ASSESSMENT OF THE COMPREHENSIVE TECHNICAL ASSISTANCE TECHNIQUE FOR ONTARIO SEWAGE TREATMENT PLANTS

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Prepared for the

Ontario Ministry of Environment and Energy
Government of Canada
The Municipal Engineers Association

Prepared by

Ministry of Environment and Energy,
Science and Technology Branch

and

Wastewater Technology Centre
operated by RockCliffe Research Management Inc.

December 1994

Évaluation de la méthode d'assistance technique globale pour les stations ontariennes d'épuration des eaux d'égout

Étude préparée pour :

le ministère de l'Environnement et de l'Énergie de l'Ontario,
le gouvernement du Canada et
la *Municipal Engineers Association*

par :

la Direction des sciences et de la technologie,
ministère de l'Environnement et de l'Énergie de l'Ontario,

et le

Centre technique des eaux usées
exploité par la société Gestion de recherche RockCliffe Inc.

Décembre 1994

REFERENCE NOTE

The activities described in this report were partially carried out when this Ministry was the Ministry of Environment (MOE). In February 1993, MOE was merged with the Ministry of Energy to form its current name of Ministry of Environment and Energy (MOEE). Notations in this report of Ministry of Environment refer to activities prior to February 1993. When MOEE is used, it refers to events or activities after February 1993.

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Manager, Water and Wastewater Optimization
Ministry of Environment and Energy
Science and Technology Branch
125 Resources Road
Etobicoke, ONTARIO M9P 3V6
Tel: (416) 235-6303 FAX: (416) 235-6059

EXECUTIVE SUMMARY

BACKGROUND

In May of 1991, the Ontario Ministry of Environment and Energy (MOEE) in cooperation with Environment Canada and the Municipal Engineers Association initiated an investigation to establish the main factors limiting the performance of Ontario municipal Sewage Treatment Plants (STPs) and to identify and evaluate procedures for improving the ability of STPs to meet current and future Ontario compliance limits. The project was comprised of three independent stages.

The overall objectives of Study 1 were to identify the principle factors limiting performance of Ontario STPs and to recommend optimization approaches to address those limitations. The objective of Study 2 was to evaluate the U.S. Environmental Protection Agency's (U.S. EPA's) Comprehensive Performance Evaluation (CPE) protocol as a tool for diagnosing performance limiting factors at STPs. The CPE is the first step of the two-step Composite Correction Program (CCP). The objective of this study (Study 3) was to apply the second step of the CCP, the Comprehensive Technical Assistance (CTA) program, at selected treatment facilities to evaluate the approach and determine if it could successfully resolve performance limitations.

STUDY APPROACH

Three municipal STPs were selected for demonstration of the CTA program. The CTA was carried out by a team of MOEE, Wastewater Technology Centre (on behalf of Environment Canada), and Ontario Clean Water Agency (OCWA) technical staff experienced in STP operation and control. Process Applications Inc., the company which developed the CCP protocol for the U.S. EPA, was retained to train the CTA facilitation team and provide telephone consultation as the CTAs progressed. Monthly average $TBOD_5$ and TSS concentrations (in place of annual average compliance) and existing monthly TP compliance were adopted as performance targets during the CTAs.

RESULTS OF THE CTAs AT EACH STP

Plant J, located in a regional municipality, is a conventional activated sludge process with a design flow of 18,200 m^3/d (4 MIGD). Nine staff operate and maintain the facility. At Plant J the plant staff have achieved a 40% reduction in $TBOD_5$ loading, and a 90% reduction in ammonia loading to Lake Ontario as a result of the 16 month CTA. Total phosphorus and TSS loadings have been maintained even though the average daily flows during the CTA were 19% higher than before the CTA.

Plant B is a package extended aeration plant with a design flow of 681 m^3/d (0.15 MIGD). Three OCWA staff operate and maintain the plant in addition to another facility and pumping stations. At Plant B, the staff achieved significant reductions in $TBOD_5$ loadings (70%), TSS loadings (59%), and ammonia loadings (46%). The total phosphorus concentrations have remained consistently below the 1 mg/L monthly average limit. During the CTA, plant B experienced average daily flows of 459 m^3/d (0.10 MIGD), a 12% reduction compared to average daily flows of 523 m^3/d (0.12 MIGD) prior to the CTA. Although the average daily flow was lower, instantaneous storm events which the plant staff successfully treated were significantly higher than those recorded before the CTA. The duration of the CTA was 10 months at Plant B.

Plant H is also an extended aeration package plant operated by OCWA. The plant design flow is 955 m^3/d (0.21 MIGD). At plant H, the staff achieved significant reductions in $TBOD_5$ loadings (89%), TSS loadings (83%) and ammonia loadings (93%). During the CTA, plant H experienced average daily flows of 858 m^3/d (0.19 MIGD), a 7% reduction compared to average daily flows of 927 m^3/d (0.20 MIGD) prior to the CTA. During the spring (March and April) of 1994, total effluent TSS and BOD_5 loadings to the receiver were reduced by 95% and 96% respectively when compared to the spring of 1992. This was accomplished with the total flows during the spring of 1994 being marginally higher than the spring of 1992. A period of 14 months was required to complete the CTA.

MONTHLY EFFLUENT TARGETS

Within three months of the CTA initiation, plant staff at two of the three demonstration facilities achieved final effluent $TBOD_5$ and TSS concentrations below 25 mg/L on a monthly average basis (in addition to monthly average limits of 1.0 mg/L for TP). At the third demonstration site the staff reduced the exceedences of monthly $TBOD_5$ and TSS objectives during the 16-month CTA in comparison to the 16 months which preceded the CTA initiation. However, TSS effluent concentrations exceeded 25 mg/L for two months during the CTA. High TSS concentrations were caused by a combination of high flows, a biological upset, and incomplete transfer of skills by an inexperienced CTA Facilitation Team. It was the considered judgement of the Facilitation Team that monthly objectives for $TBOD_5$, TSS, and TP could be consistently achieved at all three facilities through the application of CTA techniques.

OTHER FINDINGS

Additional findings and conclusions arising from the study included:

- At two of the three CTA demonstration sites, sludge disposal costs were decreased.

• At all three facilities, operations staff demonstrated the ability to identify and "operate around" minor design limitations. These limitations included poor primary clarifier efficiency (Plant J), lack of instrumentation to measure waste activated sludge flows (Plant B), and limited on-site sludge storage capacity (Plant H).

• Verbatim comments collected from members of the CTA Facilitation Team and operations and management staff at the three sites indicate a high level of support and interest in the CTA approach.

APPLICABILITY OF CTA

In summary, demonstrations at the three facilities established that the CTA approach is valuable as a tool for resolving performance limiting factors at existing sewage treatment plants. No major modifications to the approach are required prior to broadscale application in Ontario.

Since the CTA demonstrations have concluded, plant staff have continued to apply process monitoring and control concepts to achieve compliance objectives.

RECOMMENDATIONS

1. To improve the performance status of municipal STPs, it is recommended that the Comprehensive Technical Assistance technique be adopted as part of an overall optimization program in Ontario as a method for resolving performance limitations at existing facilities.

2. Personnel conducting CTAs should have a technical knowledge of wastewater treatment covering regulatory requirements, process control, sampling, and equipment maintenance. In addition, familiarity with management issues and ability to motivate and transfer skills in conjunction with well developed personnel and human relations skills, are highly recommended.

3. A number of commonly occurring barriers to optimization were identified during the CTAs. These included: lack of incentives to perform, focus on maintenance and housekeeping rather than process control, delays in approving minor modifications, inadequate sludge storage and disposal, lack of recognition of the key role of operators, and no formal mechanism to address common problems. A program should be established which resolves these barriers so that province-wide optimization efforts can be implemented.

4. Additional recommendations resulting from this assessment are:

- A team approach to applying the CTA is recommended. A team is better able to provide a consistent schedule for site visits and follow-up and will more likely possess the necessary mix of technical and human resource skills.

- CTA training is best conducted on-site at multiple facilities. Workshops alone are inadequate to equip CTA facilitators to address the complex mix of design, operating, maintenance, and administration factors limiting performance at Ontario STPs.

SOMMAIRE

APERÇU

En mai 1989, le ministère de l'Environnement et de l'Énergie de l'Ontario, Environnement Canada et la *Municipal Engineers Association* ont amorcé conjointement une enquête visant à établir quels étaient les principaux facteurs limitant le rendement des stations d'épuration des eaux d'égout en Ontario et à mettre en oeuvre des mesures qui permettraient à ces stations de se conformer aux normes antipollution actuelles et à venir. Le projet s'est déroulé en trois étapes.

L'objectif global de la première étude était la détermination des facteurs qui nuisent le plus au rendement des stations et la recommandation de mesures correctrices. La seconde étude avait pour objet d'évaluer la pertinence du protocole établi par l'Agence américaine pour la protection de l'environnement (EPA) dans l'évaluation des facteurs limitant le rendement des stations d'épuration. Le protocole constituait la première des deux étapes du programme de mesures correctrices (Composite Correction Program). Le but de la présente étude, soit la troisième étape du projet, était de mettre en oeuvre la deuxième étape du programme de mesures correctrices, soit la méthode d'assistance technique globale dans certaines stations d'épuration choisies dans le but d'en faire l'évaluation et de déterminer si son adoption contribuerait à augmenter le rendement des installations.

MÉTHODE

Trois usines d'épuration municipales ont été sélectionnées dans le cadre du projet. Celui-ci a été exécuté par une équipe composée de représentants du ministère de l'Environnement et de l'Énergie, du Centre technique des eaux usées (pour le compte d'Environnement Canada) et de techniciens de l'Agence ontarienne des eaux spécialistes de l'exploitation de usines d'épuration des eaux d'égout municipales. La société *Process Applications Inc.*, qui a élaboré le programme de mesures correctrices pour l'EPA américaine, a assuré la formation de l'équipe et un service téléphonique de soutien pendant la durée du projet. Aux fins de l'évaluation, on a établi des moyennes mensuelles (plutôt qu'annuelles) à respecter pour les paramètres suivants : D.B.O.5 totale, matières en suspension et phosphore total.

RÉSULTATS

L'usine J, qui est située dans une municipalité régionale, emploie un procédé classique de traitement par les boues activées. L'usine emploie 9 opérateurs et son débit nominal est de 18 200 m^3/j (4 millions de gallons impériaux par jour (MGIJ)). Au cours des 16 mois qu'a duré le projet, les employés de l'usine J ont réussi à réduire de 40 p. 100 la D.B.O.5 totale et de 90 p. 100 la charge d'ammoniaque rejetée dans le lac Ontario. Le phosphore total et la charge de matières en suspension sont demeurés les mêmes, malgré une augmentation de 19 p. 100 du débit quotidien moyen pendant la durée du projet.

L'usine B emploie un système d'aération prolongée et son débit est de 681 m^3/j (0,15 MGIJ). Trois employés de l'Agence ontarienne des eaux exploitent cette usine ainsi qu'une autre installation et des stations de pompage. Pendant la durée du projet, le personnel de l'usine B a réussi à réduire considérablement la D.B.O.5 totale (70 p. 100), les matières en suspension (59 p. 100) et la charge d'ammoniaque (46 p. 100). La concentration de phosphore total n'a jamais dépassé la limite moyenne mensuelle de 1 mg/L. Le débit de l'usine B pendant la durée du projet a atteint une moyenne de 459 m^3/j (0,10 MGIJ), soit une réduction de 12 p. 100 comparativement au débit quotidien moyen de 523 m^3/j (0,12 MGIJ) enregistré avant le début du projet. Bien que le débit quotidien moyen était plus bas, les débits soudains d'orage que le personnel a réussi à traiter à l' usine avaient été beaucoup plus fréquents qu'avant le début du projet. La durée du projet a été de 10 mois pour l'usine B.

À l'instar de l'usine B, l'usine H est exploitée par l'Agence ontarienne des eaux et emploie un système d'aération prolongée. Son débit nominal est de 955 m^3/j (0,21 MGIJ). Les employés de l'usine H ont réduit la D.B.O.5 totale de 89 p. 100, les matières en suspension de 83 p. 100 et la charge d'ammoniaque de 93 p. 100. Pendant la durée du projet, le débit quotidien moyen de l'usine était de 858 m^3/j (0,19 MGIJ), une réduction de 7 p. 100 par rapport aux débits quotidiens moyens de 927 m^3/j (0,20 MGIJ) enregistrés avant le début du projet. Au printemps 1994 (mars et avril), la charge de matières en suspension et la D.B.O.5 totale rejetées dans les eaux réceptrices étaient inférieures de 95 p. 100 et de 96 p. 100, respectivement, par rapport à 1992. Ce résultat a par ailleurs été obtenu malgré une légère augmentation des débits moyens enregistrés au printemps de 1994, comparativement à ceux du printemps 1992. La durée du projet a été de 14 mois pour l'usine H.

LIMITES D'EFFLUENTS MENSUELLES

En moins de trois mois après la mise en oeuvre du projet, les opérateurs de deux des trois usines ont déjà réussi à surpasser l'objectif mensuel moyen de 25 mg/L fixé pour la D.B.O.5 et les matières en suspension et à atteindre celui qui avait été fixé pour le phosphore total, soit une moyenne mensuelle de 1 mg/L. À la troisième usine, on a réussi, au cours des 16 mois qu'a duré l'étude, à réduire les charges mensuelles de D.B.O.5 et de matières en suspension comparativement aux valeurs enregistrées au cours des 16 mois précédant le projet. Par contre, la charge de matières en suspension a excédé pendant deux mois la limite de 25 mg/L. Les concentrations élevées de matières en suspension sont attribuables à une combinaison de plusieurs facteurs, à savoir des débits élevés, certaines perturbations biologiques, et l'inexpérience de l'équipe de facilitation. Selon cette dernière, les trois usines qui ont fait l'objet de l'étude pourraient atteindre systématiquement les objectifs mensuels fixés pour la D.B.O.5, les matières en suspension et le phosphore total si elles adoptaient la méthode d'assistance technique proposée.

AUTRES RÉSULTATS

Voici quelques-uns des autres résultats de l'étude :

- Deux des trois stations qui ont participé au projet ont vu diminuer leurs coûts d'élimination des boues.

- Les opérateurs des trois stations réussissaient généralement à compenser pour les lacunes techniques mineures du matériel, notamment, l'inefficacité du clarificateur primaire (station J), l'absence d'instrumentation adéquate pour mesurer le débit de vidange des boues activées (station B) et la faible capacité de stockage des boues sur les lieux (station H).

- Les commentaires recueillis auprès des membres de l'équipe de facilitation, du personnel d'exploitation et des administrateurs des trois stations indiquent un enthousiasm certain pour cette méthode.

UTILITÉ DE LA MÉTHODE

Les résultats obtenus aux trois usines de traitement montrent clairement que la méthode d'assistance technique globale permet de résoudre certains problèmes de rendement que connaissent ces usines. À notre avis, la méthode peut être appliquée presque telle quelle dans l'ensemble de l'Ontario.

Les opérateurs des usines qui ont fait l'objet de l'étude continuent de mettre en pratique la méthode afin de se conformer aux normes provinciales.

RECOMMANDATIONS

1. Nous recommandons que la méthode d'assistance technique globale soit adoptée dans les usines municipales d'épuration des eaux d'égout comme partie intégrante du programme d'optimisation du rendement des installations d'eau et d'égout en Ontario.

2. Le personnel chargé de mettre en oeuvre la méthode d'assistance technique devrait être bien au fait des règlements en vigueur en matière d'épuration des eaux d'égout, des procédés de contrôle, d'échantillonnage et d'entretien du matériel. Il devrait en outre être particulièrement à l'aise avec les questions administratives, savoir motiver le personnel, transmettre efficacement les connaissances nécessaires, et disposer d'excellentes aptitudes aux relations interpersonnelles et humaines.

3. On a noté pendant la durée du projet une récurrence de certains obstacles à

l'optimisation du rendement des usines, notamment : le manque de motivation de la part des opérateurs, le trop d'importance attachée à l'entretien et à la tenue des lieux au détriment du contrôle des procédés, les longs délais associés à l'autorisation de la moindre modification technique, le rôle méconnu des opérateurs et l'absence de méthodes de résolution des problèmes courants. Nous recommandons qu'un programme visant à éliminer ces obstacles soit élaboré pour faciliter la mise en oeuvre du programme d'optimisation à l'échelle de la province.

4. Nous recommandons par ailleurs :

- qu'une approche d'équipe soit adoptée pour la mise en oeuvre de la méthode. Nous croyons en effet qu'une équipe est en mesure d'assurer une présence constante et un suivi plus rigoureux et de présenter un meilleur profil d'aptitudes techniques et humaines ;

- que la formation soit dispensée sur place dans les installations participantes. Les ateliers ne permettent pas aux formateurs de bien rendre compte de la complexité des facteurs de conception, d'exploitation, d'entretien, et d'administration qui nuisent au rendement des usines d'épuration des eaux d'égout en Ontario.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACKNOWLEDGEMENTS

Authors:
Gerry Wheeler, Ministry of Environment and Energy, Rexdale, Ontario;
Jim Matthews, Wastewater Technology Centre, Burlington, Ontario;
Dan White, Ontario Clean Water Agency, Kingston, Ontario;
Bruce Bradley, Ministry of Environment and Energy, Rexdale, Ontario; and
David T. Chapman, Wastewater Technology Centre, Burlington Ontario.

Technical Reviewer:
Bob A. Hegg, Process Applications Inc., Ft. Collins, Colorado

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1. INTRODUCTION

1.1 Background

Presently, secondary sewage treatment plants in Ontario are required to meet annual average effluent BOD_5 and total suspended solids (TSS) concentrations of 25 mg/L as stipulated under MOEE Procedure F-S-1, "Guidelines for the Determination of Treatment Requirements for Municipal and Private Sewage Treatment Works, Discharging to Surface Waters". More stringent limits can be imposed based on local receiving water quality protection needs.

In 1990, the Ontario Ministry of Environment (MOE), in consultation with industry, municipal, and public representatives, agreed that the Municipal Industry Strategy for Abatement (MISA) program would examine effluent limits based on monthly averages in addition to annual averages.

Based on the MISA procedures for deriving monthly limits and an analysis of the historical data (1986 to 1989) from municipal sewage treatment plants in Ontario, it was concluded that conventional activated sludge plants could achieve monthly average concentrations of 25 mg/L BOD_5 and 25 mg/L TSS, while extended aeration plants could achieve monthly average concentrations of 15 mg/L BOD_5 and 20 mg/L TSS. The procedures to derive the monthly limits are detailed in a Ministry of Environment report.[1]

Figure 1 shows that for 109 secondary treatment facilities (excluding extended aeration) in Ontario, the 1989 non-compliance rate based on annual average guidelines of 25 mg/L BOD_5 and 25 mg/L TSS is 7%. However, the incidence of non-compliance for one month of the year would be 10% if "monthly limits" were applied. The rate of non-compliance for two months would be 10%, and for three months or more the rate of non-compliance would be 14%. Cumulatively this would result in a total of 34% of the 109 secondary treatment facilities being out of compliance if assessed on a monthly average basis.

Figure 2 shows that for 78 extended aeration plants in Ontario, the 1989 rate of non-compliance based on annual average guidelines of 25 mg/L BOD_5 and 25 mg/L TSS is 7%. However, the incidence of non-compliance for one month of the year would be 21% if the "monthly limits" of 15 mg/L BOD_5, and 20 mg/L TSS were applied on a monthly average basis. The rate of non-compliance for two months would be 8% and for three months or more 20%. Cumulatively this would result in a total of 49% of the 79 extended aeration treatment facilities being out of compliance if assessed on a monthly average basis.

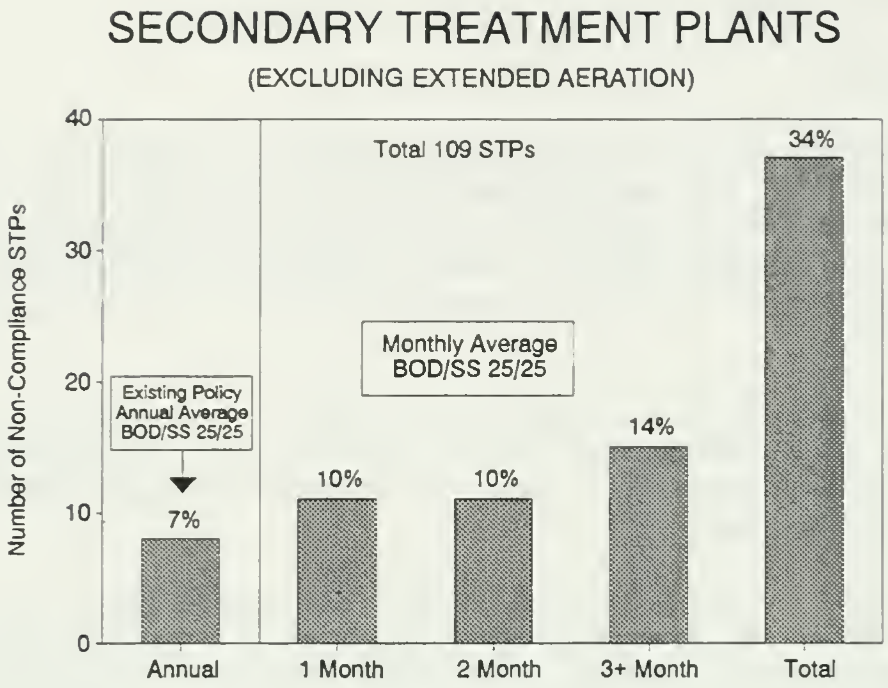

Figure 1 Performance Review of 109 Secondary Treatment Plants

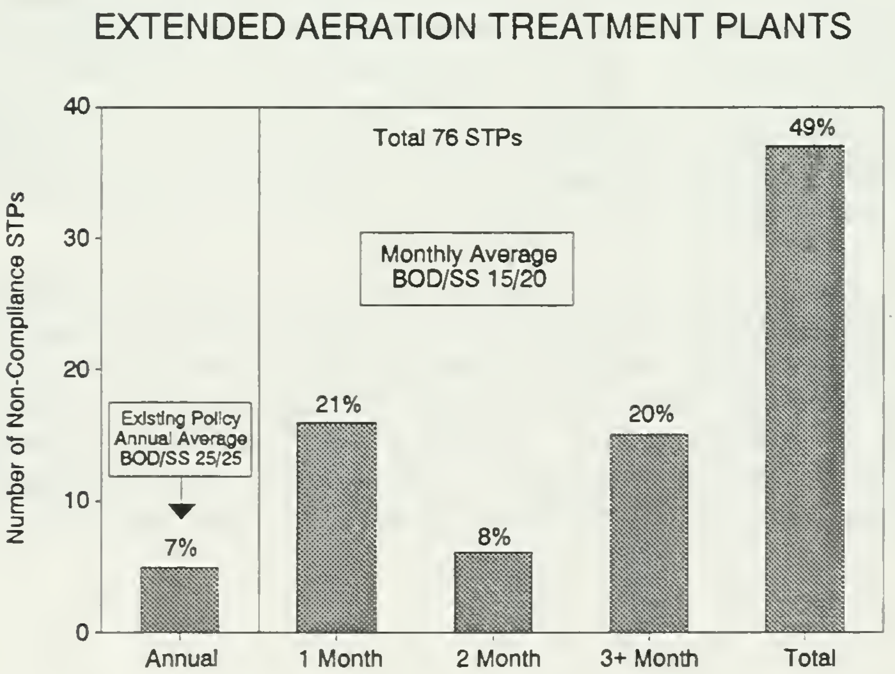

Figure 2 Performance review of 76 Extended Aeration Plants

1.2 STP Optimization Study

In May of 1991, the Ontario Ministry of Environment and Environment Canada, in cooperation with the Municipal Engineers Association, initiated an investigation with the following objectives:

1. To identify factors which contribute to poor performance at Ontario municipal sewage treatment plants (STPs).

2. To identify, evaluate, and demonstrate procedures for improving the ability of STPs to meet current and future Ontario compliance limits while minimizing capital improvements and/or expansions.

The project's three stages are outlined in Figure 3.

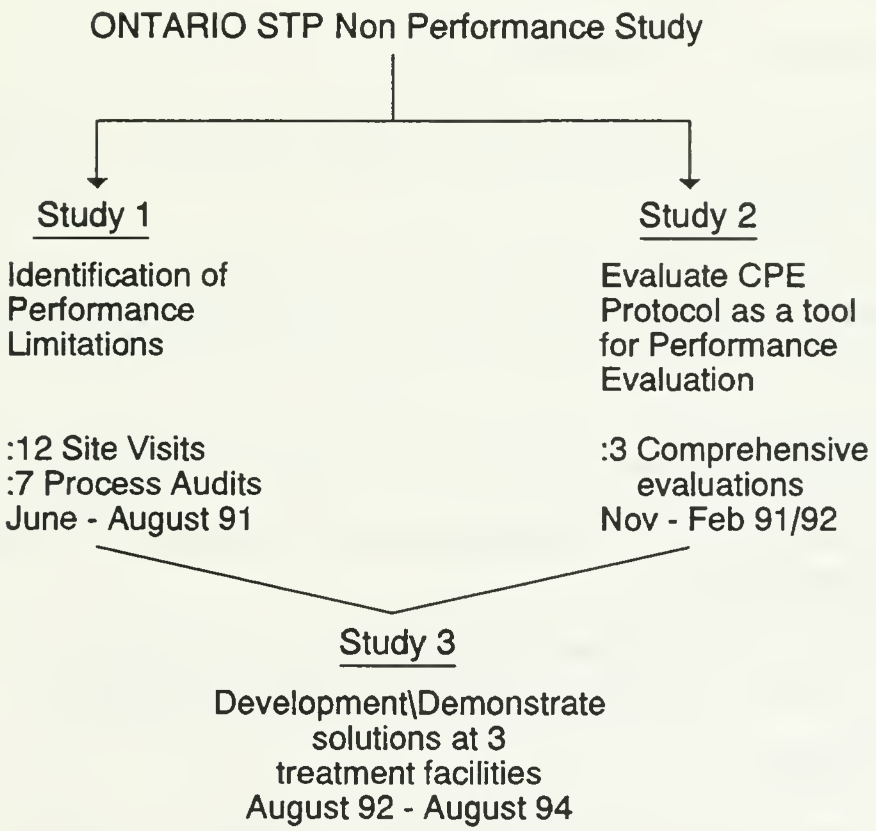

Figure 3 Overview of STP Optimization Study

Study 1 focused on identifying the limitations affecting the performance of STPs in Ontario and estimated the costs required to enable secondary treatment facilities to meet the monthly limits[2].

The objective of Study 2 was to evaluate the U.S. EPA's Comprehensive Performance Evaluation (CPE), the first component of the Composite Correction Program (CCP)[3]. The Comprehensive Performance Evaluation (CPE) was evaluated as a tool for evaluating and identifying performance limiting factors[4].

In Study 3 the second component of the CCP, Comprehensive Technical Assistance (CTA), was applied at three treatment facilities to demonstrate how factors identified as limiting performance could be addressed at existing facilities. This report presents the findings of Study 3.

1.3 Study Objectives

The objectives of Study 3 were:

1. To determine the applicability of the U.S. EPA's CTA protocol in Ontario.

2. To identify if the selected STPs could be optimized to achieve monthly average concentrations for $TBOD_5$ and TSS through the application of the CTA techniques.

3. To determine if skills transfer could be achieved to enable plant staff to continue applying the process control techniques after the completion of the CTA.

4. To determine the qualifications and skills that are required to implement the CTA techniques.

5 To determine the level of training required to enable staff to perform the CTA competently.

6. To identify what changes or modifications, if any, would be required prior to widespread application of the CTA technique in Ontario.

1.4 Report Format

This report presents the approach and findings of the study to evaluate the CTA protocol as a tool for addressing and resolving performance limiting factors.

Section 2 provides details of the origins and background of the CCP.

Section 3 overviews the selection of the three candidate sites, and provides information on the CTA Team selection and training, in addition to an overview of the CTA methodology. Also provided is an overview of how site-specific process control manuals were prepared by plant staff to document procedures.

Section 4 presents the summary results of the CTAs at each facility.

Section 5 provides a summary of the impressions and comments of the CTA Team, and comments from management and staff at the three sites where the CTA was applied.

Section 6 details the conclusions and recommendations from this assessment.

2. COMPOSITE CORRECTION PROGRAM

2.1 Origin

The U.S. federal government's Construction Grants Program, launched in 1972, provided $30 billion for the construction of wastewater treatment facilities. However, surveys showed that 60% of the facilities did not comply with their discharge permits more than half of the time. In response to this significant non-compliance rate, the Office of Research and Development of the U.S. Environment Protection Agency initiated the "East/West" studies to determine the causes of non-compliance[5][6]. Among the major findings was that the many newly constructed treatment facilities were not optimized, and that operator knowledge of biological treatment principles were not being routinely applied to derive consistent process control. Subsequently this led to the development of the Composite Correction Program (CCP)[3]. The objective of the program is to improve the ability of existing treatment facilities to meet compliance permits. In many instances, major expansions have been delayed or avoided through application of the CCP.

2.2 Overview

The CCP approach uses a two step program to economically improve the performance of STPs. The approach identifies the unique combination of design, operational, maintenance, and administrative factors contributing to discharge violations, and implements cost-effective activities for achieving compliance. Typically, the CCP approach focuses on achieving compliance or optimum performance without major capital expenditure. An overview of the approach is provided in Figure 4.

The first step of the CCP is the Comprehensive Performance Evaluation (CPE). A CPE assesses the facility to determine if the major unit processes are capable of treating the current wastewater flow and pollutant loads to the levels required by the facility's discharge permit. The CPE evaluates the operation, design, maintenance, and administration of the STP to determine how performance is affected. The CPE establishes a plant rating as follows:

Type 1. The existing major unit processes are adequate to meet current treatment requirements.

Type 2. The existing major unit processes are marginal but improved performance is likely through the use of a CTA. For Type 2 plants, the CTA focuses on clearly defining the capability of the existing facilities through optimum operations and application of concepts. Individual unit process deficiencies are identified so that plant administrators and management can implement modifications.

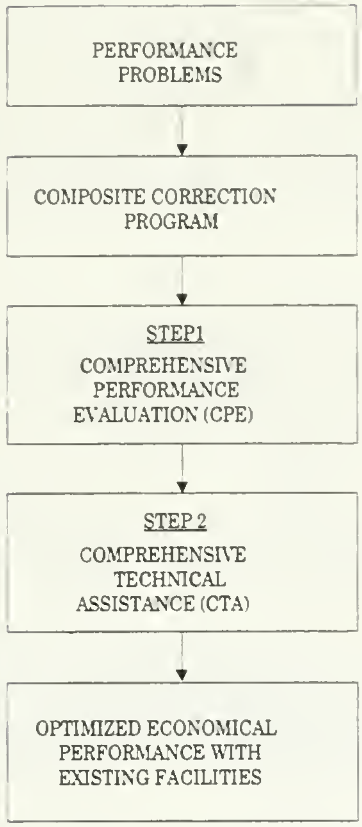

Figure 4 Overview of Composite Correction Program Approach

Type 3. For type 3 plants, major construction is indicated and more comprehensive study is warranted. Typically, a CTA is not implemented at a Type 3 plant until adequate modifications have been completed.

At Type 1 and Type 2 plants, a CTA is implemented to comprehensively address the combination of performance limiting factors identified during the CPE. For Type 3 plants, the facility is modified or a more detailed study initiated to identify upgrades.

Figure 5 shows the relationship of performance limiting factors to compliance. During a CTA, maintenance, administrative and minor design related factors must be resolved to derive a capable treatment plant. A capable plant must then be operated through the correct and timely application of good operational skills and techniques to produce a quality effluent. The CTA must resolve performance limiting factors in any of these four areas to achieve compliance or optimum performance.

The costs involved in performing CTAs in the U.S. at plants smaller than 113,650 m^3/d (25 MIGD) range from \$15,000 to \$40,000 U.S. depending on the range and complexity of the performance limitations which must be addressed. The cost of a CTA is not necessarily dependent on plant size.

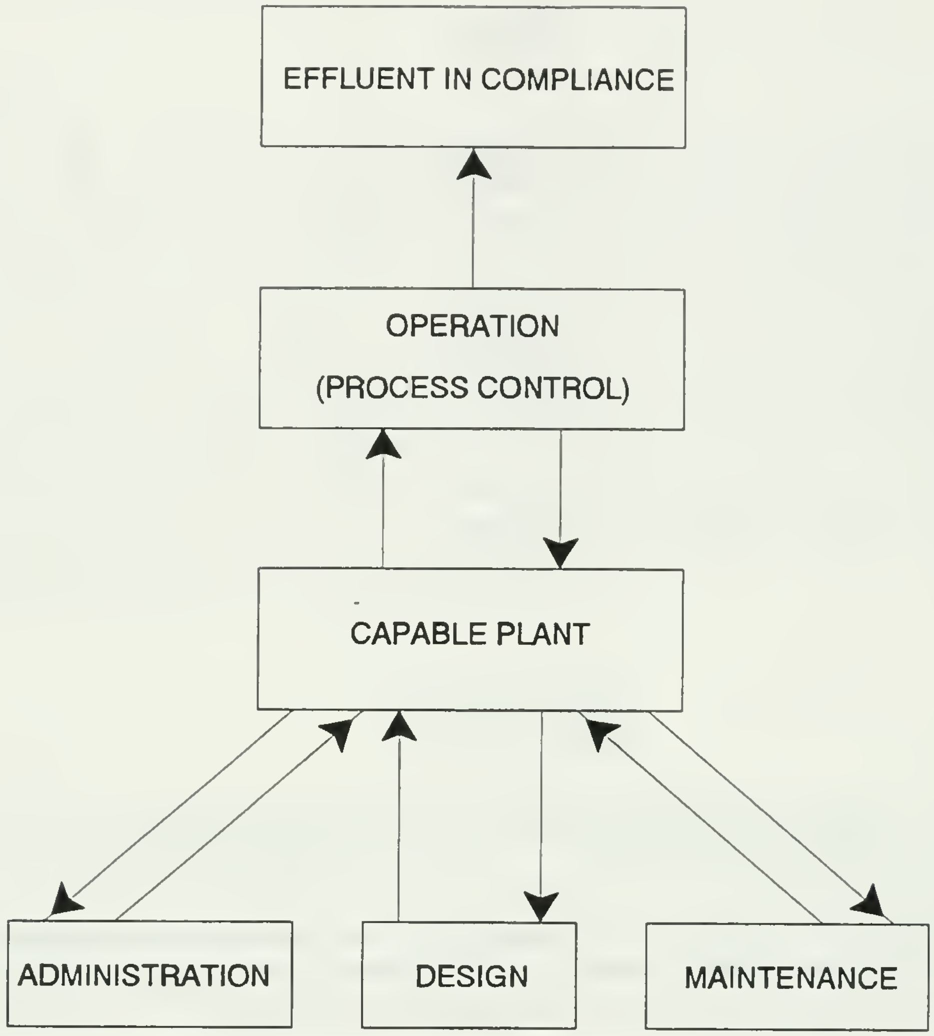

Figure 5 Relationship of Performance Limiting Factors to Achieve a Compliance Goal

3. STUDY APPROACH

3.1 Plant Selection

From the 12 plants visited in Study 1, three were selected by the project's Technical Liaison Committee as demonstration sites for CTAs. The plants were selected based on the following criteria:

Mechanical Capability
- The major unit process evaluation applied during the CPE identified that the plants were mechanically capable of achieving the desired quality effluent.

Nature of Performance Limitations
- The highest ranking performance limiting factors identified during the CPE were either administration or operations related.

STP Size
- A range of plant design capacities was desired. This enabled an assessment to be made of the logistics of applying the protocol to various sized plants, and likewise various numbers of plant staff.

Process type
- Various types of activated sludge processes (conventional, extended aeration, etc.) were included to assess the versatility of the protocol.

Operational Staff
- Plants operated by both municipalities and OCWA were included to assess the applicability of the protocol to the current operating agencies in Ontario.

Logistics
- Plant locations that minimized travel time and costs for the CTA team were desired.

3.2 CTA Technical Team

The technical team selected to undergo training in the application of CTA techniques was the same team which had been selected for training in the CPE technique. Staff from the Ministry of Environment and Energy (MOEE), the Wastewater Technology Centre (WTC, on behalf of Environment Canada), and Ontario Clean Water Agency (OCWA), provided the technical assistance at the three treatment plants.

Each team member had extensive experience in wastewater plant operations and process control in both municipal and industrial sectors. Knowledge of management requirements, training, and communication were additional non-technical team skills utilized to deliver the CTA. A brief overview of each team member's background and experience is provided in Table 1. Appendix 1 lists the addresses and telephone numbers of the CTA team and trainers.

Table 1 Profile of CTA Team

Team Member	Organization	Years Experience	Skills/Expertise
Bruce Bradley	MOEE Science & Technology Branch	21	Municipal STP Operations. Process Monitoring. Training.
Jim Matthews	Wastewater Technology Centre	14	Municipal STP Optimization and Control. Instrumentation.
Gerry Wheeler	MOEE Science & Technology Branch	15	Industrial Plant Operations and Management. Good Manufacturing Practices.
Dan White	OCWA Eastern Region	8	Municipal STP Operations. Monitoring. Data Management.

3.3 CTA Technical Team Training and Application of CTA Techniques

In August 1992, the first CTA was initiated. Mr. Bob Hegg, Process Applications Inc., who developed the CCP protocol for the U.S. EPA, trained the technical team on the CTA techniques and provided telephone consultation and assistance in reviewing the status and progress of the CTAs. The routine planning and scheduling of the CTA events was completed by the technical team. The start-up of the subsequent CTAs at the other two plants was delayed to allow the first CTA to become established and allowed the CTA team to provide full attention to one STP during the critical start-up period. After the initial 6 month period the technical team and Process Application Inc. reviewed and discussed once per month the plant performance data and the key process control parameter trends. The first CTA ran for 16 months and was completed in December 1993. The CTA report was drafted and written by the technical team members and reviewed by Process Applications Inc.

The second CTA was initiated in November 1992 and was completed in August 1993. While the combination of performance limiting factors were similar to those at the first site, the second CTA was completed in a shorter period. The treatment process was simpler at the second site and fewer staff were involved.

The third CTA was initiated in March 1993 and was completed in May 1994. A feature of this CTA was the fabrication and installation of step feed modifications to enable the plant to treat high hydraulic flows. The application of step feed as a process control technique was implemented and tested in April 1994 during spring melt.

Once each CTA was established, the CTA team maintained contact with each of the three facilities to share information and monitor progress. Likewise, quarterly review meetings were scheduled for the duration of the CTAs to review and plan the next steps in the CTAs.

3.4 Overview of Comprehensive Technical Assistance (CTA) Methodology

An overview of the main components of the CTA approach is provided in the following sections.

3.4.1 Initial Activities

Key management personnel or administrators were identified who would play an active role in supporting the on-site corrective techniques. Administrative issues addressed included adequate manpower, plant coverage (especially during nighttime, weekends, and holidays), sludge wastage and disposal, on-site laboratory equipment and off-site laboratory support to verify final effluent quality. Scheduling of site visits was planned in advance to ensure that all staff were available to participate in activities.

3.4.2 The Challenge

At the three demonstration STPs the challenge accepted by the CTA team and plant staff and management was to target monthly average effluent concentrations ($TBOD_5$, TSS, TP) as a measure of success of each CTA. The objective was to demonstrate that this performance could be consistently achieved.

3.4.3 Process Control Workshop

If the CPE identified that operator application of concepts and testing to achieve and maintain process control was inadequate, a process control workshop was specifically designed as part of the initial CTA activities. During this workshop a routine monitoring and control program was developed. The purpose of the CTA was explained during the workshop and support from the staff was sought for the CTA effort.

3.4.4 *Routine Site Visits*

Following the workshop a process control program was applied daily to ensure consistent wastage of sludge from the liquid stream to the sludge handling process each day.

During the course of the assistance program various process related problems or limitations were identified and addressed. More on-site assistance was provided at the beginning of the CTA. As the program progressed and the operations staff grew in their familiarity and confidence in applying the concepts of biological wastewater treatment, the staff assumed more responsibility for the daily operational decisions. As a consequence, the length and frequency of on-site technical assistance was reduced.

3.4.5 *Data Trending and Interpretation*

A key component of the CTA was to facilitate the operations staff to organize and graph process monitoring data that was generated on a daily basis. Plotting of key parameters enabled staff to observe trends in the process data. When correctly interpreted, this information alerted staff to trends which indicated a deterioration in process stability brought on by seasonal variations or unit process loading variations.

3.4.6 *Routine All-Staff Meetings*

Regular meetings were held to maintain staff awareness of the CTA objectives and to identify and resolve issues to preserve and maintain the established process control program. These meetings included managers not routinely involved in the daily operations of the plant. As a result, off-site management obtained a practical overview of the optimization activities and observed the impact of their support and delegation of authority. All staff had an opportunity to share in any accomplishments or successes. Conversely, these meetings enabled staff to constructively address any obstacles or failures and to formulate a plan to fix the problem and progress with their optimization activities. In addition, the plant staff had the opportunity to share their experiences with the off-site management and to appreciate the limitations within which plant management must function.

On occasion it was necessary to actively communicate to the municipal council the objectives and approach of the CTA. An additional benefit of these meetings was to heighten the awareness of the municipal council staff concerning the skills which must be continuously applied to maintain final effluent quality.

3.4.7 Special Studies

As the CTA progressed, non-routine process problems required extra attention by the operations staff. "Special Studies" included coping with unexpected high hydraulic flows caused by storm events, optimizing the performance of a secondary clarifier using polymer addition, and installing and applying step feed capability. Special studies enhanced the routine repertoire of skills and knowledge which the operations staff develop and apply on a routine basis.

3.4.8 Preparation of Process Control Operations Manuals

After the CTA was established at each facility and the process control program became a routine component of the operators daily activities, a site specific process control operations manual was drafted and prepared by the staff. The basic objective in creating the operations manual was to document the step by step procedures which were necessary to achieve effective process control. The challenge was to create a working environment which achieved full participation of all staff working together to produce a document which belonged to the staff. The role of the CTA team was to provide the necessary technical assistance to the staff to facilitate their efforts to produce the manual. Not every operator was comfortable with writing procedures. This dilemma was resolved by facilitating the operators through a collective discussion of an analytical procedure or operational issue. When consensus was obtained, a member of the discussion group was delegated the task of writing the procedure.

While the content and scope of each process control operations manual was specific to each facility, the following common format was used:

a) Analytical Procedures

This section documents the laboratory procedures required to perform specific process control tests.

b) Operational Procedures

Operational activities and adjustments which must be made on a routine basis to achieve and maintain control of the biological process are described.

c) Special Studies

Activities are documented to address specific problems identified during the CTA. Routine operational procedures incorporated information from special studies if the special study results significantly improved plant performance.

d) Emergency Procedures

This section documents any emergency situations which can have a detrimental effect on process stability. It does not document health and safety issues relating to emergency situations.

e) Process Control Workshop

This section documents some of the basic concepts of biological wastewater treatment which were applied to control the total sludge mass in the liquid train. This section acts as a reference document so that the operator can check on how mass calculations were derived and applied.

f) Plant Design Information

The design information section contains the basic information regarding the facility and the dimensions of the existing tanks and unit processes.

Operating manuals should be dynamic. Operations staff need to review, change, add or delete sections of the manuals to reflect changes in procedures. Appendix 5 lists procedures and activities which were documented during CTAs at the three demonstration sites.

3.4.9 Exit Meeting

At the conclusion of the CTA an exit meeting was held to present all of the findings identified during the assistance period. Generally, the presentations were attended by the same people who were involved at the outset of the assistance program. The meetings normally included the following items:

(1) Significant events of the CTA.

(2) CTA results and review of final effluent quality before and during the CTA.

(3) Review of process control parameters and trends analysis during the CTA.

(4) Summary and conclusions

(5) Recommendations

3.4.10 CTA Report

The CTA report was prepared to summarize the findings and conclusions presented at the exit meeting. The report assists the administrators and staff to continue focusing on achieving optimum performance from their facility after completion of the on-site technical assistance. The complete CTA reports for the three sites are included in Appendix 2, 3 and 4.

4. RESULTS

4.1 Plant J

4.1.1 Facility Background

Plant J is one of several plants providing wastewater treatment within a regional municipality. Constructed in 1977, plant J has a design capacity of 18,200 m^3/d (4 MIGD) and utilizes an activated sludge treatment process. A schematic of the plant is shown in Figure 6.

The majority of the wastewater is of domestic origin with minor contributions of winery waste, septage, and landfill leachate. The influent wastewater strength at plant J is typical for domestic treatment facilities. The plant does experience occasional high infiltration/inflow during wet periods, as indicated by the 22,730 m^3/d (5.07 MIGD) average monthly flow rate that occurred in March 1991.

Influent wastewater passes through a bar screen and enters a wet well where it is pumped to an aerated grit chamber. Wet weather flows in excess of 45,460 m^3/d (10 MIGD) can be bypassed around the plant. Following the grit chamber, the wastewater flows to two rectangular primary clarifiers. Sludge hoppers are located at the entrance to the clarifiers, and the overflow weirs are located at the end of the basins. Counter-current sludge scrapers transport the sludge to the storage hoppers.

Secondary treatment is provided by two, equally-sized, complete mix basins. Each basin contains four surface mechanical aerators for mixing and aeration. Ferric chloride is added to the effluent chamber of the aeration basins for phosphorus removal. Two circular clarifiers with peripheral weirs provide secondary clarification. The return activated sludge flow from these clarifiers is controlled by slide gates, and a screw pump is used to return the sludge to the front of the aeration basins. Following the secondary clarifiers, a Parshall flume provides flow measurement, and chlorine is added for disinfection prior to discharge. The outfall pipe into Lake Ontario provides contact time for the disinfection process.

Sludge produced in the secondary process is wasted from the return sludge flow stream and directed to the primary clarifiers. Sludge flow measurement is provided by a magnetic flow meter. Co-settled sludge from the primary clarifiers is pumped to a heated anaerobic primary digester with a fixed cover. Sludge from the heated digester is transferred to a non-heated secondary digester with a floating cover. In addition to the secondary digester, sludge storage is also provided by a storage tank constructed in 1990 at the plant. An additional small holding tank is available for storage of winery waste, which is pumped directly into the primary digester. Sludge disposal is accomplished by injection into agricultural lands located close to the plant site. On-site sludge storage is required during inclement weather and winter which could be up to five months of the year.

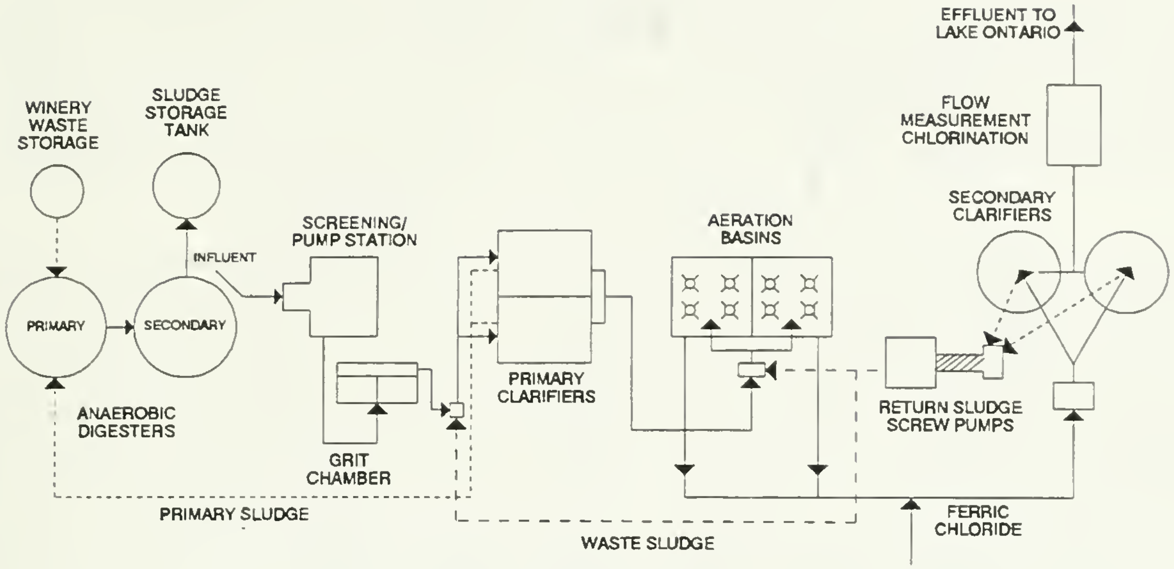

Figure 6 Plant J Flow Schematic

Plant J is staffed by a foreman and two senior operators, four labourers, a maintenance person and an area maintenance person under the direction of an Area Superintendent. Two additional staff located at the STP service the pumping stations serving the plant as well as a sewage treatment lagoon. The facility is manned ten hours per day, seven days per week. In addition to the in-house laboratory, analytical support is provided by the regional laboratory.

4.1.2 CTA Results

For the duration of the CTA, the CTA Team, regional management, plant management, and operations staff adopted monthly average criteria as a means of measuring the success of the demonstration. The targeted criteria was 25 mg/L for $TBOD_5$, 25 mg/L for TSS, and 1 mg/L for TP.

For the period of July 1992 to the end of the CTA (December 1993), the final effluent samples were collected using 24 hour refrigerated composite samplers, and analyzed daily on-site for TSS. Samples were submitted to the regional laboratory three times per week for $TBOD_5$, TSS, NH_3, NO_2^-, NO_3^-, and TP analysis. Prior to the start of the CTA composite samples were submitted twice per month to the regional laboratory and twice per month to the MOEE laboratory for analysis of $TBOD_5$, TSS, TP, and NH_3 effluent concentrations.

Figure 7 depicts the final effluent $TBOD_5$ concentrations for the period January 1991 to the end of the assistance program. The target $TBOD_5$ of 25 mg/L is depicted by the horizontal line. For the duration of the CTA the plant recorded no instances when the

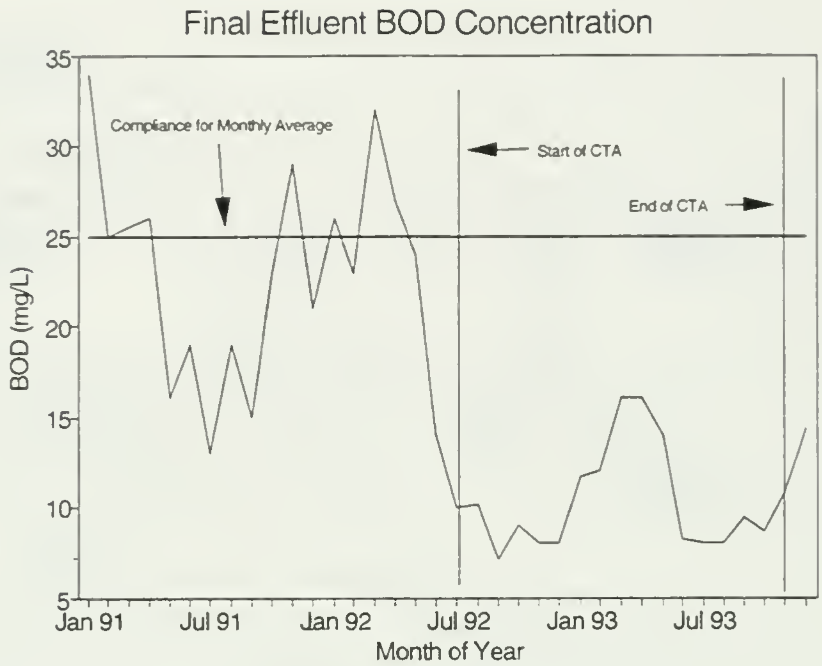

Figure 7 Final Effluent $TBOD_5$ Concentration 1991 to 1993

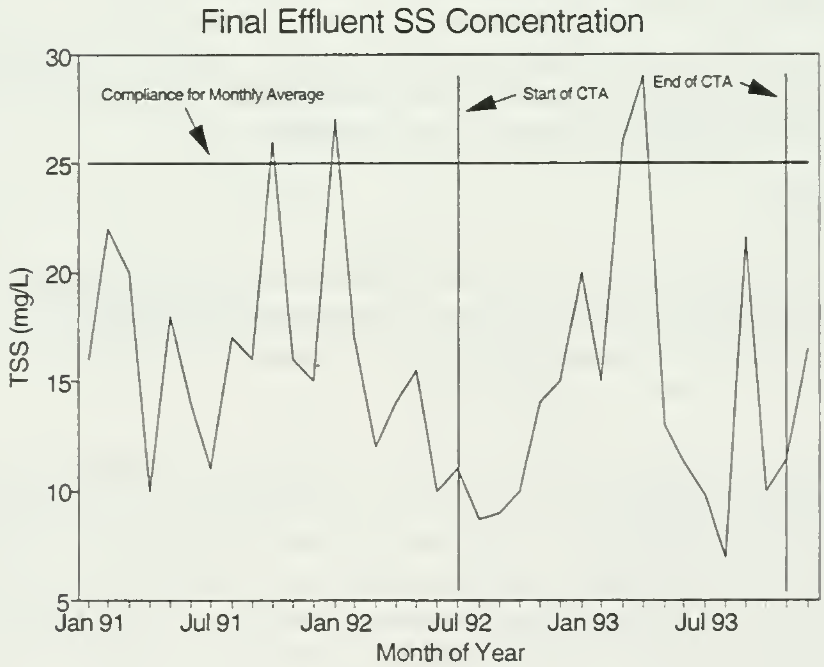

Figure 8 Final Effluent TSS Concentration 1991 to 1993

$TBOD_5$ concentration exceeded the targeted monthly average of 25 mg/L. For the twelve month period prior to the start of the CTA the plant recorded four instances (Nov 91, Jan 92, Mar 92, Apr 92) when the final effluent $TBOD_5$ exceeded the 25 mg/L target. During the CTA, the $TBOD_5$ concentration averaged 11 mg/L (July

92 to July 93), equating to an average effluent $TBOD_5$ loading of 180 kg per day. In contrast, before the CTA, for the period July 91 to July 92, the average final effluent $TBOD_5$ concentration was 21 mg/L, equating to an average effluent $TBOD_5$ loading of 296 kg per day. Significantly, the average daily flow (ADF) during the CTA was 16,500 m^3/d in contrast to 13,900 m^3/d for the twelve month period before the CTA. Although treating higher hydraulic flows during the CTA, the plant achieved a reduction in overall $TBOD_5$ loading of 40% to Lake Ontario.

Figure 8 depicts the final effluent TSS quality for the period of January 1991 to the end of the CTA. The target of 25 mg/L TSS is depicted by the horizontal line. For the duration of the CTA the plant reported two instances when the final effluent concentration was greater than the targeted 25 mg/L TSS. Likewise for the twelve month period prior to the CTA, two exceedences of the target 25 mg/L were reported. The average TSS concentration for the period of July 1991 to July 1992 was 16 mg/L. For the period of July 1992 to July 1993 the average effluent TSS concentration was 15 mg/L. Over the winter period the average final effluent TSS concentration began to increase due to process instability. This instability was further complicated by inadequate process control and corresponding periods of elevated hydraulic flows. Due to the deterioration in sludge settleability in February, March and April, 1993, and in combination with the increased ADF for the period, the average effluent TSS loading increased to 242 kg per day as compared to 220 kg per day for the twelve month period prior to the CTA.

Figure 9 depicts the final effluent TP quality for the same period. For the 12 month period prior to the start of the CTA the plant recorded one month (October 1991) when the TP average concentration exceeded the 1 mg/L compliance value. During the CTA, no instances were recorded where the plant exceeded the 1 mg/L monthly average compliance value. The average TP concentration for the period July 1991 to July 1992 was 0.6 mg/L. For the period of July 1992 to July 1993 the average TP concentration was 0.6 mg/L. The TP loading increased to 10 kg/d during the CTA as compared to 9 kg/d before. However, as previously noted, the ADF during the period of the CTA was 2,600 m^3/d higher than for the 12 month period prior to the start of the CTA. In successfully treating this additional hydraulic load the plant maintained the TP effluent concentration. As the CTA progressed, the TP effluent concentrations have shown a general downward trend.

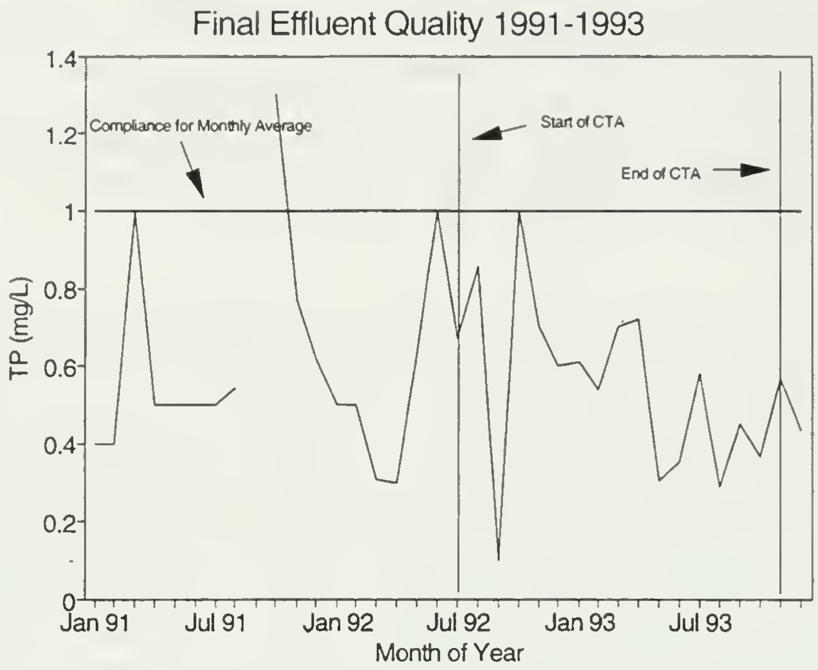

Figure 9 Final Effluent Total Phosphorus Concentration 1991 to 1993

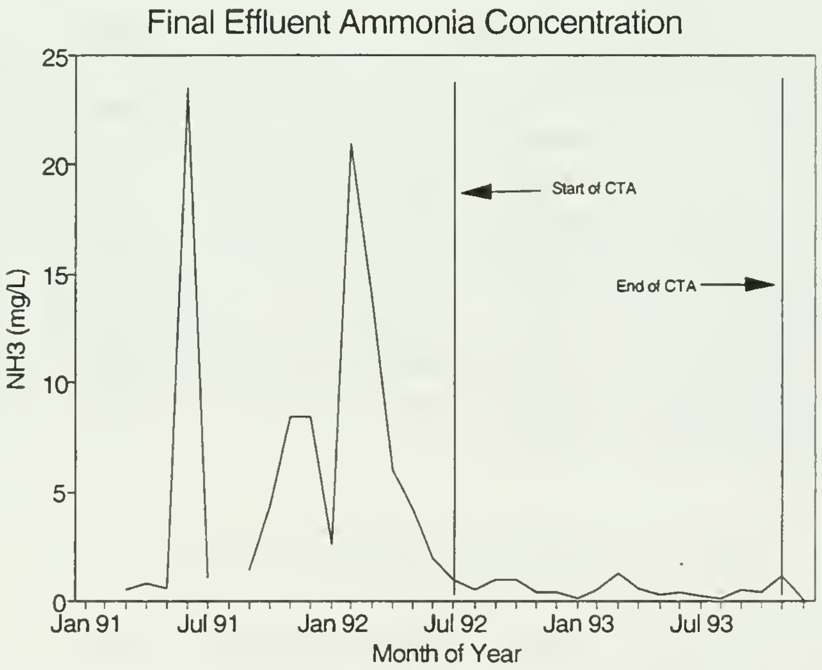

Figure 10 Final Effluent NH_3 Concentration 1991 to 1993

Figure 10 depicts the final effluent ammonia concentrations for the duration of the CTA. In addition to addressing the performance limiting factors identified during the CPE, a special study was carried out to identify if the treatment plant could achieve and maintain complete nitrification (although not designed to). Historically, the reported final effluent ammonia concentrations identified that the plant was successfully nitrifying during the summer but not during the winter. The graph identifies that nitrification was maintained for the duration of the CTA. The average ammonia concentration for the period July 1991 to July 1992 was 7 mg/L. For the period of July 1992 to July 1993 the average ammonia concentration was 0.6 mg/L. The final effluent loading during the CTA was 9.9 kg/d as compared to 97 kg/d before.

The complete CTA report is included in Appendix 2.

4.1.3 Resources Required to Achieve the CTA Results

Activities carried out by CTA facilitators included: regular site visits, management and review of operating and performance data and meetings with Municipal management and MOEE district offices to inform them of the status and objectives of the CTA. Table 2 lists the frequency and duration of site visits and briefings.

Table 2 Frequency and Duration of Site Visits and Briefings

CTA Time Period	Site Visits Per Month	Duration of Visit (h)	No. of CTA Staff	Data management (h)	No. of Manage-ment Meetings	No. of Regulatory Meetings
Apr-Jul 92	2	3	2	0	4	2
Aug-Sep 92	12	3	2	16	2	1
Oct 92-Apr 93	8	3	2	20	3	2
May-Sep 93	8	3	1	10	2	0
Oct-Dec 93	4	4	1	10	1	0

For this demonstration two team members were normally involved in site visits. Generally, two site visits per week were required to ensure that the performance related issues were addressed. The frequency was reduced to one visit per week as the issues were resolved and plant staff gained more awareness and confidence in the process control program.

In total, more than 1500 hours of facilitator time (exclusive of travel time) were spent applying the CTA at Plant J. As documented by experiences in the U.S., the level of effort and hence the cost of conducting a CTA will depend on:

- the size and complexity of the facility,
- the skills and experience of the CTA facilitators,
- the number and nature of the performance limiting factors, and
- the capabilities of STP administrative and technical staff and their level of co-operation

A key component of the CTA was to facilitate the operations staff to organize and graph process monitoring data that was generated on a daily basis. Plotting of key parameters enabled staff to observe trends in the process data. When correctly interpreted, this information alerted staff to trends which indicated a deterioration in process stability brought on by seasonal variations or unit process loading variations.

During the CTA, data trending was maintained by the CTA team. Operational and performance summaries (see Appendix 2) were distributed to the CTA team, CTA trainers, and operations staff on a monthly basis for interpretation and assessment of performance goals. An operational and performance data trending package was developed in cooperation with operations staff to facilitate continued data trending and analysis upon completion of the CTA. This trending package was customized for Plant J (i.e. existing computer and software at Plant J, typical flow ranges, etc.). The data trending package was provided in both a computerized form and a hardcopy form.

4.2 Plant B

4.2.1 Facility Background

Plant B, located in southwestern Ontario, is operated by the Ontario Clean Water Agency. The plant has a rated flow capacity of 681 m^3/d (0.15 MIGD). The Smith and Loveless Model R, factory-built sewage treatment plant was commissioned in April 1974. The treatment plant is classified as a extended aeration process with phosphorous removal and chlorination capabilities. The plant is equipped with raw sewage and secondary bypasses as depicted in Figure 11.

Flow to the plant comes from a lift station equipped with 3 transfer pumps which are capable of pumping up to 700% of the design flow which traditionally caused severe hydraulic overloading of the plant. Flow entering the plant passes through a comminutor or manually cleaned bar screen and into a 3 m^3 aerated grit tank. At present, the grit removal equipment is out of service and grit removal can only be accomplished by draining the grit tank. The flow then enters the circular extended aeration tank where it is aerated and mixed by coarse bubble diffusers mounted on the inner wall of the tank. Air is supplied by two 268 cfm positive displacement blowers which are housed in the control building. The blowers also supply air to the return activated sludge and grit chamber airlift pumps. Alum is pumped by one of two metering pumps into the discharge of the aeration tank. Mixed liquor is discharged into the centre well of a circular clarifier with a surface area of 46.8 m^2. The clarifier is equipped with an outer perimeter weir and scum removal system. Scum flows by gravity into the sludge holding tank. Final effluent is chlorinated in a 14.2 m^3 contact tank before being discharged through a 90 degree V-notch weir. Total plant flow is measured using an ultrasonic level detector and a 90 degree V-notch weir. Sludge is wasted from the return activated sludge line and transferred to a 42.5 m^3 sludge holding tank. Supernatant from the sludge holding tank is airlifted back into the aeration system prior to sludge haulage.

Waste sludge is gravity thickened in the sludge holding tank before being pumped and transported to either approved land disposal sites or sludge storage lagoons. The sludge storage lagoons were designed to handle sludge from at least two activated sludge facilities.

Plant B is staffed by a superintendent, and two operators who collectively have responsibility for another extended aeration STP, sewage treatment lagoons, and the maintenance of pumping stations.

4.2.2 CTA Results

For the duration of the CTA, the technical team, OCWA utility management, plant management, and operations staff adopted monthly average compliance criteria to measure the success of the Comprehensive Technical Assistance program. The targeted criteria were 15 mg/L for $TBOD_5$, 20 mg/L for TSS, and 1 mg/L for TP.

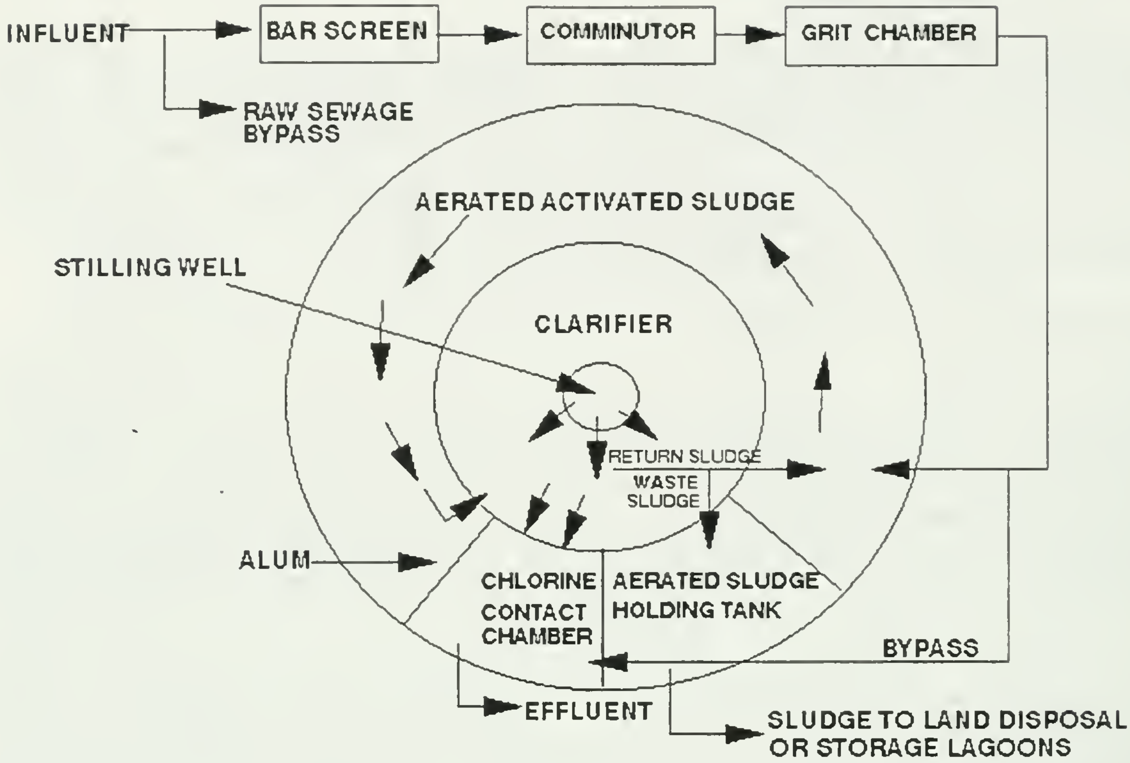

Figure 11 Plant B Flow Schematic

For the purposes of this study, during the period July 1992 to the end of the CTA, final effluent samples were collected using 24 hour refrigerated composite samplers, analyzed daily on-site for TSS and submitted to the MOEE laboratory three times per week for $TBOD_5$, TSS, NH_3, NO_2^-, NO_3^-, and TP analysis. Prior to July 1992, grab samples of final effluent were collected twice per month and analyzed for $TBOD_5$, TSS and TP. No analysis was performed for effluent NH_3 concentrations.

Figure 12 depicts the final effluent TSS quality for the period January 1991 up to the end of the assistance program. The target TSS of 20 mg/L is depicted by the horizontal line. The CTA was initiated in October 1992. During the CPE performed in February 1992 a 26% sludge non-accountability was identified (Appendix 3). This non-accountability represents approximately 6,000 kg of sludge. Knowing the susceptibility of the plant to storm flow impact and assuming that the 6,000 kg of solids were washed to the receiving stream, a final effluent TSS concentration of approximately 37 mg/L was projected for the entire year of 1991 in contrast to the reported concentration of 8 mg/L. The projected level of performance is depicted by the horizontal portion of the graph for 1991. In November 1992 the plant received two significant storm events. As the CTA was in the early stages and the optimum process control program was not yet in place, the impact of the storm event resulted in an average TSS concentration of 47 mg/L for the month. However, as the CTA progressed, the level of operator knowledge, confidence, and process control

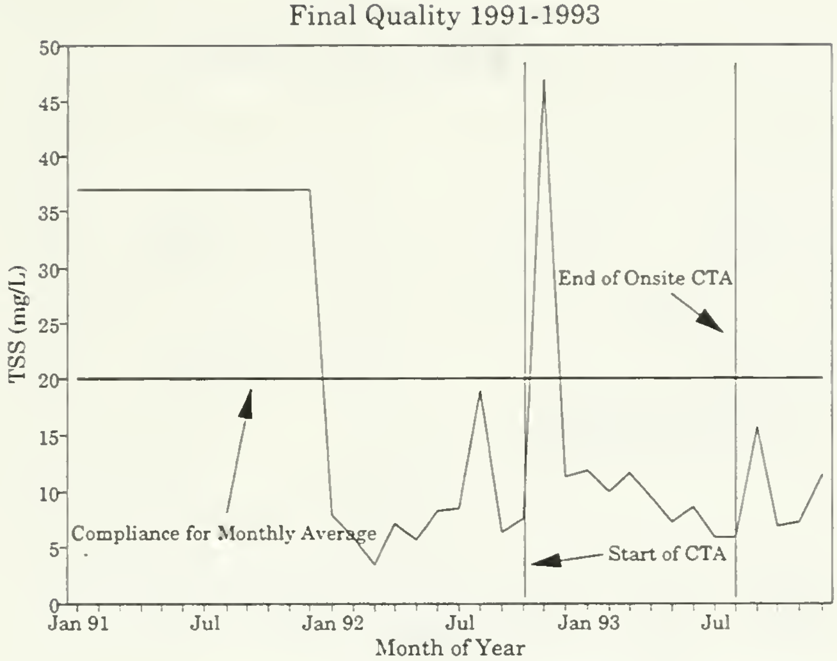

Figure 12 Final Effluent TSS Concentration 1991 to 1993

awareness improved, resulting in a downward trend in the final effluent TSS concentration till the end of the CTA in August 1993.

Figure 13 depicts the final effluent $TBOD_5$ quality for the period January 1991 till the end of the CTA. The target of 15 mg/L BOD_5 is depicted by the horizontal line. The sludge production non-accountability which resulted in a projected TSS final effluent concentration of 37 mg/L for the entire year was likewise used to calculate a projected $TBOD_5$ concentration. This projected concentration was 20 mg/L for the entire year of 1991 as compared to the reported 5 mg/L. This projected performance is depicted by the horizontal portion of the graph for 1991. Since the beginning of the CTA, the final effluent $TBOD_5$ concentration was consistently less than 10 mg/L.

Figure 14 depicts the final effluent TP quality for the same period. The plant has consistently recorded TP final effluent concentrations of less than 1 mg/L, and this consistency has been maintained for the duration of the CTA.

Figure 15 depicts the final effluent ammonia concentration for the duration of the CTA. No effluent ammonia concentrations were reported prior to CTA. As the routine process control program was established, the plant (although not designed to nitrify) started to completely nitrify as shown by the low effluent ammonia concentrations in November and December 1992. Typically the influent TKN concentration averaged approximately 40 mg/L for the duration of the CTA. However, on several occasions spikes of influent TKN were measured as high as 90 mg/L. In February 1993, the SRT was reduced from 20 to 15 days in anticipation of spring melt and high hydraulic flows to the plant. This process adjustment

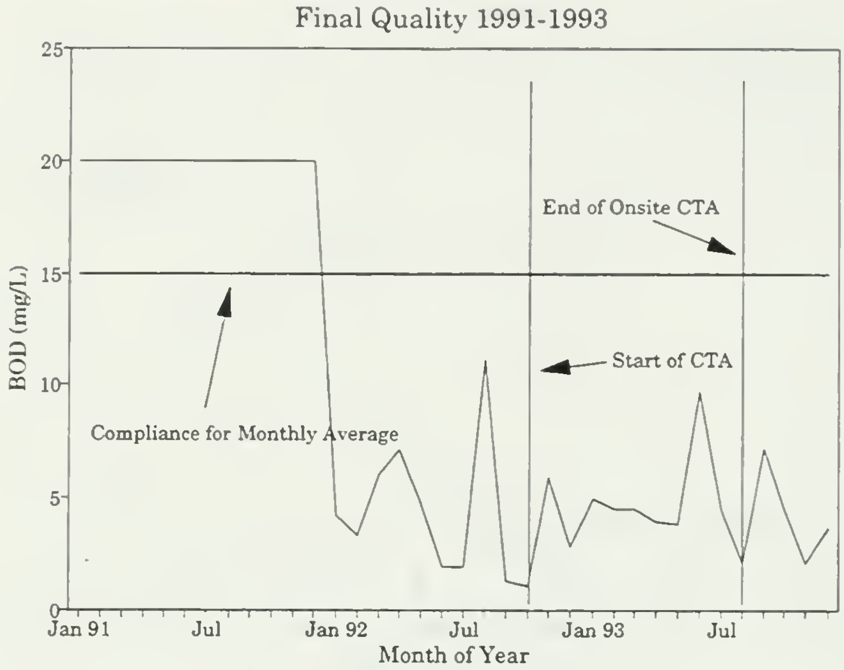

Figure 13 Final Effluent BOD_5 Concentration 1991 to 1993

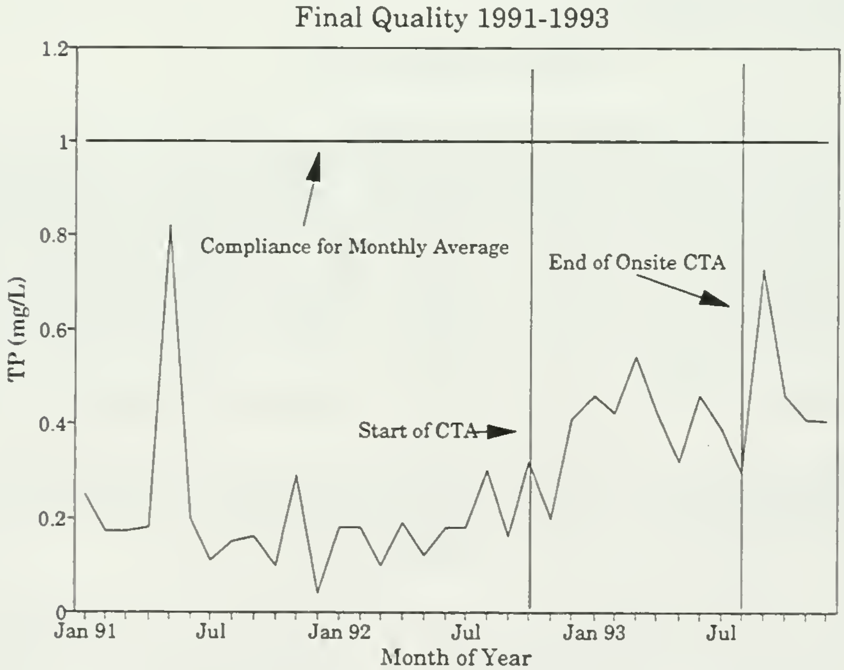

Figure 14 Final Effluent TP Concentration 1991 to 1993

increased final effluent ammonia concentrations starting in late February as the total mass of activated sludge was reduced. Additionally, with the arrival of spring and summer, increased water temperatures reduced the ability of the serviceable air blowers to supply enough oxygen for complete nitrification. Additional blower

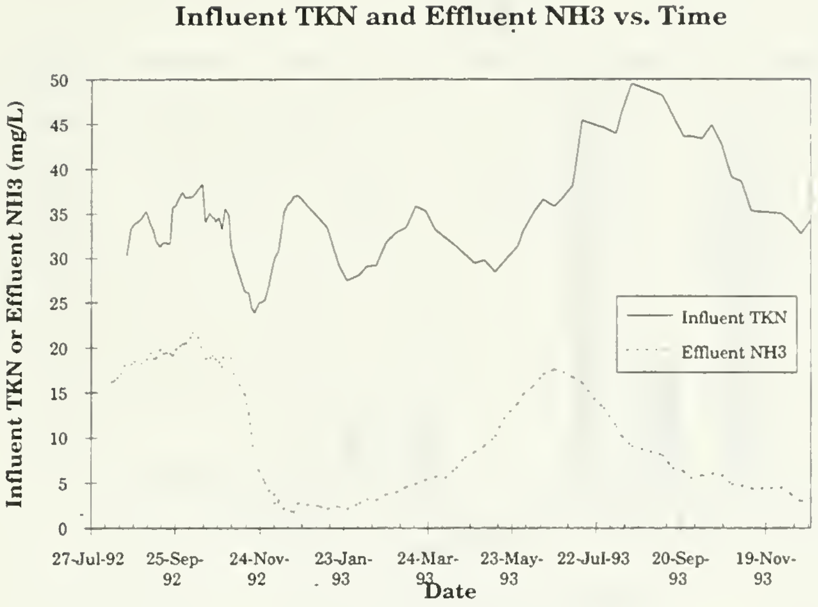

Figure 15 Influent TKN and Effluent Ammonia Concentrations July 1992 to December 1993

equipment is present on-site but is not operated continuously as it is mechanically unreliable.

Figure 16 depicts the benefit which the CTA has had in reducing the impact of storm events and consequently reducing the solids loading to the river. Prior to the CTA two significant storm events in July and September 1992 resulted in 271 kg and 94 kg of solids, respectively, being washed to the river. After the start of the CTA, another storm event on November 2nd resulted in 312 kg of solids being lost. However, as the level of operator knowledge and awareness increased and the required process control steps were put in place, the impact of subsequent storm events was significantly reduced. The storm flows successfully treated after the start of the CTA (October 1992) are significantly greater than those treated prior to the CTA. As the CTA progressed the flows successfully treated by the plant during storm events increased while the mass of solids being lost to the river were significantly reduced.

By optimizing sludge management and resolving the discrepancy between the waste sludge volumes and the volume of the haulage truck, a 55% reduction in sludge haulage costs was achieved (Table 3).

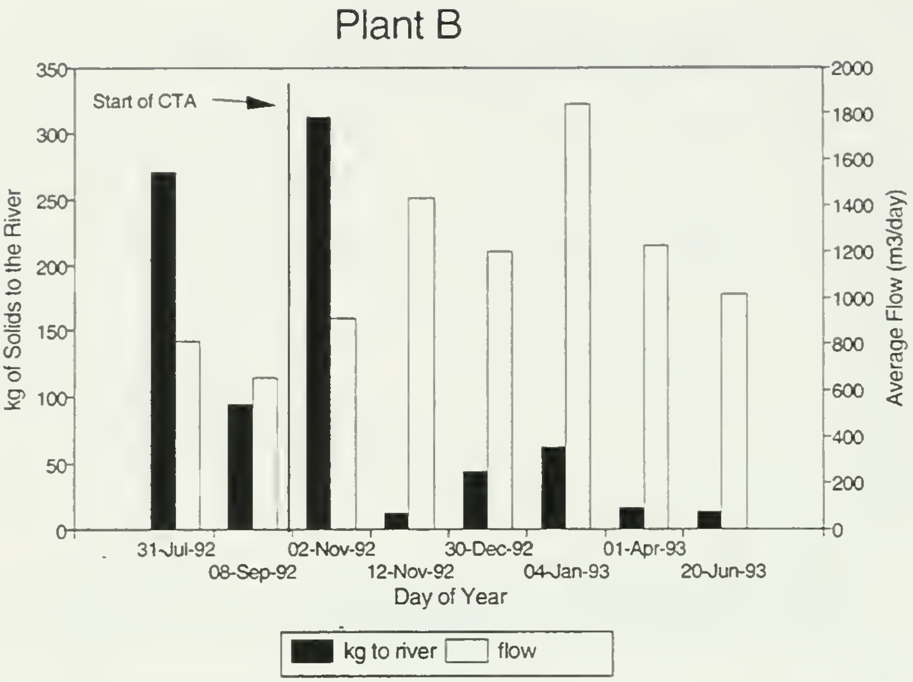

Figure 16 Assessment of Storm Impact on Solids Loading to River

Table 3 1992/1993 Sludge Haulage Costs Comparisons

Without Technical Assistance	$ 28.6 K
With Technical Assistance	$ 12.8 K
Savings	$ 15.8 K (55%)

The complete CTA report for plant B in included in Appendix 3.

4.2.3 Resources Required to Achieve the CTA Results

Table 4 identifies the frequency and duration of site visits during the CTA at Plant B. In excess of 300 hours (exclusive of travel time) were spent facilitating the CTA at Plant B. The same comments regarding the number and frequency of site visits, CTA staff requirements, data management requirements, management and regulatory meetings, apply to Plant B as well as Plant J. Due to the unavailability of computer facilities on-site, graph paper was customized for the plant to allow the operators to trend and analyze the operational and performance data on-site rather than relying on off-site computer assistance. Note that the time required to complete the CTA at Plant B was ten months as compared to 16 months at Plant J.

Table 4 Frequency and Duration of Visits and Briefings

Time Period	Site Visits per month	Duration of Visit (h)	No. of CTA Staff	Data management (h)	No. of Manage-ment Meetings	No. of Regulatory Meetings
Apr-Sep 92	0.5	4	2	0	2	1
Oct-Dec 92	4	4	2	8	3	1
Jan-Apr 93	4	4	1	6	2	0
May-Aug 93	2	4	1	6	1	0

4.3 Plant H

4.3.1 Facility Background

Plant H, located in southeastern Ontario, is operated by the Ontario Clean Water Agency. The treatment plant has a rated capacity of 955 m^3/day (0.21 MIGD).

The Smith and Loveless Ecodyne Oxigest Model 58-RE-252 factory built sewage treatment plant was commissioned in 1977. The treatment plant is classified as an extended aeration process with chlorination capabilities. Phosphorus removal is not required at the present time. There is a manual bypass gate after the headworks to divert peak flows around the treatment plant to a combined outfall main. Opening of the bypass gate allows approximately 50% of the influent flow to be bypassed.

Flow entering the headworks passes through a manually cleaned bar screen, grit channels, and comminutor. There is a bypass around the comminutor equipped with a coarse bar screen. The flow then enters the circular extended aeration tank where it is aerated and mixed by coarse bubble diffusers mounted on the inner wall of the tank. Air is presently supplied by three Roots-Connersville 336 cfm positive displacement blowers which are housed in the control building. The blowers also supply air to an aerated sludge holding tank, air lift return sludge system, and an air lift clarifier scum removal system. Waste sludge flow is removed via the return activated sludge line and transferred to the 29.4 m^3 aerated sludge holding tank. Mixed liquor from the aeration tank is discharged into the centre well of a circular clarifier with a surface area of 67.9 m^2. The clarifier is equipped with an outer perimeter weir and scum removal system. Final effluent is chlorinated in a 19.8 m^3 contact tank before being discharged through a 90 degree V-notch weir. Total plant flow is measured using an ultrasonic level detector in conjunction with a 90 degree V-notch weir.

Thickened waste sludge is hauled by plant staff to a nearby STP where it is blended and ultimately disposed of on agricultural land. The plant schematic for plant H is presented in Figure 17.

Plant H is currently staffed by a superintendent and one operator. During the first four months of the CTA program, two operators staffed the facility. Once a sound understanding of process control had been obtained, the senior operator resumed his position at a neighbouring STP. He maintained involvement with the CTA program and returned in the spring of 1994 to obtain training and implementation of stepfeed operation.

4.3.2 CTA Results

For the duration of the CTA, the technical team, OCWA operations management, plant management, and operations staff adopted monthly average compliance criteria to measure the success of the Comprehensive Technical Assistance program. The targeted criteria was 15 mg/L for $TBOD_5$, and 20 mg/L for TSS. A target criteria for

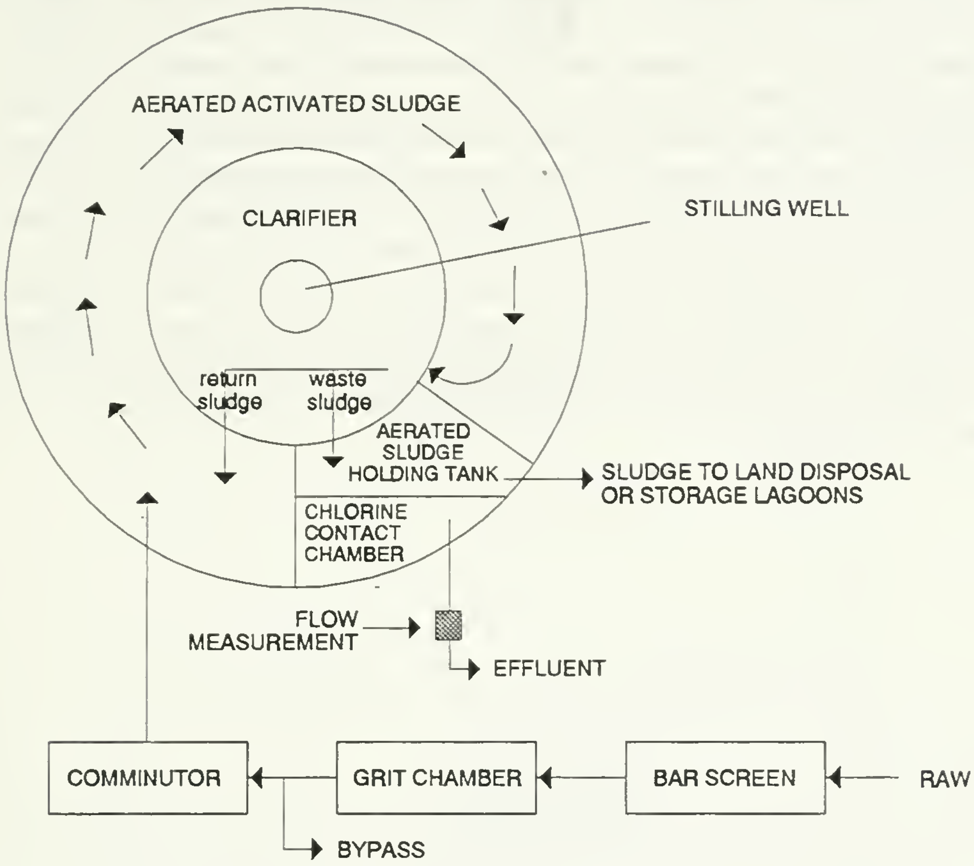

Figure 17 Plant H Flow Schematic

total phosphorus was not set since Plant H is exempt from phosphorus removal requirements under current Ministry of the Environment and Energy policy.

For the period of March 1993 to the end of the CTA final and combined effluent samples were collected using 24 hour refrigerated composite samplers, analyzed daily on-site for TSS and submitted to the MOEE Eastern Regional Laboratory once per week for $TBOD_5$, TSS, NH_3, and TP analysis. Prior to the start of the CTA, composite effluent samples were submitted twice per month for analysis of $TBOD_5$ and TSS. There was no requirement to analyze final effluent samples for TP or NH_3.

Figure 18 depicts the final effluent TSS quality for the period of January 1992 to the end of the CTA in May 1994. The target of 20 mg/L TSS is depicted by the horizontal line. For the fourteen month period prior to the start of the CTA the plant recorded four instances (Jan 92, May 92, Jun 92, Jul 92) when the TSS concentration exceeded the 20 mg/L target. For the duration of the CTA the plant reported two instances when the final effluent TSS concentration was greater than the targeted 20 mg/L TSS. In March 1993 the plant was impacted by a filamentous bulking problem, limited sludge storage, and experienced a sudden increase in hydraulic loading as a result of the spring freshet. As the CTA was in the early stages and the optimum process control program was not yet in place, the impact of the hydraulic shock resulted in an average TSS concentration of 47 mg/L for the month. In May 1993, limited sludge storage facilities continued to impact the facility. Although there was improved operator knowledge and awareness of process control, the physical mass of sludge in the system prevented good control over the distribution of activated sludge between the aeration cell and the secondary clarifier. As a result, the clarifier sludge retention time was excessive and resulted in denitrification, loss of control over the sludge blanket, and poor effluent quality. The impact of limited sludge storage and poor sludge distribution control resulted in an average TSS concentration of 21.5 mg/L for the month. However, as the CTA progressed sludge storage limitations were resolved, good process control was established and maintained, and the level of operator knowledge and confidence continued to improve, such that the final effluent TSS concentration displayed a downward trend and stabilized below the monthly target of 20 mg/L.

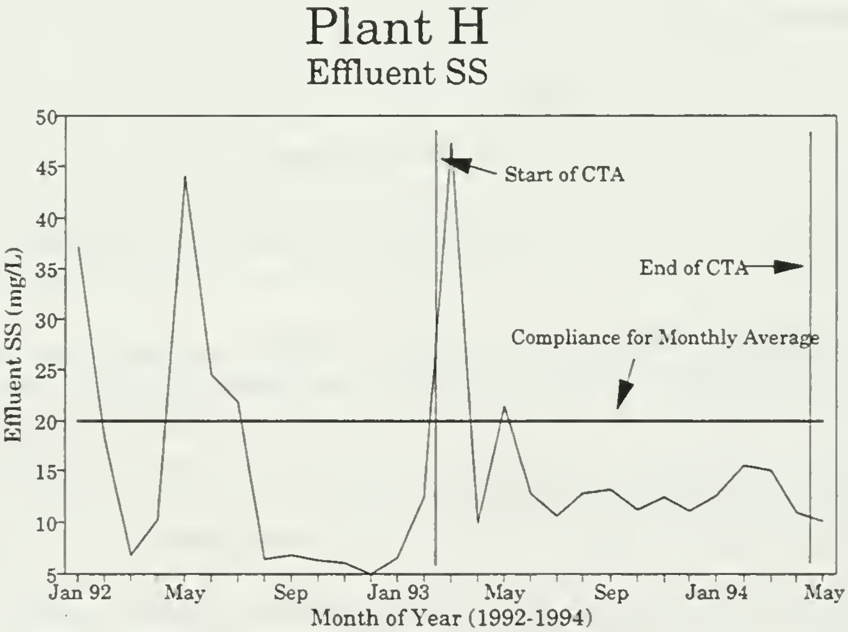

Figure 18 Final Effluent TSS Quality 1992 to 1994

Figure 19 depicts the final effluent $TBOD_5$ concentration for the period January 1992 up to the end of the assistance program. The target concentration of 15 mg/L is depicted by the horizontal line. For the fourteen month period prior to the start of the CTA the plant reported three instances (Jan 92, Apr 92, May 92) when the final effluent $TBOD_5$ exceeded the 15 mg/L target. For the duration of the CTA, the plant reported no instances when the $TBOD_5$ concentration exceeded the targeted monthly average of 15 mg/L. Since the beginning of the CTA, the final effluent $TBOD_5$ concentration was consistently maintained below 11 mg/L.

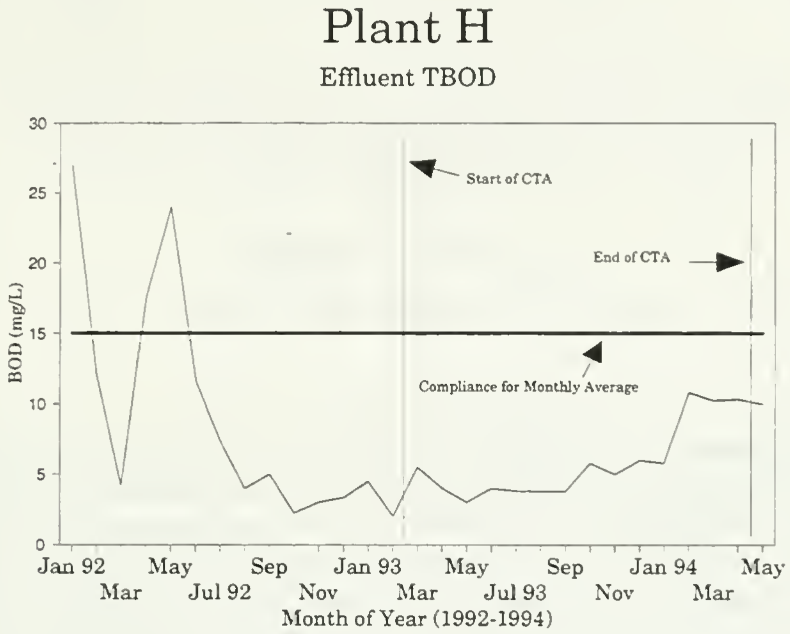

Figure 19 Final Effluent BOD_5 Quality 1992 to 1994

Figure 20 depicts the final effluent total ammonia concentration for the duration of the CTA. The plant was found to be nitrifying at the start of the CTA with the concentration of total ammonia in the final effluent fluctuating between 0.5 and 3.0 mg/L. As the CTA progressed and a routine process control program was established, control over nitrification improved, resulting in effluent total ammonia concentrations consistently below 1.0 mg/L from August 1993 to April March 1994. Typically the influent total ammonia concentration averaged approximately 20 mg/L for the duration of the CTA. However, on several occasions spikes of influent total ammonia were identified by composite sampling to be as high as 46 mg/L. In March of 1994, the plant operation was switched from conventional treatment to step feed mode in anticipation of increased hydraulic loading from the spring freshet. This process adjustment increased the final effluent total ammonia concentrations starting in mid March as changes in the activated sludge characteristics occurred, and the hydraulic retention time within the treatment plant was reduced.

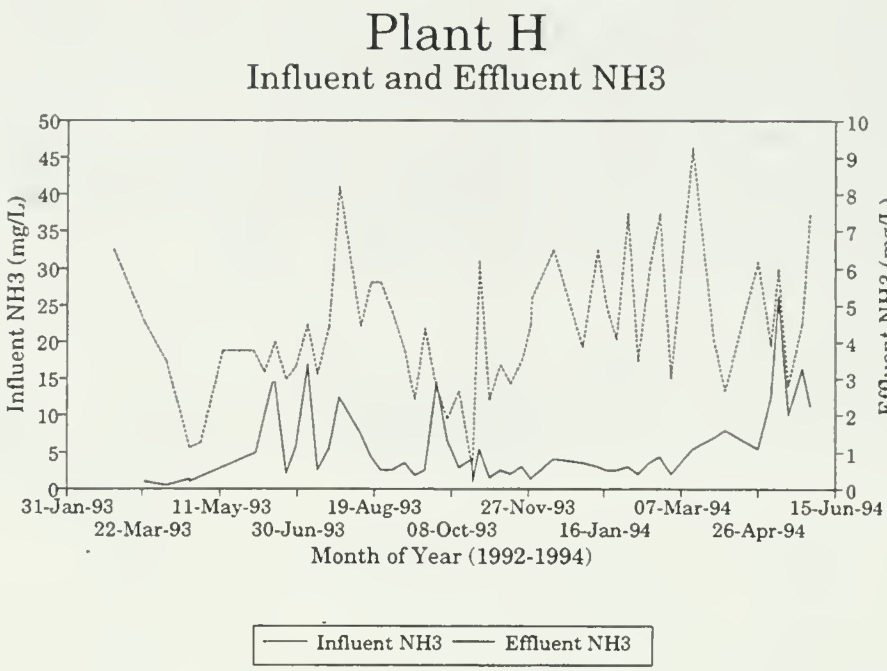

Figure 20 Influent and Effluent NH_3

Figure 21 depicts the benefit which the CTA has had in reducing the impact of storm events and spring flooding, and consequent reduction of solids loading to the river. At the beginning of the CTA, two hydraulic shock loading events in March 1993 resulted in 392 kg and 803 kg of solids being washed to the river. However, as the level of operator knowledge and awareness increased, and the required process control steps were implemented, the impact of subsequent hydraulic loading events was significantly reduced. As the CTA progressed the flows successfully treated by the plant during spring freshet and storm events increased while the mass of solids being lost to the river was significantly reduced. In November 1993, step feed was added to the treatment plant by means of a simple, low cost retrofit. Use of the step feed capability combined with maintenance of an effective process control program enabled treatment of flows approximately four times the rated design flow of the facility as shown by the high average day flows in April 1994.

Figure 22 depicts the impact of the CTA in reducing the volume and duration of raw sewage bypassing during spring months. Prior to the CTA, considerable volume and frequency of raw sewage bypassing occurred from the facility during periods of high flow encountered each spring. However, in 1993 after initiation the CTA, the volume and duration of bypassing was reduced by 25 percent and 38 percent, respectively. In the spring of 1994 with the use of the step feed capability in conjunction with skilled operation, the volume and duration of bypassing was reduced by 95 percent and 97 percent, respectively, when compared to the spring prior to the CTA. The total flow to the treatment plant remained consistent for the spring period during the three years examined.

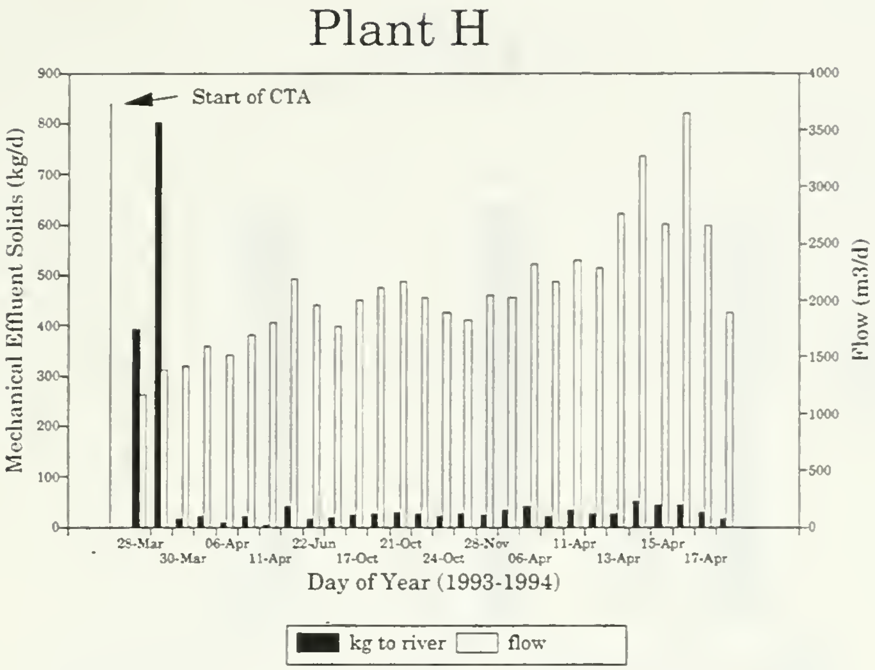

Figure 21 Impact of Storm Events on Solids Loading to River

Figure 23 depicts the reduction in $TBOD_5$ and TSS loading to the receiving stream associated with the reduction in raw sewage bypassing. Prior to the CTA, spring bypassing resulted in considerable $TBOD_5$ and TSS loading to the river as shown in the data for 1992. However, as the level of operator confidence and awareness improved and the required daily process control was put in place, the $TBOD_5$ and TSS loadings contributed from spring bypassing were each reduced by 40 percent as shown in the data for 1993. In the spring of 1994, the use of step feed in combination with good process control and skilled operations staff enabled a 96 percent and 95 percent reduction in $TBOD_5$ and TSS loadings, respectively, when compared to loadings contributed from bypassing in 1992.

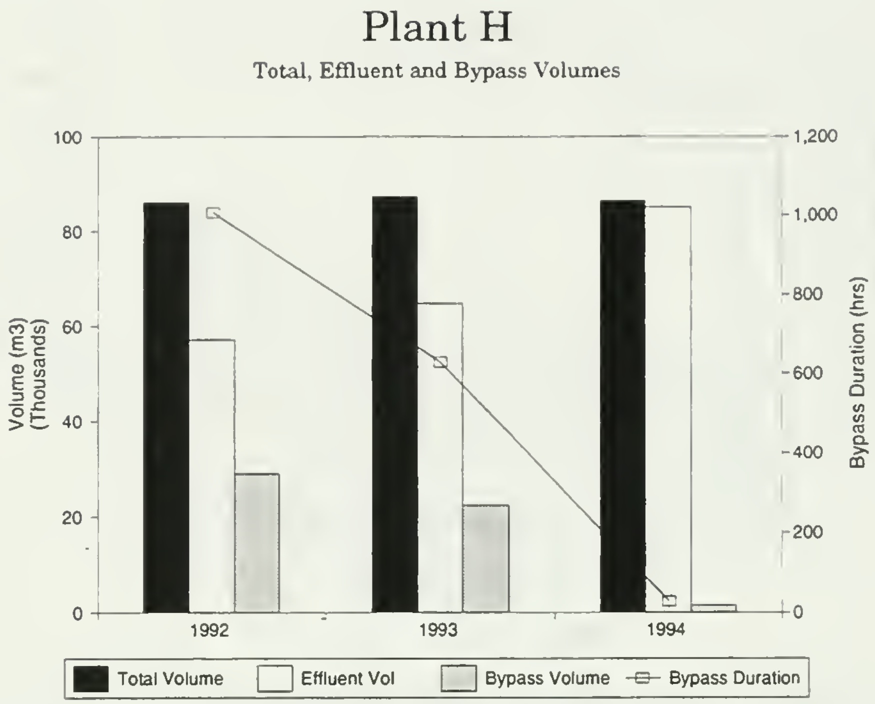

Figure 22 Comparison of Total Influent, Effluent, Bypass Volume and Duration for Spring (March and April) of 1992-1994

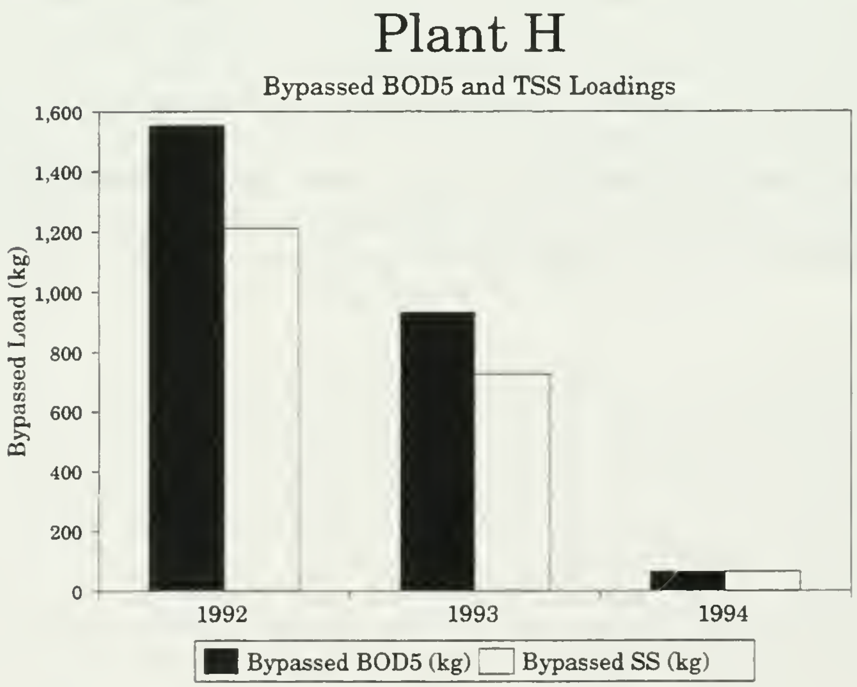

Figure 23 Total Raw Sewage Bypass BOD_5 and TSS Loadings for Spring (March and April) of 1992-1994

Figure 24 depicts the hauled sludge concentration and unit sludge handling costs per kg hauled for the duration of the CTA. Prior to and during the initial period of the CTA, the plant was affected by a filamentous bulking problem. As a result, the ability to thicken waste activated sludge in the on-site aerated holding tank was compromised as shown by the low hauled sludge total solids concentrations in May through July 1993. As the CTA progressed and the required daily process control program was applied , changes in activated sludge settling characteristics occurred, and the ability to thicken waste activated sludge was consistently improved, as shown from August 1993 to the conclusion of the CTA. By optimizing activated sludge settling characteristics through application of concepts, and consistently improving the ability to thicken waste activated sludge, a 47 percent reduction in the unit sludge haulage costs were achieved during the CTA as represented by the line graph.

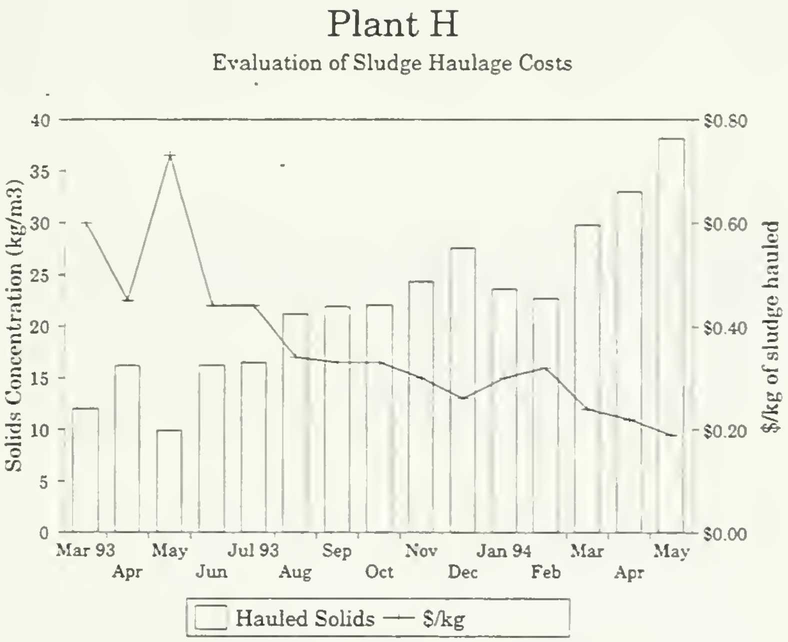

Figure 24 Evaluation of Sludge Haulage Costs 1992-1994

4.3.3 Resources Required to Achieve the CTA Results

Table 5 identifies the frequency and duration of site visits during the CTA at Plant H. The same comments regarding the number and frequency of site visits, CTA staff requirements, data management requirements, management and regulatory meetings, apply to Plant H as well as Plants J and B. Due to the unavailability of computer facilities on-site, both a customized computer program and manual based trending approach were developed for Plant H. Graph paper which was customized for the plant allowed the operators to trend and analyze the operational and performance data on-site rather than relying on off-site computer assistance. The CTA at plant H required 14 months to complete. As approval for installation of step feed capability was not completed in time to demonstrate improved performance during spring 1993, the CTA was continued until the spring 1994.

Table 5 Frequency and Duration of Site Visits and Briefings

Time Period	Site Visits Per Month	Duration of Visit (h)	No. of CTA Staff	Data management (h)	No. of Management Meetings	No. of Regulatory Meetings
Feb-Apr 93	4	5	1	12	2	1
May-Aug 93	2	5	1	6	1	2
Sep-Nov 93	1	5	1	6	0	0
Dec-Feb 94	1	5	1	6	1	0
Mar-Apr 94	2	5	1	4	0	0

5. DISCUSSION

5.1 Monthly Effluent Objectives

Under current MOEE policy, Plants J and B are required to achieve annual average concentrations for $TBOD_5$ and TSS of 25 mg/L and TP monthly average concentrations of 1.0 mg/L. Plant H has no limit for effluent TP but must achieve effluent $TBOD_5$ and TSS concentrations of 25 mg/L on an annual average basis. As previously discussed, the facilitation team, plant management and staff adopted the goal of achieving final effluent concentrations of $TBOD_5$ and TSS of 25 mg/L on a monthly average basis for Plant J. The CTA final effluent objectives for Plants B and H were 15 mg/L $TBOD_5$ and 20 mg/L TSS on a monthly average basis. Table 6 compares the rate of exceedence of monthly averages for $TBOD_5$, TSS, and TP achieved during the CTA to the period of the same duration prior to the CTA. In addition, the average daily flow rate and the type of sampling before and during the CTA are reported..

Table 6 Monthly Objective Status Before and During CTAs

Parameter	Plant J		Plant B		Plant H	
	Before	During	Before	During	Before	During
Aver. day flow (m^3/d) [% change]	14,847	15,293 [+3%]	523	459 [-12%]	927	858 [-7%]
Sampling: Type	Comp	Comp	Grab	Comp	Comp	Comp
No./month	4	12	2	12	2	4⁺
Objective exceedences*						
$TBOD_5$	5/16	0/16	0/10	0/10	3/14	0/14
TSS	2/16	2/16	0/10	1/10	3/14	2/14
TP	1/16	0/16	0/10	0/10	NA**	NA**

Notes:

*: expressed as month/month ie. number of months objective exceeded over the total number of months in the period.
**: not applicable;
+: frequency of submission of samples to MOEE regional laboratory for TSS, $TBOD_5$, NH_3, and TP; effluent TSS concentrations were also analyzed daily by the plant staff.

Staff at Plants J and H reduced exceedences of monthly objectives during the CTA period. For Plant J there were 8 monthly exceedences of the three parameters prior to the initiation of the CTA; during the CTA, there were 2 exceedences. For Plant H the number of exceedences decreased from 6 before the CTA to 2 after the CTA. In addition to reducing the number of monthly exceedences at Plant H during the CTA, as previously noted the volume of untreated sewage which was bypassed during spring runoff was decreased by 95%.

The effluent data from Plant B indicated no exceedences of TBOD5, TSS, or TP in the 10-month period prior to the start of the CTA and one exceedence of TSS after the CTA. However, prior to the CTA, performance at Plant B was based on 2 grab samples per month. In addition, the CPE conducted at Plant B prior to the CTA reviewed performance data for the period Jan. 1, 1991 to Dec. 31, 1991 and concluded that this data probably did not represent true performance. During the CTA, monitoring was therefore upgraded to 24-hour composite samples analyzed three times per week. A longer period of upgraded monitoring at Plant B prior to the initiation of the CTA would have provided a more rigorous basis for comparison.

The exceedences of monthly TSS objectives at Plants B and H occurred during the first three months of the CTA (see Figures 12 and 18). These exceedences therefore occurred during the CTA initiation phase while transfer of skills to the operators was ongoing. At Plant J two exceedences in the monthly TSS objectives occurred at months 8 and 9 following the initiation of the CTA (see Figure 8). These exceedences were attributed to a combination of high flows, a biological upset, and incomplete transfer of skills by an inexperienced CTA facilitation team. It was the considered judgement of the facilitation team that monthly objectives for $TBOD_5$, TSS, and TP could be consistently achieved at all three facilities through the application of CTA techniques.

5.2 Minor Design Limitations

During the demonstrations, a number of minor design limitations were identified as a result of the CTA activities. A description of these limitations is presented in this section, along with the approaches identified by plant staff to "operate around" the limitations.

Plant J's primary clarifiers co-thicken primary and waste activated sludge prior to transfer to anaerobic digesters. Monitoring of these units for the period July 1992 to October 1993 established that removal efficiencies were poor, averaging 0% and 21% for $TBOD_5$ and TSS respectively. To improve performance, plant staff increased monitoring, minimized sludge blanket depths, increased the number of cycles of WAS addition to the primaries to spread the loading over a longer period of time, and increased the monitoring and control of co-thickened sludge from the primaries to the anaerobic digesters. In October 1993, plant staff initiated a special study to improve settling when the primaries were receiving the heaviest solids loading. For one month, polymer was added to grit chamber effluent when WAS being added to the primaries. During the special study, the average TSS removal efficiency was increased to 55%.

Plant B lacked instrumentation to measure the flow of activated sludge wasted from the final settler to the sludge storage tank. Plant staff were able to address this shortcoming by marking the inside wall of the storage tank in increments and establishing the relationship of the increments to volume. Having a target SRT, the operator calculated the mass of sludge to be wasted each day. Based on daily measurements of TSS in the RAS, the operator estimated the required volume to be wasted to meet the target SRT. Therefore, by establishing the relationship between depth and volume for the sludge storage tank, the operators were able to measure the volume of sludge to be wasted daily and maintain consistent total sludge mass control.

Plant H has limited sludge storage. Operators have traditionally thickened waste sludge by settling it in the sludge holding tank and decanting the supernatant back to the aeration basin. With this approach, the existing storage tank can hold two days of sludge production. Through experimentation, the operator identified that the waste sludge concentration could be increased by as much as six times by turning off the recycle sludge pump and allowing the sludge in the final settler to compact for two to three hours per day prior to wasting. This approach has enabled the operator to maximize limited sludge storage volume. Using the optimized approach, the existing storage tank can handle 8 to 9 days of sludge production.

5.3 CTA Team Impressions

The four CTA team members which provided the on-site technical assistance at the three facilities have documented their verbatim comments concerning the CTA experience as follows:

"The CTA experience has first of all upgraded my people skills, as well as my technical knowledge. It has also given me a deeper understanding of the many underlying institutional barriers that need to be overcome to make an optimization program successful in Ontario."

"I experienced complete cooperation at the STP operator level while providing technical assistance."

"For the purpose of this demonstration an important component of each CTA was to establish the performance criteria (monthly average concentrations) which presented an incentive for all of the participants".

"The successful transfer of skills and growth in confidence which I have observed over the duration of the CTA is reflected in the heightened value which the plant staff place on better final effluent quality achieved with their existing facilities. Wherever the CTA is applied in the future this value needs to become a common feature."

"The CTA approach enables plant staff to develop and apply their knowledge such that improvements in the final effluent quality are achieved with assistance from the CTA facilitator."

"The CTA affords a personal approach to operator training at their own facility, complimented by class room training. The commitment to transfer skills as part of the training initiatives has generated great appreciation from the plant staff."

"The CTA activities have changed the outlook of operations staff towards their profession. This change was derived as a result of the 'empowerment' philosophy which is an inherent aspect of a CTA."

"In providing technical assistance the facilitator must remember that the purpose of the assistance program is to facilitate staff and management in addressing and resolving the performance limitations identified at their facility during the CPE. In providing assistance the facilitator must not assume responsibility for the success of the optimization initiatives adopted."

"A successful CTA must be a team effort comprised of plant staff, management, municipal staff, regulations staff and the facilitator."

"Good process control combined with data trending and interpretation is a key component of a CTA. The interpretational abilities of operations staff improved significantly as the CTA progressed. With enhanced operator control and the resulting improvements in effluent quality, the self-esteem of the operations staff likewise grows."

"Formal commitment by managers and administrators to addressing their performance limitations to improve the performance of their existing facilities is a necessity not an option. Otherwise facilitating plant managers and adminstration staff to address their plant needs will be a constant challenge for the CTA facilitators."

"Facilitating plant staff to implement a comprehensive process control and testing strategy was one of the CTA teams easier tasks."

"The majority of plant staff were eager to learn and quickly assumed responsibility for improving the performance of their facilities."

"Plant managers and administrators were constantly challenged during the CTAs to deal with the needs of a more knowledgeable plant staff and the traditional barriers which prevented empowerment of plant staff to improve the performance of their plants."

"Institutional barriers such as lack of incentives, hesitancy to approve minor plant modifications, and hesitancy to recognize operators as a valuable resource were issues identified but not resolved by the CTAs."

"My first impression of a CTA was that it would be a comfortable technical training exercise, but within a short period of time I recognized that the technical training was only one component of a complex process which includes resolution of people issues."

"A CTA facilitator must understand the definition of 'facilitation' to ensure that plant staff, managers and administrators assume responsibility for addressing their limitations. A facilitator does not have to provide the solution to the limitations, but provide a mechanism for staff to address and resolve the limitations."

"To be an effective CTA facilitator you must be open to 'learning as you go.' Every CTA is a learning experience requiring tenacity as there are many obstacles along the path to a successful CTA."

5.4 CTA Recipient Impressions

The management and staff of the plants where the CTA techniques were applied were requested to submit their impressions of the CTA technique and it's applicability for Ontario. These comments are documented here:

"I have worked at MOEE for 10 years. I used to hate getting up in the morning and going to work. There was no challenge to plant operation, or opportunity to be part of a good operations program. Since the start of the CTA, and having learned and witnessed the impact of good process control, I can't wait to get to work in the morning." ...Plant Operator

"The process control program which has been created gives me a complete routine which I can perform each day to enable process control to be maintained. I can see an environmental benefit and I know how it is being achieved. The program works! This is satisfaction! We control the plant now, instead of in the past when the plant controlled the operators." ...Plant Operator.

"Future focus and approach to manpower requirements should take the CTA findings into consideration.".....Utility Manager

"A very good and interesting program which is very worthwhile if we can provide funding to continue the program."....Plant Superintendent

"Pumping large volumes of supernate over short periods of time is the basis for a lot of our problems now.".... Maintenance staff member

"This has been a learning experience from start to finish." .... Utility Manager

"I feel we have more control over the process. We can identify problems better now than before the CTA. I hope that the program is applied at other treatment plants." ... Operator

"The CTA has enabled us to identify the 'bottlenecks' in our treatment process. We have acquired the motivation to do the best possible job with the equipment at hand.".. Operator

"The process control focus of the CTA has identified the importance of representative sampling, analytical procedures, data trending and interpretation in achieving enhanced plant performance."...Operator.

5.5 Overall Assessment of CTA Techniques

For the purpose of applying the CTA protocol in Ontario, it is the judgement of this CTA team that the procedures and methodologies do not need major alterations.

5.5.1 Training

On-site experience and training was necessary to properly apply the CTA techniques. This training must be applied at several facilities to ensure an adequate level of confidence and skill to assume the responsibility of an "independent" facilitation role.

A one-day classroom workshop given by Process Applications Inc. provided the facilitation team with an overview of the CTA approach. Telephone calls with CTA trainers (Process Applications Inc.), quarterly meetings, and monthly review of plots of performance and process variables were tools used in CTA facilitator training.

5.5.2 Facilitator skill requirements

Facilitators assume a leadership role in making process control decisions, assigning responsibilities, training staff and checking progress. This requires experience and knowledge of process operations and control as well as the ability to work with others without confrontation. As multiple skills are required, a team approach offers the best option.

5.5.3 Obstacles to Optimization

In applying the CTAs, a number of obstacles to plant optimization activities were identified. Frequently occurring obstacles were:

a) Lack of Incentives to Perform.

There is no identifiable urgency or incentive at the CTA sites for either plant staff or management to focus on performance. In some instances staff and management were not aware of the compliance limits specified in the plant Certificate of Approval. To create an incentive for optimization, a goal of achieving monthly average concentrations for $TBOD_5$ and TSS in addition to TP was therefore adopted for the study.

b) Focus on Maintenance/Housekeeping rather than Process Control

Consistent process control was not the prime focus at the demonstration sites prior to the CTAs. Maintenance and general housekeeping activities often received a higher priority.

c) Delays in Approving Minor Modifications

During the CTAs, delays in approving minor modifications were caused by (1) a lack of awareness of the need for process optimization, (2) a fear of the legal implications of approving modifications which were not familiar to approvals staff, and (3) a lack of urgency arising from competing demands and priorities.

d) Inadequate Sludge Storage and Disposal

At two of the three facilities, sludge storage was inadequate to enable the process control program to be maintained, especially over the winter.

e) Hesitancy to Recognize Key Role of Operators

There is a hesitancy to acknowledge the key role of plant operators in controlling the treatment process to achieve a good, economical effluent. To optimize performance, operator skills need to be acknowledged, encouraged and developed.

f) No Mechanism to Address Common Limitations

The common nature of the barriers identified during the CTAs points to the need for a comprehensive province-wide approach to address these limitations.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary and Conclusions

The overall objective of this study was to demonstrate the applicability of the U.S. Environmental Protection Agency's Comprehensive Technical Assistance program in Ontario. A technical Facilitation Team, consisting of staff from the MOEE, OCWA and WTC were trained and demonstrated CTAs at three STPs. Facilitators provided leadership in making process control decisions, assigning responsibilities, training staff, and measuring progress. Training, guidance, and telephone support to the Facilitation Team were provided by Process Applications Inc. A long term objective of the study was to determine if transfer of skills could be achieved so that optimized plant performance could be maintained after the CTA was concluded.

Plant J, located in a regional municipality, is a conventional activated sludge process with a design flow of 18,200 m^3/d (4 MIGD). Nine staff operate and maintain the facility. At Plant J, the staff achieved a 40% reduction in $TBOD_5$ loading, and a 90% reduction in ammonia loading to Lake Ontario as a result of the 16 month CTA. Total phosphorus and TSS loadings have been maintained even though the average daily flows during the CTA were 19% higher than before the CTA.

Plant B is a package extended aeration plant with a design flow of 681 m^3/d (0.15 MIGD). Three OCWA staff operate and maintain the plant in addition to another facility and pumping stations. At Plant B, the staff achieved significant reductions in $TBOD_5$ loadings (70%), TSS loadings (59%), and ammonia loadings (46%). The total phosphorus concentrations have remained consistently below the 1 mg/L monthly average limit. As the CTA progressed, plant staff were able to successfully treat storm flows while significantly reducing the mass of solids discharged to the receiver. During the CTA, plant B experienced average daily flows of 459 m^3/d (0.10 MIGD), a 12% reduction compared to average daily flows of 523 m^3/d (0.12 MIGD) prior to the CTA. The duration of the CTA was 10 months at Plant B.

Plant H is an extended aeration package plant operated by OCWA. The plant design flow is 955 m^3/d (0.21 MIGD). At plant H, the staff achieved significant reductions in $TBOD_5$ loadings (89%), TSS loading (83%) and ammonia loadings (93%). During the CTA, plant H experienced average daily flows of 858 m^3/d (0.19 MIGD), a 7% reduction compared to average daily flows of 927 m^3/d (0.20 MIGD) prior to the CTA. During the spring (March and April) of 1994, total effluent TSS and $TBOD_5$ loadings during bypassing were reduced by 95% and 96% respectively when compared to bypass loadings during the spring of 1992 even though total flows during the spring of 1994 were marginally higher than the spring of 1992. A period of 14 months was required to complete the CTA and ensure skills transfer for reducing bypassing during high spring flows.

For this study the Facilitation Team and plant staff adopted the goal of achieving final effluent concentrations of $TBOD_5$ and TSS of 25 mg/L or less on a monthly average basis (in addition to monthly average limits of 1.0 mg/L for TP). Monthly effluent objectives provided a necessary incentive for management and staff to achieve consistent process control. For two of the three demonstrations, plant staff achieved the monthly objectives within three months of CTA initiation. At one of the demonstration sites the staff reduced the exceedences of monthly objectives during the 16-month CTA in comparison to the 16 months which preceded CTA initiation. However, TSS effluent concentrations exceeded 25 mg/L for two months during the CTA. This was caused by a combination of high flows, a biological upset, and incomplete transfer of skills by an inexperienced CTA Facilitation Team. It was the considered judgement of the Facilitation Team that monthly objectives for $TBOD_5$, TSS, and TP could be consistently achieved at all three facilities through the application of CTA techniques.

Additional findings and conclusions arising from the study included:

- At two of the three CTA demonstration sites, sludge disposal costs were decreased.

- At all three facilities operations staff demonstrated the ability to identify and "operate around" minor design limitations. These limitations included poor primary clarifier efficiency (Plant J), lack of instrumentation to measure waste activated sludge (Plant B), and limited on-site storage capacity (Plant H).

- Verbatim comments collected from members of the CTA Facilitation Team and operations and management staff at the three sites indicate a high level of support for and interest in the CTA approach.

In summary, demonstrations at the three facilities established that the CTA approach is valuable as a tool for improving the performance and resolving operational, maintenance, and minor design limitations. No major modifications to the approach are required prior to broadscale application in Ontario.

Since the CTA demonstrations have concluded, plant staff have continued to apply process monitoring and control concepts to achieve compliance objectives.

6.2 Recommendations

To improve the performance status of municipal STPs, it is recommended that the Comprehensive Technical Assistance technique be adopted as part of an overall optimization program in Ontario to address performance limitations and improve effluent quality at existing facilities.

Personnel conducting CTAs should have a technical knowledge of wastewater treatment covering regulatory requirements, process control, sampling, and equipment maintenance. In addition, familiarity with management issues and ability to motivate and transfer skills in conjunction with well developed personnel and human relations skills, are highly recommended.

A number of commonly occurring barriers to optimization were identified during the CTAs. These included: lack of incentives to perform, focus on maintenance and housekeeping rather than process control, delays in approving minor modifications, inadequate sludge storage and disposal, lack of recognition of key role of operators and no mechanism to address common problems. A program should be established which resolves these barriers so that province-wide optimization efforts can be implemented.

Additional recommendations resulting from this assessment are:

- A team approach to applying the CTA is recommended. A team is better able to provide a consistent schedule for site visits and follow-up and will more likely possess the necessary mix of technical and human resource skills.

- CTA training is best conducted on-site at multiple facilities. Workshops alone are inadequate to equip CTA facilitators to resolve the complex mix of design, operating, maintenance, and administration factors limiting performance at Ontario STPs.

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APPENDIX 1

Listing of CTA Technical Instructor and Team

CTA INSTRUCTOR:

Bob Hegg P.E.
Process Applications, Inc.
2627 Redwing Road, Suite 340
Fort Collins, Colorado, USA 80526
(303) 223-5787

CTA TEAM:

Gerry Wheeler (Project Manager)
Ministry of the Environment and Energy
Science and Technology Branch, Water and WasteWater Optimization
125 Resources Road, Etobicoke, Ontario, Canada M9P 3V6
(416) 235-6165

Dan White
Ontario Clean Water Agency
Eastern Region
593 Norris Court
Kingston, Ontario, Canada K7P 2R9
(613) 549-2670

Bruce Bradley
Ministry of the Environment and Energy
Science and Technology Branch
Water and WasteWater Optimization
125 Resources Road, Etobicoke, Ontario, Canada M9P 3V6
(416) 235-6162

Jim Matthews
Wastewater Technology Centre
867 Lakeshore Road
P.O. Box 5068
Burlington, Ontario, Canada L7R 4L7
(905) 336-4589

APPENDIX 2

Plant J CTA Report

Prepared by:

Joint MOEE/WTC Technical Assistance Team

RESULTS OF THE COMPREHENSIVE TECHNICAL ASSISTANCE AT PLANT J

April 1994

Prepared by:

Joint MOEE/WTC Comprehensive Technical Assistance Team

Administered by:

Ministry of Environment and Energy
Science and Technology Branch
125 Resources Road
Etobicoke
Ontario
M9P 3V6

Wastewater Technology Centre
867 Lakeshore Road
P.O. Box 5068
Burlington
Ontario L7R 4L7

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2. Comprehensive Technical Assistance Team members for their continued dedication and commitment to the program.

3. Regional management staff for providing the support to enable the program to be established.

4. Plant J Superintendent, Operation Staff and Maintenance Staff.

5. Staff of the MOEE Regional office for providing support to enable the program to be maintained.

6. Mr. B. Hegg, Process Applications Inc., Fort Collins, Colorado, U.S.A. for providing the training services and guidance during the CTA.

TABLE OF CONTENTS

LIST OF FIGURES

APPENDICES

1. INTRODUCTION

1.1 Composite Correction Program Background

The Composite Correction Program (CCP) uses a two step approach to economically improve the performance of municipal sewage treatment plants (STPs)[1]. Step one is the Comprehensive Performance Evaluation (CPE). The CPE evaluates a facility to identify the unique combination of operation, design, maintenance, and administration factors contributing to poor performance. When a CPE determines that the major unit processes are capable or nearly capable of treating the existing flow and loadings, and where the performance of the STP is less than that required by the discharge criteria, the second step of the CCP, called Comprehensive Technical Assistance (CTA) is initiated. Typically, the CCP approach focuses on achieving compliance or optimum performance so that major capital expenditure can either be deferred or avoided.

A CPE was conducted November 25 - 28, 1991 at the Plant J STP and the factors limiting performance were identified. The facility was evaluated based on its ability to achieve monthly average compliance limits for BOD, SS and TP. The Plant J plant, located in southern Ontario, is operated by a Regional Municipality. The plant has a rated flow capacity of 18,200 m^3/d (4 MIGD).

Comprehensive Technical Assistance was provided to the Plant J STP together with two other facilities across Ontario as part of a development and demonstration program to identify both the optimization technical tools available and the required mechanisms for establishing an STP optimization program in Ontario.

2. SUMMARY OF CPE FINDINGS

2.1 Performance

Examination of the data during the CPE conducted at the Plant J STP showed that the plant was in compliance with its annual effluent criteria over the period from November 1990 to October 1991. The reported annual average concentration for $TBOD_5$ was 22 mg/L, 16 mg/L TSS, and 0.65 mg/L for TP. However, the plant would have had three $TBOD_5$ violations, one suspended solids violation and one TP violation under the monthly effluent standards of 25 mg/L $TBOD_5$, 25 mg/L TSS and 1 mg/L TP which were established for the optimization study. A sludge accountability analysis showed that the data evaluated represented true plant performance.

2.2 Major Unit Processes

The evaluation of the major unit processes established that the sludge holding tank capacity could limit the performance of the facility if waste sludge was not hauled on a demand basis. When the CPE was conducted in Nov. 1991, it was determined that the available sludge storage volume limited the plant capacity to approximately 4.55 m^3/d (1 MIGD). Although sludge storage severely limited the plants' capacity in the winter, it was identified that this limitation could be addressed by utilizing off-site sludge storage (e.g., regional sludge storage lagoons). The other major unit processes were rated as capable of treating approximately 18,200 m^3/d (4 MIGD).

2.3 Factors Limiting Performance

Administration Policies

The focus and capabilities of the existing plant staff were directed towards facility maintenance and not on performance-based process control activities and skills. The practice of promoting maintenance personnel to supervisory positions resulted in the perception by most plant staff that maintenance, not process control, is of primary importance. Consequently, most staff have limited experience with process control testing, data interpretation, and adjustments.

Application of Concepts & Testing to Achieve Process Control

The maintenance focus at Plant J resulted in limited application of process control techniques to optimize performance. Optimization of activated sludge processes requires attention to key concepts such as sludge mass control and sludge mass distribution through return sludge flow control. Data development and correlation of related parameters such as sludge mass, solids retention time (SRT), and sludge distribution etc., are required to determine their short-term and long-term effects on process performance. Most of these concepts and related parameters were not utilized by the plant staff at the time the CPE was conducted.

Plant Coverage

The plant was staffed for about ten hours per day. The CPE determined that optimization of plant performance through additional process control efforts requires a minimum of 16- hour coverage each day to respond to diurnal flow variations. This extent of coverage was necessary for additional testing and process adjustments (e.g., return sludge flow rates). Extended coverage would not necessarily require additional staff. By re-directing the plant goals, some of the existing skilled labourers currently working on maintenance tasks could be utilized to perform the additional testing and process adjustments.

Process Control Testing

Increasing the emphasis of process control at the plant required additional testing above the current level. Process control testing for an activated sludge plant of this size typically includes measurement of mass concentrations throughout the process (e.g., aeration basin, clarifier, return sludge); sludge blanket depths (e.g., primary and secondary clarifiers); sludge settleability; dissolved oxygen; respiration rates; and microscopic sludge examinations. Most of these tests should typically be performed at least once per day, and several of them, such as sludge concentrations, blanket depths, and settleability, should be performed on a more frequent basis (e.g., morning, early afternoon, evening).

Ultimate Sludge Disposal

The plant capacity was limited by the available sludge storage prior to disposal. The staff can increase the sludge storage volume by increasing the rate of return of anaerobic digester supernatant back to the wastewater treatment process. However, this practice was not recommended because of its detrimental effect on plant performance. Other sludge storage options, such as off-site lagoons, could be utilized to minimize the impact of this factor.

Sludge Wasting Capability

Waste sludge from the secondary process was diverted from the return sludge flow, using a control valve and flow meter. Although this system provided good flow measurement at high flow rates, continuous wasting at low flow rates resulted in frequent plugging and inadequate flow measurement. Any permanent sludge wasting system should include flow measurement equipment, which is accurate over all flow ranges.

Process Flexibility

The addition of flexibility to the aeration basins to enable operation in different modes (e.g. step feed, contact stabilization) could reduce the impact of high flows.

Inflow/Infiltration

The plant periodically experienced high infiltration/inflow that impacted plant performance. Correction of the infiltration/inflow sources or addition of flow equalization facilities may be required in the future if regulations require elimination of the bypass of raw wastewater around the plant.

2.4 Summary

The major factors limiting performance were related to administrative policies, and the lack of process control focus by the plant staff. By allocating more time for plant operation, and re-directing the plant staff activities to a performance-based process control program, it was anticipated that the Plant J facility could meet the monthly effluent standards established by the CCP for BOD_5, suspended solids, and total phosphorus without major construction. A CTA was recommended.

3. APPROACH TO CTA

The initial efforts of the CTA were directed at addressing the performance limiting factors identified during the CPE in addition to: (1) establishing a comprehensive monitoring and control program, (2) establishing procedures to enable the progress of the CTA to be communicated, and (3) providing staff training and transfer of skills to achieve a consistent level of process control.

4. CTA SIGNIFICANT EVENTS

Following the CPE, discussions were held with the Regional management to identify the items which had to be addressed before the formal start-up of the CTA. Preparations for the on-site CTA were initiated in April 1992.

4.1 April to July 1992

In April 1992 an agreement was reached between the Regional Management and the Comprehensive Technical Assistance Team to provide a CTA program at Plant J. In May 1992 the Public Works Sub-Committee confirmed it's support of the program.

In July 1992 all treatment process units were returned to service (prior to July 1992, one of the two aeration basins was out of service for another study which was being carried out at the plant prior to the CTA). A CTA process control workshop was prepared by the technical team and presented to both STP and regional management staff (see Process Control Operations Manual).

The MOEE regional office was notified of the objectives of the CTA at Plant J and Ministry staff visited the plant to get an overview of the optimization activities.

4.2 August to September 1992

A process control workshop was given to all staff. The focus of the workshop was process monitoring and sludge mass control (see Process Control Operations Manual).

Process control worksheets were developed to calculate and record the daily process control data (Appendix 2.A). Initially, the worksheets were manually drafted and revised several times by the shift operators until a consensus format was obtained. The finalized worksheet documented the daily process control activities, the sampling routine, and the sludge mass calculations for total sludge mass control.

4.3 October to November 1992

Sampling and analytical testing procedures were developed and reviewed with the operations staff. These procedures were developed and written with assistance by the operations staff and compiled in a site specific Process Control Operations Manual.

The maintenance staff installed a waste activated sludge controller to enhance the wasting flexibility over a 24 hr period.

The regional management made formal application to MOEE for approval to haul sludge to regional storage lagoons over the 1992/93 winter period.

4.4 December 1992 to January 1993

After identifying some performance problems with the primary clarifiers, discussions were held with plant staff regarding methods to optimize the operation of the clarifiers. Action steps were implemented to minimize sludge blanket depths. Monitoring frequencies were reviewed and additional wasting cycles introduced to spread the wasting over a longer period of time.

Discussions were held between plant staff and the CTA Team regarding an operating strategy to minimize sludge production and to maximize on-site sludge storage capacity until winter sludge haulage was approved.

MOEE approved winter sludge haulage to regional storage lagoons on January 12, 1993.

With availability of winter sludge haulage, the SRT was reduced to 8 days to enhance the sludge settling characteristics.

Follow-up meeting with MOEE and Regional Management to discuss mechanism to improve future off-site sludge handling.

4.5 February 1993

One primary clarifier was shut down for maintenance and repair. During the shut down, periods of elevated plant flows occurred. Operational strategies were discussed and developed to maximize primary clarifier performance.

Significant changes were observed in some control parameters. The sludge volume index (SVI) started to increase. Corresponding with this decrease in sludge settleability, the sludge distribution ratio (SDR) began to deteriorate as more of the total sludge mass was retained in the secondary clarifier. Coupled with periods of elevated plant flow, the deterioration in SVI and SDR increased the daily final effluent TSS concentrations.

4.6 March to April 1993

High flows continued to cause problems for the operations staff. The average day flows (ADF) for March and April 1993 were 20,500 m^3/d and 21,200 m^3/d respectively as compared to the 18,200 m^3/d rated hydraulic flow capability. The poor sludge settling characteristics continued to impact the secondary clarifier performance, leading to high effluent TSS. The monthly average TSS for March was 27 mg/L which exceeded the target concentration of 25 mg/L.

To enhance the sludge settling characteristics, the use of polymer was recommended. Polymer was applied for approximately 10 days at a dosage of 1 mg/L until the biological process was stabilized. While the use of polymer appeared to aid in the temporary improvement in sludge settling, the duration of polymer usage was not long enough to derive conclusive results.

The plant staff raised the SRT to 10 days from 6 to increase the active biological sludge mass to facilitate an improvement in sludge settling characteristics.

On April 1st, a significant storm flow event resulted in high solids loss in the final effluent. The clarifiers started to washout at a plant flow of 45,450 m^3/d (10 MIGD). Secondary bypass was recommended by the CTA Team. The bypass event was reported to the Spills Action Centre. The technical team assisted the plant superintendent in discussing the by-pass event with MOEE district office staff, outlining the reasons which made secondary by-passing necessary.

Due to the poor settling characteristics of the sludge, a high fraction of the system sludge mass was contained in the final settler. This resulted in consistently high sludge blanket depths in the secondary clarifier. A special study was initiated to optimize the sludge distribution ratio between the aeration basin and the secondary clarifiers. The objective was to increase the SDR so that the majority of sludge was located in the aeration basins. Before the study was initiated the SDR was typically 2:1 (aeration tank mass:final settler mass). As the study progressed the SDR was improved to 4:1 and eventually 6:1. The change in SDR was achieved by reducing the RAS flow rates, and by increased monitoring of the sludge blanket (several times per day).

4.7 May to June 1993

In May, the waste sludge control valve failed to operate properly. This resulted in 25% of the total liquid train sludge mass being pumped to the primary clarifier and subsequently wasted to the anaerobic digester. The sudden loss of active sludge mass occurred at a time when the biological process was recovering from the sludge settleability upset which started in February and which manifested itself in March. The process of rebuilding the sludge mass was initiated.

In June, the waste sludge control valve failed again. The failure resulted in a further 25% of the total sludge mass being wasted to the anaerobic digesters.

A joint meeting was held between plant staff, management, and the CTA Team to resolve the process control issues which had arisen, to address communication failures, and to implement a routine communication and reporting procedure. The objective was to ensure effective and shared communication between shift rotations, plant superintendent, regional management, and the CTA Team.

The CTA Team briefed regional management, outlining the process control adjustments which were made and also the documented communications plan which had been derived and implemented at the facility.

4.8 July to August 1993

The CTA Team drafted plant visit sheets which were completed each time that assistance was provided. This sheet covered the areas of operations, process control, design, maintenance, and other related issues which were discussed during a visit. Most importantly, it noted the decisions which were taken and implemented. Itemized tasks and staff responsibilities for completion were identified, copied, and distributed to all staff. This ensured that all staff were aware of the issues being addressed, and that consistent and complete information was supplied to all staff. Because of shift rotation and re-organization during the CTA the need for the visit sheets became even more necessary as the CTA progressed (Appendix 2.C).

Similarly, formal monthly summary reports were drafted and introduced to facilitate review of operation and performance of the treatment plant on a monthly basis. The purpose of these reports was to ensure that the status of the treatment plant was reviewed once a month (Appendix 2.D). The focus of the report was to review the process control program, encourage data trending and interpretation together with any maintenance or equipment issues. The report also contained a component for the plant superintendent to review and complete, after reviewing the issues identified by the operations staff. Likewise, a section was included for the regional management staff to include their comments after reviewing the issues identified by both the operators and superintendent. The report would then be rerouted back to the operators and superintendent as feedback.

A formal request was made by plant staff to Regional management to have sludge haulage approval extended to cover the winter period of 1993/94.

4.9 September to November 1993

Based on the experiences of the previous winter and the process control enhancements and upsets that were identified, all staff drafted a winter process control plan that would be implemented in advance of winter, while assuming that winter sludge haulage would be available. The plans were reviewed by all staff and a combined plan was derived (Special Study, Process Control Manual)

In September, a mechanical drive failure resulted in one primary clarifier being out of service for several weeks due to a delay in spare parts delivery. Consequently, one clarifier had to handle the entire raw influent hydraulic load.

In October, after the primary clarifier was returned to service, a special study was started to evaluate the use of polymer to improve the primary clarifier performance. For the period since the start of the CTA the average removal efficiencies for $TBOD_5$ and TSS had been 0% and 21% respectively. The study was continued by the operations staff for one month during which time the TSS removal efficiencies were improved to 55% on average. The polymer was added to the effluent from the degrit chamber, and was only added during the RAS wasting cycles. This strategy was adopted to improve settling when the primary clarifiers were receiving the heaviest solids loading.

Regional management staff discussed with all plant staff the proposed plant expansion and sought their input into the planning phase regarding what unit processes required priority attention.

The CTA Team, in conjunction with the operations staff, revised and upgraded the process control and data management program to improve the efficiency of data entry and display. This enabled plant staff to trend important process related parameters on a daily basis as required.

In November, the MOEE issued approval for winter sludge haulage to regional storage lagoons for an additional two years while a comprehensive regional sludge management program was being completed to incorporate the Plant J facility on a permanent basis.

In December, formal on site technical assistance ceased following the presentation of the exit meeting.

5. CTA RESULTS

For the duration of the CTA the CTA Team, regional management, plant management, and operations staff adopted monthly average criteria as a means of measuring the success of the demonstration. The targeted criteria was 25 mg/L for $TBOD_5$, 25 mg/L for TSS, and 1 mg/L for TP.

For the period of July 1992 to the end of the CTA (December 1993), the final effluent samples were collected using 24 hour refrigerated composite samples, and analyzed daily on-site for TSS. Samples were submitted to the regional laboratory three times per week for $TBOD_5$, TSS, NH_3, NO_2, NO_3, and TP analysis.

Figure 1 depicts the final effluent $TBOD_5$ concentration for the period January 1991 to the end of the assistance program. The target $TBOD_5$ of 25 mg/L is depicted by the horizontal line. For the duration of the CTA the plant recorded no instances when the $TBOD_5$ concentration exceeded the targeted monthly average of 25 mg/L. For the twelve month period prior to the start of the CTA the plant recorded four instances (Nov 91, Jan 92, Mar 92, Apr 92) when the final effluent $TBOD_5$ exceeded the 25 mg/L target. During the CTA, the average $TBOD_5$ concentration averaged 11 mg/L (July 92 to July 93), equating to an average effluent $TBOD_5$ loading of 180 kg per day. In contrast, before the CTA, for the period July 91 to July 92, the average final effluent $TBOD_5$ concentration was 21 mg/L, equating to an average effluent $TBOD_5$ loading of 296 kg per day. Significantly, the average day flow (ADF) during the CTA was 16,500 m^3/d in contrast to 13,900 m^3/d for the twelve month period before the CTA. Although treating higher hydraulic flows during the CTA than before, the plant achieved a reduction in overall $TBOD_5$ loading of 40% to Lake Ontario.

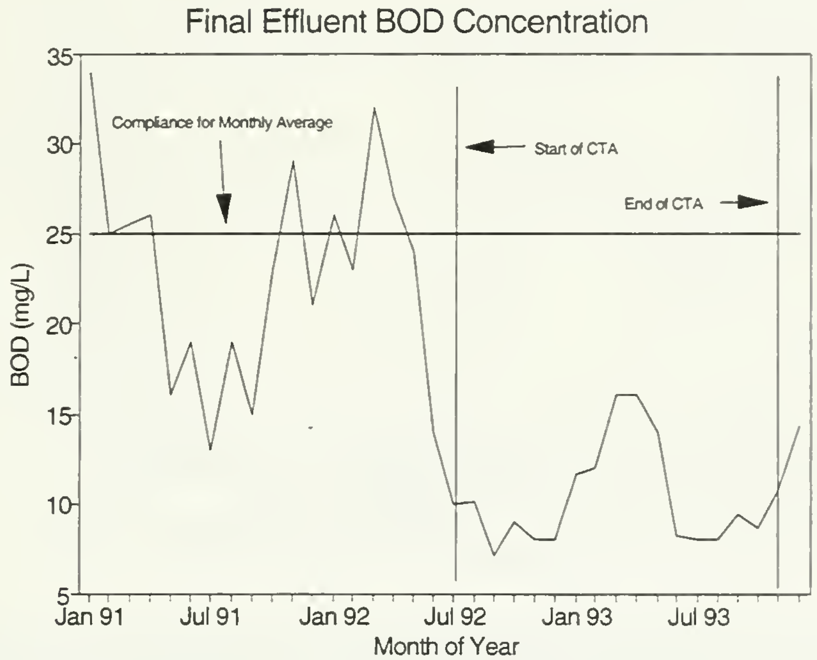

Figure 1 Final Effluent $TBOD_5$ Concentration 1991 to 1993

Figure 2 depicts the final effluent TSS quality for the period of January 1991 to the end of the CTA. The target of 25 mg/L TSS is depicted by the horizontal line. For the duration of the CTA the plant reported two instances when the final effluent concentration was greater than the targeted 25 mg/L TSS. Likewise for the twelve month period prior to the CTA two instances of exceeding the target 25 mg/L were reported. The average TSS concentration for the period of July 1991 to July 1992 was 16 mg/L. For the period of July 1992 to July 1993 the average effluent TSS concentration was 15 mg/L. Over the winter period the average final effluent TSS concentration began to increase due to process instability. This instability was further complicated by inadequate process control and corresponding periods of elevated hydraulic flows. Due to the deterioration in sludge settleability in February, March, April, 1993, and in combination with the increased ADF for the period the average effluent TSS loading increased to 242 kg per day as compared to 220 kg per day for the twelve month period prior to the CTA.

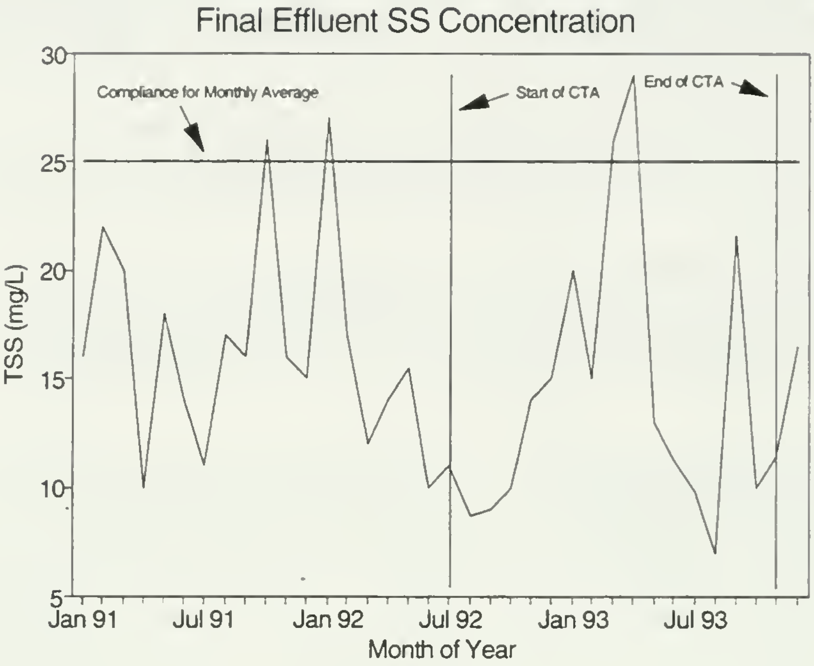

Figure 2 Final Effluent TSS Concentration 1991 to 1993

Figure 3 depicts the final effluent TP quality for the same period. For the 12 month period prior to the start of the CTA the plant recorded one instant (October 1991) when the TP monthly average concentration exceeded the 1 mg/L compliance value. During the CTA, no instances were recorded where the plant exceeded the 1 mg/L monthly average compliance value. The average TP concentration for the period July 1991 to July 1992 was 0.6 mg/L. For the period of July 1992 to July 1993 the average TP concentration was 0.6 mg/L. The TP loading increased to 10 kg/d during the CTA as compared to 9 kg/d before. However, as previously noted, the ADF during the period of the CTA was 2,600 m^3/d higher than for the 12 month period prior to the start of the CTA. In successfully treating this additional hydraulic load the plant maintained the TP effluent concentration. However, as the CTA progressed, the TP effluent concentrations have shown a general downward trend.

Figure 4 depicts the final effluent ammonia concentration for the duration of the CTA. In addition to addressing the performance limiting factors identified during the CPE, a special study was carried out to identify if the treatment plant could achieve and maintain complete nitrification (although not designed to). Historically, the reported final effluent ammonia concentrations identified that the plant was successfully nitrifying during the summer period but not during the winter period. The graph identifies that nitrification was maintained for the duration of the CTA. The average ammonia concentration for the period July 1991 to July 1992 was 7 mg/L. For the period of July 1992 to July 1993 the average ammonia concentration was 0.6 mg/L. The final effluent loading during the CTA was 9.9 kg/d as compared to 97 kg/d before.

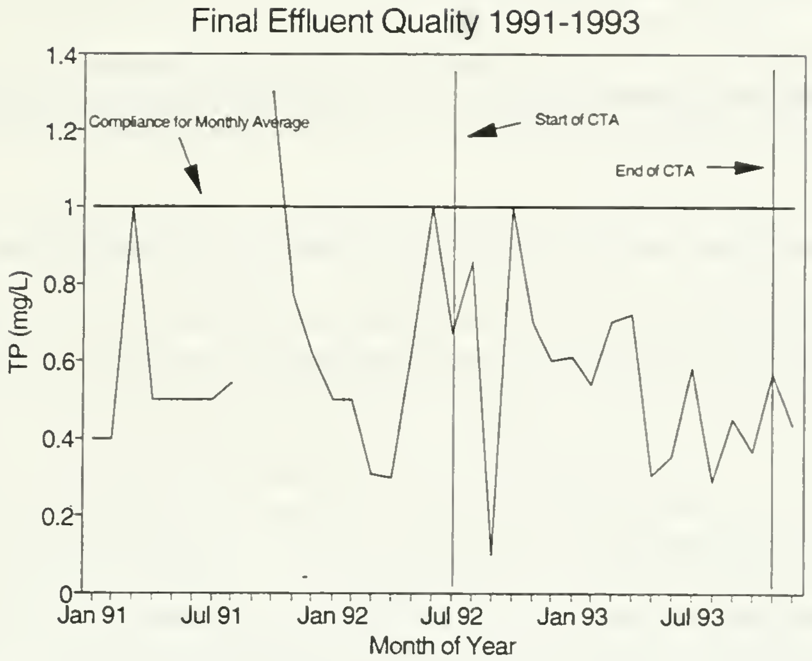

Figure 3 Final Effluent Total Phosphorus Concentration 1991 to 1993

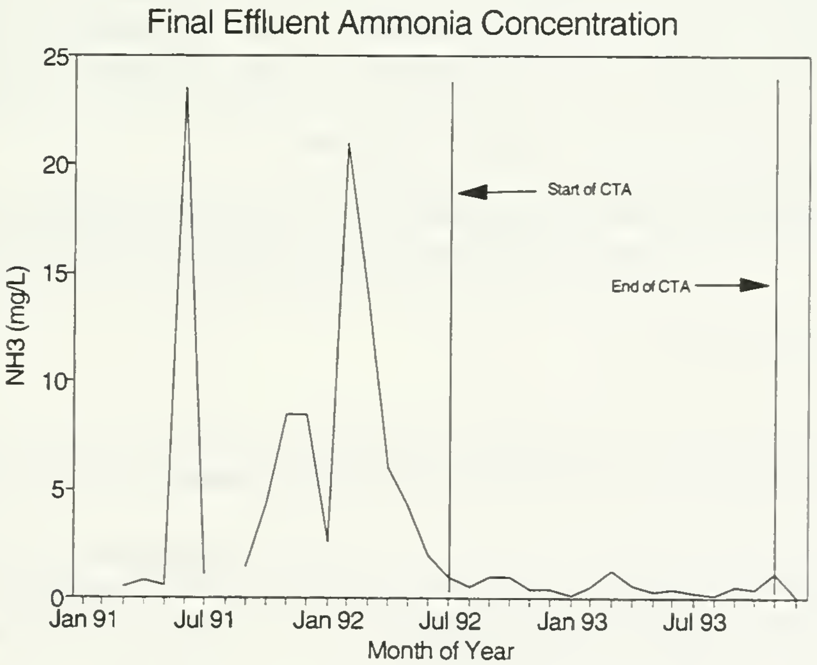

Figure 4 Final Effluent NH_3 Concentration 1991 to 1993

6. SUMMARY AND CONCLUSIONS

The CTA established a focus on the daily operational activities and the steps necessary to enable process control to be established and maintained. The operations staff have achieved a level of skill necessary to establish and maintain process control at the Plant J STP.

Since the beginning of the CTA, operations staff, with assistance from the CTA Team, have achieved a significant improvement in final effluent quality, even though the ADF during the CTA was higher than before. Significant reductions in $TBOD_5$ (40%), and Ammonia (90%) loadings to Lake Ontario has been achieved. TSS and TP loadings have shown marginal increases in loadings. The CTA has shown that under current loading the plant can consistently achieve monthly average criteria for $TBOD_5$ and TSS without any capital expenditure.

The implementation of a routine sludge mass control program focused operator attention on the amount of sludge being produced and wasted from the secondary process to the anaerobic digesters on a daily basis. The projected inadequacy of the on-site sludge storage tank for winter sludge storage was verified. In response, the Region in consultation with the MOEE District Office initiated steps to enable the routine process control program to be maintained by initiating a winter sludge haulage program to the Region's storage lagoons. This enabled the control program that was initiated in August 1992 to be maintained from season to season.

The CTA has identified that, with an aggressive process control program and close attention to sludge management, deterioration in final effluent quality can be minimized even during periods of elevated hydraulic flows and poor sludge settleability as was encountered during March and April 1993. The CTA identified to the operations staff that the proper and timely use of secondary by-pass facilities during storm conditions can reduce the impact to the environment while protecting the viability of the biological sludge mass.

The staff have demonstrated that the performance of the primary clarifiers under stressed conditions can be improved by the timely use of organic polymer.

7. RECOMMENDATIONS

- Continued regional and plant management support is necessary to enable the operations staff to maintain and enhance the demonstrated improvements in effluent quality.

- Continued enhancement of operator process monitoring, interpretation, and control skills is recommended. The operations staff have achieved a level of awareness and control to enable the demonstrated improvements to be achieved. Continued enhancement of these skills is necessary through additional training.

- A daily control routine was established to enable the operators to control the total liquid train sludge mass, and to derive the mass of sludge which should be wasted to maintain the targeted total sludge mass. Plant staff are urged to continue to derive and interpret, on a daily basis, the control data necessary to maintain this program.

The process control manual which was written by the operations staff should be routinely revised and updated in order to maintain the accuracy and relevance of the procedures.

- The continued use of 24 hr. composite samplers is recommended to accurately record plant loading, unit processes performance, and final effluent quality.

- A written policy concerning the use of the secondary by-pass facility should be developed by plant staff and regional management in conjunction with the MOEE. An understanding should be established regarding the circumstances where the use of the existing by-pass capability is necessary in order to protect the secondary biological process, and reduce the impact on the receiving water.

- Plant and regional staff must address the primary clarifier limitations to maintain overall plant performance. Critical periods when the primary clarifier limitations impact most on overall plant performance are: (1) sludge wasting when the co-thickening function is applied, (2) supernating of large volumes from secondary digesters to the primary clarifiers, and (3) high hydraulic loads.

- All Regional staff (operators, superintendent, management) should continue to develop and enhance routine communication strategies (ie. shift to shift, use of the established monthly summary report, and meetings) which were introduced during the CTA to identify and resolve all operations, design, management, and maintenance issues that can have an impact on final effluent quality.

- The current sludge management program is for two years until the Region implements a permanent management program which includes the needs of the Plant J facility. Plant staff should continue monitoring the sludge disposal requirements in order to assist in the development of the permanent sludge management program.

REFERENCES

1. Hegg, B.A., L.D. DeMers, and J.B. Barber, Handbook - Retrofitting POTW's, EPA 625/6-89-020, U.S. Environmental Protection Agency, Center for Environmental Research Information, Cincinnati, Ohio, (July 1989).

APPENDIX 2.A

Daily Operational Data Worksheet

This process control worksheet is completed each day by the operator. By following the daily routine and by completing the worksheet the operator identifies the total mass of sludge in the process and subsequently the volume which should be wasted each day in order to maintain a consistent solids retention time.

DATE	WEATHER						FLOWS					RAW SEWAG	
	Air Temp			Precip				Total Plant Flow					
	Max	Min	Aver	Rain	Snow	Total	Total	Max	Min	Beamsville	Biggar Lagoon	Suspende Solids	Temp Average
1			0.0			0.0	NA					NA	
2			0.0			0.0	NA					NA	
3			0.0			0.0	NA					NA	
4			0.0			0.0	NA					NA	
5			0.0			0.0	NA					NA	
6			0.0			0.0	NA					NA	
7			0.0			0.0	NA					NA	
8			0.0			0.0	NA					NA	
9			0.0			0.0	NA					NA	
10			0.0			0.0	NA					NA	
11			0.0			0.0	NA					NA	
12			0.0			0.0	NA					NA	
13			0.0			0.0	NA					NA	
14			0.0			0.0	NA					NA	
15			0.0			0.0	NA					NA	
16			0.0			0.0	NA					NA	
17			0.0			0.0	NA					NA	
18			0.0			0.0	NA					NA	
19			0.0			0.0	NA					NA	
20			0.0			0.0	NA					NA	
21			0.0			0.0	NA					NA	
22			0.0			0.0	NA					NA	
23			0.0			0.0	NA					NA	
24			0.0			0.0	NA					NA	
25			0.0			0.0	NA					NA	
26			0.0			0.0	NA					NA	
27			0.0			0.0	NA					NA	
28			0.0			0.0	NA					NA	
29			0.0			0.0	NA					NA	
30			0.0			0.0	NA					NA	
31			0.0			0.0	NA					NA	
TOT	0.0	0.0	0.0	0.0	0.0	0.0	NA	0.000	0.000	0.000	0.000	NA	
AV	0.0	0.0	0.0	0.0	0.0	0.0	NA	0.000	0.000	0.000	0.000	NA	
MA	0.0	0.0	0.0	0.0	0.0	0.0	NA	0.000	0.000	0.000	0.000	NA	0
MIN	0.0	0.0	0.0	0.0	0.0	0.0	NA	0.000	0.000	0	0.000	NA	0

DATE	PH	PRIMARY TREATMENT: Grit Cub/Ft	Screening Cub/Ft	Grease to digester Gallon	EFFLUEN SUSP PPM	% Red.	SECONDA TREATMENT: Mixed Liquor MLSS	D O ppm	30mn Settl	S V I	F M	ACTIVATE ED SL UDGE: Returned MIGPD	ed Susp Sol.	Waste Sludge IGPD
1	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
2	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
3	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
4	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
5	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
6	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
7	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
8	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
9	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
10	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
11	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
12	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
13	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
14	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
15	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
16	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
17	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
18	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
19	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
20	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
21	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
22	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
23	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
24	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
25	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
26	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
27	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
28	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
29	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
30	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
31	NA				NA	NA	NA	NA	NA	NA		NA	NA	NA
TOT		0	0	0	NA		NA		NA	NA	0.00	NA	NA	NA
AV		0	0	0	NA	NA	NA		NA	NA	0.00	NA	NA	NA
MA	0	0	0	0	NA	NA	NA	NA	NA	NA	0.00	NA	NA	NA
MIN	0	0	0	0	NA	NA	NA	NA	NA	NA	0.00	NA	NA	NA

DATE	PLANT EFFLUENT Susp Solid ppm	% Red.	NH3N	PHOSPATE REMOVAL Chemical used IPGD	Dosage ppm	Residual ppm	DIGESTERS Gallons	Raw Sludge % Solids	Raw Sludge % vol. Solids	Industrial % Solids	Waste % Vol. Solids	Gallons Hauled	Gallons Supernate	Digester % Solids
1	NA	NA	NA		NA			NA	NA	NA	NA			NA
2	NA	NA	NA		NA			NA	NA	NA	NA			NA
3	NA	NA	NA		NA			NA	NA	NA	NA			NA
4	NA	NA	NA		NA			NA	NA	NA	NA			NA
5	NA	NA	NA		NA			NA	NA	NA	NA			NA
6	NA	NA	NA		NA			NA	NA	NA	NA			NA
7	NA	NA	NA		NA			NA	NA	NA	NA			NA
8	NA	NA	NA		NA			NA	NA	NA	NA			NA
9	NA	NA	NA		NA			NA	NA	NA	NA			NA
10	NA	NA	NA		NA			NA	NA	NA	NA			NA
11	NA	NA	NA		NA			NA	NA	NA	NA			NA
12	NA	NA	NA		NA			NA	NA	NA	NA			NA
13	NA	NA	NA		NA			NA	NA	NA	NA			NA
14	NA	NA	NA		NA			NA	NA	NA	NA			NA
15	NA	NA	NA		NA			NA	NA	NA	NA			NA
16	NA	NA	NA		NA			NA	NA	NA	NA			NA
17	NA	NA	NA		NA			NA	NA	NA	NA			NA
18	NA	NA	NA		NA			NA	NA	NA	NA			NA
19	NA	NA	NA		NA			NA	NA	NA	NA			NA
20	NA	NA	NA		NA			NA	NA	NA	NA			NA
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22	NA	NA	NA		NA			NA	NA	NA	NA			NA
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24	NA	NA	NA		NA			NA	NA	NA	NA			NA
25	NA	NA	NA		NA			NA	NA	NA	NA			NA
26	NA	NA	NA		NA			NA	NA	NA	NA			NA
27	NA	NA	NA		NA			NA	NA	NA	NA			NA
28	NA	NA	NA		NA			NA	NA	NA	NA			NA
29	NA	NA	NA		NA			NA	NA	NA	NA			NA
30	NA	NA	NA		NA			NA	NA	NA	NA			NA
31	NA	NA	NA		NA			NA	NA	NA	NA			NA
TOT	NA			0		0.0	0	NA	NA	NA	NA	0		NA
AV	NA	NA		0.0	NA	0.0	0	NA	NA	NA	NA	0		NA
MA	NA	NA	NA	0	NA	0.0	0	NA	NA	NA	NA	0		NA
MIN	NA	NA	NA	0	NA	0.0	0	NA	NA	NA	NA	0		NA

DATE	Sludge % volume Solids	Gas Produced X 100	Prim. Digester Volatile Acid	Prim. Digester P H	CHLORINE lbs used	CHLORINE Average Dosage ppm	CHLORINE Average Resid. ppm	UTILITIES Natural Gas cub ft X 100	UTILITIES Hydro KWH X 480	UTILITIES Water m3 X 219	SEPTIC Hauled Waste to Digester gals	SEPTIC Hauled Waste to Plant gals	LAGOON Susp.Solids Influent P H	LAGOON Susp.Solids Effluent P H
1	NA			NA		NA								
2	NA			NA		NA								
3	NA			NA		NA								
4	NA			NA		NA								
5	NA			NA		NA								
6	NA			NA		NA								
7	NA			NA		NA								
8	NA			NA		NA								
9	NA			NA		NA								
10	NA			NA		NA								
11	NA			NA		NA								
12	NA			NA		NA								
13	NA			NA		NA								
14	NA			NA		NA								
15	NA			NA		NA								
16	NA			NA		NA								
17	NA			NA		NA								
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19	NA			NA		NA								
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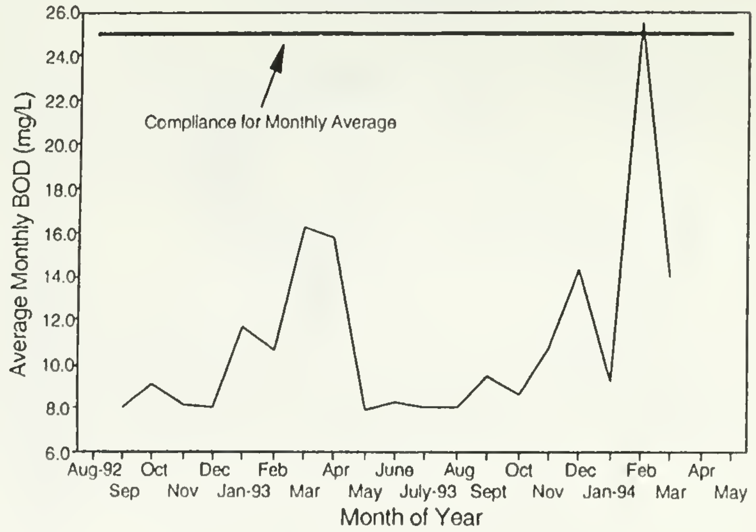
22	NA			NA		NA								
23	NA			NA		NA								
24	NA			NA		NA								
25	NA			NA		NA								
26	NA			NA		NA								
27	NA			NA		NA								
28	NA			NA		NA								
29	NA			NA		NA								
30	NA			NA		NA								
31	NA			NA		NA								
TOT	NA	0	0		0	NA	0.0	0	0	0	0	0		
AV	NA	0	0		0	NA	0.0	0.0	0.0	0.0	0	0		
MA	NA	0	0	0	0	NA	0.0	0	0	0	0	0		
MIN	NA	0	0	0	0	NA	0.0	0	0	0	0	0		

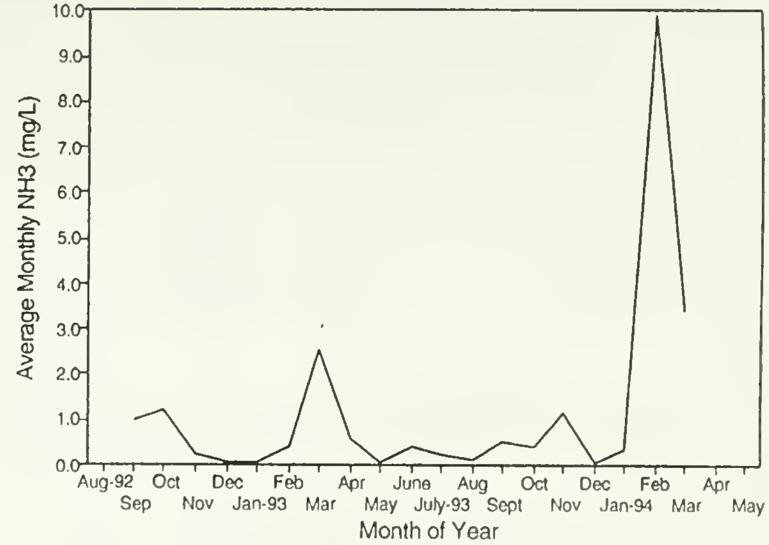
APPENDIX 2.B

Trend Analysis of Operational and Performance Data

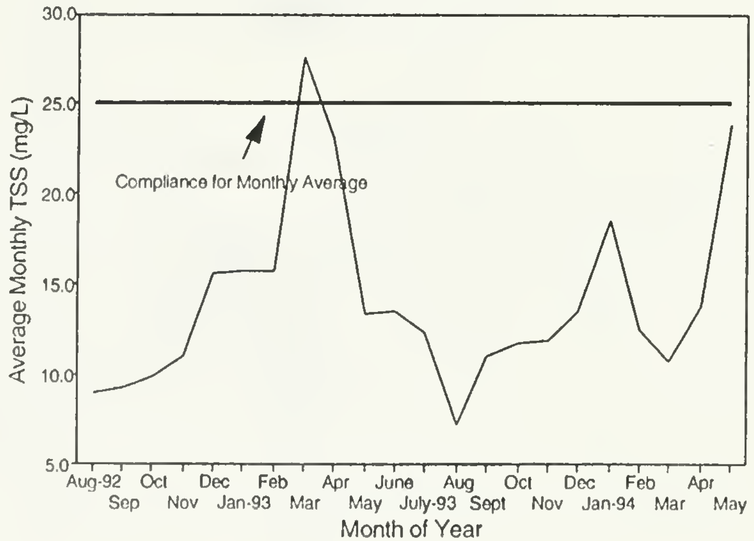
Effluent BOD vs. Time for Plant J
Municipal Wastewater Treatment Facility



Average NH3 vs. Time for Plant J
Municipal Wastewater Treatment Facility



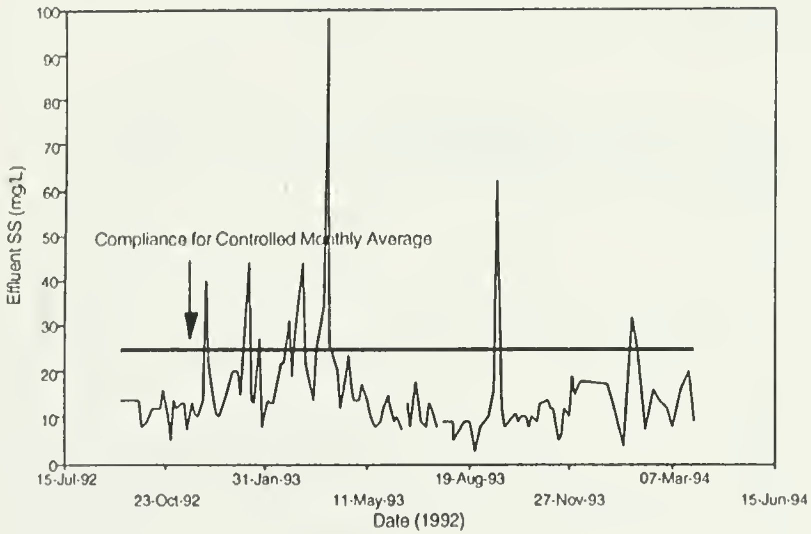
Effluent SS vs. Time for Plant J
Municipal Wastewater Treatment Facility



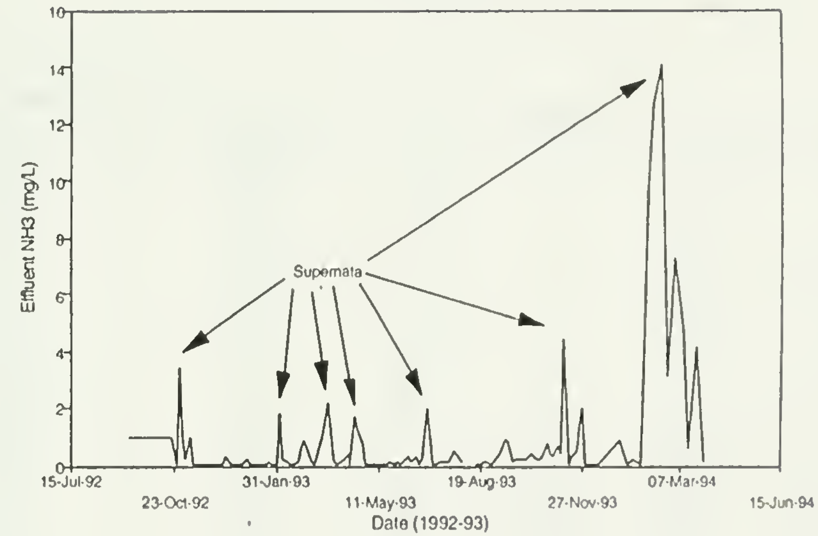
Month	TSS (mg/L) Plant	Regional	Ministry	BOD Lab	NH3 Lab
Aug-92	9.0		8.7		
Sep	9.3	12.5	9.0	8.0	1.0
Oct	10.0	10.9	10.0	9.1	1.2
Nov	11.0	11.9	14.0	8.1	0.3
Dec	15.5	18.7	15.0	8.0	0.1
Jan-93	15.8	20.1	20.0	11.7	0.1
Feb	15.8	19.8	15.0	10.7	0.4
Mar	27.6	28.0	26.0	16.2	2.6
Apr	23.2	28.8	29.0	15.8	0.6
May	13.4	12.1	13.0	7.9	0.1
June	13.6	11.3		8.3	0.4
July-93	12.4	9.8		8.0	0.2
Aug	7.2	7.0		8.0	0.1
Sept	11.0	21.6		9.4	0.5
Oct	11.8	10.0		8.6	0.4
Nov	12.0	11.4		10.8	1.1
Dec	13.6	16.5		14.3	0.1
Jan-94	18.5	16.4		9.3	0.3
Feb	12.5	15.5		25.5	9.9
Mar	10.8	13.0		14.0	3.4
Apr	13.8				
May	23.9				
Average	14.2	15.5	16.0	11.1	1.2

Performance Data Summary for Plant J

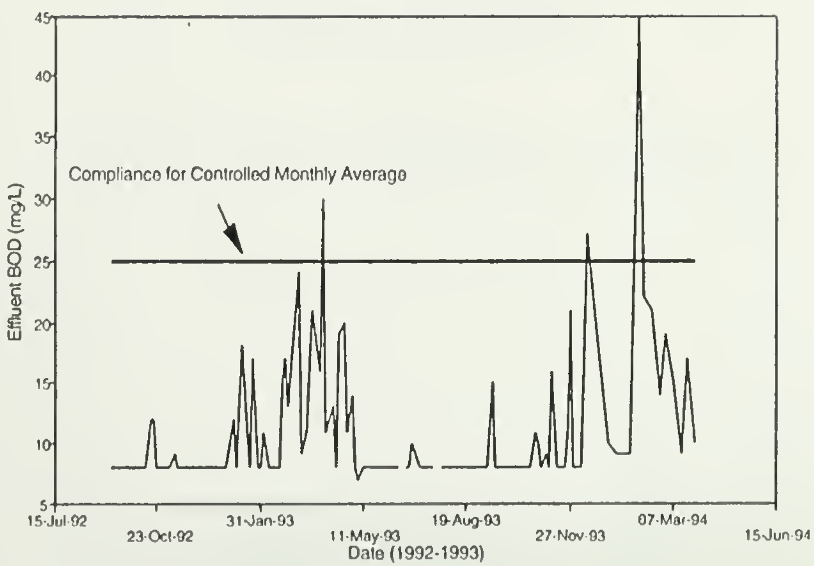
PLANT J
SUSPENDED SOLIDS



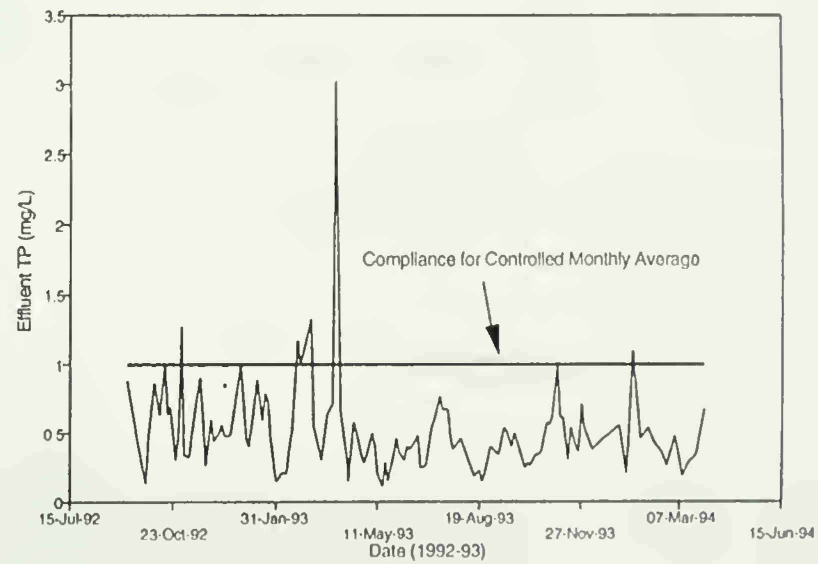
PLANT J
NITROGEN SERIES



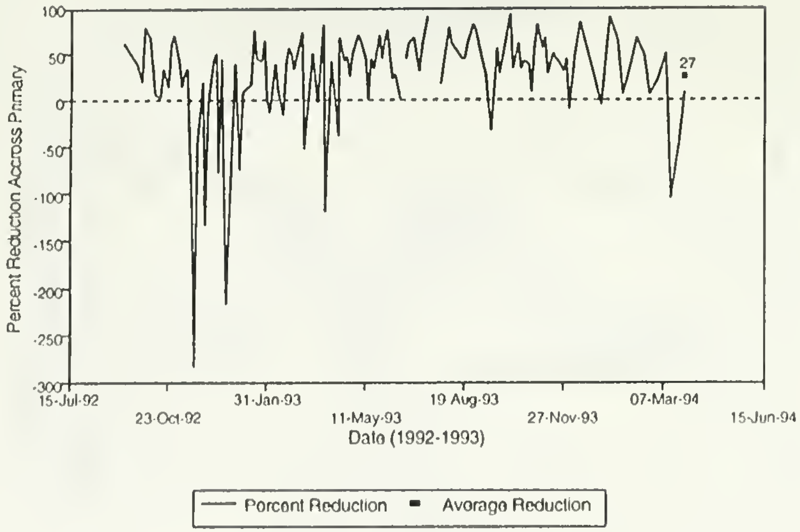
PLANT J
TBOD



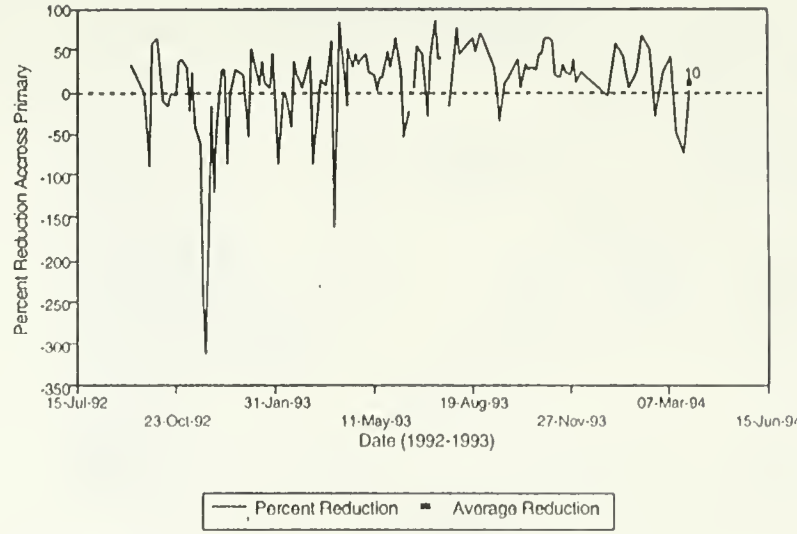
PLANT J
TOTAL PHOSPHOROUS



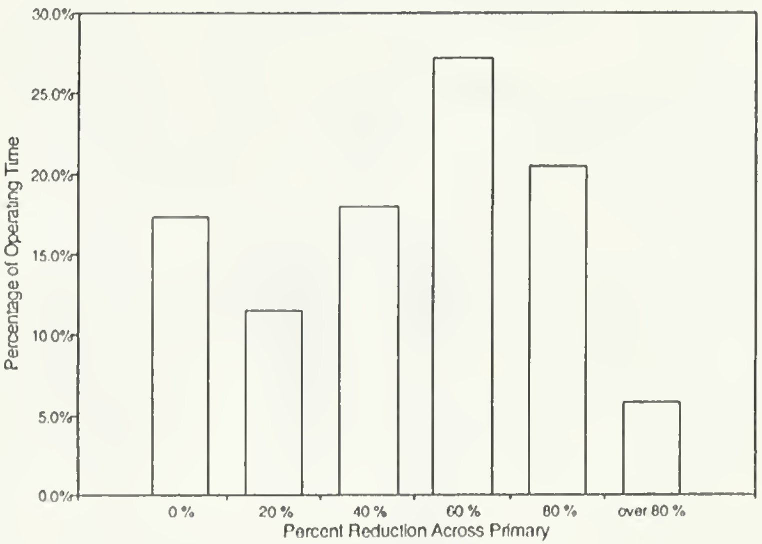
PLANT J
SUSPENDED SOLIDS



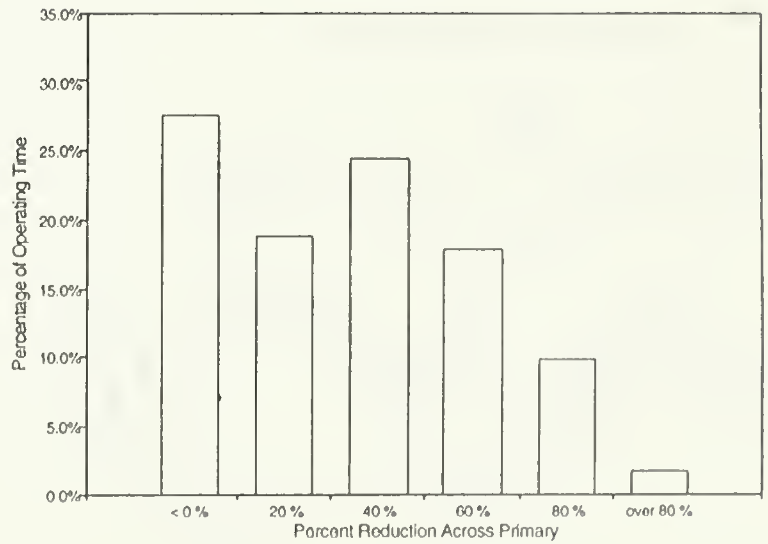
PLANT J
TBOD



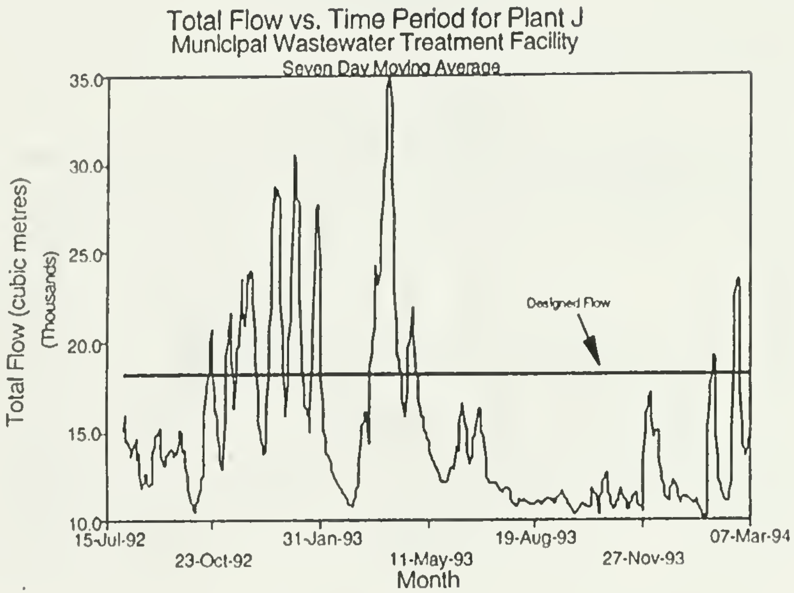
PLANT J
TSS

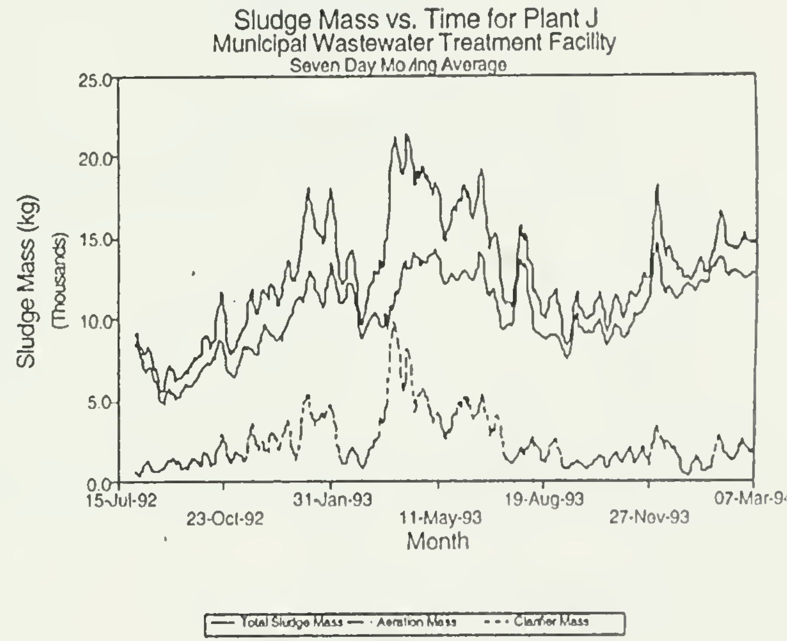


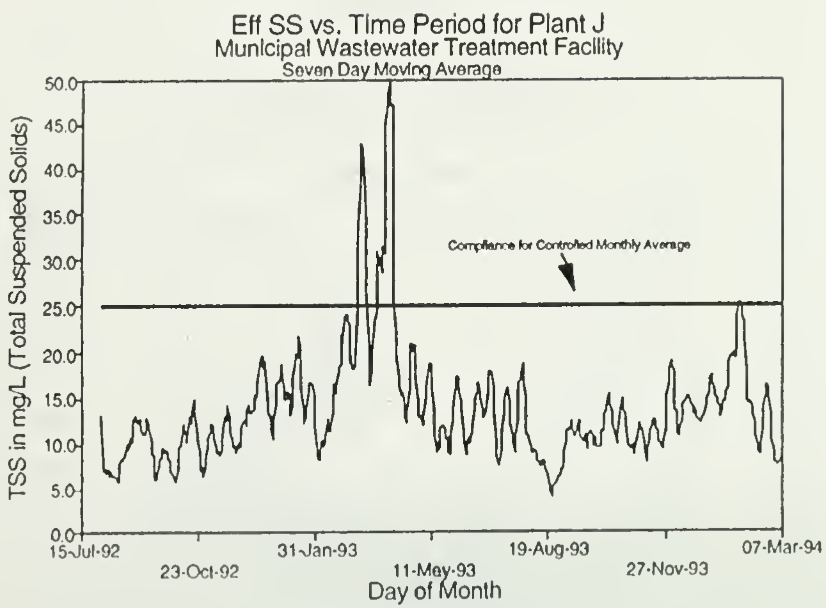
PLANT J
TBOD

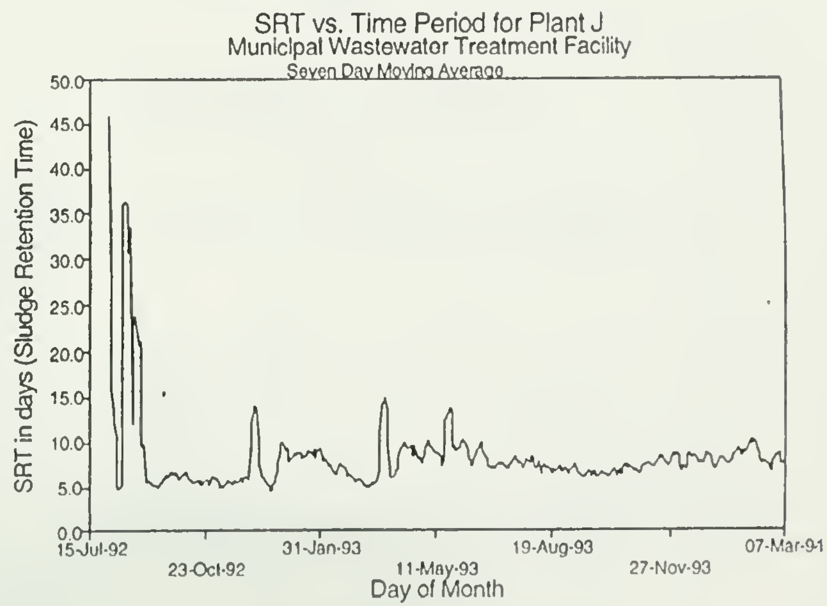


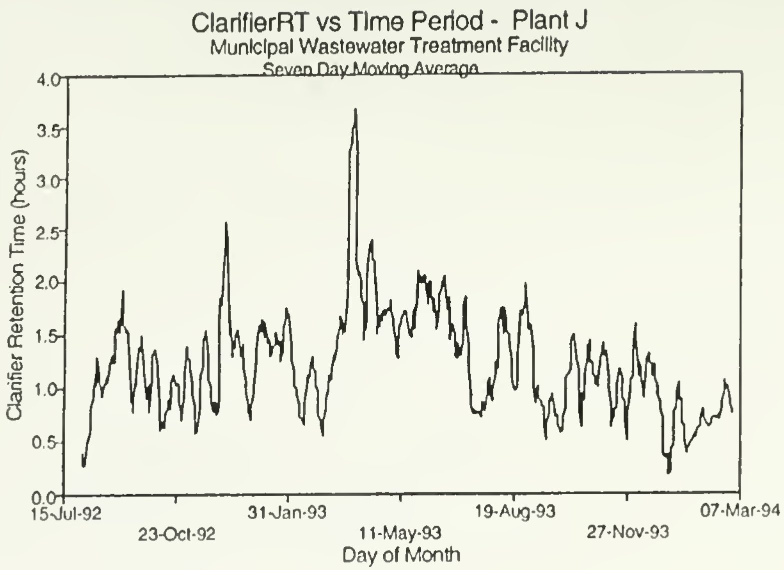
Operational Data Summary for Plant J

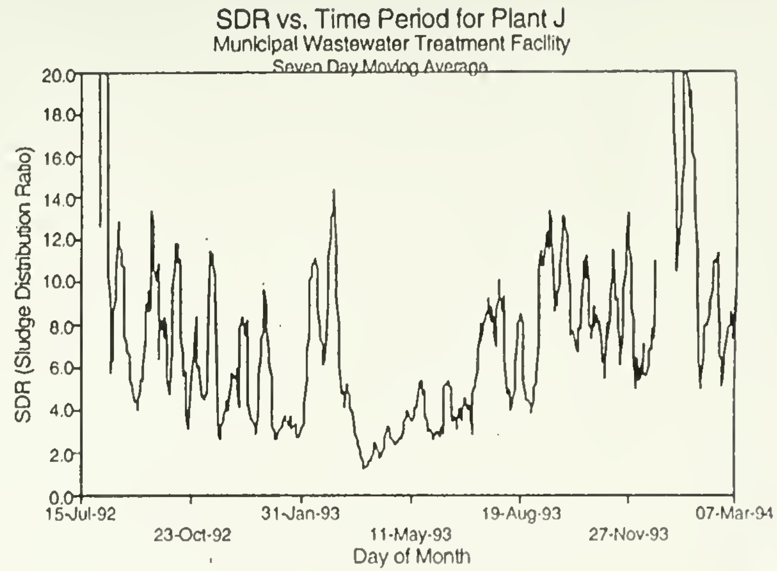


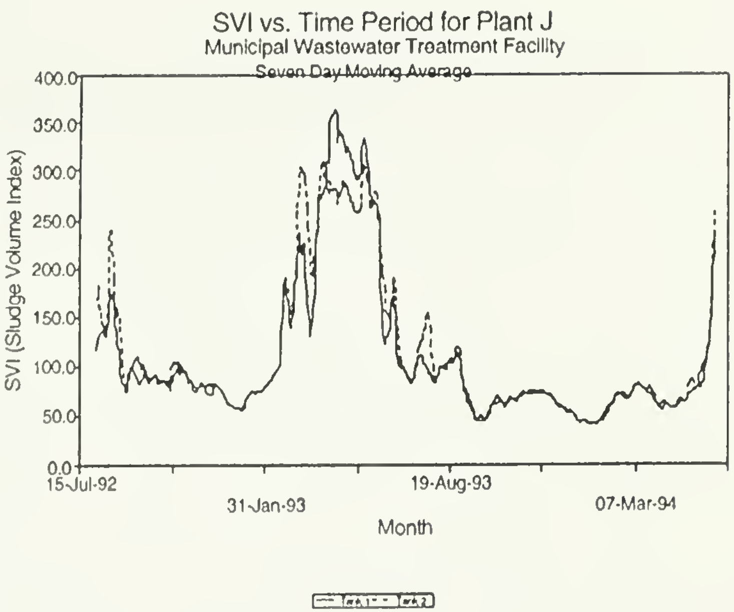







ClarifierRT vs Time Period - Plant J
Municipal Wastewater Treatment Facility
Seven Day Moving Average
Clarifier Retention Time (hours)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
15-Jul-92
23-Oct-92
31-Jan-93
11-May-93
19-Aug-93
27-Nov-93
07-Mar-94
Day of Month


SDR vs. Time Period for Plant J
Municipal Wastewater Treatment Facility
Seven Day Moving Average
SDR (Sludge Distribution Ratio)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
15-Jul-92
23-Oct-92
31-Jan-93
11-May-93
19-Aug-93
27-Nov-93
07-Mar-94
Day of Month


SVI vs. Time Period for Plant J
Municipal Wastewater Treatment Facility
Seven Day Moving Average
SVI (Sludge Volume Index)
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
15-Jul-92
31-Jan-93
19-Aug-93
07-Mar-94
Month

APPENDIX 2.C

CTA Site Visit Record Sheet

PLANT J CTA

PROCESS CONTROL COMMUNICATION NOTE

Date of Site Visit ---------------

Topics Discussed

Operations

Management

Action items proposed or decided

Operations

Management

Decisions to be communicated and discussed with Superintendent, Administration
Others - specify

Copy of this note to
Operators
Superintendent
Maintenance
Administration

APPENDIX 2.D

CTA Blank Monthly Summary Report

Plant J WPCP

DRAFT
Monthly Summary Report

Month ---------------

Year ----------------

This report is comprised of 3 sections:

Section 1	**Operations**
Section 2	**Superintendent**
Section 3	**Administration**

Completed summary to be circulated to:

Operations
Superintendent
Maintenance
Administration

SECTION 1 OPERATIONS

Process Control

Liquid Train

Solids Train - Digesters

Performance

General Comments Operations/Maintenance

SECTION 2 PLANT SUPERINTENDENT

Performance

Process Control

Budget review year to date

Personnel issues

General Comments

SECTION 3 ADMINISTRATION

Comments on process control issues

Comments on performance issues

Comments on management issues

Comments on budget issues

Any administrative questions or actions items to be addressed

APPENDIX 3

Plant B CTA Report

Prepared by:

Joint MOEE/WTC Technical Assistance Team

RESULTS OF THE
COMPREHENSIVE TECHNICAL ASSISTANCE
AT PLANT B

March 1994

Prepared by:

Joint MOEE/WTC Technical Assistance Team

Administered by:

Ministry of Environment and Energy
Science and Technology Branch
125 Resources Road
Etobicoke
Ontario
M9P 3V6

Wastewater Technology Centre
867 Lakeshore Road
P.O. Box 5068
Burlington
Ontario L7R 4L7

ACKNOWLEDGEMENTS

The author acknowledges the support and commitment provided by the following individuals and organizations:

1. Comprehensive Technical Assistance Team members for their continued dedication and commitment to the program.

2. Ontario Clean Water Agency Utility Operations Engineer for providing the support to enable the program to be established.

3. Plant B Superintendents and Operations Staff.

   For their acceptance of and commitment to the program.

4. Municipal Engineer for providing support to enable the program to be maintained.

5. Mr. B. Hegg, Process Applications Inc., Fort Collins, Colorado, U.S.A. for providing the training services and guidance during the CTA.

6. The co-funding agencies Environment Canada, and the Ministry of Environment and Energy.

TABLE OF CONTENTS

LIST OF FIGURES

APPENDICES

1. INTRODUCTION

1.1 Composite Correction Program Background

The Composite Correction Program (CCP) uses a two step approach to economically improve the performance of municipal STPs[1]. Step one is the Comprehensive Performance Evaluation (CPE). The CPE evaluates a facility to identify and prioritize the unique combination of operation, design, maintenance, and administration factors contributing to poor performance. When a CPE determines that the major unit processes are capable or nearly capable of treating the existing flow and loadings, and where the performance of the STP is less than optimum, the second step of the CCP, called Comprehensive Technical Assistance (CTA), is initiated. Typically, the CCP approach focuses on achieving compliance or optimum performance so that major capital expenditure can either be deferred or avoided.

A CPE was conducted February 25 - 28, 1992 at the Plant B STP and the factors limiting performance were identified. The facility was evaluated based on its ability to achieve monthly average compliance limits for BOD, SS and TP. The Plant B plant located in southwestern Ontario is operated by the Ontario Clean Water Agency. The plant has a rated flow capacity of 681 m^3/d (.15 MIGD), and is expected to achieve annual average compliance criteria for BOD_5 and TSS of 25, 25 mg/L respectively, and 1 mg/L TP on a monthly average basis.

2. SUMMARY OF CPE FINDINGS

2.1 Performance

Examination of the data during the CPE conducted at the Plant B STP showed that the plant was in compliance with its annual effluent criteria over the period from January 1 to December 31 1991. The reported annual average concentration for BOD_5 was 5 mg/L, 8 mg/L TSS, and 0.22 mg/L for TP. However, the plant would have had one suspended solids violation under the monthly effluent criteria of 15 mg/L BOD_5, and 20 mg/L TSS which were established for the purposes of this optimization study. Throughout the CPE evaluation monthly average criteria were applied to determine if the treatment facility could achieve the monthly average criteria for BOD_5 and TSS. The plant currently has a monthly TP regulation of 1 mg/L. A sludge accountability analysis showed that the data evaluated probably does not accurately represent true plant performance (Appendix 3.C).

2.2 Major Unit Processes

The evaluation of the major unit processes established that the sludge holding tank capacity could limit the performance of the facility if waste sludge is not hauled on a demand basis. When the CPE was conducted (Feb 1991), it was determined that the contract hauler was able to fulfil this requirement and based on this it was not rated as a limiting factor. The other major unit processes were rated as capable of treating present flows.

2.3 Factors Limiting Performance

Policies - (Administration)

At the time of the CPE, the staffing policy regarding the number of plant personnel available to operate the Plant B STP and affiliated projects inhibited optimum plant operation and performance. Responsibility for another STP, maintenance of two sewage lagoons, and servicing of ten pumping stations prevented the allocation of adequate operational and performance monitoring time at Plant B to allow for adequate process control and sludge handling to be implemented.

Management/Supervision - (Administration)

Plant supervision was focused on housekeeping and maintenance, and not performance-based process control. This practice allowed little time for operations staff to apply process monitoring and control. Staff interaction was strained, communication was stressed, and consequently the morale of all staff was low.

Application of Concepts & Testing to Achieve Process Control - (Operations)

The maintenance and housekeeping focus resulted in low priority on process control, and limited application of process control techniques to optimize performance. Optimization of the activated sludge process requires attention to key concepts, such as sludge mass control, sludge distribution through return sludge flow adjustment and process sampling. Data and trend development of related parameters is required to determine short-term and long-term effects on process performance. Adequate process sampling and proper sampling point selection of process streams are also crucial. These concepts were not being correctly applied by plant staff at the time of the CPE.

Performance Monitoring - (Operations)

During the CPE, a sludge accountability analysis was performed in which the actual and projected sludge mass produced was compared. The sludge accountability analysis for Plant B revealed that the facility produced 26 percent less sludge than the projected value. Therefore, the monitoring data probably did not accurately reflect true performance of the facility (see Appendix 3.C).

Hydraulic Surging - (Design)

During high flows, two of the three submersible pumps operated continuously and created hydraulic surging in the plant. With three pumps in operation, flows greatly exceeded the plant's physical hydraulic capability leading to potential loss of solids in the final effluent.

Alarm Systems - (Design)

Absence of adequate alarming to alert personnel of the lift station pump status potentially led to degraded plant performance. Adequate alarms would enable personnel to determine that surging is occurring, and the need for bypassing to protect the integrity of the biological process.

2.4 Summary

The major factors limiting performance were related to administrative policies regarding plant coverage and staffing, and the lack of process control focus by the plant staff. By allocating more time for plant operation and re-directing the plant staff activities to a performance-based process control program, it was anticipated that the Plant B facility could meet the proposed targeted monthly BOD_5, and suspended solids criteria without major construction. A CTA was recommended.

3. APPROACH TO CTA

The initial efforts of the CTA were directed at (1) addressing the performance limiting factors identified during the CPE, in particular, resolving the manpower shortages, (2) establishing a communication and reporting program to enable the progress of the CTA to be communicated, and (3) providing staff training and transfer of skills to achieve process control.

4. CTA SIGNIFICANT EVENTS

Following the CPE, discussions were held with the OCWA Utility Engineer to identify the items which had to be addressed before the formal start-up of the CTA. Preparations for the on-site CTA were initiated in April 1992.

4.1 Preliminary Period -- April to September 1992

- CTA Technical Team /OCWA Utility Engineer meeting (April 10, 1992).

- A commitment was made by the MOEE Utility Engineer to provide full time (8 hours) operator presence at the STP while the assistance program was being initiated and carried out.

- Composite samplers were installed to obtain representative samples of influent and effluent before and during the assistance program (July 1992).

- A CTA process control workshop (see process control manual) was prepared by the technical team in September 1992 and presented to STP staff and management.

- The technical team requested that management and staff equip the STP's laboratory for solids analysis.

4.2 Assistance Period -- October 1992

The on-site CTA was initiated in October 1992. The major activities are briefly summarized below.

CTA Technical Team site visit (October 1 1992)

- Implemented a sampling and testing schedule which enabled the total sludge mass inventory to be derived and controlled on a daily basis (See Process Control Manual).

- Developed process control worksheets to calculate and record the daily process data (Appendix 3.A).

- The waste sludge holding tank was calibrated so that accurate volumes of sludge wasted daily could be determined.

- Discussed and developed with the operations staff all procedures for sampling and testing. These procedures were developed and written with assistance by the operations staff and compiled in a site specific process control operations manual.

- A special study was initiated to focus operator attention on the sludge distribution ratio (SDR). The operator was made aware of the need to maximize the activated sludge mass in the aeration basin where the biological breakdown of dissolved organic matter occurs, and correspondingly to minimize the amount of sludge mass in the secondary clarifier. This was accomplished by monitoring and controlling the RAS flow (Process Control Manual).

- Initiated a special study to identify the optimum RAS flow rates for control purposes, i.e. day operation, nighttime, and weekends.

- Initiated an action/implementation plan to address the process control issues and allocated assignments for the operations staff with due dates to ensure timely completion.

4.3 Assistance Period -- November to December 1992

- Historically, the plant was severely impacted by hydraulic surging during high flow events. This occurred when 2 or 3 wet well lift pumps ran for extended periods of time. The result was system flooding and biological solids wash-out.

- On November 2nd a storm event resulted in continuous high hydraulic flows to the plant. The recorded average day flow was 912 m^3/d. Historically the operator had maintained a high sludge blanket in the secondary clarifier. When the storm flow reached the plant the sludge blanket in the secondary clarifier was 9 feet in depth compared to the 10 feet working depth. The sludge blanket quickly washed out resulting in a significant loss of solids mass to the final effluent. The final effluent TSS for the 24 hr period covering the storm event was 342 mg/L. The impact of this storm on plant performance was severe because the level of process awareness and control exercised by plant staff was inadequate.

- On November 12th a more severe storm flow than the November 2nd storm reached the plant. The recorded average day flow was 1,434 m^3/d with a peak flow of 2600 m^3/d. In the short period since the last storm event the operator had achieved control of the clarifier sludge blanket and had an operational strategy in place to handle a storm event. When the flow reached 1700 m^3/d the operator could no longer control the clarifier blanket and initiated bypassing to relieve the hydraulic loading on the secondary clarifier. The plant was not equipped to measure secondary by-pass at this early stage of the CTA. The operator continued to feed as much raw wastewater flow through the conventional plant as possible and only used the by-pass to maintain control of the secondary clarifier blanket. No significant loss of solids occurred from the plant. The final combined effluent TSS for the 24 hr period was 9 mg/L. Through being aware and prepared, the operator was able to minimize the impact of the storm event on the process and likewise reduced the solids loading to the receiving stream. By performing hourly checks on the clarifier sludge blanket depth the operator maintained the desired effluent quality to the river.

- CTA team met with the municipal town council to request manpower support to enable the CTA to continue, and to outline the progress of the CTA to date. The council acknowledged the benefits to date and also the potential for deferral of major plant expansion by allocating adequate operations manpower.

- In December 1992 the plant superintendent retired. Management responsibilities were allocated to a new superintendent on a part time basis.

- The CTA team met with the new plant superintendent and utility engineer to discuss CTA activities to date and derive consensus and support for the program to proceed as planned.

4.4 Assistance Period -- (January - February 1993)

- The CTA continued to focus on plant performance achieved through process control. The process control worksheet was refined and upgraded.

- Four months after the beginning of the CTA, the volume of sludge being hauled from the facility was reduced by 30% in comparison to historic volumes. This was achieved by implementing a sludge wasting program which accounted for the mass of sludge routinely being produced and wasted from the process. By concentrating the RAS before wasting to the sludge holding tank the operator was able to optimize the available volume in the holding tank. Likewise by allowing the wasted sludge to settle in the holding tank a layer of supernatant developed. This supernatant was returned to the head of the aeration tank while taking care to ensure that no significant concentration of wasted solids were returned to the aeration tank.

- A computer spreadsheet was developed by the CTA team to enable data analysis and trending for process control and plant performance monitoring (Appendix 3.B).

- In January 1993 the operations staff were rotated in order to introduce another operator to the process control techniques which had been developed at the Plant B plant. This would ensure that all operations staff would achieve a transfer of skills through the program. A one week training period was provided by the CTA technical team to assist the new operator in applying the process control techniques. The operator leaving the plant assisted in transferring the skills and duties of the control program to the incoming operator. The transition was successfully achieved with no negative impact on plant performance.

- Flow measurement weir boxes were designed and fabricated for installation on the RAS and plant secondary by-pass lines to improve monitoring and process control.

- Technical Team/All Staff Meeting (February 17 1993)

- Review of final effluent quality to date for final effluent BOD_5, TSS, TP and Ammonia since October 1992.

- The CTA team discussed plant coverage and response to storm flow events. A decision was made to install an alarm system to indicate high hydraulic loading to the plant. A protocol was established for operator response to a process alarm.

- A discussion was held regarding the plant's capability to achieve nitrification. To date, the plant had shown reduced ammonia concentration in the final effluent.

- Management and staff were made aware of the need for good sludge accountability in conjunction with plant performance (Appendix 3.C).

- The waste sludge storage tank volume was confirmed by measuring and documenting tank dimensions.

- An overall operations strategy was derived for handling storm flow events. Experience gained through operator focus on process control since the start of the CTA indicated that successful treatment of storm flows rests primarily on the operator's ability to respond to the storm event.

- High flow alarms were installed and linked to a pager system which alerted the operator to the flow event. A strategy was implemented by the superintendent and operators for responding to the process alarms.

- The flow measurement weir box was installed on the RAS line to enable better plant controllability.

4.5 Assistance Period -- March to April 1993

- Plant staff successfully handled a significant storm flow event. The plant's design flow capacity is 681 m^3/d. The average day flow for the event was 1200 m^3/d with a two hour peak flow of 1700 m^3/d. The resulting 24 hour final effluent composite suspended solids was 13 mg/L. No biological solids washout of the clarifier sludge blanket occurred and no plant by-pass was necessary.

- A sludge accountability check indicated that more sludge was being produced than was projected. Plant flow measurement, sampling, analytical procedures, and waste sludge storage tank calibration were checked.

- The calibration of the plant flow meter calibration was verified. An instantaneous check indicated that the flow meter was reading 27% lower than actual flow.

- Differences were identified between the reported volume of waste sludge hauled from the facility and the volume of sludge removed from the calibrated sludge holding tank. Historically, the plant staff recorded the volume of sludge being hauled off-site according to the calibrated volume of the haulage truck. However, the volume of sludge wasted from the treatment process to the waste sludge holding tank did not agree with the truck calibration. The dimensions of the waste sludge holding tank were checked and found to be in agreement with the design volume. To resolve the discrepancy, a cross check was performed by installing an in-line calibrated magnetic flow meter between the waste sludge holding tank and the haulage truck. Several test runs confirmed that the actual volume being hauled from the plant was 25% less than that being reported. This resulted in a further saving of 25% in waste sludge haulage cost since the start-up of the CTA. As a result of optimizing the waste sludge handling procedures an overall 58% saving in the plant operations budget for sludge haulage was achieved.

- Maintenance of an eight hour operator presence at Plant B was identified as causing manpower shortages at other projects.

4.6 Assistance Period -- May to July 1993

- Technical Team/Municipality Meeting (May 4th 1993)

- In May, the ability of the operations staff to maintain their attention on process control and performance was impacted by the onset of the summer season when grass cutting and housekeeping duties increased. The issue was resolved when the municipality provided manpower assistance to perform grass cutting duties. This enabled the plant operator at Plant B to maintain his focus on process control and performance.

- The municipality showed continued interest in the CTA because the results indicated that the existing facility could handle additional hook-ups.

- Two operators from another municipality were trained in the Plant B process control program by the Plant B operations staff and the CTA technical team.

- The fabricated flow measurement weir box was installed on the secondary by-pass line to enable an accurate measurement of by-pass volume. This would enable staff to measure and quantify plant versus by-pass flow during severe storm events.

- Process control adjustments were made to facilitate improved nitrification by increasing the total sludge mass.

- The plant superintendent and staff initiated steps to identify if reduced levels (less than 8 hours per day) of on-site plant coverage were possible without having a negative impact on plant performance.

- The plant operator drafted and documented a daily dry weather process control routine which enabled the operator to derive the relevant information needed to maintain process control. This routine is only applicable during dry weather conditions and does not outline the more comprehensive duties required during storm flow conditions (see Process Control Manual).

- A mandate was created by the OCWA utility engineer to identify the requirements for implementing the Plant B process control program at other facilities.

5. CTA RESULTS

For the duration of the CTA, the technical team, OCWA utility management, plant management, and operations staff adopted monthly average compliance criteria to measure the success of the Comprehensive Technical Assistance program. The targeted criteria were 15 mg/L for BOD_5, 20 mg/L for TSS, and 1 mg/L for TP.

For the period July 1992 to the end of the CTA, final effluent samples were collected using 24 hour refrigerated composite samplers, analyzed daily on-site for TSS and submitted to the MOEE laboratory three times per week for BOD_5, TSS, NH_3, NO_2^-, NO_3^-, and TP analysis.

Figure 1 depicts the final effluent TSS quality for the period January 1991 up to the end of the assistance program. The target TSS of 20 mg/L is depicted by the horizontal line. The CTA was initiated in October 1992. During the CPE performed in February 1992 a 26% sludge non-accountability was identified (Appendix 3.C). This non-accountability represents approximately 6,000 kg of sludge. Knowing the susceptibility of the plant to storm flow impact and assuming that the 6,000 kg of solids were washed to the receiving stream, a final effluent TSS concentration of approximately 37 mg/L was projected for the entire year of 1991 in contrast to the reported concentration of 8 mg/L. The projected level of performance is depicted by the

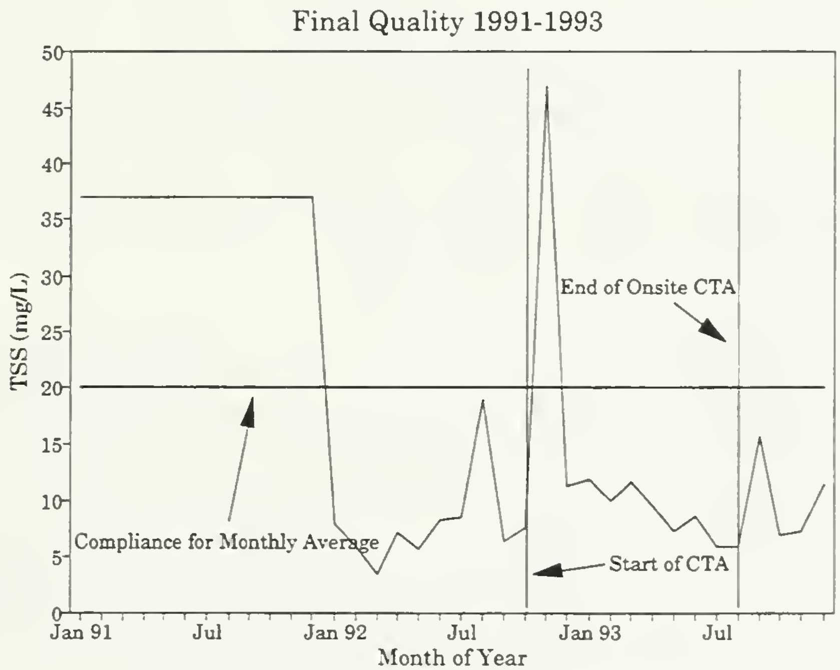


Figure 1 Final Effluent TSS Concentration 1991 to 1993

horizontal portion of the graph for 1991. In November 1992 the plant received two significant storm events. As the CTA was in the early stages and the optimum process control program was not yet in place, the impact of the storm event resulted in an average TSS concentration of 47 mg/L for the month. However, as the CTA progressed the level of operator knowledge, confidence, and process control awareness improved, such that the final effluent TSS concentration displayed a continued downward trend up to the end of the CTA in August 1993.

Figure 2 depicts the final effluent BOD_5 quality for the period January 1991 up to the end of the CTA. The target of 15 mg/L BOD_5 is depicted by the horizontal line. The sludge production non-accountability which resulted in a projected TSS final effluent concentration of 37 mg/L for the entire year was likewise used to calculate a projected BOD_5 concentration. This projected concentration was 20 mg/L for the entire year of 1991 as compared with the reported 5 mg/L. This projected performance is depicted by the horizontal portion of the graph for 1991. Since the beginning of the CTA, the final effluent BOD_5 concentration was consistently less than 10 mg/L.

Figure 3 depicts the final effluent TP quality for the same period. The plant has consistently recorded TP final effluent concentrations of less than 1 mg/L, and this consistency has been maintained for the duration of the CTA.

Figure 4 depicts the final effluent ammonia concentration for the duration of the CTA. As the routine process control program was established, the plant (although not designed to nitrify) started to completely nitrify as shown by the low effluent ammonia concentrations in November and December 1992. Typically the influent TKN concentration averaged approximately 40 mg/L for the duration of the CTA. However, on several occasions spikes of influent TKN were identified by the composite sampler to be as high as 90 mg/L. In February 1993, the SRT was reduced from 20 to 15 days in anticipation of spring melt and high hydraulic flows to the plant. This process adjustment increased final effluent ammonia concentrations starting in late February as the total mass of activated sludge was reduced. Additionally, with the arrival of spring and summer, increased water temperatures reduced the ability of the serviceable air blowers to supply enough oxygen for complete nitrification. Additional blower equipment is present on-site but is not operated continuously as it is mechanically unreliable.

Figure 5 depicts the benefit which the CTA has had in reducing the impact of storm events and consequently reducing the solids loading to the river. Prior to the CTA two significant storm events in July and September 1992 resulted in 271 kg and 94 kg of solids, respectively, being washed to the river. After the start of the CTA, another storm event on November 2nd resulted in 312 kg of solids being lost. However, as the level of operator knowledge and awareness increased and the required process control steps were put in place, the impact of subsequent storm events was significantly reduced. The storm flows successfully treated after the start of the CTA (October 1992) are significantly greater than those treated prior to the CTA. As the CTA progressed the flows successfully treated by the plant during storm events increased while the mass of solids being lost to the river were significantly reduced.

By optimizing sludge management and resolving the discrepancy between the waste sludge volumes and the volume of the haulage truck, a 58% reduction in sludge haulage costs were achieved.

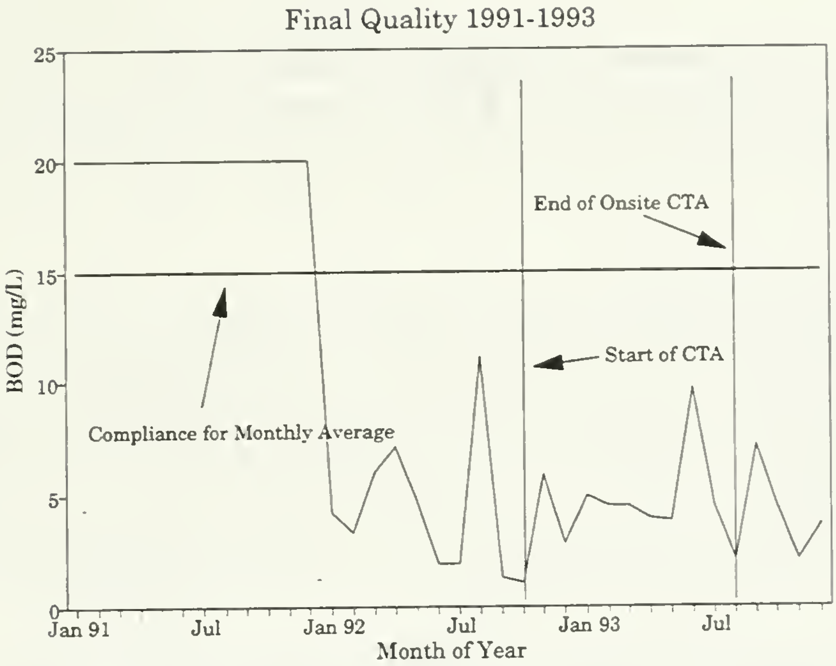


Figure 2 Final Effluent BOD_5 Concentration 1991 to 1993

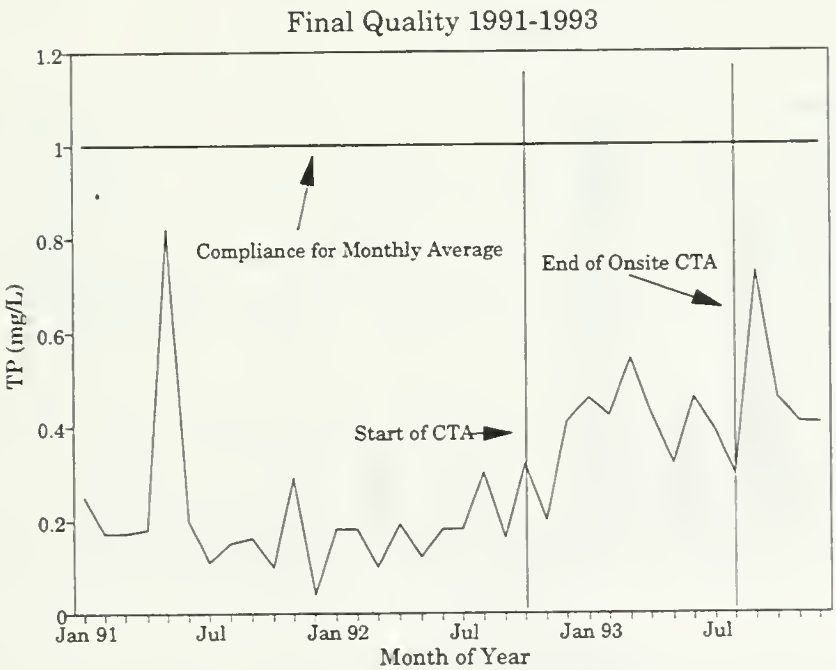


Figure 3 Final Effluent TP Concentration 1991 to 1993

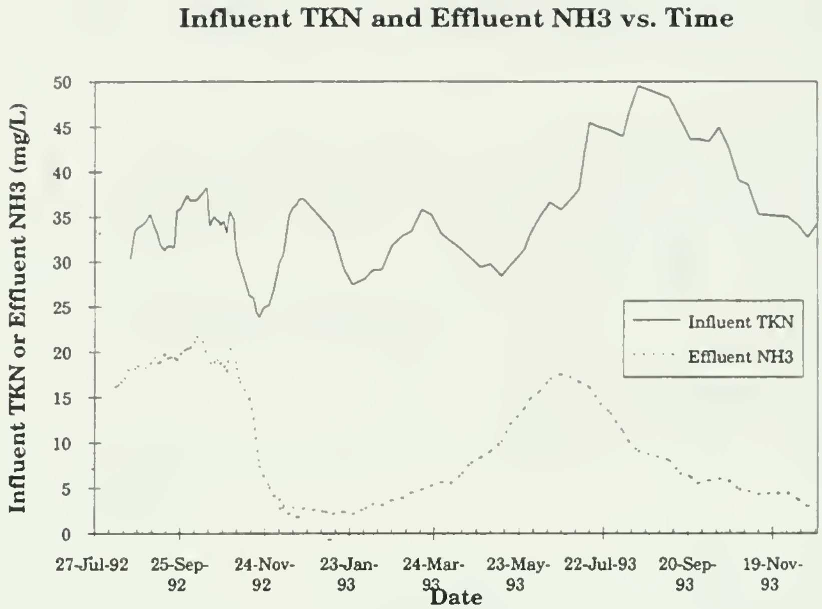


Figure 4 Influent TKN and Effluent Ammonia Concentrations July 1992 to December 1993

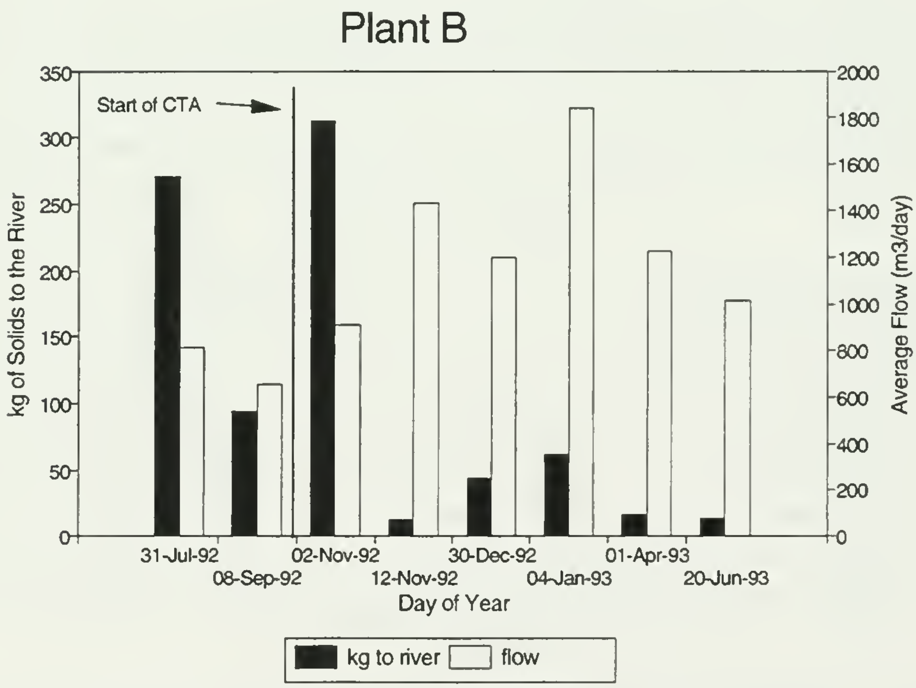


Figure 5 Assessment of Storm Impact on Solids Loading to River

6. SUMMARY AND CONCLUSIONS

Since the beginning of the CTA the plant performance has shown a significant improvement in final effluent quality. Significant reductions in BOD_5 (70%), TSS (59%) and Ammonia (46%) loadings to the river were achieved. The CTA has shown that under current loading the plant can consistently achieve monthly average compliance for BOD_5 and TSS without any capital expenditure.

The CTA created a focus on appropriate staffing levels and the steps necessary to enable process control to be established and maintained. Initially, the plant was manned for eight hours per day. This level of staffing was maintained for eight months. As the CTA progressed, the level of operator awareness and knowledge of the process enabled time on-site to be reduced to approximately five hours per day under stable dry weather conditions. The majority of operator time was dedicated to performance monitoring and process control adjustments. However, even under dry weather conditions, the level of operator time required varied depending on the variability in plant loading, the impact of process control adjustments, and the subsequent effect on the sludge characteristics.

Under storm conditions, the operators and superintendent implemented a response program which enabled the operators to respond to the process needs of the STP to maintain a stable biological process and ultimately a final effluent that met the compliance criteria. The length of time required by operators to respond to storm conditions was different for each event. Plant management support in addressing the process control requirements during storm events is key to the success of the response strategy for storm events that has been derived and implemented.

The operators achieved a level of skill necessary to establish and maintain process control at the Plant B plant. This control is reflected in the consistent high quality of the final effluent. Through the process control program at the plant, the anticipated problems caused by the on/off action of the lift station pumps at current flows were avoided. Aided by a process related flow alarm, the operator, through planning and anticipation, has minimized the impact of lift station pump surging during high flow events. In future, as average daily flows increase, consideration should be given to modifying the pump station to optimize plant capacity.

Historically, the sudden impact of storm events has resulted in process upset and loss of biological solids from the secondary clarifier. However, as the CTA progressed the impact of the storm events were significantly reduced. In future, consideration should be given to a low cost retrofit to provide step feed capability to further enhance the reduction of major storm flow impacts. Flows up to 3 times design flow were successfully handled for extended periods without exceeding the desired effluent quality (20 mg/L TSS).

The implementation of a routine sludge mass control program focused operator attention on the amount of sludge being produced and wasted from the process. The process control routine reduced the volume of sludge being hauled from the process. However, the mass of solids being removed was greater than the historic amounts. To date a 58% reduction in sludge haulage costs has been achieved.

The air lift control of RAS flow was erratic and subject to blockage during low flow conditions. Blockage of RAS flow, especially during the night time, resulted in build up of clarifier solids mass inventory. To achieve better RAS pumping reliability, consideration should be given to the installation of a timer on the air lift mechanism, or installing an alternate pump which would not rely on the air lift mechanism.

7. RECOMMENDATIONS

- Adequate staffing levels at Plant B must be maintained to enable the current level of control and performance to be continued. The level of staffing will vary depending on the prevailing conditions, and sludge settling characteristics.

- As storm events can potentially have a detrimental impact on plant performance, plant coverage during such events is necessary.

- To maintain a focus on process control and optimized performance, the operations staff must continue to prioritize their routine duties. Both plant and utility management must continue to identify plant performance as a priority and support the operations staff in maintaining the demonstrated improvements.

- The process control program which was developed by the operations staff has consistently achieved the monthly average effluent criteria of 15 mg/L BOD_5, 20 mg/L TSS and 1 mg/L TP. It is recommended that staff continue to apply the concepts to maintain process control, focus on performance, and rely on the data established by the process control program.

- To continue to accurately record plant loading and final effluent quality, the installation a of permanent 24 hr. composite sampling equipment is recommended.

- To ensure that adequate dissolved oxygen is available for process control purposes it is recommended that the three air blowers be maintained in working order.

REFERENCES

1. Hegg, B.A., L.D. DeMers, and J.B. Barber, Handbook - Retrofitting POTW's, EPA 625/6-89-020, U.S. Environmental Protection Agency, Center for Environmental Research Information, Cincinnati, Ohio, (July 1989).

APPENDIX 3.A

Daily Operational Data Worksheet

This process control worksheet is completed each day by the operator. By following the daily routine and by completing the worksheet, the operator identifies the mass of sludge and subsequently the volume which should be wasted each day in order to maintain an effective biological system.

PLANT B PROCESS CONTROL WORKSHEET

MONTH__________ YEAR__________

Date	Tima	Plant Flow (m3/d)	RAS Flow (m3/d)	RAW SS (mg/L)	MLSS (g/L)	Aeration Mass (kg)	Clarifiar Sludge Conc. (g/L)	Clarifier Mass (kg)	Total Mass (kg)	SDR	Effluent SS (g/L)	Effluent Mass (kg)	RAS Conc. (g/L)	WAS Conc. (g/L)	kg to Wasta	Volume to Wasta (m3)	Volume Actually Wasted (m3)	Mass Actually Wasted (kg)	SRT (days)	Return % of Flow	Clarifiar Retention Time (hrs)

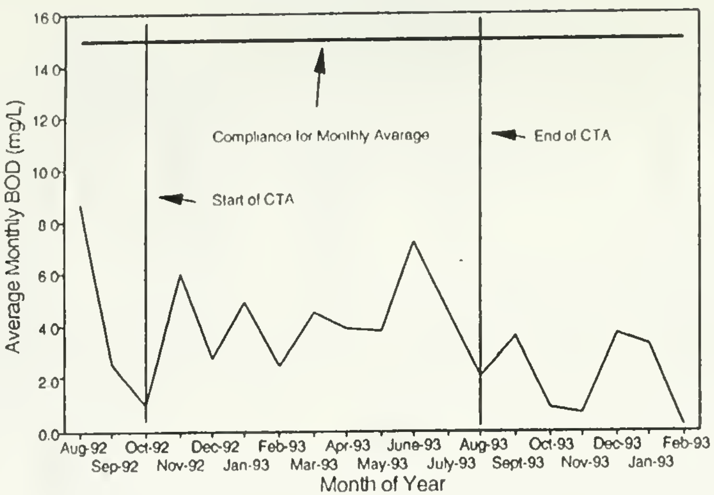
AERATION VOLUME = 556 m3
CLARIFIER VOLUME = 148 m3

TARGET SRT =

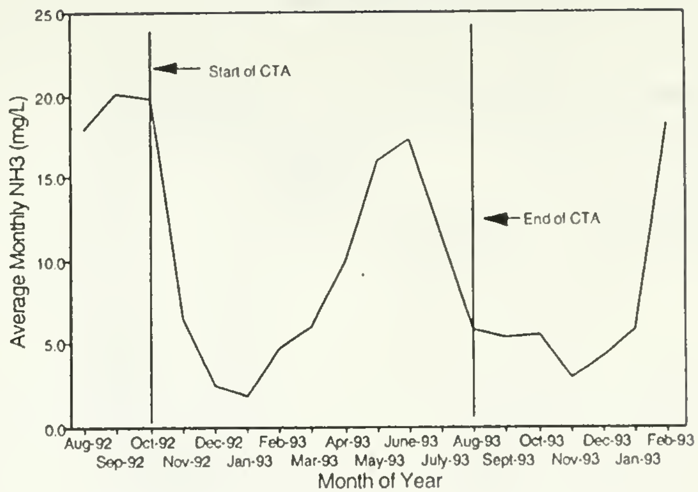
APPENDIX 3.B

Trend Analysis of Operational and Performance Data

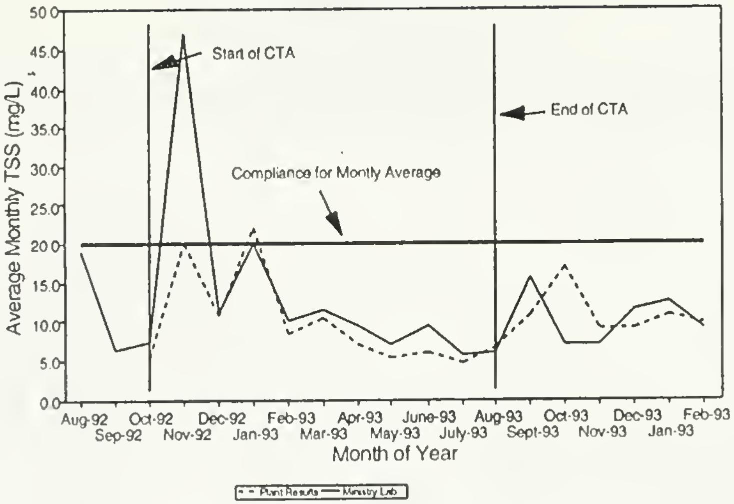
Average BOD vs. Time
Municipal Wastewater Treatment Facility



Average NH3 vs. Time
Municipal Wastewater Treatment Facility



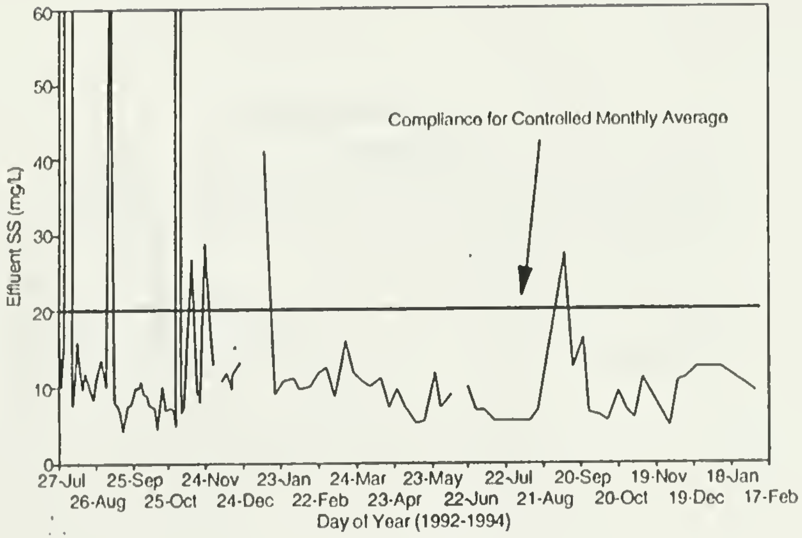
Effluent SS vs. Time
Municipal Wastewater Treatment Facility



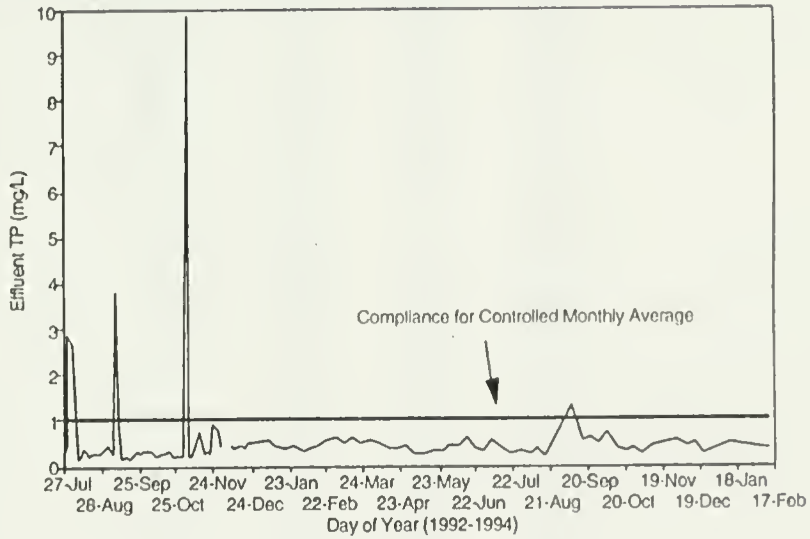
Month	TSS (mg/L) Plant	Ministry	BOD Lab	NH3 Lab
Aug-92		18.90	8.72	17.85
Sep-92		6.40	2.51	20.08
Oct-92	5.50	7.60	0.99	19.72
Nov-92	19.86	46.80	5.93	6.41
Dec-92	10.78	11.30	2.76	2.44
Jan-93	22.09	20.00	4.90	1.78
Feb-93	8.47	10.00	2.50	4.68
Mar-93	10.65	11.60	4.47	5.92
Apr-93	7.14	9.50	3.88	9.95
May-93	5.56	7.30	3.79	16.06
June-93	6.08	9.55	7.17	17.27
July-93	4.61	5.83	4.45	11.55
Aug-93	6.66	5.97	2.11	5.80
Sept-93	10.99	15.68	3.60	5.29
Oct-93	16.97	6.93	0.85	5.57
Nov-93	8.98	7.30	0.65	3.02
Dec-93	9.03	11.43	3.63	4.19
Jan-93	10.82	12.50	3.30	5.89
Feb-93	9.81	9.30	0.10	18.20
Average	10.24	12.31	3.49	9.56

Performance Data Summary for Plant B

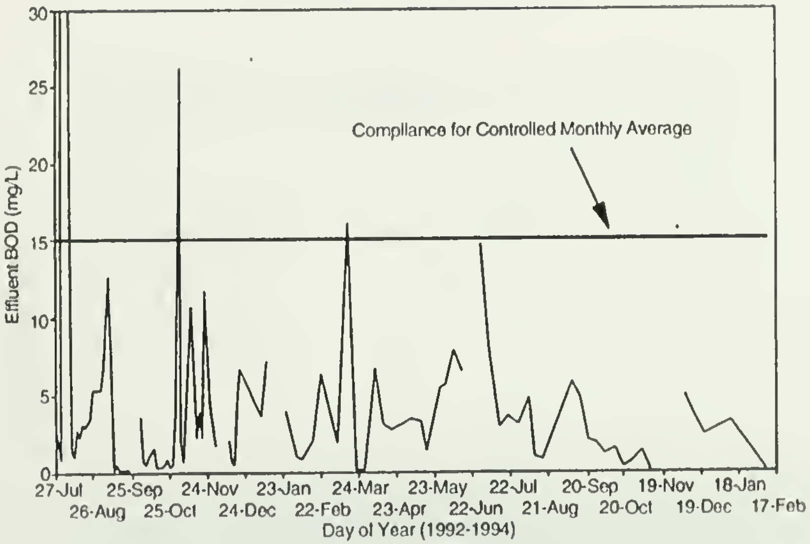
Effluent SS vs. Time
Municipal Wastewater Treatment Facility



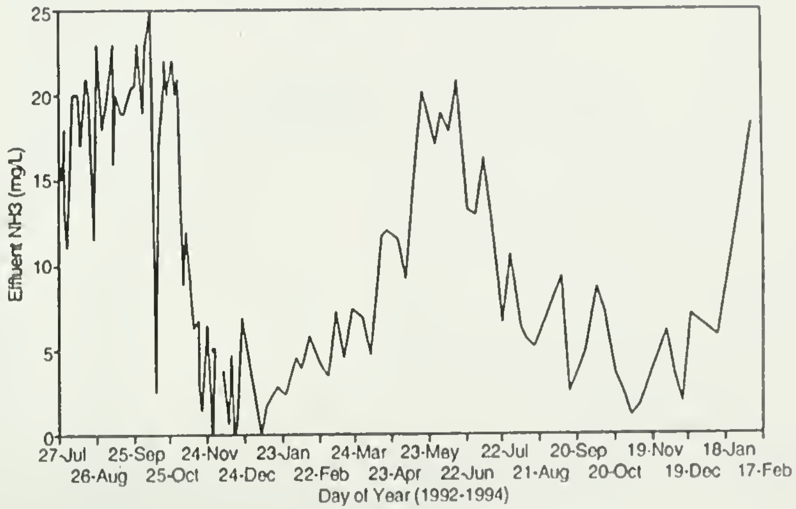
Effluent TP vs. Time
Municipal Wastewater Treatment Facility



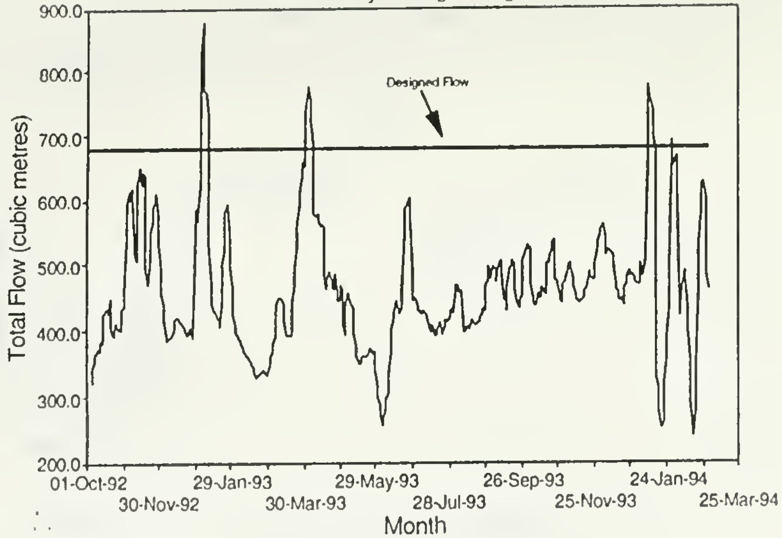
Effluent BOD vs. Time
Municipal Wastewater Treatment Facility



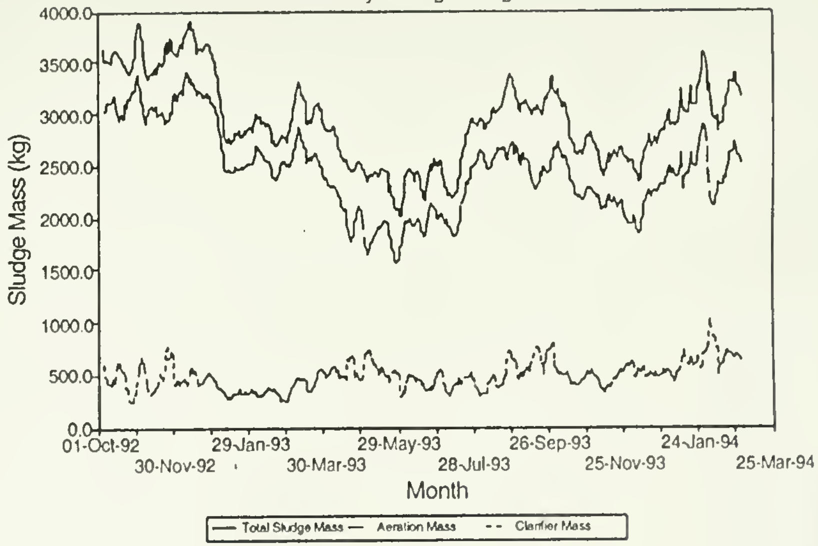
Effluent NH3 vs. Time
Municipal Wastewater Treatment Facility



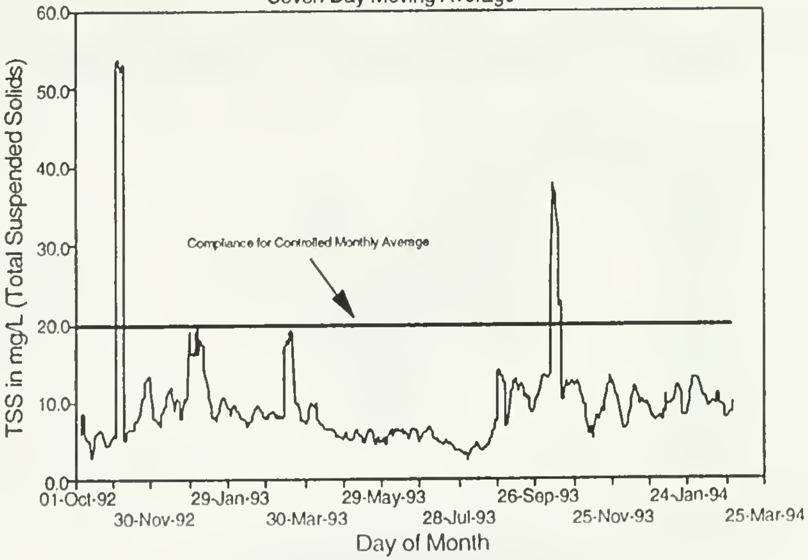
Total Flow vs. Time
Municipal Wastewater Treatment Facility
Seven Day Moving Average



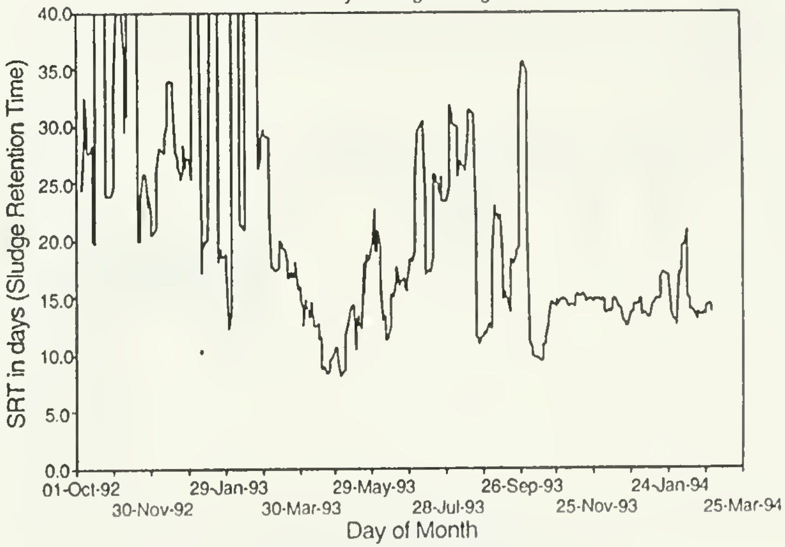
Sludge Mass vs. Time
Municipal Wastewater Treatment Facility
Seven Day Moving Average



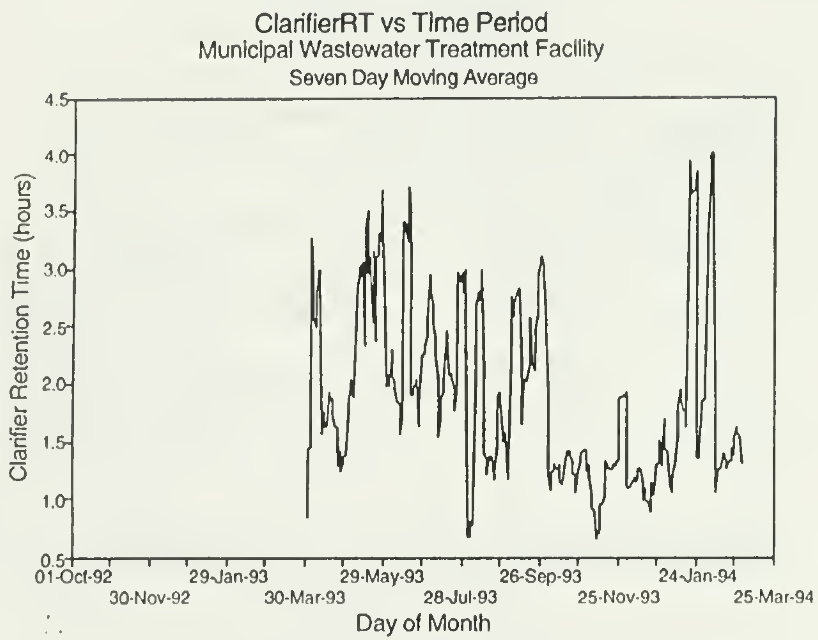
Eff SS vs. Time Period
Municipal Wastewater Treatment Facility
Seven Day Moving Average

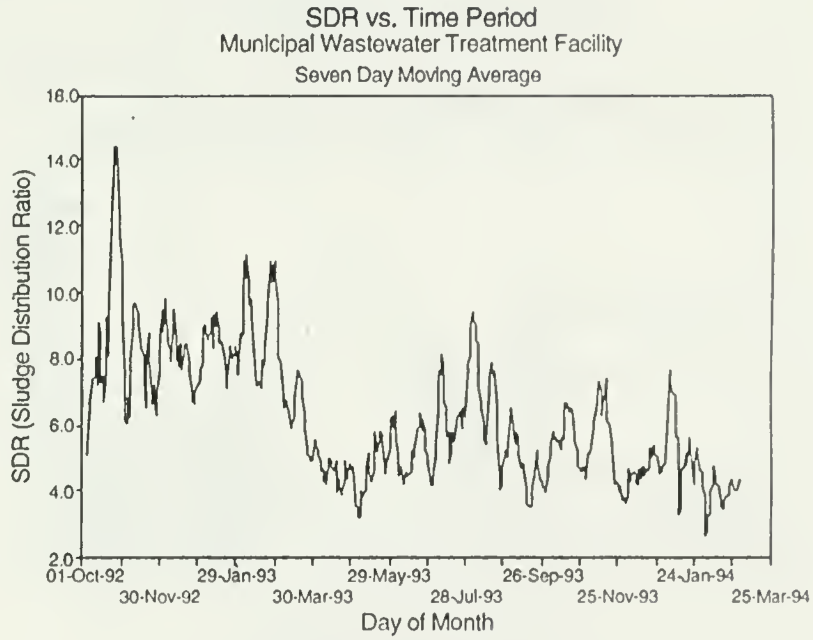


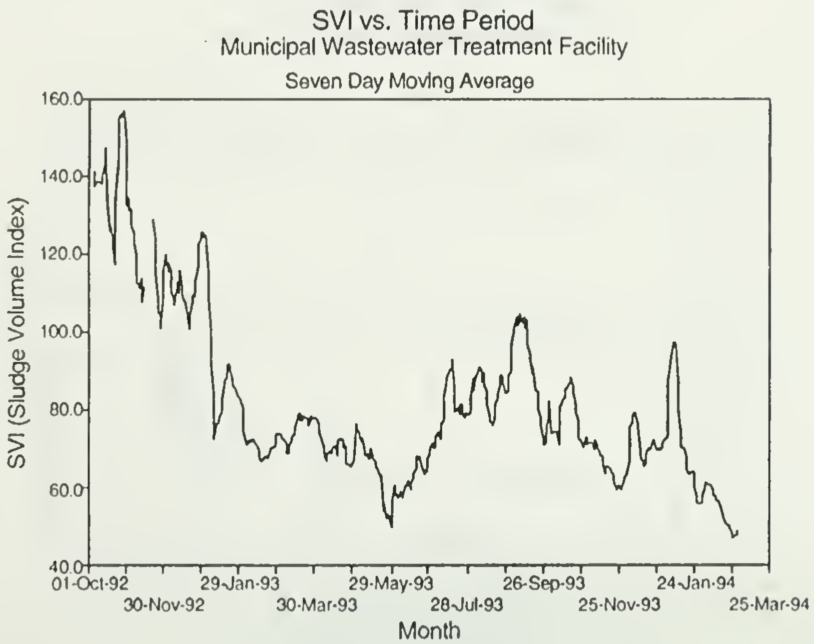
SRT vs. Time Period
Municipal Wastewater Treatment Facility
Seven Day Moving Average



Operational Data Summary for Plant B







APPENDIX 3.C

Sludge Accountability Analysis 1991

SLUDGE ACCOUNTABILITY ANALYSIS
PLANT B WATER POLLUTION CONTROL PLANT
for PERIOD JANUARY 1991 to JAN 1992

Step 1 - Sludge Mass Wasted From Final Clarifier To Sludge Holding Tank

Avg. Volume Wasted Daily = 9.19 m^3/day
Avg. Return Activated Sludge SS = 6206 mg/l

Mass Wasted =

0.00919 10^3 m^3/day x 6206 mg/L x 365 days/yr
= 20805 kg/yr

Step 2 - Projected Chemical Sludge

Avg. Wastewater Flow = 0.531 $10^3 m^3$ /day (01/91 - 12/91)
Avg. Aluminum Dose = 8.96 mg/L
Sludge Production Ratio = 3.0 mg/L sludge produced/mg Alum added[1]

Chemical Waste Sludge =

0.531 $10^3 m^3$/day x 8.96 mg/L x 3.0 mg/mg x 365 days/yr
= 5209 kg/yr

Step 3 - Projected Secondary Sludge

Avg. Wastewater Flow = 0.531 $10^3 m^3$/day
Avg. BOD Removed Across Secondary System
= 187 mg/L - 5 mg/L = 182 mg/L
Sludge Production Ratio = 0.65 kg SS produced/kg BOD_5 removed
(ref. U.S. EPA Handbook Retrofitting POTWs)

Secondary Waste Sludge =

0.531 $10^3 m^3$/day x 182 mg/L x 0.65 kg/kg x 365 days/yr
= 22,928 kg/yr

Step 4 - Total Projected Sludge Produced
(Chemical Sludge & Secondary Sludge)
= 5209 kg/yr + 22,928 kg/yr = **28,137 kg/yr**

[1]Bowker, R.P.G. and H.G. Stensel, Design Manual for Phosphorous Removal, EPA/625/1-87-001, U.S. Environmental Protection Agency, Center for Environmental Research, Cincinnati, Ohio (September 1987).

Step 5 - Evaluation

$$= \frac{\text{Total Projected Sludge Produced - Reported Sludge Wasted}}{\text{Total Projected Sludge Produced}} * 100$$

$$= \frac{28{,}137 \text{ kg/yr} - 20{,}805 \text{ kg/yr}}{28{,}137 \text{ kg/yr}} \times 100$$

= 26.1% Non Accountable. Outside +/- 15%

The projected total sludge mass produced is not within ±15% of the actual sludge mass produced. Therefore, the data probably does not reflect the current level of treatment.

Calculation of Estimated final effluent TSS concentration.

Reported final effluent TSS for period evaluated = 7.7 mg/L.
Average day flow for period = 531 m^3/day
Controlled mass of sludge to receiver = 531 m^3/day * 7.7 mg/L/1000 = 4.0887 kg/Day
= 1,492 kg/Year

Total mass of sludge wasted for period evaluated = 20,805 kg
Total accounted for mass of sludge = 20,805 kg + 1,492 kg = 22,297 kg
Projected mass of sludge produced for period evaluated = 28,137 kg

Total mass of sludge not accounted for = 28,137 - 22,297 = 5,839 kg/year

Mass of sludge not accounted for per day = 5,839/365 = 15.99 kg/day
Estimated solids concentration = 15.99 kg/day /531 m^3 /day * 1000 = 30 mg/L

Estimated final effluent TSS concentration = 30 mg/L + 7.7 mg/L = 37.7 mg/L

Estimated final effluent BOD_5 concentration

Reported BOD_5 concentration = 5.2 mg/L
Projected BOD_5 concentration due to non-accountable sludge = 30 mg/L * 0.5 = 15 mg/L estimated BOD_5.

Estimated final effluent total BOD_5 = 15 mg/L + 5.2 mg/L = 20 mg/L

APPENDIX 4

Plant H CTA Report

Prepared by:

Joint MOEE/WTC/OCWA Technical Assistance Team

RESULTS OF THE COMPREHENSIVE TECHNICAL ASSISTANCE AT THE PLANT H STP

July 1994

Prepared by:

Joint MOEE/WTC/OCWA Technical Assistance Team

Administered by:

Ministry of Environment and Energy
Science and Technology Branch
125 Resources Road
Etobicoke
Ontario
M9P 3V6

Wastewater Technology Centre
867 Lakeshore Road
P.O. Box 5068
Burlington
Ontario
L7R 4L7

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1. The Comprehensive Technical Assistance Team members for their continued dedication and commitment to the program.

2. Manager, Ontario Clean Water Agency regional office, Engineering and Technical Services, for providing the support to enable the program to be established, and authorizing funding to enable the step feed demonstration to proceed as a component of the Plant H CTA.

3. Operation Officer, Ontario Clean Water Agency, for providing the support to enable the program to be established.

4. A regional office of the Ontario Clean Water Agency for providing a member of the Comprehensive Technical Assistance Team.

5. Plant H Superintendent and Operations staff.

6. A neighbouring facility's project grouping staff for their support for the program.

7. Staff of MOEE District Abatement Office for their efforts and assistance in obtaining a Section 61 Direction under the Ontario Water Resources Act authorizing the step feed modifications.

8. Mr. B. Hegg, Process Applications Inc., Fort Collins Colorado, U.S.A. for providing the training services and guidance during the CTA.

9. The co-funding agencies Environment Canada, and the Ontario Ministry of the Environment and Energy.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

1. INTRODUCTION

1.1 Composite Correction Program Background

The Composite Correction Program (CCP) uses a two step approach to economically improve the performance of STPs. Step one is the Comprehensive Performance Evaluation (CPE). The CPE evaluates a facility to identify the unique combination of operation, design, maintenance, and administration factors contributing to poor performance. When a CPE determines that the major unit processes are capable or nearly capable of treating the existing flow and loadings, and where the performance of the STP is less than that required by the discharge criteria, the second step of the CCP, called Comprehensive Technical Assistance (CTA) is initiated. Typically, the CCP approach focuses on achieving compliance or optimum performance so that major capital expenditure can either be deferred or avoided.

A CPE was conducted from January 12 - 15, 1993 at the Plant H STP and the factors limiting performance were identified. The facility was evaluated based on its ability to achieve monthly average compliance limits for five day biochemical oxygen demand (BOD_5), and total suspended solids (TSS). The Plant H Water Pollution Control Plant, located in eastern Ontario, is operated by the Ontario Clean Water Agency (OCWA). The plant has a design average day flow capacity of 955 m^3/d (0.21 MIGD), and is expected to achieve annual average compliance criteria for BOD_5 and TSS of 25 mg/L and 25 mg/L respectively. The Plant H facility is not currently required to meet monthly average criteria for TP.

2. SUMMARY OF CPE FINDINGS

2.1 Performance

Examination of the data during the CPE conducted at the Plant H STP showed that the plant was in compliance with its annual effluent criteria over the period of January 1 to December 31, 1992. The reported annual average concentration for BOD_5 and TSS was 10 mg/L and 16 mg/L respectively. However, the plant would have had three BOD_5 violations, and four suspended solids violations under the monthly effluent criteria of 15 mg/L BOD_5, and 20 mg/L TSS which were established for the purposes of the optimization study. Throughout the CPE evaluation, monthly average criteria were applied to determine if the treatment facility could achieve the monthly average criteria for BOD_5 and TSS. A sludge accountability analysis showed that the data evaluated probably did not accurately represent true plant performance.

2.2 Major Unit Processes

The evaluation of the major unit processes established that the sludge holding tank capacity may limit the performance of the facility if waste sludge was not hauled on an as required basis.

2.3 Factors Limiting Performance

Excessive Plant Bypassing - (Design)

The treatment facility routinely experienced high flows resulting from storm events or spring melt which necessitated plant bypassing to avoid washing out the biological system. As a result the quality of the combined effluent (secondary effluent and raw sewage) leaving the treatment plant was degraded.

Application of Concepts & Testing to Achieve Process Control - (Operations)

Optimization of the activated sludge process requires attention to key concepts, such as sludge mass control, sludge distribution through return sludge flow adjustment and process sampling. Data and trend development of related parameters is required to determine short-term and long-term effects on process performance. Adequate process sampling and proper sample point selection of process streams are also crucial. These concepts and related parameters were not being utilized or correctly applied by plant staff at the time of the CPE.

Addressing Plant Needs - (Administration)

Although recognizable progress had been achieved over the latter part of 1992 in addressing the needs of the treatment facility, there were additional requirements which remained to be addressed such as reduction of plant bypassing, plant coverage during weekends and holidays, and refocussing plant staff on improved process control versus maintenance and housekeeping.

Performance Monitoring - (Operations)

During the CPE, a sludge accountability analysis was performed in which the actual and projected sludge mass produced were compared. The sludge accountability analysis for Plant H revealed that the facility produced 20 percent less sludge than the projected value; therefore, the monitoring data probably does not accurately reflect true performance of the facility.

Process Controllability - (Design)

During the CPE it was determined that measurement of return activated sludge flow was not possible. Accurate return activated sludge flow is necessary to enable continuous process control adjustments to be made in response to load variations and to changing sludge mass distribution between the aeration tank and the secondary clarifier.

Process Flexibility - (Design)

In the event of high flows resulting from storm water inflow and infiltration, the plant was found not to have the flexibility to change from conventional treatment to step feed. This limits the potential of the facility to successfully and consistently treat higher flows, thereby reducing bypass occurrences and achieving better performance.

Alarm Systems - (Design)

The present alarming system was found to announce high wet well levels, blower failure, and power failure. None of these features monitor continuous high plant flows which could potentially cause biological solids wash-out.

Sludge Storage/Disposal - (Design)

The plant monitoring data indicated that sludge storage over the winter period at a neighbouring wastewater treatment facility was adequate. However inclement weather could extend the required storage time for sludge from both facilities. If sludge storage capacity at the neighbouring facility was not available this would require internal storage of solids at Plant H and thereby threaten plant performance.

Alternate Power Source - (Design)

The absence of a standby power supply could threaten the performance of the facility in the event of an extended power failure.

2.3 Summary

The major factors limiting performance were related to excessive plant bypassing during spring periods, administrative policies regarding plant coverage, and lack of process control focus by the plant staff. By allocating more time for plant operation and redirecting the plant staff activities to a performance-based process control program it was anticipated that the Plant H facility could meet the proposed targeted monthly BOD_5, and suspended solids criteria without major construction. A CTA was therefore recommended.

3. APPROACH TO CTA

The initial efforts of the CTA were directed at addressing the performance limiting factors identified during the CPE, in particular, reduction of spring bypassing, establishing a communication and reporting program to enable the progress of the CTA to be documented, and providing staff training and transfer of skills to achieve and sustain process control.

4. CTA SIGNIFICANT EVENTS

Following the CPE, discussions were held with the OCWA Acting Manager of Utility Operations, and OCWA Operations Officer to identify the items which had to be addressed before the formal start-up of the CTA. The initial on-site CTA activities were initiated in February 1993. Significant project events are summarized below.

4.1 February 1993

CTA Technical Team/MOEE Utility Engineer Meeting (February 1, 1993).

- A commitment was made by the OCWA Regional Area, Acting Manager of Utility Operations, Operations Officer, and a neighbouring facility's project group Superintendent to provide full time (8 hours), and weekend operator coverage at the STP during the assistance program.

- Plant coverage would be achieved during the initial assistance activities by providing a combination of operator and senior operator time to allow two individuals to learn and benefit from technical assistance.

- A commitment for funding the necessary step feed modifications at the STP was made by the Acting Manager of Utility Operations.

- OCWA identified a need for obtaining legal permission to modify the plant in an expedient manner, and recommended that a Direction under Section 61 of the Ontario Water Resources Act (OWRA) be obtained.

- The Joint CTA Technical Team requested that management and staff equip the STP's laboratory for solids analysis.

February 1993

- The CTA Technical Team prepared a Section 61 Direction request and supporting documentation for modification to provide step feed capability at the plant, and forwarded the document to the MOEE's Regional District Abatement Office for processing.

- A CTA process control workshop was prepared by the technical team in February 1993 and presented to the STP staff.

- Daily and monthly process control worksheets were developed to calculate and record daily process control data (Appendix 4.A).

- The waste activated sludge holding tank was calibrated and a calibration table prepared so that accurate daily wasted sludge volumes could be determined.

- The CTA Technical Team prepared drawings, and specifications for the step feed modifications required at the STP for tendering purposes (Appendix 4.B).

4.2 March 1993

On-site CTA activities were initiated in March 1993. The major activities are briefly summarized below.

CTA Technical Team site visit (March 5, 1993)

- Through discussions with operating staff, procedures were developed for sampling and testing. These procedures were written with assistance provided by the team to the operations staff and compiled in a site specific process operations manual (Process Control Manual).

- A sampling and testing schedule was implemented which enabled the total activated sludge mass inventory to be determined and controlled on a daily basis, (see Process Control Manual).

- A special study was initiated to focus the operations staff's attention on the distribution of activated sludge mass between the aeration basin and the secondary clarifier, commonly referred to as the Sludge Distribution Ratio (SDR). The operations staff were informed of the need to maximize the mass of activated sludge in the aeration basin where the biological breakdown of organic matter occurs, and correspondingly to minimize the activated sludge mass in the secondary clarifier. This was accomplished by monitoring and controlling the return activated sludge (RAS) flow (Process Control Manual).

- A second special study was initiated to identify the optimum RAS flow rates for SDR control purposes, i.e. diurnal variations and lower weekend flows.

March 1993

- The plant was found to be experiencing a severe filamentous bulking problem when the daily process control program was implemented.

- On March 11th plant staff identified conditions which were preventing the required volume of sludge to be wasted from the process. Plant staff observed that the filamentous bulking inhibited thickening of the sludge and supernating from the on-site sludge storage tank. The inability to obtain waste activated sludge having a high solids concentration often resulted in a calculated waste sludge volume which exceeded the volume of the on-site storage tank. Sludge storage limitations had also developed at the neighbouring plant thereby restricting acceptance of

Plant H's waste sludge on demand.

- During the weekend of March 27th and 28th, the plant flows increased suddenly as a result of spring melting and subsequent inflow into the village's collection system. The recorded average daily flows were 1,160 m^3/d and 1,375 m^3/d respectively. The peak flows on each of the days were 1,818 m^3/d and 4,546 m^3/d respectively. Historically, operations staff maintained a high sludge blanket in the secondary clarifier resulting from the poor settling filamentous bacteria growth. On both days operations staff visited the plant site. On March 27th, the operator found nothing unusual occurring; however, within a period of less than two hours after leaving the site, flows increased sharply and the clarifier sludge blanket quickly washed out. On March 28th, the operator arrived at the plant mid morning and found the clarifier washing out, the operator immediately initiated bypassing to prevent further activated sludge solids loss to the receiving waters and damage to the biological process. The wash outs resulted in a significant loss of activated sludge mass to the final effluent. The final effluent suspended solids for each of the days was 392 mg/L and 803 mg/L respectively.

- On March 30th, sustained high flows were experienced at the treatment plant. The recorded average daily flow treated by the extended aeration plant was 1,408 m^3/d with a peak flow of 2,273 m^3/d. The operations staff achieved control of the clarifier sludge blanket twenty-four hours after the sharp increase in hydraulic loading and subsequent wash-out and had developed an operational plan to handle high flow events and sustained increases in hydraulic loading. The staff determined through monitoring the clarifier sludge blanket and adjusting RAS flow that only 50 percent of the storm flow could be pumped through the plant without increasing the potential of further solids wash-outs. Raw sewage flow to the plant was based on the control of the sludge blanket. No significant loss of activated sludge solids occurred from the plant. The final plant effluent TSS was 15.5 mg/L. A 24 hour composite sampler was not in place at the time to sample combined effluent. Through being informed and prepared, the operations staff were able to minimize the impact of the sustained increase in hydraulic loading on the biological process and reduced the solids loading to the receiving water.

- On March 26th, the CTA Team and the neighbouring facility's Project Grouping Superintendent contacted the MOEE Regional District Abatement Office to discuss the status of the Section 61 Direction, and the sludge storage limitations impacting the Plant H STP's performance. The CTA Team requested a meeting be held with the District Abatement officials to identify the objectives of the CTA program and the Direction's status. A meeting was scheduled for April 13th, 1993.

- The CTA Team was informed on March 31st by the District Abatement

Office that processing of the Section 61 direction had been initiated.

4.3 April to May 1993

- Twenty-four hour composite sampling capability was obtained for sampling the plant's combined effluent (blended final effluent and bypassed raw sewage).

- On April 11th, plant staff handled an extended period of elevated hydraulic loading which produced an average day flow of 1,802 m^3/d, and a peak flow to the headworks of 5,400 m^3/d. The bypass flow for the 24 hour period was 1,430 m^3/d. The plant's final effluent TSS was 2 mg/L, while the TSS in the combined effluent was 46 mg/L. Having developed an operational plan to handle sharp hydraulic loading fluctuations and sustained elevated flows, operations staff continued to maximize raw sewage flow through the treatment plant and minimize raw sewage bypassing to the receiving stream.

- On April 13th, the CTA team, OCWA Area officials, and District Abatement officials met to discuss the CTA, the status of the Section 61 Direction, and the sludge storage situation at the neighbouring project and the effect on the Plant H STP's performance. The goals and objectives of the CTA, and rationale for the proposed plant modifications were presented by the CTA team. District Abatement officials expressed support for the CTA approach; however, concurrence to proposed solutions for the sludge storage limitations affecting the plant was not obtained. District Abatement officials indicated that approval for winter sludge utilization would not be granted, and obtaining approval for proposed sludge storage in local septage lagoons would be remote. The date identified by the District Abatement Office for completion of the Section 61 Direction was April 19th, 1993.

- A computer spreadsheet was developed by the CTA Team to enable data trending and analysis for process control and plant performance monitoring (Appendix 4.C).

- The CTA Team met with plant management and staff to review the CTA activities to date, review and explain the process control program implemented by the plant staff, and reinforce support for the program. The operations management identified that plant staff were more enthusiastic about their work since the start of the CTA.

- A V-notch weir box was installed on the RAS line enabling improved process controllability, and a V-notch weir plate was installed in the bypass channel to improve bypass flow measurement.

CTA Team/Plant Staff Meeting (April 28, 1993)

- The CTA Team, plant staff and local contractors met at the plant for the purpose of obtaining quotations for modifications to the existing facility to provide step feed capability.

- A discussion was held regarding plant coverage, response to storm events, and sustained increases in hydraulic loading. A decision was made to install an alarm to indicate high hydraulic loading to the plant. A protocol was also established for operator response to the alarm.

- A weir discharge table (flow in inches through the V-notch) was created for the V-notch weir box which had been installed on the RAS line to assist in proper adjustment of the RAS flow.

- A discussion was held regarding the final effluent flow metering installation and flooding of the existing V-notch weir during periods of high flow. The CTA Team suggested relocating the Milltronics ultrasonic measuring device to a more quiescent area of the contact tank, where the unit might be calibrated to a small rectangular weir.

- A discussion was held regarding the plant's ability to achieve nitrification. Plant monitoring data had shown an appreciable reduction of ammonia in the final effluent to date. Plant staff had also reported a sharp increase in oxygen demand in the aeration section which resulted in the operation of an additional blower.

April to May 1993

- Since the plant was nitrifying, the plant staff were encouraged to focus on improving the SDR to reduce the mass of sludge in the secondary clarifier and minimize the potential for denitrification in the secondary clarifier.

- A high flow alarm was installed and linked to a dialler/paging system which alerted the operations staff of a sustained period of elevated hydraulic loading. A strategy was implemented by the superintendent and operations staff for responding to the alarm.

- Minor improvements in sludge settling characteristics were observed. However, a filamentous bulking problem persisted throughout the month of April 1993.

- The plant staff were unable to waste the required mass of activated sludge from the system on a daily basis as a result of the limited sludge storage capacity at the neighbouring facility.

- A review of the process control data for April 1993 (period of sustained elevated hydraulic loading) revealed that the plant staff successfully handled sustained hydraulic loading events resulting from the spring freshet for the entire month of April. The plant's design average daily flow capacity of 955 m^3/d was exceeded 24 of 30 days in April. The average day flow for April was 1,350 m^3/d or 141 percent of the design flow. The average effluent TSS for the same period was 9.8 mg/L.

- On April 27th, the CTA Team contacted the District Abatement Office to obtain an update on the status of the Section 61 Direction. The CTA Team was informed that a first draft of the Direction would be completed by April 30th. MOEE officials also indicated that the contingency plans included in the supporting documentation for the request for Direction may require more detail.

- On May 6th, further enhancements to the Section 61 Direction were requested by the MOEE Regional District Abatement Office.

- On May 12th, land utilization of sludge from the neighbouring facility resumed, allowing waste activated sludge to be hauled from Plant H on demand.

- Refinements were made to the monthly process control worksheet.

- On May 18th, plant operations staff contacted the CTA Team and reported operational difficulties. The plant staff had great difficulty in controlling the sludge blanket level in the secondary clarifier during a storm flow event. The CTA Team discussed the incident with plant staff. It was concluded that the poor performance was caused by the inability to waste appropriate masses of sludge from the system and the subsequent large inventory of activated sludge in the process. This restricted control over the SDR, clarifier sludge retention time (CSRT), and allowed denitrification to occur in the secondary clarifier contributing to excessive solids loss to the effluent. The effluent TSS for the storm event was 319 mg/L.

- On May 26th, the MOEE District Office contacted the CTA Team and explained that more detailed contingency plans were required before a Section 61 Direction could be issued. The CTA Team requested a meeting with District Office officials for the purpose of finalizing all information requirements so that a Section 61 Direction could be secured. This meeting took place on June 7, 1993.

4.4 June to September 1993

- A comparison of raw sewage bypass flow data for 1992 versus 1993 showed that in 1993 the plant staff had achieved a 25 percent reduction in the overall volume of sewage bypassed. This reduction was achieved through improved process control and plant coverage.

- On June 2nd, the MOEE District Office requested the MOEE's Technical Assessment Section's surface water unit to comment on the proposed step feed modifications for the plant with respect to receiving water considerations. A copy of the Plant H Section 61 Direction supporting documentation was furnished by the CTA Team for the surface water unit's review. After review, the Technical assessment section had no objections to the proposed step feed modifications, concluding that receiving water considerations were not critical based on the existing flows in the Ottawa River.

- On June 7th, the CTA Team met with MOEE District Office officials. MOEE District Office officials identified the need for additional documentation to be supplied by Utility Operations and the CTA Team before a Direction allowing step feed modifications to the plant could be issued. Also requested was an explanation of step feed and contact stabilization, action plans outlining the events expected to take place during installation of the step feed components, and detailed contingency plans. The CTA Team provided the additional documentation, including contingency plans for conditions of activated sludge washout and controlled bypassing on June 9, 1993.

- Trend analysis of the operational and performance data identified that the activated sludge settling characteristics had improved significantly during the period from May 1st to June 15th, 1993 (Appendix 4.C). This improvement was a direct result of the plant staff's ability to adhere to a daily wasting routine as part of the process control program, and ability to haul waste sludge to the neighbouring facility on demand. The CTA Team discussed this improvement with plant staff and the lengthy biological response time required for the change in settling characteristics to occur.

- On June 21st and 22nd a heavy rainfall was received in the Plant H area. Forty-two millimetres (42 mm) of rain were received during the 48 hour period. Improved sludge settling characteristics achieved through good process control combined with the implementation of a strategy to treat high flows allowed the operations staff to successfully handle the storm event without bypassing raw sewage. The average day flows for the two days were 2,191 m^3/d and 1,948 m^3/d respectively. The peak flow on both days was 2,400 m^3/d. The resulting 24 hour composite effluent TSS on each of the days were 18 mg/L and 8 mg/L respectively.

- The CTA Team was notified by the MOEE District Office on July 2, 1993, and was informed by MOEE officials that the Plant H Section 61 Direction had been approved. A copy of the Direction document was received on July 7, 1993.

- The CTA Team reviewed with plant staff the procedure used for wasting sludge. When wasting activated sludge from the system, plant staff would thicken sludge in the secondary clarifier by shutting off the RAS flow for 2 to 3 hours prior to wasting. Staff conducted a special study to compare direct WAS wasting versus sludge thickening and wasting. Staff demonstrated the following during the special study: (1) Direct RAS wasting took 2 - 3 times longer than thickening followed by wasting; (2) On-site WAS storage was limited to 2 - 3 days when wasting RAS, while concentrating prior to wasting provided 4 - 5 days of on-site storage; (3) When wasting RAS directly the WAS suspended solids concentration was found to be highly variable and resulted in poorer control over the solids residence time (SRT). Conversely, thickening sludge prior to wasting produced a WAS of consistent suspended solids concentration, and allowed better control over the SRT.

CTA Team/Plant Management Meeting (July 20, 1993)

- A review of the daily operational data and final effluent quality to date for BOD_5, TSS, SRT, total mass, and SVI was presented by the CTA Team.

- A discussion was held regarding sludge storage contingencies for the Plant H WPCP for the upcoming winter of 1993/94. Plant management presented several sludge storage contingencies for the plant. The contingencies were prioritized by all.

- The CTA Team identified that some reduction in the required daily volume of WAS had been achieved through application of good process control. Since the beginning of the CTA in March 1993 to July 1993, the average daily volume of WAS generated had decreased from 7.5 m^3/d to 5.0 m^3/d. It was recognized that a reduction in the daily volume of WAS would have a considerable impact on alleviating some sludge storage pressures during the winter months.

- A discussion was held regarding the current level of plant staffing. Plant management identified that they did not see a need for two operations staff at Plant H since the period of sustained hydraulic loading had passed, and stable conditions existed at the plant. Subsequently, management requested that the senior operator resume his position at the neighbouring facility. The CTA Team agreed to this request since both operations staff had developed a sound understanding of process control at their facility. It was agreed that the senior operator would maintain involvement with the CTA, and also would be permitted to return to the plant during the spring of 1994 to receive training on the use of step feed.

June to September 1993

- The senior operator for the neighbouring facility returned to his duties at the neighbouring facility leaving one operator to maintain the process control program at Plant H.

- The senior operator applied his knowledge gained from participating in the Plant H CTA and implemented a daily process control program at the neighbouring STP. The senior operator trained another operator within the neighbouring facility in the daily process control program and it was applied to another STP. Noticeable performance improvements were achieved at both plants.

- The contract to fabricate and install the step feed capability at the plant was awarded on July 30th, 1993. The contractor informed the CTA Team that fabrication of the step feed components would not begin until September 1993 and estimated that fabrication components would require approximately 2 months. Installation was estimated to require 3 to 4 days.

- The Operations staff drafted and documented a daily dry weather flow routine for process control which enabled the operator to derive the relevant information to maintain process control (see Process Control Manual).

- The CTA Team recognized the level of skills developed by the operations staff, and reduced the frequency of site visits. Communications with the plant staff were maintained by telephone and fax machine.

- Further refinements were made to the monthly process control worksheet to include a column for reporting clarifier sludge retention time.

- On September 2nd, a storm produced periods of heavy rainfall in the Plant H area. The impact of the storm was evident at the treatment plant for two days following the initial rainfall. On September 2nd and 3rd, plant staff successfully treated average day flows of 1800 m^3/d and 1780 m^3/d respectively. The effluent TSS concentrations in the final effluent for each of the days were 20 mg/L and 17 mg/L respectively. There was no raw sewage bypassed during the storm event.

- On September 9th, the contractor provided plant staff and the CTA team with shop drawings of the step feed components for review and approval.

4.5 October to December 1993

- On October 20th and 21st another storm occurred in the Plant H area. The plant staff successfully treated average day flows of 2166 m^3/d and 2021 m^3/d respectively. The peak flows on each day exceeded 2400 m^3/d. The effluent TSS concentrations were 13 mg/L and 12 mg/L respectively. On October 21st, plant staff had to bypass raw sewage to avoid overflowing the aeration cell. The bypassed flow was 308 m^3/d. The combined effluent BOD_5 and TSS concentrations for this period were 5 mg/L and 11 mg/L respectively.

- The contractor was contacted on October 21st to determine the status of fabrication of the step feed components. The installation was scheduled to take place from November 22-24, 1993 inclusive.

- Installation of the step feed components began on November 22th and was completed on November 24th. A representative from the MOEE District Abatement Office visited the site during the first day of installation. The modifications were completed within 20 hours at a total cost of $ 13,696.00.

- Plant management expressed concern to the CTA Team regarding increased sludge haulage costs for the facility during the CTA. A summary of sludge haulage costs covering the period from March to November 1993 was prepared. The summary indicated that sludge haulage costs were high during the initial period of the CTA, as a result of poor activated sludge characteristics which prevented thickening of WAS, and required larger volumes of activated sludge to be wasted. However, the summary also showed that the actual unit sludge haulage costs had been reduced by 50 percent as the CTA program progressed and good process control was established and maintained.

- On November 28th and 29th, plant staff successfully handled another storm flow event. The average day flows for each day were 2045 m^3/d and 2014 m^3/d respectively. The effluent TSS concentrations on each day were 11 mg/L and 16 mg/L respectively. Plant staff found it necessary to bypass raw sewage on November 29th to prevent washing out biological solids. The bypass flow for the period was 345 m^3/d. The combined effluent BOD_5 and TSS concentrations for the period were 20 mg/L and 9 mg/L respectively. Plant staff were not familiar with the principles and operation of step feed when the storm event occurred, therefore did not utilize the step feed mode of operation.

4.6 January to May 1994

- Plant operating staff identified that historical high flow events were actually greater than reported, and the existing weir arrangement, when flooded, would not provide accurate flow measurement. The plant superintendent agreed to have a new weir plate fabricated to enable measurement of higher flows.

- The CTA team prepared and presented a step feed workshop to the plant staff to provide them with the theory and principles of step feed operation.

- On March 23rd, plant staff identified that the average daily flows at the treatment plant had increased substantially, signalling that the spring freshet had begun, and the plant operation was switched from conventional to step feed mode.

- The monthly process control worksheet was further refined to provide sections for recording pertinent process control data when operating in step feed mode.

- A new 90 degree V-notch weir plate was fabricated and installed in the final effluent contact tank and the measuring device was recalibrated to the new weir.

- During the period April 13th through April 17th inclusive, plant flows peaked at the treatment plant. The design average daily flow for the facility is 955 m^3/d. The recorded average daily flow for the period was 2998 m^3/d, and the average daily peak flow for the period was 3767 m^3/d. The average effluent TSS concentrations for the period was 13 mg/L. Plant staff found it was necessary to bypass on April 14th and 17th; the bypassed flows on each day were 880 m3/d and 521 m3/d respectively. A 24 hour composite sample of combined effluent collected on April 14th had a BOD_5 and TSS concentration of 15 mg/L and 66 mg/L respectively. The OCWA Area Manager, and the plant's Operations Officer were present at the facility on April 13th and witnessed operation of step feed while the plant was subjected to maximum flows during the spring freshet period.

- On April 13th, the plant staff determined that, under the current operating conditions, the treatment plant could handle a sustained flow of 3900 m^3/d. On April 14th, operating staff fabricated and installed a rectangular weir plate into the head of the plant's bypass channel which would allow sustained flows in excess of 3900 m3/d to automatically overflow and bypass.

- The flows to the treatment plant fell below 2000 m^3/d, and the plant was returned to the conventional mode of operation. The period of high flows resulting from the spring freshet subsided by May 4th.

- A comparison of flow data for the spring freshet period for the years 1992, 1993, and 1994 was conducted by the plant operating staff and the CTA team. The comparison of 1992 versus 1994 data showed that, as a result of optimizing plant performance through process control and step feed modifications, a 95 percent reduction in raw sewage bypassing was achieved during the spring freshet period of 1994. This reduction in bypassing coincided with a 49 percent increase in plant effluent flow, while the total flow (plant effluent and raw sewage bypass flows) to the treatment plant for the same period remained consistent. The average plant effluent BOD_5 and TSS concentrations for the 1994 freshet period were 9 mg/L and 13 mg/L respectively.

5. CTA RESULTS

For the duration of the CTA, the technical team, OCWA operations management, plant management, and operations staff adopted monthly average compliance criteria to measure the success of the Comprehensive Technical Assistance program. The targeted criteria was 15 mg/L for BOD_5, and 20 mg/L for TSS. A target criteria for total phosphorus was not set since the Plant H facility is exempt from phosphorus removal requirements under current Ministry of the Environment and Energy policy.

For the period March 1993 to the end of the CTA, final and combined effluent samples were collected using 24 hour refrigerated composite samplers, analyzed daily on-site for TSS and submitted to the MOEE Eastern Regional Laboratory once per week for BOD_5, TSS, NH_3, and TP analysis.

Figure 1 depicts the final effluent TSS quality for the period of January 1992 to the end of the CTA in May 1994. The target of 20 mg/L TSS is depicted by the horizontal line. For the fourteen month period prior to the start of the CTA the plant recorded four instances (Jan 92, May 92, Jun 92, Jul 92) when the TSS concentration exceeded the 20 mg/L target. For the duration of the CTA the plant reported two instances when the final effluent TSS concentration was greater than the targeted 20 mg/L TSS. In March 1993 the plant was impacted by a filamentous bulking problem, limited sludge storage, and a sudden increase in hydraulic loading as a result of the spring freshet. The average TSS concentration for the month was 47 mg/L. In May 1993, limited sludge storage facilities continued to impact the facility. The physical mass of sludge in the system prevented good control over the distribution of activated sludge between the aeration cell and secondary clarifier. As a result, the clarifier sludge retention time was excessive and resulted in denitrification, loss of control over the sludge blanket, and poor effluent quality. The average TSS concentration for the month was 21.5 mg/L. However, as the CTA progressed, sludge storage limitations were resolved, good process control was established and maintained, and the level of operator knowledge and confidence continued to improve, such that the final effluent TSS concentration displayed a downward trend and stabilized below the monthly target of 20 mg/L.

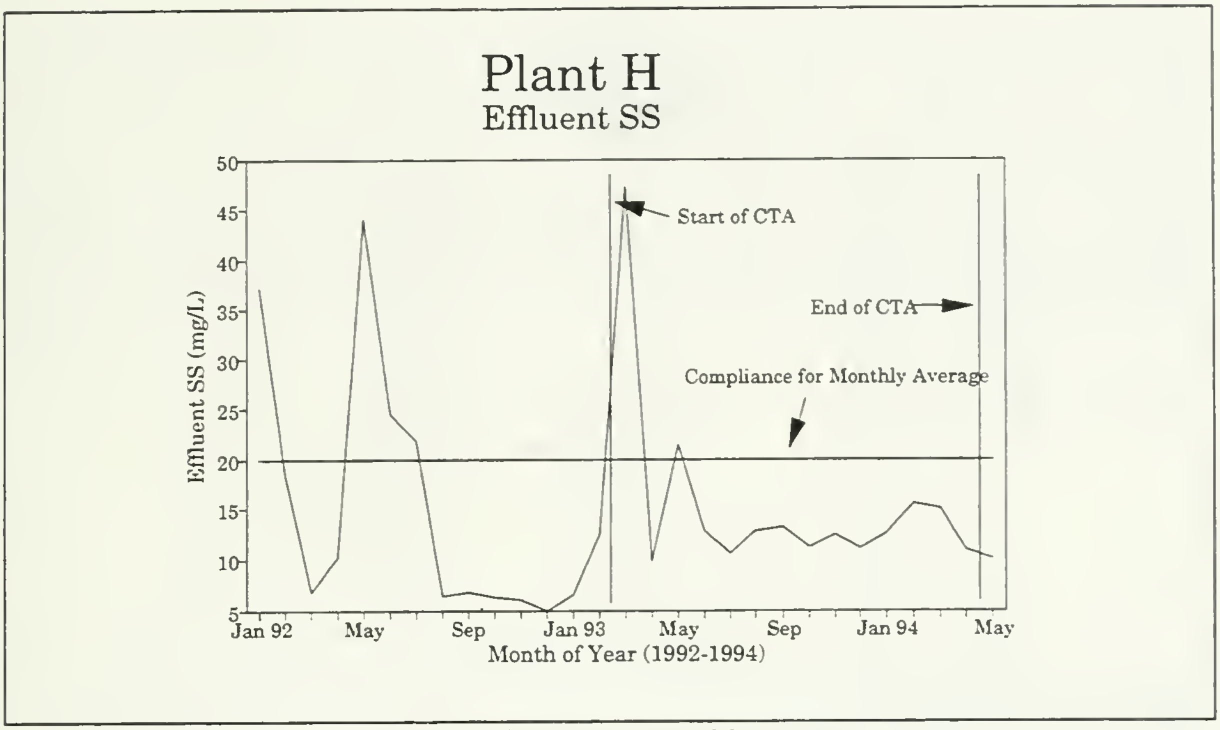

Figure 1 Final Effluent TSS Quality 1992 to 1994

Figure 2 depicts the final effluent BOD_5 quality for the period January 1992 up to the end of the CTA in May 1994. The target concentration of 15 mg/L is depicted by the horizontal line. For the fourteen month period prior to the start of the CTA the plant reported three instances (Jan 92, Apr 92, May 92) when the final effluent BOD_5 exceeded the 15 mg/L target. For the duration of the CTA the plant reported no instances when the BOD_5 concentration exceeded the targeted monthly average of 15 mg/L. Since the beginning of the CTA, the final effluent BOD_5 concentration was consistently maintained below 11 mg/L.

Figure 3 depicts the final effluent total ammonia concentration for the duration of the CTA. The plant was found to be nitrifying at the start of the CTA with the concentration of total ammonia in the final effluent fluctuating between 0.5 and 3.0 mg/L. As the CTA progressed and a routine process control program was established, control over nitrification improved, resulting in effluent ammonia concentrations consistently below 1.0 mg/L from August 1993 to April March 1994. Typically the influent total ammonia concentration averaged approximately 20 mg/L for the duration of the CTA. However, on several occasions spikes of influent total ammonia were identified by composite sampling to be as high as 46 mg/L. In March of 1994, the plant operation was switched from conventional treatment to step feed mode in anticipation of increased hydraulic loading from the spring freshet. This process adjustment increased the final effluent total ammonia concentrations starting in mid March as changes in the activated sludge characteristics occurred, and the hydraulic retention time within the treatment plant was reduced.

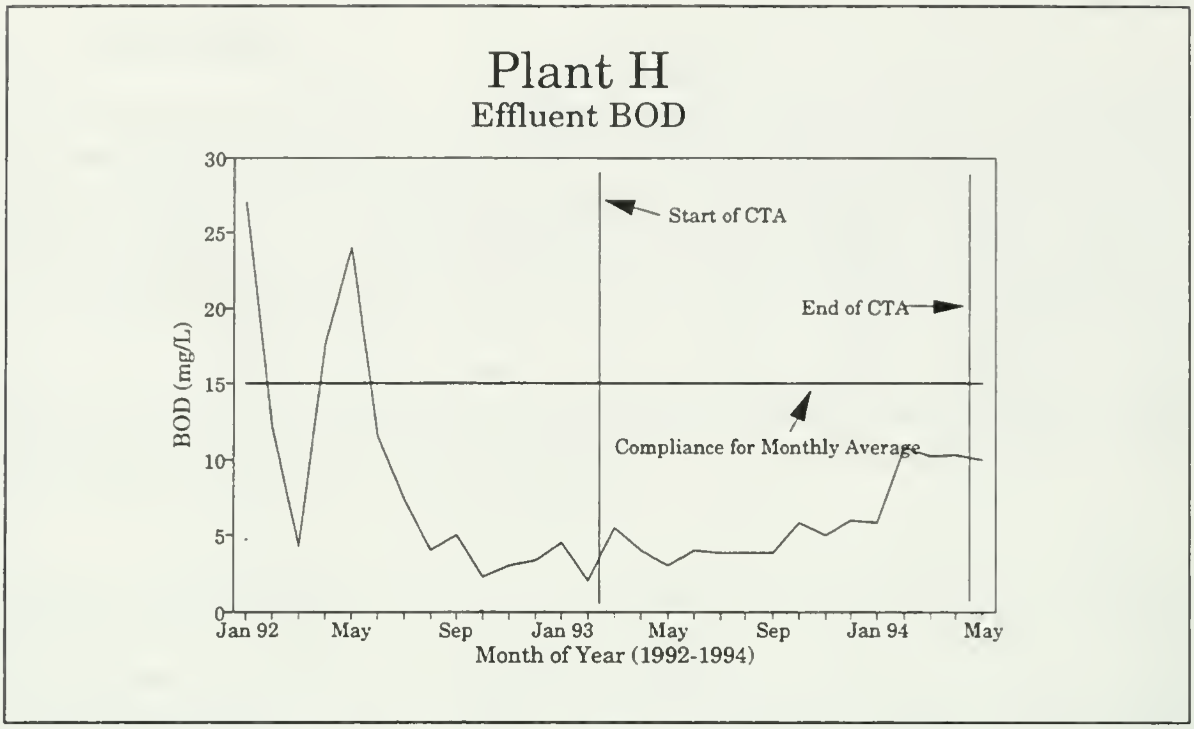

Figure 2 Final Effluent BOD_5 Quality 1992 to 1994

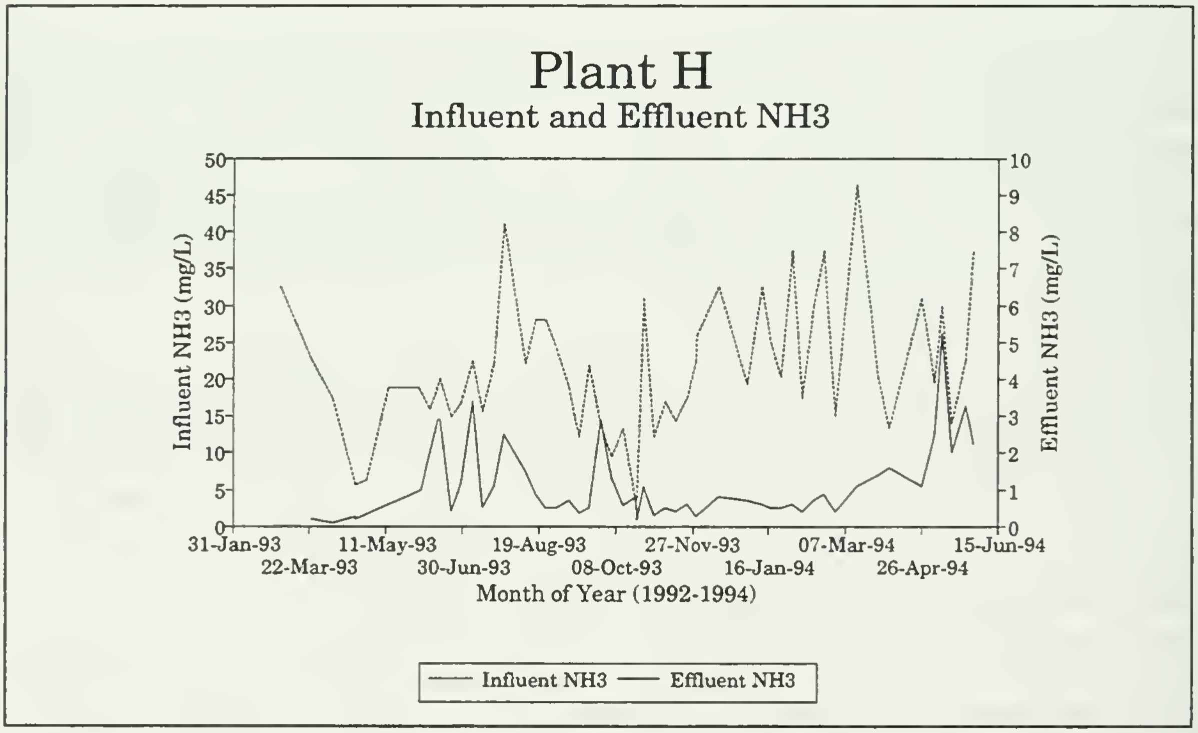

Figure 3 Influent and Effluent NH_3

Figure 4 depicts the benefit which the CTA has had in reducing the impact of storm events and spring flooding, and consequently reducing the solids loading to the river. At the beginning of the CTA two hydraulic shock loading events in March 1993 resulted in 392 kg and 803 kg of solids, respectively, being washed to the river.

However, as the level of operator knowledge and awareness increased, and the required process control steps were implemented, the impact of subsequent hydraulic loading events was significantly reduced. As the CTA progressed the flows successfully treated by the plant during spring freshet and storm events increased while the mass of solids being lost to the river were significantly reduced. In November 1993, step feed capability was added to the treatment plant by means of a simple, low cost retrofit. Use of the step feed capability combined with maintenance of an effective process control program enabled treatment of flows approximately four times the rated design flow of the facility as shown by the high average day flows in April 1994.

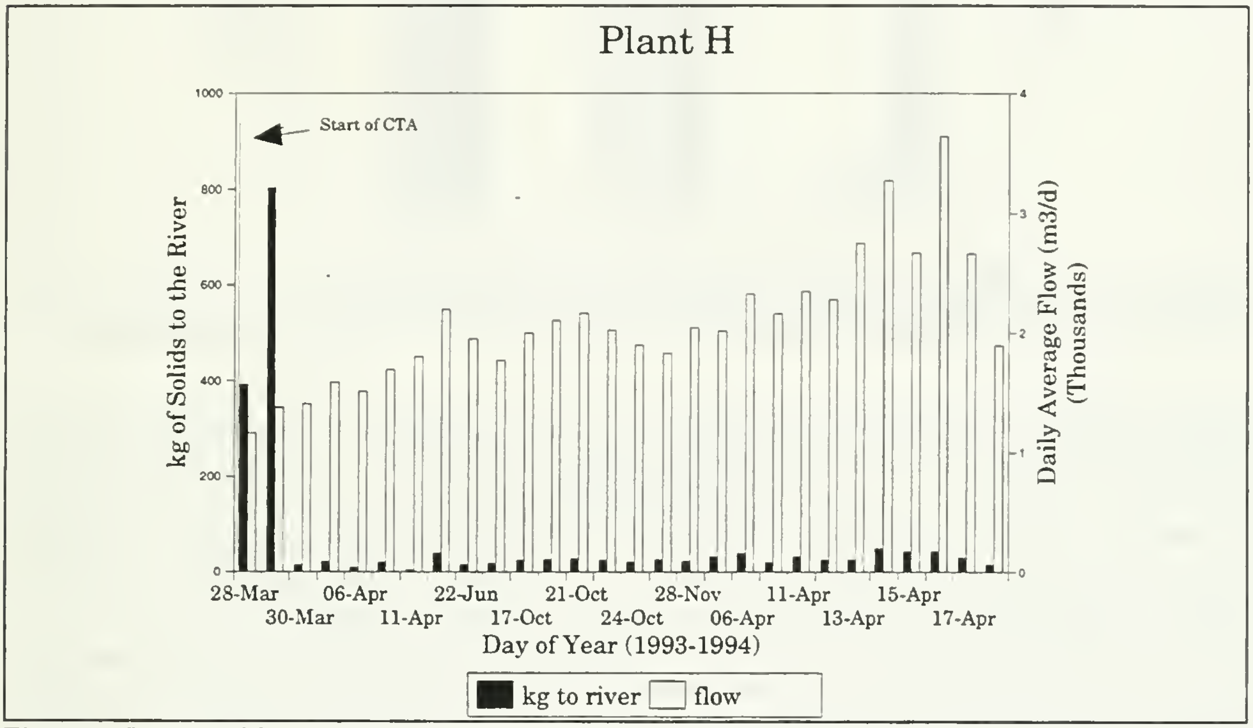

Figure 4 Impact of Storm Events on Solids Loading to River

Figure 5 depicts the benefit which the CTA has had in reducing the volume and duration of raw sewage bypassing during spring months. Prior to the CTA considerable volume and frequency of raw sewage bypassing occurred from the facility during periods of high flow encountered each spring as shown in the data for 1992. However, in 1993 after initiating the CTA, and the level of operator knowledge and preparedness increased and the required process control steps were implemented, the volume and duration of bypassing was reduced by 25 percent and 38 percent, respectively. In November 1993 the plant was retrofitted to provide step feed capability. In the spring of 1994 with the use of the step feed capability in conjunction with good process control and skilled operations staff, the volume and duration of bypassing was reduced by 95 percent and 97 percent, respectively, when compared to the spring prior to the CTA. The total flow to the treatment plant remained consistent for the spring period during the three years examined.

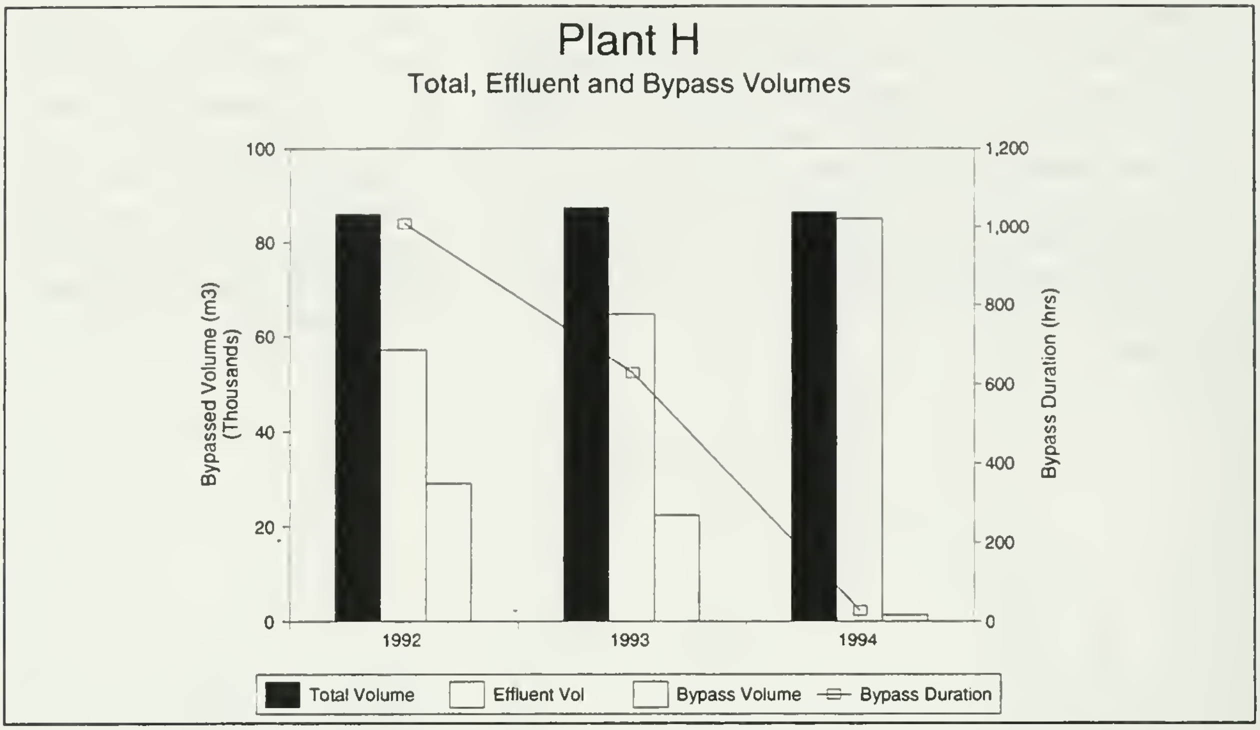

Figure 5 Comparison of Influent, Effluent, Bypass Volume and Duration for Spring of 1992-1994

Figure 6 depicts the reduction in BOD_5 and TSS loading to the receiving stream associated with the reduction in raw sewage bypassing. Prior to the CTA, spring bypassing resulted in considerable BOD_5 and TSS loading to the river as shown in the data for 1992. However, as the level of operator confidence and awareness improved and the required daily process control was put in place, the BOD_5 and TSS loadings contributed from spring bypassing were each reduced by 40 percent as shown in the data for 1993. In the spring of 1994, the use of step feed in combination with good process control and skilled operations staff, enabled a 96 percent and 95 percent reduction in BOD_5 and TSS loadings, respectively, when compared to loadings contributed from bypassing in 1992.

Figure 7 depicts the hauled sludge concentration and unit sludge handling costs per kg hauled for the duration of the CTA. Prior to and during the initial period of the CTA, the plant was affected by a filamentous bulking problem. As a result, the ability to thicken waste activated sludge in the on-site aerated holding tank was compromised as shown by the low hauled sludge total solids concentrations in May through July 1993. As the CTA progressed and the required daily process control program was applied, changes in activated sludge settling characteristics occurred, and the ability to thicken waste activated sludge was consistently improved, as shown from August 1993 to the conclusion of the CTA. By optimizing activated sludge settling characteristics through application of concepts, and consistently improving the ability to thicken waste activated sludge, a 47 percent reduction in the unit sludge haulage costs were achieved during the CTA as represented by the line graph.

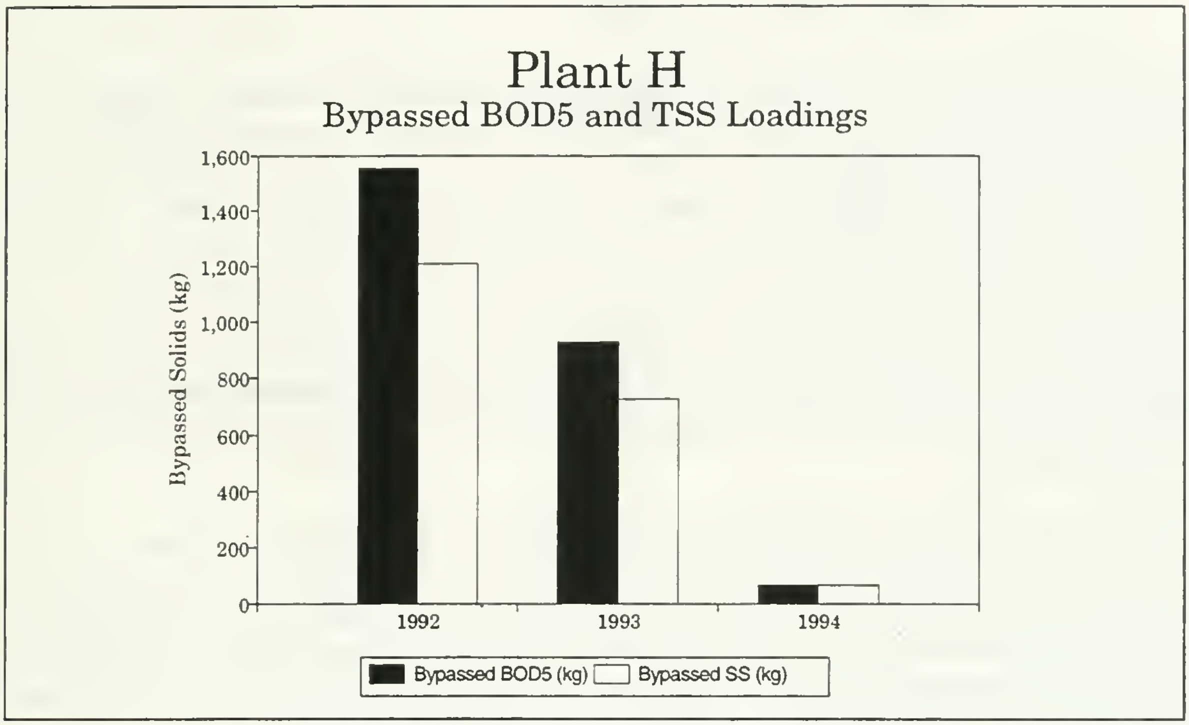

Figure 6 Total Raw Sewage Bypass BOD_5 and TSS Loadings for Spring (March and April) of 1992-1994

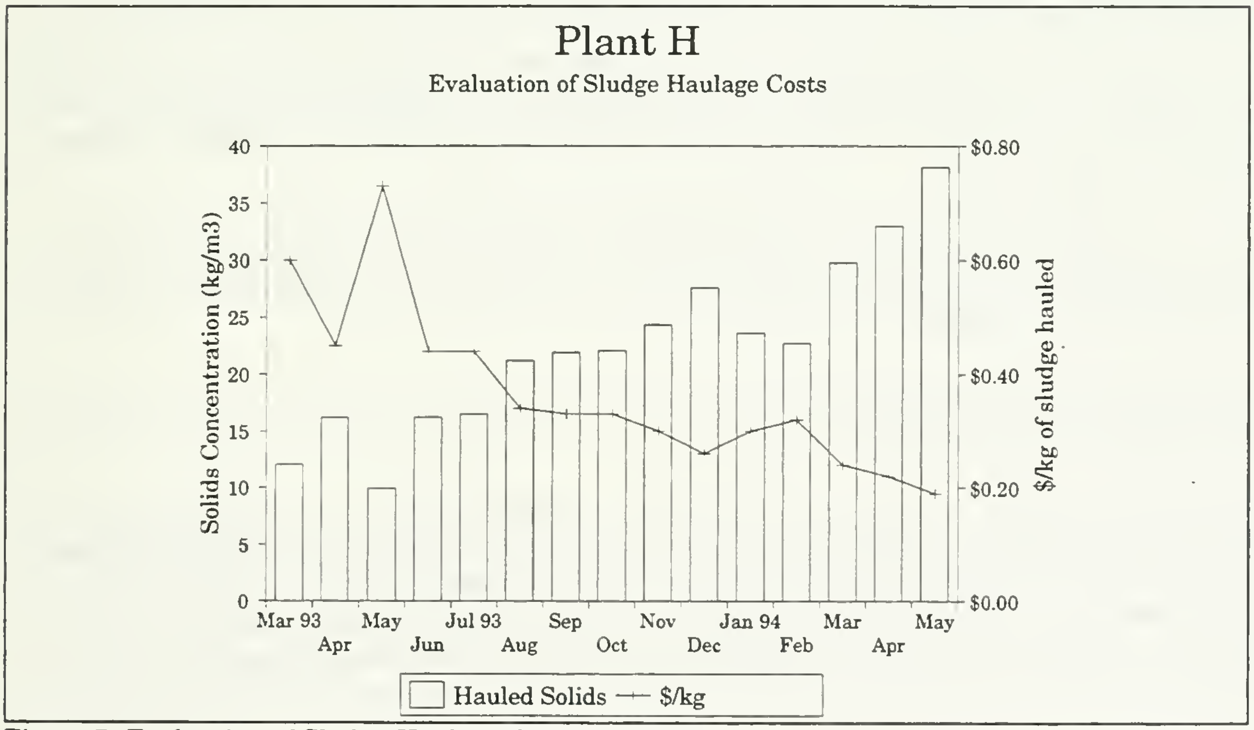

Figure 7 Evaluation of Sludge Haulage Costs 1992-1994

6. SUMMARY AND CONCLUSIONS

Since the beginning of the CTA the plant performance has shown a significant improvement in final effluent quality. Significant reductions in BOD_5 (89%), TSS (83%) and Ammonia (93%) loadings to the river were achieved. The CTA has shown that under current loading the plant can consistently achieve monthly average compliance for BOD_5 and TSS without additional capital expenditure.

The CTA established a focus on demonstrating that the significant volume and frequency of raw sewage bypassing which had occurred historically during spring months could be reduced through establishment and maintenance of process control, improving plant coverage, and performing a low cost retrofit at the facility to provide step feed capability.

Initially, the plant was staffed by two operations staff for eight hours per day. Involvement of two operations staff allowed a senior staff member responsible for other activated sludge plants to benefit from the CTA activities. As the CTA progressed, the level of operator awareness and understanding of the process enabled one staff member to operate the facility effectively while spending four hours on-site during stable dry weather flow conditions.

During the spring of 1993, following the start of the CTA, raw sewage bypass flow and duration was reduced by 25 % and 38 % respectively. The step feed retrofit was performed in late 1993 at a total cost of $ 13,696.00. During the spring of 1994, the use of step feed enabled the raw sewage bypass flow and duration to be reduced by 95 % and 97 % respectively. Flows greater than 4 times the design flow were successfully handled for extended periods without exceeding the desired effluent quality (20 mg/L TSS).

Plant management support in recognizing and addressing the need to respond to storm events, and provide plant coverage during periods of spring freshet is vital to the success of the response strategy.

The operations staff developed a high level of skill required to establish and maintain process control at the Plant H plant.

The implementation of a routine process control program based on total sludge mass, focused the attention of operations staff on the amount of sludge being produced and wasted from the activated sludge process to the aerated holding tank. The process control activities consistently reduced the volume of sludge being hauled from the process; however, the mass of solids being removed was greater than the historic quantities. To date a 47 % reduction in unit sludge haulage costs has been achieved.

7. RECOMMENDATIONS

- Adequate staffing levels and plant coverage at the Plant H STP must be maintained to enable the current level of control and performance to be continued.

- Plant and area operations management must continue to identify plant performance as a priority and support the operations staff in maintaining the demonstrated improvements.

- It is recommended that staff continue to utilize the daily process control program which was developed and established during the CTA. Data trending should also be continued.

- It is recommended that use of step feed capability be continued during storm flows and spring freshet.

- To enable totalized flow measurement of bypassed raw sewage it is recommended that the temporarily installed ultrasonic measuring device be permanently installed for future monitoring.

- Modification to the air lift control of RAS flow should be investigated (ie. installation of a timer in conjunction with an electrically activated solenoid valve or installation of an alternate pump arrangement).

- It is recommended that 24 hour composite sampling equipment be made available for monitoring combined effluent quality.

- Long term sludge storage options should be developed for the facility.

REFERENCES

1. Hegg, B.A., L.D. DeMers, and J.B. Barber, Handbook - Retrofitting POTW's, EPA 625/6-89-020, U.S. Environmental Protection Agency, Center for Environmental Research Information, Cincinnati, Ohio, (July 1989).

APPENDIX 4.A

Daily Monthly Process Control Worksheets

These process control worksheets are completed each day by the operator. By following the daily routine and by completing the worksheet, the operator identifies the mass of sludge and subsequently the volume which should be wasted each day in order to maintain an effective biological system.

DAILY PROCESS CONTROL WORKSHEET DATE: ____________

TIME	FLOW METER	FLOW/hr m3	TREATED FLOW m3	RETURN RATE m3/d	RAS % of PLANT FLOW	BYPASS GATE SETTING	BYPASS FLOW m3	D.O. mg/L	SBD ft.	SBD DARK ft.	CLARIFIER MLSS g/L	AERATION MLSS g/L	CLARIFIER MASS kg	AERATION MASS kg	SDR
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AVG.															
TOTAL															

Please do not write in the shaded areas of this form.

COMMENTS/PROBLEMS/OTHER OPERATIONAL CHANGES: This section does not exclude the requirement for bound plant logbook entries.

PROCESS CONTROL WORKSHEET

Day	Time	Total Flow (m3/d)	Peak Flow (m3/d)	Flow Splitting % Tank # 1 %	Flow Splitting % Tank # 2 %	MLSS TANK # 1 (g/L)	MLSS TANK # 2 (g/L)	Average MLSS (g/L)	Aeration Mass (kg)	Clarifier Sludge Conc. (g/L)	Clarifier Mass (g/L)	Total Mass (kg)	AVG. SDR	Effluent S.S. (g/L)	Effluent Mass (kg)	RAS Conc. (g/L)	Waste Sludge Concentration (g/L)	Wasted Volume (m3)	Wasted Mass (kg)	SRT (days)	Kg to Waste	m3 to Waste

Data Forward from Last Day, Previous Month

Current Monthly Data Month: ________ Year: ________

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AERATION VOLUME: 796 m3

CLARIFIER VOLUME: 301 m3

TARGET SRT: ________ days

COMPLIANCE CRITERIA

Monthly: 15/20/NA BOD/SS/TP

Current: 25/25/NA BOD/SS/TP

SDR = Sludge Distribution Ratio

SRT = Solids Residence Time

Revised April 11, 1994

PROCESS CONTROL WORKSHEET

Day	Tank #1 30 MIN (%)	Tank #2 30 MIN (%)	Average 30 MIN (%)	SVI	AVE. SBD (in.)	D.O. Tank #1 (mg/L)	D.O. Tank #2 (mg/L)	Temp. (deg. C)	Precipitation (mm)	Weather Conditions S, R, SN, C	Hauled Volume (m3)	Hauled Sludge Concentration (mg/L)	Supernatant Volume (m3)	Supernatant Concentration (mg/L)	BYPASS FLOW (m3/d)	BYPASS DURATION (hours)	Combined Effluent SS (mg/L)	RETURN RATE (m3/d)	RETURN RATE (%)	CSRT (h)	Sodium Hypochlorite IN (L)	OUT (L)	USED (L)	ADD (L)	RES (mg/L)

Data Forward from Last Day, Previous Month

Current Monthly Data Month: ________ Year: ________

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SBD = Sludge Blanket Depth Weather Conditions: S = Sunny, R = Rain, SN = Snow, C = Cloudy Revised April 11, 1994

CSRT = Clarifier Sludge Retention Time

APPENDIX 4.B

Step Feed Retrofit Description and Specifications

Comprehensive Technical Assistance Program

Modification of Treatment Facility to provide for Step Feed Capability

Request for Quotation to Manufacture and Install Equipment

February 26, 1993

Work Description and Specifications

Task 1.0 Comminutor Modification

1.1 Modify existing influent headworks to enable connection to step feed distribution channel.
1.1.1 Install flow control gate in influent trough. (Figure 1)

1.2 Extend height of comminutor swing gate to an equal height with rest of comminutor trough. (Figure 1)

1.3 Fabricate distribution box (if piping is used), complete with control gate to enable regulation of flow to step feed channel. (Figure 1 to 4)
1.3.1 Install 1 inch bar screen at distribution box inlet. (Figure 1)

Task 2.0 Construction and installation of distribution channel.

2.1 Construct and install channel to enable plant flow to be diverted to the latter one-half of the aeration tank. (Figure 2)
2.1.1 Length of channel to be 91 feet 6 inches.
Channel can be constructed to be either open or closed to atmosphere.

2.2 If open channel, width of channel must be 12 inches.
Depth of channel to be 12 inches. Material to be determined by contractor.
If piping is used, diameter must be 12 inch. Materials can be flexible or corrugated piping.

2.3 Channel to be installed clockwise from comminutor.

2.4 Nominal drop in length of channel to be adequate to achieve gravity drainage.

Task 3.0 Construction and installation of flow control baffle in aeration tank. Figure 1 to 3)

3.1 Baffle to be inserted in aeration tank at pre-designated point.

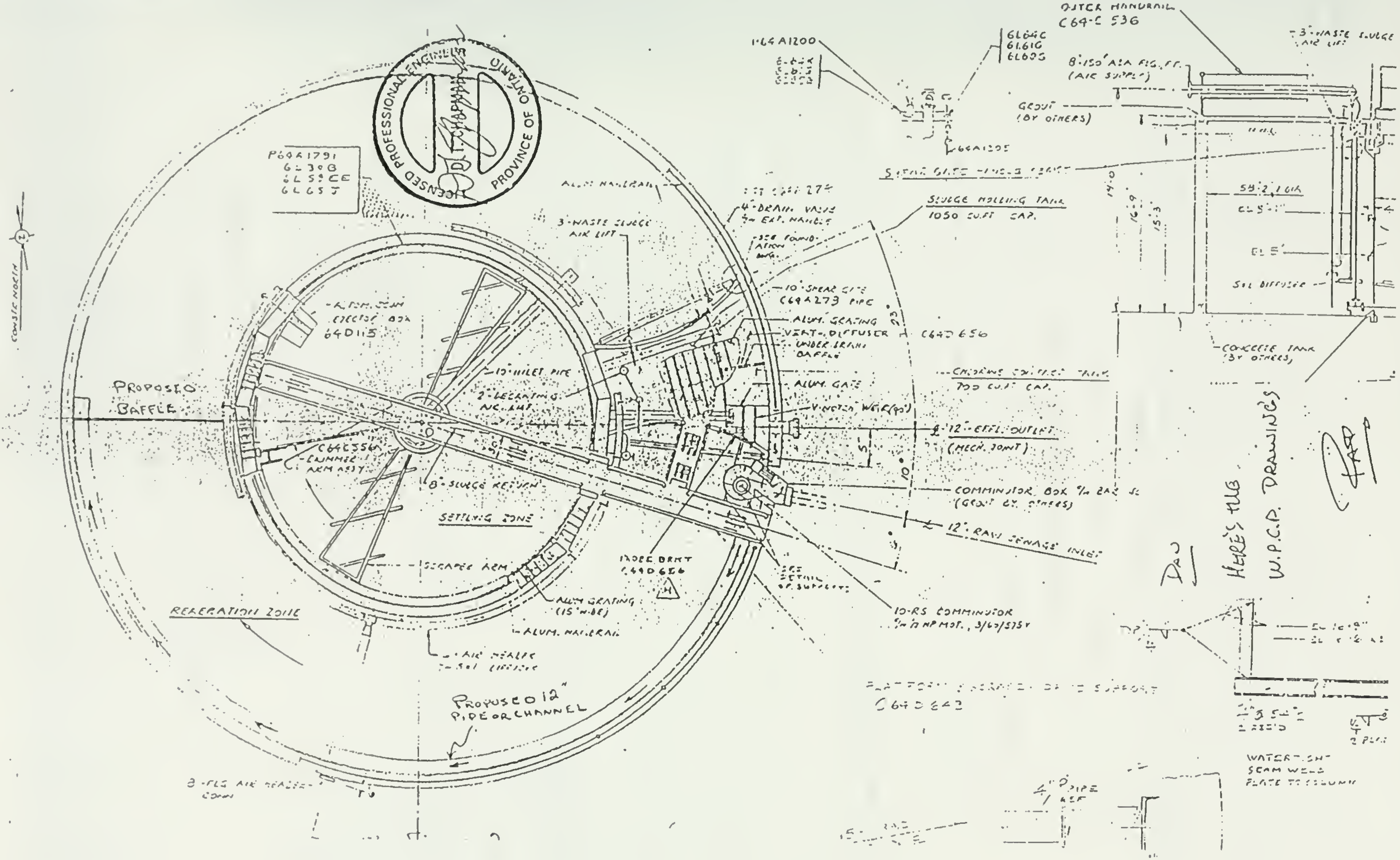
3.2 Baffle to be constructed of steel or wood, width 14 feet, and depth 16 feet 9 inches.

3.3 Baffle opening to be inserted approximately mid depth.(onside closest to outer aeration tank wall). Area of opening to be 10 inches by 12 inches, or similar dimensions to provide 120 square inches of open space. Opening to be fitted with an adjustable sliding gate to enable flow control. Gate to be made of galvanized steel. (Figures 3 to 4) (with [illegible] hardware in control [illegible] ; [illegible])

3.4 Second opening to be installed at base of baffle to enable controlled drainage of divided tank. Opening to be fitted with gate to enable open and closed function. (Figures 3 to 4) (include opening + closing [illegible])

All measurements are approximate and must be measured and verified on-site by the contractor providing the quotation.

EXISTING FACILITY WITH PROPOSED MODIFICATIONS



Dan

Here's the W.P.C.P. Drawings

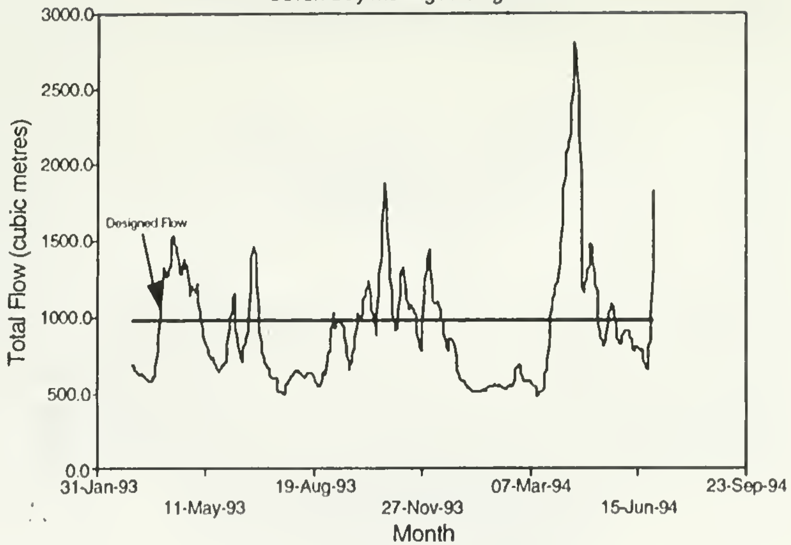
[signature]

APPENDIX 4.C

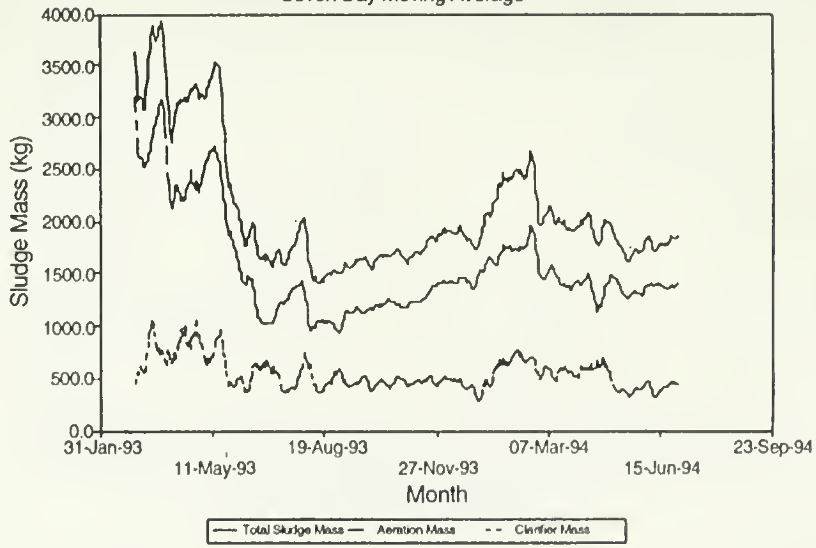
Trend Analysis of Operational and Performance Data

Operational Data Summary for Plant H STP

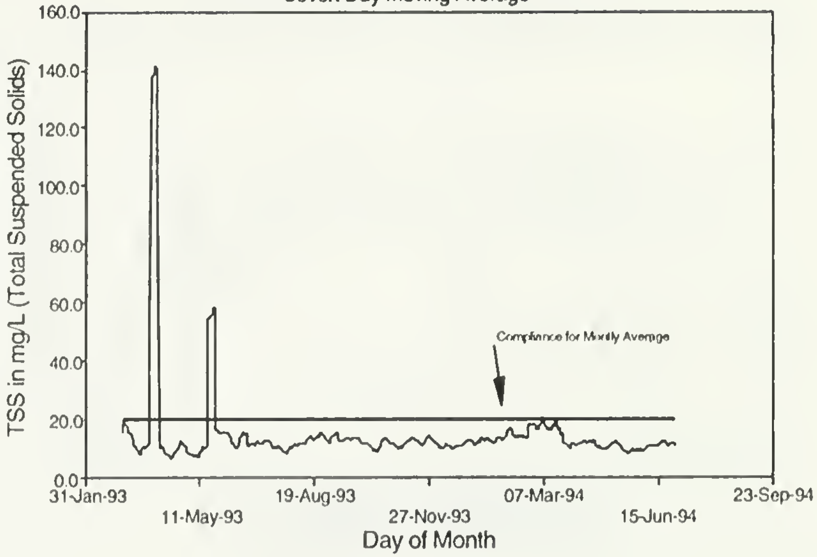
Total Flow vs. Time for Plant H
Municipal Wastewater Treatment Facility
Seven Day Moving Average



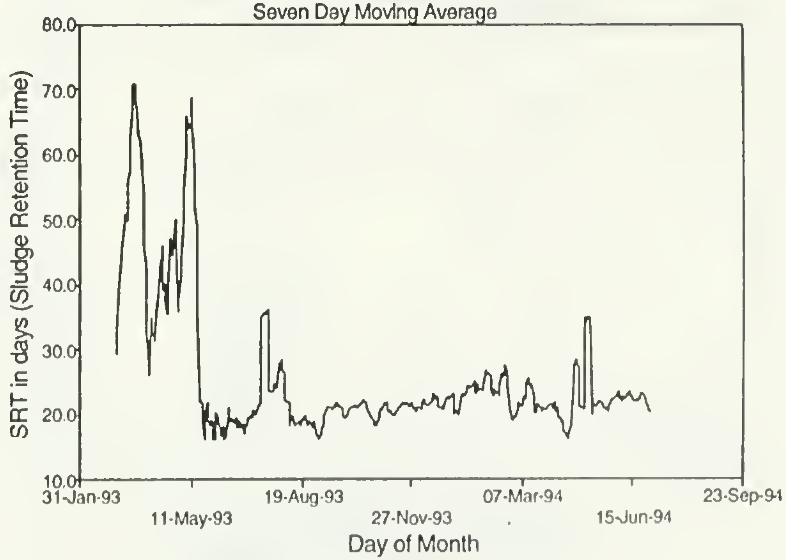
Sludge Mass vs. Time for Plant H
Municipal Wastewater Treatment Facility
Seven Day Moving Average



Eff SS vs. Time Period for Plant H
Municipal Wastewater Treatment Facility
Seven Day Moving Average

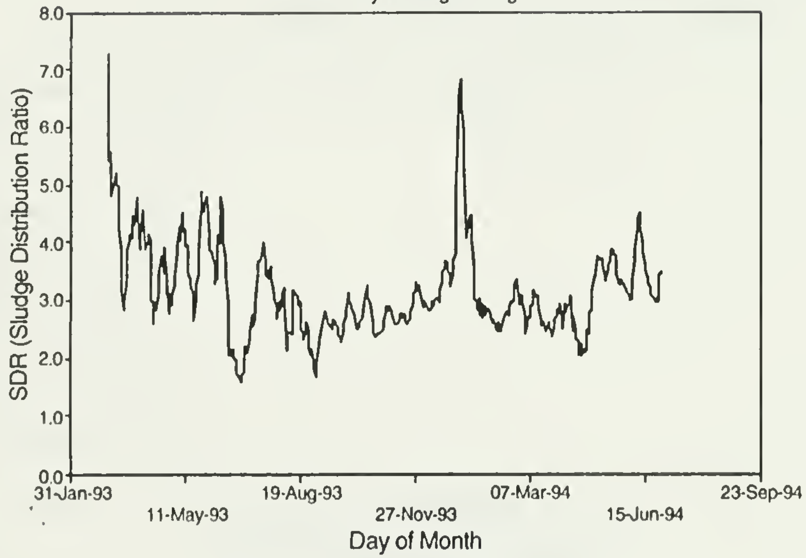


SRT vs. Time Period for Plant H
Municipal Wastewater Treatment Facility
Seven Day Moving Average

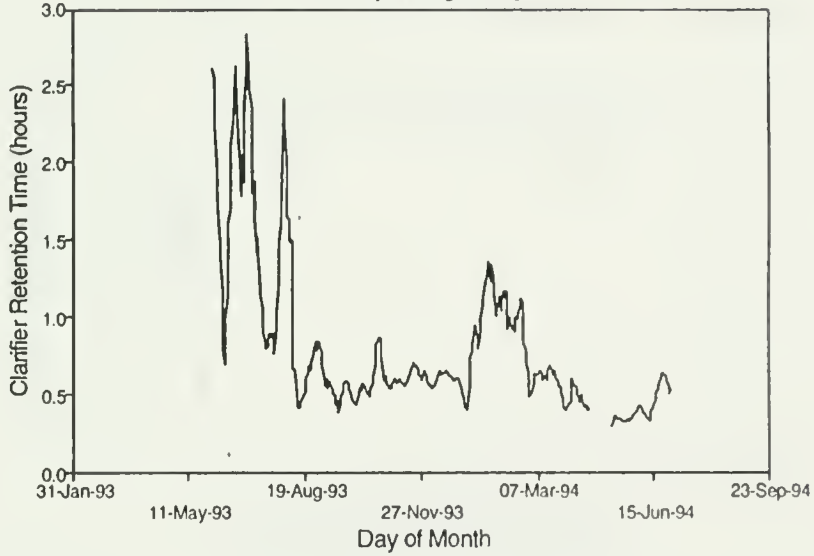


Operational Data Summary for Plant H STP

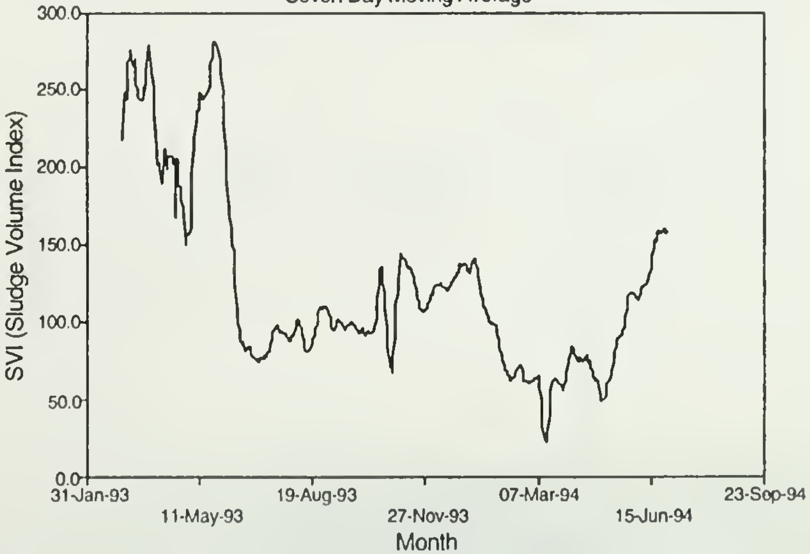
SDR vs. Time Period for Plant H
Municipal Wastewater Treatment Facility
Seven Day Moving Average



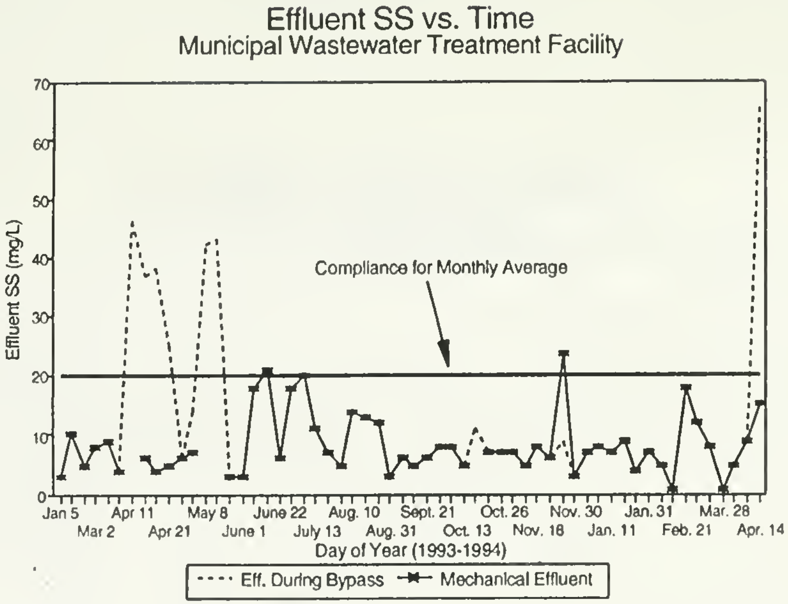
ClarifierRT vs Time Period - Plant H
Municipal Wastewater Treatment Facility
Seven Day Moving Average

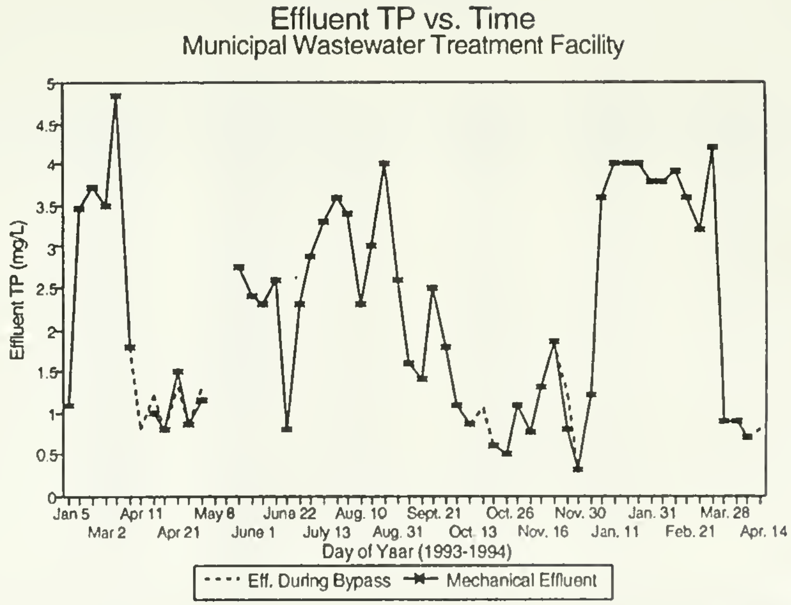


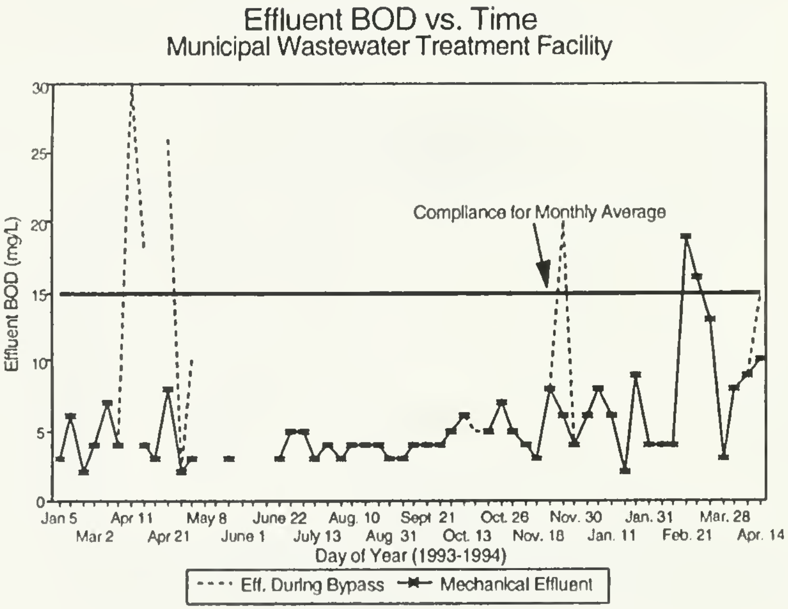
SVI vs. Time Period for Plant H
Municipal Wastewater Treatment Facility
Seven Day Moving Average

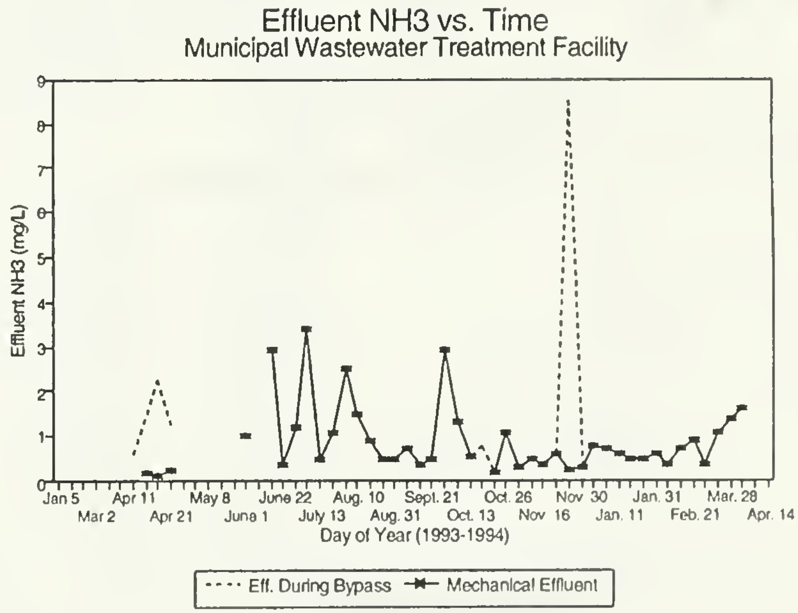


Performance Data Summary for Plant H

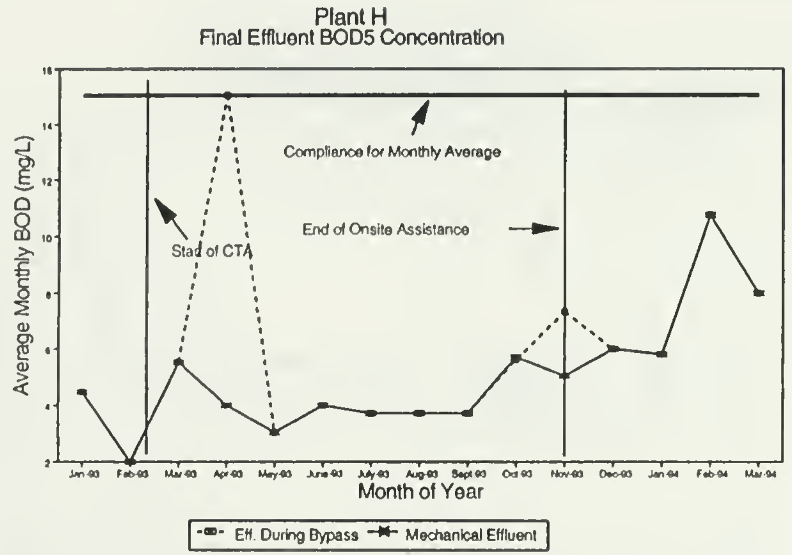


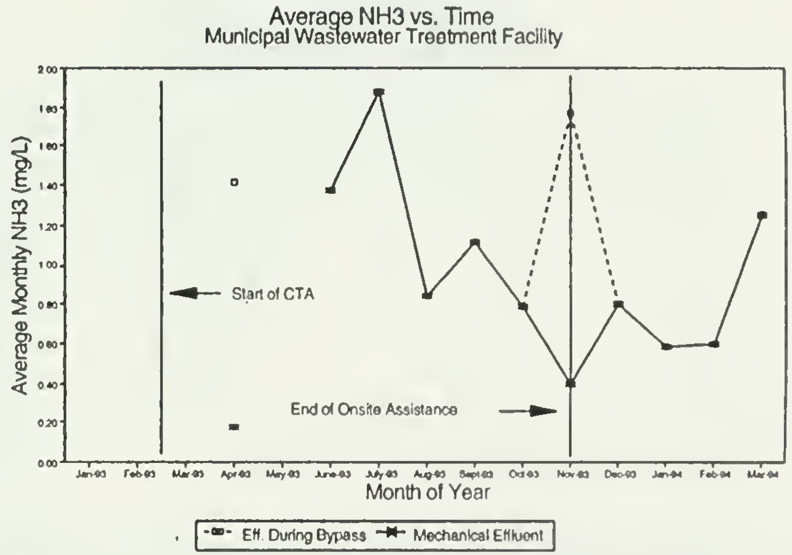


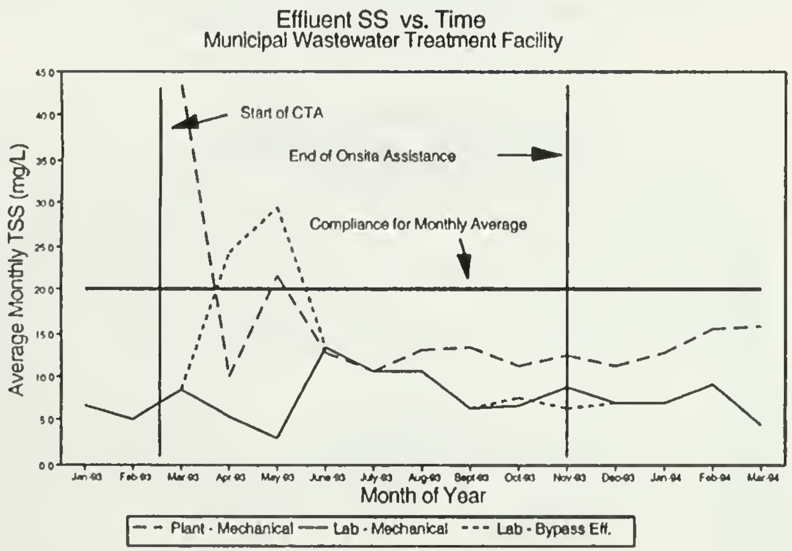




Monthly Average Data Summary for Plant H







Month	TSS (mg/L) Plant Lab			BOD Lab		NH3 Lab	
	Mechanical	Ministry Lab Mechanical	Combined	Mechanical	Combined	Mechanical	Combined
Jan-93		6.5	6.5	4.5	4.5		
Feb-93		5.0	5.0	2.0	2.0		
Mar-93	43.4	8.5	8.5	5.5	5.5		
Apr-93	9.8	5.3	24.3	4.0	15.0	0.2	1.4
May-93	21.5	3.0	29.3	3.0	3.0		
June-93	12.8	13.2	13.2	4.0	4.0	1.4	1.4
July-93	10.6	10.8	10.8	3.8	3.8	1.9	1.9
Aug-93	12.9	10.5	10.5	3.8	3.8	0.9	0.9
Sept-93	13.3	6.3	6.3	3.8	3.8	1.1	1.1
Oct-93	11.2	6.8	7.6	5.8	5.6	0.8	0.8
Nov-93	12.5	8.8	6.3	5.0	7.3	0.4	1.8
Dec-93	11.1	7.0	7.0	6.0	6.0	0.8	0.8
Jan-94	12.6	7.0	7.0	5.8	5.8	0.6	0.6
Feb-94	15.6	9.0	9.0	10.8	10.8	0.6	0.6
Mar-94	15.6	4.5	4.5	8.0	8.0	1.3	1.3
Average	15.6	7.5	10.4	5.0	5.9	0.9	1.1

APPENDIX 5

List of activities and procedures which were documented while preparing and drafting the site specific process control operations manuals

SECTION 1: ANALYTICAL PROCEDURES
- Clarifier Sludge Sampling
- Measure of pH
- Microwave Drying
- Return Activated Sludge Sampling Method
- Sartorius Balance
- Sludge Volume Index
- Total Suspended Solids
- Total Volatile Suspended Solids
- Washing Glass Fibre Papers

SECTION 2: INSTRUMENTATION CALIBRATION
- Dissolved Oxygen Meter

SECTION 3: SPECIAL STUDIES
- Adjustment and Setting of Aeration Basin Tip Gates
- Aeration Tank Flow Equalization
- Bypass alternative (solids holding)
- Bypass alternative (turn off air to aeration)
- Determine the Accuracy of the Sludge Wasting Control
- Documentation of storm event (no bypass)
- Impact of turning on second blower
- Impact on Dissolved Oxygen by Adjustment and Setting of Aeration Basin Tip Gates
- Polymer Addition to the Secondary Clarifiers
- Sludge Mass Distribution
- Supernating to the Aeration Basins

SECTION 4: PROCESS CONTROL EMERGENCY PROCEDURE
- Start up of diesel generator (emergency or test)

SECTION 5: PROCESS CONTROL OPERATIONS PROCEDURES
- Alum dosage rate calculation
- Collecting clarifier sludge sample
- Digester Supernating and Sludge Transfer to Holding Tank
- High plant flows
- Plant bypass
- Programming and Setting of Waste Sludge Controller
- RAS Suspended Solids Sampling
- Recording RAS flow
- Secondary Bypassing
- Secondary sludge mass distribution control
- Sludge wasting
- Solids retention time
- Supernating and sampling procedures
- Supernating from secondary digester and sludge holding tank
- Wasting
- Weekday work activities

SECTION 6: PROCESS CONTROL WORKSHOP

SECTION 7: PLANT DESIGN SPECIFICATIONS