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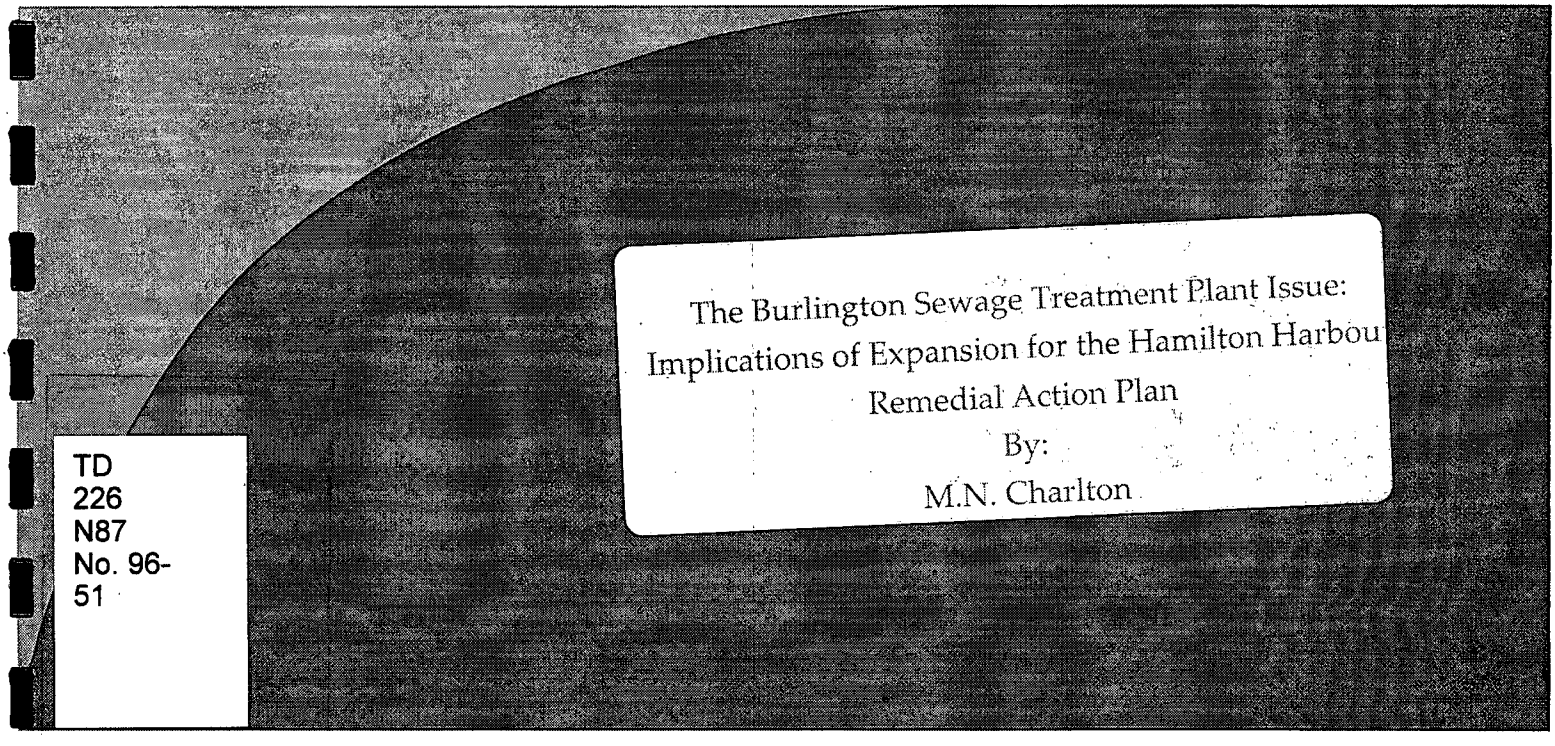

The Burlington Sewage Treatment Plant Issue: Implications of Expansion for the Hamilton Harbou Remedial Action Plan

By:

M.N. Charlton

96-51

THE BURLINGTON SEWAGE TREATMENT PLANT ISSUE: IMPLICATIONS OF EXPANSION FOR THE HAMILTON HARBOUR REMEDIAL ACTION PLAN

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Management Perspective

Projected population growth in Burlington requires new arrangements to treat the increased amount of sewage. Halton Region's preferred option (W_2O Inc 1995a) is to "upgrade and expand" the Burlington Sewage Treatment Plant (STP). The Bay Area Implementation Team (BAIT) requested an analysis of implications for the Hamilton Harbour Remedial Action Plan (RAP). The proposed option would expand the flow through the plant from 93,000 m^3/d to 140,000 m^3/d. Discharge of sewage receiving only primary treatment would be eliminated and the monthly compliance limit for phosphorus concentration in the effluent would be 0.50 mgP/l. The effluent averaged about 0.50 mgP/l in 1994 with some secondary bypassing unaccounted for. At present design flows of 93,000 m^3/d the daily phosphorus load to the Harbour would be 45-50 kg. At the projected flow of 140,000 m^3/d the daily phosphorus load to the Harbour would be 70 kg. The short term RAP goal is to decrease this load to 30 kgP/d. At current flows, this would require a concentration of about 0.30 mgP/l.

The preferred option would, therefore, increase the nutrient load to Hamilton Harbour; this is inconsistent with the RAP goals.

The Burlington STP comprises up to 25% of the phosphorus load of Burlington and Hamilton combined.

Performance variations at the Burlington STP can be as large or larger as those at the Hamilton STP.

Performance variations at the two largest STPs are consistent with short term variations in phosphorus in Hamilton Harbour water.

The Harbour is responding to nutrient loading as predicted from global relationships between nutrient loading and water quality problems. The RAP goals are reasonable, defensible, and consistent with Provincial guidelines for water quality.

Full adherence to RAP nutrient load goals is needed to bring about improvements to water quality in the Harbour agreed to in the RAP process.

Secondary bypassing of barely treated sewage into the Harbour from Burlington STP occurs up to 153 times per year. This problem can be minimized without expansions needed for influent of increased population but this may require plant modifications.

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The Burlington Sewage Treatment Plant Issue: Implications of Expansion for the Hamilton Harbour Remedial Action Plan

Executive Summary

Projected population growth in Burlington requires new arrangements to treat the increased amount of sewage. Halton Region's preferred option (W_2O Inc 1995a) is to "upgrade and expand" the Burlington Sewage Treatment Plant (STP). The Bay Area Implementation Team (BAIT) requested an analysis of implications for the Hamilton Harbour Remedial Action Plan (RAP). The proposed option would expand the flow through the plant from 93,000 m^3/d to 140,000 m^3/d. Discharge of sewage receiving only primary treatment would be eliminated and the monthly compliance limit for phosphorus concentration in the effluent would be 0.50 mgP/l. The effluent averaged about 0.50 mgP/l in 1994 with some secondary bypassing unaccounted for. At present design flows of 93,000 m^3/d the daily phosphorus load to the Harbour would be 45-50 kg. At the projected flow of 140,000 m^3/d the daily phosphorus load to the Harbour would be 70 kg. The short term RAP goal is to decrease this load to 30 kgP/d. At current flows, this would require a concentration of about 0.30 mgP/l.

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Rationale to Consider only Hamilton and Burlington STPs for This Report.

There are several sources of phosphorus in Hamilton Harbour. The Dundas and Waterdown STPs either have tertiary filters or phosphorus loads that are as low as they can be. These are not, therefore, a management issue beyond discussions of whether the discharge sites are appropriate. Hamilton is gradually eliminating combined sewer overflows (CSOs) for sanitary and aesthetic reasons. CSO controls are not, therefore, a management option or an issue. Contributions of phosphorus from Cootes Paradise will reflect the Dundas STP, CSOs, and a large load of suspended sediment with unknown availability. The largest phosphorus contributions subject to further remediation come from the Hamilton and Burlington STPs. The following sections show that the Harbour water quality responds to phosphorus loading changes from the large STPs. Therefore, to simplify the discussion, the information has been restricted to the main sources with control issues; the Hamilton and Burlington STPs.

Progress in the last 10 years: predicting the future

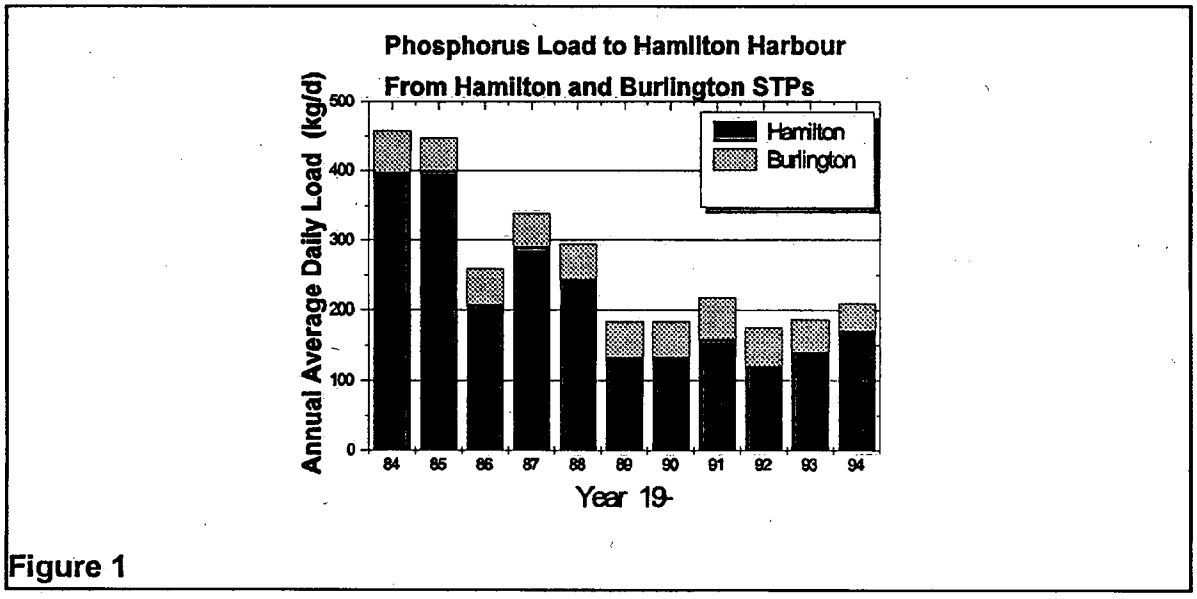

Figure 1

There has been a large reduction in STP loading beginning in the 1970s. Progress in the last 10 years at the Burlington and Hamilton plants is shown in Fig.1. In the last 10 years, reductions in STP phosphorus loads have occurred mostly at the Hamilton plant which is the larger of the two (345000 m^3/d vs. 77000 m^3/d in 1994). Consequently, Burlington's proportion of the total has risen to about 25% since 1989. Burlington's effluent has,

however, improved substantially in 1993 and 1994 with several months below 0.50 mg/l phosphorus.

The summer concentrations of phosphorus in the Harbour during 1984-94 have responded in proportion to the reductions in the combined Hamilton plus Burlington load (Fig.2). The total summer phosphorus concentrations used in Fig.2 are probably about 0.01 mg/l higher than the mean. The RAP predicted that, when its initial goal of 170 kgP/d for the two large STPs was met, the concentration of phosphorus in the water column would be about 0.034 mg/l. Although these initial goals have not yet been met, figure 2 shows that the relationship between concentrations of phosphorus measured in the centre of the harbour and the actual loadings reductions achieved to date is consistent with the predicted relationship. The response relationship in figure 2 shows that the RAP final goal of 0.017 mgP/l in the Harbour would be achieved at the final target load of 72 kgP/d from the two plants. In other words, reality confirms the accuracy of the RAP's understanding of how the Harbour responds to loadings reductions from the two main STPs

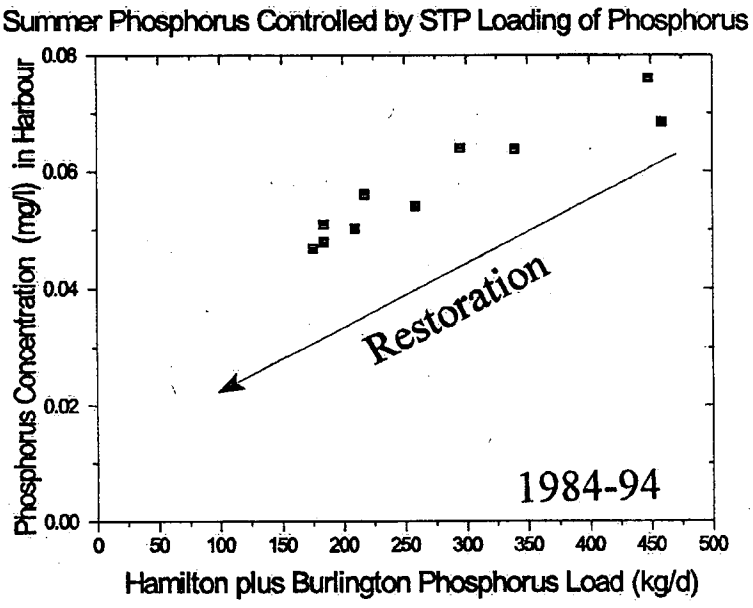

Figure 2

The main point of Fig.2 is that the initial and final goals of the RAP for ambient phosphorus concentrations in the Harbour can be approached by phosphorus load reductions at the Hamilton and Burlington STPs.

Response of Hamilton Harbour Water Quality Indicators to Nutrient Loading

A study sponsored by the Organization for Economic Cooperation and Development (OECD) was begun in 1972 to discover the relationship between nutrients and the trophic state of lakes. This study (Vollenweider and Janus, 1981) provided statistical analyses of the average relationship between phosphorus and chlorophyll and between chlorophyll and Secchi transparency. Over one hundred Canadian lakes were included in the study as well as hundreds of other lakes worldwide.

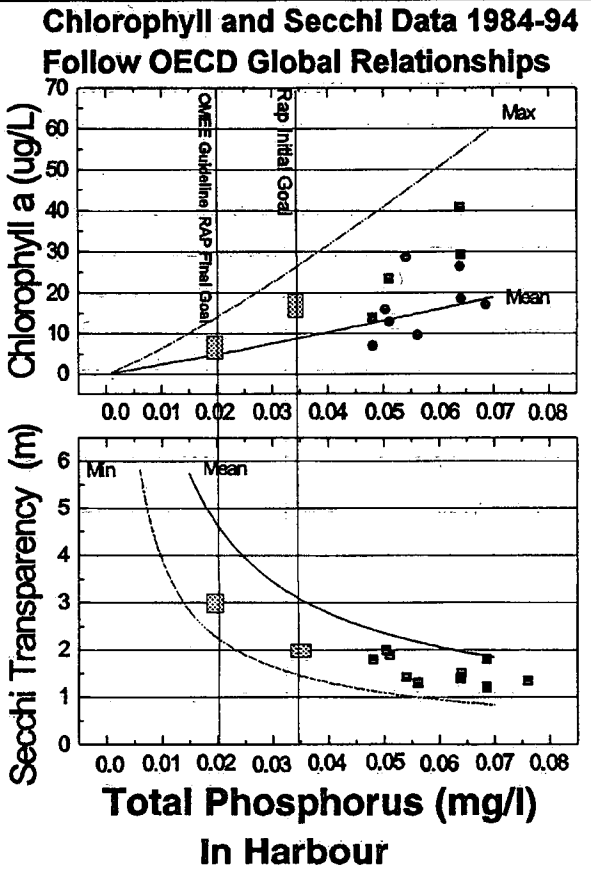

Figure 3

The statistical relationships are shown as the plotted lines in Fig.3. Chlorophyll concentrations curves are predicted from the phosphorus concentrations on the X (bottom) axis. In turn, the Secchi transparency curves are predicted from the chlorophyll. The chlorophyll concentration and Secchi transparency in the harbour for 1984-94 are shown in the figure as solid symbols. The shaded areas in the figure represent the RAP initial and final goals for Chlorophyll and Secchi transparency.

The OECD relationships in Fig.3, although not intended to represent any one particular case, are fairly accurate depictions of the actual situation in the Harbour. In other words, the maximum chlorophyll is actually about 30 ug/l when the mean is around 10 ug/l. Secchi depths are typically 1.5 to 2.0 m as in Fig.3.

Chlorophyll

Figure 3 shows that algal populations have responded well to load reductions at the main STPs. Several of the latest summer averages are below the initial goal of 15-20 ug/l. Following the trend to the RAP final phosphorus load goal of 72kg/d, the final RAP goal of 5-10 ug/l chlorophyll seems achievable, again, by load reductions at the two main STPs. The maximum chlorophyll in a season, however, can be three times the mean. Therefore, full achievement of RAP final phosphorus load goals at the Hamilton and Burlington plants will be necessary to effect acceptable algal populations.

Secchi Transparency

Figure 3 shows that Secchi depth has responded to phosphorus load changes in the last 10 years. The initial RAP goal of 2m is in sight as the average in 1994 and 1995 was almost 2m. The range of values is, however, 1.5 to 2.5 m. Thus, phosphorus loads will have to decline further to meet RAP initial goals. Extending the trend in Fig. 3 in the expected curvilinear shape, the data suggest that the final RAP goal of a 3m Secchi transparency will be achieved at the final RAP phosphorus load goal of 72 kg/d for the Hamilton and Burlington plants.

The OECD relationships reinforce the RAP report:

1. Hamilton Harbour's water quality is consistent with predictions based on the OECD worldwide data. There do not appear to be any reasons to expect fundamentally unusual responses.

2. Now that the system is not heavily overloaded with phosphorus, water quality is responding and can be expected to respond in the future to decreased phosphorus loadings. This is shown by the downward slope for chlorophyll and the upward slope for Secchi transparency.

3. RAP expectations of improved water quality in response to decreased phosphorus loads are reasonable.

Summary

Water quality improvements (phosphorus, Chlorophyll, Secchi transparency) in Hamilton Harbour correlate well with phosphorus load reductions at the Hamilton STP and the sum of Hamilton and Burlington load.

The Burlington phosphorus load has been about 25% of the main STP combined loads since 1989.

The response of the main indicators of phosphorus, chlorophyll, and Secchi transparency indicates that somewhat more nutrient load reduction is needed to reliably meet RAP initial goals.

The response of the main indicators of phosphorus, chlorophyll, and Secchi transparency indicate that full reduction of phosphorus loading to RAP final phosphorus load goals at the Hamilton and Burlington STPs will be needed to achieve RAP water quality goals.

The Scale of Proposed Expansion

The RAP documents do not consider expansion of STP loads. Indeed, the success of the RAP depends on nutrient load reductions.

The major policy issue is whether an expansion of flow at the Burlington STP is a threat to the achievement of the RAP Goals.

How much of a deviation is the proposed expansion of the Burlington (Skyway) plant? The following table presents load scenarios at the 1994 flow volume without the possible 5kg/d of primary bypass phosphorus (W_2O Inc 1995), the present design maximum flow volume, an interim expanded flow, and the maximum proposed flow volume.

Table 1: Phosphorus load scenarios at various flow and effluent concentrations:

Flow	(1000s) m^3/d	concentration mg/l		Load kg/d	RAP Target
	77	1.00		77	
	77 (1994 actual)	0.50		38.5	
design flow	93 (conventional)	1.0	(permitted)	93.0	
	93	0.50		46.5	
	93	0.32		***30.0***	***Initial***
	93 (tertiary)	0.13		***12.0***	***Final***
interim	120 (conventional)	0.50		60	
	120 (conventional)	0.40		48	
	120 (tertiary)	0.25		30	
	120 (tertiary)	0.10		12	
expanded	140 (conventional)	0.50		70	
	140 (conventional)	0.40		56	
	140 (tertiary)	0.25		35	
	140 (tertiary)	0.10		14	

The 1992 load from the Skyway plant was 54 kgP/d according to data reported to OMEE (A. McClarty pers comm). The eventual mean performance of the expanded conventional Burlington Skyway plant is unknown at this time. At a compliance limit of 0.50 mgP/l, a reasonable expectation is, however, that the plant would produce an average effluent of 0.40 mgP/l total phosphorus which is half way between the proposed compliance limit of 0.50 and 0.30 which may be achieved under optimal operating conditions at conventional

plants. This seems reasonable since the proponents claim an operating monthly upper limit of the plant would be 0.50 mgP/l.

Burlington's STP is currently allowed to discharge effluent of 1.0mg/l total phosphorus; a load of 93 kg/d would be produced at the maximum designed flow of 93,000 cubic metres per day. In 1994 the STP performed at an average of 0.50 mgP/l which would represent a load of 46.5 kg/d at the maximum design present flow. There were, however, periods early in the year, when under experimental trials, increased chemical addition achieved effluent concentrations of 0.30 mgP/l which, when coupled with good control of effluent suspended solids, resulted in a loading rate approaching the RAP target of 30 kgP/d. Therefore, at a reasonable performance expectation of 0.40 mgP/l, the expanded Burlington STP would produce 56 kg/d which represents an increased load. Compared to the 1992 load of 54 kgP/d, the expanded plant at a design capacity of 140,000 m^3/d would be about equal. Compared to loads of 1994, however, the expanded plant would cause a 30% increase in phosphorus load.

Only by comparing the performance of the proposed upgrade and expansion with performance permitted at the present design flow or to a year such as 1992 does an advantage appear. Presently, the plant is operating well below its permitted effluent limit of 1.0 mgP/l. The plan to expand the Skyway STP flow will result in an increased phosphorus load to Hamilton Harbour. Additionally, at either interim or final expansion flows of 120 or 140 thousand cubic metres daily, some sort of tertiary treatment would likely be required to meet the initial RAP goal of 30kgP/d.

Table 1 shows that tertiary treatment would enable the Skyway plant to meet the initial and final RAP goals. The operating range of tertiary treatment effluent is between 0.10 and 0.30 mgP/l (XCG 1995). Optimized tertiary plants can operate below 0.10 mgP/l in the effluent (XCG 1995). Thus, there is the opportunity to accommodate growth and improve the Harbour by utilizing tertiary technology. Alternatively, RAP loading goals may be achieved by discharge to Lake Ontario.

Secondary Bypassing at the Skyway plant

According to the South Halton Wastewater Master Plan Progress Report No1 (W_2O Inc. 1995b) secondary bypassing occurred 157 times in 1992, 123 times in 1993, and 43 times in 1994. Apparently, these events represent hydraulic overload of the plant caused by infiltration to the collection system during rainfall events. One interpretation of this information is that partially treated sewage should never be discharged and therefore the plant is already too small. Although STPS are designed to handle peak flows of 2-2.5 times average flows they may still experience bypass under exceptional conditions.

About 4% of the sewage gets only primary treatment according to the No.1 progress report. At a flow of 77,000 m^3/d, and a primary effluent of 6 mg/l phosphorus, the scale of the secondary bypass would be:0.04 X 77000 x 6 =18480g/day = 18.5 kg/day. The W_2O consultants state, however, a fair estimate of secondary bypassing is 5 kgP/d.

The No.1 progress report (W_2O Inc., 1995b) states relative to meeting the RAP effluent goal of 0.30 mgP/l: "The capability of secondary treatment plants to achieve phosphorus levels of about 0.30 mg/l without tertiary filtration has been demonstrated at several Ontario plants, including those in Collingwood, Midland and Bellville....With optimization of the chemical dosing at the Skyway WWTP, it is possible that the target phosphorus level could be achieved in secondary effluent from the plant. However, the current peak flow limitation of the secondary plant, which causes secondary bypassing, would prevent the achievement of that limit in final plant effluent (consisting of secondary and secondary bypass)...Thus, one scenario for achieving the target phosphorus levels at the rated capacity would be to increase the secondary clarifier surface area in the existing plant by adding a fourth set of clarifiers envisioned in the original design."

The secondary bypasses are evidence that the plant is undersized today. Rain events causing the bypasses occur in the summer; this means that extra and avoidable phosphorus has been discharged at the time of year most likely to experience resultant water quality problems.

A full analysis of the available secondary bypass data should be conducted; unfortunately time was insufficient for this report.

The proposed upgrade to the STP to eliminate secondary bypassing at present flows should be in place already regardless of whether the plant is expanded to handle more population.

Performance of Burlington and Hamilton STPs: Importance of Burlington

Burlington

STP performance data were obtained from A. M°CLarty of OMEE West Central office. Monthly data of 1994 for the Burlington Skyway plant are shown in Fig 4.

The mean measured effluent concentration and load were 0.50 mg/l and 37.7 kg/d respectively. The interim RAP load goal for this plant is 30 kg/d. At an effluent annual average TP of 0.50 mg/l, this plant performed substantially better than its 1.0 mgP/l limit. The ability of the plant to produce the low loads of March and October is evidence that performance close to RAP requirements is possible. The cause of the upward variations should be found and corrected..

There was a steady degradation of performance during the critical months before and during the summer of 1994. The highest load was 2.7 times the lowest during the summer season when algal populations can grow on the excess phosphorus. The performance variations do not appear to have a simple relationship to the flow treated.

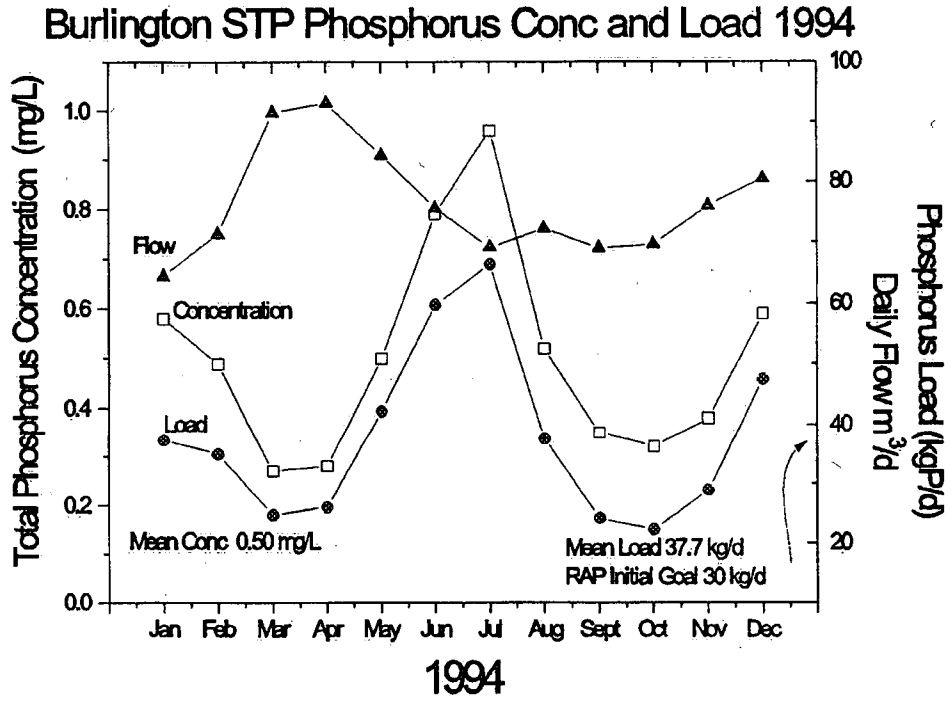

Figure 4

Hamilton

The Woodward Avenue STP (Fig.5) performed at 0.51mgP/l TP and an average load of 171.3kgP/d compared to the initial RAP goal of 140 kgP/d. The effluent average concentration in 1994 was well below the certificate of approval specification of no more than 1.0 mg/l.

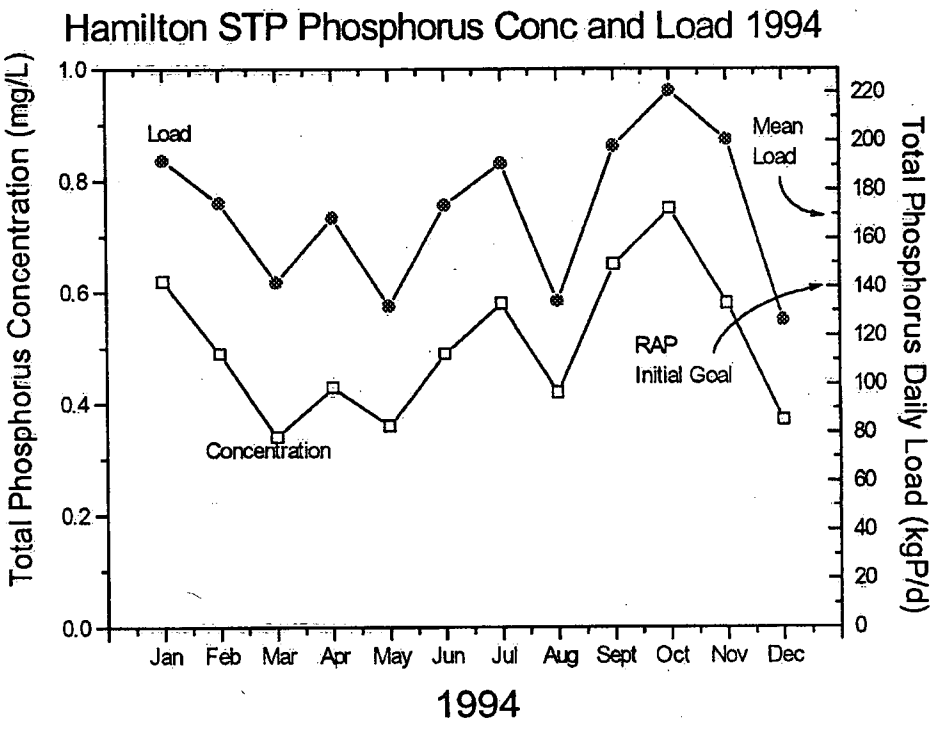

Figure 5

Again, there was a steady degradation of performance during the summer season. Comparing March to Sept, the load increased by 39% whereas the Burlington load increased by 270%.

Burlington Compared to Hamilton

Figure 6 shows the 1994 combined load for Burlington and Hamilton. The combined degradation of performance during the warm months resulted in some of the highest loads during the summer period.

As a percentage of the combined Burlington plus Hamilton load, the Burlington load was more than 25% during the summer.

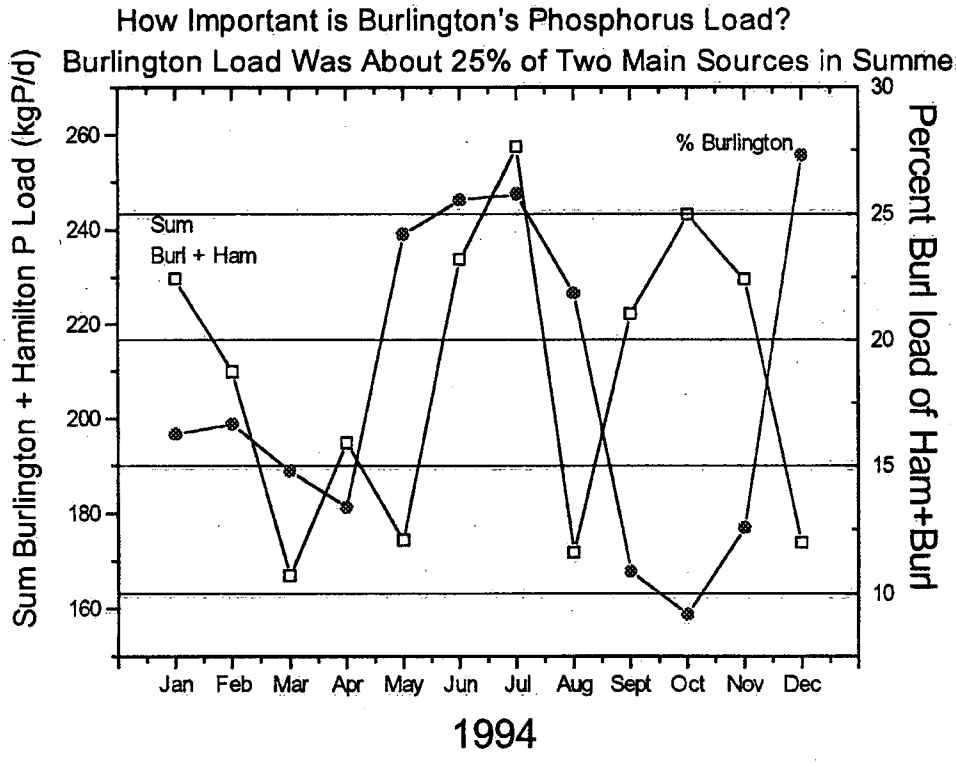

Figure 6

About one half of the water flowing into Hamilton Harbour is treated sewage. The phosphorus in sewage is 10-20 times more concentrated than in the ambient Harbour water. The difference is caused by processing in the Harbour and some dilution by stream flow. In the summer, the Harbour is thermally stratified into a warm upper layer and a cold lower layer. Then, the sewage flows into the upper layer causing excessive algal growth.

In the summer period when phosphorus loads are critical for water quality, Hamilton's load increased by 30 kgP/d whereas Burlington's load increased by 42 kgP/d. Thus, in quantitative terms, Burlington's upsets, or whatever caused the load increases, were as

important as Hamilton's. The effects of the Burlington STP cannot be marginalized or assumed unimportant simply because the overall load is less than Hamilton's.

Summary

* STP performance was highly variable especially at the Burlington plant in 1994.

* Variations at the Burlington plant caused a 270% increase in phosphorus load during the summer months of 1994 as compared to periods within the year when the highest level of performance was achieved.

* If the best performance had been maintained month after month (1994) at Burlington, the initial RAP goal for that STP would have been achieved.

* The load variations at the two plants caused the highest load rates during the critical summer months. During the 1994 season, phosphorus concentrations increased in Hamilton Harbour so that the mass in the top 10 m increased at 45kg/d. . The increase in loading in the same period was eventually 80-100kg/d. Thus, the concentration changes seen in the Harbour in 1994 are consistent with the degradation in performance at the Burlington and Hamilton STPs.

* The Burlington load rate is significant. In 1994, the Burlington STP represented about 25% of the controllable phosphorus problem during the critical summer months.

  Variations in the Burlington plant performance were quantitatively larger than those at the Hamilton plant during the summer of 1994.

* The Burlington and Hamilton plants in 1994 exceeded initial RAP phosphorus load goals by 22% and 26% respectively. An important difference, however, is that the Burlington plant faces a flow increase from the 1994 average of 76,000m^3/d to 140,000m^3/d (+83%) under the preferred option plan of Halton Region.

* If, the concentrations in Burlington effluent greater than 0.50mg/l TP are removed from 1994 data, then the remaining average loads in 1994 would have been at 0.35mg/l. While there is no indication that an average of 0.35mg/l TP would be produced under an operational limit of 0.50, the initial RAP goal would be achieved at 1994 flows and an average of 0.35mg/l TP effluent. Thus, if construction and adherence to the 0.50 limit occurs in advance of population growth, a temporary reduction in load may occur in the short term. In the long term, however, the

Harbour faces increased phosphorus loads instead of reductions recommended in the RAP.

* At a mean concentration of 0.35mg/l TP, the maximum development by year 2011 would cause an average load of 49kg/d which would be a substantial increase from 1994, from the RAP initial goal, and especially from the RAP final goal of 12kg/d.

* It is understood that the operation of biological wastewater treatment plants is complex. They are not only subject to very wide ranges in the quantity and characteristics of incoming wastewaters, but these variations occur on an hourly, daily and seasonal basis. There are many interactions between the various unit operations of primary settling, aeration and clarification in the liquid train, and that operation of the downstream sludge digestion process can have a direct impact on the liquid train performance and vice-versa.

* It is understood that a number of potential performance bottlenecks were identified in a comprehensive facility audit completed in 1991. While some of these issues were addressed through a combination of modification and upgrade (aeration capacity) and attempts to modify operating practice, a number of the identified measures have not been implemented. In 1995, Halton Region has initiated, on a cooperative partnership basis, an internal assessment/optimization approach to the operation of its sewage treatment plants. A multi-disciplinary team including management representatives and technical personnel have been involved in the assessment of the Burlington Skyway plant. A number of operational control strategies have been changed and other efforts are underway to accommodate some of the current constraints of the facility. It is anticipated that this will help to eliminate some of the significant variations identified above.

BATEA and Monitoring:

The Halton Region study mentions that "BATEA" (best available technology economically achievable) will be used at the expanded Skyway plant. To Halton Region, "BATEA" means an effluent phosphorus limit of 0.050 mgP/l without upgrading the basic plant conventional operation with tertiary filters. There is no consensus, however, on the meaning of BATEA. Tertiary filters are used in critical water quality situations in Europe and locally at Dundas, Orangeville, Minden, Bradford, Bracebridge, Keswick, Innisfil, Port Carling, Uxbridge, and Victoria Harbour. Apparently, operating costs associated with tertiary filters are minimal. Either tertiary filters or diversion of treated sewage to Lake Ontario will be necessary to meet the agreed upon RAP final water quality goals.

Discussions during the preferred option exercise have mentioned the need to monitor the Harbour, after expanding the Skyway STP, in order to assess whether or not further treatment technologies would be required. Superficially, this appears to be a reasonable

and logical approach appealingly consistent with the RAP. Under this logic system, however, every nutrient source could be gradually increased because the effects of each small increment would not be detectable. Because of mixing in the Harbour and natural variability in water quality and in the performance of STPs, proof of the effects of gradual Skyway expansion would not be found until it is too late. Every gram of sewage phosphorus damages the Harbour; yet, monitoring can give the unfounded impression that the opposite is true if attempts are made to answer unreasonable questions with monitoring data. Clearly, we know already that the Harbour water quality responds to the phosphorus loading from the two main STPs and every means available must be used to reduce these loads.

Recommendations

1 The draft preferred option of Halton Region to expand the Skyway STP in Burlington would increase phosphorus load to Hamilton Harbour; this is inconsistent with progress towards better water quality in Hamilton Harbour as recommended by the Hamilton Harbour Remedial Action Plan.

2 The draft preferred option of Halton Region would result in a phosphorus load of 70 kg/day compared to the initial RAP target of 30 kg/day and the final RAP target of 12 kg/day for the Skyway plant.

3 The Remedial Action Plan is consistent with Provincial guidelines which recommend a total phosphorus concentration of no more than 0.020 mgP/l in Hamilton Harbour. It has been demonstrated herein that the main cause of deleterious higher concentrations, and potential improvements, is the phosphorus loading from Burlington and Hamilton's STPs. Furthermore, the response of the Harbour is predictable from worldwide experience and is not unusual. Additionally, the impact of the Burlington STP has been demonstrated. Therefore, the RAP goals for the Burlington STP should be adhered to.

4 The preferred option portion of Halton Region to upgrade the Skyway STP in Burlington is required to minimize bypassing of barely treated sewage into Hamilton Harbour. The required clarifying capability should be installed as soon as possible.

5 The causes of sporadic higher level performance in terms of effluent TP concentrations at the Skyway STP should be exploited in an attempt to minimize phosphorus in the plant effluent. A full synthesis of available data on studies of plant design, recommended modifications, actions taken and operations should be conducted.

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