Chapter 14 COUNTERMEASURES FOR CONSERVATION OF DRINKING WATER SOURCE

1. Introduction

Among every use of public water bodies, the one as a source for drinking water supply is the most important. The water supply as a social infrastructure is indispensable not only for our healthy and comfortable daily life, but also for our social and economic activities in a modern society. Therefore, it is always required to secure water of good quality and enough quantity by a public water supply system.

However, it became difficult to secure good-quality water for a drinking water supply in Japan in recent years. Then, the two laws, "Law of Execution of Preservation Project of Water Resource for Water Supply" and "Law Concerning Special Measures to Preserve Water Quality of Water Resource for Drinking Water", (hereinafter referred to as "the two laws for water source conservation") were newly established for the purpose of protecting water sources for drinking water supply in March, 1994.

So far, although not much time has passed since their establishment or no effect of their application has been observed yet, the two laws for water source conservation were applied to some water bodies, and plans for the water quality conservation of drinking water sources were elaborated. Successful and effective implementation of countermeasures for water source conservation can be expected through the application of the two laws.

In this chapter, background, outlines and the present status of application of the two laws are described.

2. Background and consequences of establishment of the two laws

An important background of the establishment of the two laws for water source conservation was the fact that it was difficult to cope with the deterioration of the quality of raw waters for drinking water supply under the legislation at the previous time. Background and consequences of the establishment of the two laws are described below.

2.1 Deterioration of drinking water quality

Various problems of drinking water quality, such as trihalomethane formation caused by chlorination, groundwater contamination with organic solvents like trichloroethylene, contamination with agricultural chemicals, and occurrence of offensive taste and odor due to eutrophication, emerged in recent years. Trihalomethanes (THMs) are a part of disinfection by-products to be formed in the course of chlorination for disinfection and other purposes, and they consist of chloroform, bromodichloromethane, dibromochloromethane and bromoform. Results of animal experiment show that THMs are carcinogenic.

The waterworks tried to make every effort in order to cope with the problems as mentioned above and to secure good quality drinking water so as to meet the Water Quality Standards for Drinking Water Supply. The effort included change in treatment system from prechlorination to intermediate chlorination and introduction of advanced processes such as activated carbon treatment, ozonation, and biological treatment. It was, however, impossible to control every contaminant in water treatment, and the establishment of essential measures for raw water contamination control was needed.

A typical example of drinking water contamination problem was offensive taste and odor as shown in Fig. 14-1, and about twenty million people suffered from offensive taste and odor every year all over Japan. On the other hand, the result of a nationwide survey as of FY 1991 on THMs concentration in

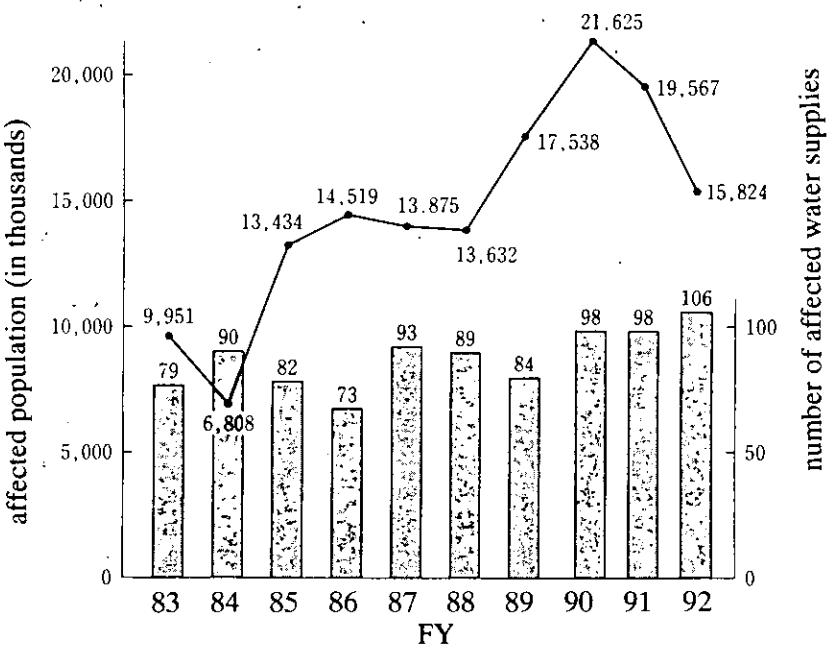


Fig. 14-1 Occurrence of abnormal odor of drinking water

drinking water conducted by the Ministry of Health and Welfare showed that at least anyone of the concentrations of five items related to THMs exceeded 70% of its standard value in 63 drinking water supplies (about 4% of the total), corresponding to served population of about 2.5 million, out of totally about 1,600 drinking water supplies (including bulk water supplies) in Japan excluding the ones depending only on groundwater as shown in Table 14-1 (70% of the standard value is used as a target taking the change in their concentrations into account). Moreover, the contamination of drinking water with various chemical substances took place in many drinking water supplies, and frequent accidental raw water contamination due to the discharge of industrial effluents sometimes obliged a waterworks to interrupt taking raw water.

Table 14-1 Number of waterworks where THM concentration exceeded 70% of its standard value

Item	Number of waterworks exceeding 70% value
Total THMs	39
Chloroform	27
Bromodichloromethane	39
Dibromochloromethane and bromoform	0

Note 1) The sum of numbers exceeding 70% value is not 63 because more than two items exceeded 70% values in some waterworks.

2) The standard values are as follows:

Total THMs	0.1 mg/L	Dibromochloromethane	0.1 mg/L
Chloroform	0.06 mg/L	Bromoform	0.09 mg/L
Bromodichloromethane	0.03 mg/L		

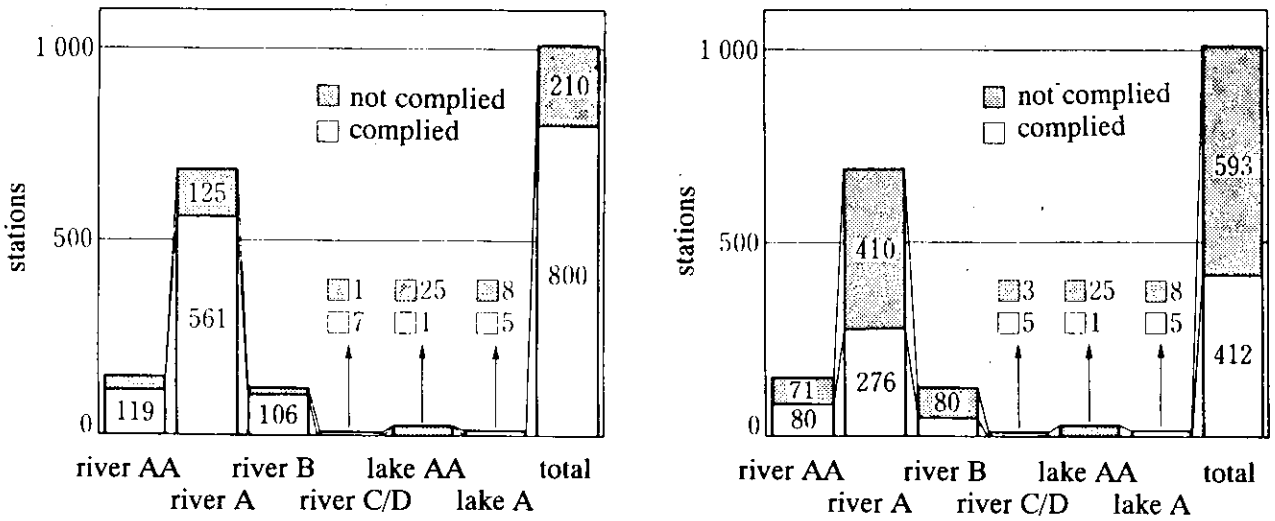
As a consequence, people became to feel more and more uneasy about the safety of drinking water. This was clearly reflected in the prevalence of household water purifiers and bottled waters, and it became remarkable especially in recent years that people tended not to drink tap waters.

2.2 Legislation regarding conservation of drinking water source at previous time .

There was no adequate legislation regarding the conservation of a drinking water source before the establishment of the two laws for water source conservation.

On the side of drinking water supply administration, the Water Works Law states that the central and local governments shall take measures necessary for cleansing a source for drinking water supply while the nation shall try to keep it clean, and the waterworks can, if necessary, request a relevant administrative agency to take appropriate measures for the pollution control of drinking water sources. Nevertheless, since no clear procedures to be taken in response to such a request were defined in any regulation, this section of the law was rarely applied.

On the side of environmental administration, the Environment Agency has implemented the category designation of the Environmental Quality Standards for a public water body based on the Basic Environment Law (formerly the Basic Law for Environmental Pollution Control) and application of the Effluent Standards based on the Water Pollution Control Law. However the effectiveness of the category designation of the Environmental Quality Standards is limited because there is no provisions on punishment for a case when it is not observed. Therefore, the compliance with the Environmental Quality Standards for drinking water sources as of FY 1990 was not satisfactory as shown in Fig. 14-2. Furthermore, the Environmental Quality Standards were applied only to 28.6% sources out of the total drinking water sources (including the ones for bulk water supply), but no standards were applied to the remaining 71.4% sources.



(a) Compliance with the standards at monitoring stations on BOD and COD in FY 1990

(b) Compliance with the standards at monitoring stations on all items in FY 1990

Fig. 14-2 Compliance with the Environmental Quality Standards at drinking water sources

Other laws concerning the water quality conservation of drinking water sources include the Law Concerning Special Measures for Conservation of Lake Water Quality, Sewage Works Law, River Law, Agricultural Chemicals Regulation Law, the Law Concerning the Examination and Regulation on Manufacture etc. of Chemical Substances, etc. Nevertheless, all of these laws are not directly related to the water quality conservation of drinking water sources, and they have no clear provisions on methods and procedures for its effective implementation as is in the case of the Water Works Law.

2.3 Amendment of the Water Quality Standards for Drinking Water Supply

As a consequence of growing uneasiness for possible adverse health effects caused by the contamination of drinking water, accumulation of scientific knowledge on the health effect of contaminants in drinking water, and revision of the Guidelines for Drinking-Water Quality by the World Health Organization, the Water Quality Standards for Drinking Water Supply were amended in December, 1992, as shown in Table 14-2. The amendment was for the first time since the last one in 1978 and after thirty-five years interval since the extensive one in 1957. As a result, the standards were strengthened with increasing the number of the standard items from 26 to 46. In addition, the Items Relating to the Comfortableness of Water Quality (13 items) and their target values, as shown in Table 14-3, and the Items Relating to Monitoring (26 items) and their guideline values, as shown in Table 14-4, were newly established.

Besides, the Environmental Quality Standards for Water-Items Related to the Protection of Human Health were also amended in March, 1993, in accordance with the amendment of the Water Quality Standards for Drinking Water Supply as mentioned above. In addition, the Monitoring Substances (25 items) and their guideline values were established as a supplement to the standards, and the Effluent Standards were amended accordingly in December, 1993.

Table 14-2 Water Quality Standards for Drinking Water Supply

	Item	Standard value
1	Standard plate count	not more than 100 /mL
2	Coliforms	not to be detected
3	Cadmium	not more than 0.01 mg/L
4	Mercury	not more than 0.0005 mg/L
5	Selenium	not more than 0.01 mg/L
6	Lead	not more than 0.05 mg/L
7	Arsenic	not more than 0.01 mg/L
8	Chromium (hexa-valent)	not more than 0.05 mg/L
9	Cyanides	not more than 0.01 mg/L
10	Nitrate- and nitrite-nitrogen	not more than 10 mg/L
11	Fluorides	not more than 0.8 mg/L
12	Carbon tetrachloride	not more than 0.002 mg/L
13	1,2-Dichloroethane	not more than 0.004 mg/L
14	1,1-Dichloroethylene	not more than 0.02 mg/L
15	Dichloromethane	not more than 0.02 mg/L
16	*cis*-1,2-Dichloroethylene	not more than 0.04 mg/L
17	Tetrachloroethylene	not more than 0.01 mg/L
18	1,1,2-Trichloroethane	not more than 0.006 mg/L
19	Trichloroethylene	not more than 0.03 mg/L
20	Benzene	not more than 0.01 mg/L
21	Chloroform	not more than 0.06 mg/L
22	Dibromochloromethane	not more than 0.1 mg/L
23	Bromodichloromethane	not more than 0.03 mg/L
24	Bromoform	not more than 0.09 mg/L
25	Total trihalomethanes	not more than 0.1 mg/L
26	1,3-Dichloropropene (DD)	not more than 0.002 mg/L
27	Simazine (CAT)	not more than 0.003 mg/L
28	Tiuram	not more than 0.006 mg/L
29	Thiobencarb (Benthiocarb)	not more than 0.02 mg/L
30	Zinc	not more than 1.0 mg/L
31	Iron	not more than 0.3 mg/L
32	Copper	not more than 1.0 mg/L
33	Sodium	not more than 200 mg/L

Table 14-2 Water Quality Standards for Drinking Water Supply (continued)

	Item	Standard value
34	Manganese	not more than 0.05 mg/L
35	Chlorides	not more than 200 mg/L
36	Calcium, magnesium, etc. (Hardness)	not more than 300 mg/L
37	Total solids	not more than 500 mg/L
38	Anionic surfactant	not more than 0.2 mg/L
39	1,1,1-Trichloroethane	not more than 0.3 mg/L
40	Phenols	not more than 0.005 mg/L (as phenol)
41	Organic substances (Potassium permanganate consumption)	not more than 10 mg/L
42	pH	not less than 5.8 or not more than 8.6
43	Taste	not abnormal
44	Odor	not abnormal
45	Color	not more than 5 degrees
46	Turbidity	not more than 2 degrees

Note 1) Items 1-29 are those Relating to Human Health, and items 30-46 are those Relating to the Acceptability of Drinking Water to Consumers.
2) The standards were enforced on December 1, 1993.

Table 14-3 Items Relating to Human Health

	Item	Target value
1	Manganese	not more than 0.01 mg/L
2	Aluminum	not more than 0.2 mg/L
3	Residual chlorine	not more than approx. 1 mg/L
4	2-Methylisoborneol	Powdered activated carbon treatment: not more than 0.00002 mg/L Granular activated carbon treatment: not more than 0.00001 mg/L
5	Geosmin	Powdered activated carbon treatment: not more than 0.00002 mg/L Granular activated carbon treatment: not more than 0.00001 mg/L
6	Threshold odor number (TON)	not more than 3
7	Free carbon dioxide	not more than 20 mg/L
8	Organic substances (Permanganate consumption)	not more than 3 mg/L
9	Calcium, magnesium, etc. (Hardness)	not less than 10 mg/L or not more than 100 mg/L
10	Total solids	not more than 30 mg/L or not more than 200 mg/L
11	Turbidity	not more than 1 degree at tap or not more than 0.1 degree at inlet of distribution facility
12	Langhelier's Index (Corrosiveness)	not less than approx. -1 and as near 0 as possible
13	pH	Approx. 7.5

Note 1) Although the standard values are established on manganese, permanganate consumption, hardness, total solids, turbidity and pH, the values as listed above are additionally established considering better quality drinking water.
2) The value on residual chlorine should be referred to on the condition that disinfection is implemented according to the regulation.

Table 14-4 Items Relating to the Acceptability of Drinking water to Consumers

	Item	Guideline value
1	*trans*-1,2-Dichloroethylene	not more than 0.04 mg/L
2	Toluene	not more than 0.6 mg/L
3	Xylene	not more than 0.4 mg/L
4	*p*-Dichlorobenzene	not more than 0.3 mg/L
5	1,2-Dichloropropane	not more than 0.06 mg/L
6	di(2-Ethylhexyl)phthalate	not more than 0.06 mg/L
7	Nickel	not more than 0.01 mg/L
8	Antimony	not more than 0.002 mg/L
9	Boron	not more than 0.2 mg/L
10	Molybdenum	not more than 0.07 mg/L
11	Formaldehyde	not more than 0.08 mg/L
12	Dichloroacetic acid	not more than 0.04 mg/L
13	Trichloroacetic acid	not more than 0.3 mg/L
14	Dichloroacetonitrile	not more than 0.08 mg/L
15	Chloral hydrate	not more than 0.03 mg/L
16	Isoxathion	not more than 0.008 mg/L
17	Diazinon	not more than 0.005 mg/L
18	Fenitrothion (MEP)	not more than 0.003 mg/L
19	Isoprothiolane	not more than 0.04 mg/L
20	Chlorotharonil (TPN)	not more than 0.04 mg/L
21	Propyzamide	not more than 0.008 mg/L
22	Dichlorvos (DDVP)	not more than 0.01 mg/L
23	Fenobcarb (BPMC)	not more than 0.02 mg/L
24	Chlornitrofen (CNP)	not more than 0.0001 mg/L(see Note)
25	Iprobenfos (IBP)	not more than 0.008 mg/L
26	EPN	not more than 0.006 mg/L

Note) The value is a provisional one.

2.4 Movement towards enactment

Following the circumstances as written above, the Ministry of Health and Welfare, which is responsible for supervising waterworks, convened the "Wise Men Meeting Concerning Water Quality Conservation of Drinking Water Sources" several times in order to obtain opinions on measures for the conservation of drinking water sources. As a result, from the viewpoints, that measures taken by waterworks are limited, and countermeasures for the water quality conservation of drinking water sources are important for securing the safety of drinking water, the council prepared a report including the recommendations as follows in February, 1993:

1) Enhancement of the regulation concerning effluent discharge from industries and other facilities considering the circumstances of each area,
2) Proper use of agricultural and other chemicals,
3) Implementation of various projects for proper treatment of domestic wastewaters, and
4) Protection of a small-scale water supply from the development activities in its upstream area.

Moreover, the Living Environment Council of the Ministry of Health and Welfare pointed out in its report, "Regulatory system concerning the promotion of implementation of projects for the water quality conservation of drinking water sources" (November, 1993), that it was necessary to develop a new regulatory system in an early stage in order to promote projects for the water quality conservation of drinking water sources.

On the other hand, the Central Council for Environmental Pollution Control of the Environment

Agency also pointed out in its report, "Measures to be taken for the water quality conservation of public water bodies with respect to drinking water supply" (December, 1993), that new measures including legislation were necessary from the viewpoint of securing safe and good quality drinking water if the existing regulatory system was not adequate.

Based on the above consequence, both the "Law of Execution of Preservation Project of Water Resource for Water Supply" (under the jurisdiction of the Ministry of Health and Welfare, the Ministry of Agriculture, Forestry and Fisheries, and the Ministry of Construction) and the "Law Concerning Special Measures to Preserve Water Quality of Water Resource for Drinking Water" (under the jurisdiction of the Environment Agency) were established in March, 1994 for the purpose of promoting measures for the water quality conservation of drinking water sources from the viewpoints as shown in Fig. 14-3, and they were enforced in May, 1994.

3. Outlines of the two laws for water source conservation and their application

Outlines of the two laws for water source conservation, which were newly established as written above, and the present status of their application are described here. Since the cases of their application include some where a relevant prefecture government already prepared a plan for promoting the implementation of projects for the water quality conservation of drinking water sources, such an example will be introduced.

3.1 Outlines

Outlines of the two laws for water source conservation are as described below. The "Law of Execution of Preservation Project of Water Resource for Water Supply" (hereinafter referred to as the "Project Execution Law") aims at promoting the implementation of projects concerning the development of a sewerage system and a combined-type private sewage treatment system, and river environment improvement for the purpose of coping with the contamination of drinking water sources with THM precursors, off-flavor substances, and other contaminants. The "Law Concerning Special Measures to Preserve Water Quality of Water Resource for Drinking Water" (hereinafter referred to as the "Special Measures Law") mainly aims at regulation of industrial wastewaters for the purpose of coping with the contamination of drinking water sources only with THM precursors.

The two laws for water source conservation will be applied to a case where it is difficult that the efforts only by a relevant waterworks are not satisfactory for securing drinking water as to meet with the Water Quality Standards for Drinking Water Supply because the level of contamination is too high. The two laws will be applied based on a request of a waterworks, and a plan for the water quality conservation including such measures as mentioned above, according to their necessity, will be prepared for each area.

The Project Execution Law requires that the projects for the water quality conservation of drinking water sources based on the law shall be designated with their implementation period of about five years and their target area along a stretch of the water body from the raw water intake to a 15-20 km upstream point.

The Special Measures Law also requires that the effluent standards on THMs formation potential for industrial discharges shall be established within the ranges as shown in Table 14-5 in a plan for the water quality conservation. When establishing the effluent standards, a 75 percentile value $\times$ (4/3) was selected as a lower limit and a 95 percentile value $\times$ (4/3) as an upper limit based on the distribution of typical daily-average effluent quality data of each industry taking available technologies for industrial wastewater treatment and adequate effluent quality level necessary for securing water source conservation. The lower limit corresponds to a level which is feasible from the technical point of view and will not be an excessive burden to industries. The upper limit corresponds to a level which is attainable through proper operation of a treatment facility considering the present level of wastewater treatment technology. The coefficient of 4/3 is a ratio of the maximum and the daily-average.

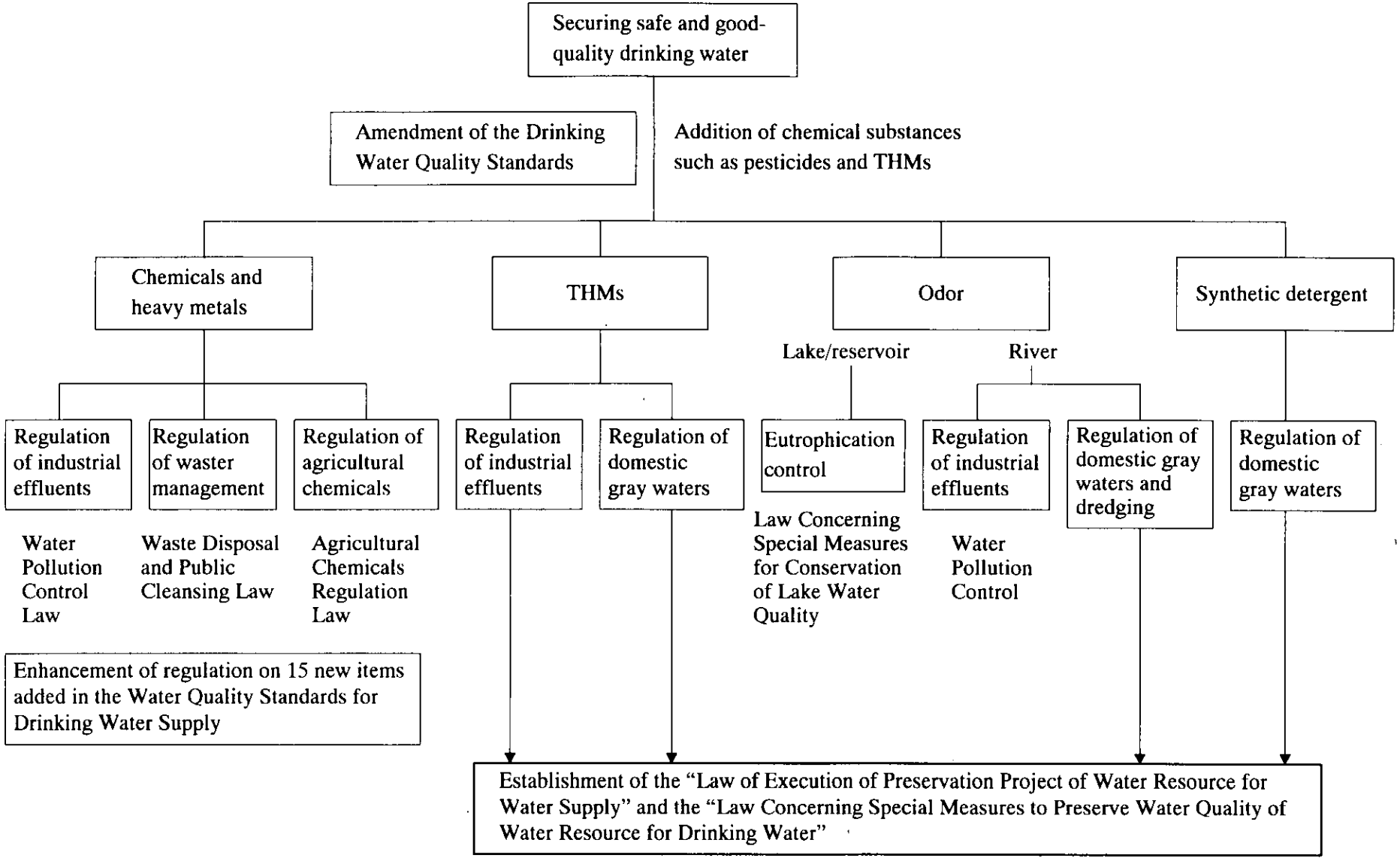


Fig. 14-3 Countermeasures for the water quality conservation of drinking water sources

Table 14-5 Effluent Standards on THMs formation potential for Industrial discharges

Code	Category	Lower limit	Upper limit
012	Livestock feeding	1.3	5.2
121	Meat and dairy processing industry	0.4	0.6
122	Seafood processing industry	0.4	3.6
123	Vegetable and fruit canning industry, Agricultural product processing industry	0.8	1.1
129	Other food industry	0.3	0.8
131	Beverage industry	0.6	1.4
132	Brewing industry	0.4	0.5
14	Textile industry(excluding garment industry)	0.6	1.7
181	Pulp industry	1.0	1.7
182	Paper industry	0.4	0.8
202	Inorganic chemical industry	1.0	4.3
203	Organic chemical industry	1.0	4.5
206	Medical industries	0.4	0.6
286	Metal-plating and chasing industry, heat processing industry (excluding enameling industry)	0.4	1.0
30	Electric devise industry	0.2	0.4
383	Sewage works	0.2	0.3
721	Laundry	0.2	0.3
8712	Night soil disposal facility (excluding on-site treatment facility)	0.4	0.8
9521	Slaughterhouse	0.4	0.6
On-site domestic wastewater treatment facility			
	Facility other than rural wastewater treatment facility	0.2	0.6
	Rural wastewater treatment facility	0.2	0.3
Others		0.2	-

3.2 Application

The way of application of the Project Execution Law is shown in Fig. 14-4. A prefecture plan in the figure means a plan to be prepared by a prefecture for promoting the implementation of projects for the water quality conservation of drinking water sources.

If a waterworks propose a request as specified in the Special Measures Law, the waterworks is considered that it also proposed a request as specified in the Project Execution Law, and vice versa.

The two laws for water source conservation are applied in the areas as shown in Table 14-6 based on the requests by 10 waterworks until the end of FY 1996, and a prefecture plan has been prepared in 4 cases.

4. Example of application: Takuma Town Waterworks in Kagawa Prefecture

An example of Takuma Town Waterworks in Kagawa Prefecture, where the application of the two laws for water source conservation were requested and a plan for promoting the implementation of projects for the water quality conservation of drinking water sources has been prepared, is introduced below.

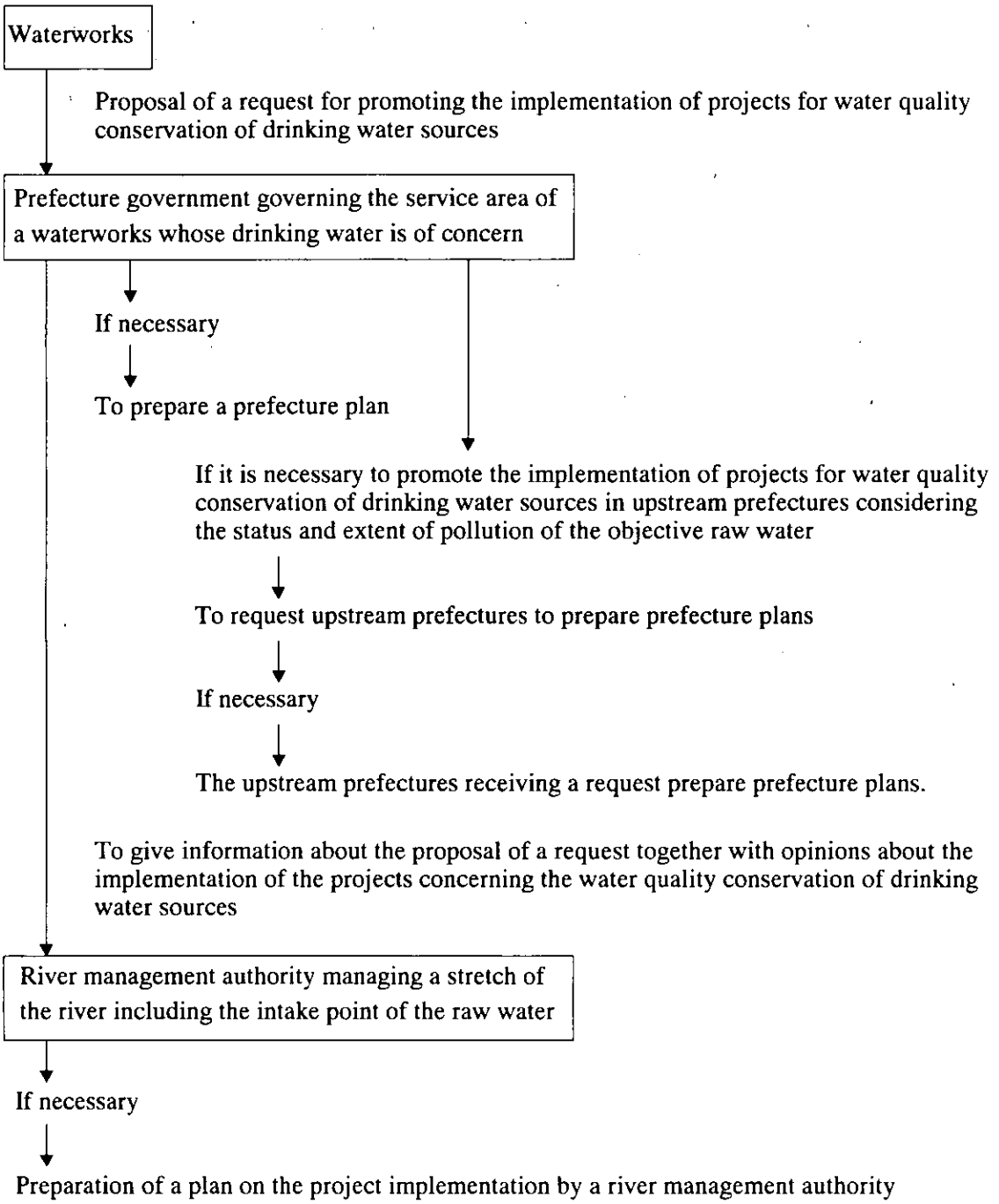


Fig. 14-4 Application procedure of the "Law of Execution of Preservation Project of Water Resource for Water Supply"

4.1 Profile of the waterworks and reasons for request proposal

Takuma Town Waterworks in Kagawa Prefecture, whose profile is shown in Table 14-7, was founded in 1951, and its planned served population as of 1995 was 18,700 persons with a planned water supply capacity of 17,200 m^3/d. Shioki Water Purification Plant of Takuma Town Waterworks took raw water from Takase River of Takase River Basin (a second-class river). Total THMs formation potential of its raw water exceeded 100 μg/L, and total THMs concentration in drinking water also sometimes exceeded 70% of its standard value of 100 μg/L, i.e. 70 μg/L. Therefore, the waterworks took or tried to take the measures as follows:

1) Proper operation of granular activated carbon adsorption facility, mixing of the purified water with other purified water supplied by a prefecture waterworks, etc. (implemented in FY 1994)
2) Change in water purification system from prechlorination to intermediate chlorination (planned to implement in FY 1995)

Table 14-6 Application of the Project Execution Law

	Implementing organization (River)	Prefecture	Proposal	Status of plan preparation
1	Ishikawa Town (Kitasu River)	Fukushima	June, 1994	Completed (Dec., 1994)
2	Sukagawa City (Shakado River)	Fukushima	June, 1994	Completed (Dec., 1994)
3	Takuma Town (Takase River)	Kagawa	Sep., 1994	Completed (June, 1995)
4	Kakogawa City (Kako River)	Hyogo	Sep., 1994	Under preparation
5	Prefecture waterworks (Yoro River)	Chiba	Oct., 1994	Completed (March, 1995)
6	Prefecture waterworks (Kako River)	Hyougo	Nov., 1994	Under preparation
7	Toso Regional Water Supply Authority (Kurobe River)	Chiba	Nov., 1994	Under preparation
8	Prefecture waterworks (Okukubi River)	Okinawa	July, 1995	Under preparation
9	Prefecture waterworks (Taiho River)	Okinawa	July, 1995	Under preparation
10	Prefecture waterworks (Tengan River)	Okinawa	July, 1995	Under preparation

Table 14-7 Profile of Takuma Town Waterworks in Kagawa Prefecture

Name of water source (Intake point)	Takase River of Takase River Basin
Upstream area within 20 km	Takuma Town, Mino Town and Takase Town
Name of water purification plant	Shioki Water Purification Plant (No.1 and 2) (Treatment capacity: 5,190 m^3)
Planned served population	18,700 persons
Served population	14,866 persons
Planned water supply capacity	17,200 m^3 (10,000 m^3 from Kagawa Aqueduct, 2,000 m^3 from Toyonaka Town)
Average water supply capacity	11,101 m^3

The waterworks concluded that the standard value might be exceeded only with the measures as written above because measures to be taken solely by the waterworks were limited, even if improvement to some extent could be expected with the second measure, and BOD of the drinking water source did not comply with the environmental quality standards whereas discharges of domestic wastewaters tended to increase.

Takuma Town Waterworks proposed a request to Kagawa Prefecture for the application of the two laws concerning water source conservation in September, 1994, based on the reasons as mentioned above.

4.2 Preparation of a prefecture plan

Receiving the request as written above, Kagawa Prefecture Government immediately organized a task force for the preparation of a plan consisting of staffs in charge from relevant departments of the government with recognizing the appropriateness of the request and the necessity of promoting the implementation of projects concerning the water quality conservation of drinking water sources. Kagawa Prefecture Government completed "a Plan for Promoting the Implementation of Regional Projects Concerning the Water Quality Conservation of Drinking Water Sources: Upstream Areas of the Raw Water Intake of Shioki Water Purification Plant of the Takuma Town Waterworks" with taking three upstream municipalities into its scope in June, 1995.

The plan included descriptions on implementing organizations, target areas, number of facilities, served population, treatment system, implementation period and rough cost estimates concerning three projects on the development of rural wastewater treatment systems and the other three projects on the development of on-site household wastewater treatment facilities as regional projects necessary for the water quality conservation of drinking water sources. The plan also mentioned proper management of livestock wastes.

In addition, it is described in the plan that the quality of drinking water sources were deteriorated; BOD concentration at the intake point was 2.2-11 (5.2 in average) mg/L, which did not comply with the environmental quality standard, and total THMs formation potential of the raw water was so high as 0.134-0.464 (0.299 in average) mg/L according to a result of water quality monitoring in FY 1993.