Ara-kawa

Map of River

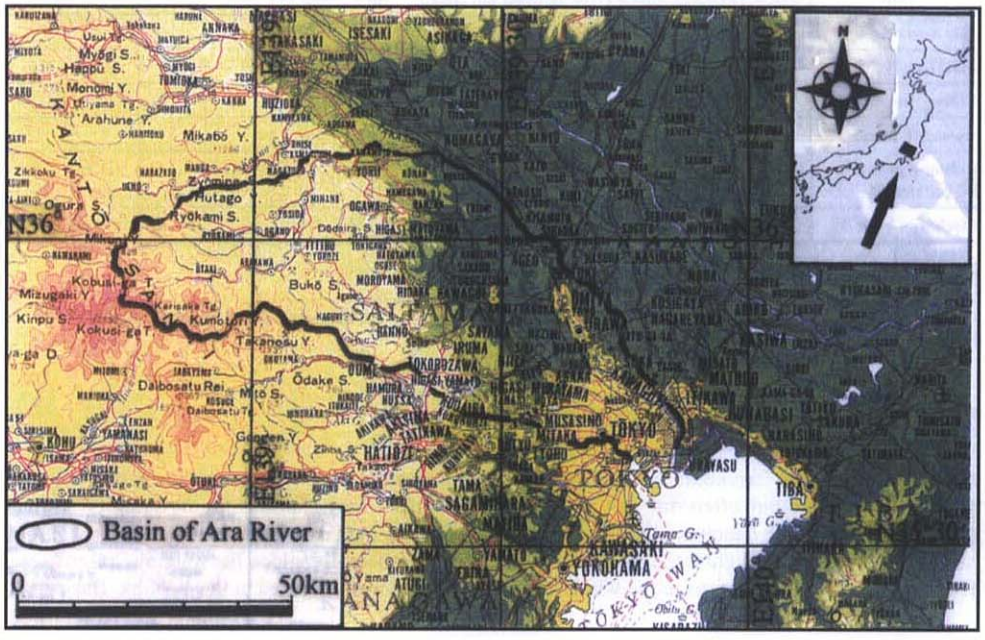


Table of Basic Data

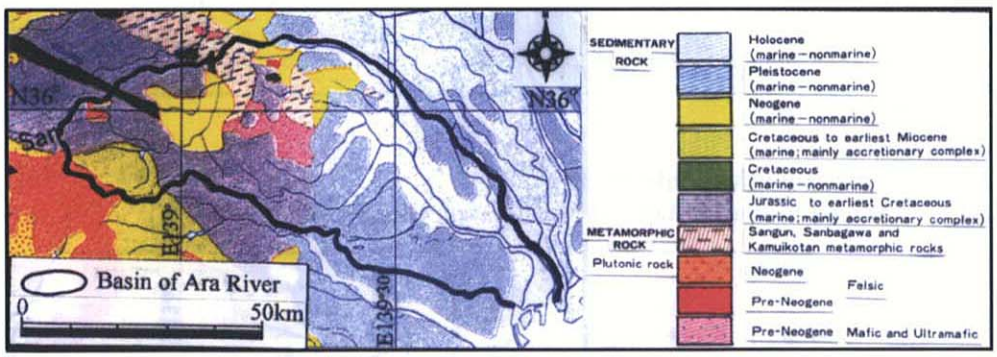
Name: Ara River		**Serial No.:** Japan-2
Location: Central Honshu, Japan	N 35° 39′ ~ 36° 10′	E 138° 43′ ~ 139° 52′
Area: 2 940 km^2	**Length of main stream:** 173 km	
Origin: Mt. Kobushi-gatake (2 475 m)	**Highest point:** Mt. Kobushi-gatake (2 475 m)	
Outlet: Tokyo Bay, Pacific Ocean	**Lowest point:** River mouth (0 m)	
Main geological features: (Upper basin) Paleozoic, Tertiary; (Lower basin) Quaternary (alluvial and diluvial)		
Main tributaries: Akabira River (250.0 km^2), Iruma River (737.3 km^2), Shingashi River (392.3 km^2), Sumida River (243.9 km^2)		
Main lakes: None		
Main reservoirs: Chichibu Reservoir (26.9 x 10^6 m^3, 1984), Arima Reservoir (7.6 x 10^6 m^3, 1984)		
Mean annual precipitation: 1 367 mm (1951~1980), at Chichibu		
Mean annual runoff: 26.4 m^3/s at Yorii (927 km^2) (1952~1985)		
Population: 9 046 643 (1985)	**Main cities:** Tokyo, Omiya, Urawa, Kawagoe, Chichibu	
Land use: Forest (48.2%),Paddy field (5.1%), Agriculture (6.5%), Water surface (4.0%), Urban (26.5%) (1985)		

1. General Description

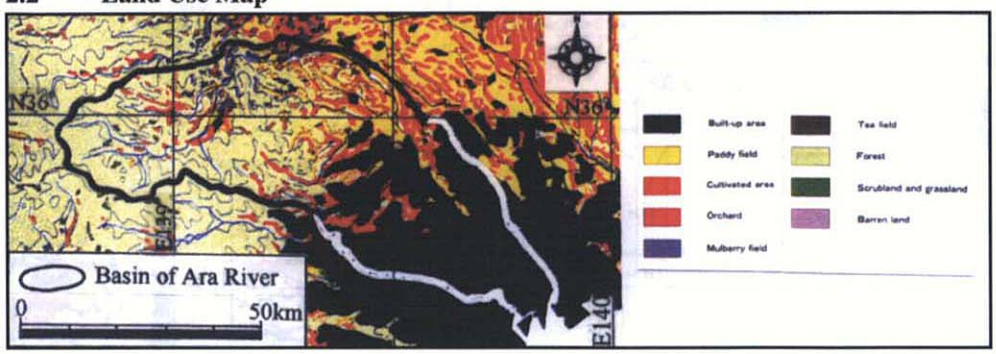
The Ara River is a representative urban river of Japan. It originates from Mt. Kobushi (2 475 m) in the central Honshu Island, flows first to the north-east, then to the south-east and then due south. After passing through the eastern part of the Greater Metropolitan Tokyo area, the Ara River finally flows into the Tokyo Bay of the Pacific Ocean. The length of the main stream is 173 km and the catchment area is 2 940 km^2. The major branches are the Iruma, Shingashi and the Akabira Rivers, all confluencing from the west to the right bank of the river. The downstream branch, 23.5 km to the river mouth, is called the Sumida River whose 243.9 km^2 basin drains the most highly urbanised and industrialised parts of Tokyo and Saitama Prefectures. The major meteorological causes of precipitation are Baiu fronts in early spring and typhoons in early summer, which normally create three undulations in the annual discharge pattern. The average annual precipitation is 1 330 mm, which is relatively low compared with 1 800 mm average in Japan. The total population of the basin was 9.05 million (1985) and the corresponding population density has been 3 076 persons/km^2, the highest among the nation's 109 Class A river basins. To prevent flooding Metropolitan Tokyo, a 22 km long 500 m wide Ara River Diversion Canal was completed in 1930 connecting the left bank of the river at Iwabuchi-suimon and the Tokyo Bay, which is now called the main channel of the Ara River. The Ara River is important to the Greater Metropolitan Tokyo in many respects. But the downstream delta areas suffer from water pollution, land subsidence and floods. Projects of waste water control, river front amenity design and the construction of large scale super levees are now being implemented thereby leading the nation's environmental infrastructure planning and construction.

2. Geographical Information

2.1 Geological Map



2.2 Land Use Map

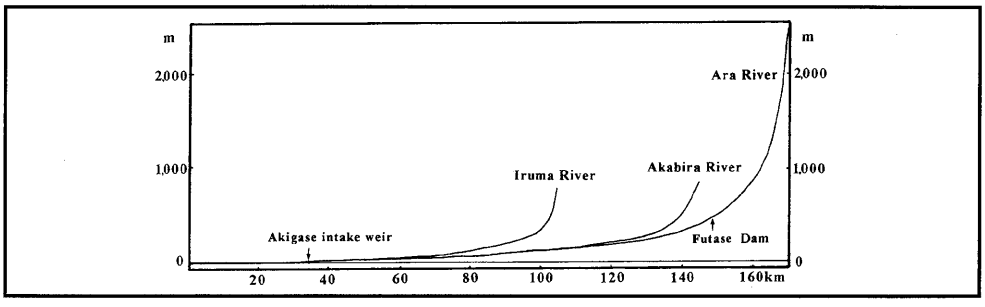


2.3 Characteristics of River and Main Tributaries

No.	Name of river	Length [km] Catchment area [km^2]	Highest peak [m] Lowest point [m]	Cities Population (1985)	Land use [%] (1985)
1	**Ara** (Main river)	173.0 2 940.0	Mt. Kobushi-gatake, 2 475 River mouth, 0	Chichibu, Omiya, Urawa, NE part of Tokyo 9 046 643	A, O (6.5) F (48.2) L (4) P (5.1)
2	**Akabira** (Tributary)	32.0 250.0	Mt. Ryokami, 1 724 ----------	- 24 934	U (26.5) Other (9.7)
3	**Iruma** (Tributary)	69.4 737.3	Mt. Arima, 1 214 ----------	Hanno, Sayama, etc. 625 946	
4	**Shingashi** (Tributary)	25.7 392.3	---------- ----------	Kawagoe, Asaka, etc. 2 190 876	
5	**Sumida** (Lower branch)	23.5 243.9	---------- ----------	NE part of Tokyo 3 966 430	

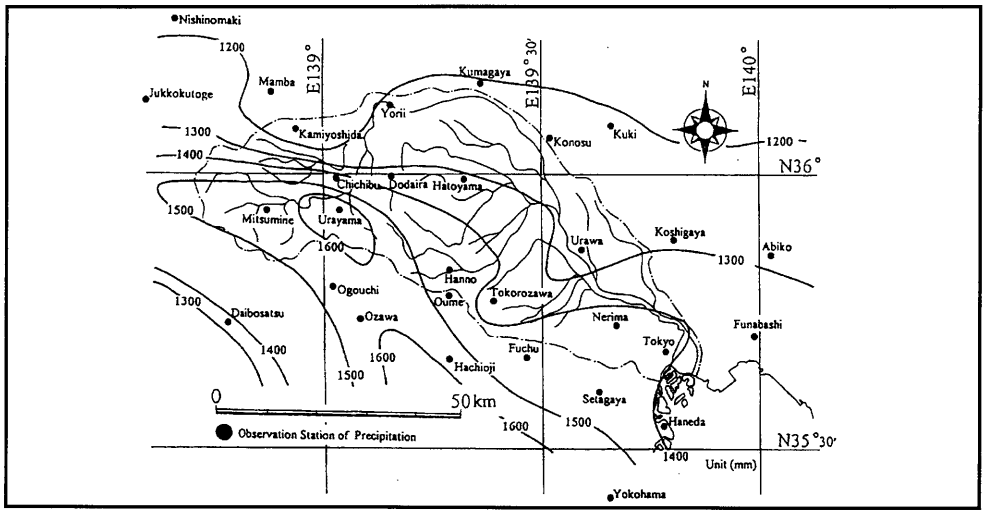
A: Other agricultural field (vegetable, grass) F: Forest L: Lake, River, Marsh O: Orchard P: Paddy field U: Urban

2.4 Longitudinal Profiles



3. Climatological Information

3.1 Annual Isohyetal Map and Precipitation Observation Stations



3.2 List of Meteorological Observation Stations

No.	Station	Elevation [m]	Location	Observation period	Mean annual precipitation [mm]	Mean annual evaporation	Observation items [1)]
30708 *	Mitsumine	988.0	N 35° 56′ 00″ E 139° 56′ 00″	1949~present	1 581 1949~1985	-	P
30712 *	Naguri	249.0	N 35° 53′ 00″ E 139° 11′ 00″	1936~present	1 661 1936~1985	-	P
30711 *	Ogano	240.0	N 36° 00′ 50″ E 139° 10′ 10″	1936~present	1 200 1936~1985	-	P
30715 *	Ogawa	100.0	N 36° 03′ 21″ E 139° 15′ 56″	1955~present	1 263 1955~1985	-	P
43156 #	Chichibu	218.0	N 35° 59′ 24″ E 139° 04′ 42″	1898~present	1 367 1951~1980	-	DS, P
43056 #	Kumagaya	30.0	N 36° 08′ 48″ E 139° 23′ 00″	1896~present	1 207 1951~1980	-	DS, P
43241 #	Urawa	8.0	N 35° 52′ 24″ E 139° 35′ 24″	1898~present	1 401 1951~1980	-	DS, P
47662 #	Tokyo	35.8	N 35° 41′ 12″ E 139° 45′ 54″	1898~present	1 405 1961~1990	-	DS, E, P, SR
	Iwabuchi	10.0	N 35° 40′ 54″ E 139° 44′ 58″	1925~present	1 125 1925~1985	-	P
	Onagi	10.0	N 35° 40′ 51″ E 139° 51′ 06″	1931~present	1 172 1931~1985	-	P

*: Serial number used in Rainfall Yearbook, River Bureau, Ministry of Construction.
#: Serial number used by Meteorological Observatory, Japan Meteorological Agency.
1) DS: Duration of sunshine, E: Evaporation, P: Precipitation, SR: Solar radiation.

3.3 Monthly Climate Data

Station: Kumagaya

Observation item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Period for the mean
Temperature [°C]	3.2	3.9	7.0	12.9	17.7	21.1	24.6	26.2	21.9	16.0	10.6	5.6	14.2	1961~1990
Precipitation [mm]	24.7	40.8	57.7	86.3	106.6	169.8	134.3	159.2	185.6	116.8	58.4	27.3	1 167.5	1961~1990
Evaporation [mm] *	67.4	75.3	100.3	118.0	127.9	110.2	128.5	142.9	94.0	76.8	65.7	60.6	1 167.6	1946~1965
Solar radiation [MJ/m²/d] **	9.5	11.4	14.1	15.7	17.2	13.5	13.6	14.3	10.7	10.9	8.8	8.4	12.4	1974~1990
Duration of sunshine [hr]	207	179	198	175	193	123	129	171	116	149	163	195	1 998	1961~1990

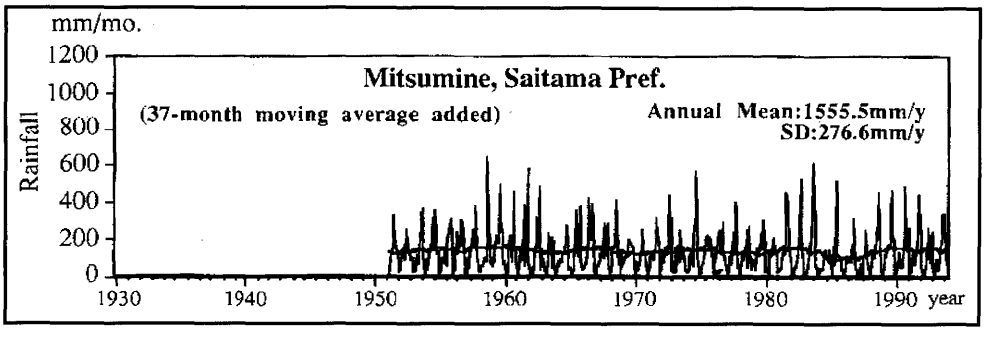
* 20 cm diameter pan evaporation.
** Observed at Maebashi Meteorological Observatory (about 40 km NW of Kumagaya).

Station: Tokyo

Observation item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Period for the mean
Temperature [°C]	5.2	5.6	8.5	14.1	18.6	21.7	25.2	27.1	23.2	17.6	12.6	7.9	15.6	1961~1990
Precipitation [mm]	45.1	60.4	99.5	125.0	138.0	185.2	126.1	147.5	179.8	164.1	89.1	45.7	1 405.3	1961~1990
Evaporation [mm] *	45.6	-	75.2	121.0	84.0	96.5	97.3	129.5	100.4	75.9	56.5	51.9	-	1989
Solar radiation [MJ/m²/d]	8.5	9.9	11.7	14.3	16.0	13.6	13.9	14.6	10.4	9.4	7.6	7.4	11.4	1974~1990
Duration of sunshine [hr]	175	150	165	161	182	123	137	177	110	129	137	166	1 811	1961~1990

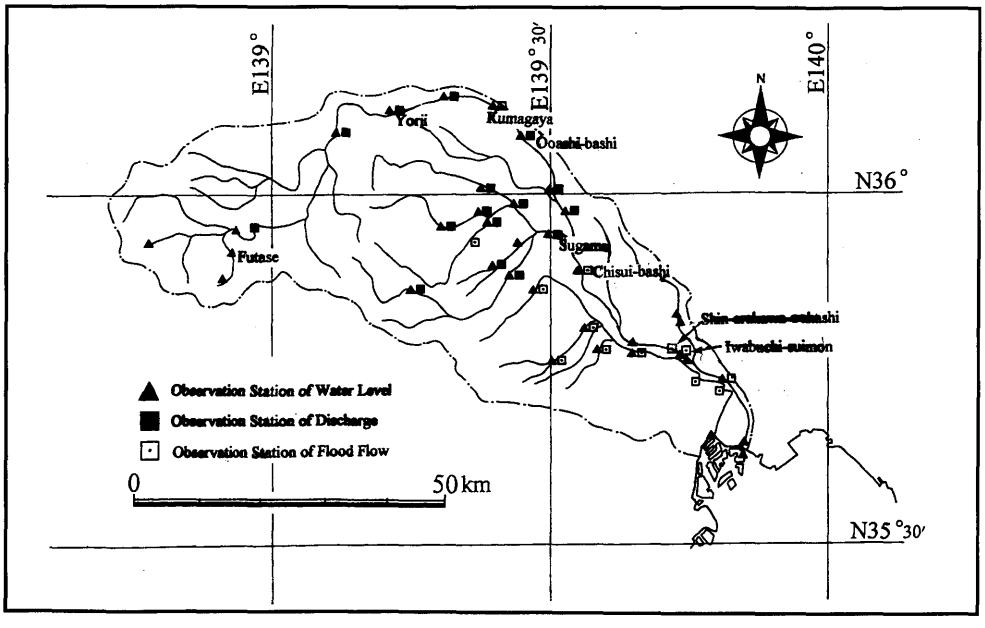
* 120 cm diameter pan evaporation.

3.4 Long-term Variation of Monthly Precipitation



4. Hydrological Information

4.1 Map of Streamflow Observation Stations



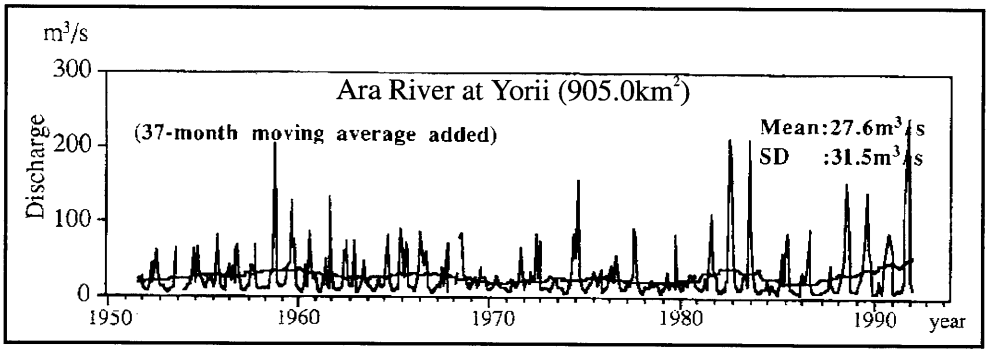
4.2 List of Hydrological Observation Stations

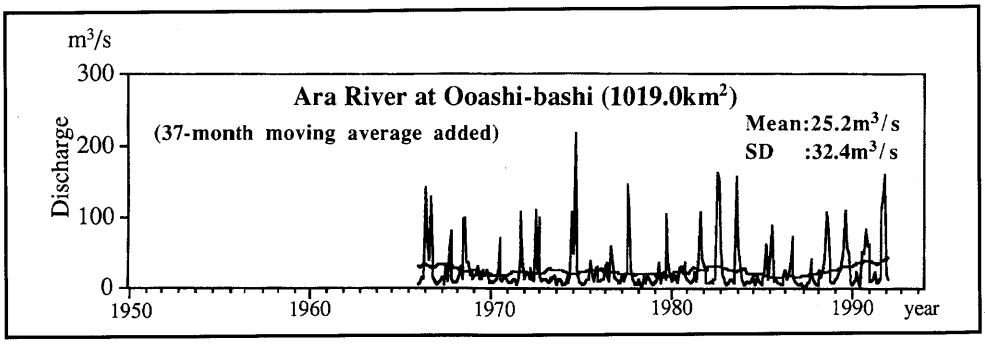
No.	Station	Location	Elevation** [m]	Catchment area (A) [km^2]	Observation period	Observation items[1] (frequency)
30702 *	**Yorii**	94.6 km from the river mouth	75.5	905	1952~present	H1, Q(h)
30705 *	**Oashi-bashi**	68.3 km from the river mouth	13.2	1 019	1966~present	H1, Q(h)
30717 *	**Sugama**	5.8 km from the confluence of the Iruma river, and 50.6 km from the river mouth	2.8	713	1966~present	H1, Q(h)
-	**Iwabuchi-suimon**	20.4 km from the river mouth	-1.1	2 137	1977~present	H1, P, WQ
-	**Chisui-bashi**	42 km from the river mouth	-1.34	2 020	-	H1, Q(f,h)
-	**Shin-arakawa-ohashi**	21.4 km from the river mouth	-	2 137	1928~present	H1, Q(f,h)

No.*	$\overline{Q}$ [2] [m^3/s]	Q max [3] [m^3/s]	$\overline{Q}$ max [4] [m^3/s]	$\overline{Q}$ min [5] [m^3/s]	$\overline{Q}$ / A [m^3/s/100km^2]	Q max / A [m^3/s/100km^2]	Period of statistics
30702 *	30.2	5 512.0	1 534.2	4.4	3.3	609.1	1952~1993
30705 *	26.0	5 586.7	1 389.3	1.9	2.6	548.3	1966~1993
30717 *	23.5	1 638.5	745.4	1.0	3.3	229.8	1966~1993
-	-	-	-	-	-	-	-
-	-		-	-	-	-	
-	-	-	-	-	-	-	-

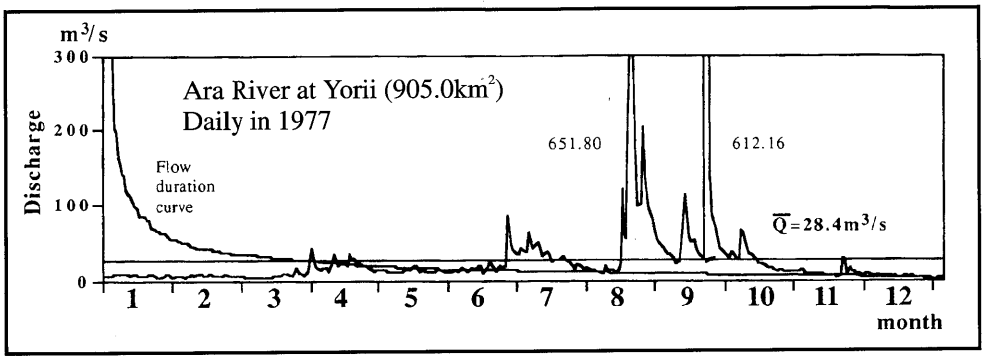
* Serial number used by Streamflow Yearbook, River Bureau, Ministry of Construction.
** Elevation (above mean sea level) of the zero point of water level measurement gauge.
1) H1: Water level in recording chart. Q: Discharge, (including the use of H-Q curve), P: Precipitation, WQ: Water quality, h: Hourly, f: Only during flood.
2) Mean annual discharge.
3) Maximum discharge.
4) Mean annual maximum discharge.
5) Mean annual minimum discharge.

4.3 Long-term Variation of Monthly Discharge





4.4 Annual Pattern of Discharge



4.5 Unique Hydrological Features

The main channel of the Ara River once flowed further east but shifted a bit to the west near Kumagaya in 1629 as a result of development of rice paddy irrigation. Since then the river system has changed a great deal especially in its downstream reaches from the urban development of Tokyo. The present system may be considered as nearly all man-made using various river engineering works such as cut-off channels, diversions, levees, large sewage tunnels and networks, etc. The rapid and wide urbanisation and industrialisation of the Tokyo area since 1955 have resulted in remarkably high flood peaks (Ref: Hydrological Observation Data in Shakujii-gawa Basin, Public Works Research Institute, Ministry of Construction, in PWRI Publication no. 714, 1972).

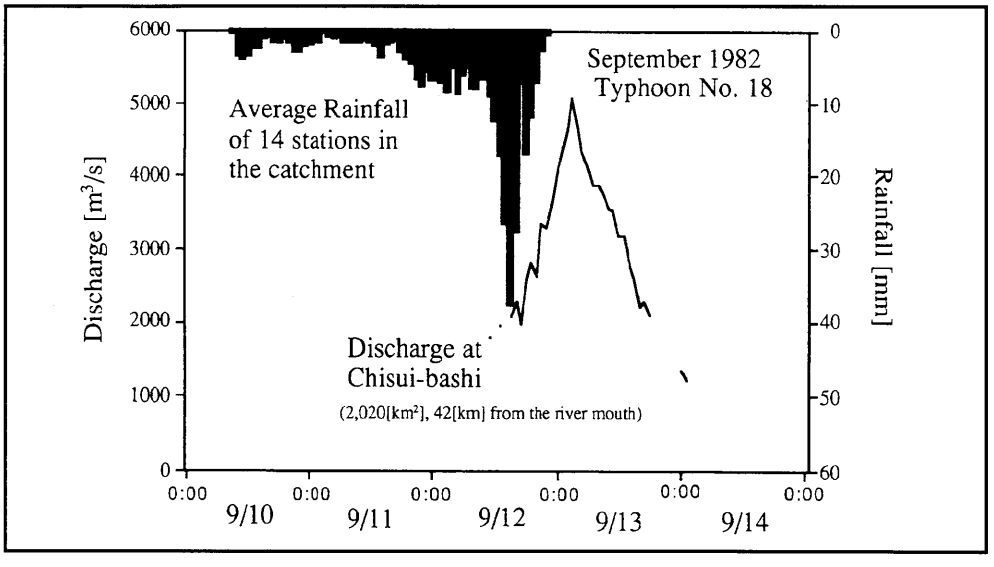
4.6 Annual Maximum and Minimum Discharges

At Yorii [905 km^2]

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]
1952	6.24	399	12.31	3.9	**1973**	-	86	-	3.8
1953	7.20	285	2.09	3.5	**1974**	-	3 968	-	2.4
1954	9.19	1 844	1.09	4.4	**1975**	-	112	-	4.3
1955	10.11	946	1.04	2.5	**1976**	-	143	-	4.1
1956	9.27	1 023	2.19	3.7	**1977**	-	1 862	-	2.8
1957	9.11	419	1.14	4.1	**1978**	-	283	-	2.8
1958	9.18	3 625	6.24	5.5	**1979**	-	920	-	2.0
1959	8.14	3 350	11.28	8.6	**1980**	-	239	-	3.7
1960	8.20	550	3.24	3.7	**1981**	-	3 082	-	4.3
1961		1 196		2.7	**1982**	-	5 512	-	3.4
1962		755		3.1	**1983**	-	3 388	-	5.2
1963		159		2.5	**1984**	-	1 402	-	4.4
1964		409		-	**1985**	-	2 112	-	3.9
1965		1 574		2.8	**1986**	-	2 056	-	3.3
1966		2 260		2.5	**1987**	-	527	-	4.6
1967		611		1.0	**1988**	-	1 149	-	4.8
1968		-		-	**1989**	-	2 394	-	4.6
1969	-	146	-	4.4	**1990**	-	1 294	-	3.9
1970	-	228	-	4.2	**1991**	-	2 573	-	4.4
1971	-	2 247	-	2.5	**1992**	-	601	-	5.1
1972	-	1 100	-	3.6	**1993**	-	2 468	-	6.0

1), 2) Instantaneous observation by recording chart.

4.7 Hyetographs and Hydrographs of Major Floods

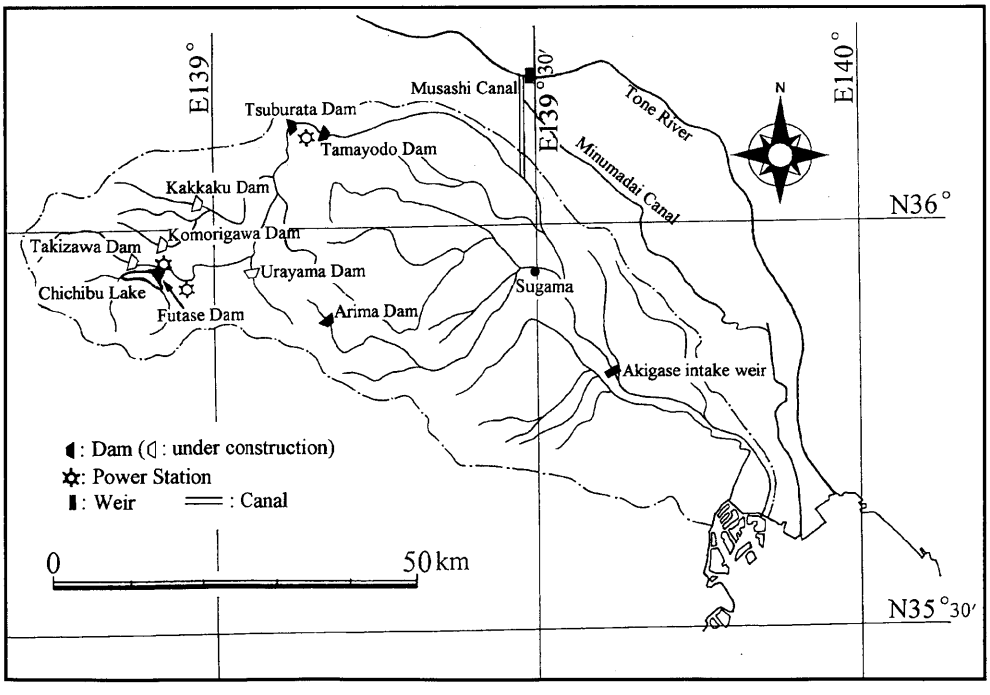


5. Water Resources

5.1 General Description

The Ara River generates 43.7 MW at 9 hydro-power stations upstream, irrigates about 15 000 ha of paddy fields in the middle reaches, supplies 40.3 m^3/s of municipal and 3.4 m^3/s of industrial water downstream as of 1991 and serves for navigation up to about 20 km from the river mouth. It has the Chichibu Reservoir (26.9 x 10^6 m^3) and other small ones. Two medium size reservoirs, Takizawa (63 x 10^6 m^3) and Urayama (58 x 10^6 m^3) are under construction. The Ara River receives water from the Tone River via two major inter-basin transfer canals, the Minumadai and the Musashi. The Minumadai Canal was built in 1728 for paddy field irrigation as well as for navigation. The Musashi Canal, 14.5 km long and 50 m^3/s in capacity was built in 1968. The canal water received near Konosu is diverted again by the Asaka Conduit (built in 1964) at Akigase for municipal water supply to Tokyo and Saitama prefectures and for lowflow augmentation in the Shingashi and Sumida Rivers. The Sumida River Basin is very densely populated and highly industrialised, resulting severe water pollution. The BOD has been close to 40 ppm during the 1960's. It has been experiencing serious land subsidence due to groundwater mining. Approximated 84 km^2 (1975) of the basin is below the mean sea level. Various regulatory measures have improved the situation at the present time. The construction of super levees with width 30 times the height on which large buildings, roads, and parks may be built has improved the safety and landscape of the riparian lands thereby increasing the economical values.

5.2 Map of Water Resources 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
Ara	**Futase (Chichibu)**	170.0	26.9	21.800	F, N, P	1961
Ara	**Tamayodo**	893.0	3.324	0.280	A, P	1964
Nakatsu	**Takizawa**	108.6	58.0	58.000	F, N, W	(2000)*
Urayama	**Urayama**	51.6	56.0	56.000	F, N, P, W	(1997)*
Komori	**Komori**	21.8	20.64	19.940	F, N, W	- *
Yoshida	**Kakkaku**	32.1	10.25	9.250	F, N, W	(1997)*
Arima	**Arima**	16.9	7.6	7.250	F, N, W	1985

Major Interbasin Transfer

Name of transfer line	Names of rivers connected		Length [km]	Maximum capacity [m^3/s]	Purpose [1]	Year of completion
	From	To				
Minumadai Canal	Tone River	Ara River	102.9 [2]	43.4	I	1968 [3]
Musashi Canal	Tone River	Ara River	14.52	50.0	I, W	1968

* Under construction

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

2) The total length of the main canal network.

3) Originally built in 1728, designed and supervised by an engineer Izawa-Yasobei-Tamenaga. The current canal is by the latest major reconstruction in 1968.

5.4 Major Floods and Droughts

Major Floods

There exists a number of historical records of floods giving death tolls, damages, inundation stages, etc. since the 17th century, including the large floods of 1742, 1791, 1824, 1859, 1890. Among them, the flood of 1742 was the most severe. The following are for recent floods:

Date	Station Catchment area [km^2]	Peak discharge [m^3/s]	Rainfall [mm] Duration*	Meteorological cause	Dead and Missing	Major damages (Districts affected)
1910. 8	Shin-arakawa-ohashi (2 137)	-	477.0 3 days	Typhoon	369[1)]	River banks broken at 178 sites. 270 000 houses inundated. 1 679 houses washed away.
1917. 10	〃	-	213.5 3 days	-	562[2)]	10 000 houses washed away. 130 000 houses inundated.
1938. 9	〃	-	314.1 3 days	Typhoon	29	River banks broken at 10 sites. 150 000 houses inundated.
1941. 7	〃	5 000	343.5 3 days	-	-	River banks broken at several sites.
1947. 9	〃	7 015	445.9 3 days	Typhoon Catherine	114	River banks broken at 3 sites. 1 418 houses washed away.
1948. 9	〃	3 392	255.5 3 days	Typhoon Ion	8	20 000 houses inundated. 469 houses washed away. River banks broken at 14 sites.
1949. 8	〃	2 142	204.0 3 days	Typhoon Kitty	-	-
1958. 9	〃	4 405	281.5 3 days	Kanogawa Typhoon	-	River banks broken at 20 sites.
1966. 6	〃	3 156	231.7 3 days	Typhoon No. 4	-	4 050 ha and 7 897 houses inundated in the Shingashi Basin.
1974. 9	〃	3 676	-	Typhoon No. 16	-	River banks broken at 6 sites.
1982. 8	〃	4 561	331.0 3 days	Typhoon No. 10	-	-
1982. 9	〃	5 268	324.5 3 days	Typhoon No. 18	-	-

* Estimation over the catchment above Furuya Hongo.
1) Including the losses in the Tone River Basin adjacent to the north of Ara River.
2) In Metropolitan Tokyo.

5.5 Groundwater and Water Quality

Groundwater

Station	Iwabuchi (deep) (83-02-083-1)*		Iwabuchi (shallow) (83-02-083-2)*	
Ground surface elevation [m]**	5.79		5.79	
Well depth, Screen depth [m]	67, 62-67		144, 108-144	
Date	1986.1.21	1986.8.22	1986.1.22	1986.8.25
pH	8.72	8.20	8.80	7.96
Electrical conductivity [μS/cm]	256.00	170.00	-	-
DO [mg/l]	7.69	2.49	4.81	7.18
COD [mg/l]	5.1	1.95	3.53	1.56
T-N [mg/l]	1.36	0.81	0.57	0.67
T-P [mg/l]	0.202	0.112	0.076	0.072
Alkalinity [mg/l]	93.4	81.7	79.4	114.00
Cl-[mg/l]	14.1	2.99	19.7	20.8

* Serial number of wells used by Groundwater Quality Yearbook, River Bureau, Ministry of Construction.
** Above mean sea level.

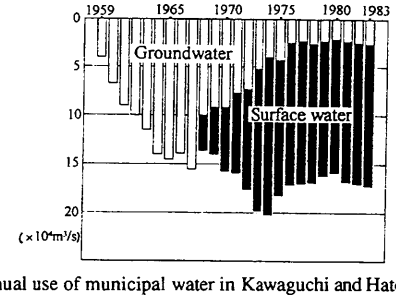
River Water Quality[1] at Chisui-bashi[2] in 1994

Date	Jan 25	Feb 15	Mar 8	Apr 19	May 24	Jun 21	Jul 19	Aug 23	Sep 20	Oct 18	Nov 15	Dec 13
pH	7.3	7.6	7.4	7.7	7.9	7.4	7.3	7.4	7.4	7.6	7.4	7.5
BOD [mg/l]	2.3	3.1	3.0	2.2	2.0	1.5	2.7	1.0	0.9	1.3	1.9	2.4
COD_{Mn} [mg/l]	2.8	3.5	3.5	3.5	3.2	4.3	6.0	3.8	3.7	2.3	3.1	3.3
SS [mg/l]	4.4	5.0	6.2	6.5	9.9	13.5	37.0	18.2	47.3	7.2	5.6	6.6
Coliform group [3] [MPN/100ml]	0.17 x 10^4	0.18 x 10^4	0.54 x 10^4	0.17 x 10^4	0.46 x 10^4	0.92 x 10^5	0.35 x 10^5	0.17 x 10^5	0.92 x 10^5	0.80 x 10^4	0.17 x 10^4	0.14 x 10^5
Discharge [4] [m^3/s]	50.0	49.3	48.4	49.3	45.7	88.6	153.8	142.8	208.2	78.7	61.5	49.2

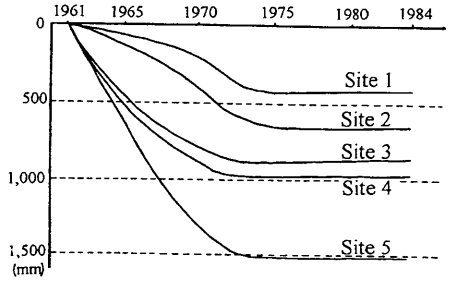
1) Criteria of selecting observation date: During normal flow condition.
2) Location of the station: 42 km upstream of the river mouth.
3) Measurement method: BGLB (brilliant green lactose bile) culture, MPN (most probable number) method.
4) Discharge on the water quality observation date.

5.6 Other Notable Features of Water Resources

In the lower part of the river basin, groundwater mining has induced severe land subsidence from the mid 50's to the early 70's. But when the withdrawal was reduced to a sustainable level, the subsidence quickly stopped.



Annual use of municipal water in Kawaguchi and Hatogaya.



Land subsidence in Kawaguchi at various sites.

6. Socio-cultural Characteristics

The Sumida River, the lower reach of the Ara River, has been loved by the people of Tokyo (called Edo until 1868) for more than a thousand years. Since the Edo era, the Sumida has been a popular place for social activities such as cherry blossom watching in spring, boat cruising and watching fireworks in summer, Sumo wrestling and other traditional downtown activities. There are many poems, stories, dramas and paintings about the Sumida, including a Yokyoku song "Sumidagawa" of Noh stage and many Ukiyoe prints by Hiroshige of the 19th century. The Sumida is known as the museum of bridges since there are 30 bridges of various design spanning its breadth.

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