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WATER DEMAND MANAGEMENT: AN EVALUATION OF A "SOFT" SOLUTION FOR THE HAMILTON HARBOUR REMEDIAL ACTION PLAN

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ABSTRACT

The investigation of actions for the remediation of Hamilton Harbour has focussed largely on the traditional "end of the pipe" solutions to the problems of municipal wastewater treatment. This paper attempts to place one "at source" solution, water demand management, into the context of the remedial action plan. Fully developed relationships between volumes of water usage and the quality of sewage treatment facility effluent have not yet received an adequate degree of investigation. Nevertheless, ample evidence is available to suggest that water demand management is the most cost effective method for the remedial action of municipal water pollution for Hamilton Harbour.

KEYWORDS

Sustainable development; wastewater; water demand management; water conservation; remedial action plan; Hamilton Harbour; municipal sewage treatment facility.

INTRODUCTION

Hamilton Harbour is one of 42 Areas of Concern that were designated by the International Joint Commission of Canada and the United States as having a high degree of environmental degradation. Hamilton Harbour is located at the western end of Lake Ontario where it is separated from the Lake by the Burlington ship canal. The surface area of the Harbour is 2150 hectares, with a mean depth of 13 meters, a maximum depth of 26 meters and a hydraulic residence time of about 90 days.

The environmental problems of the Harbour include contaminated sediments, severe eutrophication with algal growths, high metal concentrations and other contaminants in the water column, excessively accumulated body burdens of contaminants in fish and other aquatic biota, widespread bacterial contamination, poor water clarity, an environmentally stressed warm water fishery and a greatly reduced and stressed wildlife population.

Urban centers, mainly the cities of Burlington and Hamilton, located in the watershed, comprise in excess of half a million people contributing wastewater to the Harbour through four wastewater treatment plants and 26 combined sewage (sanitary and storm) overflows (CSO's). The Harbour's deep water port supports the largest concentration of heavy industry in Canada. While the drinking water for the watershed is largely from intake pipes located in Lake Ontario (some 368,000 cubic meters/day), that water is largely discharged to the Harbour making it the single largest source of water input to the Harbour.

Two companies make up the iron and steel industry and are the only users of Hamilton Harbour that directly withdraw and discharge water from the Harbour. Some 20 million cubic meters (cu.m.) per day are withdrawn, used largely as contact cooling water, then discharged through their secondary level wastewater treatment facilities.

Major loadings to the Harbour in 1987 included:

- o Ammonia - total discharges of 7500 kg/day (4 mg/l) including 850 kg/day from the industrial discharges.
- o Phosphorus - total loadings of 520 kg/day of which 10 kg/day came from industrial discharges, 290 kg/day from the Hamilton sewage treatment plant (STP), 40 kg/day from the Burlington STP, and 78 kg/day from CSO's.
- o Other steel industry - including zinc at 80 kg/day (77% of total harbour loadings of zinc); phenols at 38 kg/day (harbour concentrations of 0.4% µg/l); PAH's at 1.8 kg/day; cyanide at 184 kg/day; iron at 3270 kg/day (80% of all loadings to the harbour); and 12000 kg/day of suspended solids.

From a nutrient perspective, the sewage treatment plants are clearly the major source of pollution to the Harbour, and as a consequence, any attempts at remedial action must concentrate on reducing the impact of these inputs. Preliminary target loads were set, by the RAP writing team, at 3600 kg/day for ammonia and 200 kg/day for total phosphorus. Although swimming is not permitted in the Harbour currently, control of bacteria from sewage treatment plant by-passes, sewage treatment effluent, and combined sewer overflows would be a prerequisite for contact recreational activities as part of the remedial action plan.

WATER PRICING

Water demand management is an economically efficient approach to water conservation, in as much as appropriate market pricing affects the demand for water use and consumption. Water has traditionally been considered a free good in our society and one that is available in abundance. It is this illusion of abundance that has led to policies that contribute to waste and inefficiency in the use of water (Postel,1984). Because water is not considered in the market as are other goods, it has become used without due regard for quality.

Market forces would foster conservation and a reallocation of water supplies to their highest valued uses (Postel, 1984). Brooks and Peters (1988) present overwhelming evidence that higher prices for water do lead to reductions in use, and that water is more valuable in some uses than in others. Although the response to a given price increase may vary depending on its relative price elasticity, the general relationship between water prices and water usage is readily understood and intuitively comprehensible. Some countries, such as England, France, West Germany, and the Netherlands have recently adopted economic principles in the allocation of water resources and the pricing of water services (Foster and Sewell, 1981).

In Canada, water is not priced at the marginal cost of equivalent water quality replacement and, in addition, there is seldom any charge for the withdrawal of water from a waterbody or for the dumping of wastes into it. A recent survey of Canadian communities (Environment Canada, 1989) showed that 71%, including those with the highest water use, set prices for water using a flat or declining block rate basis. Less than 2%, of those communities surveyed, had a volume based schedule where the consumer paid more for each additional unit of water used in the household. Even among those with a block rate, the first block was so great by volume that the effect was equivalent to a flat rate.

WATER USE IN HAMILTON HARBOUR

Water and sewer rates in Hamilton and Burlington, the two major communities that surround Hamilton Harbour, are fairly typical of rate schedules in Ontario. Burlington's water and sewer rates are based on a uniform structure, where the price of each cubic meter of water is the same regardless of the quantity used or discharged. Residential users are charged a monthly service charge based on 100% of water consumption up to a maximum of 46 cu.m. per month per residential unit. The residential sewer surcharge incorporates a 15% discount to allow for water not discharged into the sanitary sewer system. Commercial and industrial users pay slightly higher monthly water and sewer service charges but face the same per unit rates as residential customers ($0.2914/cu.m. for water and $0.3539/cu.m. for sewers- 1989). Current average household consumption is approximately 300 cubic metres per year.

In Hamilton, water and sewer rate structures are a combination of flat rates and uniform or declining rates, the flat portion representing a cost for minimal service. Residential users are charged a minimum $5.63 per annual quarter for the first 14 cu.m. of water and $0.26 for each additional cu.m. Sewer rates are based on 116% of water consumption. Unlike Burlington where all users are metered, there are 66,000 properties in Hamilton that pay a flat rate regardless of water use. Industrial and commercial users face a minimum pipe-dependent charge for the first unit of volume and a declining block rate thereafter.

WATER MANAGEMENT

Recent cross sector water use and pricing data analysis, by Arthur Shaw of Environment Canada (1988) has demonstrated the elasticity of demand with respect to price for municipal water services across Canada. In general, his conclusions are that for each one dollar increase in the cost, to consumers, of an additional cubic meter of water used, there would be a 45% decline in water use across the country. This would vary from a high of 76% in British Columbia to a low of 21% in Ontario.

Applying this analysis to Hamilton Harbour, and using Ontario-wide average price elasticities, an increase of $1.00/cu.m., at the margin, would lead to a reduction in total water usage of 21%. Nevertheless, such an arbitrary rate increase in the cost of water would still leave a rate structure that is not economically efficient. System efficiency would be optimized only if prices for water track the costs of equivalent quality supply; that is, marginal cost pricing. This would involve a rate structure that rises with quantity used, to reflect the deterioration of water and loss of opportunity value of the resource. Brooks and Peters (1988) suggest that such a rate structure would exhibit a step-like pattern, likely in response to the lack of analysis to support a continuously smooth deterministic supply function. Theoretical studies suggest that reductions of 50% in water consumption could result from increasing block rates.

WASTEWATER QUALITY

The full impact of water demand management, as a remedial action to improve the quality of water discharged from the sewage treatment plants into Hamilton Harbour, is still largely uncertain at this time. If the sewage treatment plants continue to meet existing contaminant targets and standards (e.g., 0.1 mg/l for phosphorus) while processing a water volume reduced by 21%, it follows that there would be an equivalent (21%) reduced mass loading of these contaminants to the Harbour. This is supported by a study on "In-Home Conservation and Wastewater Management" by W.J. Hopp and W.P. Darby (1981) in which a ten percent reduction in water use, with required modifications to the treatment process, was attributed to lead to an equivalent (10%) reduction in biochemical oxygen demand and total suspended solids.

This ability to reduce pollutant loadings through reductions in the dilutant quantity is supported further by Bohac and Sierka (1978). Over the range of process loading factors used in the design of conventional activated sludge processes, they found that the total substrate removal is virtually constant. Thus, there is no indication that increasing wastewater strength while proportionately decreasing wastewater flow will impair the ability of these plants to meet a mass loading discharge requirement. Major reductions in flow could yeild benefits for existing facilities by eliminating hydraulic overloads, extending the service life of components, or reducing overall operation and maintentance requirements.

The effects of flow reduction on various municipal wastewater treatment facilities were studied during the 1976-77 drought in California (Koyasako, 1980). Areawide water conservation programs achieved flow reductions of 5-63%, which resulted in increased influent 5-day biochemical oxygen demand and total suspended solids concentrations ranging from 15 to 40%. Although operational problems were encountered in the collection systems and at the treatment plants, they were not severe enough to affect plant operation greatly. In fact, effluent quality was generally improved.

THE ECONOMICS OF WATER EFFICIENCY

The city of San Jose expects to save in excess of $60 million in capital and operating cost savings, over the next ten years, through its extensive water conservation program. Furthermore, the residents of the city, themselves, are expected to save over $46 million, over that period, through energy and water costs savings. In Tuscon, Arizona, a combination of price increases and public education efforts, to encourage installation of household water-saving devices and replacement of watered lawns with desert landscaping, led to a 24% drop in per capita water use (Postel, 1984). As a result, the Tucson utility's pumping costs were reduced and the drilling of new water-supply wells was deferred.

An estimate of the economic savings to Hamilton Harbour municipalities of the impacts of an effective water demand management program, a one dollar per cubic meter increase in the price of water usage services, can be based on a 21% reduction in pumping, treatment and distribution costs. Total pumpage would decline by about 27 million cu.m. per year at an average cost saving of $0.03/cu.m., or about $0.75 million per annum. Wastewater treatment, assuming minor changes to handle the reduced flows at comparable average operating costs, could lead to an additional saving of $1.5 million per annum. The municipal sewage facility managers have indicated that there might be increased operating and capital costs (increased chemical use, longer sludge retention times and higher sludge removal costs) associated with higher concentrated wastewater.

The revenue implications from a rate increase as great as $1.00/cu.m. are considerable from a financial perspective for the municipalities and the remedial action plan. Allowing for a 21% reduction in water demanded, a consequence of the price elastic effect, the marginal revenue from that size of increase in these municipalities would total $70 million per year. That would approximate the estimate for the installation of all the necessary containment construction for the existing combined sewer overflows, in one year alone. However, the rate increase should not be onerous for the municipal tax payers, who would, essentially, end up paying twice as much for their water supply as before the rate increase. The average municipal resident would not pay more than $400 per year, an amount still relatively low by international comparisons of water pricing.

SUMMARY

Water demand management, in conjunction with or as an element of a water conservation program, would appear to be the single most cost effective action for the remediation of Hamilton Harbour. By making water more realistically priced, by raising its price closer to its true economic value, greater efficiency in the allocation and use of Hamilton Harbour water would be achieved. This would lead to a number of benefits for the Area of Concern:

- o mass loadings of municipally generated wastewater contamination would be reduced;
- o consumers would have a greater awareness and respect for water, use it less wastefully and contribute to long term sustainability of the resource;
- o revenues would be raised from the users of the water to more appropriately pay the costs of water services, the costs of Harbour clean-up, and the costs associated with mitigation of water deterioration through use; and
- o costs for the provision of water services and the costs of mitigating the effects of societal water use would be more equitably recovered from society.

Finally, in the context of equitable treatment, it follows that improvements in water quality associated with other users in the Harbour could also be expedited by the institution of an appropriate pricing scheme for direct water withdrawals and discharges. As the market for environmental goods and services approaches the efficiency of other markets, better allocation decisions, of resources among uses, could be made such that waste is eliminated and long term sustainable development achieved. A first step in that process is to recify the notion that water is a free good, of little value, and to price it appropriately.

REFERENCES

Bhatt, N. R. and C. A. Cole, 1985. Impact of Conservation On Rates And Operating Costs. JOURNAL OF WATER RESOURCES PLANNING AND MANAGEMENT, 111 (2) 192-206.

Bohac, C.E. and R. A. Sierka, 1978. Effect of Water Conservation on Activated Sludge Kinetics. JOURNAL OF THE WATER POLLUTION CONTROL FEDERATION, 50 (10)2313-2326.

Brooks, D. and R. Peters, 1988. WATER: THE POTENTIAL FOR DEMAND MANAGEMENT IN CANADA. Science Council of Canada, Ottawa.

Chechalk, J., pers. comm. Manager of Utility Finance, Finance Department, Regional Municipality of Hamilton-Wentworth. Hamilton, Ontario.

Cober, C., pers. comm. Public Works Department, Regional Municipality of Halton. Oakville, Ontario.

Environment Canada, 1986. CANADA WATER YEAR BOOK 1985 - WATER USE EDITION. Supply and Services Canada, Ottawa.

Environment Canada, 1989. MUNICIPAL WATER RATES IN CANADA, 1986-CURRENT PRACTICES AND PRICES. Social Science Series No. 21, Inland Waters Directorate, Environment Canada, Ottawa.

Flack, E. F., 1981. Residential Water Conservation. ASCE, JOURNAL OF THE WATER RESOURCES PLANNING AND MANAGEMENT DIVISION, 107 (WR1) 85-95.

Foster, H.D. and W.R. Sewell, 1981. WATER- THE EMERGING CRISIS IN CANADA. James Lorimer and Company, Toronto.

Furry, W., pers. comm. Process Supervisor, Engineering Department, Regional Municipality of Hamilton-Wentworth. Hamilton, Ontario.

Halliday, J., pers. comm. Manager of Operations, Engineering Department, Regional Municipality of Hamilton-Wentworth. Hamilton, Ontario.

Hamilton Harbour Writing Team, 1989. Remedial Action Plan for Hamilton Harbour: Stage I Report, Environmental Conditions and Problem Definition. Hamilton, Ontario.

Henningar, G. W., 1984. Water Leakage Control and Sonic Detection. CANADIAN WATER RESOURCES JOURNAL, 9 (3), 51-57.

Hopp, W.J. and W. P. Darby, 1981. In-Home Conservation and Wastewater Management. ASCE, JOURNAL OF THE WATER RESOURCES PLANNING AND MANAGEMENT DIVISION, 107 (WR2) 401-418.

Koyasako, J.S., 1980. EFFECTS OF WATER CONSERVATION INDUCED WASTEWATER FLOW REDUCTION. EPA Report, EPA-600/2-80-137. US EPA, Cincinatti, Ohio.

Maddaus, W.O., Parker, D.S., and A.J. Hunt, 1983. Reducing Water Demand and Wastewater Flow. JOURNAL OF THE AMERICAN WATER WORKS ASSOCIATION, 75 (7), 330-335.

Palmini, D. J. and T. B. Shelton, 1983. Noncrisis Use of Household Water-Saving Devices. JOURNAL OF THE AMERICAN WATER WORKS ASSOCIATION. 75 (7), 336-341.

Postel, S., 1984. WATER: RETHINKING MANAGEMENT IN AN AGE OF SCARCITY. Worldwatch Paper 62, Worldwatch Institute, Washington D.C.

Robinson, J. E., Fitzgibbon, J. E. and B. A. Benninger, 1984. Integrating Demand Management of Water/Wastewater Systems: Where Do We Go From Here? CANADIAN WATER RESOURCES JOURNAL, 9 (4), 29-36.

Skorda, M., pers. comm. Financial Analyst- Utilities, Finance Department, Regional Municipality of Halton. Oakville, Ontario.

Shaw, A., 1988. SENSITIVITY OF MUNICIPAL WATER USE TO WATER PRICE. Inland Waters Directorate, Environment Canada, Ottawa. (unpublished)

Siegrist, R. L., 1983. Minimum-Flow Plumbing Fixtures. JOURNAL OF THE AMERICAN WATER WORKS ASSOCIATION, 75 (7), 342-347.

Yust, L., pers. comm. Manager of Waste, Water Plants Operations, Public Works Department, Regional Municipality of Halton. Oakville, Ontario.