 20	May. 20	Jun. 17
Time	8:10	12:50	18:30	0:10	5:50	7:00	11:15	11:00	14:40	8:40	13:00	8:45
pH	7.7	8	8.2	7.9	7.7	7.9	7	7.6	7.5	7.3	7.5	7.5
BOD [mg/l]	1.6	1.6	4.3	2.9	2.2	0.8	<0.5	0.7	1.5	2.1	0.6	2
COD_{Mn} [mg/l]	2.3	2.7	5	4.7	3.5	2.1	2.2	4.1	4.2	3.3	2.3	3.2
SS [mg/l]	3	3	3	9	4	3	3	5	5	5	3	7
Discharge[3] [m^3/s]	27.58	25.70	25.70	12.56	12.56	44.62	65.18	50.08	50.08	45.71	45.71	60.82

Date	Jun. 17	Jun. 17	Jun. 18	Jul. 16	Jul. 16	Aug. 21	Aug. 21	Sep. 16	Sep. 16	Sep. 16	Sep. 17	Oct. 21
Time	14:10	22:45	4:10	9:00	12:00	9:20	16:00	8:20	16:20	22:20	4:05	8:45
pH	7.5	7.4	7.4	7.1	6.9	7	7.1	7.6	8	7.9	8.1	7.5
BOD [mg/l]	2.1	1.2	1	0.9	<0.5	1.2	2.3	2.1	2.5	2	1.7	1.3
COD_{Mn} [mg/l]	3.2	3.2	3.5	2.9	2.5	3.6	3.8	3.6	3.6	3	3.2	3.4
SS [mg/l]	6	5	8	6	6	11	5	5	3	4	5	4
Discharge[3] [m^3/s]	60.82	60.82	43.04	129.90	129.90	115.12	115.12	23.40	23.40	23.40	22.25	18.64

Date	Oct. 21	Nov. 18	Nov. 18
Time	13:00	10:00	15:00
pH	7.7	7.5	7.6
BOD [mg/l]	1.8	1.3	1.8
COD_{Mn} [mg/l]	3.6	3	3.3
SS [mg/l]	5	4	4
Discharge[3] [m^3/s]	18.64	10.54	10.54

1) Observed once a month on a dry day normally several days after rainfall.
2) Located near Okayama City ?? km upstream from the river mouth.
3) Discharge observed at Miyasu on the water quality observation date.

6. Socio-cultural Characteristics

The Yoshii-gawa Basin has been a base for social, economical and cultural activities in the eastern part of the Okayama Prefecture.

The downstream area of the Yoshii-gawa Basin has a long development history of around 1,300 years (since 700's, Nara Period). Active transport by riverboats called as Takase-bune along the Yoshii-gawa had brought cultural prosperity as well as economic prosperity of this area since the beginning of the development history. In the early Edo Period (1,600's), some public works were undertaken in this area. New rice-producing regions were reclaimed by drainage around the Kojima Bay, and then rice production was increased to improve finance of the local government. Riverbed excavation was also done for securing water resources for newly reclaimed rice farms and for improving riverine transportation. Since Meiji Period, the downstream area has been developed as an industrial area, and has become an important hub of both railway and highway transportations. As a cultural activity, Saidai-ji Eyo Hadaka Matsuri (Naked Festival at Saidai-ji Temple) is well known worldwide.

The Tsuyama City located in the midstream area of the Yoshii-gawa Basin has been the center of the north part of the Okayama Prefecture since Nara Period (700's). Exchange between Tsuyama and Okayama Cities by riverine transport was active until opening of a railway. Recently, the Tsuyama City invited some industies, and is now being developed as an inland industrial city. It is now known as the second largest local city of stainless industry.

In the upstream area, natural environment is well preserved. Okutsu and Yunogo Hot Spring Areas are famous as historic spas. Okutsu-kei, Hyono-sen, Ushiro-yama and Nagi-san Quasi National Park, Yubara Okutsu Prefectural Natural Park and Yoshii-gawa Shuryu Prefectural Natural Park are included in this area.

7. References, Databooks and Bibliography

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