5．発表論文

Watershed Management Approach in Sewage Works

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1. INTRODUCTION

In April 2003, the Sewerage and Watershed Management Subcommittee, which was set up by the Urban Planning and Historical Landscape Section of the Social Infrastructure Council of the Ministry of Land, Infrastructure and Transport, published a report entitled "The Policy Concept of Sewerage Construction/Management and Watershed Management". This report was epoch-making in that it gave a definition to "the approach to watershed management". The definition is as follows:

Bringing together sewerage managers in the basin, tying them up extensively with other bodies including local citizens and businesses, and among those stakeholders,

(1) sharing a common concept and purpose,

(2) sharing the risks and the burdens required to reduce them, and

(3) while reducing overall risks and burdens to the minimum, promoting the achievement of common objectives via co-operation

The report calls above-mentioned approach "watershed management approach" in sewage works.

In order to address water-related issues including water pollution, this issue must be identified as a common problem for local governments and citizens/businesses in the basin, and a variety of efforts such as wastewater treatment must be mobilized effectively. The "Comprehensive Basin-wide Plan of Sewerage Systems (CBPSS)" is a typical example of the watershed management approach in sewage works. As compared with other water administrations, a sewerage administration strongly suggests the necessity of "the watershed management approach", because sewerage managers are all local authorities, i.e. municipalities and prefectures. One river basin generally has plural municipalities, and the benefit of sewage works spreads over wider area beyond administrative boundaries.

Hereinafter, the concept and practices of CBPSS are outlined. CBPSS was legislated into Sewerage Law in 1970 and have been formulated in over 100 river basins across the country. Following focus is the new policy on Tokyo Bay Renaissance. This policy is unique in that it was established in the basic policy of "Urban Renaissance" of the Government of Japan and all the

ministries and agencies concerned are involved. Finally the study on water quality trading is described. The study has just started in order to rationally approach the consensus on the best combination and cost-allocation of advanced treatment between sewage treatment plants.

2. COMPREHENSIVE BASIN-WIDE PLAN OF SEWERAGE SYSTEMS (CBPSS)

CBPSS typifies the watershed management approach in water administration in Japan.

2.1 Aim

CBPSS is a master plan of sewerage systems which Article 2-2 of the Sewerage Law obliges each prefecture government to formulate in principle for pollution control in all the public water bodies where water environmental quality standards are set on the basis of Article 16 of Basic Environment Law. In order to achieve and keep fulfilling the standards through sewerage construction and management most effectively, CBPSS is formulated as a master plan of individual sewerage projects from the viewpoint of watershed management.

2.2 Planning Items of CBPSS

CBPSS is drawn up for the public water body that is polluted by wastewaters discharged by the sources in two or more municipal areas. The main items described in CBPSS are as follows:

(1) basic policy relating to sewerage construction
(2) effluent discharge from sewerages and planning of sewage treatment areas
(3) basic layout, structure and capacity of main sewerage facilities
(4) priority of undertaking of sewerage projects

After liaison with the relevant authorities and then referring to the opinions of the municipalities, prefecture government draws up a draft of the plan. In the case of the water bodies pertaining to plural prefectures, relevant prefecture government is supposed to have conference with the Ministry of Land, Infrastructure and Transport (MLIT) as well as the other relating prefecture governments for the adjustment on the assignment of pollution load reduction to prefectures concerned. On the basis of reached consensus, draft CBPSS is submitted to MLIT, which then gives approval to the prefecture's request after discussing the planning proposal with the Ministry of Environment.

2.3 Assignment of Allowable Loads to Prefectures

As mentioned above, when the basin extents over two or more prefectures, agreement must be reached between the relevant prefectures regarding the pollution load reduction before the formulation of CBPSS in each prefecture. The agreement is basically made on the "allowable pollution load" representing a load discharge permit that should be fulfilled for the water body to achieve its environmental standards. Regional bureau of MLIT plays an important role in making adjustments between prefectures, taking fairness and efficiency into account, on the basis of the simulation of pollution loads and water quality.

The assignment of allowable loads to prefectures was finished in Tokyo Bay, Osaka Bay, Ise Bay and Seto Inland Sea, as well as for major rivers such as Tone, Kiso and Yodo Rivers. Figure 1 shows an image of the assignment of allowable pollution loads to prefectures relating to Tokyo Bay.

In March 1997, the committee on CBPSS for Tokyo Bay was held by the Kanto Regional Construction Bureau of the Ministry of Construction (the present Kanto Regional Development Bureau of MLIT), and the consensus shown in Table 1 was reached regarding the future

allowable pollutions loads between Tokyo Prefecture, Kanagawa Prefecture, Saitama Prefecture, and Chiba Prefecture.

Table 1. Assignment of Allowable Load Targets between Prefectures Relating to Tokyo Bay (t/day)

	COD	Total Nitrogen	Total Phosphorus
Tokyo Metropolitan Area	56	73	3.5
Kanagawa Prefecture	27	30	1.3
Saitama Prefecture	41	38	1.7
Chiba Prefecture	68	54	3.3
Other areas	26	25	0.7
Total	218	220	10.5

Note: Other areas mean northern three prefectures above Metropolitan areas. Pollution loads come also from these areas via Tone River into Tokyo Bay.

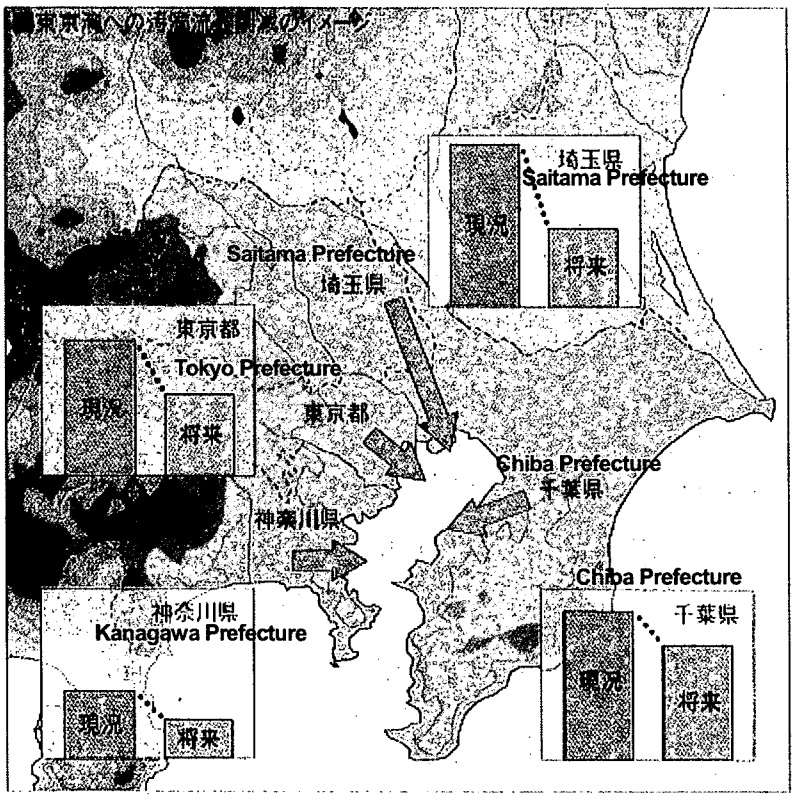

Figure 1. Image of Future Allowable Pollution Loads in Tokyo Bay Basin
Left histogram: present load, Right histogram: future allowable load

In Tokyo Bay basin, assuming that the construction of sanitary sewer network will be almost finished by the target year of 2012, load was estimated for each prefecture as of 2012 and allowable load was assigned to each prefecture in this proportion. However, allowable pollution load is generally assigned to each prefecture in proportion to the load contribution in base year to water quality at the point of observation.

The result of subtracting the allowable load from the future load, which is projected on the assumption that no additional measures will be taken before the target year, is defined as "load reduction". The load reduction is assigned not only to sewage treatment plants, factories and other point sources, but also to non-point sources such as urban areas and agricultural areas. Natural loads such as forests, plains and rain are in principle not taken into account for the load reduction assignment. In this case, load reduction is often assigned assuming that all sources, which are assigned load reduction, should achieve the same reduction rate. However, there are actually no legal guaranties whatsoever for any point sources other than sewerage. In other words, CBPSS scheme has no legal effect on the factories, even if the load reduction is assigned to them in the formulating process of CBPSS.

In the planning process of CBPSS for Tokyo Bay, the load reduction is assigned to the related sources as shown in Figure 2

Table 2. Assignment of Load Reduction to Sewerage (t/day)

	Future Load	Allowable Load	Load Reduction	Load Reduction by Sewerage
COD	326	218	108	66
Total N	405	220	185	174
Total P	26	10.5	15.5	14.1

Figure 2 shows the assignment of nitrogen load reduction among sources in Tokyo Bay Basin.

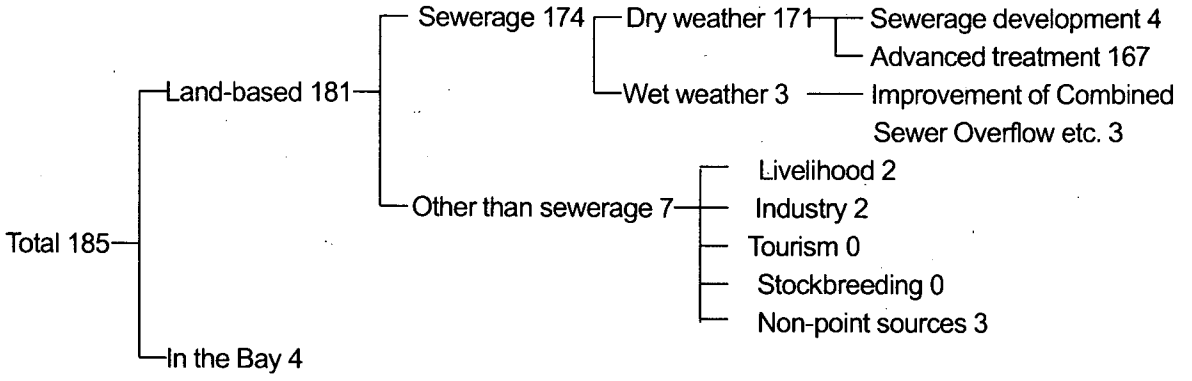

Figure 2. Assignment of Total Nitrogen Load Reduction in Tokyo Bay Basin (t/day)

After the assignment of load reduction relating to sewerage among prefectures, each prefecture government assigns its own portion between sewerages. This assignment is often made assuming that the water quality of future effluent should have almost no difference between sewage treatment plants. But some prefectures set more stringent load reduction for large-scale treatment plants than for small scale..

2.4 Implementation of CBPSS

About 200 CBPSSs are supposed to cover almost whole of Japan, and 123 plans have already been drawn up as of January 2003.

3. ACTION PLAN FOR TOKYO BAY RENAISSANCE

3.1 Urban Renaissance Project "Ocean Renaissance"

The Urban Renaissance Headquarters chaired by the Prime Minister was established on the basis of the Cabinet decision in May 2001 to promote urban revitalization projects which are creating new society of 21st century from the viewpoints of the environment, disaster prevention and internationalization, and to promote general consolidation of policies aimed at urban revitalization such as making effective use of land resources. The Urban Renaissance Headquarters, in its fifth meeting (December 2002), decided the basic policy of "Ocean Renaissance" for the Metropolitan area where water pollution has become a chronic problem. The policy includes the formulation of "Action Plan for Tokyo Bay Renaissance (Action Plan)", through collaboration among relevant authorities such as related local authorities and government agencies, focusing in particular on the water quality improvement in offshore coastline areas.

To develop and effectively promote the Action Plan for better water quality, in February 2002, was established "Tokyo Bay Renaissance Conference (Conference)" in which four prefectures including the Metropolis of Tokyo, three major cities and related government ministries/agencies participate. The Conference set up following subcommittees: "Organizing Subcommittee", "Land-based Measure Subcommittee", "Ocean-based Measure Subcommittee" and "Monitoring Subcommittee".

As a result of the discussion at the Conference as well as Subcommittees, in March 2003, the Conference published the Action Plan, which contains policies and measures to be implemented by relevant authorities to achieve common objectives of restoring Tokyo Bay to a clean, beautiful and ecologically sustainable ocean in 10 years.

The Action Plan, as shown below, has some unique features, and is full of suggestions for the future policy-making of watershed management.

(1) Ocean renaissance is evaluated from the viewpoint of regenerating the urban environmental infrastructure in the Metropolitan area.

(2) This is a joint project between local authorities and relevant government ministries.

(3) It poses not only environmental standards for the ocean environment, but also local targets which are close to the needs of the urban population.

3.2 Action Plan for Tokyo Bay Renaissance

3.2.1 Objectives

The Action Plan puts forward the objectives outlined below from the viewpoint that city residents can understand them easily. It is also recognized that we need to promote initiatives for

improvements through the cooperation and joint activities of a wide range of parties concerned, including administrative agencies.

Objectives

We will seek to recover a familiar and beautiful sea and to create opportunities to comfortably enjoy recreation activities in and near the water. We want a Tokyo Bay that enhances the quality of life for residents of the metropolis and a marine environment in which many organisms can live.

In order to assess how far this objective is being achieved, the bottom layer DO (dissolved oxygen) was selected for the common index of the achievement. It is a marker indicating daily stresses on benthic organisms living all the year around.

3.2.2 Key Areas

In accordance with the objectives outlined above, key areas were employed corresponding to regional needs, on the basis of the evaluation of the current environment and water use situation.

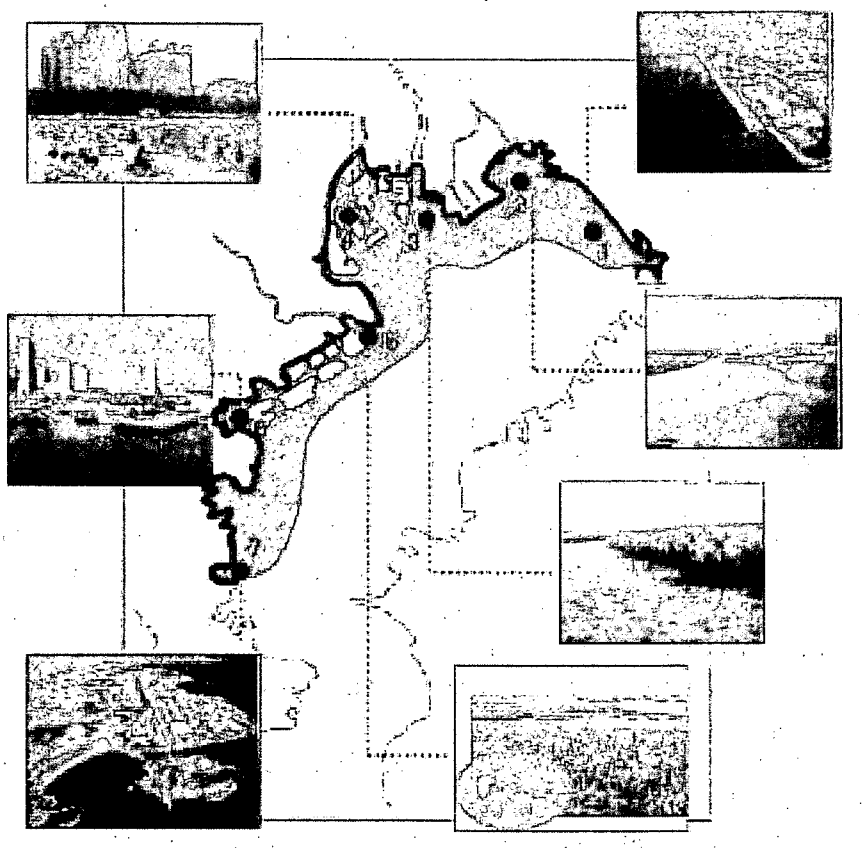

Figure 3. Key Areas and Appeal Points
Key areas , Appeal point: ●

Scope of key areas: Offshore of coastline from Kanazawa Ward in Yokohama City and Chuo Ward in Chiba City
Key areas concept:: Areas to be improved with special emphasis for Tokyo Bay Renaissance

Appeal points concept: Places where citizens will be able to readily feel the effect of the improved environment as a result of the measures taken—places where we can plainly evaluate the effects of the measures. (The appeal points are different from the sites where actual measures are taken.)

Seven representative points (appeal points) have been selected and the image of improvement, corresponding indexes and targets are described for each point as shown in Figure 3 and Table 3.

Table 3. Outline of Appeal Points

No.	Point name	Location	Image after improvement	Indexes	Aims, objectives: Environmental evaluation classification for 7 prefectures and cities; "objectives that city residents can understand"
1	Vicinity of Inage and Makuhari Beach	Sites around artificial beaches at Inage, Kemigawa and Makuhari	Beaches with greenery for comfort and recreation	- Environmental evaluation classification of 7 prefectures and cities (Note 1) - Organisms	- Above environmental evaluation classification Level II for 7 prefectures and cities (Note 2) - Water environment where organisms such as blowfish, goby, short-necked clam and lugworm can live.
2	Vicinity of Sanbanse	Precious tideland and shallow maintained in deepest areas at head of bay	Protection of natural environment of Sanbanse and restoration of the sea as amenity for residents	Study results of work of Sanbanse Renaissance Plan Study Group	Study results of work of Sanbanse Renaissance Plan Study Group (Ref.) Objectives at stage of interim summary To secure: - Living species and environmental diversity - Continuity between land and sea - Sustainability and recuperative power of environment - Productivity of fishing grounds - Citizens' enjoyment of nature
3	Vicinity of Kasai Seashore Park	The waters around park and Sanmaizu	Protection of natural environment and tideland/beach for animals	- Environmental evaluation classification for 7 prefectures and cities - Organisms	Above bottom environmental classification Level III - Environment where short-necked clam and trough shell can live - Environment where little tern can build nests
4	Vicinity of Odaiba	Odaiba Seaside Park and Sibaura Canal	Beautifully landscaped waterfront enjoyable for citizens	- Environmental evaluation classification for 7 prefectures and cities - Organisms - Water quality	Above bottom environmental classification Level III - Environment where short-necked clam and Japanese dosinia can live - In fiscal 2015, eliminate days (zero days/year) when white solids (fats) from combined sewer system drift ashore on rainy days at Odaiba Seaside Park. - Water purification experiment at Odaiba Seaside Park will aim at objective water quality stated below. (Experiment to be conducted between 2002 and 2005.) COD 5mg/l Fecal coliforms 100pieces/ 100mL
5	Vicinity of Tamagawa River mouth	Waters surrounding tidelands near Tamagawa River Mouth and Hanedasu	Raise diverse animals; create beach rich with nature	- Environmental evaluation classification for 7 prefectures and cities - Organisms	Above environmental evaluation classification Level II for 7 prefectures and cities - Sea environment where short-necked clam, freshwater clam, lugworm, mud skipper, goby, Japanese seaperch, Chigogani and Ashiharagani can live. Environment where longbill, plover, little

					tern, oriental reed-warbler, spot-billed duck, gallinule and other wild birds come more frequently and build nests without fear.
6	Vicinity of Minato Mirai 21	Waters around Yokohama Port Inner Harbor	Water amenity zone open to citizens. Waterfront where people can feel port atmosphere.	- Environmental evaluation classification for 7 prefectures and cities - Water quality - Organisms	- Above environmental evaluation classification Level II for 7 prefectures and cities - Achieve and maintain water environment targets for Yokohama City - Sea environment where blowfish and sea perch can live and brown seaweed and other plants form marine forest.
7	Vicinity of Sea Park and Hakkeijima	Bathing beach at Kanazawa and marine recreation waters	Waterfront where people can enjoy various marine sports such as bathing, shellfish gathering and fishing.	- Environmental evaluation classification for 7 prefectures and cities - Water quality - Organisms	- Above environmental evaluation classification Level III for 7 prefectures and cities - Achieve and maintain water environment targets for Yokohama City - Marine environment where Japanese whiting and Osagani can live, and eelgrass and other seaweed form marine forest.

Note 1. Environmental evaluation classification for 7 prefectures and cities means the bottom environmental evaluation classification set by the Specialized Subcommittee for Improving Water Quality, the Committee for Measures against Environmental Problems at the Summit of 7 Prefectures and Cities.

Note 2. This aim was set on the basis of the current status at a distant observation point due to absence of an observation point near the appeal point. Readers must consider this point.

3.2.3 Period of the Plan

The period of the plan is the ten-year starting in fiscal 2003.

3.2.4 Promotion of policies to achieve the objectives

(1) Measures to Reduce Land Pollution Loads

(a) To reduce pollution loads from the land, specific measures should be efficiently implemented, while steadily pursuing the Plan for Reduction of Area-wide Total Pollutant Load.

(b) Advanced treatment for preventing eutrophication should be promoted in addition to the development of conventional wastewater treatment

- Advanced treatment should be started in about 20 sewage treatment plants.

(c) Wet weather load should be reduced.

- The combined sewer systems should be reconstructed so that the total load of BOD may be reduced to the level of separate sewer system.

(d) In addition to the removal of organic pollution load by river purification facilities or dredging, the reduction of nutrients should be promoted for the restoration of swamps and estuary tidelands.

(e) To reduce the load from non-point sources, sound growth of trees and thickness of the underbush by proper thinning and development of multiple-layered forests should be promoted. Also, treatment of storm water and control of storm water runoff by installing storage and infiltration facilities should be conducted to reduce the pollutant loads from non-point sources..

(f) Regarding the collection of floating garbage, the efforts of local citizens should be promoted.

(g) Cost allocation should be studied for sharing the total cost appropriately among stakeholders in the basin including the application of economic instruments.

(2) Promotion of Environmental Improvement Measures in the Sea

(a) Reduction of ocean area pollution load

- Regarding the accumulated organic substances in canals, etc, efforts should be made to effectively remove the bottom mud (improving bottom sediment by development of shallows using good sediments (covering sand) originating from dredged sludge or good-quality soil).
- There is a plan to use cleanup ships to completely collect and remove garbage floating on the ocean surface. The development of the technology to recover red tide and its application should be conducted.
- Efforts to collect garbage on the seabed and clean up beaches or tidelands in cooperation with NPOs and fishing association should be promoted.

(b) Enhancement of Purification Function in the Sea Waters

- Existing, precious tidelands and shoal should be conserved as much as possible while maintaining harmony with the other public welfare.
- Tidelands, shoals, beaches and stony shores will be reclaimed/created.
- Harbor structures should be developed to accelerate adhesion of living organisms. Gently sloping seawalls, reclaiming deep ditches, aeration of seawater should be promoted to create an ecological environment for bottom marine lives.
- From the point of long-term view, an information network on tidal flats and shallow water areas should be established.

(3) Monitoring of Tokyo Bay

(a) Improvement of Monitoring

- The monitoring of bottom layer DO and benthic organisms should be strengthened.
- Ocean currents and water quality should be monitored extensively by monitoring posts and ships
- Events such as the red tide should be monitored in real time by artificial satellites.

(b) Sharing and Transmission of Monitoring Data

- A website to collect pertinent information should be set up together with related links.

(c) Community Monitoring Activities

- Beach cleaning and classification survey of drifting garbage should be performed in cooperation with local residents.
- Cooperation with NPOs that perform environmental conservation activities such as "Sea Guards" in Tokyo Bay should be strengthened.
- More opportunities should be provided where environmental conservation activities performed by citizens and NPOs can be presented to the public.

3.2.5 Other

(1) Experimental Initiatives

(a) Water purification by the Metropolitan Government in Odaiba

(b) Monitoring by regular ferries

(c) Observation by marine shortwave radar

(d) International exchanges

(2) Follow-up on the Action Plan

The progress of the Action Plan should be followed up, while assessing and promoting its steady implementation. The Action Plan should be reviewed as necessary.

4. STUDY ON WATER QUALITY TRADING BETWEEN SEWAGE TREATMENT PLANTS

4.1 Background

In the Action Plan for Tokyo Bay Renaissance, it is determined that the cost allocation should be studied for sharing the total cost appropriately among stakeholders in the basin including the application of economic instruments. Also, the report "Opinions on Businesses and Enterprises - towards an Autonomous, Self-governing Local Community" which was published by the Council for Decentralization Reform in October 2002, proposed that "cost-sharing in the whole basin should be considered from the viewpoints of the responsibilities of both dischargers and beneficiaries in order to efficiently achieve the objectives of water quality environmental standards in basin units".

On the basis of these plan and proposal, the MLIT set up "Study Committee on Water Quality Trading between Sewage Treatment Plants" in 2002, which performed investigations based on simple model calculations for pollution load discharge permit trading targeted at advanced sewage treatment in Tokyo Bay basin.

4.2 Pollution Load Discharge Permit Trading Model Targeted at Sewage Treatment Plants in Tokyo Bay Basin

In order to quantitatively appreciate the effect of discharged load limits trading on total cost reduction, a simple trading model was designed for advanced sewage treatments in Tokyo Bay basin.

(1) Assumptions

(a) Targeted areas: Tokyo Bay basin (Tokyo Metropolitan Area (Tokyo Prefecture), Kanagawa Prefecture, Saitama Prefecture, Chiba Prefecture)

(b) Targeted pollutant to be traded: equivalent total COD obtained by converting nitrogen and phosphorus into COD considering eutrophication in addition to COD. Equivalent COD was defined as COD+3.24xT-N+51.09xT-P in this study.

(c) Targeted sewage treatment plants: 77 municipal sewage treatment plants in Tokyo Bay basin

(d) Pollution load: to simplify the model, completion of secondary treatment is assumed for all the sewerage systems.

(e) The baseline for the trading is assumed to be the same as the assignment of allowable load targets between prefectures relating to CBPSS for Tokyo Bay. (See Table 1)

(2) Concept of the Model

(a) Load reduction according to each categorized advanced treatment option

The pollution load discharge for each categorized advanced treatment option is calculated by "daily effluent flow x categorized effluent water quality". Table 4 shows the categorized effluent water quality for each treatment level. Pollution load reduction is obtained by the difference between thus calculated load discharges.

(b) Estimation of marginal unit cost for every advanced treatment option

- The marginal cost of advanced treatment of level 1 was estimated based on querying survey toward municipalities. The marginal unit cost is the marginal cost divided by load reduction.
- The unit costs of level 2 and level 3 were obtained by multiplying the marginal unit cost of level 1 by the unit cost ratios, which were estimated through studies on standard model cases.

-Marginal unit costs of level 2 and 3 are the differences between above unit costs of level 2 and 1, and level 3 and 2, respectively.

(c) Balanced price in trading

- Arrange the advanced treatment options according to marginal unit cost, and then accumulate the load reduction of options in this order. (See Figure 5) When the accumulated load reduction reaches the goal of total load reduction, then the marginal unit cost of final option is the balanced price.

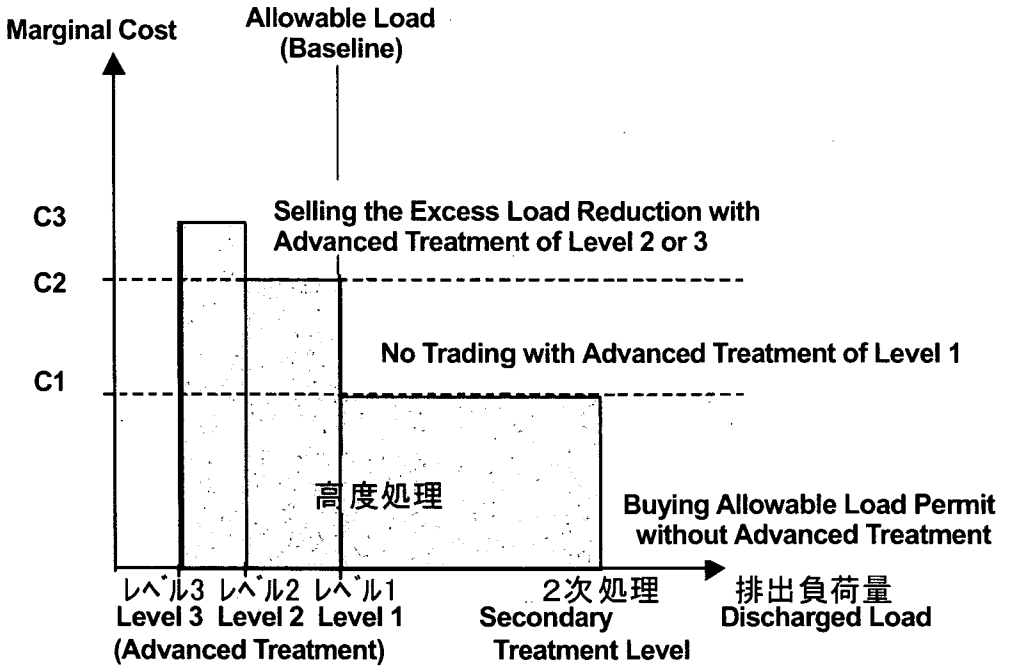

Figure 4. Estimation of Load Reduction and Its Cost for 3 Options of Advanced Treatment

Table 4. Effluent Water Quality for Categorized Treatment Option (mg/L)

	Secondary Treatment	Advanced Treatment		
		Level 1	Level 2	Level3
COD	15	8	8	5
T-N	25	8	5	3
T-P	2.0	0.4	0.2	0.1
Example Method	Conventional Activated Sludge	A2O	Flocculants addition +Step-feed multistage denitrification-nitrification	Level 2 +Post-denitirification

(3) Effect of Load Trading (Cost Reduction Effect)

(a) Overall effect

As the result of the simulation of water quality trading relating to advanced sewage treatment in Tokyo Bay basin, it was shown that a maximum overall cost reduction of about 10% could be expected. (See Figure 5)

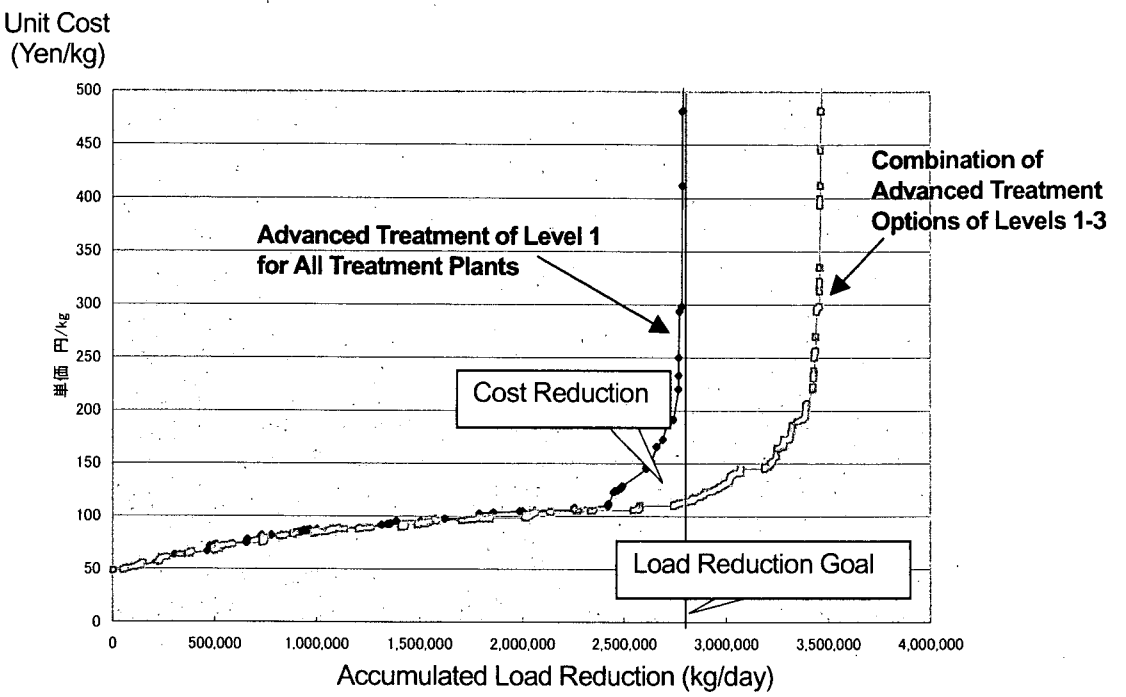

Figure 5. Accumulated Load Reduction in Order of the Options of Lower Unit Cost

(b) Cost reduction effect for each prefecture

Tokyo Prefecture is a seller, while Saitama Prefecture, Chiba Prefecture and Kanagawa Prefecture are buyers of load discharge permit, as a whole. Cost reduction ratio is about 10% in Saitama Prefecture, Chiba Prefecture and Tokyo Prefecture, and about 20% in Kanagawa Prefecture

(c) Difference in cost reduction effect between treatment plants

Of 77 treatment plants, 23 treatment plants are buyers, and 46 treatment plants are sellers. 8 treatment plants are neither buyers nor sellers, because they select the advanced treatment plant of level 1. The cost reduction is a maximum of 90% on the buyer side and a maximum of 28% on the seller side.

(d) Leveling effect on burdens between treatment plants

Although the unit costs of advanced treatment of level 1 vary widely among treatment plants, the net expenses (=cost of advanced treatment + payment, or – receipt in the trading) of all the treatment plants converge to some range as the result of trading. The burdens, therefore, are leveled between treatment plants.

5. THE FUTURE OF WATERSHED MANAGEMEN APPROACH IN JAPAN

Watershed management approach is a pregnant key word for policy-making in addressing water-related issues in general. Particularly this approach is needed in sewerage administration, because local authorities conducting sewage works are apt to focus on their own benefits alone, leaving public welfare beyond their administrative boundaries.

Inundation Control Law in Specific Urban River Basin was enacted last June on the basis of the concept of watershed management approach. According to this law, all the stakeholders including citizens as well as prefecture governors, mayors, river managers and sewerage managers in the river basin are regulated and obliged to do their duties. For example nobody can develop building estate over regulation scale without storm water runoff control. Relevant public sectors must go into partnership with each other to establish the Basin-wide Plan of Inundation Control (BPIC), which stipulates public authorities in the river basin take concerted actions toward the prevention against flood and inundation damages. Sewerage managers are, therefore, supposed to take joint responsibility for inundation control in the whole river basin together with the river manager and other public authorities concerned.

CBPSS and BPIC typify the legally realized scheme of watershed management approach. But many water-related problems still remain for solution through watershed management approach in Japan.